Louisiana State University

NOLA: 20LSUaAaMC-6

Blight to Bioswales: Engineered Nature Parks in New Orleans' Abandoned Lower 9th Ward Community

Louisiana State University

Task 6: Open Task

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I. Executive Summary

In 2005, Hurricane Katrina made landfall in New Orleans resulting in calamitous flooding and damage to the majority of the city, with the greatest devastation being within the Lower 9th Ward. Although there have been several recovery attempts and volunteer efforts, the community has not quite returned to its original state. The Lower 9th Ward of New Orleans has been seeking an implementable development plan for the blighted lots that are found in mass numbers throughout the area.

Being one of the rainiest cities in the United States, New Orleans has an annual average rainfall of 64.16 inches. Under the Storm Water Code of the City of New Orleans, there is a requirement that the first 1.25 inches of a given rainfall must be retained on the property of any new developments. Runoff from such rain events inevitably collects various pollutants from neighborhood lawns, road debris, heavy metals and hydrocarbons. Our team designed a bioretention system that would occupy a portion of abandoned lots while providing extensive vegetation surfaces to treat air pollutants. With the utilization of low impact development, green infrastructure, and locally obtained sustainable materials, storm water runoff and ambient air remediation will be achieved.

Upon extensive research, it was found that 4 feet is an adequate depth for a bioretention design system in order to achieve maximum results of storm water treatment and storage. In the selected block area, the bioretention system will be developed at the lowest level of the street gradient. The total area of the block was measured to be 24116 m^2 (259578 ft^2). Following a conservative model, the given design storm of 35 mm resulted in a calculated retention surface area of 278 m^2, which reasonably accounts for 16% of the block area.

The soil type in the ward requires soil to be replaced in the bioretention bed due to limited permeability of the clay soils. The materials that would be used are combinations of sand, gravel, charred pecan shells "biochar" and charred oyster shells, specifically focusing on mixtures of these media. Pecan and oyster shells are both local and abundant wastes in Southern Louisiana, making them an appropriate choice for such a design. Charring pecan and oyster activate sorption properties and creates calcium oxide – causing phosphorous to precipitate and settle. Organic and inorganic pollutants would thus be remediated with the implementation of charred pecan and oyster shells.

Leaf samples were taken from various sites in the Lower 9th Ward and sorbed organics measured by GC-MS. The results showed that several of the contaminants found on the leaf cuticle are intermediates from detergent production and various hydrocarbons. The implementation of a living wall that is 7 feet by 15 feet will substantially increase the potential of contaminant sorption to leaf cuticles. Only native plant species will be used.

The estimated total cost of installation was approximated to be $14,158. The cost of maintenance and upkeep is also estimated to be an annual $850. Beth Butler's group, A Community Voice, will take on responsibility for general maintenance, such as landscaping and replanting vegetation. With the utilization of sustainable materials that are all local to Louisiana, and the communal support to help with upkeep, the cost of implementation is kept minimal.

An imperative aspect to the Blight to Bioswales project was the direct involvement of people from the Lower 9th Ward. This was executed through extensive discussion and interviews with local residents of all age groups – students, working class, and retired – in regards to how they would feel about a project like this being constructed.

Overall, the interviewees had very constructive and positive feedback. Some residents were critical and skeptical, but claimed to be very appreciative to see that consideration was given to their personal opinions. Questions were asked about the value the project would bring to the community and how much support the interviewees thought it would receive within the Lower 9th community and from the city of New Orleans. These types of questions were important for getting a variety of opinions from people looking at the project from varying point of views. It gave first-hand insight from residents who would be affected from the project's implementation, and the team wanted to make sure that the people felt they would benefit from it on as an individual. In addition to improving stormwater runoff quality, this project also addresses air quality concerns while designing a place the community of the Lower 9th Ward can be a part of and enjoy for years to come.

II. Introduction

On August 29, 2005, the levees of the Industrial Canal along the Lower 9th Ward in New Orleans burst open as Hurricane Katrina, a Category 5 hurricane, wreaked havoc along the coast of Louisiana. Billions of gallons of water surged through the levee's breach, leaving streets in the Lower 9th Ward, an historical sub district of New Orleans east bank, covered in water up to 12 feet deep. The residents that had not already evacuated were left to fend for themselves during the storm, many of which were forced to retreat to their rooftops as water flooded their homes. According to Tim Bayard, a retired NOPD captain who participated in rescue efforts, six-dozen bodies were recovered from the Lower 9th Ward area following the storm.[15]

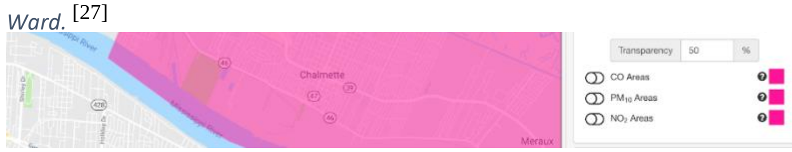
Before Hurricane Katrina, the Lower 9th Ward was a community known for its unique culture, music, and culinary traditions. A once vibrant community of 20,000 residents was now left with only 7,000 residents after the storm. The Lower 9th Ward, cut off from the mainland of New Orleans by shipping channels, was the last community to be pumped dry and have power and water services restored.[1] Properties were abandoned due to the economic hardships of returning to rebuild, leaving the local government to buy many of the blighted, deserted properties. According to Councilwoman Cyndi Nguyen of New Orleans Council District E, over 2,000 properties remain abandoned in the Lower 9th Ward as of August 2018.[31] In Figure 1, a City Council map of the Lower 9th Ward marking abandoned lots with white pins shows a majority of the neighborhood is plagued by empty properties.

Figure 1: City Council map of Lower 9th Ward with abandoned lots marked by white pins. [3]

In an interview by Beth Butler, a leader of a non-profit organization called A Community Voice, she explained that the blighted and abandoned properties undermine the sense of community for residents of the Lower 9th. Beth's organization works closely with residents and stakeholders to identify and address locally felt social challenges. “The residents want things to come back to the way it was before Katrina – so people can return home… the community deserves something good, something nice,” Beth explained. Community activists are seeking a development plan for these blighted lots to bring their neighborhood back to life and end the disconnect between residents in the Lower 9th Ward.

Another ongoing problem faced by the Lower 9th Ward today, keeping potential residents and stakeholders out of the community, are environmental issues, such storm water management and urban air pollution. New Orleans is the third rainiest city in the United States, receiving an average annual rainfall of 64.16 inches.[11, 17] The Stormwater Code of the City of New Orleans requires the detention or retention and filtration of the first 1.25 inches of storm water from a given rainfall event on a newly developed property.[3] In the Lower 9th Ward, containing mostly overgrown and underdeveloped lots, storm water moves quickly through the neighborhood collecting nitrogen and phosphorus from lawns, pollutants associated with automobiles, such as heavy metals and hydrocarbons, and sediment or debris from dilapidated streets and demolished buildings. The polluted storm water is quickly routed to Lake Pontchartrain, a brackish estuary that is home to aquatic animals and vegetation in some of Louisiana’s most important wetland areas. The storm water from the Lower 9th Ward is detrimental to the health and environment of aquatic ecosystems adjacent to the storm water outflow.

