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Multi-purposeful Water Design for Monte Sano Park in Baton Rouge

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Multi-purposeful Water Design for Monte Sano Park in Baton Rouge

A Thesis

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ABSTRACT

Today, water-related disasters, including hurricanes, flood, and stormwater surge, are occurring more frequently than in the past due to extreme weather brought by climate change all over the world. In August 2016, Baton Rouge had a historic heavy rain which brought flood and negative economic impacts specifically on the north Baton Rouge area. To mitigate the negative impact of future flooding, in Monte Sano Park and its neighborhoods in north Baton Rouge, it would be helpful to implement green infrastructure which utilizes natural infiltration process of soils and plants to slow, store, and treat the stormwater as well as enhances community well-being by creating open spaces. To figure out issues on site and to determine emphasis in the site, the thesis addresses site survey and site analysis at four different scales including East Baton Rouge Parish, Monte Sano Bayou watershed scale, Monte Sano Park scale, and the design focus site scale. The site analysis at the site scale including water quality and quantity survey, existing plant and wildlife, and soil survey reveals the site-specific issues and opportunities. Based on the analysis, the study proposes site design by utilizing the site potential. The design implements green infrastructure in the site to mitigate negative impact and to enhance community well-being.

Chapter 1. Introduction

1.1. Rationale of the Topic and the Site

In August 2016, an inland tropical depression brought historic heavy rainfall of 7.1 trillion gallons precipitation (enough water to fill Lake Pontchartrain four times) in Louisiana.[1] This thousand-year rainfall event caused the Amite River and the Comite River to flood as well as affected bayous, canals, lakes, and other waterbodies throughout South Louisiana (Figure 1). The Louisiana Economic Development Office estimated the economic damage of the flood was 836 million dollars, with over 8,000 businesses and 143,700 employees affected by the storm and the flood in East Baton Rouge Parish.[2]

North Baton Rouge in East Baton Rouge Parish is one of the areas severely affected by the rainfall and the flood because of topographic, geographic, and social vulnerability. In this age of climate change, creating multi-beneficial open spaces with stormwater management in vulnerable areas is an immediate mission of landscape architects. In this context, stormwater management should not only control water quality and quantity but should also add values to mitigate flood impact as well as to enhance community well-being by creating open spaces. For example, stormwater management with green infrastructure mitigates flood impact but also has multiple benefits such as improving biodiversity and providing people with ecosystem services.

The study site is Monte Sano Park and its neighborhoods located in north Baton Rouge (Figure 2). The area was flooded by the 2016 flood as the result of overflow from the Monte Sano Bayou flowing in the park. At the site scale, the study site has multiple opportunities to mitigate flood impact and to create useable open spaces for adjacent neighborhoods. The site offers opportunities for resilient and sustainable design solutions for stormwater management with green infrastructure and has many opportunities to explore such solutions at different scales. Because the Monte Sano Bayou flows both east and west, depending on the surface level of the Mississippi River, the site is

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[1] LSU Coastal Sustainability Studio, *Louisiana Community Resilience Institute*, (Louisiana, LSU CSS, 2017), 10.

[2] Dek Terrell, *The Economic Impact of the August 2016 Floods on the State of Louisiana,* (Louisiana, Louisiana Economic Development, 2016), 2-9.

seasonally influenced by both upstream and downstream flows of water. This dynamic natural influence is one of the unique characteristics of the site. In addition, the site is located in a complex area surrounded by a variety of land use types. At the parish scale, the site has the potential to connect with a proposed loop of the East Baton Rouge Parish Capital Area Pathway Project (Figure 3).[3] Thus, the site offers opportunities for resilient and sustainable design solutions for stormwater management and has many opportunities to enhance community well-being by connecting existing projects in north Baton Rouge.

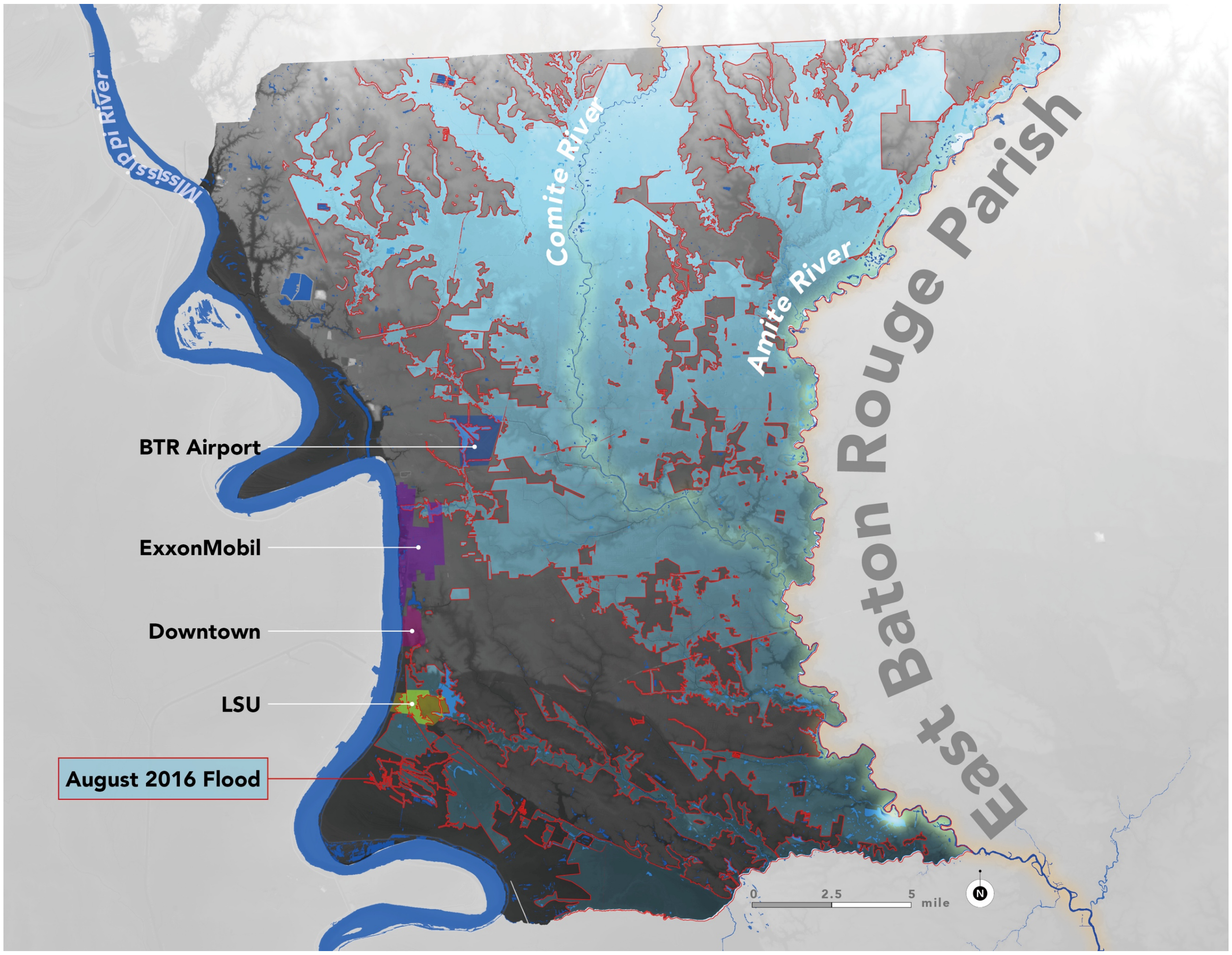

Figure 1. August 2016 Flood Extent in East Baton Rouge Parish (Light blue indicates flooded areas)

[3] BREC, *Capital Area Pathway Project,* (Louisiana, BREC, 2015), 1.

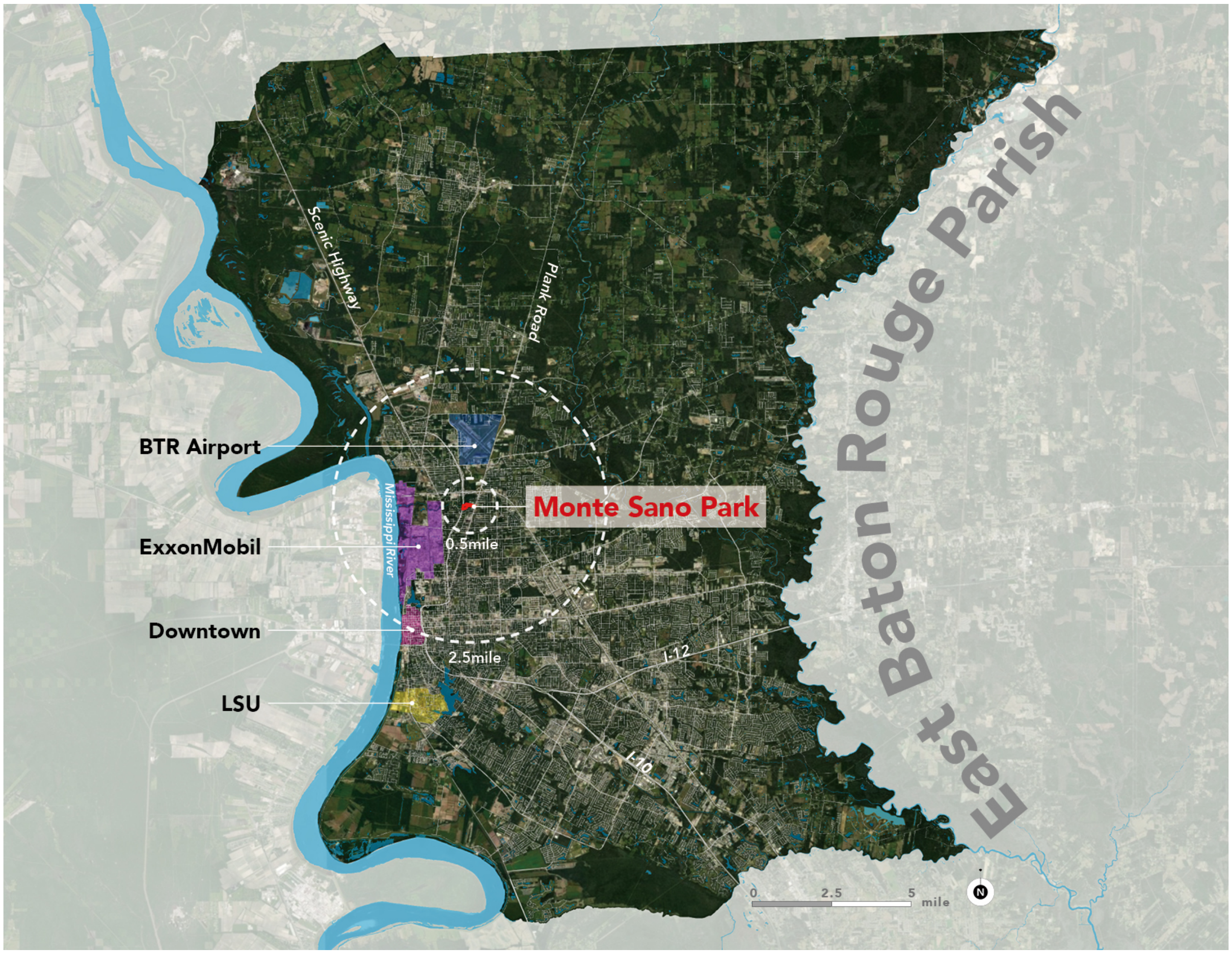

Figure 2. Location of Study Site in East Baton Rouge Parish

This design thesis consists five chapters. Chapter 1 introduces the site context and background. The site background includes general opportunities and issues. Chapter 2 showcases literature reviews and precedent studies related to stormwater management with green infrastructure. Chapter 3 provides the methodology of my proposed design including site analysis at different scales, the design goal, and the design strategy. Chapter 4 illustrates the site design and the vision for the future of the study area. Chapter 5 is the conclusion with summary of the thesis.

1.2. Site Introduction: Site Context and Background

Monte Sano Park is a 54.15 acres park located north of East Baton Rouge Parish between the Plank Road and the Scenic Highway (Figure 2). The park is administered by

Recreation and Park Commission for East Baton Rouge Parish (BREC). This municipal agency has planned the “Capital Area Pathway Project” providing bike and pedestrian pathways in entire East Baton Rouge Parish (Figure 3).

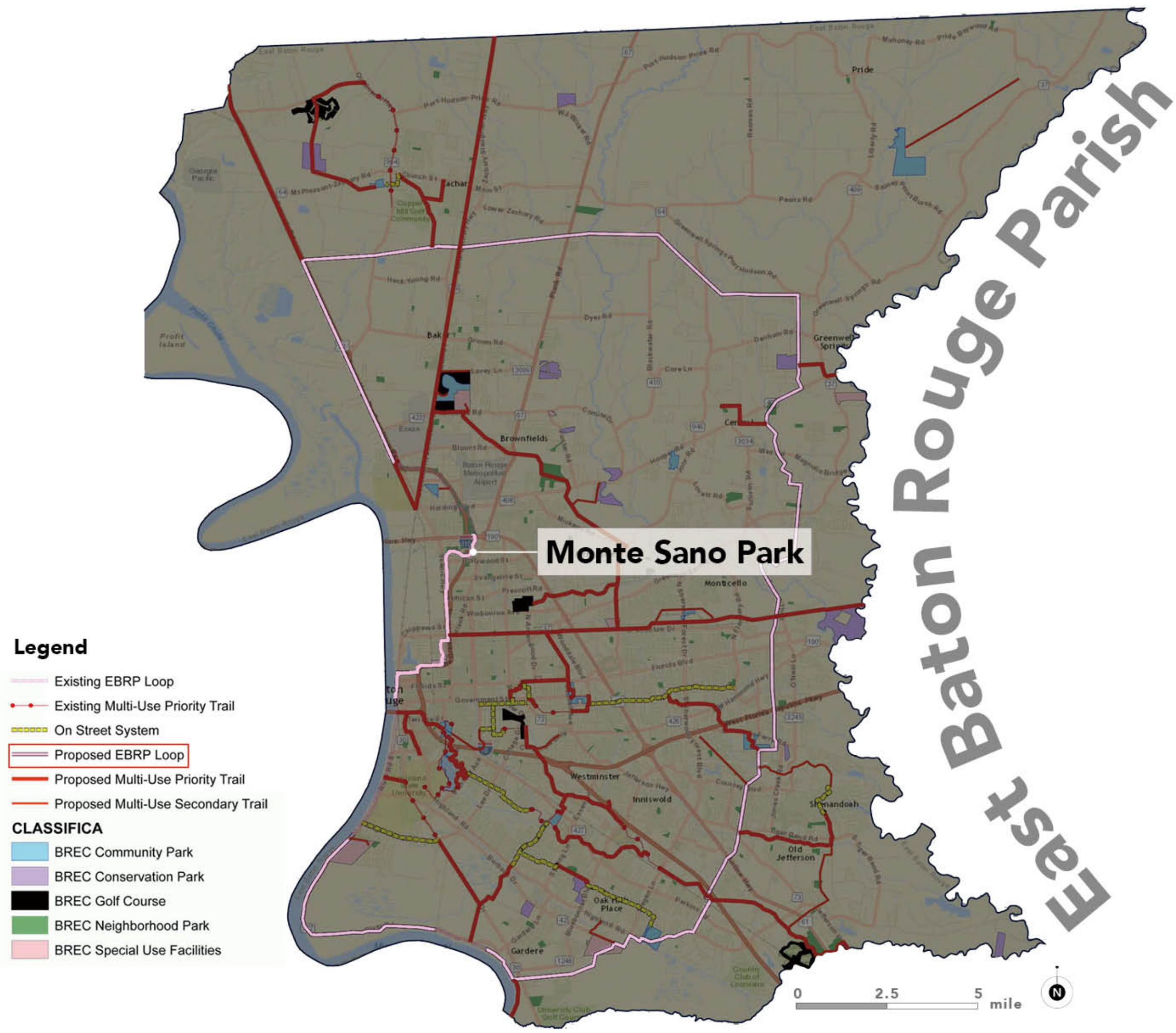

Figure 3. Capital Area Pathway Project by BREC

Monte Sano Park is a part of the proposed “East Baton Rouge Parish Loop” between Scotlandville Parkway Park and downtown Baton Rouge. Surrounding the park consists of diverse land uses such as an industrial site, a residential area, woods, a commercial area along the Plank Road, and some programmed parks (Figure 4 and 5). The Baton Rouge Airport is also about a one-mile distance from the site. In Monte Sano

Park, the features include the bayou, a concrete canal (in degraded physical condition), a large area of grassland, tree canopies, two concrete paved parking lots, a recreation center, an unlighted ball field, a playground, a basketball court, and a church (Figure 6). The most prominent feature of the park is the Monte Sano Bayou which divides the park into north and south parts. Because the bayou flows alternatively toward and from the Mississippi River through the petrochemical industrial site, the site is highly influenced by water quantity and quality from the Mississippi River. The Monte Sano Bayou from Plank Road to the Mississippi River can be divided six sections based on certain characteristics (Figure 7). Among the six sections, the "section 6" between Plank Road and Interstate 110 in the Monte Sano Park is selected as the design site because of its specific opportunities and challenges (Figure 8). In Chapter 3, the site is analyzed in greater detail.

