SOCIO-ECONOMIC REVITALIZATION THROUGH BROWNFIELD RECLAMATION

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ABSTRACT

Brownfields are defined as real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of hazardous substance, pollutant, or contaminant (epa.gov). Brownfield remediation is land rehabilitation.

There are many brownfield sites that exist around the world today. These locations are nuisances because of their effect on the environment. They can be eyesores, riddled with dilapidated structures and debris that put chemicals into the soil, affect local watersheds, become prime areas for violence and/or other activities viewed as unsafe, etc. The impact these areas have on the health of living organisms is a major concern.

This affects the neighborhoods in close proximity to a brownfield site. Many of the inhabitants of these neighborhoods live on property considered to be low in value due to the brownfields. The lack of interest in these areas keeps other citizens away thus decreasing the chance of the land being considered for reclamation. This can create a difficult situation if these people are to keep their neighborhoods clean and safe without professional assistance.

The questions raised through this project are: can brownfield reclamation be helpful for these communities? How would it impact them? Would it have a positive or negative effect?

Not only do remediated landscapes have the potential to create attractive and functional spaces but they can also positively impact the local economy. Jobs can be created during the construction phase and after the project is completed if the context and/or needs of the surrounding neighborhoods are taken into consideration. Through this project, the end result should prove that brownfield reclamation can bring about socio-economic revitalization.

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CHAPTER I

INTRODUCTION & GENERAL INFORMATION

There are currently thousands of brownfield sites in the United States of America. These vacant spaces are some of the most badly damaged landscapes in the country. Many problems can occur within their boundaries that can potentially harm the environment and any living organism that comes into contact with it. Throughout this document there will be examples of the potential harm that these sites can cause.

These sites can be utilized for the good of the city they are located within as well as the people that may live in close proximity to them. In this document there are examples of how this has been achieved. What follows is an investigation of sites in the old industrial corridor of Knoxville, TN that were chosen, based on certain criteria that will be explained, to see if socio-economic revitalization can be achieved by brownfield reclamation.

The City of Knoxville

The city of Knoxville is located in East Tennessee and is recognized by its mountainous landscapes, close proximity to the Tennessee River and the presence of the University of Tennessee (the state's land grant institution).

City officials look to expand upon the existing urban infrastructure (Knoxville Community Development Corporation, Proposal to the EPA for Brownfields Grant Fund, 2010). Knoxville, like many major cities across the U.S., has brownfields scattered throughout its lands. With preparations of expanding the downtown area in the works, this investigation of reusing brownfields could influence ways to achieve redevelopment to offer citizens a healthy place to be a part of a growing community. This can come in the form new recreational spaces (parks, ball fields, etc.) that encourage healthier lifestyles, venues and/or activities that promote community involvement, new development that promotes socio-economic benefits for the city, etc.

Figure 1: Illustration of proposed downtown expansion by the City of Knoxville

(Knoxville Community Development Corporation, Proposal to the EPA for Brownfields Grant Fund, 2010).

The image above is a preliminary vision of the desired expanded downtown area. The plan appears to mainly incorporate more buildings, hardscapes and street improvements over the existing brownfields. All of these aspects are certainly intricate for the renewal of the area but is that all that is needed? Further investigations will reveal if more is required to ensure the success of the project area and the people living within close vicinity to it. The idea of an expanded downtown scene was taken into consideration during the design phase of this project. It was used as a starting point for ideas to implement in the design.

CHAPTER II

BACKGROUND & ISSUES

In this chapter I will relate the issues and opportunities involved with brownfield remediation. These include urban growth and the remediation of brownfields, brownfield reclamation, legal obligations, laws and issues, how brownfields can rehabilitate through mixed use and park programming, etc.

A literature review was conducted to obtain an understanding of the history of American industrialization and the processes behind the remediation of brownfields (legal and physical). A list of readings was evaluated and the ones most fitting were chosen. Those which were selected appeared to be most successful at explaining these items.

Urban Growth and the Emergence of Brownfields

The major development and transformations of the American urban setting started during the industrial era. It began with urban growth and large population shifts. New technology (transportation and building techniques) also made a major impact. Between 1860 and 1920 the total U.S. population tripled in size from 31 million to over 105 million (Mohl, 1985, pg. 9). This drastic rise in population was due to large amounts of immigrants (mainly Europeans) leaving their homelands in search for the “American Dream” and the advance in medical technology. Within that same 60 year time frame the urban population went from 6 million to over 54 million people because of the better economic opportunities the city offered when compared to rural areas (Mohl, 1985, pg. 9).

Higher employment rates, entertainment, social and recreational experiences were presented by urban life. The typical urban setting started off as “walking cities” because that was the main form of transportation due to high density of buildings in small areas. Only the wealthy could afford horse and carriage. Urban mass transit evolved as omnibuses, steam powered commuter rails, horse-cars and mechanically powered vehicles were invented to help move the masses from one destination to another. This major improvement in transportation also changed the physical make-up and the urban setting. Now streets required wider lanes for the new transportation methods thus taking away from building widths (giving birth to skyscraper and vertical growth in buildings). Due to the fact that transportation was becoming more available, citizens started moving towards the outskirts of the city (the suburbs) to get away from the harsh conditions presented by urban life. The urban core was considered to be over crowded,

dirty, crime ridden, aesthetically unpleasant, etc. Housing in the core of the city now started to become what is known as the “slums” as more factories appeared.

There are many things to consider when discussing the history of urban societies. One of the most important aspects of any urban setting is the inhabitants that occupy it. Early American cities were shaped by the migration of large amounts of people to the big city. In the heart of urban dwellings one could find many different types cultures intertwined in a small density area. This led to several distinct areas within these locations where similar cultures banded together to survive in their new setting. Major corporations at that time saw opportunities to expand their production rates by building their factories near these large density areas. The citizens were willing to take chances working in the harsh conditions in pursuit of the “American Dream”.

Advances in mass transit also played a major role in shaping American cities. As the “walking city” slowly disappeared, groundbreaking methods of transporting large amount of people from one place to another were being implemented. Horse and carriage was being replaced by commuter rails and eventually motor powered vehicles. Now that the roads had to widen to support vehicles, the buildings could no longer widen but grew vertically. As the skyscraper became popular so did apartments (for the wealthy and middle class) and tenements (for the poor). Cities became too clustered and the suburbs was more of a pleasant place to raise a family. This is important because we see a trend of people migrating back to rural areas or locations with less population density. The city got to the point where it was viewed as a dirty, crowded place. Loud noises can be a nuisance and crime becomes a concern as well.

There are many vacant buildings and sites still affected by pollution produced years ago. Just like the impact it had on the industrial era, advances in technology can be used to make life easier for people who live within the vicinity of brownfields. Many projects transformed these sites into parks and commercial properties. With the housing market declining and new developments being shut down before full completion, many abandoned sites could be cleaned, remolded and used to construct new homes (this would be better than clearing new land and could potentially beautify an area that needs the aesthetic value). With thoughtful planning and well executed procedures, reconstructed brownfield sites could bring people back to the city.

Brownfield Reclamation

In the United States there are over 500,000 sites labeled as “brownfields” in need of reclamation (Berger, 2008, pg. xvii).

Reclamation is defined as the healing of the landscape in such a way as to improve its original state (Berger, 2008, pg. 3). The process is similar to how muscles tear while working out and how they heal afterwards to become even stronger. Good reclamation is a state when the reclaimed landscape benefits the ecosystems found within that site (Berger, 2008). It is understood that if primary food chains are intact and the circle of life continues (one that will benefit future generations) then the remediation goal has been achieved.

Ecological succession plays a significant role in the remediation process. Succession is defined as the growth and development of natural ecosystems through a process of maturation (Berger, 2008, pg. 42). Common chemicals found on brownfields (pesticides, radiation, oil, and other pollutants) impair ecosystems and can cause them to malfunction. Under this type of stress, living organisms within the ecosystem cannot properly conduct processes that help their environment strive towards maturity. The role of a reclamation ecologist is to set secession back in motion to a damaged landscape (Berger, 2008, pg. 50). Nearby or adjacent ecosystems should be used as guides and the disturbed system should be set on its own to establish a new, stable state.

A first step in bio-remediation would be to cleanse the site of chemicals or toxins. Bio-remediation would help renew the soil after the majority of the more visible chemicals have been extracted by ecological processes. The study of nearby ecosystems will help with the transition of beautifying (using native plant materials for example). In some cases introducing new species to an area can be one way of assisting a landscape to regain its balance, but this could have unknown consequences (this goes back to research and gaining more information through observation). Success, in the end, can be achieved by well thought out design and the input of people whose backgrounds range anywhere from architecture to marine biology.

One pattern that seems to be a growing trend is that companies and divisions of government will provide support in reclaiming abandoned landscapes. When a well thought out design is put in the place of a brownfield, it can bring new revenue and economic incentives to the area. What would our cities look like and how would they change if higher percentages of brownfields were reclaimed? The reclamation of these abandoned sites can create potential for unique spaces in our urban environments.

Legal Obligations, Laws and Issues

Redeveloping on brownfield land can be a difficult task for professionals and real estate practitioners. A proper understanding of the legal obligations and liabilities associated with brownfield redevelopment is required to ensure that proper reclamation is achieved.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Superfund Law were the first of its kind when it came to regulations of brownfields (Geltam, 2000, pg. 44).

In 1997, the EPA started showing more interest in the development in these underused areas by putting forth its Brownfields National Partnership Action Agenda (Geltam, 2000, pg. 305). This was designed to empower states, communities and other stakeholders in economic redevelopment to work cohesively to reuse brownfields. This included funding pilot programs (research groups), clarifying liability issues, starting partnerships between groups with similar goals, conducting outreach activities, developing job training programs and addressing environmental justice concerns (Geltam, 2000, pgs. 305-306).

The adoption of cleanup programs and the allowance of more freedom for state and local governments to deal with their brownfield sites directly have created a bigger buzz for the renewal of these areas. Now that organizations like the EPA (Environmental Protection Agency) accept newer remediation practices, people realize the incentives of building new infrastructure in place of an unwanted area (mainly the potential for accumulating new revenue). The demand for the use of these spaces rose over the past decade due to growing populations thus giving more reason for people to create the resources to revive them (Simons, 1998, pg. 9).

Common laws and federal statutory causes of action and their potential of affecting brownfields is an important tool to become familiar with for anyone interested in brownfield land. These include the Clean Water Act (CWA), Clean Air Act (CAA) and the Toxic Substance Control Act (TSCA). The CWA protects bodies of water or wetlands that contain life within its ecosystem (Geltam, 2000, pg. 23). The CAA regulates air pollution generated by stationary (building, structure, facility, or installation) and mobile sources (vehicles) (Geltam, 2000, pg. 21). The TSCA helps control chemicals, including PCBs, asbestos and indoor radon. All three of these are often found in old buildings (Geltam, 2000, pg. 26).

Individual state brownfield statues are enacted to provide brownfield stakeholders with limited protection from environmental liabilities. These include CERCLA equivalents, which are laws similar to that of CERCLA that impose liability for cleanup expenditures on landowners (Geltam, 2000, pg. 69). Many of these programs were created to address sites not only considered to be brownfields but places that pose a significant health risk. They also involve many voluntary clean up groups in their efforts. State Environmental Lein Laws are present in almost all states and parallel CERCLA (Geltam, 2000, pg. 70). They authorize state environmental agencies to clean up hazardous waste sites and seek reimbursement from the property owner.

The Southeast United States (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina and Tennessee) has key brownfield laws and programs. This region was the last to add voluntary cleanup programs to their agenda. Tennessee state legislature amended the Hazardous Waste Management Act of 1983 to introduce the Voluntary Clean Up and Assistance Program (Geltam, 2000, pg. 196). Their agenda is to clean-up sites, monitor them and maintain conditions after a site has been rejuvenated. Tennessee is one of the states that amended its state equivalent of CERCLA to include specialized lender liability protection (Geltam, 2000, pg. 197).

All of these mandates protect the environment and to ensure that our future societies have a chance to sustain themselves. Without these laws there would be more abandoned brownfield sites.

PRECEDENT ANALYSIS

Case studies on brownfield sites transformed into successful and functional designs were conducted to gain an understating of methods used to achieve successful remediation. The examples chosen gave insight to problems that resemble possible constraints this particular project could face. This includes soil contamination, water contamination, how to connect reclaimed brownfields sites to existing infrastructure and how to create a landscape that offers amenities to people who live nearby.

Al-Azhar Park - Cairo, Egypt

Figure 2: Masterplan of Al-Azhar Park

The Al-Azhar Park in Cairo, Egypt offers insight on how a brownfield site can become a unique solution to a series or problems found within inner city zones. The main concepts taken from this design scheme are the socio-economic transformation of the surrounding communities in close vicinity to the park, the methods behind the transformation of the original site to its current state and the design choices that make the park a dynamic space.

Prior to the construction of the park, this 74 acre site served as a landfill for the city for over 500 years. Due to this and the harsh weather patterns of the region (dry, hot weather patterns with low precipitation rates) the site was unstable. The quality of the soil structure deteriorated as hills were created by the mounds of trash (one hill recorded to be 131 ft. high). The neighborhoods surrounding the site contained some of the highest concentrations of poor citizens in the city. These areas lacked adequate sanitation and were riddled with dilapidated buildings.

The WAQF System of Islamic Endowment and Aga Khan Trust for Culture set out to use this location as a testing ground to explore ways to reverse the site conditions. The initial process of remediation began with the removal of trash and debris from the site. Unwanted soils from different sections were discarded or treated for reuse. Over 53 million cubic ft. (18,000 truckloads) of contaminated

soils was removed from the landfill. Of the 53 million cubic ft. over half of it was treated for reuse elsewhere on the site. The last step involved introducing certain nutrients back to the soil and placing foundations underneath building structures to ensure long term stability.

During the process of removing contaminated soil, historic references were found that played a significant role in the development of the park. Construction crews found a medieval wall, towers, galleries, entrances and other structures that hold historical and cultural value to the region. It was considered one of the most important archaeological discoveries within Islamic Egypt in the past decade. The landscape architects working on site decided to implement these ancient structures within their design.

The project was completed by Sites International and Sasaki Associates in 2005 and boasts a plethora of new features. This includes a 26 ft. wide linear path that connects the park to different areas, various garden sizes and shapes, recreational areas, playgrounds, regionalized architectural structures and water features.

The implementation of large freshwater reservoirs underneath the park was carried out to establish a better water supply for different uses within the park. Since Cairo receives less than 80 milliliters of precipitation annually it was important that these features were introduced to facilitate the needs of the new plant material. The plant material chosen mainly consisted of those native to the region. A local body of water, the Nile River, was used to feed water features like the artificial pond near the entrance of the site and for irrigation purposes as well. These manifestations made the park self-sustaining.

One of the main highlights of the new park was that it involved the local neighborhoods in many ways since the construction phase and continues to do so. Almost everything installed in the park was made by local artisans. This includes benches, light poles, bollards, nurseries, etc. The park sparked a demand for workers to carry out the construction and maintenance. With the large amount of land allocated for nurseries, the amount of restaurant facilities and heavy maintenance operations, many jobs were created. Money made from park activities and grants go towards the up keeping of the local communities. For example, in 2004 over $4 million was raised and spent on socio-economic rehabilitation of these neighboring communities. This includes the rebuilding of dilapidated infrastructure, cleansing of neighborhoods and the establishment of programs that educate the citizens on ways and methods of bettering themselves in different aspects of life. This project gained high merit because not only did it succeed in preserving their culture and all things valuable to the citizens of these adjacent neighborhoods, it empowered them to continue to thrive in their own environment. This design helped revitalize the surrounding communities socially and economically.

The project was successful in providing the city with useable greenspace that served several purposes. This increased activity in the area and provided jobs for citizens in neighboring communities. The park is an investment for all users due to the fact that money made in the park is invested in the local populations. I want to use this model of community development as an approach to carry out my thesis project.

Shanghai Houtan Park

Figure 3: Masterplan and view of Shanghai Houtan Park (www.asla.org)

This award winning 35 acre park was constructed on top of a former industrial site located on Shanghai's Huangpu riverfront. It was once littered with industrial/construction debris and the water was considered to be that of the lowest grade. Through this project the landscape team wanted to provide multiple ecosystem services that would be productive, mediating, resilient, life supporting educational and aesthetically pleasing.

A linear constructed wetland (1 mile long) was designed in a way that effectively treated the contaminated water from the Huangpu River. Cascades and terraces are utilized to oxygenate the water as well as add sound and aesthetic beauty to the park. Many different wetland plants absorb pollutants. Plants were chosen carefully to display year round interest.

This wetland acts as a flood protection buffer. The terrace design of the wetland corresponds with the elevation difference with the city and the river, allowing people to approach the water's edge. A rip-rap wall was constructed in place of old wall structure which allows native plants to grow along the bank to prevent erosion.

The main feature of the design, the terraced landscape, is reminiscent of Shanghai agricultural heritage. The system was set up as a tool for people to learn about agricultural practices in the city. Crops and wetland plants were used for this effect. To honor the industrial heritage of the site, industrial structures and materials were reused. One old building has been retrofitted to display hanging gardens while materials have been recycled to create art pieces, new paving material for boardwalks and shelters.

A network of paths weaves the parks landscapes together. There is the main loop and a series of perpendicular paths that go through the wetland and terraced areas. This creates multiple avenues between the park and its surroundings. Nodes incorporated in the path system encourage small gatherings. Screens along the path break up spaces and enclosures surrounded by trees to exhibit the art pieces.

Gowanus Canal Sponge Park

Figure 4: Masterplan of Gowanus Canal Sponge Park (www.asla.org)

Formerly a wetland creek, the Gowanus canal (100 ft. wide X 14 miles long) in Brooklyn is surrounded by industrial buildings and residential neighborhoods. The conditions around the canal once left it cut off and unused by the public. The neighboring industrial practices damaged the soil structure and water quality severely.

The idea of Sponge Park was sparked due to the low water quality found in the Gowanus Canal. The lack of maintenance in the area has caused the canal bulkheads to erode. New York's combined sewer system was also a concern. During storm events, runoff would enter the storms drains and mix with the raw sewage. During heavy rainfall the sewage and storm water would overflow into the canal making the water unfit for recreational use.

The goal of this project was to address the lack of public waterfront access and the physical division of neighborhoods resulting from modern urban infrastructure.

As a solution the park utilizes plants that remediate contaminants in soil and water. Floating remediation wetlands utilized aquatic organisms that work with plants to break down toxins and take up heavy metals and biological contaminants in sewage. A new streetscape system slows down and remediates the water before it reaches the canal. These streets connect parts of the city to the park. A variety of plants were used help beautify the area. Many of the plants utilized thrive in the Tennessee region. Some of these include:

- Feather Reed Grass
- Service Berry
- Hawthorn
- Witch Hazel
- Red Elderberry

The design honors the cultural context by linking important historic sites, recreation areas and neighborhood facilities together. The plan calls for a historical industrial structure with standout architecture that could be transformed into a cultural symbol for the area.

Menomonee River Valley Project

Figure 5: Masterplan of Menomonee River Valley Project

(Redevelopment Authority of the City of Milwaukee, MENOMONEE VALLEY INDUSTRIAL CENTER AND COMMUNITY PARK MASTER LAND USE PLAN, 2006)

Milwaukee's Menomonee River sits in the heart of the city. This project area is located on a once thriving 25 acre railyard that dilapidated over time. Industrial activities on the site over the years led to severe soil and water contamination in the adjacent Menomonee River. The river had been invisible and inaccessible to people for years. The adjacent active railroad tracks were also something to consider. The fact the area could provide opportunities for the surrounding neighborhood inspired the city to investigate the areas for potential uses.

The plan provided a landscape that offered altered land and hydraulic conditions to mosaics of bio-diverse landscapes (forests, prairie, ephemeral wetlands) utilizing plants that are native to the area. These plants were used to not only add aesthetic value but to also degrade the hazardous chemicals found in the soil. These changing settings were also used as an educational tool for park users.

Through analysis conducted on the natural history of the river, the original river course was discovered along with its hydraulic conditions and vegetation. This information provided visual links between historic river conditions and current patterns. Vacant buildings are retrofitted using sustainable design techniques to function as community centers, offices, etc.

With 415,000 people living within three miles of the site (and the majority of them representing the population utilizing welfare aid and having health problems) the

planners set goals on revitalizing economic opportunities and supplying access to the park for recreational purposes.