Figure 2: iTree simulation of Sulfur Dioxide non-attainment area near Lower 9th Ward. [27]



An additional environmental problem in the Lower 9th Ward is the community’s adjacency to a Sulfur Dioxide non-attainment area, meaning SO_2 levels are higher than the standards defined by the Clean Air Act, as seen by the iTree simulation in Figure 2.[27] SO_2 is a critical air pollutant, often released from refineries, that has a potent smell, and can cause severe irritation to the nose and throat. Other air pollutants such as carbon monoxide (CO), nitrogen dioxide (NO_2), particulate matter (PM), ozone (O_3), and gaseous hydrocarbons also threaten the air quality for residents in the Lower 9th Ward. In fact, in 2018, New Orleans saw more ground level ozone air quality -s for sensitive groups than it did in the previous three years combined, a problem that is expected to persist in the future.[24] Poor air quality is detrimental to the health of the residents in the Lower 9th Ward and very likely to hinder growth in the area as future homebuyers seek healthier communities to live in.

Project Objectives

This study considered two primary objectives: managing storm water and reducing the adverse effects of urban air pollution, while also addressing the issue of abandoned properties following Hurricane Katrina in New Orleans' Lower 9th Ward community. The first objective was to select and design a Best Management Practice (BMP), such as a retention system, that could both store and filter storm water on abandoned properties as suggested by the Environmental Protection Agency and the Stormwater Code of the City of New Orleans.[3, 22] The selected BMP designed and deployed on the properties needed to be effective in removing pollutants before releasing the storm water from the property and also capable of storing enough storm water during a rainfall event to meet local regulations, while remaining cost effective.

Similarly, the air pollution remediation method deployed on the abandoned lots needed to partially mitigate the exposure of air pollutants to the Lower 9th Ward residents visiting the properties. The overall goal was to create an area of clean air where residents could escape from the harmful effects of urban air pollution, such as the high SO_2 concentrations released from the local refineries. The materials used for the overall remediation design needed to be sustainable, cost effective, and safe for residents visiting the properties.

Ultimately, the study sought to use Low Impact Development (LID) and Green Infrastructure (GI) to create an engineered nature park that would fill abandoned properties and address environmental issues in the Lower 9th Ward community.[9] The implementation of the proposed project and the inspiration for the overall project's design would be based on feedback from Lower 9th Ward residents, community leaders, and environmental professionals through a series of interviews. The re-development of the blighted lots would create a healthy environment for residents and wildlife, and bring back the sense of community for the people of the Lower 9th Ward by providing a place for recreation, community engagement, and the promotion of public health.[28]

III. Proposed Design

Guidance by the Environmental Protection Agency and the Stormwater Code of the City of New Orleans suggested a bioretention system be used as the BMP for storm water storage and filtration.[3, 21] The purpose of the bioretention system is to store storm water in the soil underground and to naturally filter pollutants from the water that passes through the soil layer. According to Albert Jarrett, PhD., a professor for the Department of Agriculture and Biological Engineering at Penn State University, bioretention systems have been shown to remove up to 98% of metals and reduce 40% of total nitrogen and 65% of the phosphorus found in polluted storm water.[10] The problem with using a bioretention system in New Orleans is that the local soil is made mostly of clay, which has a slow infiltration rate and would likely clog the retention system given the high rainfall intensity in the Lower 9th Ward area.[26] To bypass the problem of a slow infiltration rate presented by the local soil, the study proposed digging out a swale and filling it with layers of natural materials that could better infiltrate storm water and be effective in removing common pollutants associated with storm water runoff. The project proposed a layered system with gravel base, natural filter media, construction sand, and pea gravel, from top to bottom receptively, as shown in Figure 3. The natural filter media, responsible for a majority of the pollutant filtration, would be a combination of local and sustainable materials. The Minnesota Stormwater Manual recommended using Drinking Water Treatment Residuals, a by-product of drinking water treatment, as it is proven to be effective in reducing phosphorus concentrations from storm water.[10] However, the treatment residuals can be hard to find in large amounts, as many of the treatment facilities in Louisiana do not produce them. The study turned to local and recycled products that are available in abundance, such as cullet, oyster shells, and pecan shells. Although cullet, recycled waste glass, was available locally, research did not provide any evidence to the material's ability to remove heavy metals from water, a common pollutant found in storm water runoff. Both oyster and pecan shells are known to be effective in physically and chemically removing nutrients, heavy metals, and hydrocarbons from water, so both of the materials were selected as the natural filter media for the initial bioretention design.[13, 22]

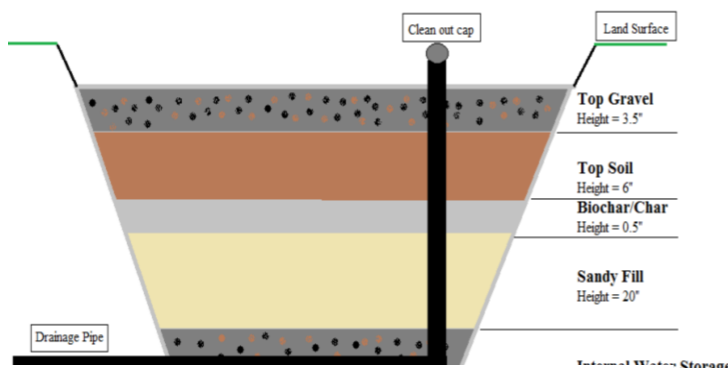


Figure 3: Proposed Bioretention System

In creating a process for air pollution remediation, the study proposed using native plant species combined with Green Infrastructure to mitigate the effects of harmful pollutants in the air. A Canadian study has shown that pine trees can effectively capture PM, drought tolerant deciduous broadleaf trees reduce ozone levels, and magnolias are tolerant to NO_2 in urban settings and indirectly reduce ozone as well.[8] Low maintenance native trees such as live oak, cascade falls bald cypress, and pecan trees, would be planted to reduce air pollution on the re-developed properties. In addition to native trees, a green wall, also known as a living wall, would be constructed to intercept air pollutants on the property. The proposed living wall works similarly to trees, however, the wall itself increases the density of leaves in the area, leading to a higher uptake of air pollutants. The wall would be designed as a 7 feet tall by 15 feet wide durable lattice structure, optimal for the maximum leaf coverage as the vines would grow both vertically and horizontally on the structure.[7] While a solid wall was initially proposed for the design, a lattice structure was finally selected due to safety concerns brought up by Beth Butler in an interview, when she mentioned homeless people might hide behind the walls.