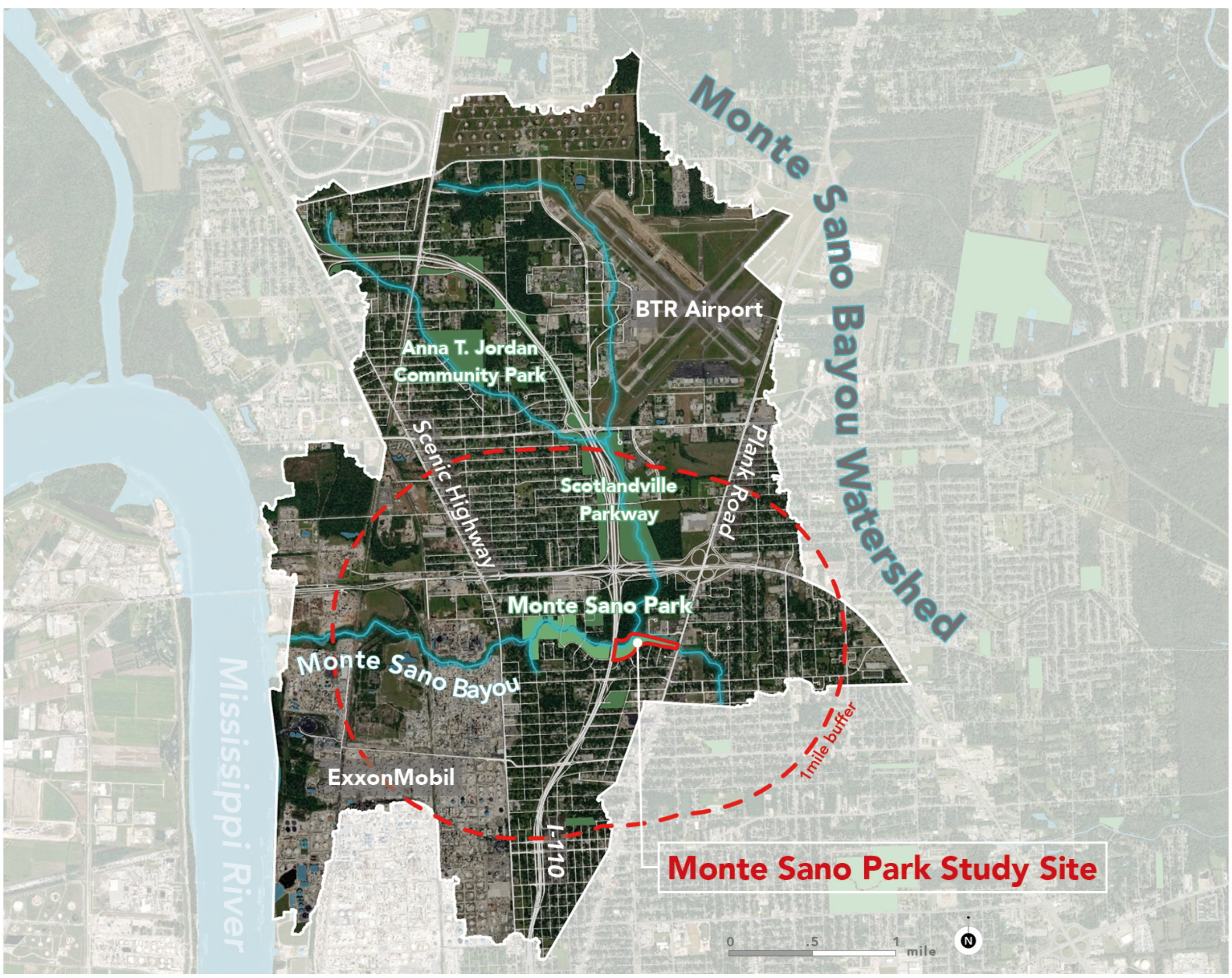

Figure 4. Location of the Study Site at Monte Sano Bayou Watershed

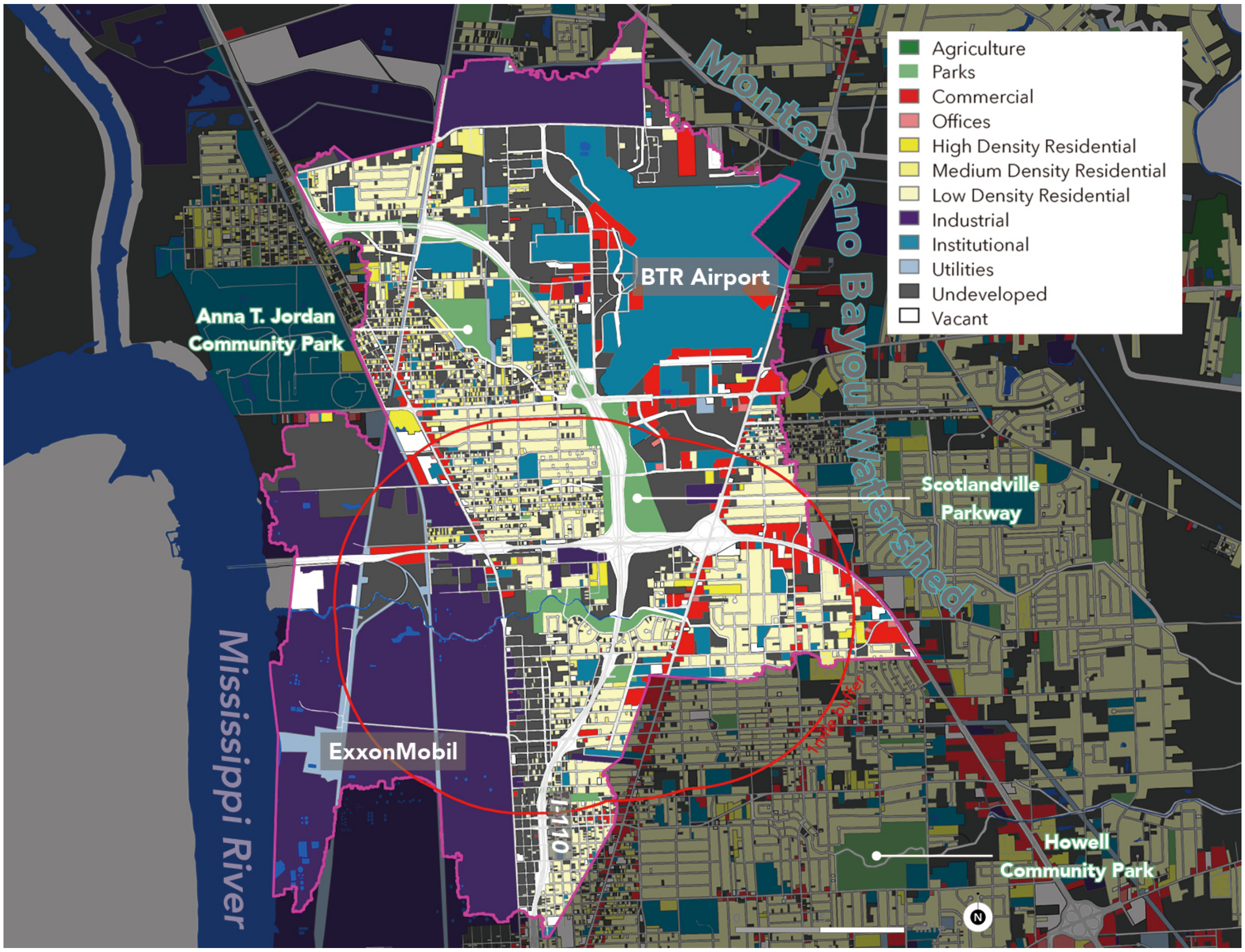

Figure 5. Land Use around the Study Site at Watershed Scale

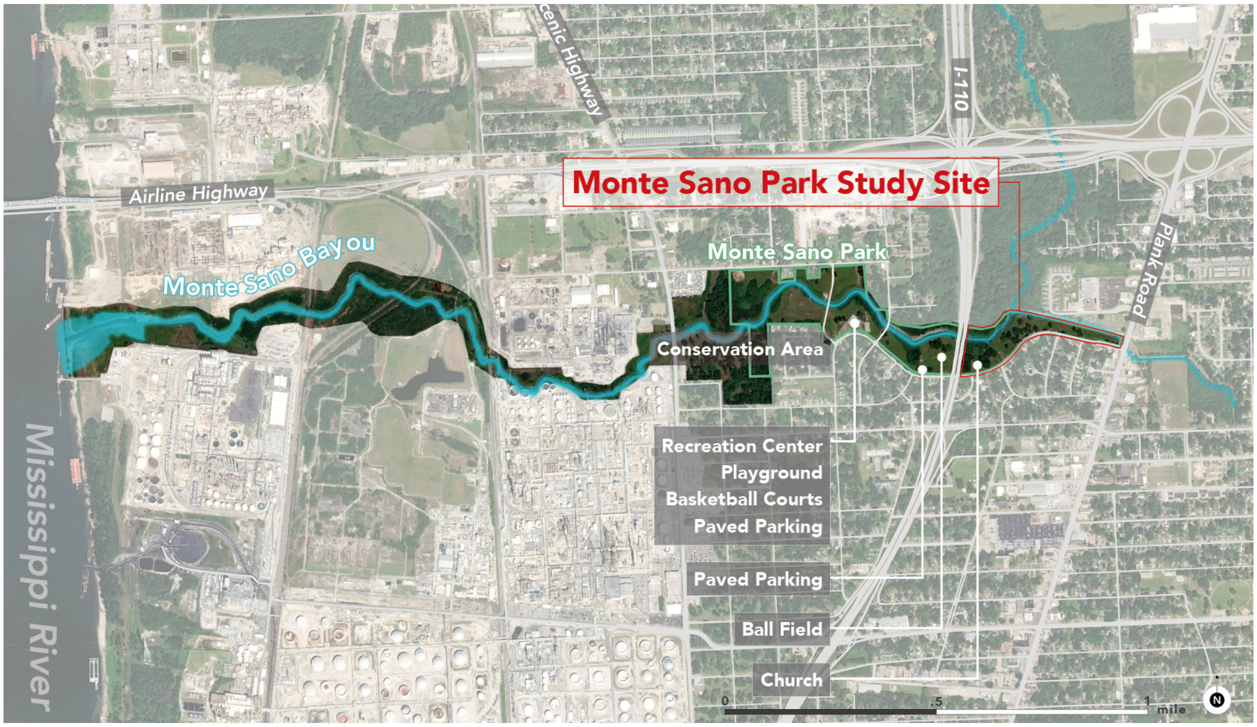

Figure 6. Park Elements between Mississippi River and Plank Road

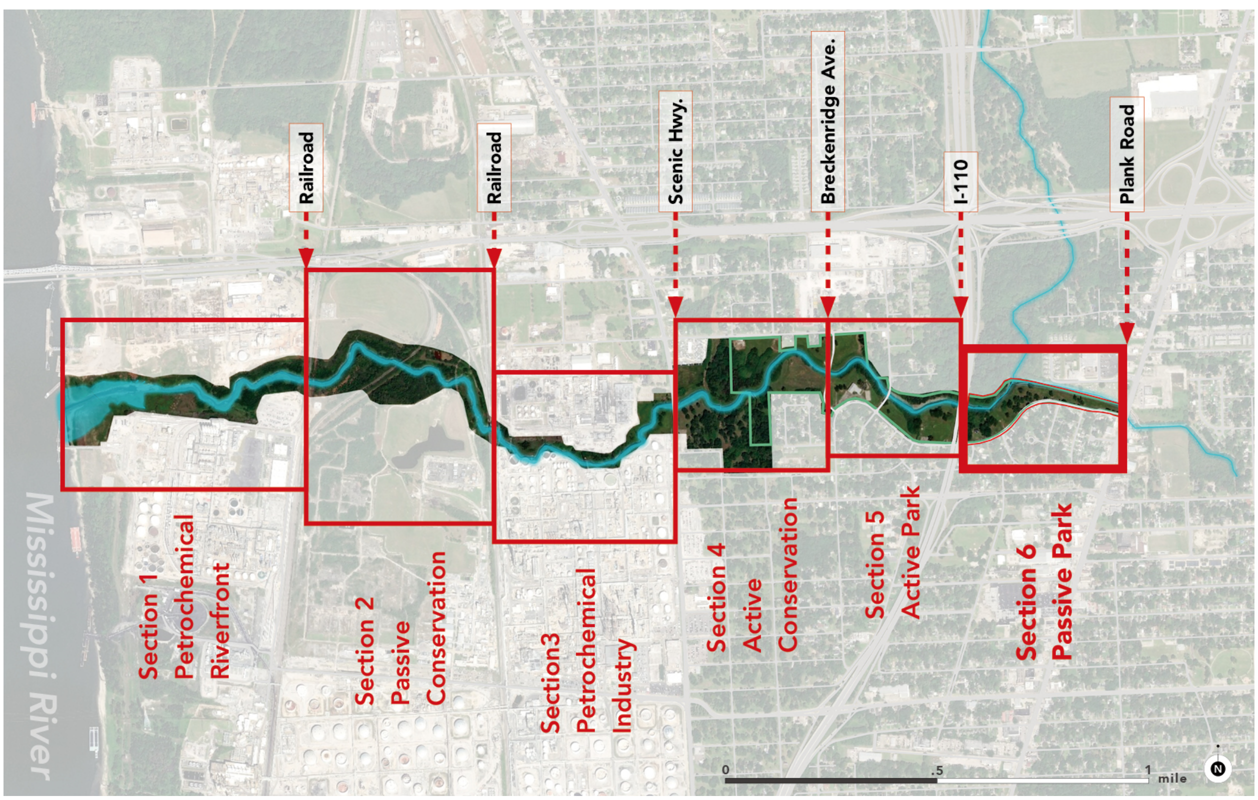

Figure 7. Six Sections of Monte Sano Park

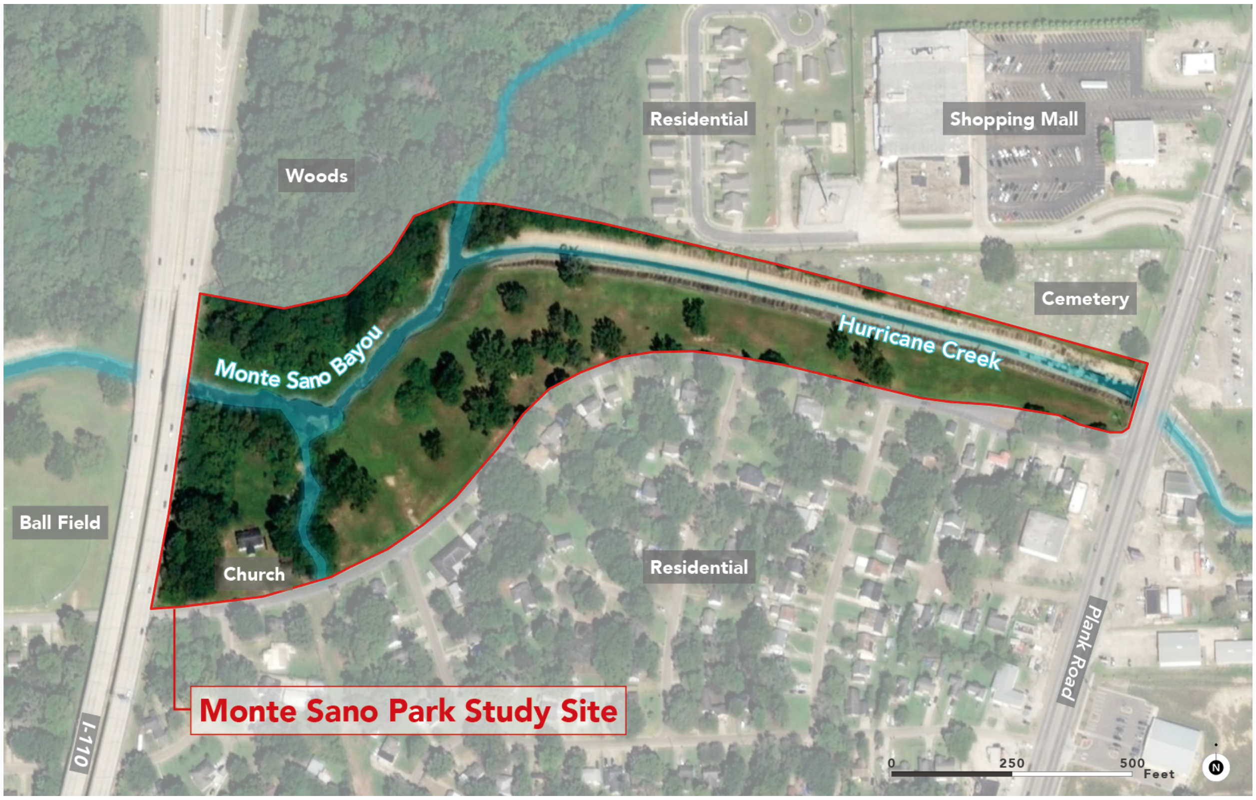

Figure 8. Design Site

1.3. Problems on the Site

My analysis has identified three different issues within the design site. Generally speaking, the first issue on the site is the lack of stormwater management with low and seasonally fluctuating water quantity. The design site, including the houses adjacent to the Monte Sano Park, has experienced the flood in August 2016 (Figure 9). Thanks to Monte Sano Bayou and the holding capacity of the floodplain, the damage was somewhat mitigated. However, Hurricane Creek, which is lined with vulnerable concrete, accelerated the stormwater runoff into the park. In general, conventional infrastructure such as pipes and concrete canals, changes hydrographic characteristics of a canal, increasing stormwater runoff volumes and peak flows.[4] As a result, the 2016 rainfall event caused an overflow of Monte Sano Bayou because water in the bayou was unable to flow into

[4] A.E. Barbosa, *Key issues for sustainable urban stormwater management,* (Lisbon, Elsevier 2012), 6787.

the Mississippi River. Some houses in the neighborhood were flooded and a part of the concrete walls of Hurricane Creek collapsed from erosion (Figure 10).

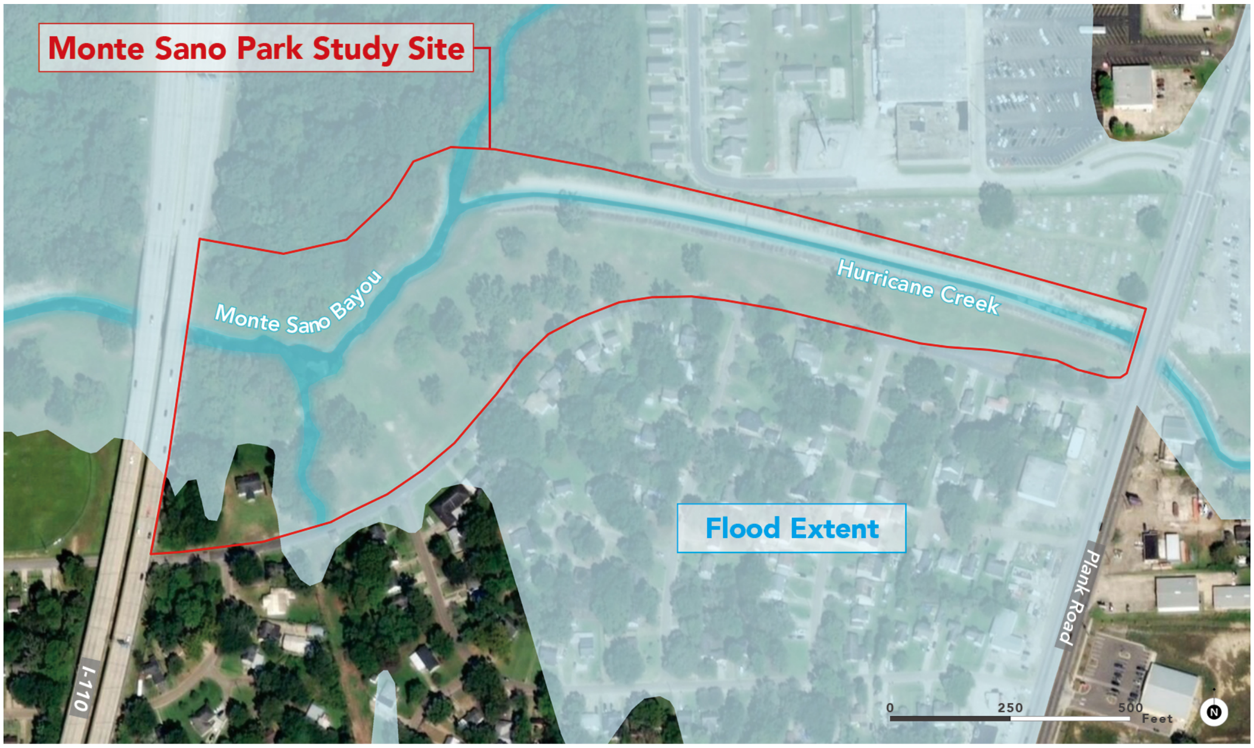

Figure 9. August 2016 Flood Extent at Design Site

Figure 10. Site Problem: Collapse of Hurricane Creek

The second issue of the site is poor water quality. Because bayous usually flow back and forth and are swampy and sluggish, they easily to get polluted compared to fast-flowing streams that move debris and pollutants. In addition, people use the bayou as if a sewer by draining wastewater from individual house through drainage pipes. According to Barbosa,[5] extreme precipitation will pose not only increased volume problems but also water quality impacts whenever stormwater is discharged to water bodies. The site needs a treatment system to purify the wastewater and stromwater runoff before the polluted water flows into the bayou. Both the wastewater and trash make the bayou polluted (Figure 11*)*. Air pollution from adjacent petrochemical plants is another negative impact on the water quality of the bayou because the emission from the plants dispersed by precipitation (Figure 12).[6]

Figure 11. Site Problem: Trash in Monte Sano Bayou

[5] Ibid., 6789

[6] "What is Acid Rain?" EPA.org. accessed March 5, 2019. https://www.epa.gov/acidrain/what-acid-rain

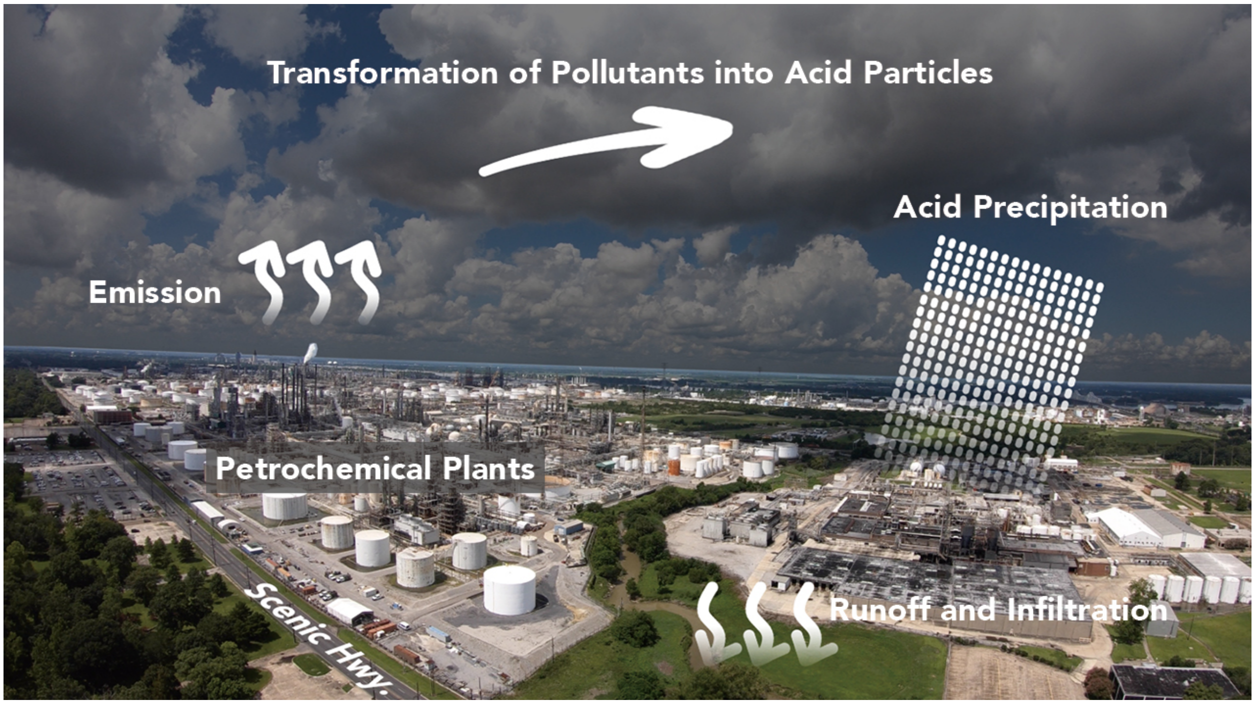

Figure 12. Site Problem: Pollution from Adjacent Industrial Plants (created by author based on EPA's "What is Acid Rain?")

The third issue is a social circumstance of the neighborhoods. Compared with the demographics of the East Baton Rouge Parish, the neighborhood around the Monte Sano Park is relatively young, low-income, and less-educated (36 percent of the population in the census tracts do not have high school diploma, Figure 13). Noise from the highway I-110 and the airplanes and odor from the petrochemical plants are negative impacts influencing on the well-being of the community. According to Human Health and Well-being Policy Statement by American Society of Landscape Architects, mitigating environmental stressors such as pollutions improves physical and mental health of human.[7] Thus, mitigating environmental stressors made by massive infrastructures such as the paved canal and the highways can improve well-being of the community.