Schools in the area were chosen with a 2 mile radius, to teach children about ecological processes and how they could assist with site restoration. This included people planting trees and monitoring water quality. Nature trails were included as a way to provide a combination of recreational and educational opportunities for students and adults. An outdoor science classroom was installed to offer students in-the-field experience while they learned about the local ecology.

With topography, train tracks and freeways interfering with leaving parts of the city disconnected from the park, investments were made to implement more bike and pedestrian paths along the existing Hank Aaron State Trail. Pedestrian bridges were also implemented to span over active railroad yards.

Summary of Precedent Analysis

These brownfield reclamation projects showcase ways how brownfield property can be transformed into usable space that serves a significant purpose in the corresponding communities.

Al-Azhar Park in Cairo, Egypt shows how reclaiming brownfields can create building and park programs that heal social and economic gaps within the city. By providing unique services to citizens in the adjacent neighborhoods, many of them are able better provide for themselves and their family. Money generated from park activities is invested back into the adjacent slums to create economic growth therefore providing assistant and hope for its inhabitants.

The Gowanus Canal Sponge Park project displays how the right plant selection can can remediate soil and water. Native plants arranged in channels cleansed contaminated water before it washes into the canal. These channels were implemented in the new streetscapes that were also used to connect neighborhoods with key locations in the city. This provided the neighborhoods with a touch of aesthetic beauty and supported non-vehicular modes of transportation (walking, running, biking, etc.)

The Menomonee River Valley Project also used plant material to cleanse water but in the form of a riparian zone that captured run before it entered the Menomonee River. This design also provided alternative means of transportation for it users. Another interesting aspect of this project was how it was used as an educational tool to teach children about ecological processes. This shows how landscapes can be used educate people about the natural world.

CHAPTER III

METHODS

The initial steps taken to conduct this thesis project were a series of literature reviews on several books, magazines and online publications. This gave insight on the history of urban spaces, how brownfields were produced, how they impact the environment and how they can be remediated. Preliminary research on case studies of successful brownfield projects was also conducted to obtain a general idea of some of the common difficulties associated with reclaiming brownfield land. One tool that became useful throughout the project was the Tennessee Brownfield Redevelopment Toolbox. This document, prepared by the state of Tennessee, is a guide that breaks down the brownfield redevelopment process (see Figure 6).

Identifying the proper site to investigate was important since the aim was socio-economic upliftment of impoverished neighborhoods. Several meetings were set up with city officials in Knoxville, TN and the Environmental Protection Agency to acquire the appropriate information to help locate a site. This included data and maps of the city that listed brownfield areas, their history and speculated site contaminants. Government written reports on the current state of brownfield reclamation in Knoxville, TN were also used.

After the appropriate site was selected, an inventory was put together to gain more insight on its present state as well as how it influenced the city. Site visits, collecting vast amounts of inventory, photo documentation, creating base maps, more literature review and interviewing local communities centers (with the Wesley House being the main one) were carried out to successfully achieve this goal.

Comprehensive analysis was the next step in the process. The site was selected and the potential contaminants were identified. The potential user groups were observed and the needs of the communities and city were taken into account (this last feature was gathered through interviews and reading the *Critical Problems and Service Gaps in Knox County* report produced by the Nine Counties. One Vision. Social Service Task Force). For a solution to be put together, more literature review and case studies were completed to identify resolutions specific to the chosen site. The analysis was diagramed in a way that viewers could comprehend the information relevant to this thesis.

Once the analysis was completed and the proper solutions for this brownfield site along with the neighboring communities were identified, detailed drawings were used as a method of design investigation and design communication.

The Tennessee Brownfield Redevelopment Toolbox

The Tennessee Brownfield Redevelopment toolbox explains the brownfield renewal process in a straightforward manner. The main focus of the guide is to familiarize users the 5 steps that are needed if one chooses to develop on brownfield land. These steps are:

Step 1: Site Identification and Project Planning

Step 2: How to Determine if you have Contamination on your Site

Step 3: Cleaning up your Site

Step 4: How the Tennessee Brownfields Program can help when a Site is Contaminated

Step 5: The End of the Line – Redevelopment of your Brownfields

Figure 6: Diagram of the Tennessee Brownfield Redevelopment Process

For this project, the guidelines above were used to create similar steps to achieve the same goal.

CHAPTER IV

SITE SELECTION

Knoxville Brownfields: I-275 / North Central St. Corridor Study

The area that was chosen to help conduct this thesis investigation is the I-275 North Central Street corridor. One reason why this site was chosen is the fact that the city plans to redevelop the area so the downtown can expand. Brownfield land will be utilized to achieve this goal. There are over 40 sites that are labeled as brownfields in the area.

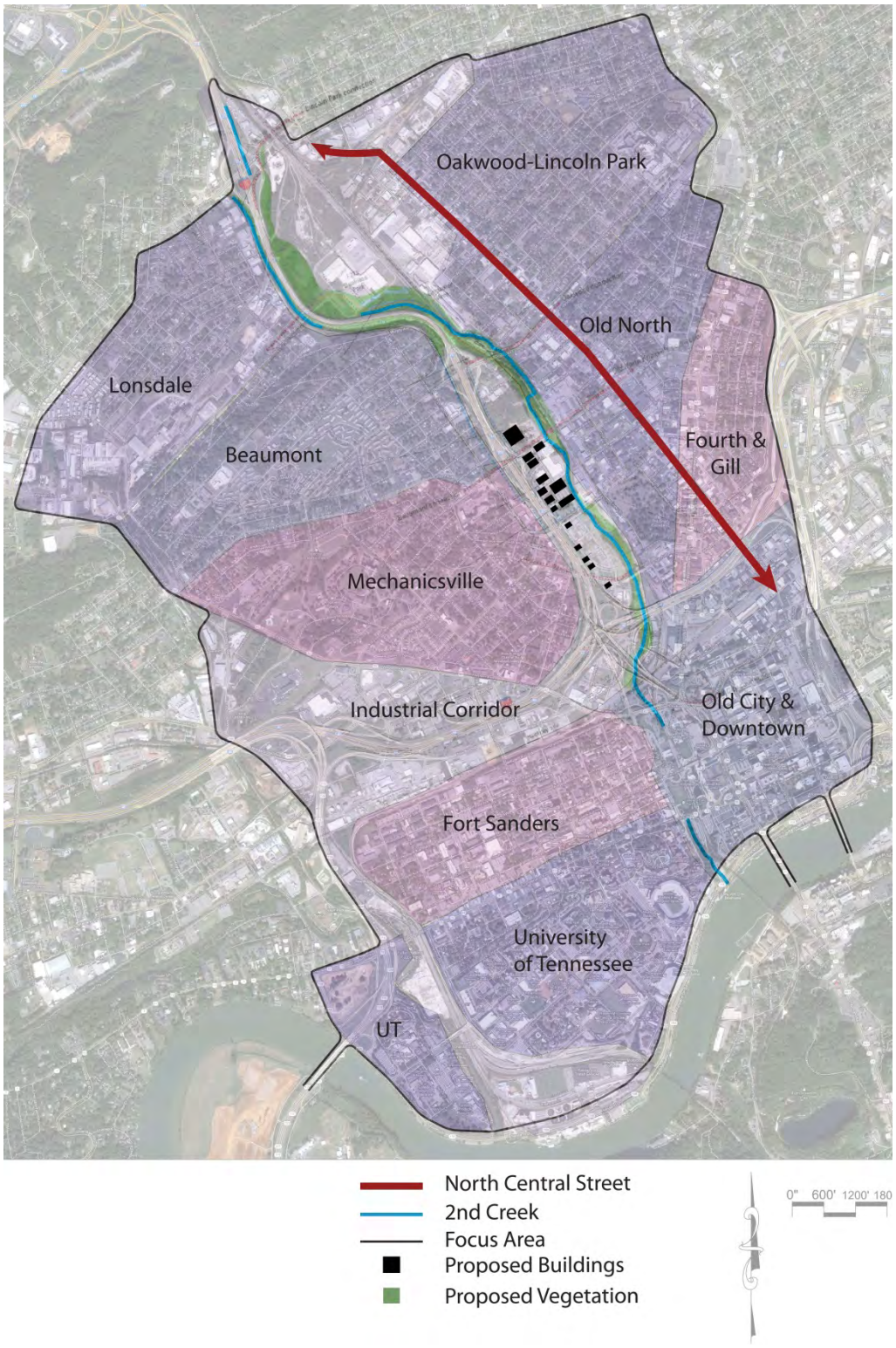

Figure 7: Map of Knoxville downtown expansion plans proposed by the city

The city of Knoxville proposed a redevelopment plan focusing upon expanding the downtown area into the project site. The majority of the lands that will be used for this project are considered brownfield sites. The city of Knoxville has also proposed a greenway that follows 2nd Creek.

There is a rich history within this landscape. In the late 1800's, this system of spaces became a key piece in the industrialization and overall establishment of Knoxville, TN. The railroad system was utilized in this timeframe by many large cities within the United States as a means to import and export goods. Knoxville was no different and this corridor was once home to many stores, textile mills, railroad repair facilities and buildings used for industrial purposes.

As the city grew and new technology paved the way for new means of transportation, the existing site has abandoned industrial land. The abandonment of this area left behind vacant land, dilapidated buildings and severe environmental problems. For example, the 2nd Creek watershed (that flows between the sites) is damaged from polluted run-off and the soil on these sites are contaminated by several different chemicals.

Soil Contamination

Site Contaminants Assessment

Many of the soils located on the brownfield sites in the study area have been labeled as contaminated and investigations are being conducted by the city of Knoxville to better assess the area. The following maps in this section provide better insight on this topic.

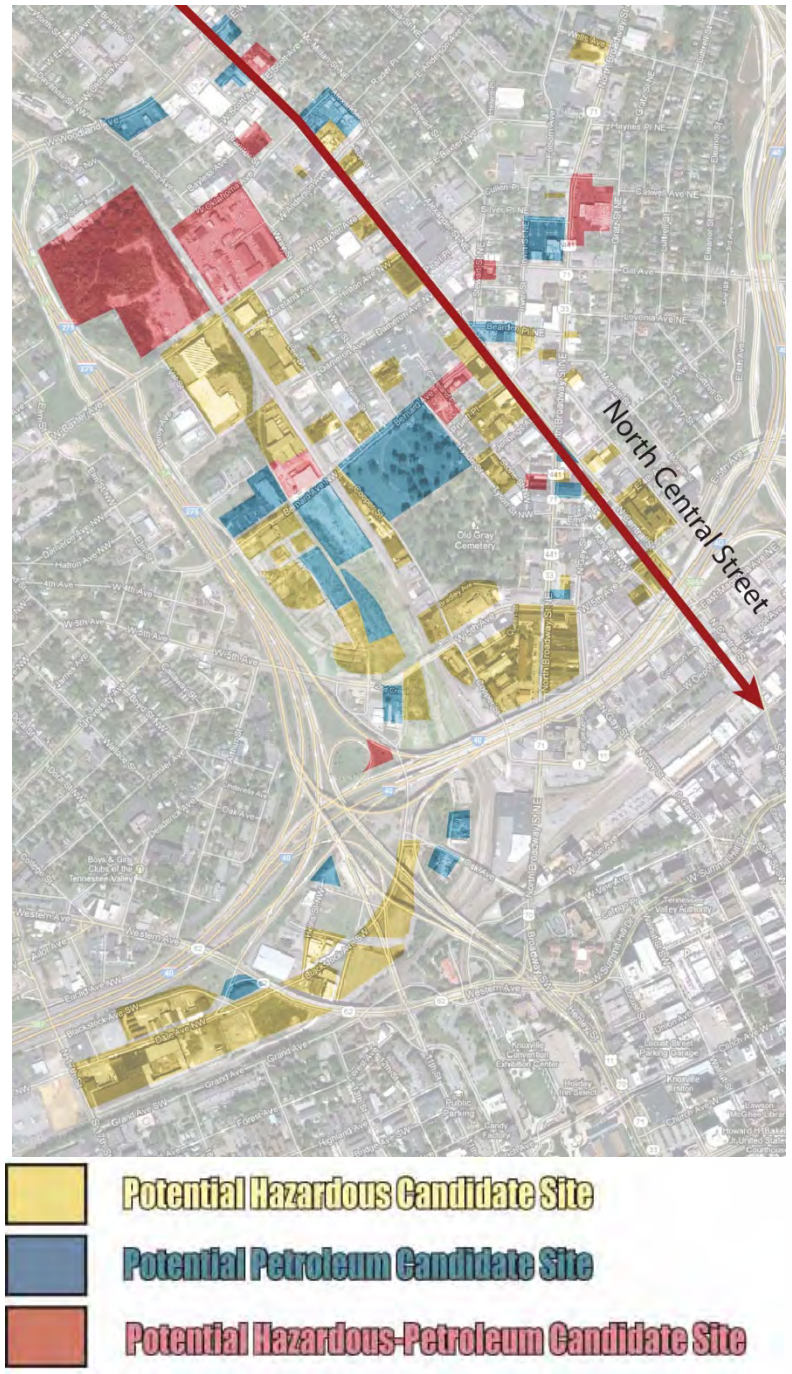

Figure 8: Potential assessment candidate sites

This map shows the sites within the project area that are identified as brownfields. These properties have been separated into different categories based on the contaminant that is speculated to be present in the soil. This investigation was conducted by officials the city of Knoxville.

To identify with specific sites and communicate them, each brownfield property was given a name (if it previously unnamed) and labeled. The brownfields that where most recognized by the city are Brookside Mills, Palm Beach, Phillip's Metals and the Hackney Site. All of these sites were the locations of major mills and factories during the city's industrial height. These properties are also larger in size than the other brownfields.

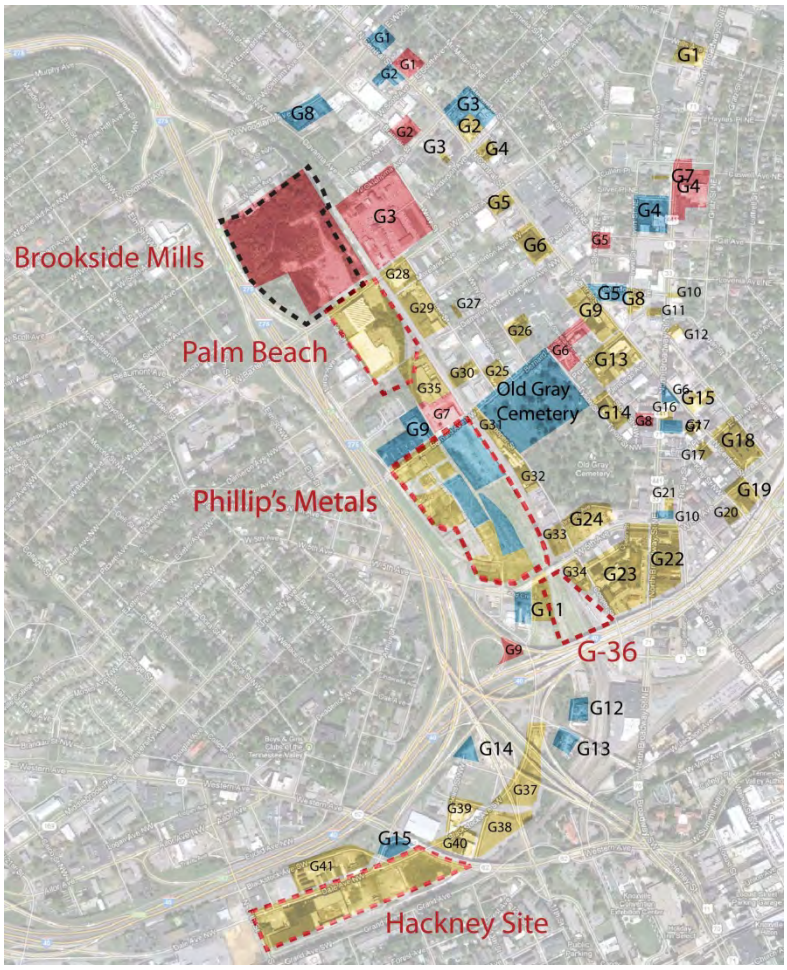

Figure 9: Labeled brownfield sites

Potential Hazardous Candidate Sites

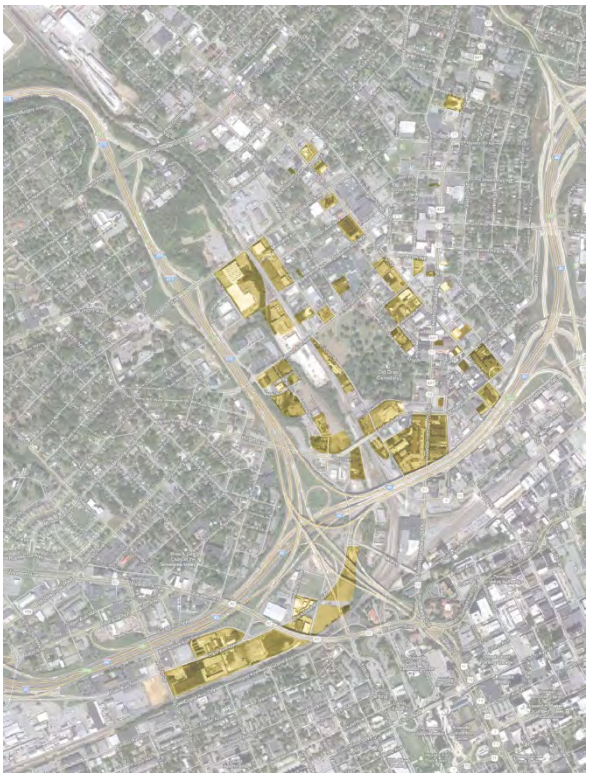

Figure 10: Potential hazardous candidate sites

Contaminants such as polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), lead based paint, asbestos containing buildings materials, industrial chemicals including chlorinated solvents, creosote, and various priority pollutant metals may be found in these locations. Some of these chemicals can originate from materials found in buildings (lead and asbestos manly) and others can come from machinery or similar items used for industrial practices. These chemicals can have devastating effects in the air, water and soil.

Potential Petroleum Candidate Sites

Figure 11: Potential petroleum candidate sites

These parcels of land are believed to be contaminated by petroleum hydrocarbons including gasoline and diesel fuel (Knoxville Community Development Corporation, Proposal to the EPA for Brownfields Grant Fund, 2010). These chemicals usually originate from vehicular or heavy machinery used on site. Since this area once housed several factories that relied on the railroad system to transport goods, it is safe to assume that this is where the chemicals came from. Petroleum spills can have devastating environmental effects if it gets into the soil or water.

Potential Hazardous & Petroleum Candidate Sites

Figure 12: Potential hazardous & petroleum candidate site

These sites are a combination of the preceding categories. They are believed to have a combination of hazardous materials found on the property with petroleum hydrocarbons being one of the main concerns.

These brownfield sites within the study area are plagued with contaminants that are harmful to the environment and the inhabitants that live in close range to them. For these parcels of land to be reused they must be remediated. In this investigation to achieve socio-economic revitalization through brownfield reclamation, a small selection of sites will be chosen to conduct this study. More information is needed to choose which site would be best suited to reclaim.

I-275 Industrial Corridor - Site Context

There are several distinct neighborhoods and districts that surround the project area. By conducting further investigations within these locations, a better idea of what these areas lack from a social and economic standpoint can be obtained. A thorough understanding of what should be programmed on the selected brownfield land will also be achieved.