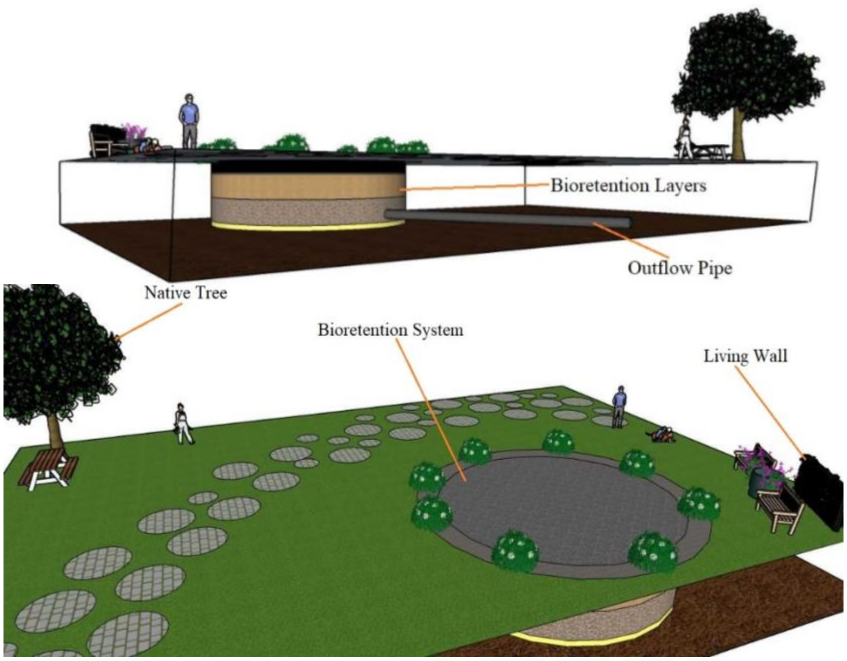


Figure 4: Proposed engineered nature park design for Lower 9th Ward abandoned properties.

The proposed engineered nature park layout for the abononded properties, as seen in Figure 4, contained the bioretention system for stormwater management and the living wall and native trees for air pollution remediation. The top layer of the bioretention system contained a sloped low maintenance gravel layer with short shrubs to improve the overall aesthetics of the park. The proposed bioretention system contained an outflow pipe at the bottom of the system that was to release storm water into the municipal storm water drainage system adjacent to the re-developed property. To prevent clogging in the drainage pipe, a clean out cap would be attached to the drainage pipe to remove debris from the pipe using high air pressure. The nature park would also contain picnic tables and benches for residents to relax and enjoy the clean air in the green space. The remaining area of the property would contain a walkway and open field to provide residents a safe public space to excersise and walk their pets.

IV. Project Methodology

Bioretention Performance Simulation

In creating a bioretention system for storm water treatment on blighted properties in the Lower 9th Ward, various filter materials were selected based on their ability to remove common storm water pollutants such as heavy metals (zinc and copper); organics (nitrogen and phosphorus) and hydrocarbons (oil and grease). Metals would need to be removed through a physical process called as adsorption, which requires a material that has a high affinity for heavy metals common in storm water.[4] Sand was selected for heavy metal removal, as it is known to be an effective adsorbent of heavy metals, and is recommended for metal filtration by the Minnesota Stormwater Manual, which suggests using a minimum of 60-70% construction sand in a bioretention system.[6, 14] Sand is also known to be effective in the removal of hydrocarbons from polluted water in oilfield produced water treatment processes.[6] Oyster shells, a byproduct of Louisiana's seafood industry, were selected for the removal of phosphorus from storm water. Recent studies in Korea have shown that burning and crushing oyster shells creates calcium oxide, which when combined with a polluted water containing phosphorus, forces the dissolved phosphorus to precipitate out of the solution.[29] Pecan shells, a byproduct of Louisiana's agriculture industry, were also selected as a filter material for its known ability to sorb heavy metals and its use in the oil and gas industry as a filter for hydrocarbon removal in wastewater.[2, 22] Pea gravel was selected as the material for the internal water storage component of the bioretention system, which is where most of the nitrogen removal was expected to occur through denitrification.

Sources of oyster and pecan shell byproducts were identified at local seafood restaurants in New Orleans and through Bergeron Pecan Shelling, who reported sending off "truck loads" of pecan shells to landfills in Texas following a harvesting period. After obtaining enough pecan and oyster shells for experimenting, the shells were prepared for storm water treatment testing. First, both the oyster and pecan shells were charred separately for 3 hours in a furnace at 700 F°.

After charring, the shells were crushed to a fine dust using a mortar and pestle. Burning the pecan shells activated the sorption properties of the material, similar to properties seen in activated carbon filters. As suggested by studies from Korea, burning and crushing the oyster shells would create calcium oxide, which is useful for phosphorus removal from water. [24]

After the filter materials were prepared, four plastic columns were constructed with an outflow valve to simulate the bioretention filtration process as seen in Figure 5. The 6.5 inch diameter pipes were 4 feet long to fit a 3.5 feet retention system, which was scaled down from the original 4 feet system that would be implemented in the final design. For experimental purposes, the water storage layer was reduced from 18 to 12 inches as the amount of water being treated in the experiment would be less than actual size. Below the 9.5 inches of topsoil and gravel would be the first filtration layer, containing only a ½ inch of charred material to remove the initial pollutants running through the system. Being the top-most layer of the filtration system allows for the easy replacement of the charred shells when the material is spent after five to ten years of filtration. Below the charred materials would be 20 inches of sand, which would be responsible for removing the remaining pollutants from the storm water. The sand would make up a majority of the bioretention system, as recommended by the Minnesota Stormwater Manual.[13]

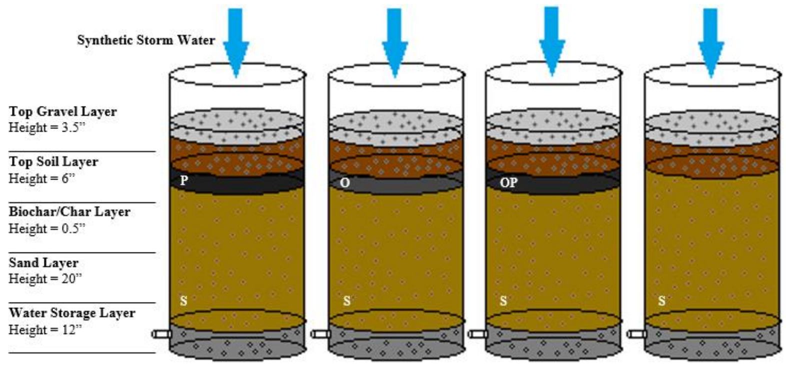


Figure 5: Bioretention columns used to test effectiveness of filtration materials. P = Pecan, O = Oyster, OP = Oyster/Pecan Mixture, S = Sand

The four plastic columns were used to test four different filtration scenarios: the first containing only pecan biochar as the first filtration layer, the second containing only oyster char as the first filtration layer, the third containing a mixture of charred pecan and oyster materials, and the fourth, the control column, containing only construction sand as a filtration layer. The hypothesis for the bioretention simulation experiment was that a mixture of the charred oyster and pecan shells would produce the highest removal efficiency of heavy metals, organics, and hydrocarbons compared to pecan shells, oyster shells, or sand as a filter alone. The sand filter was expected to have the lowest removal efficiency as it lacked the filtration benefits provided by the extra charred shell layer.

To test the designs, 2 L samples of synthetic storm water were created based on normal storm water characteristics in urban areas. [24] The prepared synthetic storm water solution for the experiment contained known initial concentrations of dibasic sodium phosphate, sodium nitrate, calcium chloride, cupric sulfate, nickel chloride, zinc chloride, toluene, and crude oil, as shown in the table found in Appendix A. Although lead is a critical pollutant often found in urban storm water, it was left out of the experiment for safety concerns. Heavy metal removal in the proposed design would be based solely on the calcium, copper, nickel, and zinc removal results.