[7] "Human Health and Well-Being." ASLA.org. accessed March 15, 2019. https://www.asla.org/uploadedFiles/CMS/Advocate/Public_Policies/Public/Human_Health_and_Well-Being.pdf

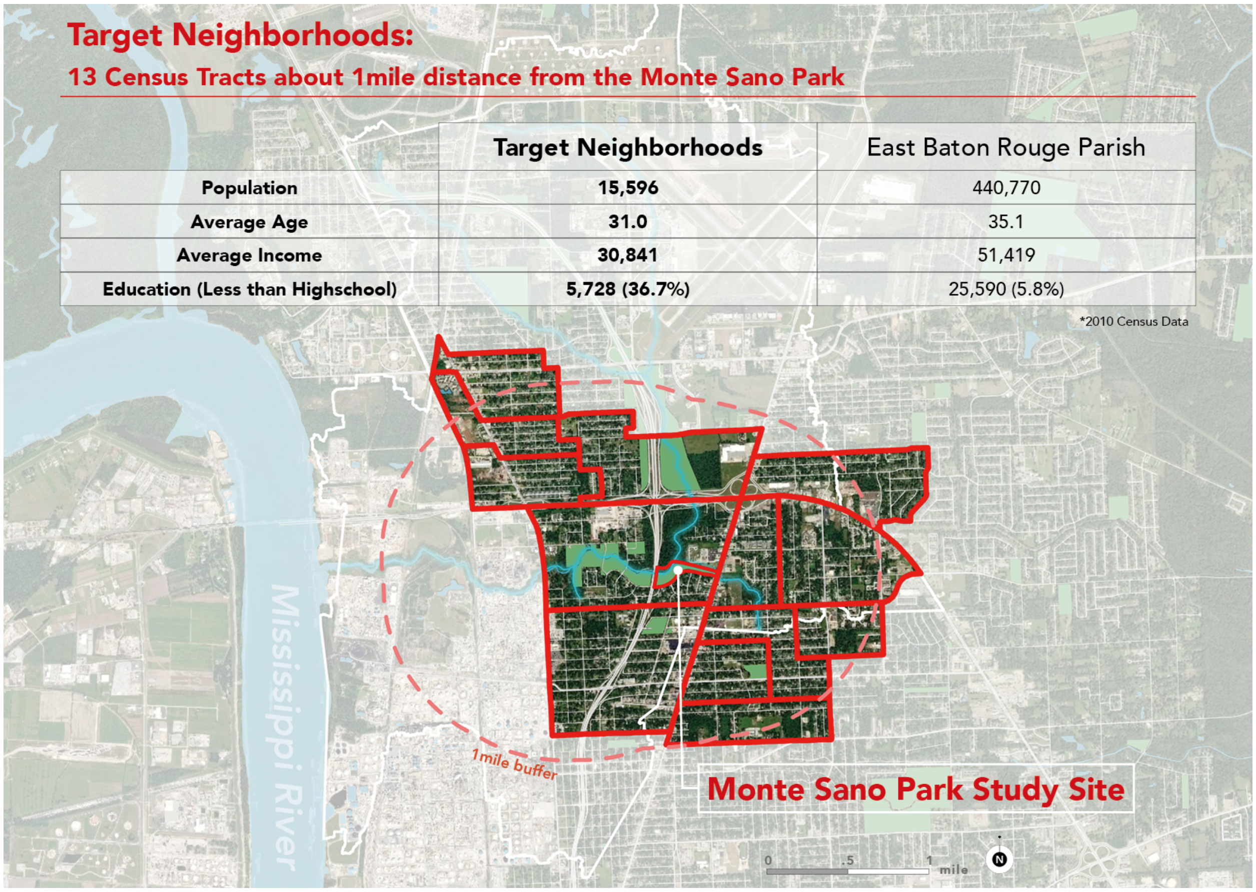

Figure 13. Site Problem: Social Issues in Target Neighborhoods

The three issues are all related to infrastructure (Figure 14). Thus, improving and redesigning the infrastructure can be a strategy to solve the issues on the site. These primary problems of the site are discussed more in Chapter 3.

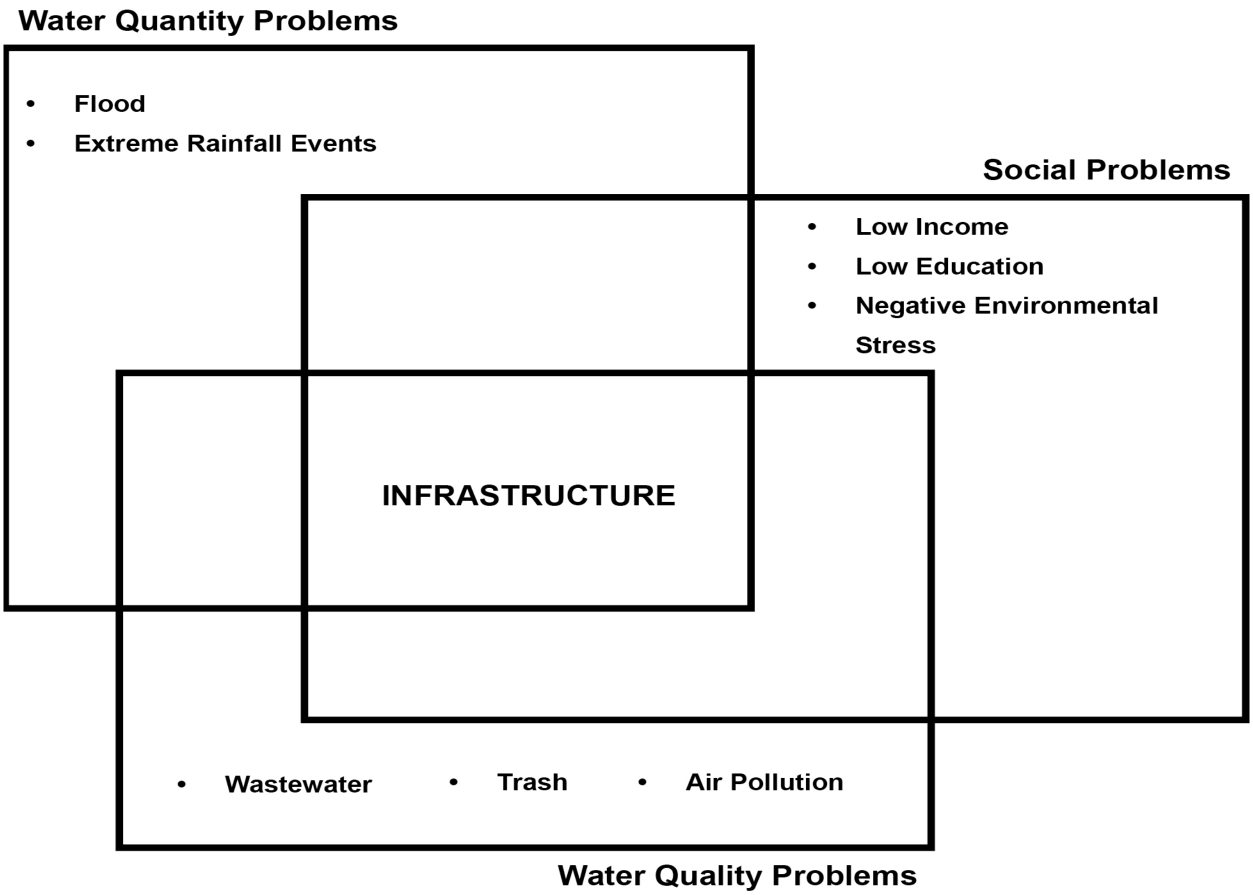

Figure 14. Diagram of Site Problems

1.4. Identification of Possible Solutions

Green infrastructure has significant possibilities to address the identified issues on the site. Green infrastructure is multi-beneficial, cost-effective, and resilient approach to managing wet weather impacts providing many community benefits.[8] Creating multi-beneficial open spaces with green infrastructure is one of the possible solutions for the site. Green infrastructure has the potential to control and improve water quantity and quality as well as add value to locations where green infrastructural strategies are installed. The United States Environmental Protection Authority (EPA) mentions “while single-purpose gray infrastructure −conventional piped drainage and water treatment system− is designed to move urban stromwater away from the built environment, green

[8] “What is Green Infrastructure.” EPA.gov. accessed February 28, 2019. https://www.epa.gov/green-infrastructure/what-green-infrastructure

infrastructure reduces and treats stormwater at its source while delivering environmental, social, and economic benefits."[9] Since each above-mentioned problem has infrastructural problems, multi-beneficial green infrastructure is an appropriate strategy for the design site. Characteristics and adaptations of green infrastructure will be reviewed in the research and precedents investigation in Chapter 2.

[9] Ibid.

Chapter 2. Literature Review and Precedents

2.1. Stormwater Management with Green Infrastructure

Stormwater management with green infrastructure is defined by various organizations. The American Society of Landscape Architects (ASLA) defines green infrastructure as "when nature is harnessed by people and used as an infrastructural system it's called green infrastructure."[10] EPA describes "green infrastructure as a cost-effective, resilient approach to managing wet weather impacts that provides many community benefits."[11] In Europe, the European Commission (EC) explains green infrastructure as "a network of healthy ecosystems often provides cost-effective alternatives to traditional 'grey' infrastructure and offers many other benefits for both EU citizens and biodiversity."[12] These organizations showcase examples of benefits and elements of green infrastructure in a variety of scales. For example, ASLA introduces multiple scales of green infrastructure from forest and nature preserves to green roofs and green walls.[13] Understanding characteristics of green infrastructural elements and potential of adaptability to a site is necessary when green infrastructure is installed. The summary of descriptions of green infrastructure by different organizations helps to understand benefits and adaptability of green infrastructure (Table 1). Each organization defines benefits and elements of green infrastructure differently because each organization has different missions and populations they serve. For instance, ASLA provides a variety of scales of green infrastructure addressing wide-ranging landscape architectural topics. The Federal Emergency Management Authority (FEMA), on the other hand, focuses on mitigation benefits of green infrastructure.[14] By synthesizing the definitions, this thesis defines that green infrastructure is a human creation having sustainable, resilient, and cost-effective stormwater management characteristics that

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[10] "Professional Practice Green Infrastructure." ASLA.org. accessed February 28, 2019. https://www.asla.org/greeninfrastructure.aspx

[11] "What is Green Infrastructure." EPA.gov.

[12] "Green Infrastructure." European Commission.eu. accessed February 28, 2019. http://ec.europa.eu/environment/nature/ecosystems/index_en.htm

[13] "Professional Practice Green Infrastructure." ASLA.org.

[14] FEMA, *Federal Insurance and Mitigation Administration,* (2017), 2.

protects, restores, or mimics natural water processes that are designed to reduces and treats stormwater. With the objective to manage excessive rainwater, green infrastructure functions to reduce flooding and improve air and water quality.[15] The elements of green infrastructure include; forest, nature preserves, wildlife habitats, parks, drainage corridors, constructed wetlands, retention and detention ponds, rain gardens, bioswales, green roofs and walls, permeable pavements, and stormwater planters.

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[15] Scott Slaney, *Stormwater Management for Sustainable Urban Environment, (Australia, The Image Publishing Group Pty Ltd, 2016), 12.*

Table 1. Summary of Green Infrastructure Organizations (created by the author)

GREEN INFRASTRUCTURE ORGANIZATION	Definition	Benefits	Elements / Types	Characteristics
ASLA (American Society of Landsape Architects)	When nature is harnessed by people and used as an infrastructural system it's called "green infrastructure."	absorbing and sequestering atmospheric carbon dioxide (C02) / filtering air and water pollutants / stabilizing soil to prevent or reduce erosion / providing wildlife habitat / decreasing solar heat gain / lowering the public cost of stormwater management infrastructure and providing flood control / and reducing energy usage through passive heating and cooling	forests / nature preserves / wildlife habitat / corridors / constructed wetlands / green streets / green roofs and walls	a variety of scales
EPA (United States Environmental Protection Authority)	Green infrastructure is a cost-effective, resilient approach to managing wet weather impacts that provides many community benefits.	reducing and treating stormwater at its source while delivering environmental, social, and economic benefits.	downspout disconnection / rainwater harvesting / rain gardens / planter boxes / bioswales / permeable pavements / green streets and alleys / green parking / green roofs / urban tree canopy / land conservation	implementation
FEMA (Federal Emergency Management Agency)	Green infrastructure is a sustainable approach to natural landscape preservation and storm water management that can be used for hazard mitigation activities as well as provide additional ecosystem benefits.	flood risk reduction and drought mitigation / ecosystem benefits / community's resilience to the impacts of climate change	a series of bio-detention sites along the natural water body or storm water flow path	risk reduction, mitigation
NGICP (National Green Infrastructure Certification Program)	Stormwater management practices that protect, restore, or mimic the natural water cycle are referred to as green infrastructure (GI).	Pleasant environment by creating "green" features (collections of trees, bushes, and plants) distributed throughout developed areas / Reduction of the "heat island effect" in cities and developed areas / Reduction of stormwater volume and risk of flooding and erosion / Treatment by filtering or removing stormwater pollutants such as heavy metals, nutrients, sediment, and pathogens from runoff, which helps protect local streams, and rivers / Temporarily stores stormwater locally to be used by trees and vegetation, reducing the amount of potable water that is needed for watering and irrigation / Pervious surfaces that absorb rain and runoff, allowing water to penetrate into the soil and replenish groundwater aquifers / Increasing community green space which encourages more outdoor recreation / Contributing to urban renewal / Creating new long term green jobs to perform construction, inspection and maintenance of the GI.	bio retention / permeable pavements / rainwater harvesting / rooftop stormwater detention / dry wells / stormwater wetlands	implementation / education
GIC (Green Infrastructure Center)	Green infrastructure is made up of the interconnected network of waterways, wetlands, woodlands, wildlife habitats, and other natural areas; greenways, parks, and other conservation lands; working farms, ranches and forests; and wilderness and other open spaces that support native species, maintain natural ecological processes, sustain air and water resources and contribute to health and quality of life (McDonald, Benedict, and O'Conner, 2005).	Contributing to health and quality of life, such as forests that clean the air and filter and absorb stormwater.	Environmental chapters in comprehensive plans and/or to implement existing comp plan goals for resource assessments and conservation / Park, open space and recreational planning or strategic land acquisition / Strategies for determining where to zone land for conservation or growth / Lands for purchase of development rights or transfer of development rights / Heritage tourism strategies and viewshed protection / Urban tree canopy surveys and management / Transportation planning for roads and mutli-modal planning / Targeting land for conservation easement programs / Protection of at risk or endangered species, such as the Delmarva Fox Squirrel / New ordinance development (stream buffers, water protection, historic landscape overlays) / Rezoning decision basis either for upzoning or downzoning / Conserving forest cover to protect surface water quality and supply, mitigate stormwater runoff, and facilitate the infiltration of water into groundwater aquifers.	planning with green infrastructural concept
EC (European Commission)	A network of healthy ecosystems often provides cost-effective alternatives to traditional 'grey' infrastructure and offers many other benefits for both EU citizens and biodiversity.	wide range of ecosystem services such as water purification, air quality, space for recreation and climate mitigation and adaptation / Improving environmental conditions and therefore citizens' health and quality of life / Supporting a green economy, creating job opportunities and enhancing biodiversity.	Natura 2000 Forest / wild flower verge / wildlife overpass / multifunctional farming / fish ladder / reedbed / biodiversity-rich business park / beehives / hedgegrow / green roofs / green walls	green infrastructure as a policy

The landscape characteristics of Monte Sano Park consists of the bayou a grassland with tree canopy, and a concrete canal. This study has the goal of determining appropriate elements of green infrastructure to apply to mitigate defined stormwater flooding issues. It is necessary to understand the potential of each type of green infrastructure for the site including green infrastructure as shown in Table 1. Among various types of green infrastructure, the six types of green infrastructure are described below as appropriate elements to apply to the design site;

- Forest and Nature Preserves
- Constructed Wetlands
- Bioretention
- Permeable Pavement
- Green Roofs and Walls
- Planter Boxes

2.1.1. Forest and Nature Preserves

Large created or defined existing green spaces to be preserved can be employed as green infrastructure. In developed urban areas, it is critical to preserve natural areas which have permeable surfaces and together consists of a healthy bio-logically diverse. According to ASLA;

> *preserving and restoring natural areas is a remedy for long-term regional, urban, and suburban challenges, such as climate change, pollution, and loss of productive agricultural lands. Governments, organizations, and communities must continue to invest in forests and nature reserves, protecting nature in the process. As urbanization continues, it's critical for communities to work regionally to coordinate planning and design for maintaining forests and reserves. Green infrastructure of special natural, scenic, and cultural significance should be protected and preserved. In rural*

areas, existing parks should be rehabilitated to protect vanishing landscapes.[16]

2.1.2. Constructed Wetlands

Wetlands store and filter stormwater by the soil and the vegetation. The National Green Infrastructure Certification Program (NGICP) describes that stormwater wetlands generally are large, shallow, and vegetated basins or regions designed to store and improve stormwater runoff.[17] In Louisiana, specifically, loss of wetlands by urban development in impermeable areas accelerates risk of flood. Constructed wetlands can retrieve the permeable surfaces and can mimic the functions of natural wetlands to capture stormwater and create diverse wildlife habitat. They are often created in engineered soil in trenches, small islands, and ponds.[18]

2.1.3. Bioretention

ASLA and NGICP summarize function and types of bioretention. According to ASLA, bioretention uses plants and soils to infiltrate and treat stormwater runoff.[19] NGICP provides that "bioretention facilities are shallow basins that capture stormwater runoff and use trees and plants to help treat the captured flow. Filtration, infiltration, and evapotranspiration are all used to capture, treat, and temporarily store and locally use stormwater. Variations of bioretention include rain gardens, curb cuts/curb extension, stormwater planters/tree boxes, tree trenches,

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[16] "Professional Practice Green Infrastructure: Forest and Nature Preserves." ASLA.org. accessed February 28, 2019. https://www.asla.org/ContentDetail.aspx?id=43533

[17] "Type of GI." NGICP.org. accessed February 28, 2019. https://ngicp.org/program/for-applicants/what-is-green-infrastructure/

[18] "Professional Practice Green Infrastructure: Constructed Wetlands." ASLA.org. accessed February 28, 2019. https://www.asla.org/ContentDetail.aspx?id=43537

[19] "IMPROVING WATER EFFICIENCY: RESIDENTIAL BIOSWALES AND BIORETENTION PONDS." ASLA.org. accessed February 28, 2019. https://www.asla.org/bioswales.aspx

and bioswales/vegetated swales."[20] ASLA also defines detailed benefits of bioretention by adapting EPA's Environmental Assessment,[21] Vancouver's Capital Regional District,[22] and National League of Cities.[23] According to the summary, bioretention benefits include;

- Reduced runoff: In a typical road, a 4-meter (13-feet) swale can reduce approximately 25 percent of total rainfall runoff.
- Reduced pollutants: Bioswales/bioretention ponds remove pollutants by filtering stormwater runoff through natural vegetation and soil-based systems.
- Recharged groundwater: Instead of releasing stormwater into the drainage system, stormwater can be filtered and may provide some groundwater recharge.
- Improved energy efficiency: Sustainable, decentralized stormwater management systems may be more cost effective than centralized stormwater systems. At the minimum, these natural technologies reduce pressure on existing systems and the maintenance costs associated with centralized stormwater management systems.[24]

2.1.4. Permeable Pavements

Asphalt and concrete surfaces in developed areas such as highways, roadways, sidewalks, and parking lots accelerate stormwater runoff and convey

[20] "Type of GI." NGICP.org.
[21] "Urban Storm Water Preliminary Data Summary." EPA.gov.
[22] Capital Regional District. "Bioswales" CRD.bc.ca. accessed February 28, 2019. https://www.crd.bc.ca/education/green-stormwater-infrastructure/bioswales
[23] "Stormwater Management: Swales." NLC.org. accessed February 28, 2019. https://www.nlc.org/program-initiative/sustainable-cities-i%20nstitute/topics/water-and-green-infrastructure/stormwater-%20management/stormwater-management-swales
[24] "IMPROVING WATER EFFICIENCY: RESIDENTIAL BIOSWALES AND BIORETENTION PONDS." ASLA.org.

pollutant.[25] By developing the impermeable surfaces, the loss of the natural soil and vegetation within the urban catchment significantly affects the hydrologic cycle by increasing runoff rates and volumes and limiting evapotranspiration and interception.[26] Instead of the conventional pavements, permeable pavements are made with very small "holes" or voids and are installed over an engineered, uncompacted storage bed. Stormwater passes through the surface and then is temporarily stored to allow infiltration into the soil beneath the storage bed.[27] This type of green infrastructure has proven to be cost-effective. EPA introduces an example in Sultan, WA, which reduced construction costs over $260,000 by installing permeable pavements.[28]

2.1.5. Green Roofs and Walls

The strategy of green roofs and green walls is possible green infrastructure that can be installed on existing or new buildings. EPA explains that "green roofs are covered with growing media and vegetation that enable rainfall infiltration and evapotranspiration of stored water."[29] With soils and vegetations on the green roofs, stormwater runoff is reduced and treated in place. In addition to that, green roofs can be habitats for wildlife and serve recreation purposes for people.

2.1.6. Planter Boxes

Planter boxes can be installed along streets and adjacent to buildings connecting to downspouts. This green infrastructural element also captures and stores stormwater but also can be attractive to wildlife and people. The planters are ideal for relatively small sites such as a streetscaping feature in dense urban

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[25] Steven Strom, *Site Engineering for Landscape Architecture,* (New Jersey, John Wiley and Sons, Inc., 2013), 148.
[26] Palla. "Key issues for sustainable urban stormwater management," *Journal of Hydrology.* Volume 528, Issue 20, (Elsevier 2015), 361
[27] "Type of GI." NGICP.org.
[28] "Permeable Pavements." EPA.gov.
[29] "Green Roofs." EPA.org.

areas.[30] This element could be set along streets or could connect to downspouts on existing buildings.