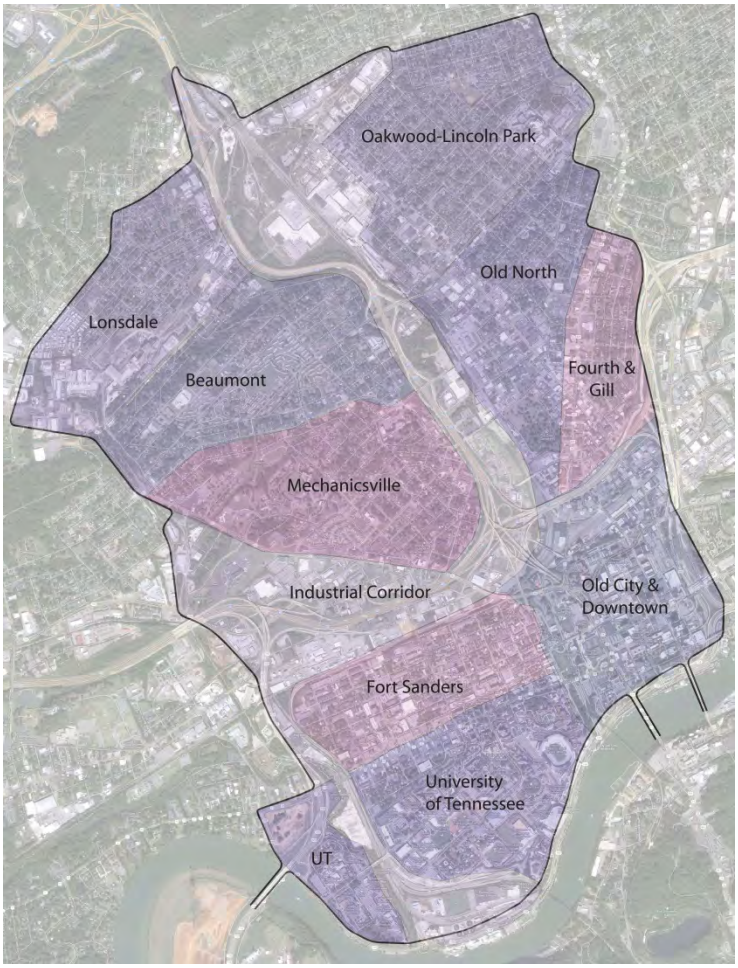

Figure 13: Map of neighborhoods surrounding the industrial corridor

The sites surrounding the industrial corridor consist of different neighborhoods, the University of Tennessee and the downtown area. Each of these locations has a distinct feel, atmosphere and user group. Since these locations are within close proximity to the project area, it is safe to assume that if the brownfields in the industrial corridor were redeveloped on and the site programming catered to the needs of Knoxville citizens, then the people that are located in these immediate districts would be the main user groups of the redeveloped site. Gaining information on the demographics of these user groups is important if socio-economic revitalization is to be achieved.

Old City & Downtown Area

The Old City consists of a historic district with several buildings that are on the National Registrar of Historic Places. The downtown area has over 6.2 million sq. ft. of downtown office space and offers hundreds of services. Arguably the

largest attraction downtown is the Market Square which is a popular public space that offers many different shops and restaurants to choose from along with outdoor venue space.

University of Tennessee

This major university hosts almost 28,000 students from all 50 states and more than 100 foreign countries with nine undergraduate colleges and eleven graduate colleges.

Neighborhoods

The neighborhoods that surround the industrial corridor are the most impacted by the brownfield land located in the industrial corridor. These include Lonsdale, Beaumont, Mechanicsville, Fort Sanders, Oakwood-Lincoln Park, Old North Knoxville and Forth & Gill. Some of the inhabitants live next door to brownfield land and must deal with the debris, polluted 2nd Creek corridor, contaminated soil, air pollution, etc. that comes as a result of the neglected properties.

Since these people live closer to the brownfields than anyone else in the city, their needs are more substantial given the current circumstances. A closer look into their economic status reveals that they struggle with more than environmental problems.

Neighborhood Demographics

Neighborhood	Area (sq. mi.)	Population	Males to Female Ratio	Dominant Race	Median Household Income	% of Population Below Poverty Level
Lonsdale	3.5	7,192	45.8% / 54.2%	White	$19,768	41.1%
Beaumont	.33	1,112	48% / 52%	White	$13,369	40.7%
Mechanicsville	1.2	2,367	47.4% / 52.6%	Black	$16,279	42.8%
Fort Sanders	.55	4,929	52.7% / 47.3%	White	$17,018	54.5%
Oakwood-Lincoln Park	NA	26,707	47.5% / 52.5%	NA	$27,529	NA
Old North Knoxville	.6	2,089	52.1% / 47.9%	White	$20,255	31.3%
Fourth & Gill	.58	1,074	54.7% / 45.3%	White	$20,931	35.2%

Table 1: Neighborhood Demographics (city-data.com & zillow.com)

Based upon the demographics the neighborhoods to the east of the industrial corridor are better off than those to the west of it. More income is generated in the eastern households and the quality of living (conditions of roads, houses, property, etc.) is substantially better. With many of these neighborhoods consisting of individuals who are living below the poverty level, it is apparent that there is a major economic struggle in the area.

Critical Problems and Service Gaps in Knox County

To assess exactly what the conditions are in the Knoxville area the *Nine Counties. One Vision. Social Service Task Force* engaged the University of Tennessee Social Work Office of Research and Public Service (UT-SWORPS) to conduct a comprehensive needs assessment for the Nine Counties region. The purpose of this needs assessment was to provide community organizations and leaders with information to make decisions about service priorities and allocation of resources. The analysis in this report was used to make decisions in this thesis project as well. The main problems listed among communities in Knoxville were:

(1) African Americans living in poverty
(2) Female-headed household with children living in poverty
(3) Affordable child care
(4) Shortage of good paying jobs
(5) People unable to afford medical care
(6) Unemployment among African-Americans
(7) Transportation
(8) Safe, affordable housing
(9) Needs of Growing elderly population
(10) High child rate death
(11) Children or teenagers experiencing behavioral or emotional problems at home or at school
(12) High mortality rates
(13) Multi-problem families
(14) People having a lot of anxiety, stress, or depression
(15) Grandparent responsible for grandchildren

Words in red represent the problems that can be eased by this design proposal. The rest can be alleviated to some degree through the same proposal.

Shortage of Good Paying Jobs

New buildings, gardens, streetscapes, etc. all have to be designed, constructed and maintained. This involves many professions collaborating to get the tasks completed. In the process many new jobs can be created to ensure that the

project is a success. These can range from architects providing blueprints for new buildings to people hired in the community to maintain park space and plant material.

Transportation

To promote the public usage of newly developed spaces, various transportation methods or improvement on existing transportation infrastructure should be provided. This ranges from vehicular routes to walking trails if applicable. The goal for this area of Knoxville is to provide various ways (vehicular, running, biking, bus system, etc.) to the project site and possibly other areas of the city. This can benefit those who have troubles with affording a car and the maintenance that goes into taking care of it.

Safe, Affordable Housing

Affordable housing can be supplied to the citizens in the area by implementing sustainable design which can cut costs on monthly bills. Examples of this include positioning buildings that take advantage of sun light and air flow, using to keep a house cool or warm, installing energy sufficient light bulbs, etc. Safety can be provided by providing the adequate lighting throughout the occupied space and by beautifying the unclean areas. Dirty locations that lack sufficient lighting and are usually promote unwanted activity.

People having Anxiety, Stress or Depression

Anxiety, stress and depression can be alleviated through design by providing the people in the surrounding neighborhoods with access to opportunities that reverse these disorders. This can also include destinations that supply recreational activities (ball fields, open spaces, greenways, etc.) which encourage healthier lifestyles. In this particular case the remediation of a brownfield can bring about relief for the people living within close proximity to it by removing the environmental hazards that may occur on site. By cleaning up chemicals, removing dilapidated structures, replacing weeds with quality plant material, etc. a brownfield can be converted into a suitable destination. This transformation can bring about more prosperity to an area thus giving citizens something to cherish.

Neighborhood Programming

Figure 14: Map of site programming in study area

Upon further investigation of the site context, the lack of parks and open green space within the boundary stands out. This is unfortunate due to the large amount of available land that is not being used along the industrial corridor. There are a number of public schools and youth facilities within a couple of miles of the site context. The schools range from pre-school through high school. Facilities like the Boys and Girl Club and The Wesley house are used as after school and mentoring programs for the students.

There are also church facilities and community centers within the study boundary. These places stimulate community outreach and gathering, it is important to consider where they are in consideration with the proposed design.

There are organizations in the area that promote youth activities and community enhancement. If the users of this space were to obtain more parks and open land to support these functions it could stimulate more community involvement and interest from others members within the neighborhoods. This could help lead to the transformations needed in these areas.

Transportation

A goal of the project is to provide better access for the individuals in the neighborhoods. Inadequate transportation is one of the major complaints from the study conducted by the Nine Counties. One Vision. Social Service Task Force. The lack of transportation ties in with many other social inequities. The goal is to provide a multimodal transportation network (car, bus, bike and pedestrian) for these neighborhoods thus giving them access to locations around the city and redeveloped brownfield site proposed in this document. The site will be chosen based on which one has good access points for all of the neighborhoods to help promote its usage.

Major Roads and Avenues

Figure 15: Map of major vehicular routes

There are two major highways (I-275 and I-40) that go through the study area as well as a couple of major thoroughfares. This creates large amounts of vehicular activity throughout the area. While adequate vehicular access is desired for potential visitors who live further away, the introduction of pedestrian friendly routes is still needed. It will promote less vehicular use (therefore decreasing the amount of harmful emissions released by car exhaust) and give those who do not have the means to obtain vehicular transportation other outlets.

Knoxville Bicycle Map

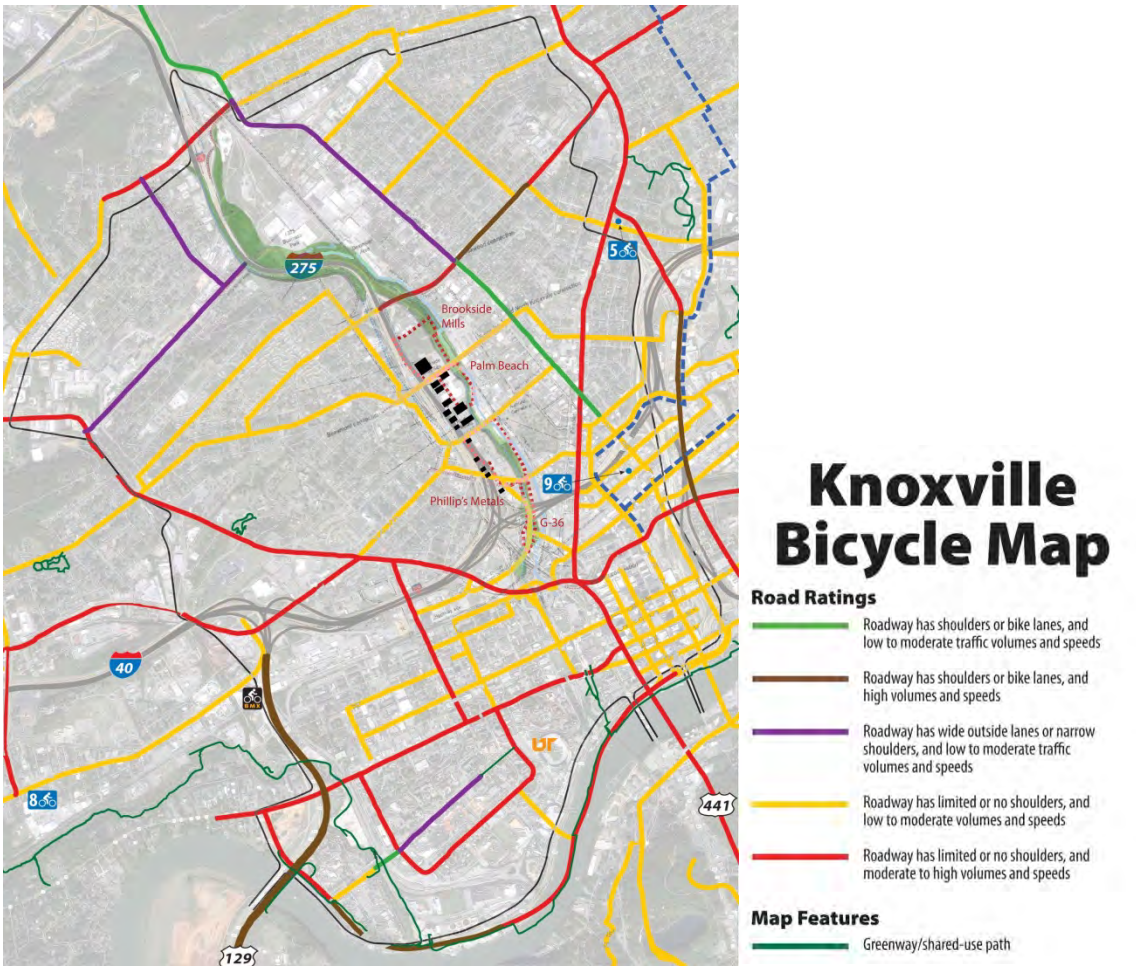

Figure 16: Knoxville bicycle map

To promote pedestrian friendly routes a better understating of the existing conditions is needed. The Knoxville Bicycle Map reveals street/sidewalk conditions and traffic intensity levels for different thoroughfares in the city. This bike route map shows that there are not enough pedestrian friendly roads in the study area (the streets highlighted in yellow and red lack good shoulders). Many of the streets do not have adequate sidewalks for bike routes or pedestrian flow. Street and shoulder improvements are needed for the residents in the local neighborhoods to gain better access to different areas of the neighborhood.

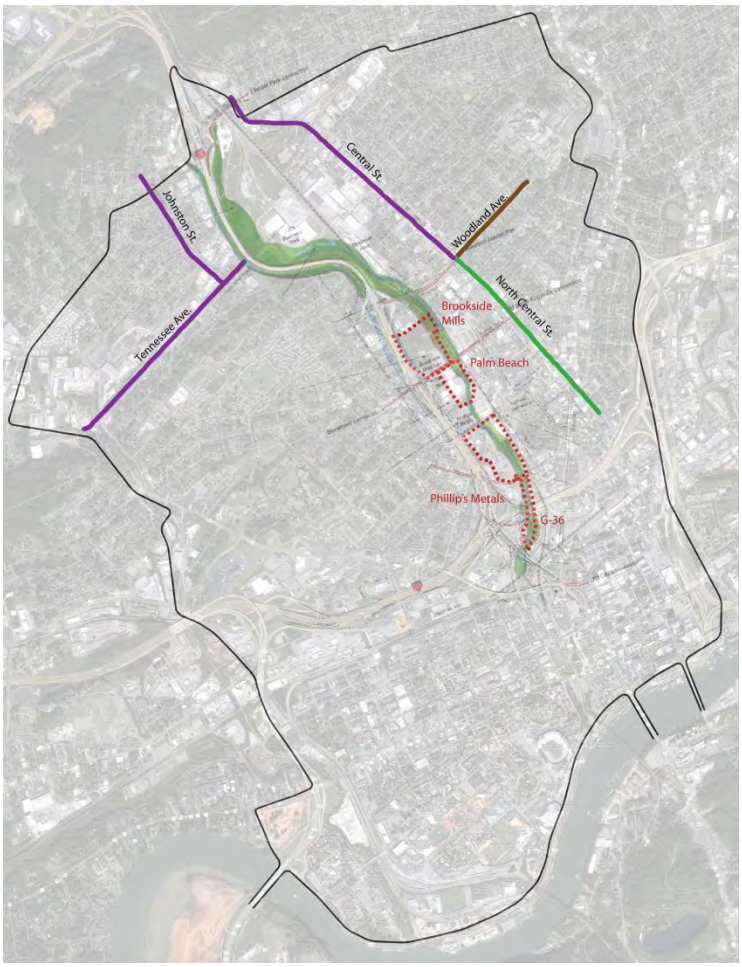

Figure 17: Map of streets with good shoulders

By taking a closer look at the bicycle map it becomes clear that there is a shortage of roads within the study area that are bike and/or pedestrian friendly. Tennessee Ave, Johnston St., Central St., North Central St. and Woodland Ave are the only ones that are usable. None of these streets connect the neighborhoods to the proposed redevelopment area. Sidewalk conditions have to be improved in order for the inhabitants of these neighborhoods to gain non-vehicular access to the site.

Streetscape Study

Due to the lack of pedestrian friendly routes through the study area, an investigation on road conditions was conducted. Finds from this study were used to makes recommendations for improved pedestrian flow through the area.

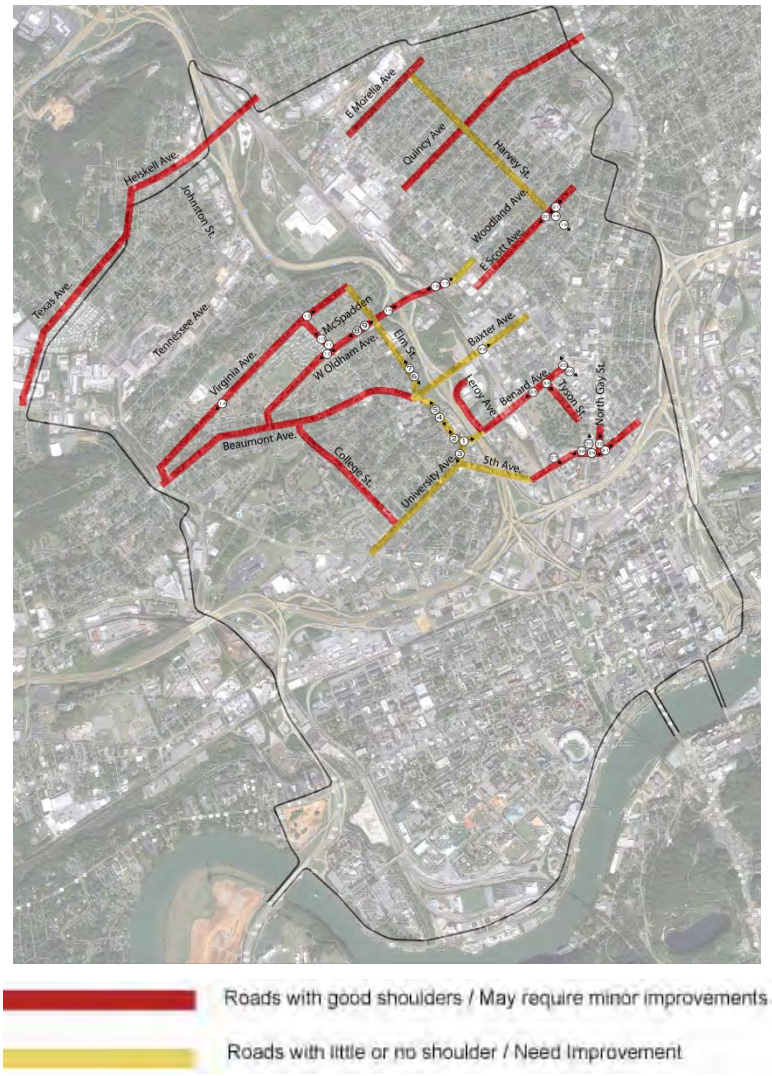

Figure 18: Sidewalk street study map

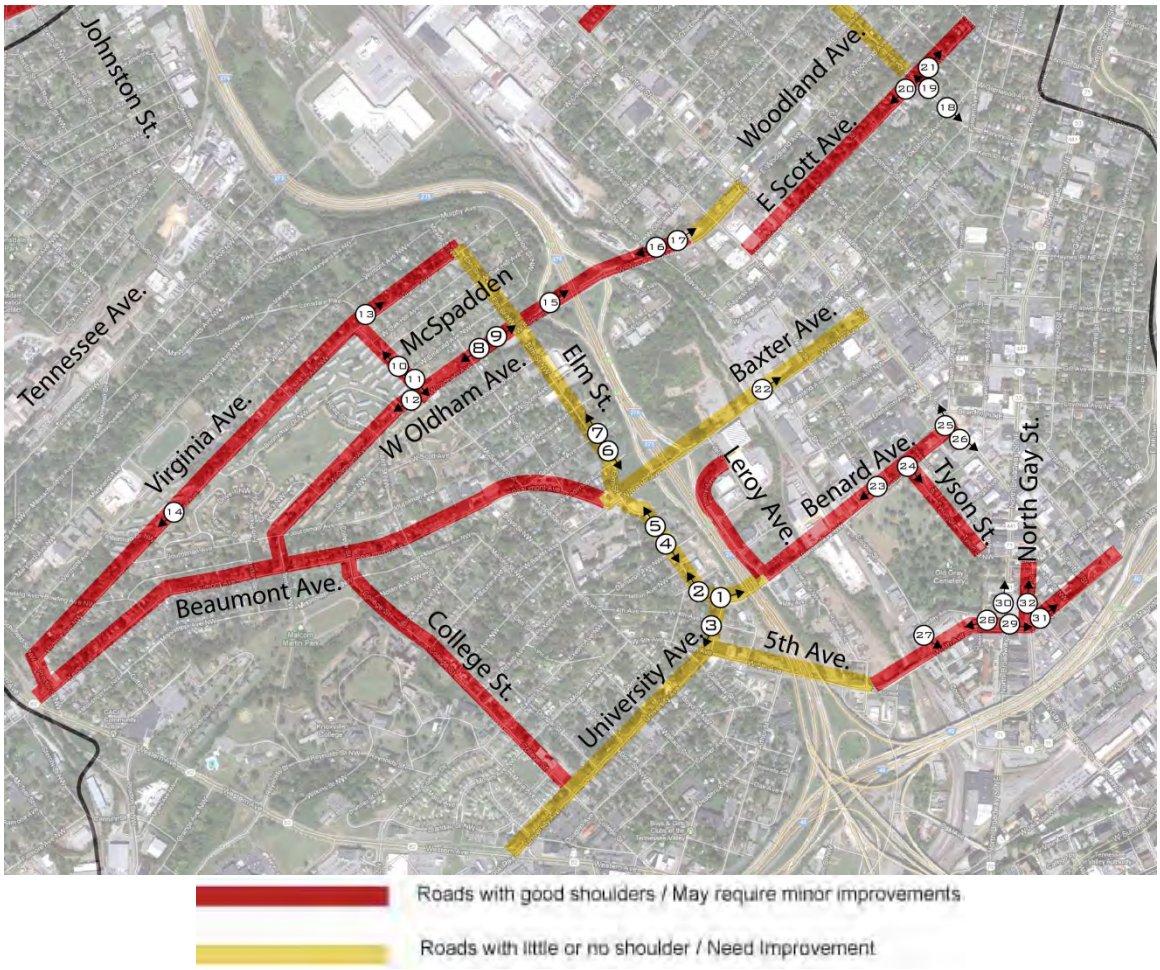

Figure 19: Zoomed in sidewalk street study map

Figure 20: Pictures of sidewalks/roads and their conditions (1)