After the synthetic storm water was prepared, 1.5 L of storm water was slowly poured into each of the four bioretention columns. Following a retention time of 24 hours, filtered storm water samples were collected through the outflow valves at the bottom of the bioretention columns. During the experiment, the column containing only a sand filter, acting as a control, leaked such that an insufficient amount of storm water was collected for the analysis. Collected samples were analyzed for the final concentrations of the chemicals initially added to the synthetic stormwater samples.

Bioretention Sizing Model

To construct bioretention systems on blighted lots throughout the Lower 9th Ward area, a method was determined to size each bioretention system, which ultimately depended on the amount of storm water entering any lot. Given that some block areas in the Lower 9th Ward have more impervious land compared to other blocks, it was understood that the bioretention systems on the properties throughout the community would have different surface areas. A spreadsheet model was created to determine the surface area of the bioretention system required to treat and store the storm water entering a property, allowing users to input land and precipitation parameters for any given block.

The sizing model used a block analysis, with the conservative assumption that all storm water on the block area was entering the lot, which includes the bioretention system. The model required users to input certain block parameters such as pervious and impervious curve numbers, pervious and impervious areas, the area of the abandoned property housing the bioretention system, and the depth of the bioretention layers. To run a sizing simulation, the model required users to input the amount of precipitation produced by a typical severe storm for any given block area.

The model combined two methods to determine the surface area of bioretention required to treat and store storm water entering a property. The first method is the NRCS Curve Number Method, which is commonly used to determine the amount of runoff entering a specified area.[2] The method first determines the amount of excess rainfall coming from the pervious and impervious areas of the block, which is used to determine the total volume of rainfall entering a property. The second method, provided by the Tennessee Permanent Stormwater Management and Design Guidance Manual, uses the total runoff volume entering a lot area calculated by the NRCS Curve Number Method to determine the surface area of the bioretention system. Equation 1 depicts the equation used for calculating bioretention surface areas provided by the manual.

$$Surface\ Area = \frac{Total\ runoff\ volume - Volume\ reduced\ by\ an\ upstream\ SCM}{Storage\ Depth}$$

Equation 1: Equation for calculating bioretention surface area.

The volume reduced by an upstream SCM refers to the amount of rainfall that is already consumed by other Stormwater Control Measures or bioretention systems within a specified block area. The storage depth refers to the sum of the height of the bioretention layers multiplied by their specific void ratios.

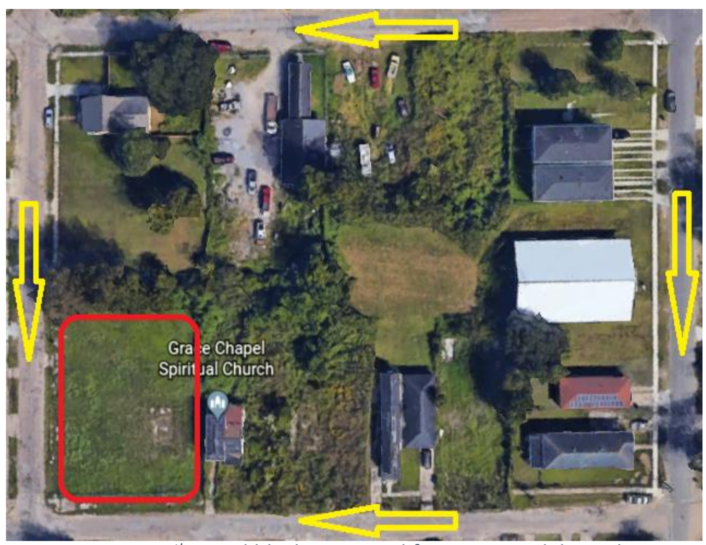


Figure 6: Lower 9th Ward block area used for sizing model simulation. Red box: nature park housing bioretetntion system, Yellow arrows: flow direction of storm water runoff.

To test the spreadsheet sizing model, an arbitrary block in the Lower 9th Ward containing a single abandoned property was selected for analysis as shown in Figure 6. The lot housing the bioretention system, outlined in red in Figure 6, was selected because it was downstream of the storm water running through the block area based on the slope of the roads outlining the block, as shown by the yellow arrows in Figure 6. In addition, it was made sure that the selected lot was the lowest elevation of the block area, so runoff from neighboring lots would move towards the bioretention system to be treated. To complete the test of the sizing model, pervious and impervious areas were measured using Google Earth measuring tools. The pervious and impervious curve numbers were determined using Water-Resources Engineering (3rd Edition) by David A.Chin, which provides curve numbers based on typical soil properties. For the purpose of the simulation, a severe storm producing 35 mm of rainfall in 1 hour was used.[30, 19] After all of the land and precipitation parameters were determined, values were input into the model as shown in Appendix B under "User Inputs". For this simulation, the volume reduced by upstream SCM was assumed to be negligible, as no other bioretention systems already existed on the block area.

Air Pollution Remediation

To determine how the addition of plants to blighted properties in the Lower 9th Ward would help mitigate air pollution in the area, existing plants were analyzed in three different locations. The analysis sought to explain how well certain air pollutants, such as SO_2 and volatilized hydrocarbons, accumulate on the leaves.

First, three sampling locations were selected based on their differences in vegetation and automobile or boat traffic density. One of the sampling locations was near the industrial canal, which had light vegetation and high boat traffic. At the canal, 10 leaves were sampled from a black willow tree and 10 leaves from an ivy vine. The second sampling location was at the Sankofa Nature Trail and Wetland Park, which had very heavy vegetation and light traffic, but was situated adjacent to the SO_2 non-attainment area. At the nature trail, 10 leaves were sampled from a magnolia tree. The third sampling location was on the side of a highway, which had light vegetation and heavy traffic. Near the highway, 10 leaves were sampled from an old oak tree.

Leaf sampling was done by taking 10 leaves from each tree or vine and inserting them into a jar with 75 mL of Dichloromethane (DCM). The jar was swirled for 2 minutes and the leaves were removed and discarded. The DCM strips the leaves and removes the cuticle from the tissues, in order to separate the analysis of contaminants in the cuticle from the tissues. These samples were brought back into the lab, where the leaf tissues were run through the Accelerated Solvent Extractor (ASE) using the solvent hexane acetone. Hexane acetone was used in order to remove the pollutants from the leaves. The ASE extracts compounds from samples quickly with a small solvent volume. Once this was done, the solution was concentrated down to 1 mL before running it through the Gas Chromatography Analyzer (GC). Similarly, the cuticles of the leaves in DCM were vaporized and exchanged with hexane acetone. Afterward, the solution was concentrated down to 1 mL before running it through the GC, which provided a breakdown of the chemical concentrations in each leaf sample.

Public Participation Plan

A deeply rooted connection to the Lower 9th Ward community was imperative to the success of this project. After Hurricane Katrina devastated the Lower 9th Ward of New Orleans, the community has struggled to return to its original state and revitalize the area. Throughout the outreach process, the team worked to embody the thoughts and opinions of the residents for the project's preliminary design.

The project's team collaborated with Beth Butler and her organization in order to create something that would improve the lives of the residents of the Lower 9th Ward. Butler guided the team to help get the project progressing and expressed the importance of talking directly to the residents. The team narrowed down the list of contacts to a few that would represent the Lower 9th Ward and the city of New Orleans in different ways, from typical residents and members of A Community Voice to a legislative director for the city. The chosen interviewees represent different parts of the community, but all have deep-rooted connections to the area and want the best for it.