2.2. Precedents of Stormwater Management with Green Infrastructure

This chapter provides precedent studies utilizing green infrastructure with emphasis on constructed wetlands, bioretention (retention basins and rain gardens), and planter boxes because these elements of green infrastructure have potentials to be installed in the study site, Monte Sano Park.

2.2.1. Buffalo Bayou Park

Buffalo Bayou Park, an award-winning project by SWA Group, is located Houston, Texas. Although the scale of the Buffalo Bayou is larger than the Monte Sano Bayou, the Buffalo Bayou project has green infrastructural elements which can be applicable to the Monte Sano Bayou. After Hurricane Harvey in 2017, the park and trails have come back quickly.[31] One week after the Hurricane Harvey, there was still water on the basin along the Buffalo Bayou (Figure 15)[32]. Three weeks after the Harvey, the basin came back to the usual condition (Figure 16)[33]. Open spaces, detention, and retention basins along the Buffalo Bayou functioned to mitigate the flooding impact. The buffers such as retention and detention basins along the bayou function to mitigate negative impacts but also create open spaces for pedestrians and cyclists (Figure 17). The project successfully created multi-beneficial spaces for both mitigation and recreation.

[30] "Planter Boxes" EPA.org.
[31] Urban Land Institute, "Buffalo Bayou Park," ULI Case Study, ULI.org. accessed March 4, 2019, https://casestudies.uli.org/buffalo-bayou-park/
[32] Ibid.
[33] Ibid.

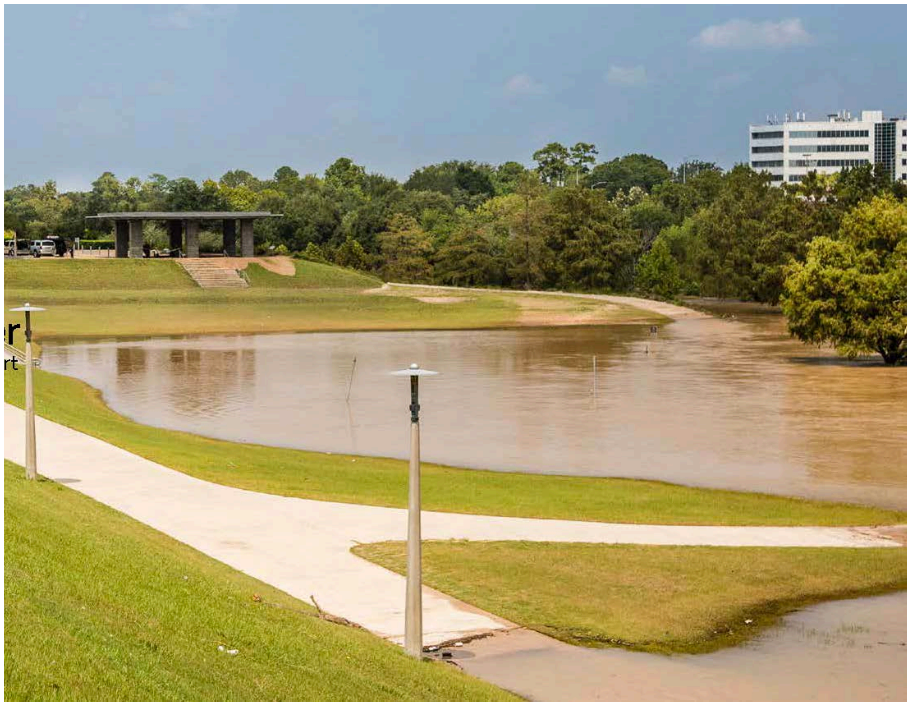

Figure 15. One week after Hurricane Harvey (ULI.org)

Figure 16. Three Weeks after Hurricane Harvey (ULI.org)

Figure 17. Trail and Bench along the Buffalo Bayou (taken by the author)

2.2.2. Eastern Valley Way Inlet Wetlands

A project of Eastern Valley Way Inlet Wetlands is designed by OXIGEN (Australia-based landscape architecture firm) in Canberra, Australia (Figure 18).[34] The project introduced a new wetland into Lake Ginninderra filtering stormwater, preventing sediments and pollutants, and providing new ecological habitats and recreation.[35] The two constructed wetlands are located between Lake Ginninderra and broad catchment zone (Figure 19).[36] Stormwater flows from the urban development into the lake through the wetlands addressing to improve water quality and to slow the runoff velocity. The project feature, which connects the runoff and the lake by creating wetlands to improve stormwater quality and wildlife

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[34] "Eastern Valley Way Inlet Wetlands + Public Realm," OXIGEN.net.au, accessed March 4, 2019, http://www.oxigen.net.au/easternvalleywayinlet

[35] Ibid.

[36] Slaney, *Stormwater Management for Sustainable Urban Environment, 311.*

habitat, could be applicable to the Monte Sano Bayou study site because the site is also a mediation between the Mississippi River and two upstream flows, upper Monte Sano Bayou and Hurricane Creek. Creating wetland in the study site (see Figure 8) can be a solution to improve quality of water flowing from both the Mississippi River and the upstream bayou and creek.

Figure 18. Wetland and Pedestrian and Bike Bridge (OXIGEN.net.au)

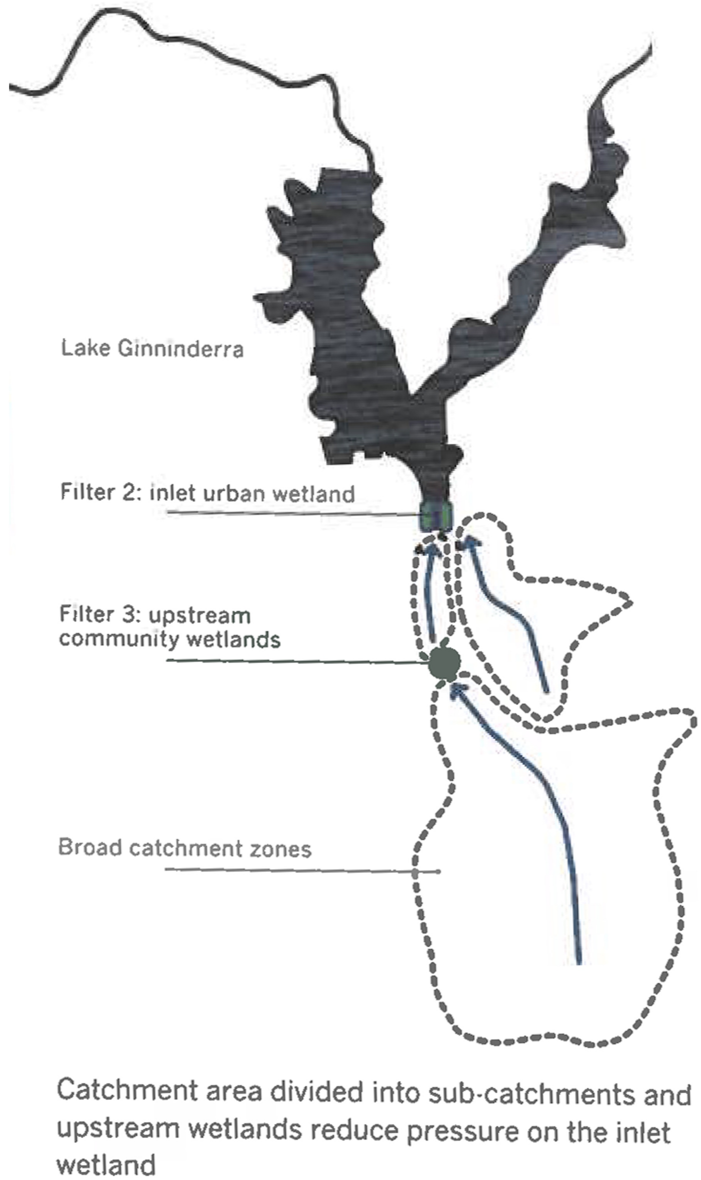

Figure 19. Diagram of Locations of Wetlands (Slaney, 311)

2.2.3. Greater New Orleans Urban Water Plan

Greater New Orleans Urban Water Plan is not one specific project but provides comprehensive, integrated, and sustainable water management strategies.[37] The primary statement of the plan is changing idea of stormwater management from paving, piping, and pumping to slowing, storing and using, and

[37] Waggonner & Ball Architects, "Greater New Orleans Urban Water Plan: Vision," (New Orleans, 2013), accessed March 4, 2019, 12.

circulating and recharging.[38] The article created by Waggonner & Ball Architects provides illustrated toolbox of stormwater management (Figure 20). [39] This comprehensive toolbox is helpful to apply the elements to the study site. For example, the small scale green infrastructural elements introduced in the article such as rain gardens, harvesting cisterns, and bioswales are appropriate to the study site.

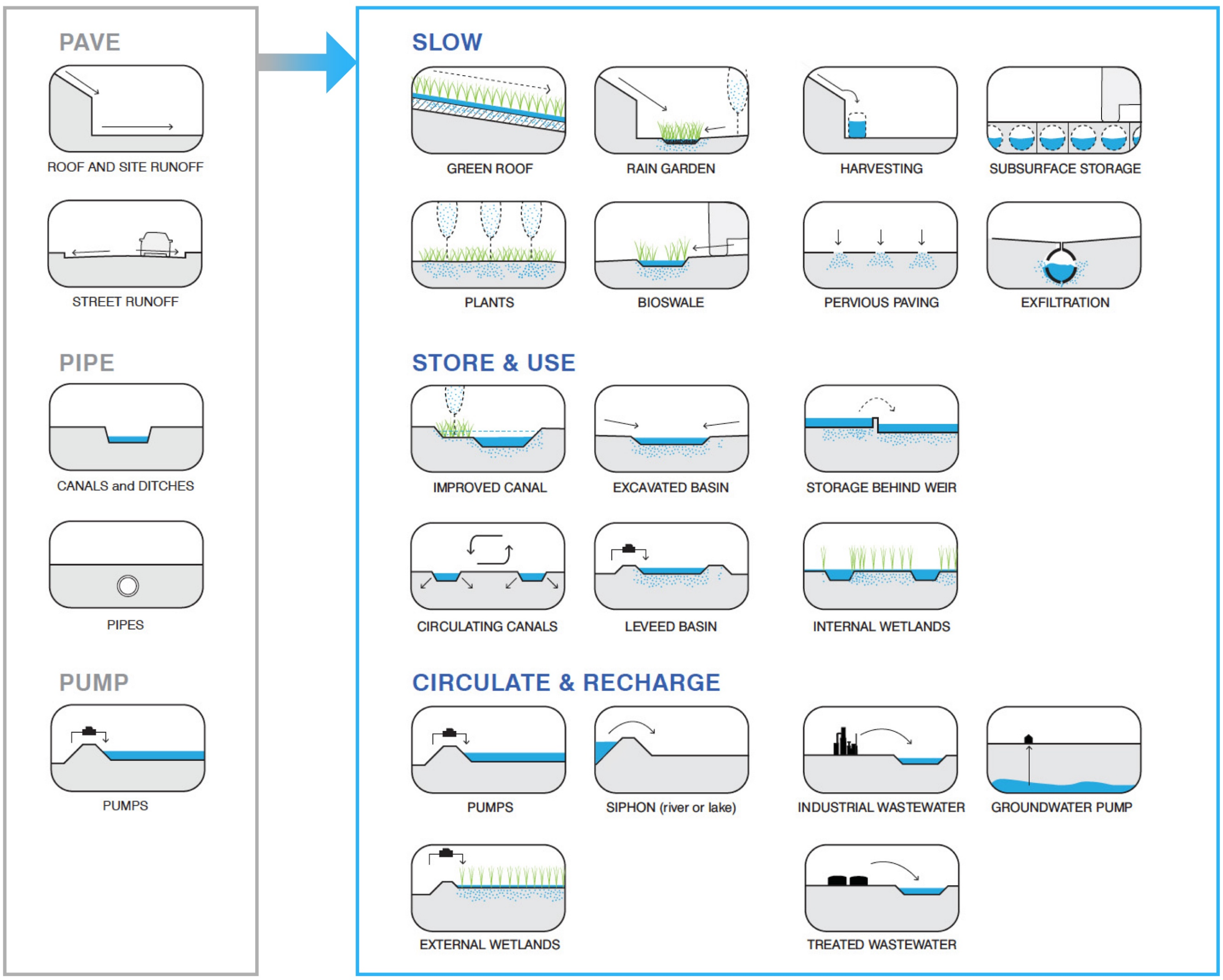

Figure 20. Illustrated Stormwater Toolbox (created by Waggonner & Ball Architect)

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[38] Ibid., 176.
[39] Ibid., 176 – 177.

Chapter 3. Methodology of Design

3.1. Site Analysis at Different Scales

This chapter describes the process of design at different scales including East Baton Rouge Parish (EBRP), Monte Sano Bayou Watershed, Park Scale (Plank Road to Mississippi River), and the selected design site I will make specific design proposal for.

3.1.1. East Baton Rouge Parish Scale

First of all, the study site was selected based on the opportunities and the problems that exist. As mentioned in the first chapter, Monte Sano Park provides an opportunity to connect to an existing proposal called “Capital Area Pathway Project” by BREC (Figure 3). The pathway plan proposes a loop in East Baton Rouge Parish (EBRP) by connecting a number of targeted green spaces.

In addition, meltwater from the Mississippi River flows into the site seasonally and extreme heavy rainfalls in the Amite River Watershed affects the site beyond the ridge of the watershed (Figure 21). According to U.S. climate data, the largest amount of average monthly precipitation is 6.42 inch in June (Figure 22).[40] The season of the peak of precipitation is different from the peak of water surface of the Mississippi River.

[40] U.S. climate data in Baton Rouge, https://www.usclimatedata.com/climate/baton-rouge/louisiana/united-states/usla0033

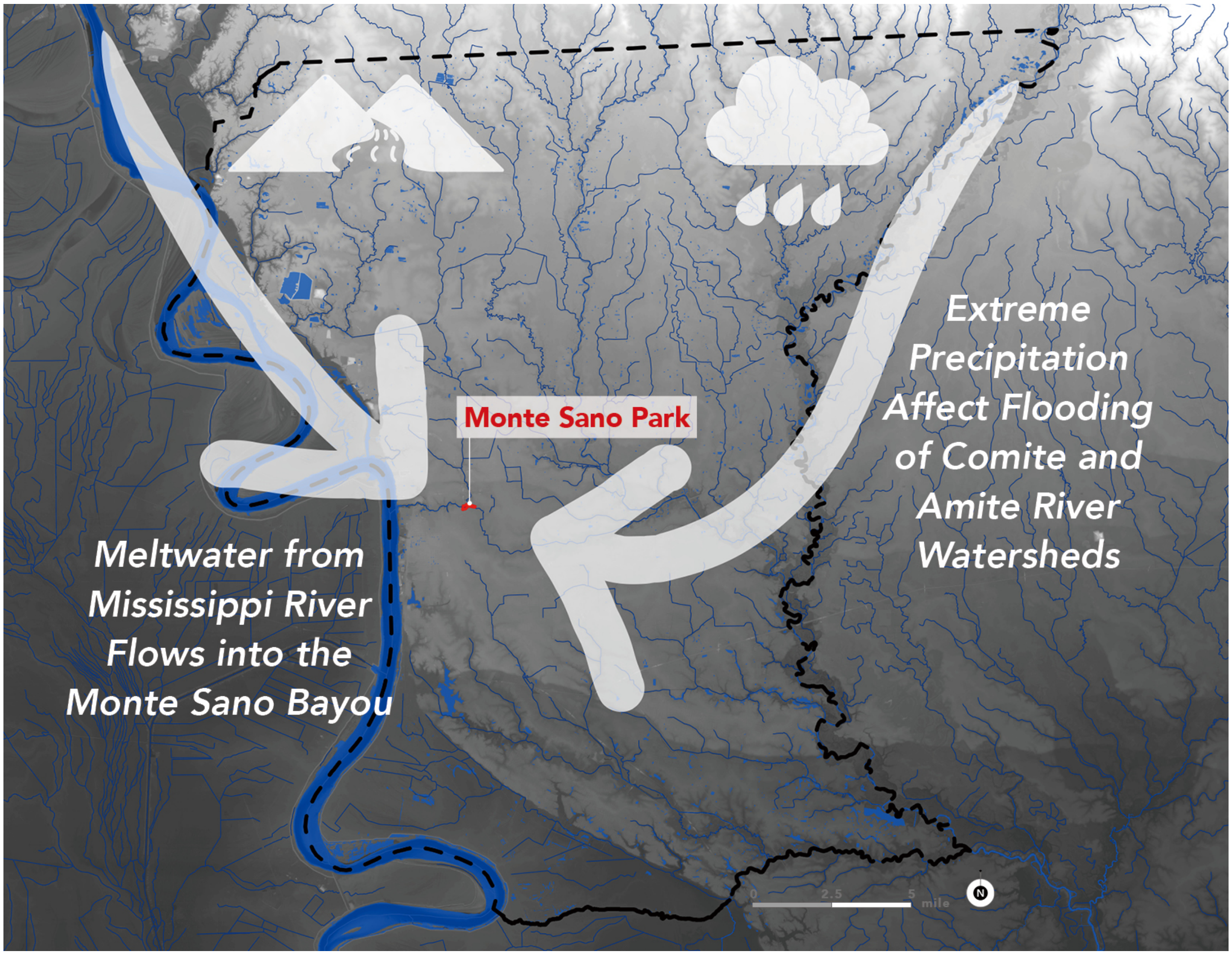

Figure 21. Hydrological Impacts on the Site

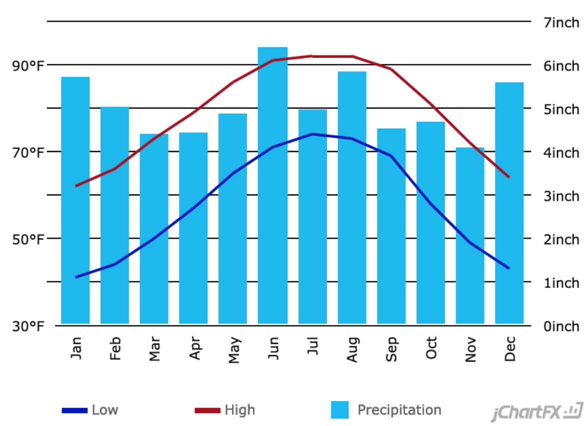

Figure 22. Average Precipitation in Baton Rouge, https://www.usclimatedata.com/climate/baton-rouge/louisiana/united-states/usla0033

To figure out how meltwater affects the water level of Monte Sano Bayou, the study uses the nearest USGS water gage data. The closest gage is located at the Mississippi River (the location is shown in Figure 23). Using the gage data of 2016 and satellite imagery from the Google Earth, the study visualizes the relationship of the flood stage of the Mississippi River and the water height of the Monte Sano Bayou (Figure 24). The satellite images help to find the differences of water height of the Monte Sano Bayou. This analysis proves that the Monte Sano Bayou gets much water when the surface level of the Mississippi River gets higher and flows into the bayou itself. When climate change brings heavy precipitation and when the Mississippi River's flood-level is high, the Monte Sano Bayou could not capture the water both from precipitation and overflow from the Mississippi River and could be flooded dramatically.