Figure 21: Pictures of sidewalks/roads and their conditions (2)

Figure 22: Pictures of sidewalks/roads and their conditions (3)

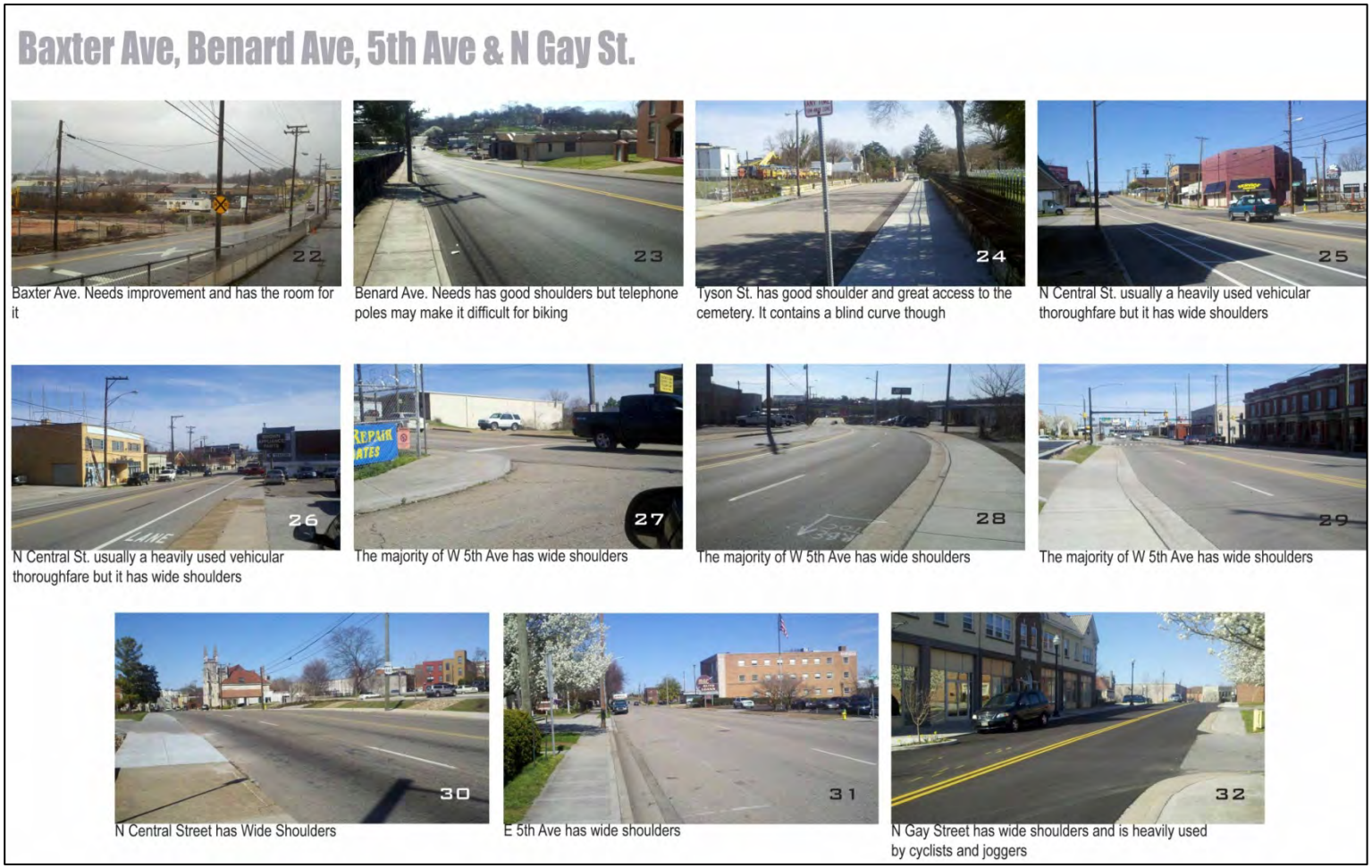

Figure 23: Pictures of sidewalks/roads and their conditions (4)

Proposed Shoulder Improvement

Figure 24: Section showing proposed shoulder improvements

The proposed sidewalk improvement will allow room for pedestrian/bike friendly access to different sites around the study area. These improvements are suggested for the streets highlighted in yellow in (Figure 19). If implemented, this will create more possibilities for the people living in the vicinity to get around without using a vehicle. These improvements will also promoting healthy lifestyles in the form of walking, running and/or biking.

Figure 25: Diagram showing proposed shoulder widening (1)

Figure 26: Diagram showing proposed shoulder widening (2)

Figure 27: Diagram showing proposed shoulder widening (3)

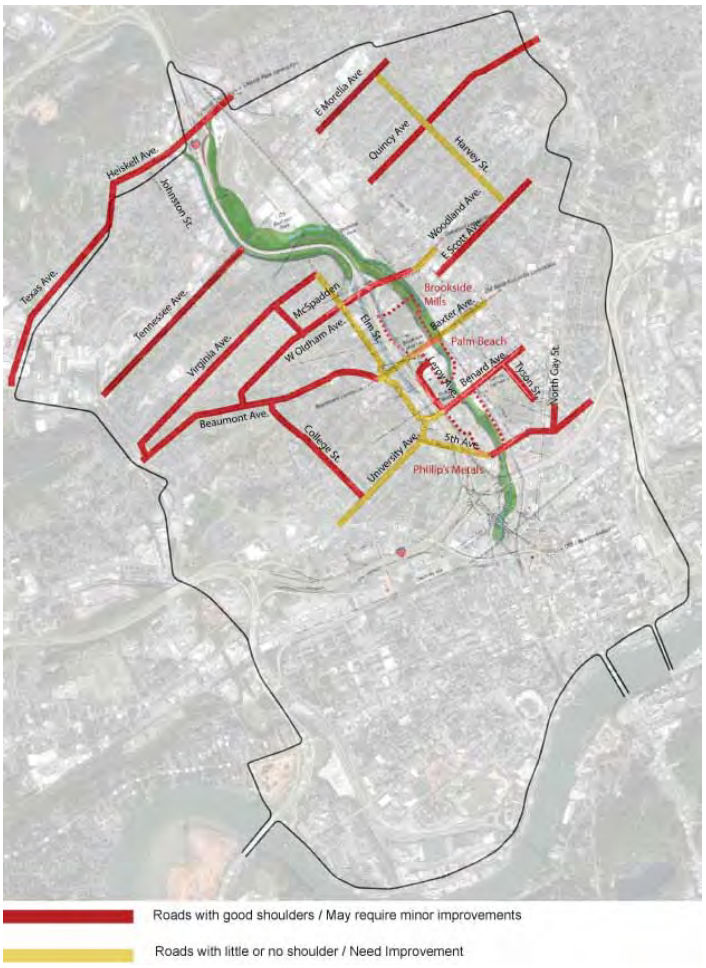

Figure 28: Map showing proposed street improvements

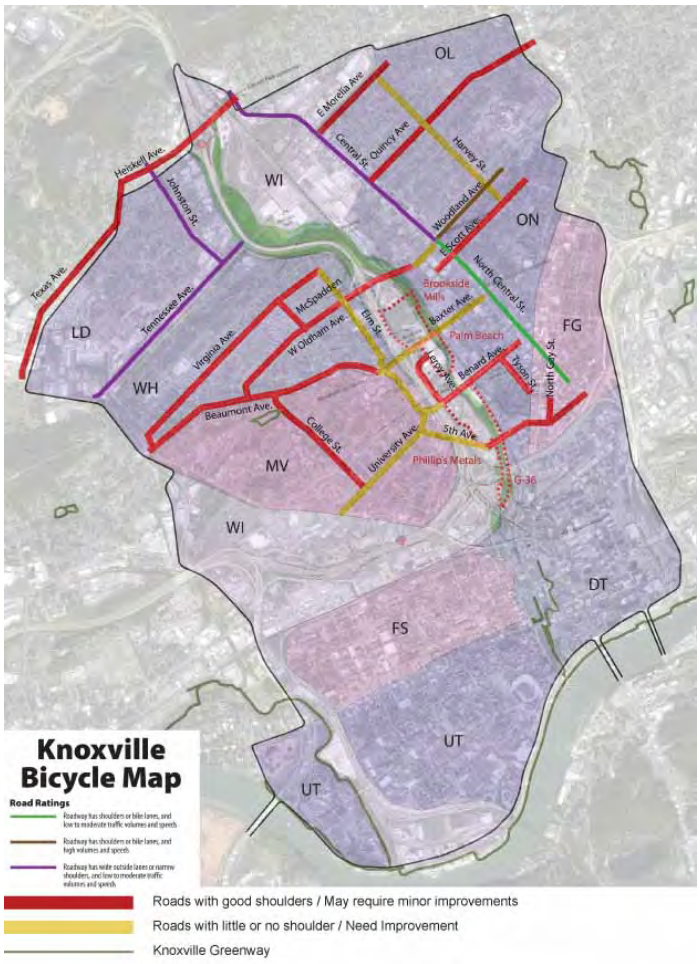

Figure 29: Map showing proposed street improvements with existing good streets

Due to the lack of pedestrian friendly routes through the study area, an investigation on road conditions was conducted. The roads that had enough shoulder room and the ones that need slight improvement were selected. The roads highlighted above have potential to become successful avenues for pedestrian flow because there is enough room between the street and property lines to widen the shoulder or improve shoulder conditions. Three main roads (Baxter Ave, Benard Ave and West 5th Ave) are examples of the streets that were selected. If these three roads were improved upon then instance access into major brownfield site like Brookside Mills, Palm Beach, Phillip's Metal and G-36 are available.

By improving the sidewalk conditions in the project area neighborhoods have a connection with the city of Knoxville's proposed redevelopment scheme. The 2nd Creek greenway corridor also provides opportunities for these neighborhoods to connect with people from the downtown area and the University of Tennessee.

Overall, through the sidewalk improvements and the greenway, city becomes less fragmented. The brownfield sites that are accessible through these connections are prime candidates for remediation and redevelopment.

Existing Bus Routes

To further improve upon the existing transportation networks, the Knoxville KAT bus route system was examined. Analysis shows there are several bus stops in the area but not that many of them are in close vicinity of the industrial corridor. Better streetscapes will encourage people to walk and bike but extra bus routes will be needed to carter to individuals, mainly the elderly, who may not have other options.

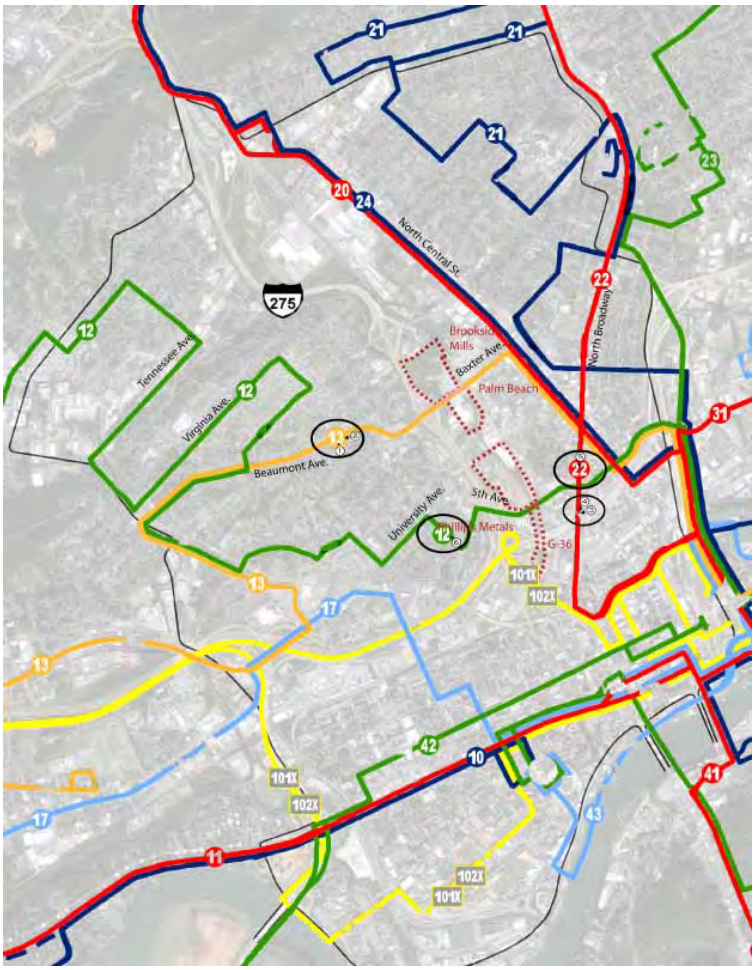

Figure 30: Map showing Knoxville bus routes

This bus route map reveals that only four stops are located near the vicinity of the clustered brownfield sites. Two of the buses pass through Baxter Ave. and Fifth Ave. More bus routes are needed for this area but the routes that run along Baxter Ave. and Fifth Ave. pass by three major brownfield sites (Phillip's Metals, Palm Beach and Brookside Mills). Bus stops can be added along these routes to provide pedestrians access to the sites. A proposal was made to showcase how improvements can be made that would spark people's interest to ride the bus.

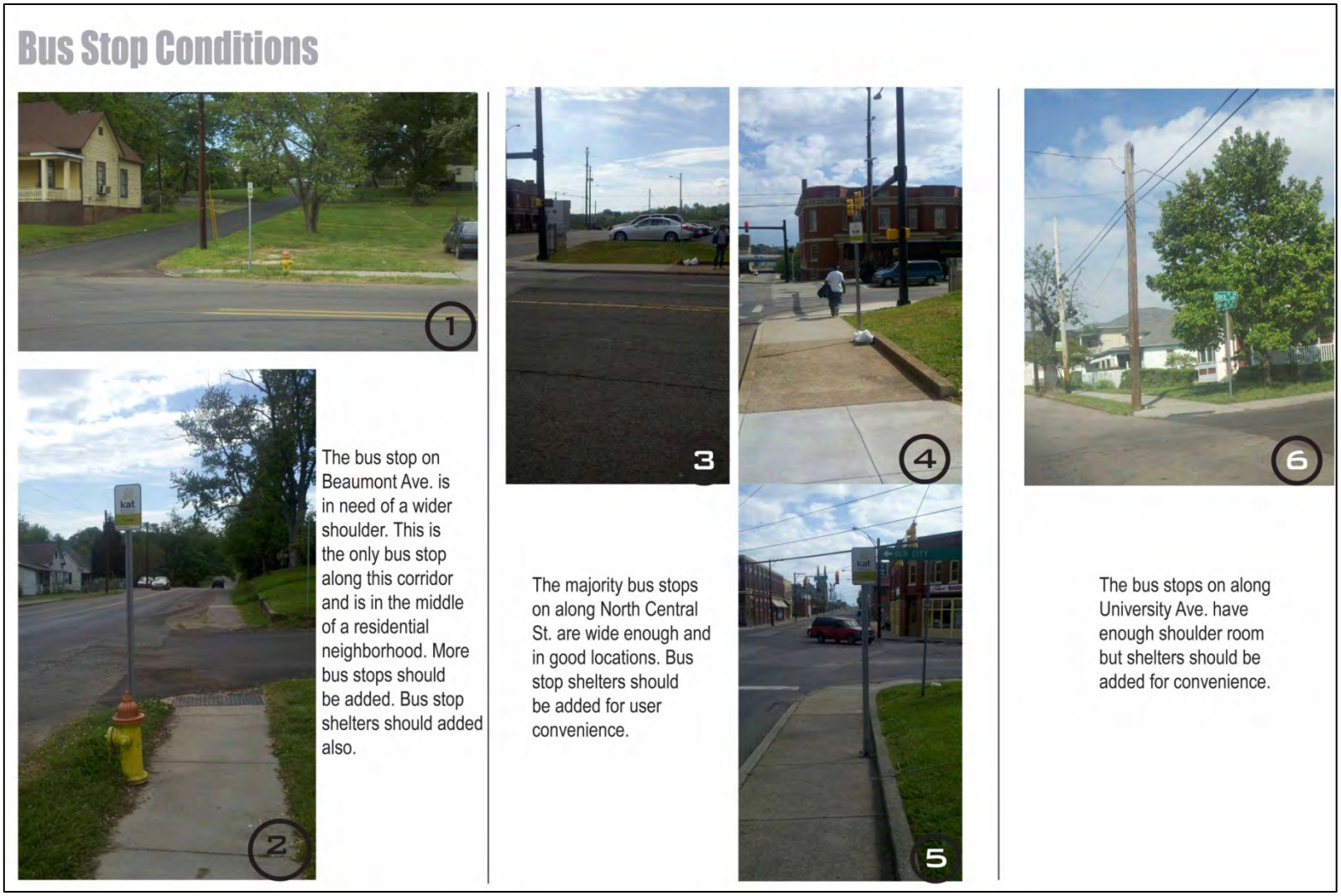

Figure 31: Pictures of bus routes and their conditions

Figure 32: Study on bus stops in Athens, GA

The 2nd Creek Greenway

Along with the expansion the downtown area, the city of Knoxville proposed a greenway that follows 2nd Creek. The access to this potential corridor is important for the citizens of the surrounding neighborhoods due to the fact it can provide access from their neighborhoods to other parts of the city. The creek flows along the side of some of the major brownfield sites like Brookside Mills, Palm Beach, Phillip's Metals and G-36. A design for the Brookside Mills property has already been designated therefore leaving the other three choices as strong candidates.