After a quick description of the Blight to Bioswale project, the interviewee would share their thoughts, opinions and concerns about its implementation. Questions were asked about the value that the project would bring to the community and how much support the interviewees thought it would receive within the Lower 9th Ward. These types of questions were important for getting a variety of opinions from people looking at the project from varying point of views. It gave first-hand insight from residents who would be affected from the project's implementation, and the team wanted to make sure people felt they would benefit from it.

Once the bioretention system and living wall have been constructed, the area will be a place the community can come to enjoy. Beth Butler's organization, A Community Voice, will be responsible for general maintenance for the area, and LSU or colleges in New Orleans, such as Tulane University or the University of New Orleans, will have the opportunity to get involved with the community to keep the space prevailing as a spot for the residents to be a part of and be proud of. Field trips for children of the surrounding elementary schools could be orchestrated for an educational experience to learn about the local plants and the importance of water treatment.

V. Economic Analysis

The cost analysis for this project, in Appendix C, involves two major components: construction costs and annual maintenance. Responsibility for the maintenance and upkeep of the area will be taken on by A Community Voice, Beth Butler's organization. The estimated time to complete the project construction is about five months, which also accounts for any problems during construction and potential weather delays. For the construction of the bioretention system and nature park, two portable bathrooms, at an estimated cost of $5,000, must be on site to comply with OSHA standards. If materials need transportation via18-wheelers, shipping will cost $2 per mile with Moving Mountains, LLC. Gardeners and landscape architects will be needed on-site to oversee the living wall and planting of native vegetation around the bioretention area.

The project lot area is 18,880 ft^2. To begin construction, 266 yd^3 must be excavated for the pipes and media bed for the bioretention system. This volume was determined from the surface area of the bioretention system, which is 278.24 m^2, and the depth, which is 0.73 m, from Appendix B. The cost of soil excavation is $4.50 per yd^3 so the total for excavation would be $1196.50.[20] The pipe installation for a 68-yard pipe for the bioretention system will cost $3150. A 40-yard dumpster with a 10-ton weight limit will be rented for material disposal from Budget Dumpsters: New Orleans. The 10-day rental will be $469, which includes tax, delivery, pickup, and disposal.[16]

For the primary treatment of the storm water, various medias will be put together to form a bioretention system with a volume of 265.88 yd^3. The media will consist of topsoil, oyster shell biochar, pecan shell biochar, construction sand, gravel and regular pecan and oyster shells. The Chimes, a local restaurant, will donate the oyster shells, and Bergeron’s Pecans will donate the pecan shells. The quantity of construction sand needed is 185.02 yd^3, and at $30 per ton. it will cost $1499. The gravel will cost $3495 because 166.4 yd^3 of gravel is needed at $25 per ton. Lastly, topsoil will cost $3001 because 55.57 yd^3 is needed at $54 per yard.[5] The total cost of materials for the water treatment system for the Blight to Bioswales project will be $7995.

Surrounding the water treatment system will be a living wall and other greenery to improve the air quality while also making the area aesthetically pleasing. To effectively reduce air pollution in the area, all vegetation for Blight to Bioswales will be native species bought or donated from local nurseries. Three or four of each local plant-type will be planted around the bioretention system. Louisiana Irises are $10.13 from The Plant Garden. Gulf Coast Yuccas are $10 and Cry-Baby trees are $10 from Urban Roots Garden Center. A Community Voice will donate Swamp Sweetbells. Seven shrubs or trees will also be planted on the project area: one $17 Red Buckeye, two, $25 Silverbell trees and one, $10 Pecan tree will be purchased from Gurrey's Seed and Nursery, two $60 Magnolias will be purchased from The Tree Center, and one oak tree will be donated from SOUL NOLA. Eight Star Jasmines will be used for the living wall, which are $19.95 a piece from The Plant Garden. The 7 feet by 15 feet wooden lattice to construct the living wall will also be donated by Beth Butler's group, A Community Voice. The total cost for plants and trees for the project area will be $567.52.

To keep the bioretention system running and the plants thriving, annual maintenance costs must be accounted for. Semi-annual inspections will be conducted on the bioretention system and water quality, which will cost $250 per year. Visits for debris removal will occur semi-annually and will cost $100 per year. Sediment removal will occur annually for $500 per year.[18] Other general maintenance such as plant replacement, mowing, weeding, etc. will be taken care of by Beth Butler's group, a Community Voice, so the total maintenance cost will be $850 per year.

Capital costs for the bioretention system and nature park are estimated at $14,157 (Cost estimation table in the Appendix). To compute a present worth cost for the entire system, annual costs are estimated at $850 per year (A) with a yearly increase of $25 per year (G). Using a rate of return of 6% and a project lifetime of 20 years leads to a present worth costs of 14,157 + (850)*(P/A) (with an interest rate of 6%, and life of 20 years) + 25*(P/G)(6% with a lifetime of 20 years) = 14157 + (850*11.4699) + (25*87.2304) = $26,087.

VI. Health, Safety, and Environmental Considerations

The Blight to Bioswales project will be interesting in its health, safety, and environmental concerns as it is unique compared to many other projects. Not only will storm water and polluted air be treated through the technology implemented within the park, but human safety will also be taken into consideration as the treatment lot will be disguised as a green space for residents and visitors to come and enjoy.

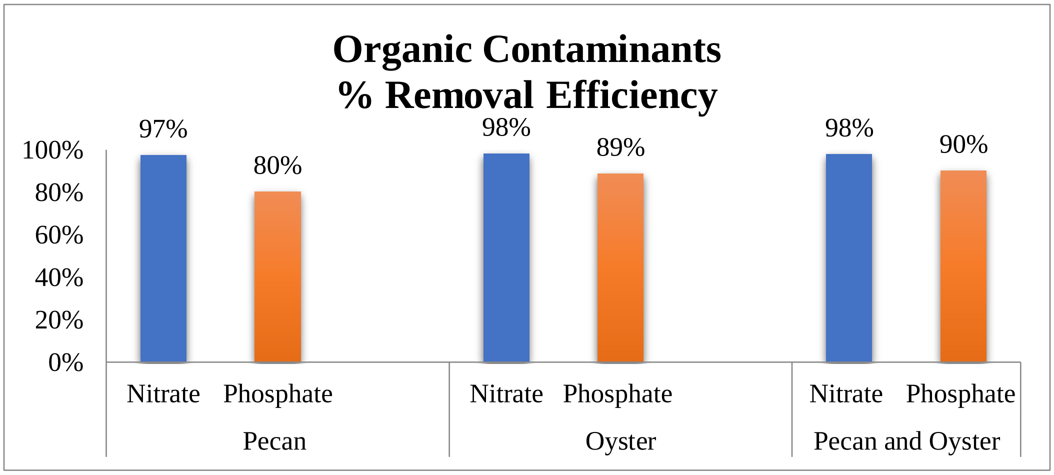
There are many health, safety, and environmental issues to take into consideration when dealing with storm water in the Lower 9th Ward. When dealing with urban runoff in Louisiana, eutrophication is a large issue to the natural and man-made waterways throughout the state, especially with the stifling summers and stagnant air. Through the bioswale system, the phosphate and nitrate levels in the storm water will be reduced to lower than the standards for storm water runoff set by the Louisiana Department of Environmental Quality in Louisiana Administrative Code Title 33, Part IX, Chapter 11.[8] Not only will the phosphates and nitrate removal be well within the LDEQ standards, but all other constituents called for in the code will be as well. Increased traffic volume has caused the concentration of hydrocarbons in water bodies to increase, which are human carcinogens and also pose a threat to aquatic ecosystems, but the presence of these will be reduced as well. Since the treated effluent will be discharged into an existing underground storm water drainage network, the water will likely never come into contact with humans, thus removing the possibility of disease or sickness due to contact. The only possibility of human contact with polluted water due to the Blight to Bioswale system is during large rain events when water would pond as it infiltrates through the filtration materials. Overall, the bioretention system will decrease the health risks posed by polluted storm water to the residents of the Lower 9th Ward and the surrounding ecosystem.