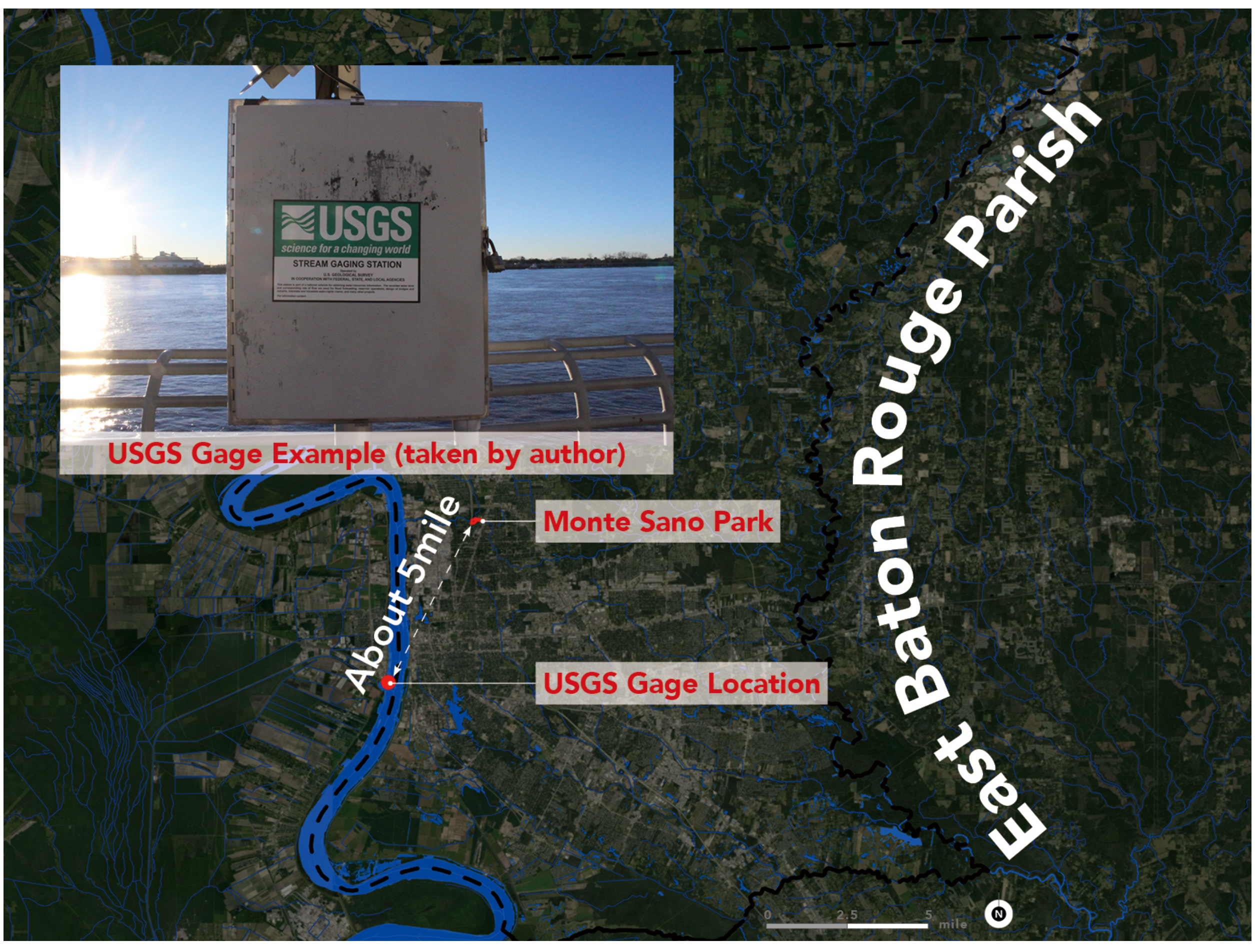

Figure 23. USGS Water Gage Location

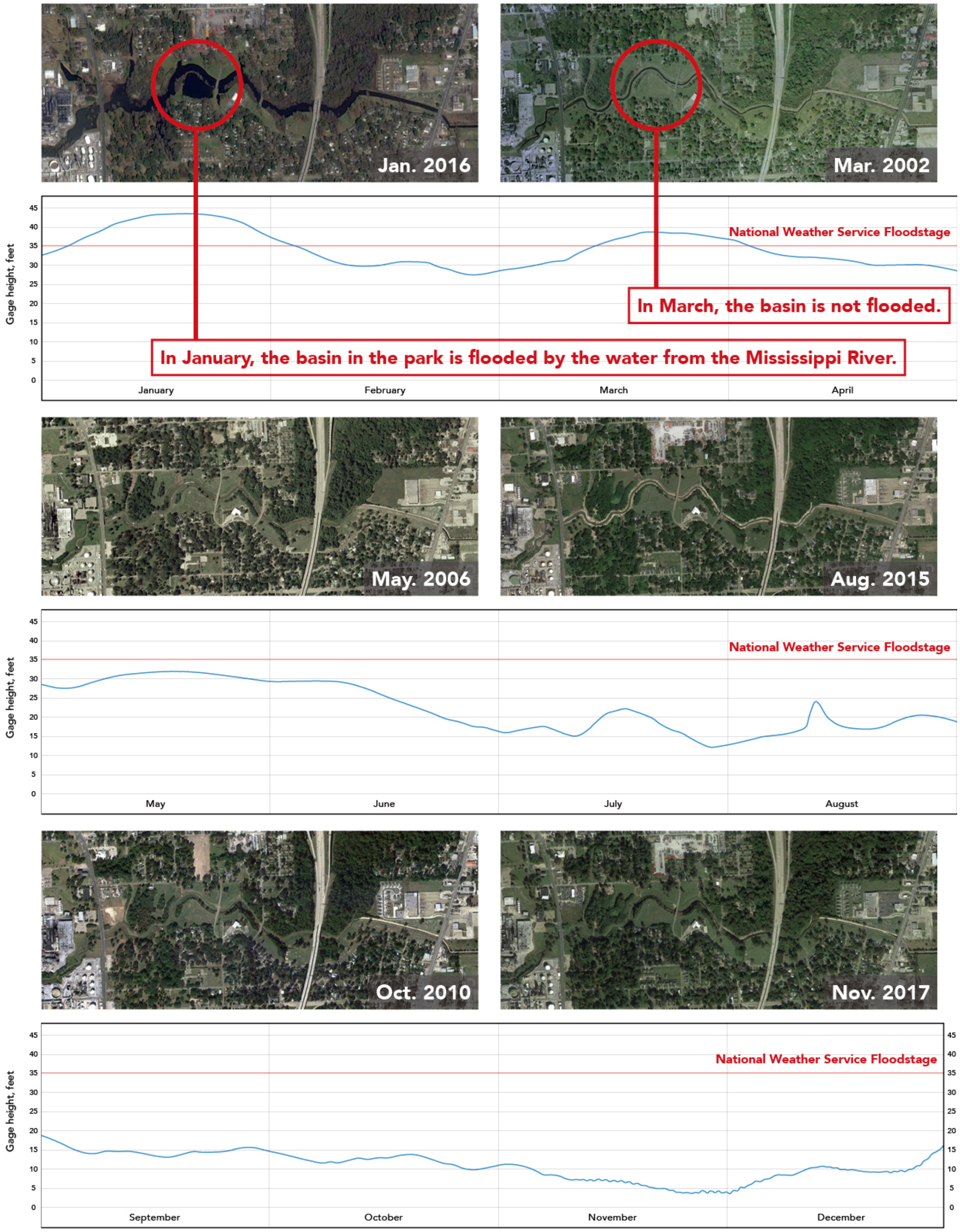

Figure 24. Annual gage height data (2016) of the Mississippi River Stage with Satellite Images of the Monte Sano Bayou. The graph is modified by the author and the data and images are provided by the USGS (https://nwis.waterdata.usgs.gov) and Google Earth.

3.1.2. Monte Sano Bayou Watershed Scale

Although water flows into the Monte Sano Bayou from the Mississippi River in the particular season, usually the bayou flows from east to west. Because of the airport, chemical plants, and other residential developments in the watershed, the runoff on these developed impermeable surfaces have negative impact on the bayou (Figure 25). This runoff accelerates the discharge of stormwater into the bayou and conveys animal wasters and trash into the bayou.[41] The picture of the upstream bayou with vegetation (Figure 26) proves that the bayou is flat and flows slowly (the location of the picture is shown in the Figure 25). Because standing water could be a source of diseases and pollution, green infrastructure is helpful to treat the negative components in water.[42]

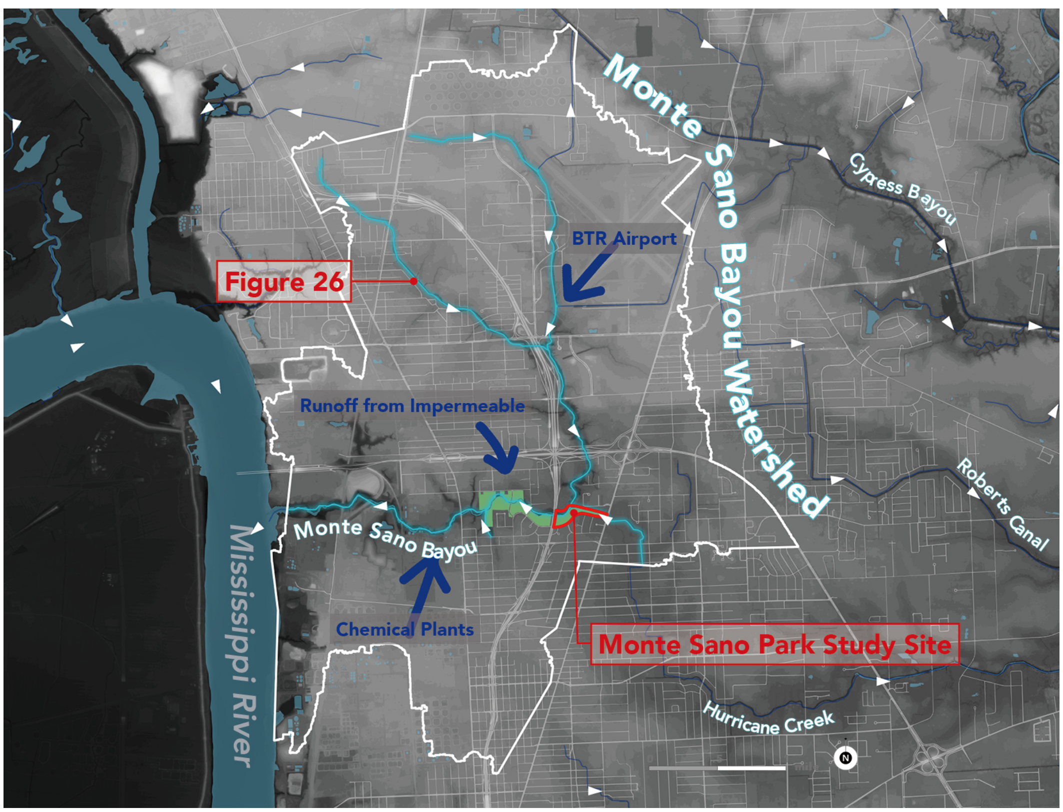

Figure 25. Hydrological Analysis at Watershed Scale

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[41] Thomas Liptan, *Sustainable Stormwater Management,* (Portland, Timber, 2017), 15.
[42] Ibid.

Figure 26. Upper Monte Sano Bayou (location is shown in Figure 25)

Although there are impermeable developments in the Monte Sano watershed, there are existing permeable surfaces including parks and undeveloped lands which could ecologically connect to the Monte Sano Park. The permeable areas in the ecological analysis map (Figure 27) have potential to be green infrastructural site to infiltrate, slow, and store stormwater. In the Monte Sano watershed, the total areas of waterbody, parks, conservation (designated by the city of Baton Rouge), agriculture, undeveloped, and vacant is 4.38 square mile, which is about 37 percent of the watershed (11.85 square mile). Including yards in residential areas, the total of permeable surfaces in the watershed could be more than a half of the watershed. Though each permeable spot is small, the total permeable lands can infiltrate, slow, and store large amount of stormwater. This idea is referred to as “Sponge City,” which is a resilient and eco-friendly theory to infiltrate and purify water in a natural way.[43]

[43] Yu Kongjian, “Sponge City Theory Review,” *Stormwater Management in Landscape Design*, (United Kingdom, Design Media Publishing (UK) Limited, 2017), 11.

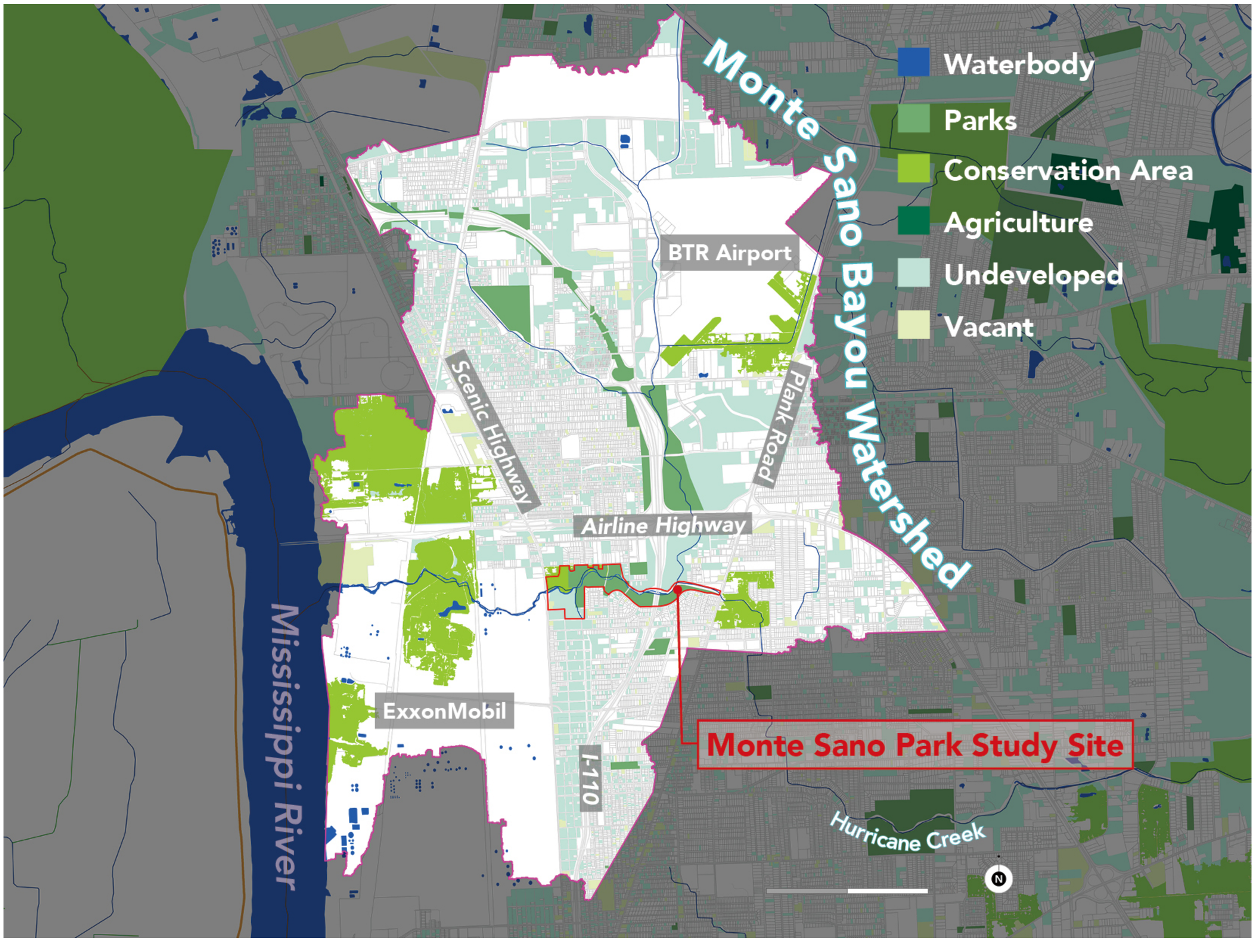


Figure 27. Ecological Analysis at Watershed Scale

3.1.3. Monte Sano Park Scale

Focusing on the park scale, the obstructions such as the highway I-110 and industrial plants are disconnecting ecological connection of the Monte Sano Bayou. Adjacent industrial areas are also taking the riparian areas away from the bayou. To enhance bayou's ecological potentials including habitat and recreation opportunities, possible solutions are to retrieve the riparian areas from the industrial areas, to expand buffers of the bayou, and to reconnect with existing conservation areas (Figure 28).

At the mouth of the Monte Sano Bayou, observation proved that the water from the Mississippi River flowed into the Monte Sano Bayou on January 1, 2019 when the height of the Mississippi River was 32.85 feet (Figure 29).

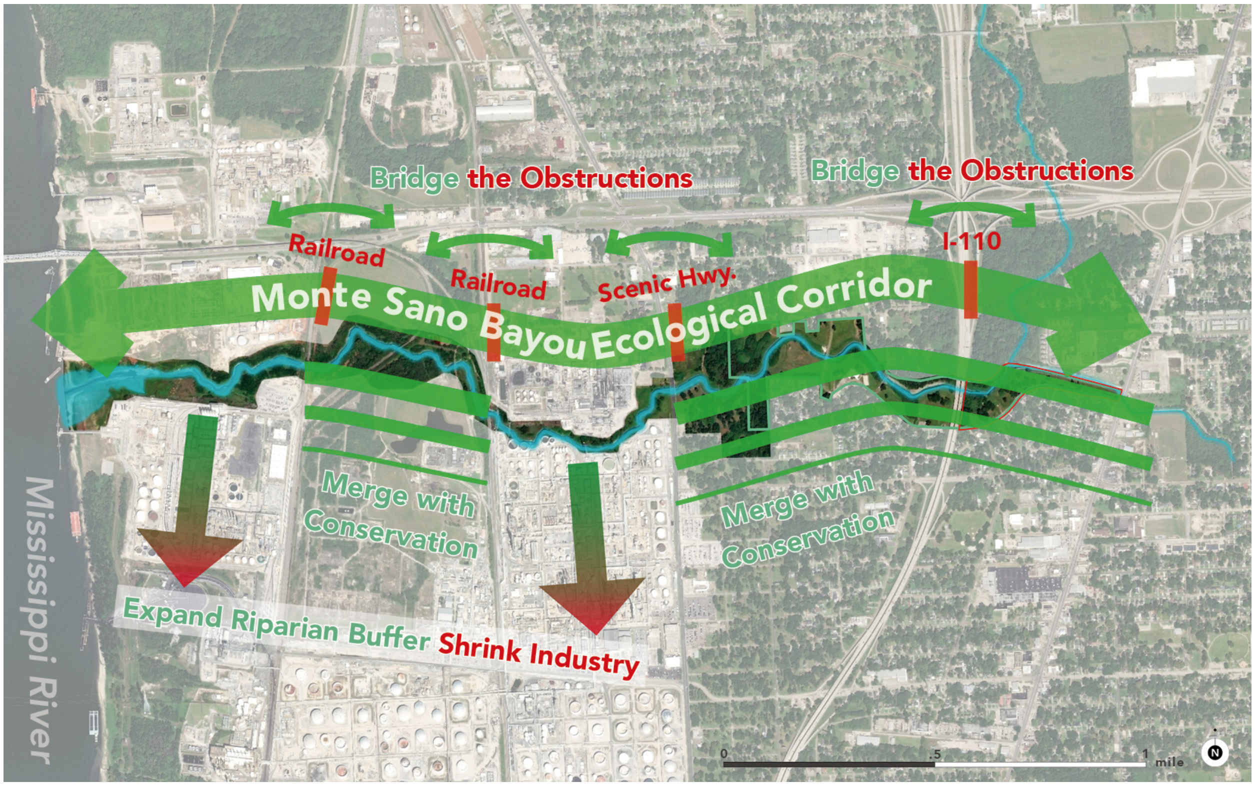


Figure 28. Site Opportunity and Issues at Park Scale

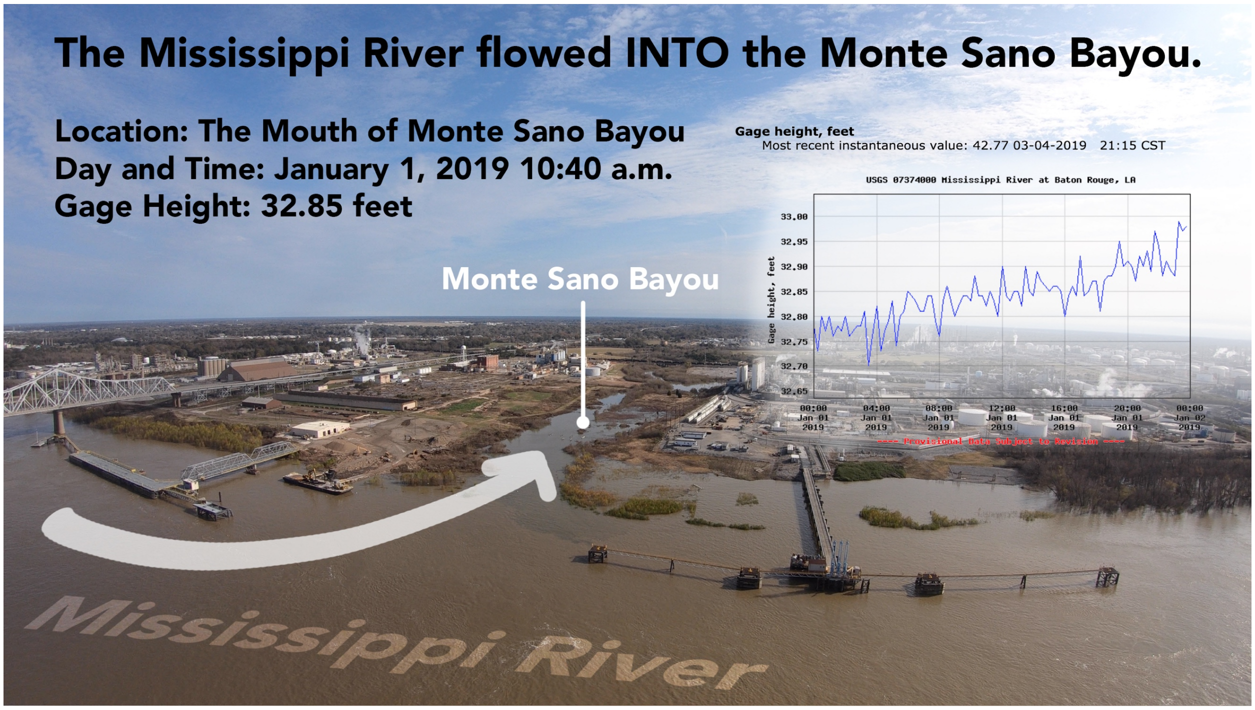


Figure 29. Aerial Photo at Mouth of Monte Sano Bayou (data provided by the USGS)

3.1.4. Design Site Scale

At the site scale, the study addresses analysis by GIS data and site visits with UVA (unmanned aerial vehicle). This study uses a UVA to obtain high resolution orthographic imagery with geospatial information such as latitude, longitude, and altitude (Figure 30). The result of site survey with drone can be visualized by using Agisoft (Figure 31).[44] Agisoft can process the data and export DEM (digital elevation model) and point clouds. The exported DEM and point clouds can be visualized in 3D modeling software such as Rhino (Figure 32). The survey with UAV helped to comprehend the site from different perspectives which cannot be observed from the ground level. The innovative technologies of both hardware and software are changing the ways to address landscapes.