Figure 33: Map of the 2nd Creek corridor

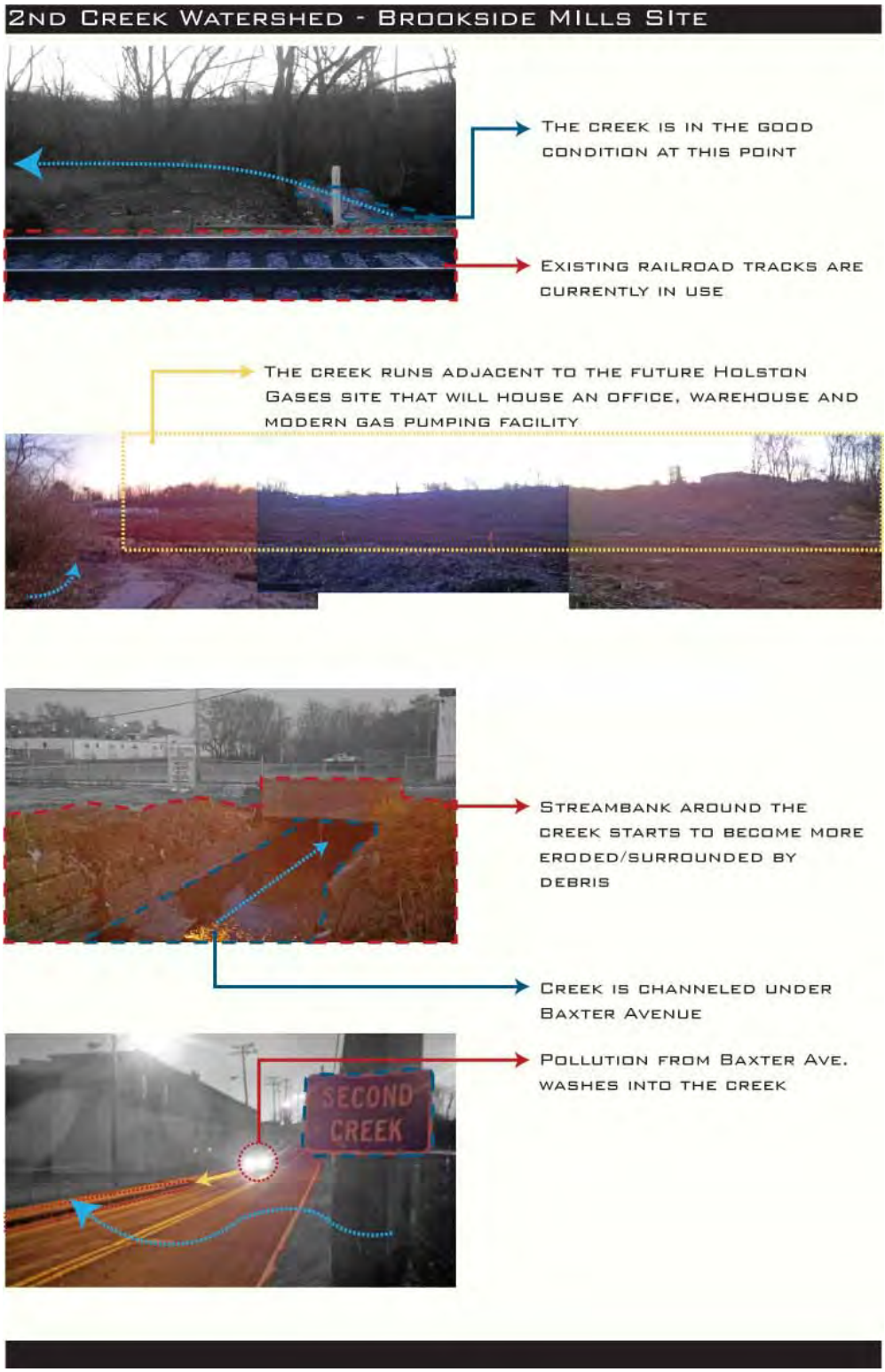

Figure 34: 2nd Creek preliminary corridor inventory (1)

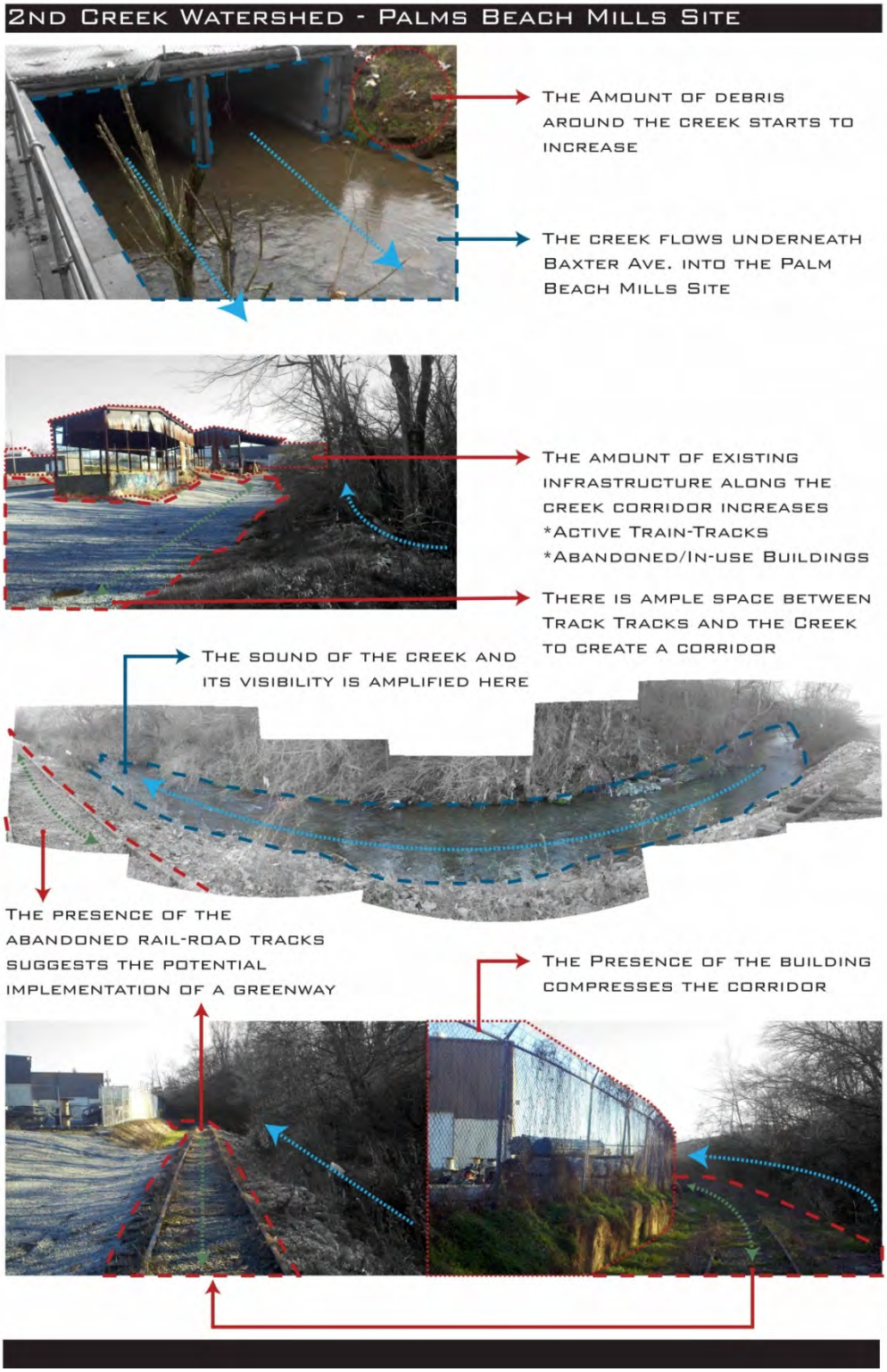

Figure 35: 2nd Creek preliminary corridor inventory (2)

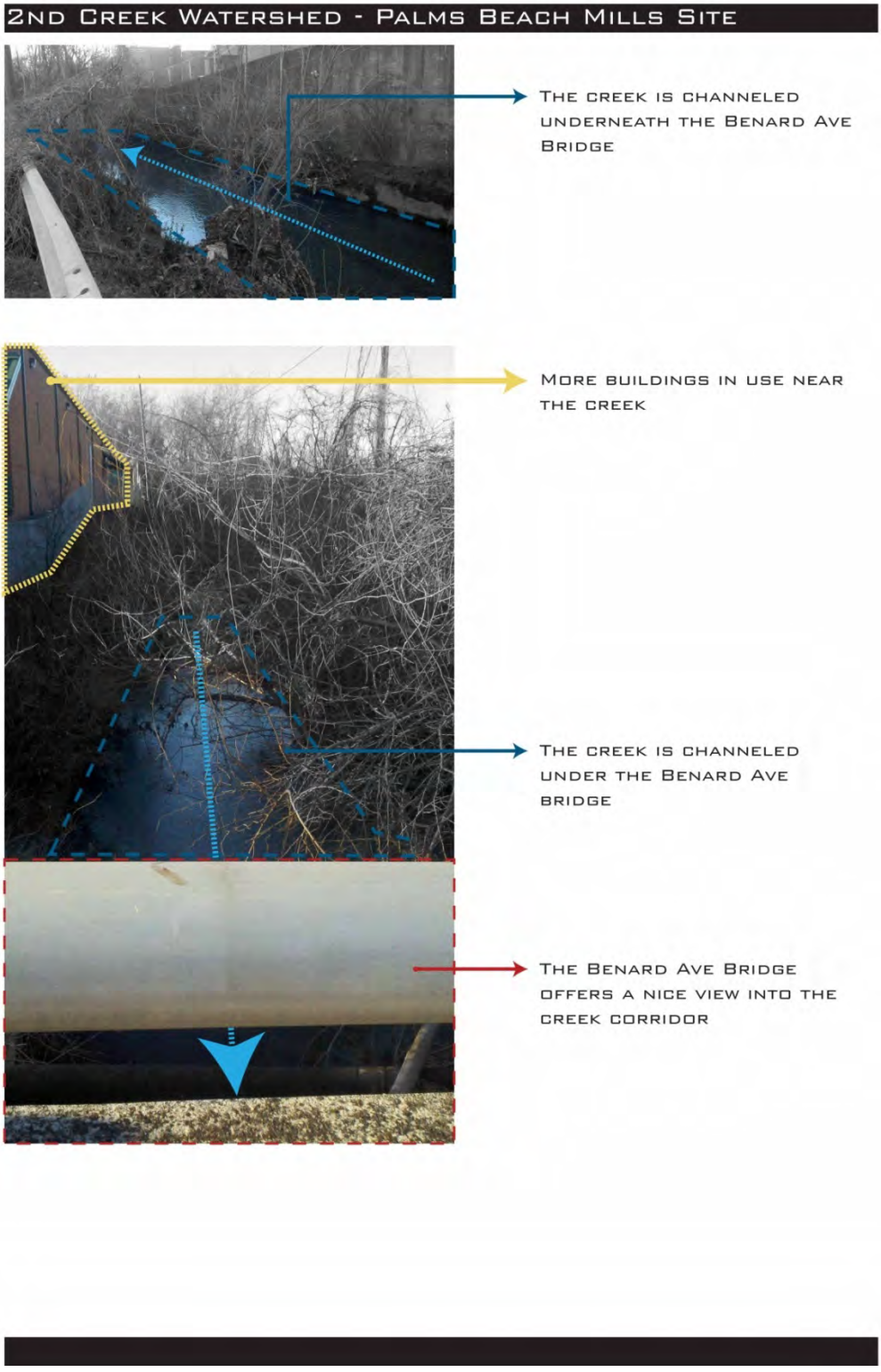

Figure 36: 2nd Creek preliminary corridor inventory (3)

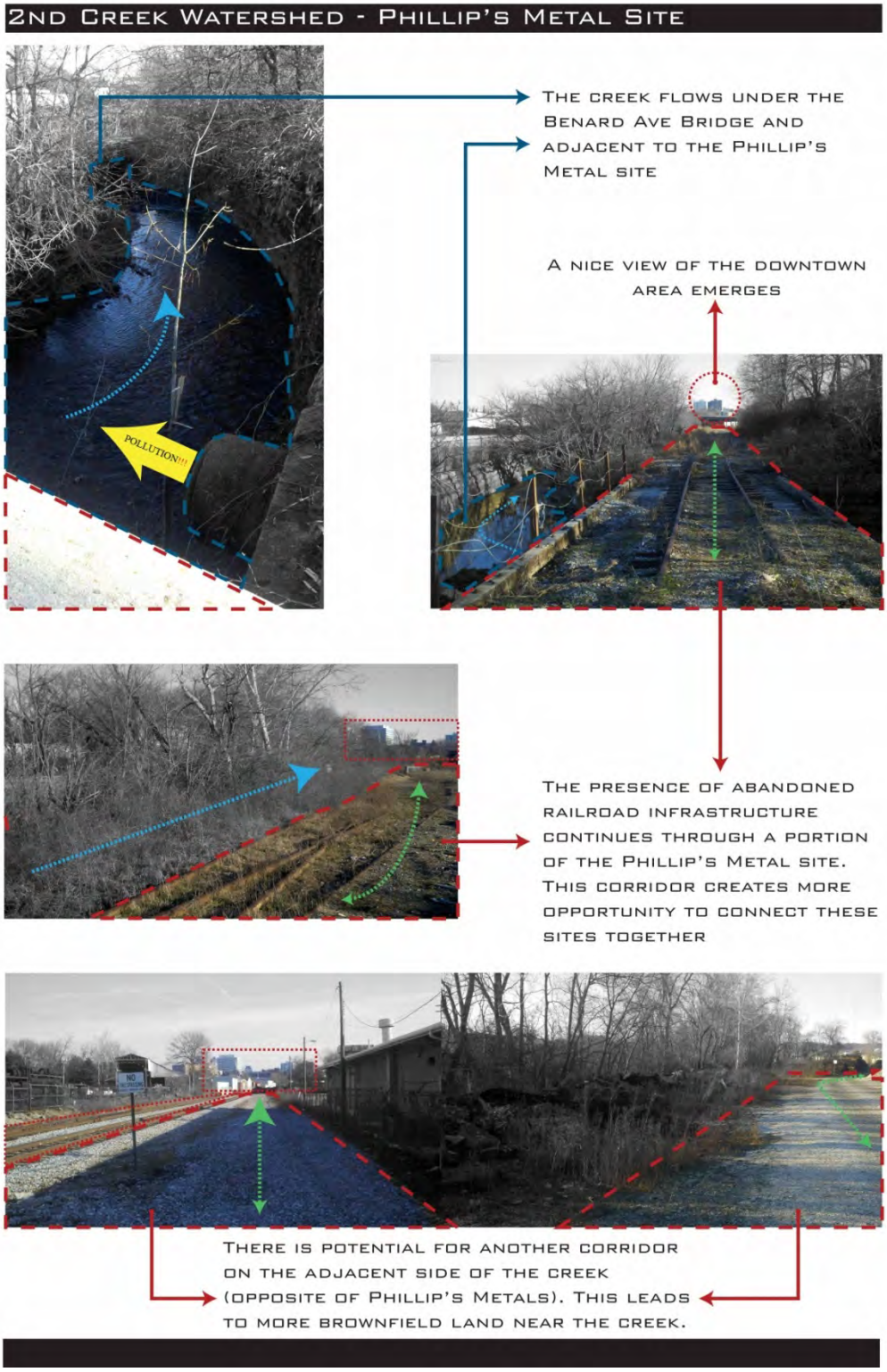

Figure 37: 2nd Creek preliminary corridor inventory (4)

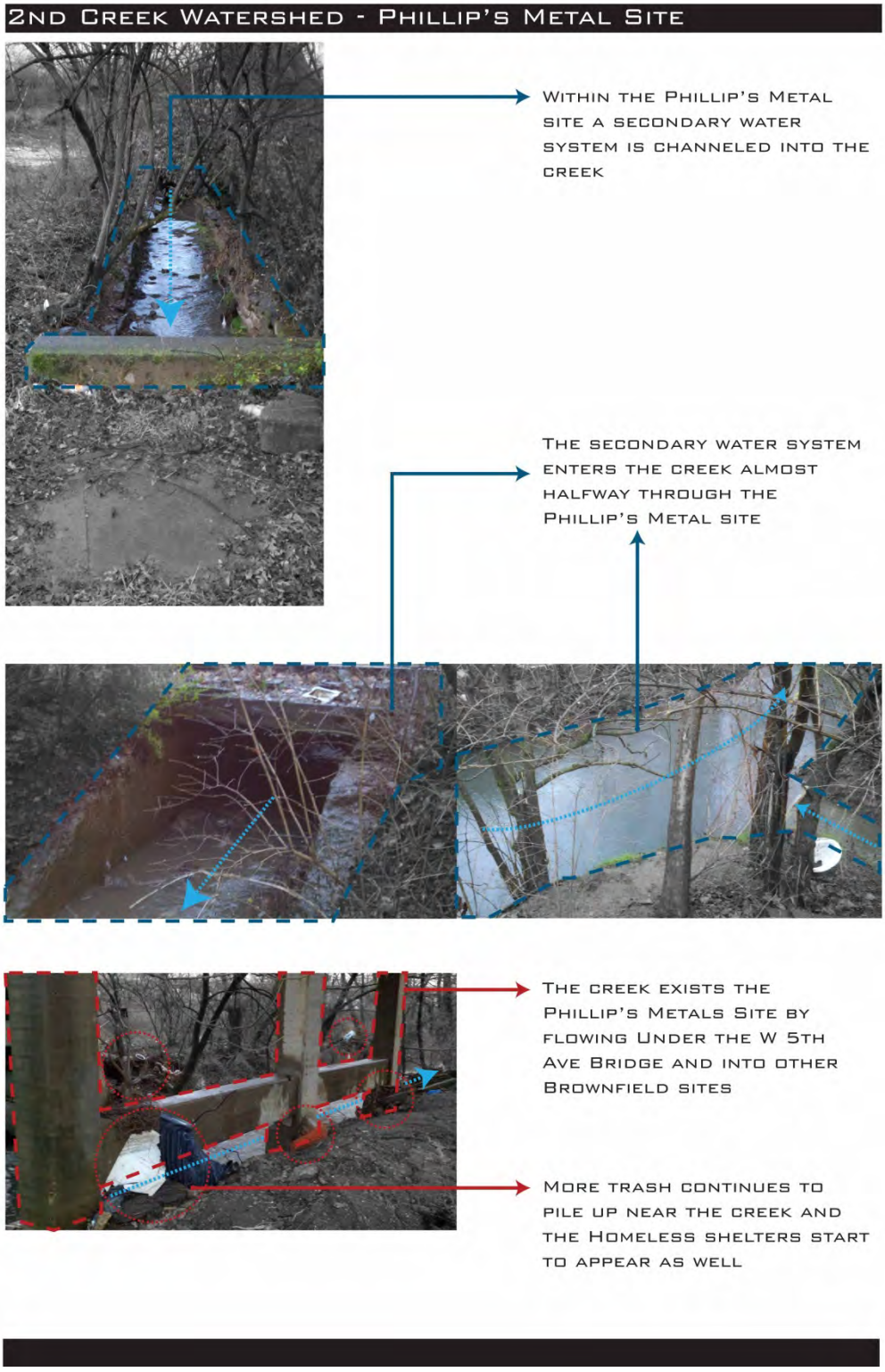

Figure 38: 2nd Creek preliminary corridor inventory (5)