New Orleans has seen more air quality alerts in 2018 than the past three years combined, according to Louisiana Department of Environmental Quality data.[24] The state is currently experiencing a high-pressure weather system that has created the perfect conditions for ozone formation, directly affecting sensitive groups. Other main pollutants that affect the New Orleans area are carbon monoxide, nitrogen dioxide (NO2), and sulfur dioxide (SO_2).[8] Although these are all problematic to residents' health, the Lower 9th Ward is on the border of a nonattainment area for SO_2.[27] In early March of 2019, Dillard University students tested the air quality of the Lower 9th Ward on a windy, overcast day, and the results showed severe levels of volatile organic compounds, which can irritate the eyes, nose and throat.[25] Through the use of native plants, a living wall, and green infrastructure, the air quality should improve and lower the health risks associated with air pollutants.

Along with the health, safety, and environment concerns related to the air quality and storm water of the park, there are also hazards associated with the amenities of the park. There will be no playground equipment so there will be no associated hazards for children using and misusing the equipment. However, there will be a depression in the middle of the park where the bioretention is located and that could pose a tripping hazard. A walking path will be around the system indicating where to walk, which will help prevent residents from tripping. Other than the tripping hazard due to the bioswale and walking path there are no unforeseen safety issues that are special to the Blight to Bioswale system.

VII. Results and Discussion

Bioretention Storm Water Filtration



The organics analysis of the filtered storm water sample collected from the three bioretention columns yielded the results shown in Figure 7. From the results, it was observed that all three of the filter material types displayed significant removal of nitrate and phosphate from the contaminated storm water. As it was expected, the pecan shell material removed the least amount of phosphate, while the oyster shell material removed the most. Nitrate removal was observed to be consistent among all three materials. Ultimately, the pecan and oyster shell mixture displayed the highest removal efficiency for both nitrate and phosphate.

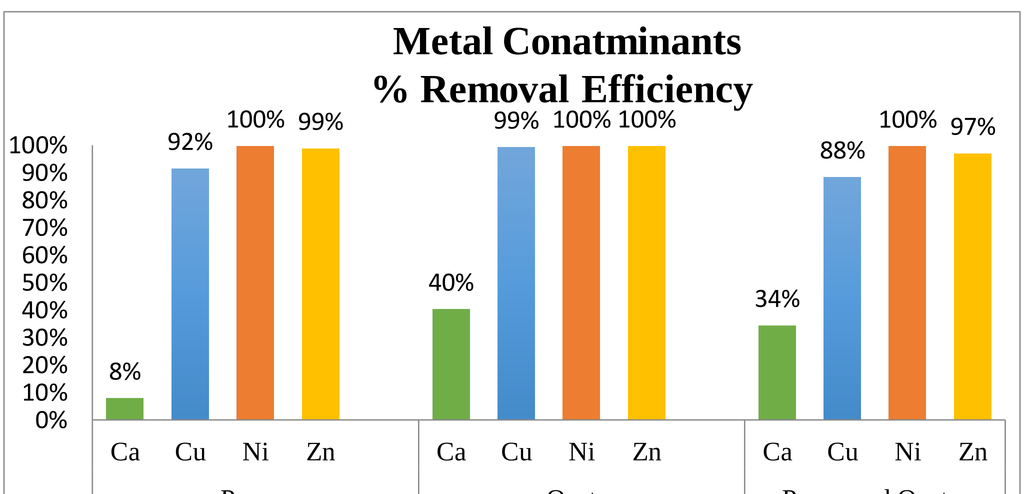


Figure 8: Metal contaminants removal efficiency based on the type of filter media used.

The results from the heavy metals analysis of the filtered storm water obtained from the three bioretention columns are displayed in Figure 8. From these results, it was observed that copper, nickel, and zinc were well removed from all of the filter medias, however, calcium saw low removal efficiencies in all the medias. The results showed that the oyster shell filter media produced the highest removal efficiencies of all of the heavy metals studied in the analysis.

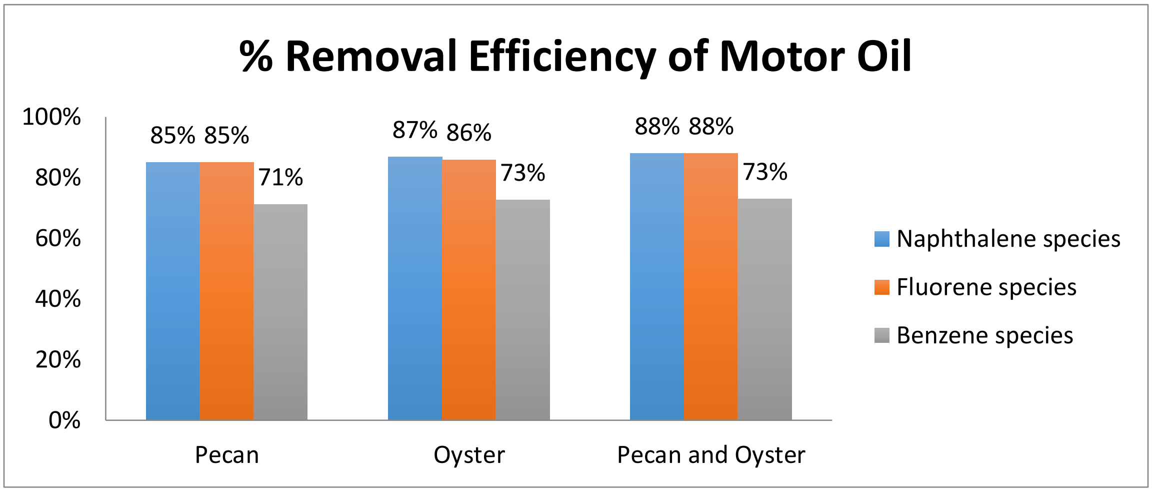


Figure 9: Motor oil removal efficiency based on the type of filter media used.

The results from the hydrocarbon removal analysis obtained from the three different bioretention columns is displayed in Figure 9. All of the filter medias showed substantial removal of naphthalene, fluorine, and benzene species from the motor oil initially added to the storm water sample. Similar to the organics removal efficiency results, the pecan and oyster shell mixture produced the highest removal efficiencies for all of the hydrocarbon species in the motor oil.