Figure 30. Site Survey with UAV (DJI Phantom Pro 4, photo taken by Dr. Takeyama)

[44] Agisoft. https://www.agisoft.com/

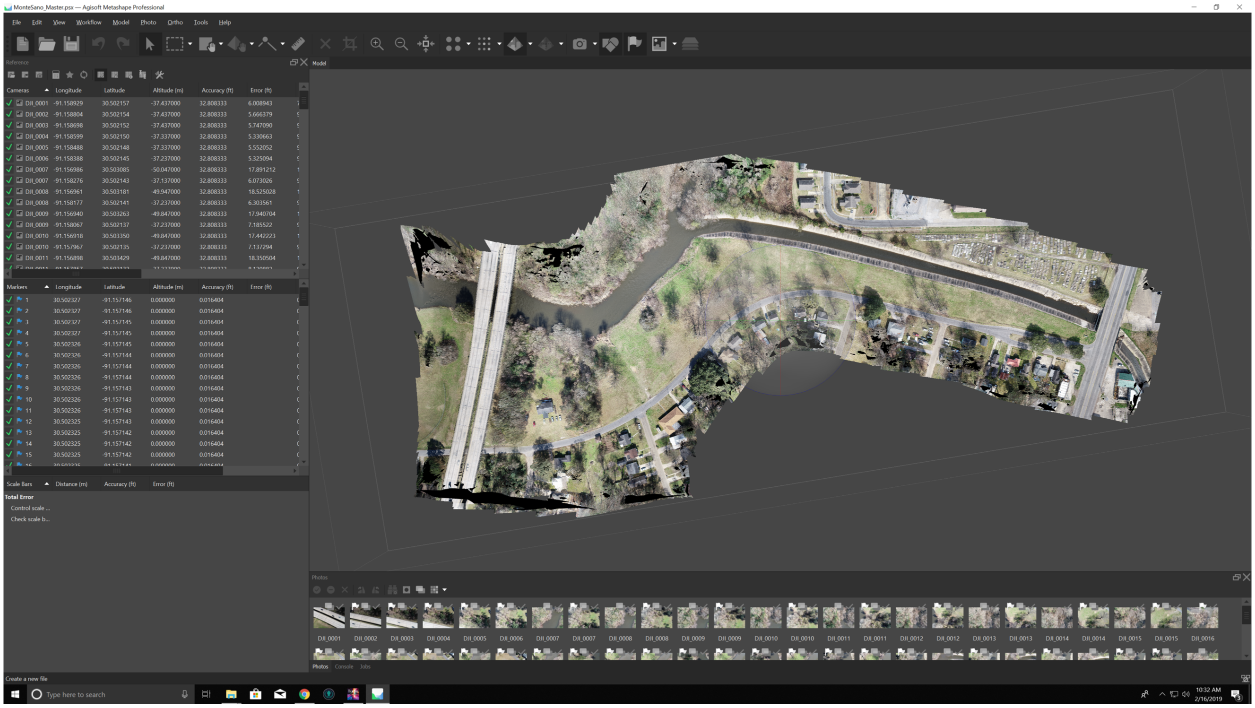


Figure 31. Visualization of Geospatial Data in Agisoft

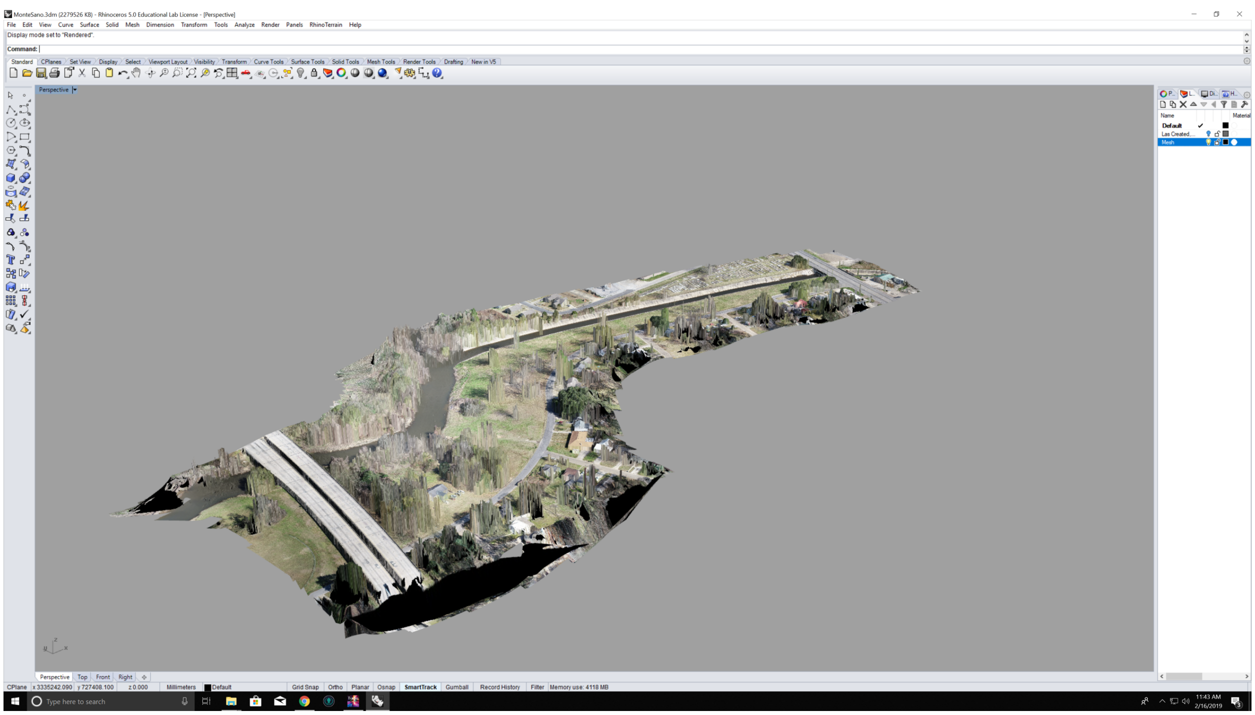


Figure 32. Importing DEM and Point Clouds in Rhino

At the site scale, the study addressed vegetation, wildlife and circulation, hydrology, and soil analyses.

Vegetation in the site is influenced by hydrologic impacts and topography. Observed existing plants are shown in Figure 33. The diversity of vegetation is rich at the steepest location in the site. There are few trees in frequently flooded riparian zones (Figure 34). The proposal will enhance the existing plants attracting wildlife and people as well as plant trees in poor vegetated areas to improve both biodiversity and stormwater management.

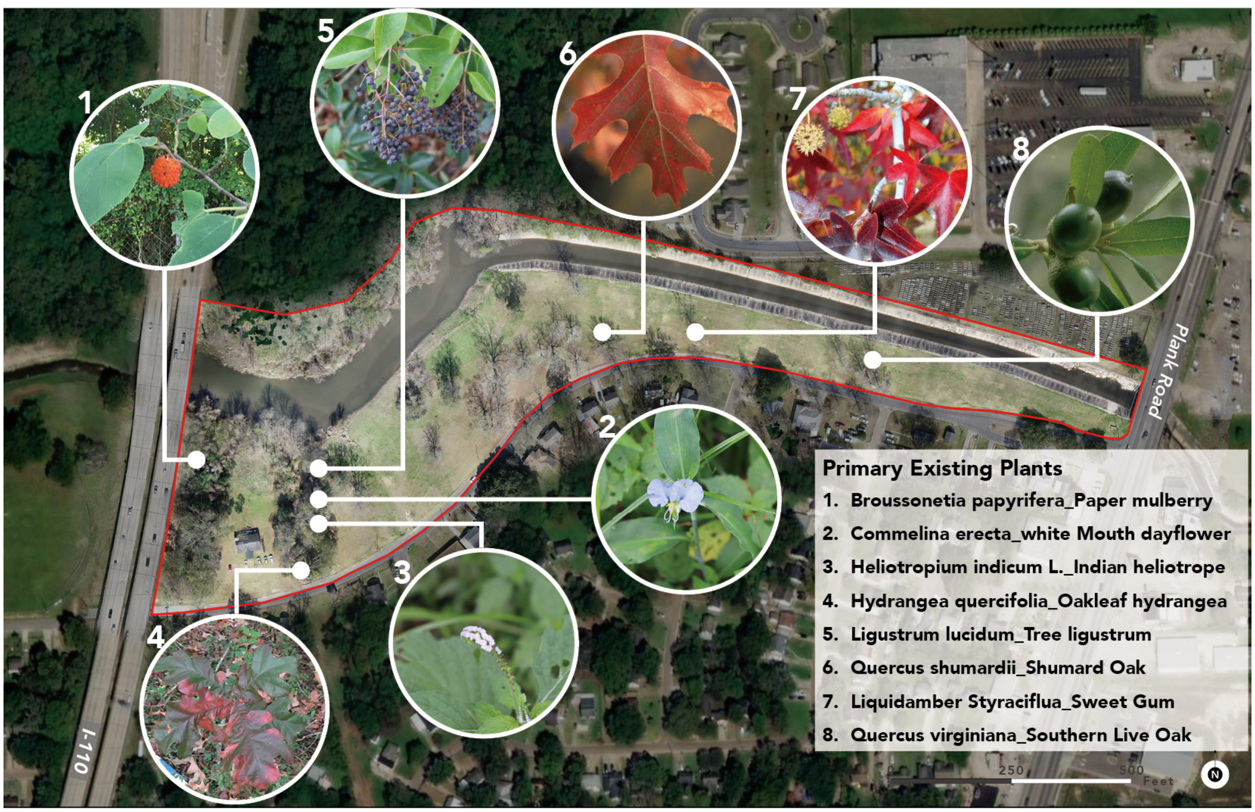


Figure 33. Existing Plants in Design Site

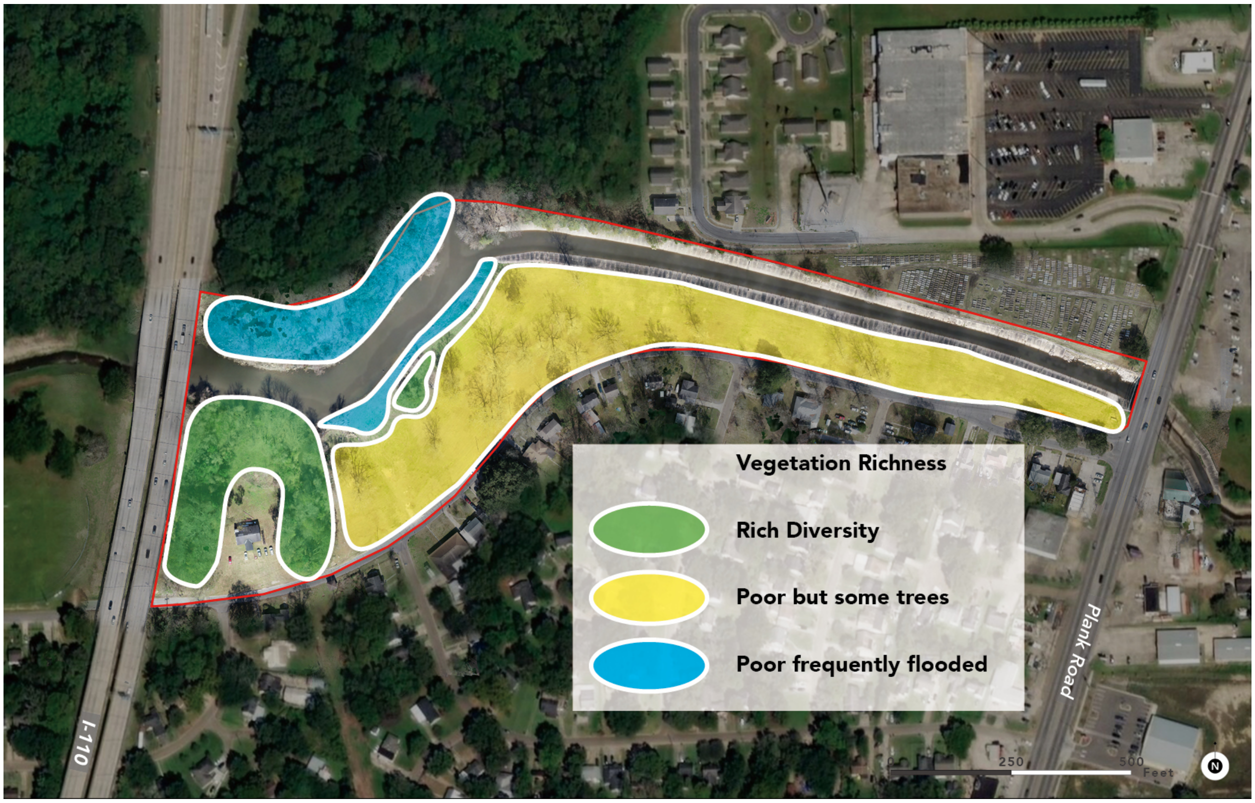


Figure 34. Vegetation Analysis in Design Site

Although the design site is adjacent to the highway and developed areas, the wildlife in the site is unexpectedly diverse. Figure 35 illustrates the observed wildlife and its evidence in the site. Birds, reptiles, mammals, fish, and many insects were observed. The existing biodiversity should be preserved and enhanced. To determine the areas primarily preserved and improved, the study analyzed the wildlife and human circulation based on the observation (Figure 36).

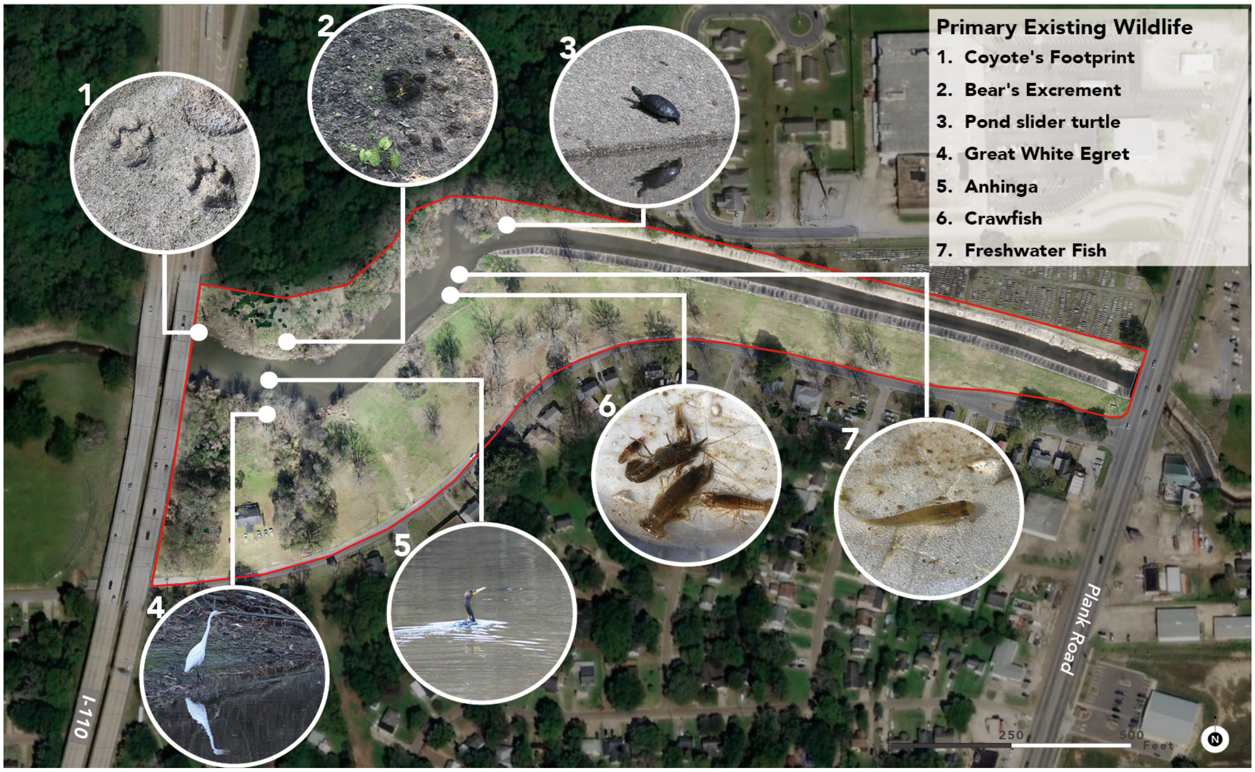


Figure 35. Existing Wildlife in Design Site

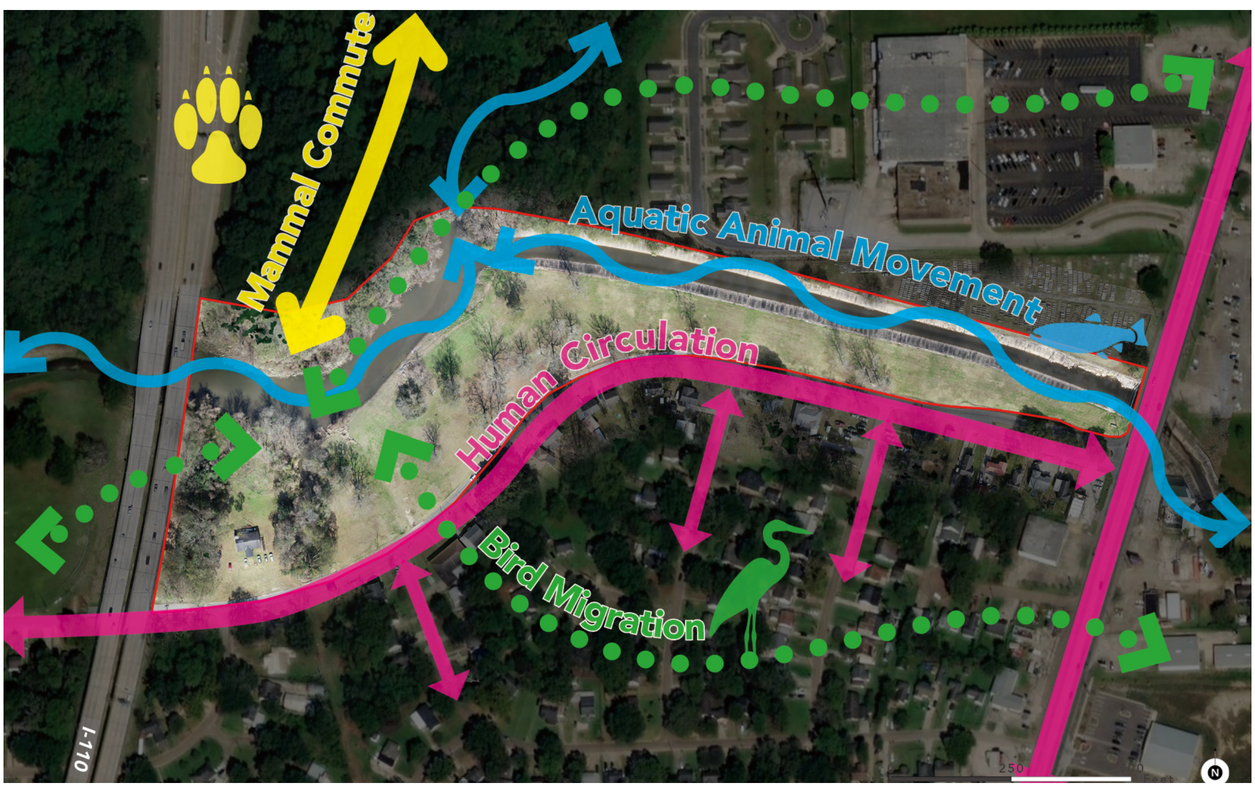


Figure 36. Wildlife and Human Circulation in Design Site

Hydrological analysis in the design site investigates water quality and quantity. To investigate the water quality in the Monte Sano Bayou, I took water samples at three different points by using a toolkit (Figure 37 and 38). Point 1 is under Plank Road in Hurricane Creek (Figure 39). Point 2 is at the confluence of the Monte Sano Bayou and the Hurricane Creek (Figure 40). Point 3 is at the pipe conveying water from the residential area to the bayou (Figure 41). A day before the investigation was rainy, which should be considered because the rainfall might have made water in the bayou thin. As a result, Point 3 was the most polluted point among the three points (Table 2). Interestingly, though Point 3, where the wastewater flows from residential area, was the most polluted, the vegetation of the area is most diverse in the design site. The author collected sample water by using strings and a water bottle (Figure 42).