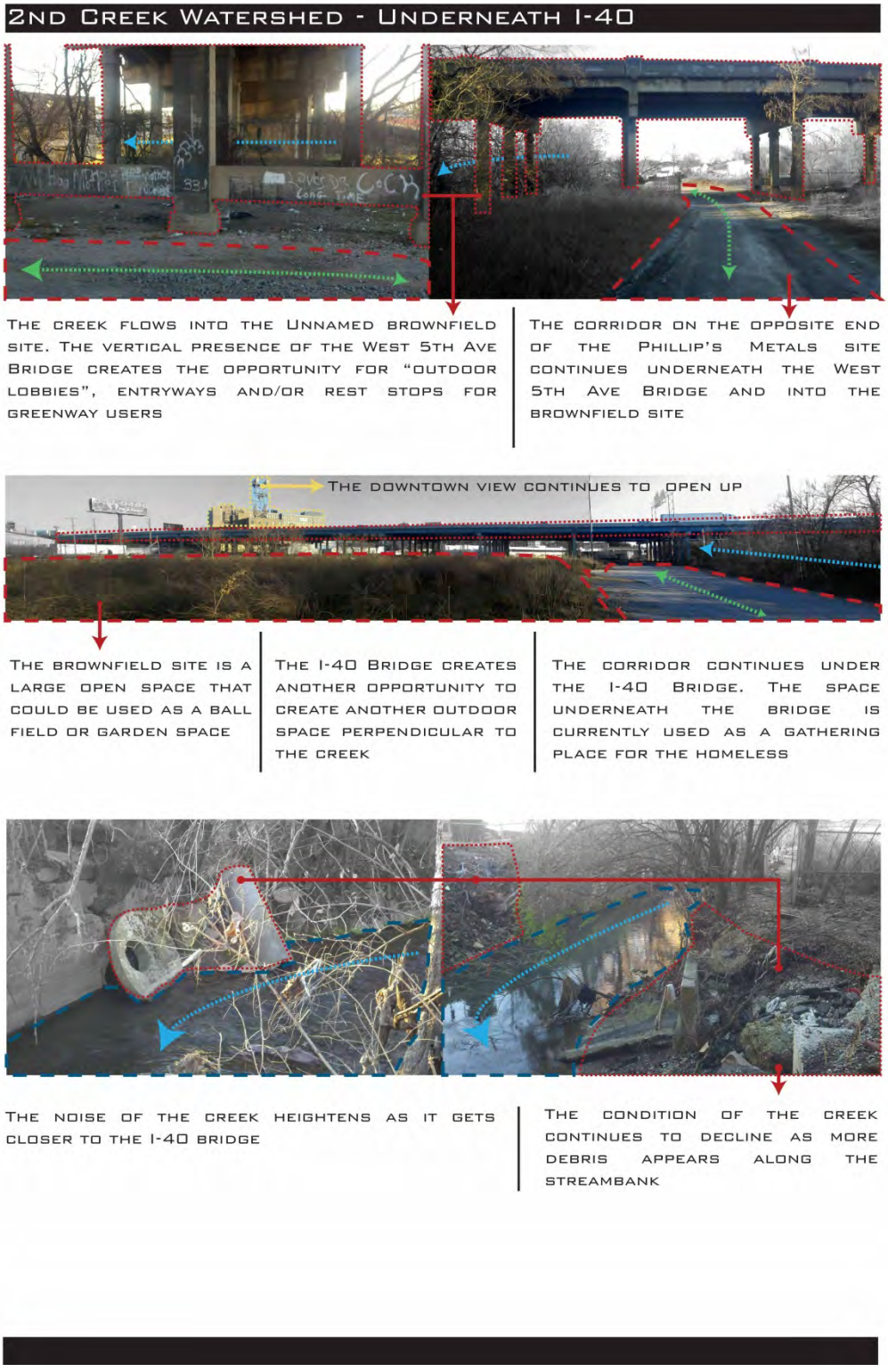

Figure 39: 2nd Creek preliminary corridor inventory (6)

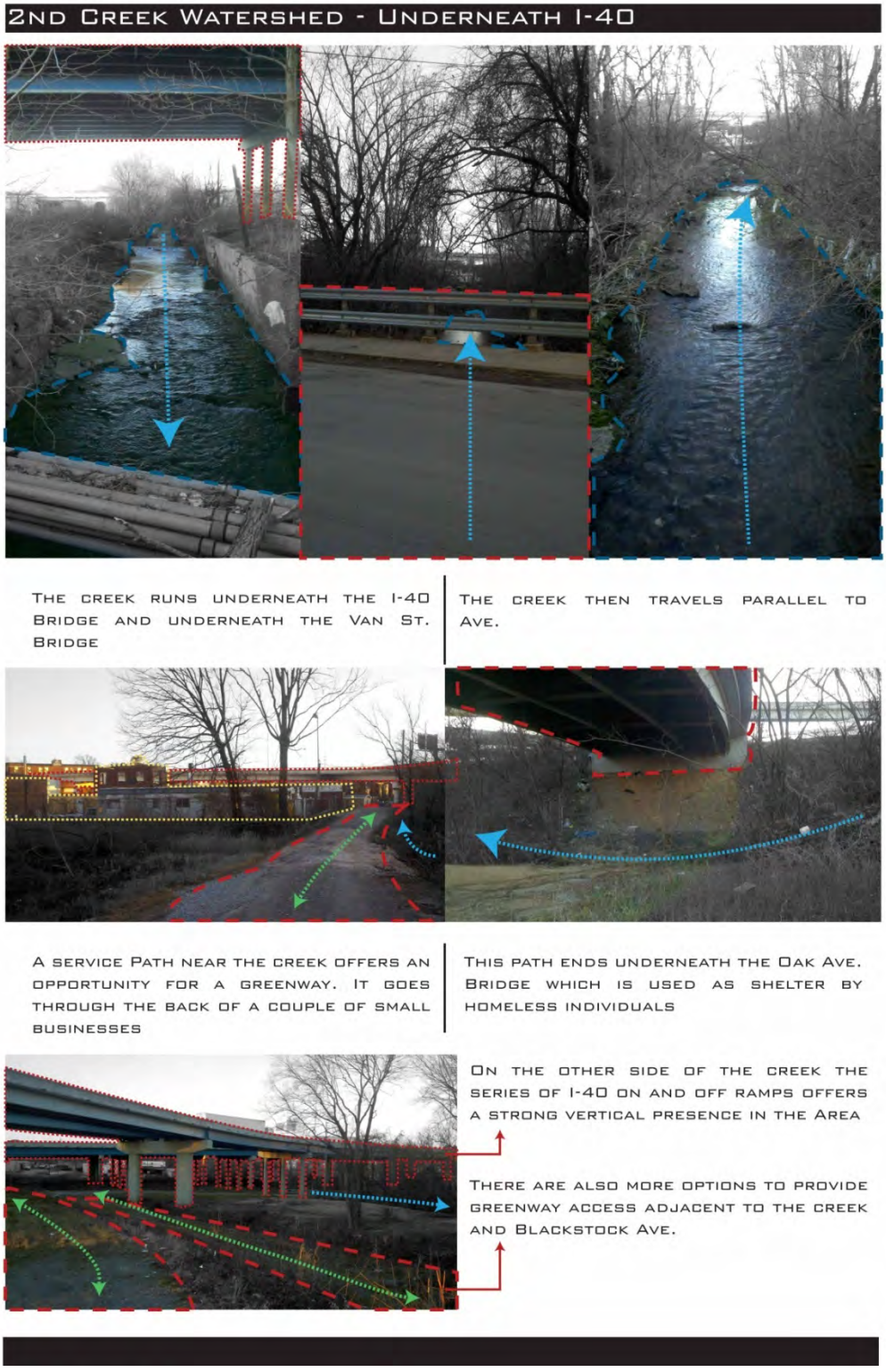

Figure 40: 2nd Creek preliminary corridor inventory (7)

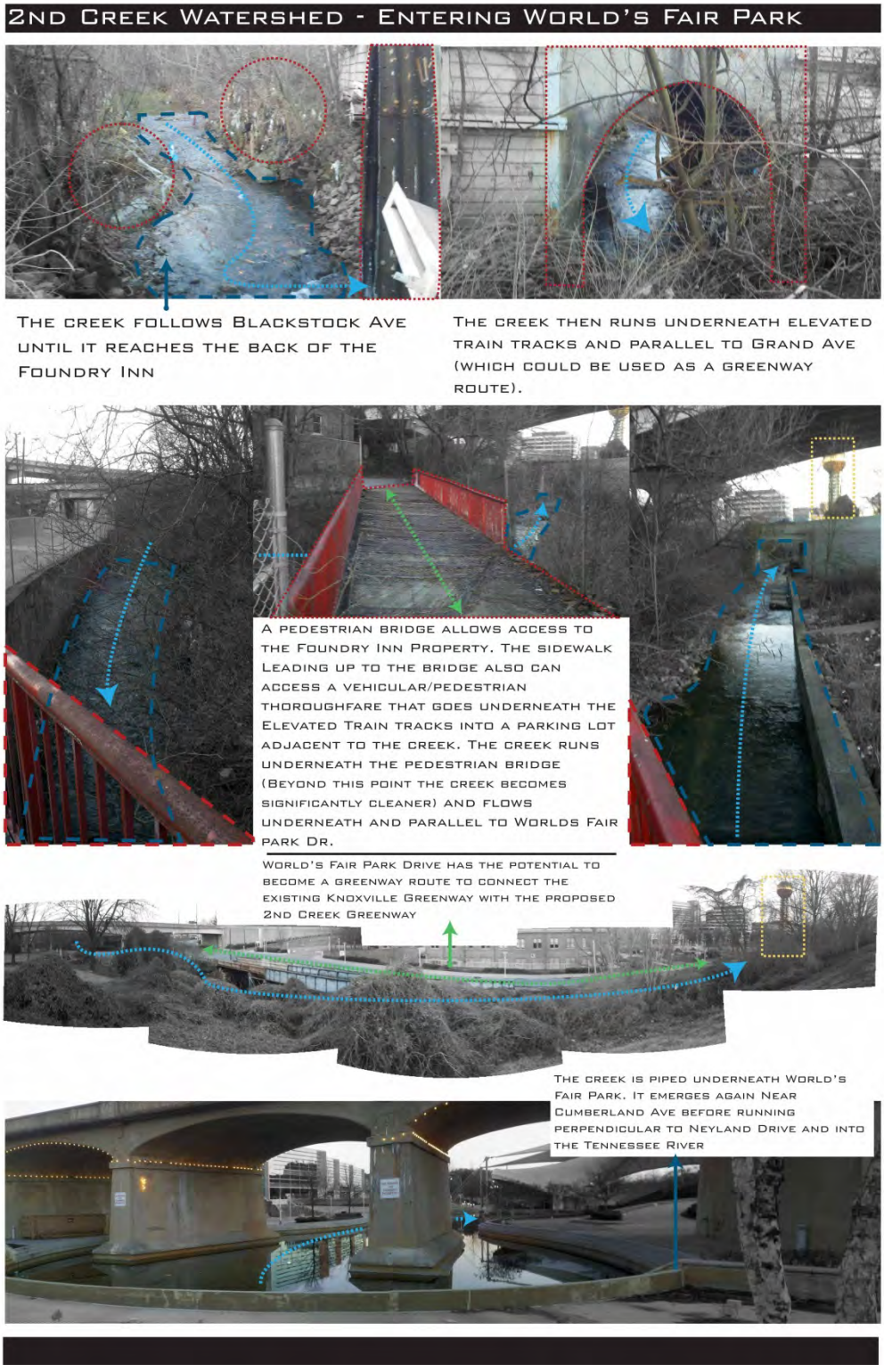

Figure 41: 2nd Creek preliminary corridor inventory (8)

2nd Creek Greenway Plan

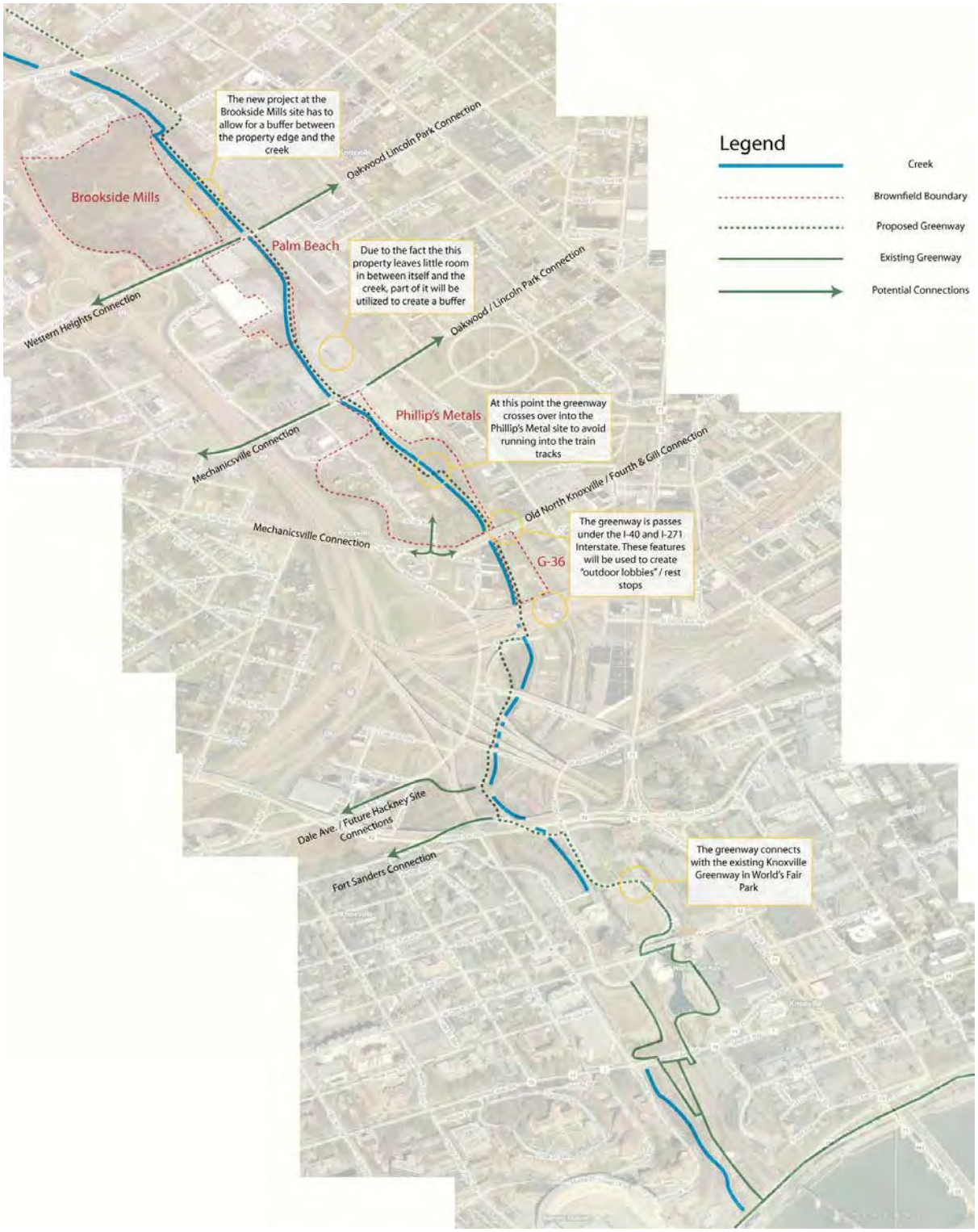

Figure 42: Proposed greenway map

Overall Connections

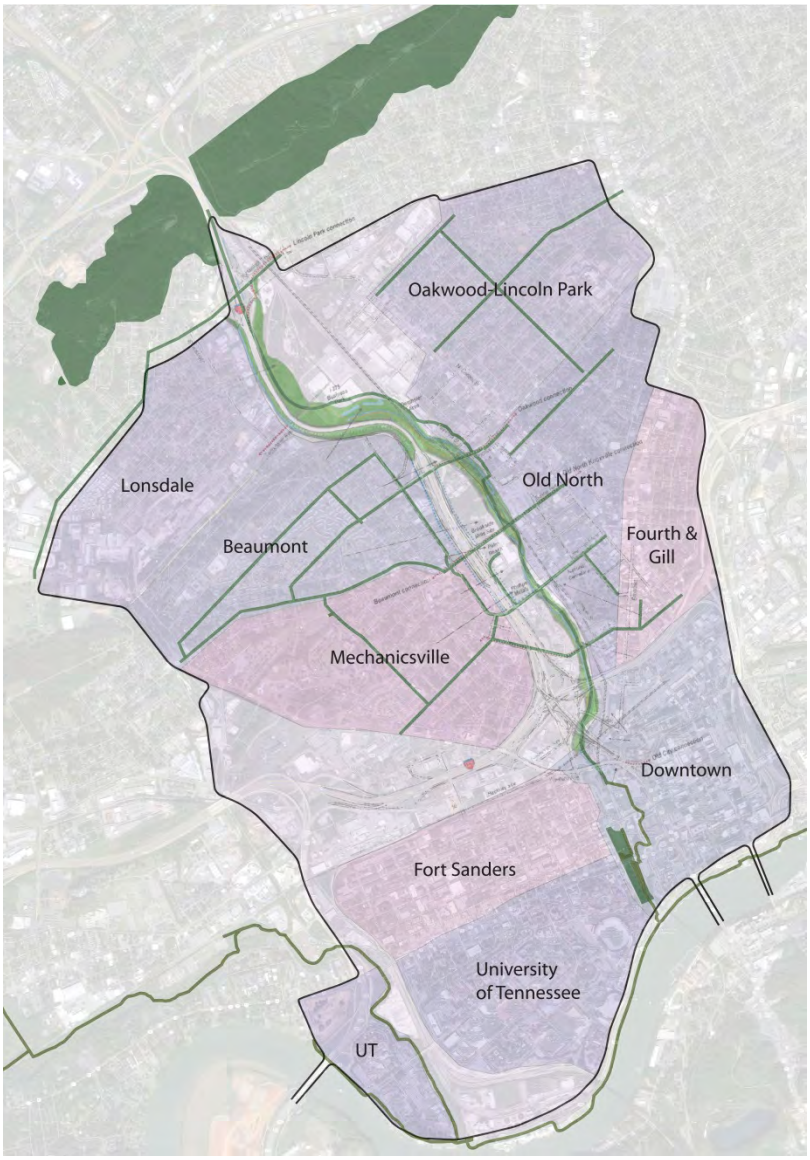

Figure 43: Map showing overall proposed Knoxville connections

In the pursuit of creating sufficient multimodal transportation routes in the city through analysis, several concerns arise. Even though there is good vehicular circulation throughout the project area, its current state does not support other methods of transportation. Sidewalk conditions should be improved and the number of bus stops in the area should increase to promote alternative means of transportation. The improved street connections have the potential to encourage those who do not have vehicular transportation (maybe even those who do) to

bike, run or jog to other locations in the neighborhood or city. The addition of the proposed greenway route will encourage people to practice safe, non-vehicular transportation into areas outside of their neighborhood. The addition of bus routes and bus stops in these neighborhoods will provide an alternative to vehicular transportation throughout the city. It also can promote people to drive the bus more thus decreasing the number of motor vehicles on the road. These proposed connections will link the neighborhoods and other destinations within Knoxville together, via the greenway, pedestrian, bus and vehicular routes.

Proposed Sites for Remediation and Redevelopment

Figure 44: Map of proposed sites for remediation and redevelopment

The Phillip's Metal site and G-36 site were chosen for the design project for these reasons:

- They are connected to the surrounding context by way of vehicular access (Figure 31), the Knoxville bus system (Figure 30), the proposed road improvements (Figure 29) and the proposed greenway (Figure 42)
- They both have open space which allows for site programming (this is a necessary criteria due to the large number of people living in the adjacent neighborhoods [see Table 1])
- 2nd Creek flows adjacent to both properties which provides the opportunity of finding methods that can help reverse the effects from it being neglected and the chemicals that wash into it
- Multiple contaminants are found on these sites (those found on potential candidate sites and on potential petroleum sites) which provides an opportunity to explore several solutions that can correct this

CHAPTER V

SITE INVENTORY

Based on the historical use of the Phillip's Metal site, it is severely contaminated. Once used as a scrap yard and metal recycling plant, parts of this location are littered with many types of debris. It is speculated that petroleum contaminated soils are located here as well as other types of hazardous contaminants (Knoxville Community Development Corporation, Proposal to the EPA for Brownfields Grant Fund, 2010). This is important because 2nd creek runs adjacent to the property. The site labeled G-36 is not as contaminated as the Phillip's Metals site but it is believed to have hazardous contaminants present. The site is across the creek from the Phillip's Metal site and creates an opportunity where more programmed space can be added to the design because it is a large open area. More details were needed to understand these sites for remediation and reclamation.