Bioretention Sizing

After inputting the known values for the selected block area with a specified abandoned property to house the bioretention system, the NRCS Curve Number Method, the first component of the conservative sizing model, produced the volume of rainfall entering an 18,880 ft^2 property, as shown in Appendix B. The model determined that 203 m^3 or 53,704 gallons of water would be entering the lot during a severe storm. Using this known volume of water entering the property, the second component of the sizing model determined that the surface area of the bioretention needed to treat and store this volume would need to be 278 m^2 or 2,992 ft^2.

The results from the model showed that the bioretention system on the 18,880 ft^2 property would need to be about 16% of the land to treat and store all of the water entering the system.

Air Remediation

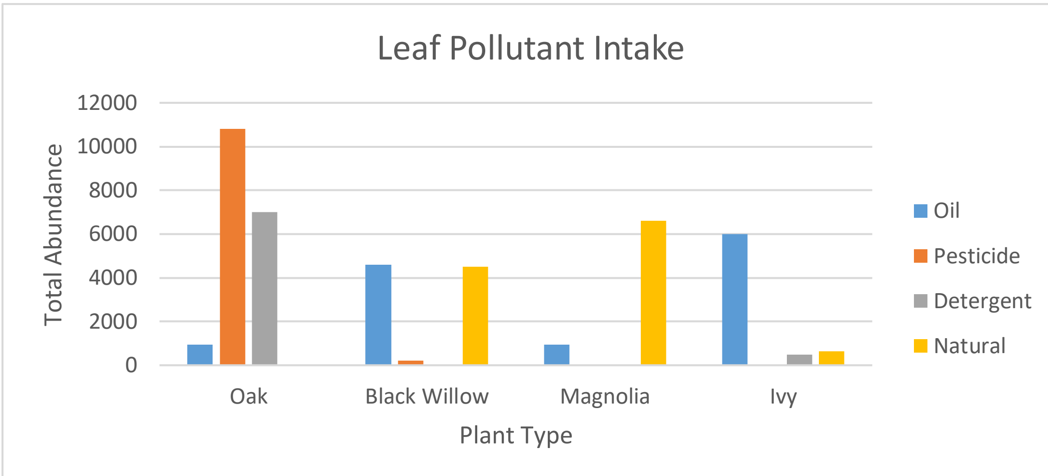


Figure 10: Total abundance of oil, pesticide, detergent, and natural air pollutants detected from leaf samples from four different plants in the Lower 9th Ward.

The results from the leaf analysis of the samples collected from the three different sites are displayed in Figure 10. The oak tree sample collected from the highway showed the highest uptake of pesticide and detergent based air pollutants, such as heneicosane and cyclohexane. The magnolia tree in the nature park saw the highest content of naturally-occurring substances, , such as heptaflorobutyric acid and beta-pinene. The ivy vine plant saw the highest uptake of oil based air pollutants, such as cyclotetradecane. The plants located near high traffic areas, which were the ivy, black willow, and oak tree, saw high concentrations of oil based air pollutes. The plant located in an area with thick vegetation, being the magnolia tree, showed the highest concentrations of substances that occur naturally in plants with very low amounts of pollutants. Although SO_2 was known to be a critical pollutant in the area, traces of SO_2 were not detected on the sampled leaves.

Community Outreach

Throughout the project's progression, interviews were conducted to determine the impact the Blight to Bioswale project would have on the Lower 9th Ward community. Tanya Harris, a selected interviewee, has lived in the Lower 9th Ward her whole life, before and after Hurricane Katrina. She and Beth ended up taking refuge together after Katrina and both described the difficulty of low-income living and picking yourself back up. The team met her at her house and walked around the neighborhood while she discussed historical and political issues regarding the community. She mentioned how the community has become more elderly as younger generations quickly move away, thus stressing the importance of creating something the community could take part in and have more pride for their community and their home. She also mentioned the poor air quality of the area with all the nearby industry. She suggested that the team talk to a representative of San Kofa, which developed a small nature walk and garden facility near her house.

The next person the team came into contact with was Gary Shaffer, a professor at Southeastern Louisiana University, who's company, Wetland Resources, LLS, designed and built the San Kofa park within the Lower 9th Ward community along the Industrial Canal. Shaffer's one suggestion was to include Bald Cypress and Water Tupelos in the design, because both species knock down the damaging waves atop storm surges and stay upright during hurricanes. While continuing to follow Tanya's advice, the team interviewed Mr. Brock, an elderly resident of the Lower 9th Ward since birth. After conducting a phone interview, he suggested an apprehensive view on the project. He seemed uncertain about the concept, but figured it could be a nice addition to the community.

Jo Jackson has lived in the Lower 9th Ward since 1987 and has worked with a community outreach program, Great Expectations, that works toward getting everyone active in the community. After Katrina, she became involved with Beth's group, A Community Voice. She loved the idea of the green wall for air remediation, but voiced her concerns of lot ownership and that the project does not hit a priority for the area.

VIII. Conclusion

The use of green infrastructure to reduce storm water and pollution runoff has become more prevalent as engineers seek ways to enhance water quality while improving human health and the environment. The water treatment system will have a layer of oyster and pecan shells together because overall, the mixture proved most efficient in removal of metal contaminants, organic contaminants and motor oil. In addition to improving the water quality, planting native vegetation, such as magnolias, an oak tree, and star jasmine, around the bioswale and constructing a living wall will improve the air quality of the Lower 9th Ward, an area congested with air pollutants from construction projects, traffic, and local refineries.

An imperative aspect to the Blight to Bioswales project was the direct involvement of people from the Lower 9th Ward. This was executed through extensive discussion and interviews with local residents, where the team received constructive and positive feedback. The interviews gave first-hand insight from residents who would be affected from the project's implementation, and the team wanted to make sure the residents felt they would benefit from it. The Blight to Bioswales project would successfully improve the storm water and air quality of the Lower 9th Ward, while also encompassing community involvement in creation of an area that can be enjoyed for years to come.

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X. Appendices

Appendix A. Synthetic Storm Water Recipe for Bioretention Experiment (2 L sample)

Pollutant	Chemical	Value
Phosphorus	Dibasic Sodium Phosphate	1.2 mg/L
Nitrogen	Sodium Nitrate	4 mg/L
Calcium	Calcium Chloride	240 mg/L
Copper	Cupric Sulfate	16 mg/L
Nickel	Nickel Chloride	16 mg/L
Zinc	Zinc Chloride	120 mg/L
Toluene	-	10 µL/L
Zinc	-	12 µL/L

Appendix B. Lower 9th Ward Bioretention Sizing Model Simulation

User Inputs	
Impervious Curve Number (CN)	98.00
1-Hour Precipitation (P,mm) ***	35.00
Pervious Curve Number (CN_p) *	80.00
Parking Lot Area (m^2)	891.23
Road Area (m^2) **	3617.15
Building Area (m^2)	2211.83
Lot Area (m^2)	1753.64
Lawn Area (m^2)	15641.72
Top Soil Layer Depth (m)	0.15
Sand Layer Depth (m)	0.51
Oyster Layer Depth (m)	0.01
Pecan Layer Depth (m)	0.01
Gravel Layer Depth (m)	0.46

Rainfall from Pervious [1]	
Effective Precipitation (P_{eff},mm)	46.38
Storage Available from Pervious (S_{perv}, mm)	63.45
Rainfall Based on P_{eff} & S_{perv} (Q_{perv}, mm)	11.69