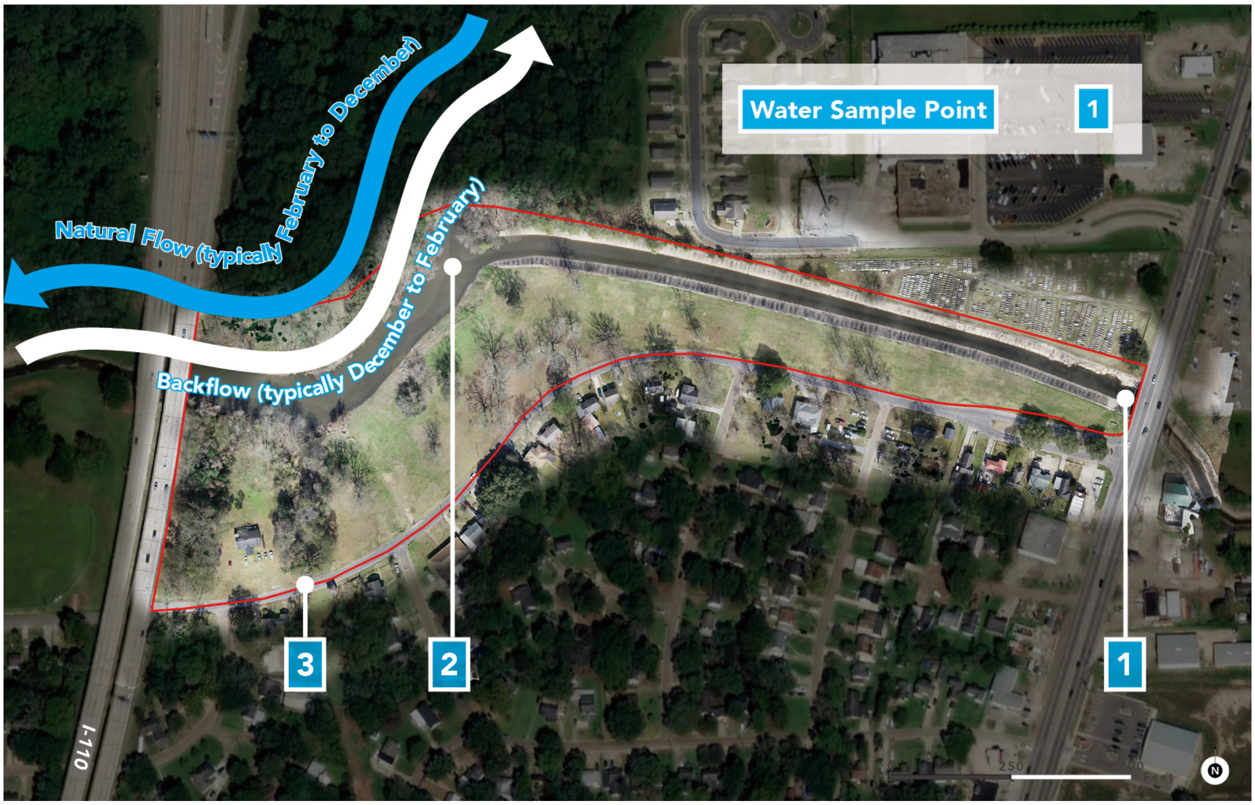


Figure 37. Water Quality Sampling Location

Figure 38. Water Quality Toolkit (left) and Result (right)

Figure 39. Water Sampling Point 1: Under the Plank Road

Figure 40. Water Sampling Point 2: Confluence at Monte Sano Bayou and Hurricane Creek

Figure 41. Water Sampling Point 3: Drainage Pipe (taken by Dr. Takeyama)

Table 2. Result of Water Quality Survey

	Point 1	Point 2	Point 3
pH	7.80	7.54	7.49
Chlorine	0.00	0.00	0.09
Phosphate	0.61	0.30	0.83

Figure 42. Sampling Water at Point 3 (taken by Dr. Takeyama)

In addition to the water quality, Figure 43 shows two feet interval contour lines to figure out the runoff pattern and flood pattern of the Monte Sano Bayou. The lightest blue is the area where was flooded in 2016. The second lightest blue-colored area is seasonally flooded area when meltwater flows from the Mississippi

River. The darkest blue-colored area indicates the lowest stage of the bayou during summer to December when the Mississippi River's stage is low. The gap between lowest water level and highest water level is about 12 feet difference.

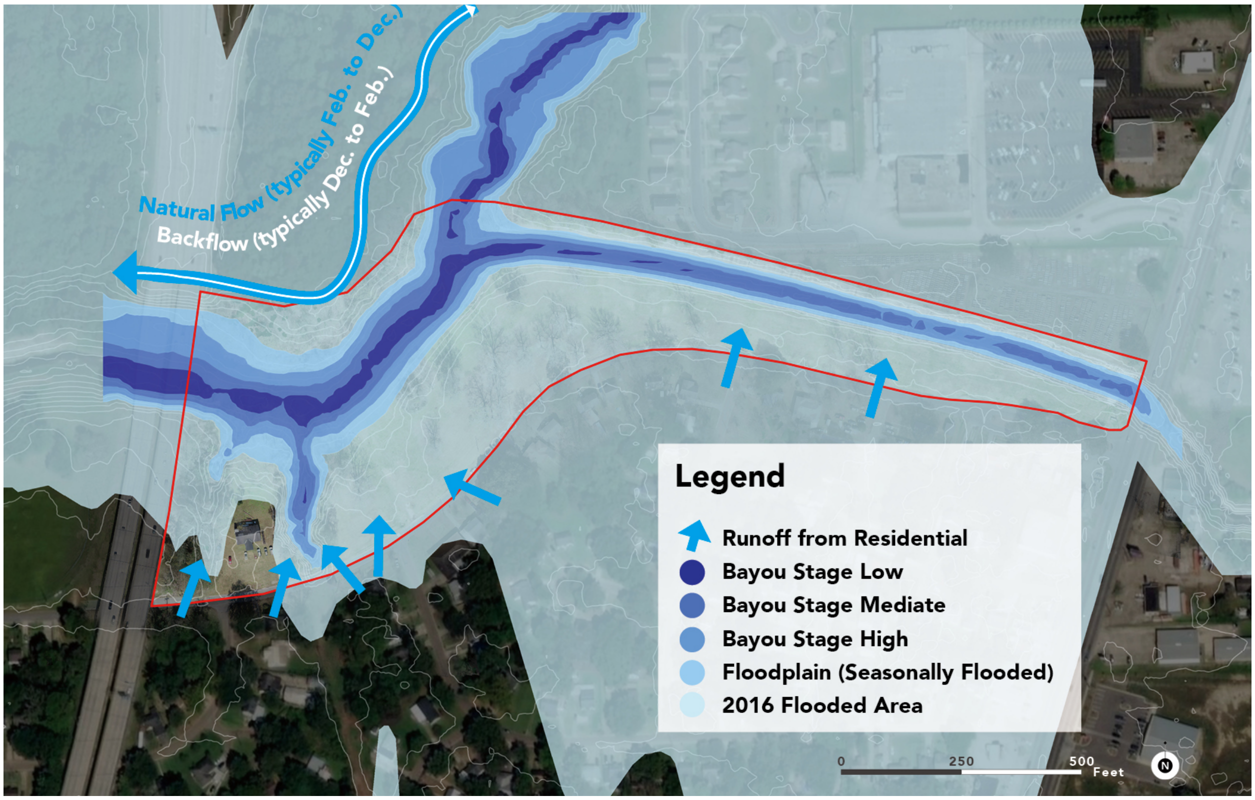


Figure 43. Water Quantity Analysis

To figure out existing runoff potential (Q = cubic feet per second) in the site, the hydrological analysis conducted the rational method (Q=CiA) by using runoff coefficient (C), rainfall intensity (i), and drainage area (A) in the site. The total acreage of the study site is 16.3 acre consisting of lawn (approximately 10.96 acre), tree canopy (approximately 2.67 acre), and a concrete canal (approximately 2.67 acre). This calculation uses 1-hour intensity rainfall of 100-year event. The result of calculation is below;[45]

[45] "Rational Equation Calculator," LMNO Engineering, Research, and Software, Ltd, accessed March 5, 2019, https://www.lmnoeng.com/Hydrology/rational.php

Area 1 (lawn)

Q = 17.262 (cfs)

C = 0.35

i = 4.50

A = 10.96 (acre)

Area 2 (canopy)

Q = 3.004 (cfs)

C = 0.25

i = 4.50

A = 2.67 (acre)

Area 3 (concrete)

Q = 11.414 (cfs)

C = 0.95

i = 4.50

A = 2.67 (acre)

The outcome of the calculation showcases that when heavy precipitation (4.5 inch/hour) falls on the study site, 31.68 cubic feet of water discharge into the site in each second. This means that each 100 seconds, the site discharge approximately same amount of a capacity of average of water tower (if the average of a water tower's capacity is 20,000 gallons).[46] The proposal should reduce this large amount of discharge by implementing green infrastructure.

Soil in the study site is another important consideration to install green infrastructure. The United States Department of Agriculture (USDA) provides Web Soil Survey (WSS) enable users to gain GIS data and information of soil capacity.[47] The soil in the study site is shown in Figure 44. The site mainly consists of OpB, CcA, FeF, and CEA soil types. The result of the survey provides that all types of

[46] "How Do Water Towers Work?" Wonderopolis, accessed March 5, 2019, https://wonderopolis.org/wonder/how-do-water-towers-work

[47] "Web Soil Survey," USDA.org, accessed March 5, 2019, https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

soil have high level of availability of water storage in their profiles. The problem figured out by the soil analysis is that even though the CcA soil type has great potential to infiltrate and slow the stormwater, the most of CcA soil is covered with the concrete. The opportunity, on the other hand, the FeF soil type which is floodplain could be enhanced its green infrastructural potential by converting the grass into a wetland or meadow.

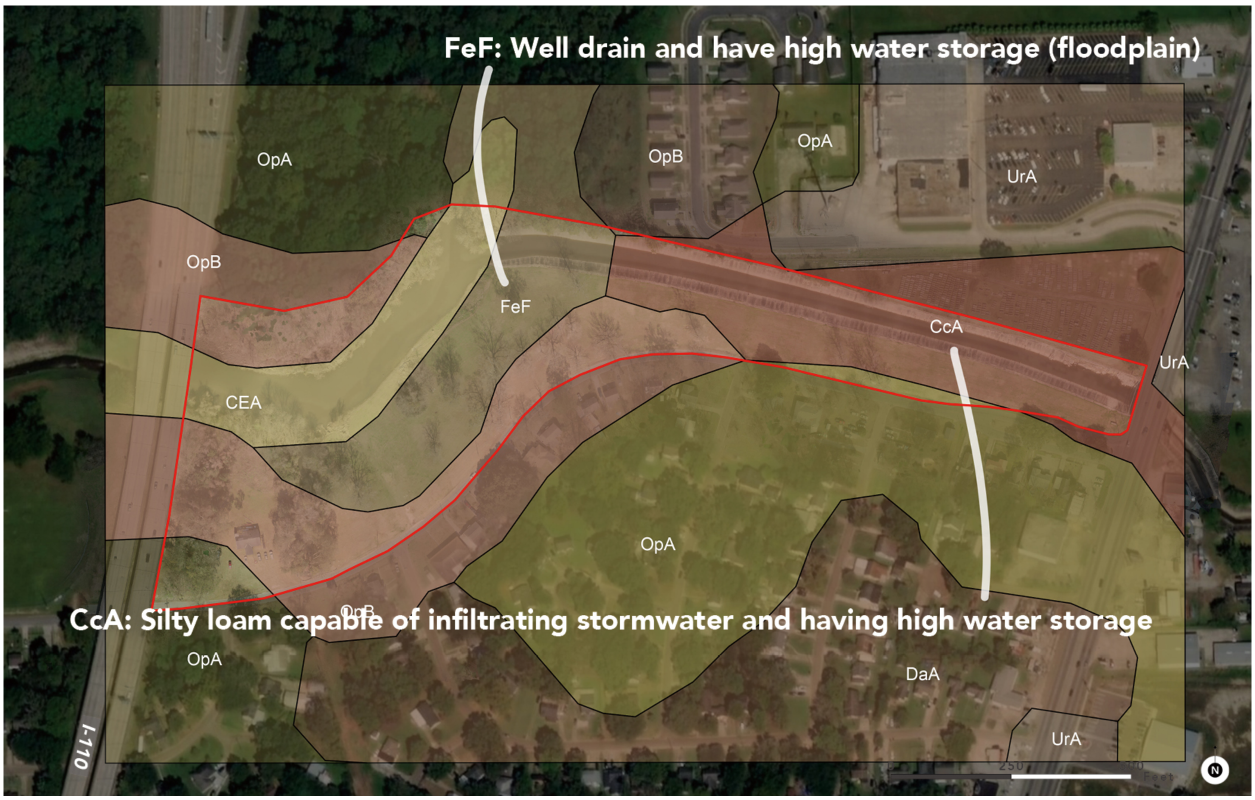
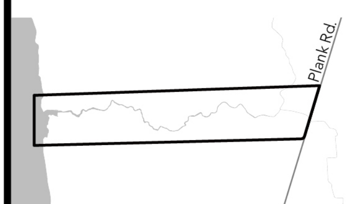
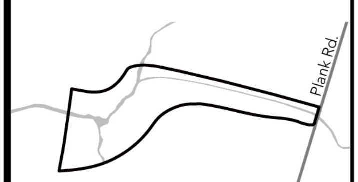


Figure 44. Soil Analysis in Design Site

To summarize, the study site has problems of lack of stormwater management but has great opportunities providing multiple benefits at the site scale. Table 3 summarizes the opportunities and problems in this study at four different scales.

Table 3. Summary of Opportunities and Problems

SCALE	OPPORTUNITIES	PROBLEMS
EBRP 	• Connect to potential projects (CAPP).	• Flood from Amite and Comite. • Seasonal water flow from the Mississippi.
WATERSHED 	• Comprehensive "Sponge City" plan with permeable surfaces.	• Runoff from impermeable development. • Obstruction between parks, conservation, and natural areas.
PARK 	• Linear park / ecological corridor. • Connect Plank Road and the Mississippi River.	• Obstruction on the Monte Sano Bayou.
DESIGN SITE 	• Rich biodiversity. • Improve community well-being by accessing to nature.	• Lack of stormwater management. • Ignore the potential og ecology such as soil and vegetation.

3.2. Design Strategy and Goal

The study develops design strategy and goal based on the analyses. To determine the appropriate strategy, the study defines emphasis in the site (Figure 45). Based on the importance in the figure 45, the study defines site program with circulation (Figure 46).

The circulation plan provides visitors with access to nature as well as limits the accessibility to preserved areas.

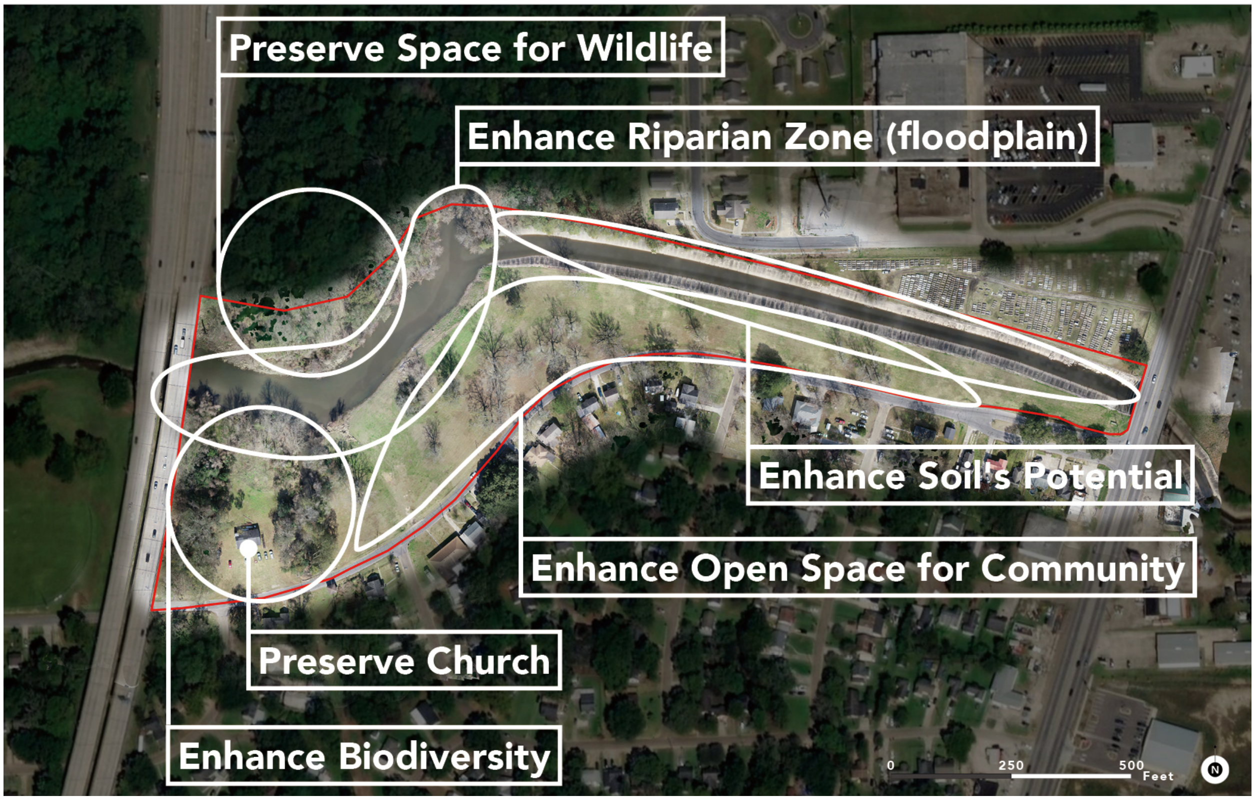


Figure 45. Emphasis and Preservation in Design Site

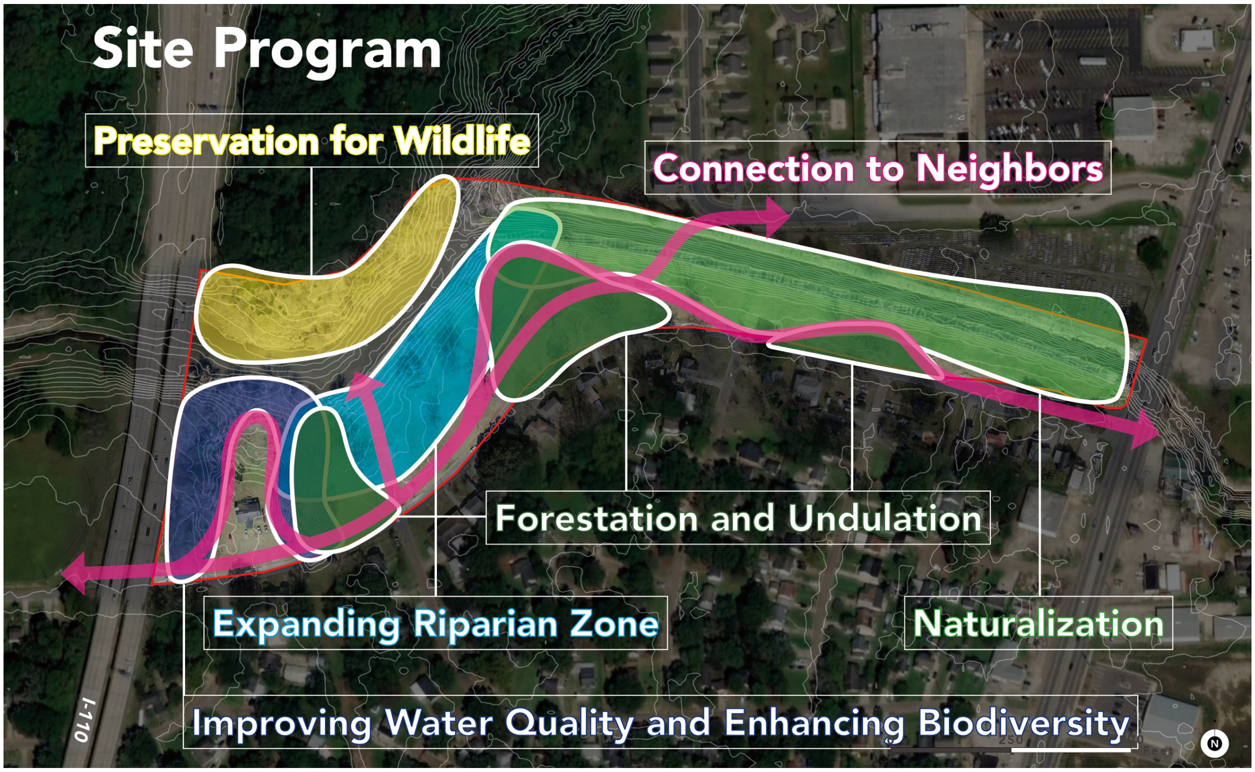


Figure 46. Site Program

The strategy of the plan is to mitigate negative stormwater impacts on the site by installing green infrastructure and to create accessibility to experience nature in the site by creating circulation and enhancing existing biodiversity. The possible green infrastructure elements to address the program are shown in Figure 47. The goal of the study is to provide neighborhoods and other visitors with experience of natural bayou landscape as well as to mitigate future flood impact in the neighborhood.