Potential Soil Contaminants

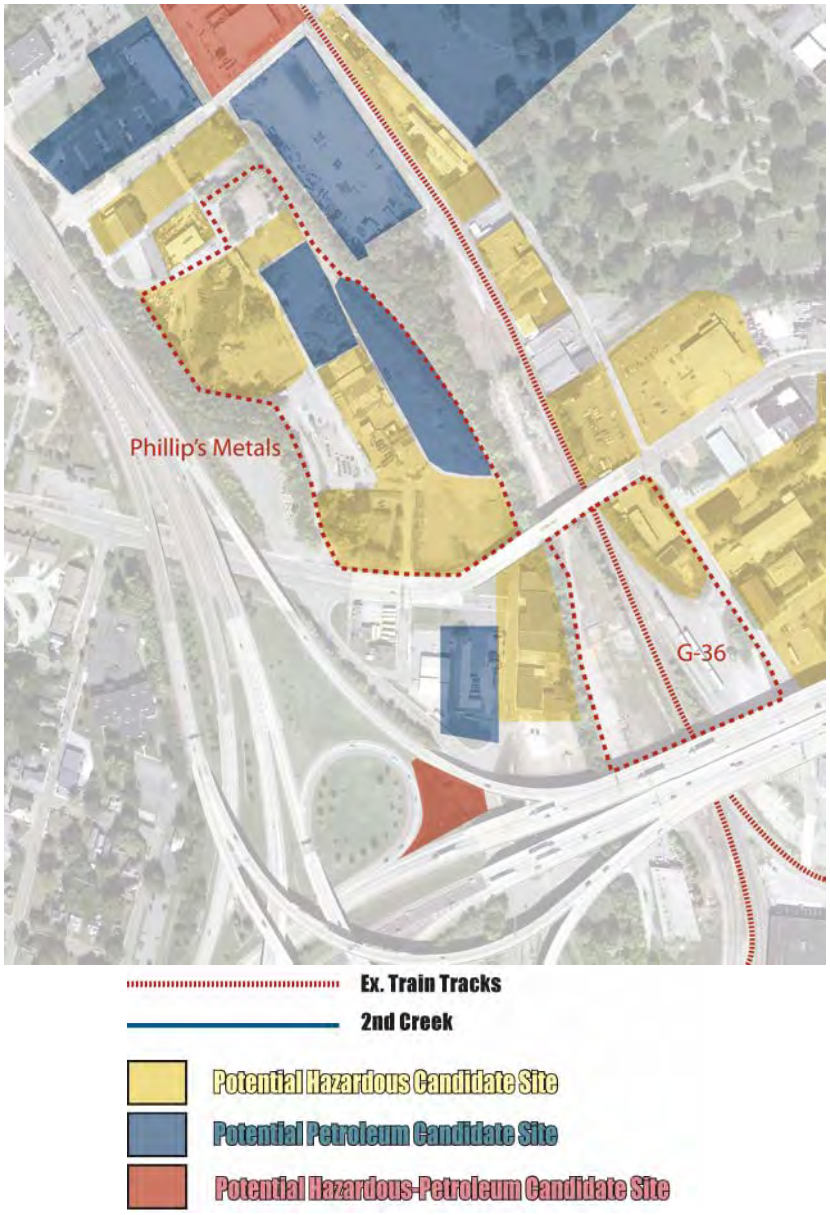

Figure 45: Map showing potential contaminants

A report by the city of Knoxville indicates that chemicals such as petroleum hydrocarbons including gasoline and diesel fuel, polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAH), lead based paints, asbestos containing building materials, industrial chemicals including chlorinated solvents, creosote, and various priority pollutant metals are found on these sites(Knoxville Community Development Corporation, Proposal to the EPA for Brownfields Grant

Fund, 2010). As stated before, the existence of these different contaminant categories creates an opportunity to showcase different remediation techniques on the sites (which are explained further in this document). This provides an opportunity to educate the people in the city on different remediation techniques.

Soil Types

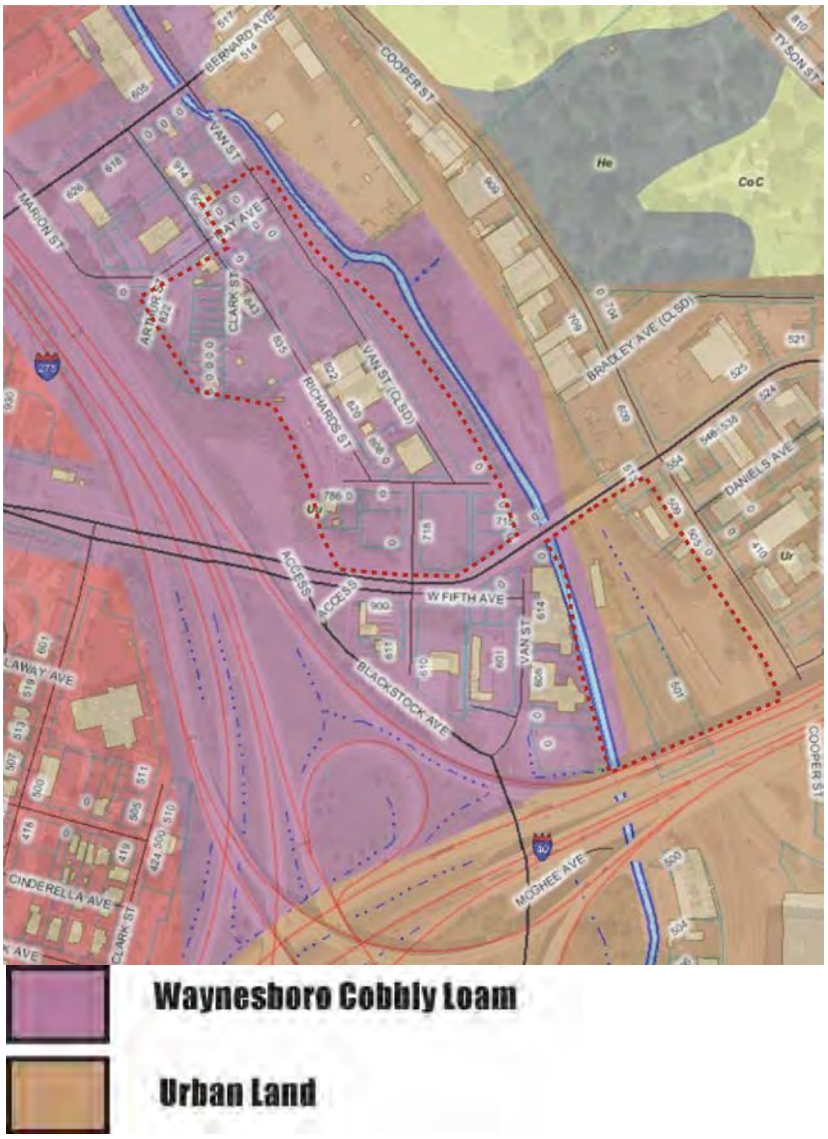

Figure 46: Map showing soil types and conditions (kgis.org)

This soil map shows that there are different soil types within the site boundaries. Understanding the soil characteristics is important for this project when analyzing what remediation technique to use (see Table 2).

Waynesboro cobbly loams have a decrease in clay content in the lower part the subsoil. They are strongly acidic and well drained soils. Soil depth to the bed rock is more than 60 inches (surface 0-5 inches, subsurface 5 to 15 inches, subsoil 15 to 62 inches). Soils of this nature are well suited to hay, use as a pasture or cropland while being moderately suited for urban development (United States Department of Agriculture, Soil Survey of Knox County, Tennessee, 2006).

Urban land soils have impervious ground cover (concrete, asphalt, etc.) and structures on top of it. Uses are usually limited to construction, renovation, landscaping and building roads/streets. Urban land soils have impervious ground cover (concrete, asphalt, etc.) and structures on top of it. Uses are usually limited to construction, renovation, landscaping and building roads/streets. On site analysis is needed to determine the soil structure and potential use of the area (United States Department of Agriculture, Soil Survey of Knox County, Tennessee, 2006).

FEMA Flood

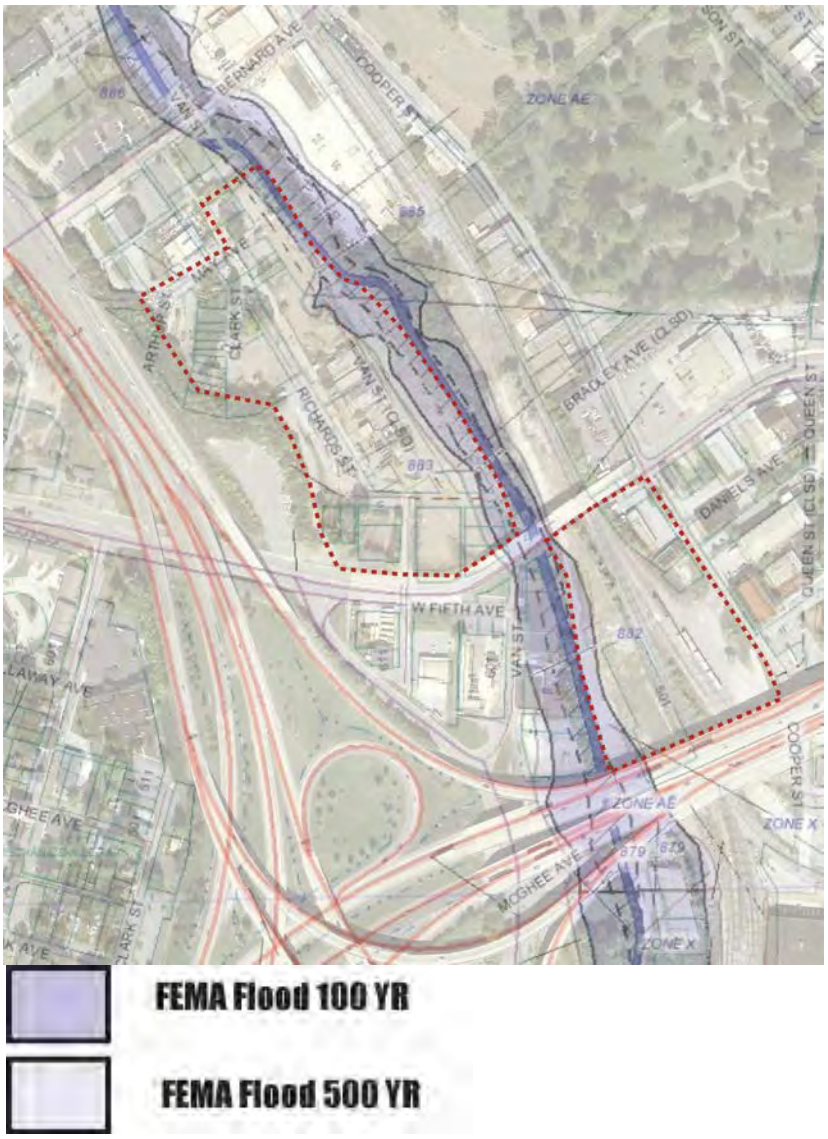

Figure 47: Map showing FEMA Flood levels (kgis.org)

2nd Creek flooding has been has been a concern for many years on certain properties adjacent to the creek corridor. On these particular sites the creek shows signs of being a concern when it comes to flooding. This is a major concern when considering site programming. Areas on the site that are prone to flooding should be designed accordingly. Another stress factor is that contaminants and debris from the site wash into the creek during flood events.

Land Use

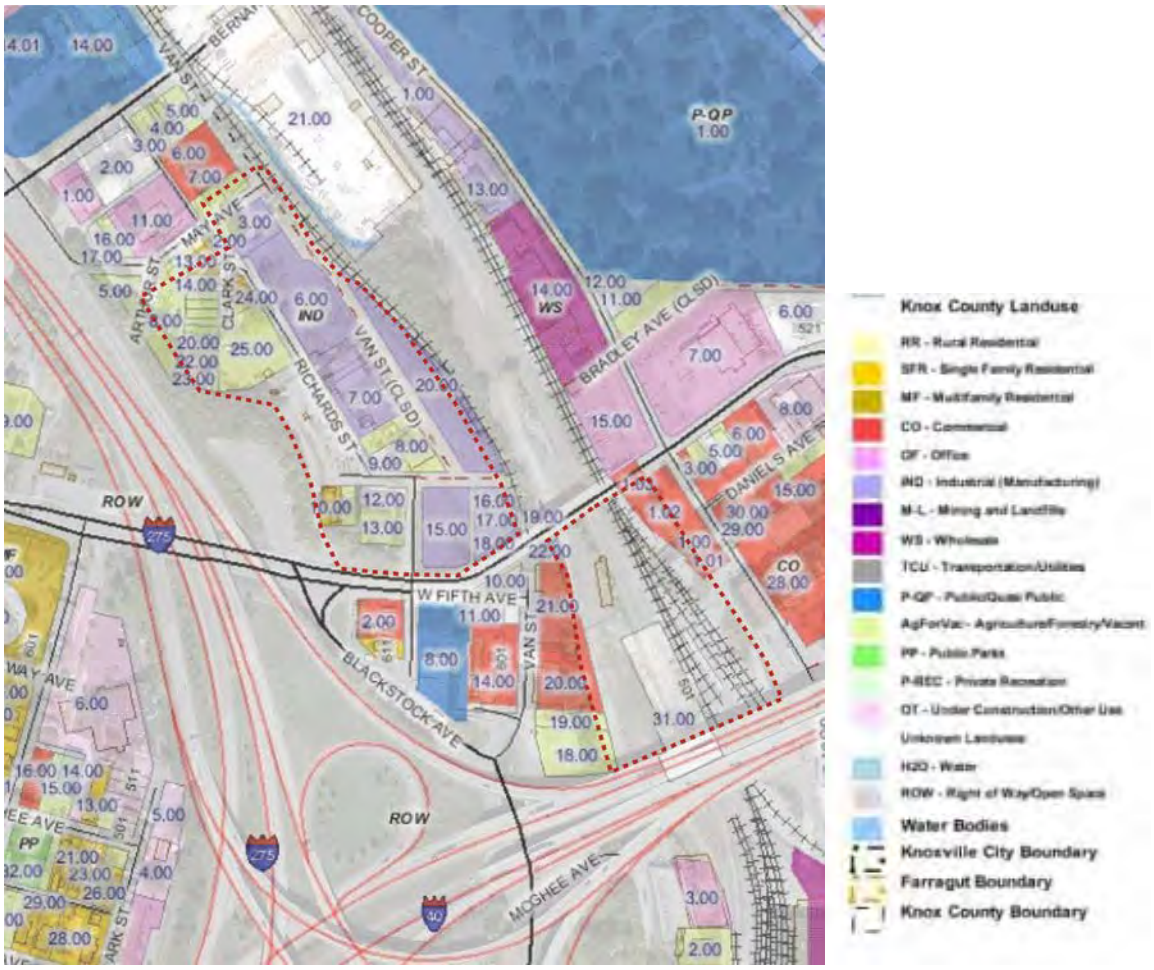

Figure 48: Map showing current land use (kgis.org)

The land use map reveals that this site has had many uses over the years. Most of it is considered industrial or manufacturing use. This further insinuates that these properties have contaminates in the soils due their old/current use. The shops along Richard St. are closed and abandoned. Phillip's Metals has relocated under the name of PSC Metals. There are two office buildings and a residential building in use on the north-west end of property. Consideration needs to be taken during the design phase to ensure that these businesses remain operational during redevelopment of the site.

Topography & Land Formations

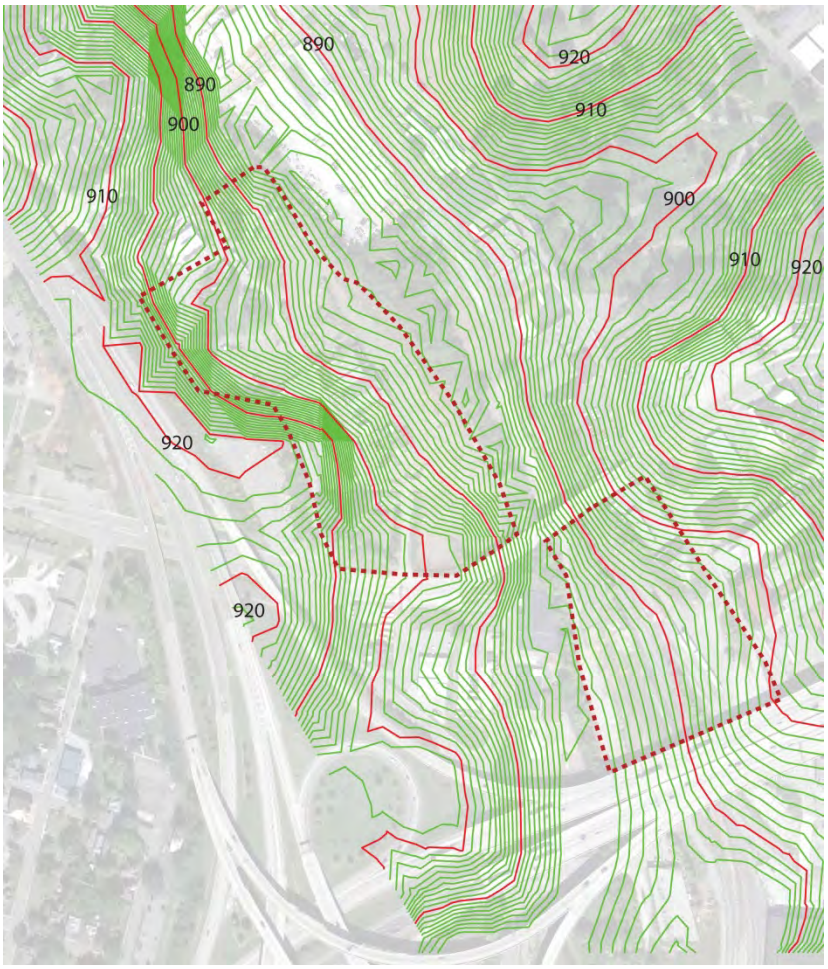

Figure 49: Map showing site topography

Land Formations

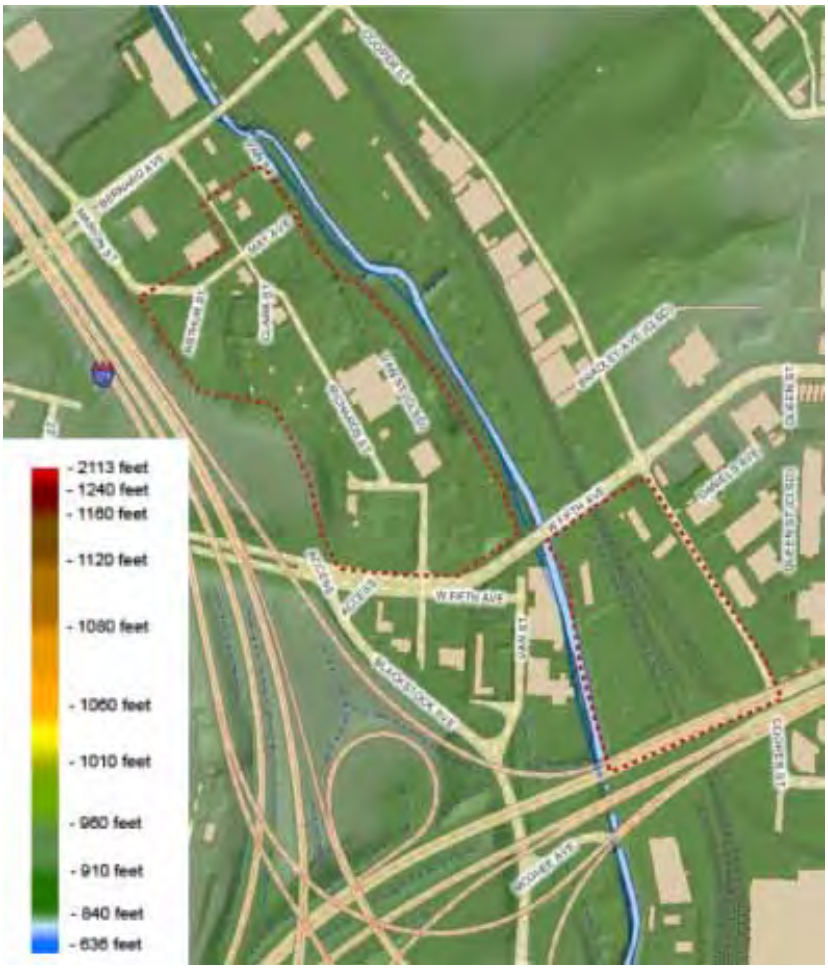

Figure 50: Map showing site land formations (kgis.org)

The site topography reveals that these sites sit within the bottomlands of the project area as the creek bottom is the lowest point. Not much topographical change exists but the fact that the land slopes towards the creek should be taken into consideration because the chemicals in the soil washes into 2nd Creek.

Vegetative Cover

Figure 51: Map showing current vegetative cover

The vast majority of the vegetative cover on site is along its borders. The creek is surrounded by invasive plants and weeds. The plants up against the 1-275 viaduct and the West 5th Ave Bridge provide a decent air quality buffer and noise barrier against the incoming traffic. This a good thing but more attractive plant material should be put in place to beautify the area.