Area Calculations	
Impervious Area (m^2)	6720.21
Pervious Area (m^2)	17395.36
Total Area (m^2)	24115.56

Rainfall Excess from Impervious [1]	
Storage Available from Impervious (S_{imp}, mm)	5.18
Rainfall Excess from Impervious (Q_{imp},mm)	29.47

Rainfall Volume Entering Retention Area [1]	
Rainfall Excess from Total Area (Q, mm)	8.43
Rainfall Entering Lot Area (V, m^3)	203.29

Biorentention Surface Area [2], [3], [4]	
Storage Depth (m)	0.73
Surface Area (m^2)	278.24

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* Pervious curve number: assuming good conditions, where grasss covers 75% or more of area
** accounting for sidewalks and driveways
*** New Orleans INTL Station; daily average rainfall, 2014-2018
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Appendix C. Economic Analysis

COST ANALYSIS			
	Price	Quantity	Total

Bioretention Materials			
Pecan Shells	$0	--	$0
Oyster Shells	$0	--	$0
Sand	$30/ton	185.02 yd^3	$1,499.00
Gravel	$25/ton	166.4 yd^3	$3,495.00
Top Soil	$54/yd	55.57 yd^3	$3,001.00
			$7995.00
Living Wall			
Star Jasmine	$19.95	8	$160.00
Plants			
Louisiana Iris	$10.13	4	$40.52
Gulf Coast Yucca	$10.00	4	$40.00
Swamp Sweetbells	$0.00	4	--
Cry-Baby Tree	$10.00	4	$40.00
			$120.52
Trees			
Red Buckeye	$17.00	1	$17.00
Silverbell Tree	$25.00	2	$50.00
Magnolia	$60.00	2	$120.00
Pecan Tree	$10.00	1	$10.00
Oak Tree	$0.00	1	$0.00
			$197.00
Labor			
Soil excavation	$4.50/yd^3	266 yd^3	$1,196.50
Material disposal	$469.00	--	$469.00
Pipe Installation	$3,000.00	--	$3000.00
Biochar Activation	$1.29/lb	790.63 lb	$1,020.00
			$5,685.40
TOTAL CONSTRUCTION COSTS: $14,157.92			
Maintenance			
Debris removal	$50/ visit	2/ yr	$100.00/ yr
Sediment removal	$500/ year	1/ yr	$500.00/ yr
Erosion repair	$75/ yd^2	--	--
Inspection	$125/ visit	2/ yr	$250.00/ yr
			$850.00/ yr
TOTAL ANNUAL COST: $850 / yr			

XI. Audits

Economic Audit

LSU

E. J. Ourso College of Business
Stephenson Department of Entrepreneurship & Information Systems

March 22, 2019

Re: Economics Audit of Blight to Bioswales: Engineered Nature Parks in New Orleans' Abandoned Lower 9th Ward Community

To Whom It May Concern:

The audit principle can be summarized in one equation: R x C = r, i.e., identifying potential high risks and finding ways to reduce them to residual or acceptable risks. Economics audit means reducing potential high risks to residual risks with the most economic ways. In practices, the principle consists of three concentric circles. In the context of the proposed project, the capital C in the inner circle means Control, i.e., A Community Voice has standard operation procedures to manage *anomalies* during the day-to-day operations of using the proposed system depicted in Figures 3 and 4. The design team needs to have detailed specifications regarding the capacity and the limitations of the proposed system, so that standard operation procedures with control mechanisms can be developed.

The capital C in the middle circle means Coaching, i.e., A Community Voice has standard operation procedures to work with the *partners* to develop, maintain and expand the proposed system. For examples, what the total cost of ownership is, how much is the budget, what materials shall be used, who the suppliers shall be, etc. The capital C in the outer circle means Collaborating for the Community Resilience, i.e., A Community Voice can use the proposed system to help make cities *resilient* as documented in Making Cities Resilient: New Orleans / Gothenburg Exchange (http://sdmi-resilient-cities.com). If the design team can revise and expand the proposal with some standard operation procedures for the last two Cs, that will make the proposal more competitive.

Sincerely yours,

Yesho Chen

Ye-Sho Chen, Ph.D.
Director of International Experience
Francis M. Dud Coates MBA Professorship
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JONES WALKER

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March 22, 2019

VIA EMAIL
Ms. Sarah E. Wannamaker
swanna1@lsu.edu

Re: Blight to Bioswales

Dear Sarah:

For the purposes of determining the feasibility of your college engineering project and for no other purpose, you have asked for an opinion regarding whether it would be legally possible for the City of New Orleans (the "City") to expropriate blighted property in the Ninth Ward in New Orleans for a public purpose, including Bioswales. The answer is yes; it is possible.

Louisiana law and constitutional principles would govern the expropriation process. The property owner must be afforded due process and a hearing prior to the taking, and the property owner must be compensated for the fair value of the property taken. Under certain circumstances, the City may utilize the "quick takings" procedure, wherein the City takes ownership of the property and deposits in cash the fair value of the property with the Orleans Parish Clerk of Court. The property owner could either accept the amount offered by the City, or could litigate over the amount of compensation due. Also, the property owner must be identified. If it is difficult to identify the property owner (or owners if more than one) from the public records, then the City must undertake another lengthy process to identify the owners.

This opinion may only be used for the purposes of your college engineering project, and may not be used by any other party or for any other purpose. If this project is actually implemented, then a much more thorough legal analysis must be performed.

Good luck with your project.

Very truly yours,

Brandon K. Black

{B1265401.1}

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Health and Safety Audit

LSU

College of Engineering
Bert S. Turner Department of Construction Management

MEMORANDUM

Engineered Nature Parks in New Orleans Project Health and Safety Ramifications

The project as outlined proposes impacting the management of storm water runoff and the reduction of the adverse effects of urban air pollution by creating more green spaces.

Storm water run-off is precipitation that falls to the ground and comes into contact with possible contaminants from areas such as roadways, parking lots, and rooftops. Storm water can carry these pollutants directly into water sources. This in turn can endanger the lives of humans, animals, and plant life. Managing storm water run-off helps eliminate or reduce these negative impacts. This project addresses this potential hazard.

Man-made surfaces such as parking lots, abandoned structures and concrete slabs and driveways, can be bad for the environment for many reasons. More pavement means less green space, thereby reducing the number of trees and plants that serve as natural "air cleaners" by absorbing carbon dioxide in the air and releasing oxygen. It also means less open soil that can collect rainwater. Another negative effect of fabricated surfaces is that they can create an urban heat island. The asphalt or concrete more readily absorbs and retains the heat from the sun's rays than the surrounding ground, which can result in raising the surrounding temperatures a few degrees. This project would also reduce this phenomenon by converting these abandoned surfaces to green spaces.

Concerning worker safety during the construction phases of this project, the primary anticipated hazards will be demolition hazards associated with the removal of any existing structures and pavement that needs to be removed, excavation hazard management to create the bio retention system, and hearing conservation management due to the noise levels of required construction equipment. Additional concerns for this project would include use of appropriate PPE as well as monitoring for caught in or struck by hazards. However, overall safety management of this project should not require anything beyond the scope of similar construction projects.

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