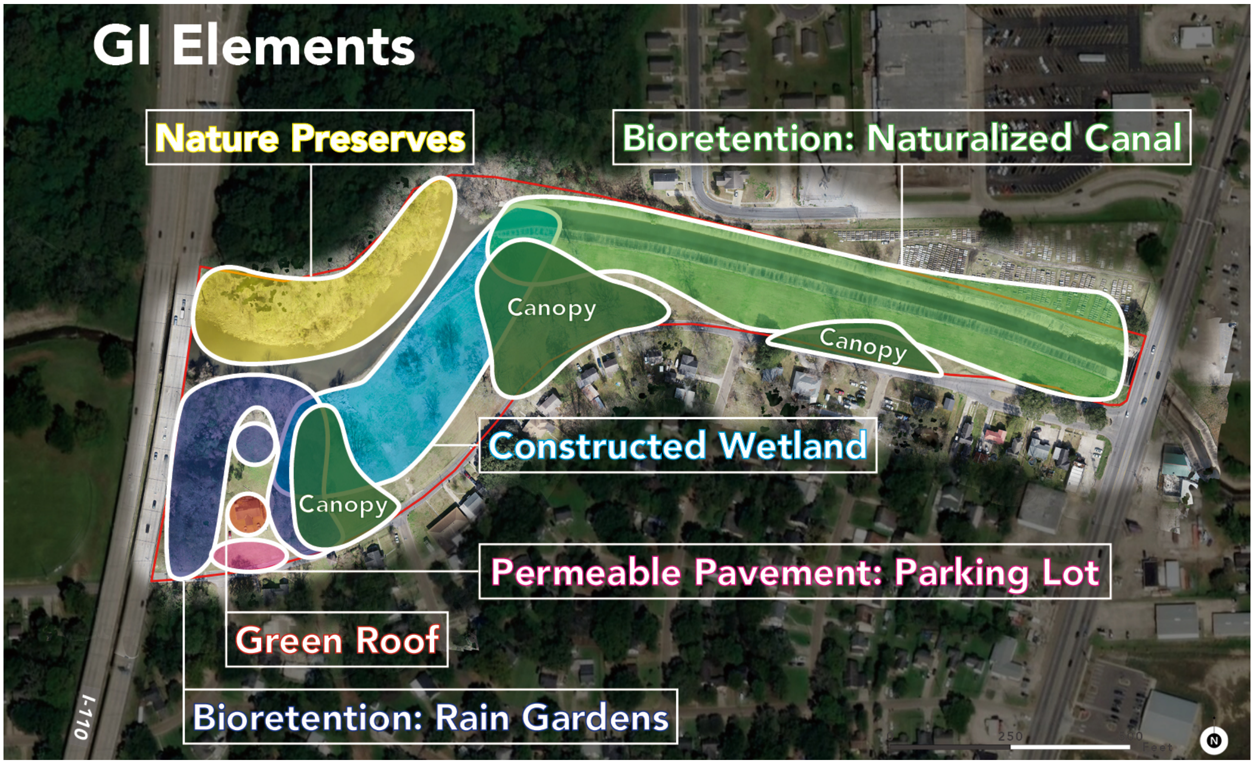


Figure 47. Green Infrastructure Elements

Chapter 4. Design Proposal

4.1. Site Design

To achieve the goal, the study proposes site design based on the site analysis and program. This chapter illustrates a schematic site design, renderings that illustrate perspective views in the site, and sections diagrams showing the relationship of water level and elements in the park. Figure 48 is the schematic design of the study site with annotation of elements.

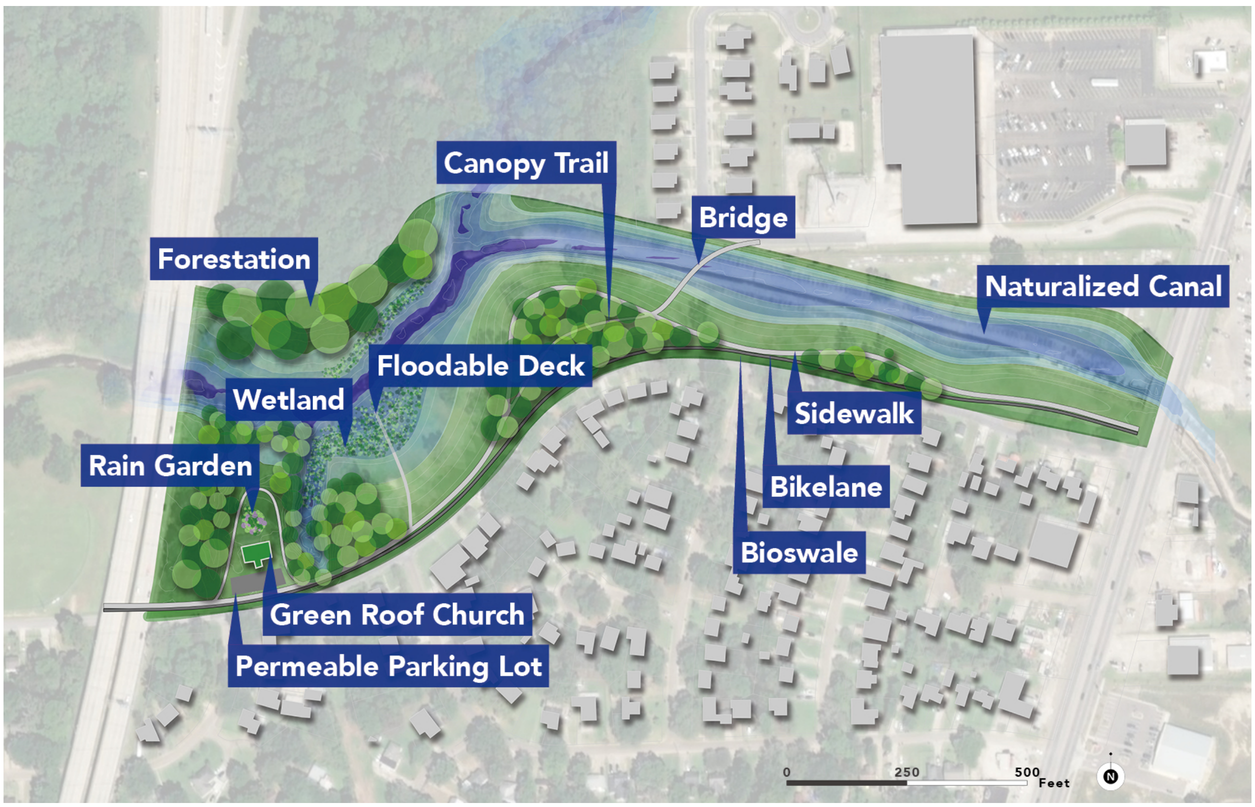


Figure 48. Schematic Design

The proposed rain garden behind the existing church captures precipitation, slows runoff velocity, and also provides wildlife with habitats (Figure 49 and 50). Canopy is another green infrastructure element in the proposed design. Canopy can reduce runoff velocity as well as provide people with shade. The proposal serves access to the water by creating a canopy trail and an open space in front of the bayou (Figure 51). Between

the existing roadway and the proposed bike lane, there is a linear bioswale which can reduce stormwater runoff from the road and function as amenity along the edge of the site (Figure 52). Proposed wetland in the site can mitigate runoff velocity and treat stormwater before the water flows into the bayou (Figure 53). Figure 53 also showcases the proposed deck which is designed to be flooded. The intention of the deck is to let people know how water influences on the life. The series of section diagrams of the floodable deck illustrates different water level of the Monte Sano Bayou and height of the proposed deck (Figure 54).

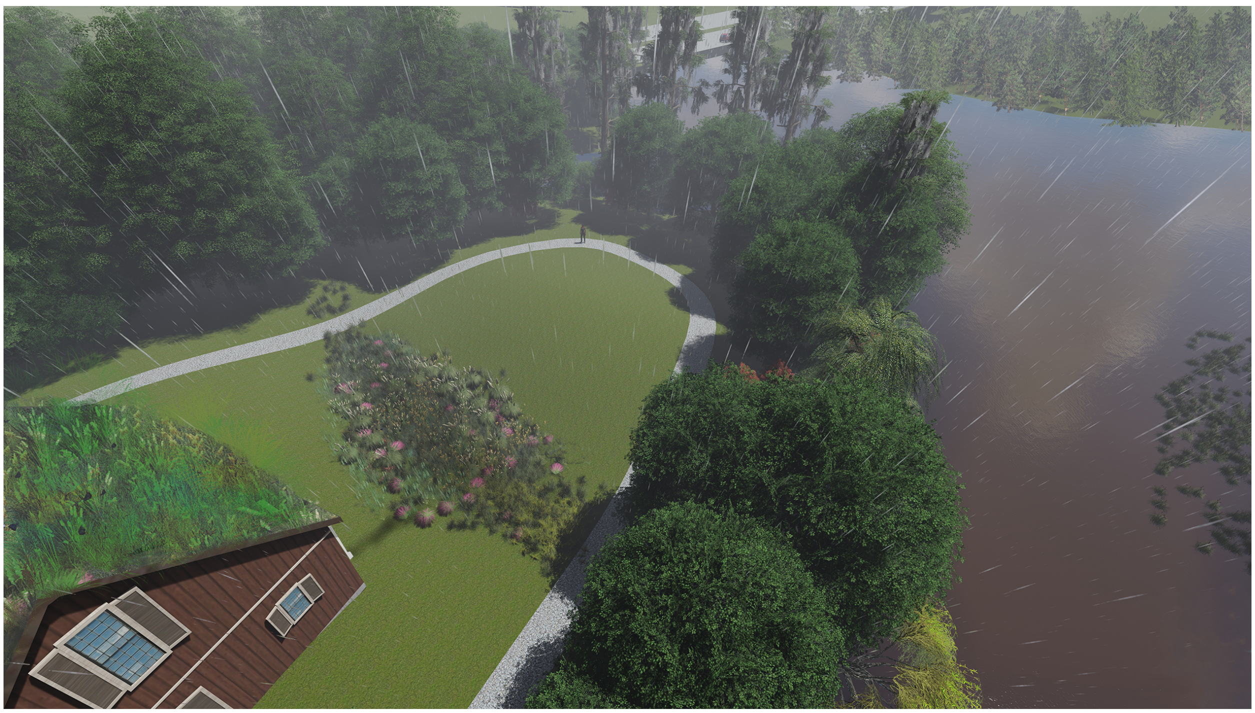


Figure 49. Rain Garden

Figure 50. Rain Garden with Flow Direction

Figure 51. Canopy Trail and Bayou Front Open Space

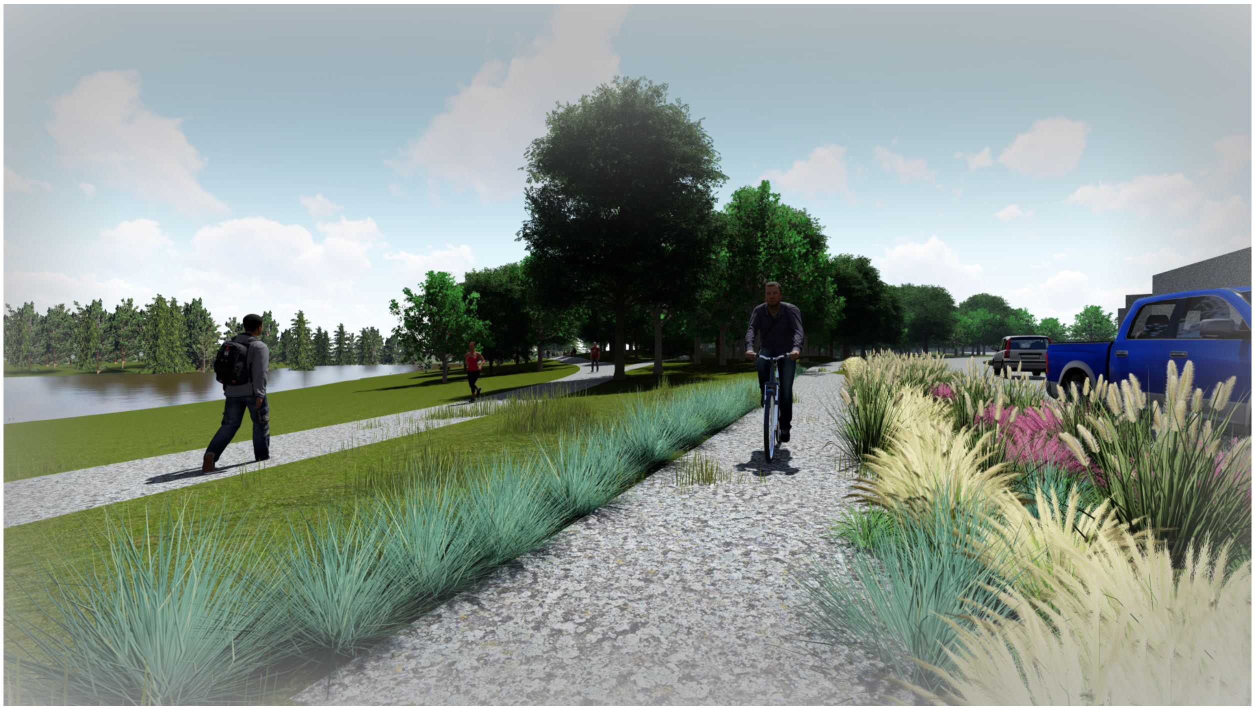


Figure 52. Bioswale and Bike Lane

Figure 53. Floodable Deck and Wetland

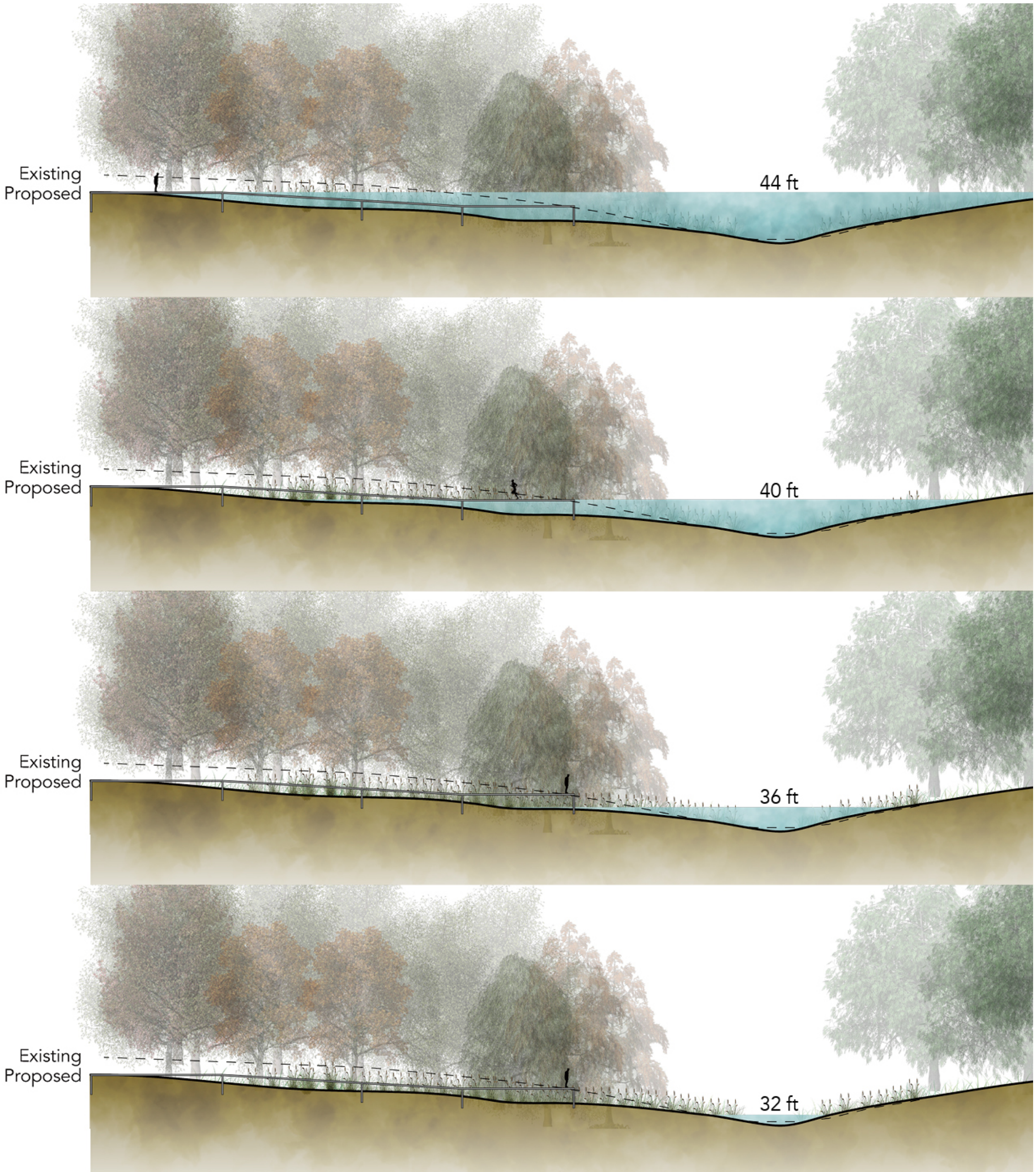


Figure 54. Seasonal Difference of Water Level at Floodable Deck

This green infrastructural system in the site contributes mitigating flood impact as well as create spaces for people. Successfully, the proposed design reduces the discharge in the site. The total discharge in the proposed site is about 6.975 cfs. The

result accomplished to reduce about 80 percent of discharge in the site. The detail is below;

Area 1 (meadow)

$Q = 0.5$ (cfs)

$C = 0.01$

$i = 4.50$

$A = 11.10$ (acre)

Area 2 (canopy)

$Q = 5.625$ (cfs)

$C = 0.25$

$i = 4.50$

$A = 5.00$ (acre)

Area 3 (concrete)

$Q = 0.85$ (cfs)

$C = 0.95$

$i = 0.20$

$A = 0.2$ (acre)

4.2. Vision for the Future

The proposed design is just a first step to create a comprehensive plan with green infrastructure for north Baton Rouge to mitigate future flood impacts and to enhance well-being. Ideally, the designed Monte Sano Park will connect to existing green spaces and existing human circulations. Figure 55 is a future vision for the Monte Sano Park and its surroundings. The green corridor plan along the Monte Sano Bayou provides natural trail experience for people, habitat for wildlife, and mitigation of flood. The plan also connects existing proposal, Capital Area Pathway Project. In the future, this proposal of redesign for the Monte Sano Park will contribute mitigating future flood impact and creating well-being for north Baton Rouge.

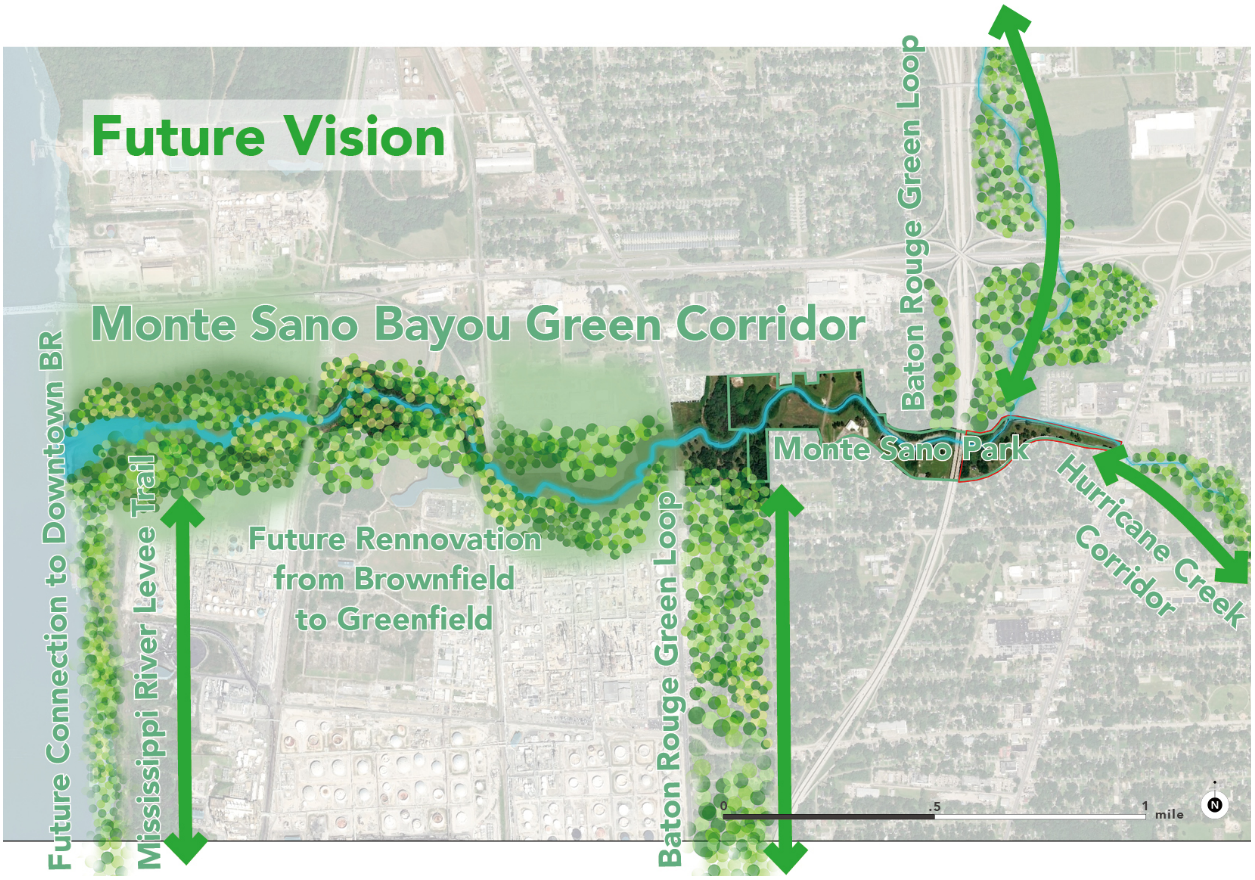


Figure 55. Future Vision for Monte Sano Bayou

Chapter 5. Conclusion

In conclusion, the proposal of redesigning the Monte Sano Park could mitigate the future flood impacts and the water quality issue as well as provides people with opportunity to access to nature. The dynamic hydrological influence from the Mississippi River seasonally affects in the Monte Sano Park. This ecological phenomenon could negatively affect by bringing flood. However, this unique influence could give vegetation nutrient as well as could educate people about how water interacts their environment. In addition, the adjacent natural areas have opportunities to expand the green spaces, to provide wildlife with habitat, and to provide people with ecosystem service. These nature areas could function as green infrastructure.

This project proves that designing open spaces with green infrastructure has multiple benefits including improvement stormwater management and creating spaces for people. The multi-purposeful design approach with green infrastructure should be implemented more for sustainable well-being communities.

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