Impervious Surfaces

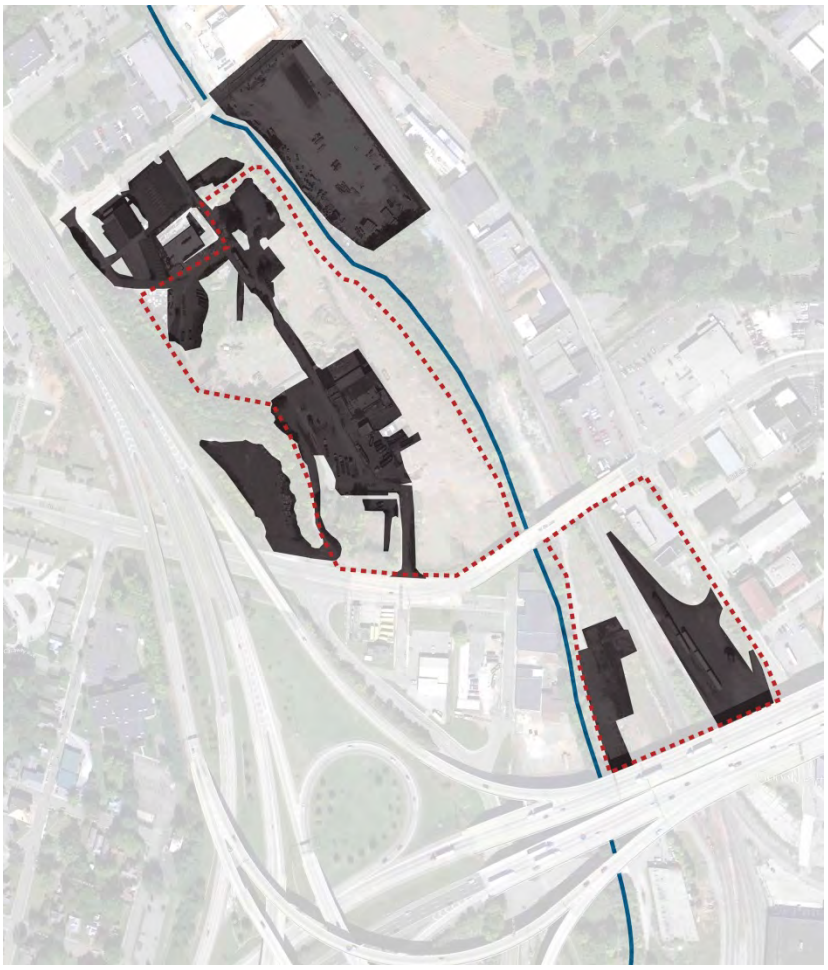

Figure 52: Map showing site imperviousness

Impervious surfaces are abundant within the project perimeter. This mainly consists of roads, withered concrete foundations and asphalt parking lots. Implementing pervious surfaces (once the soil condition becomes less of a problem) should be considered to promote sustainable design and eliminate the amount of chemicals washed into 2nd creek.

Existing Circulation

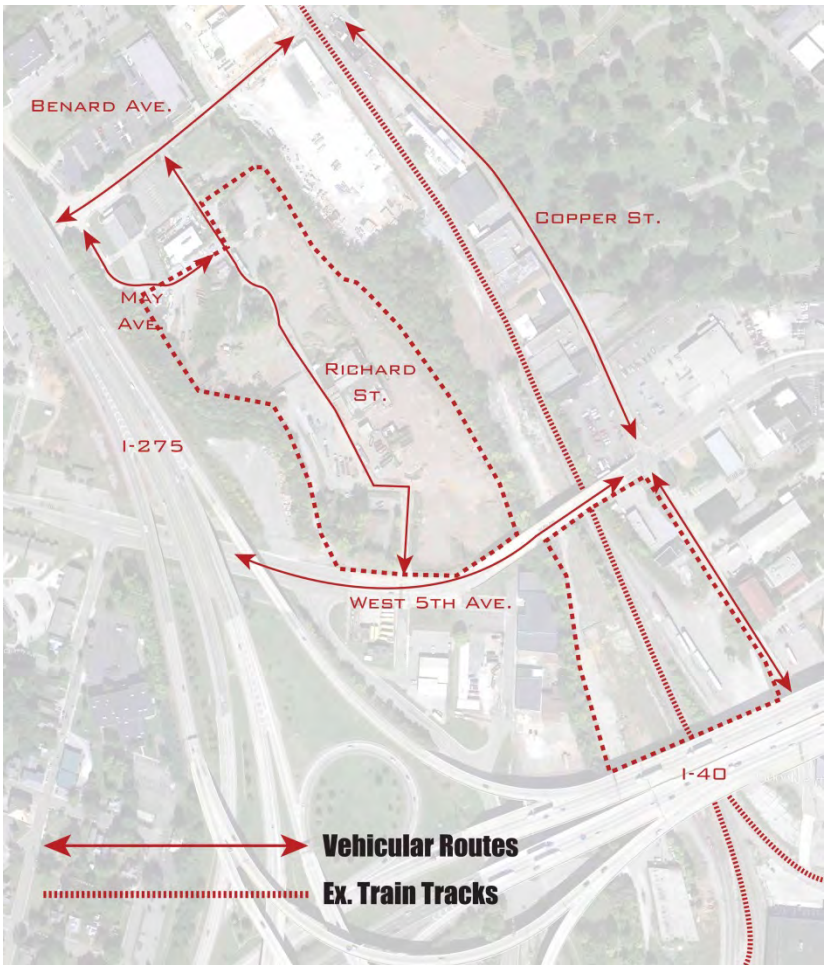

Figure 53: Map of site circulation

Currently there are no pedestrian friendly thoroughfares that lead individuals to the site or that encourage exploration through it. This has to change to inspire visitors to use the space. While streets and two major highways pass along the borders of the site, only one small, underutilized road goes through the area. The existing train tracks travel through the vacant lot between West 5th Ave and I-40. This is a concern when pedestrian safety is considered.

CHAPTER VI
SITE ANALYSIS & ASSESSMENT

Based on the findings from the site inventory, analysis was conducted to gain a better understanding of the sites chosen for remediation and reclamation.

Site Analysis

Site Topography and Hydrology

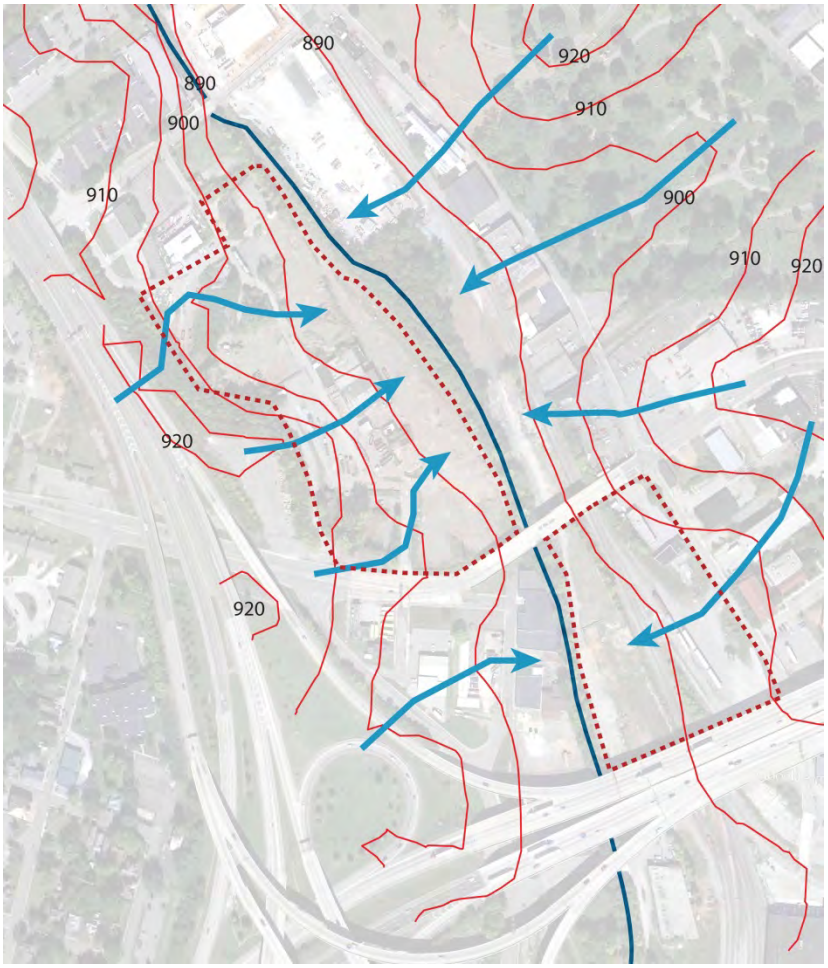

Figure 54: Map of site hydrology

As stated before, the topography and land formations reveal that this site sits within bottomlands. During a storm event runoff will surge to this area. One concern is the amount of water flowing from adjacent properties into 2nd Creek which is the lowest point on the site. Debris and soil contaminants wash into the

watershed in the progress. For these types of situations, a properly designed riparian buffer zone would eliminate these concerns.

The establishment of a riparian buffer would also help with the problem of flooding if the proper plants are chosen. This would help set a good boundary between the creek and the surrounding infrastructure.

Vegetative Cover

The inventory of existing site vegetative cover revealed that the creek is surrounded by many invasive plants. A selection of native plants will encourage a healthy riparian ecology, stream bank structure and provide aesthetic value. While the plants located near I-275 and the West 5th Ave Bridge blocks noise from the freeway and improves air quality, more quality plants can achieve the same goal.

Pedestrian Circulation

Pedestrian circulation is important for the success of this project. Based on the circulation studies conducted, there is a lack of pedestrian friendly infrastructure throughout the entire study area. These sites are no different. To remedy this situation more pedestrian friendly avenues need to be implemented.

Land Use and Land Cover

It has already been determined that more affordable housing and mixed use landscapes are needed in this area for the redevelopment of this brownfield site based on the study conducted by the *The Nine Counties. One Vision. Social Service Task Force*. With the creek within close proximity of the sites it would be more ideal to implement more impervious surfaces when hardscaping is needed. This would establish a more sustainable landscape because problems associated with runoff will be addressed and maintained through design.

Assessment

The conditions of the Phillip's Metal and G-36 site have been identified. Eliminating the pollutants in the soil and those washing into 2nd Creek is the main priority. The site cannot be used for socio-economical upliftment of the people in the neighborhoods if they can't come into contact with it due to the presence of pollution. Once this is changed then the redevelopment of the site can begin. The Tennessee Brownfield Redevelopment Toolbox was used to acquire more knowledge on the process of transitioning from the remediation to the redevelopment stage.

CHAPTER VII

SITE REMDIATION & RECLAMATION

Phase 1 – Cleaning the Site

Once steps 1 and 2 mentioned in the Tennessee Brownfield Redevelopment Toolbox are completed, the next phase involves the cleaning of the site. For the sites chosen this includes improving the quality of the soil, groundwater, creek and air. Once the conditions are identified, steps should be taken to make the best out of the project area. For this site this would include:

- Removing debris left over from scrap metal yard
- Removing invasive plant material
- Identify condition of existing infrastructure and probability of reuse
- Demolishing/Renovating old buildings
- Conducting tests on soil, air, and groundwater and creek water to determine what contaminants plague the site
- Taking samples and running lab tests to help determine what plants and microbes to add into the soil to help with the overall remediation of the site.

This step could take 3 months to a year to complete.

Figure 55: Section cut through Phillip's Metal Site showing cleanup phase

Phase 2 - Remediation

There are several remediation techniques to use on brownfield land. The choice of what technique to use depends on the site conditions, what the site will be used for after successful remediation rates are achieved and many other factors. Knowing that the soils are damaged by a wide away of chemicals and the project is aimed at socio-economic upliftment, the following remediation techniques were chosen:

Phytoremediation

Phytoremediation involves the use of vascular plants, algae and fungi to remove degrade or contain hazardous wastes in soil, sediments, surface water and groundwater. The majority of the process takes place in the rhizosphere (region of the soil in contact with the roots of a plant) via metabolic processes. There are several different phytoremediation procedures which include hydraulic control, phytodegradation, phytoextraction, phytostabilization, phytovolatilization, rhizodegredation and rhizofiltration.

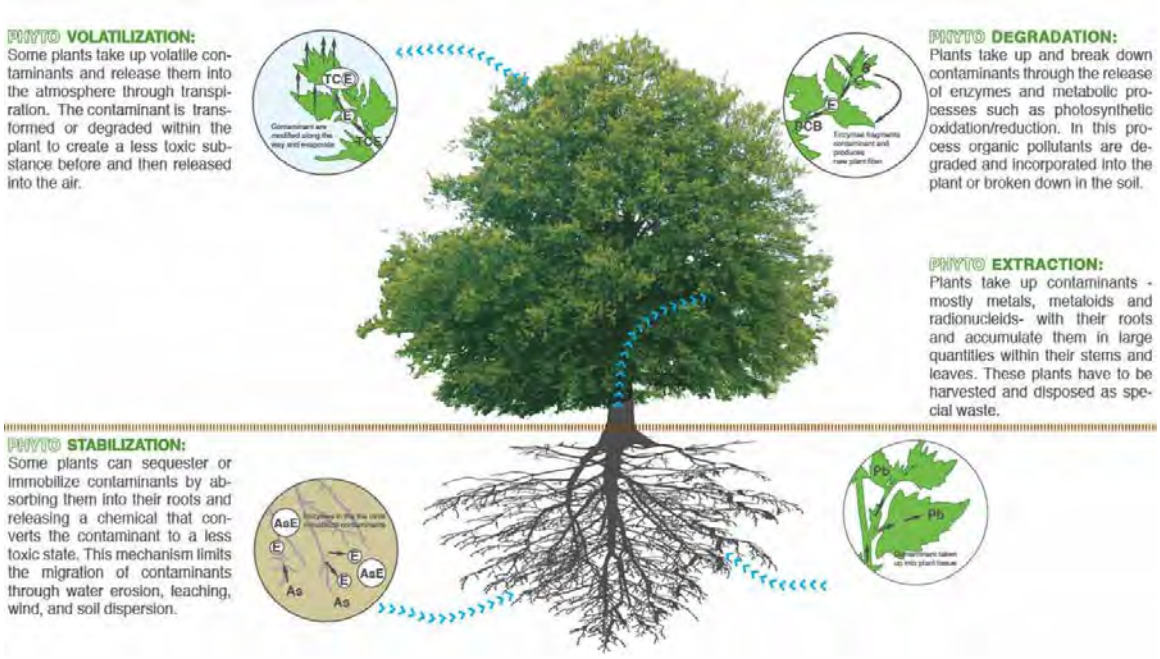

Figure 56: Diagram showing the different phytoremediation processes (www.youarethecity.com)

Phytoremediation is becoming popular to use on brownfield sites due to several factors. It is an in-situ treatment (on site) which decreases the risk of contaminants leaving the vicinity as opposed to ex-situ (off site) techniques. This is important in case the site is located within a populated area. It is also known to treat a wide range of chemicals that include:

- Petroleum hydrocarbons
- Benzene, toluene, ethylbenzene, and xylene (BTEX)
- Polycyclic aromatic hydrocarbons (PAH)
- Polychlorinated biphenyls (PCB)
- Trichloroethene (TCE) and other chlorinated solvents
- Ammunition wastes and explosives
- Heavy metals

- Pesticide waste
- Radionuclides
- Nutrient wastes (such as phosphates and nitrates)

In some cases phytoremediation can destroy most or all of these pollutants therefore leaving minimal or no residual contamination (EPA, Brownfields Technology Primer: Selecting and Using Phytoremediation for Site Cleanup, pg. 5). Another key feature of the procedure is that the installation, operating and maintenance can be low (short-term and long-term). In some instances other remediation procedures can cost up to 20 times more than phytoremediation techniques. Most importantly phytoremediation involves traditional farming techniques to install and can be aesthetically pleasing. Wetlands, forests, grasslands, etc. can be used in design schemes to enhance or restore the physical appearance of brownfields sites.

There are some considerations and limitations to phytoremediation. One of the most prominent is the time it can take for the process to clean the site due to the fact that plants have to establish themselves. The success of achieving appropriate remediation rates depends on a several factors like soil acidity, weather, rainfall rates, type of contaminants located on site, future land use, etc. Phytoremediation is limited to shallow soil depth and groundwater therefore deeper soil depths are more difficult to work with. To our benefit, the conditions found on the sites chosen for this project are suitable for phytoremediation. Overall, phytoremediation is a great way to treat hazardous contaminants on site if time and soil depth aren't major constraints. It can be an aesthetically pleasing, low cost approach to brownfield remediation.

Bioremediation

Bioremediation is a remediation technique that uses natural processes to eliminate harmful chemicals in the environment (EPA, A Citizen's Guide to Bioremediation, 2001). The main catalysts that cause the breakdown of wastes during the process are called microbes. Microbes are "microscopic bugs" that live in soil and water (EPA, A Citizen's Guide to Bioremediation, 2001). They thrive off hazardous materials found in the environment such as gasoline and oil. The microbes are effective at breaking down these chemicals and changing them into water or harmless gasses like carbon dioxide. They perform this aerobically (in an oxygenated environment) or anaerobically (in a non-oxygenated environment).

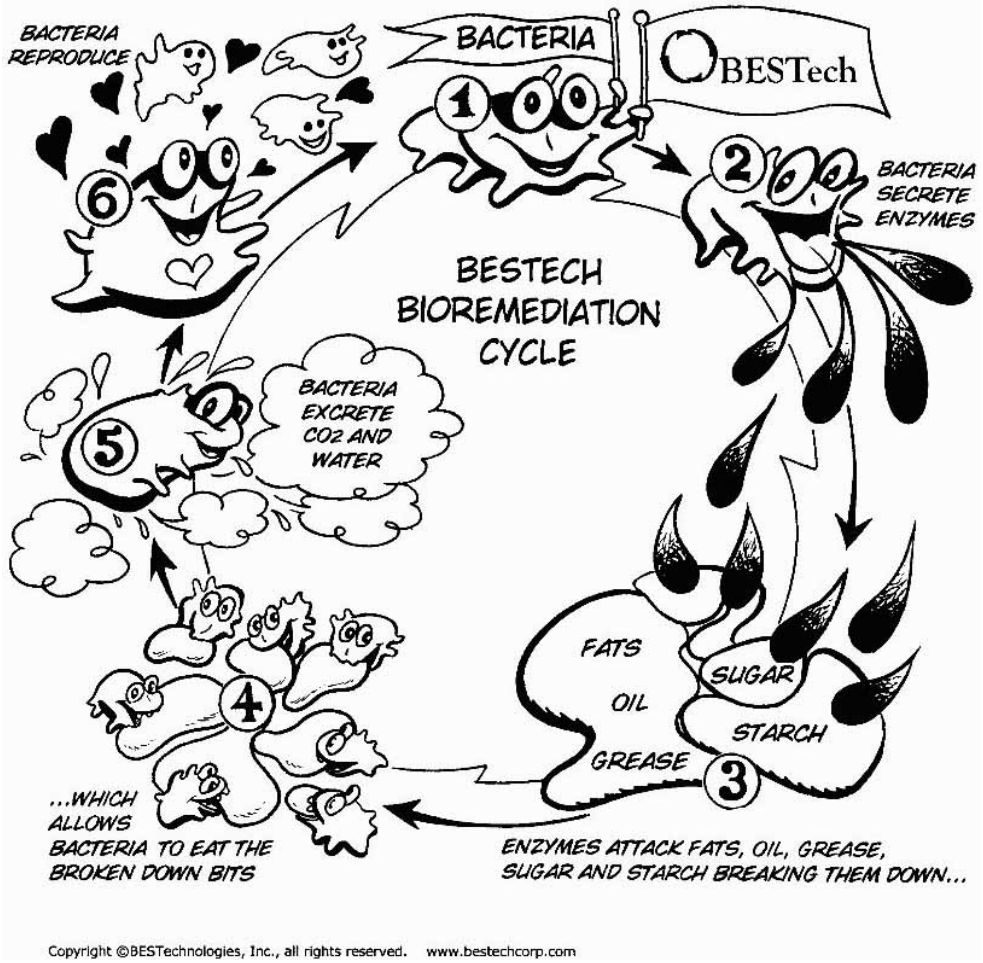

Figure 57: Diagram showing the bioremediation process (www.bestechcorp.com)

This technique is considered new, innovative and site specific. For this process to function properly there are many factors to consider. The right temperature, nutrients/fertilizers and amount of oxygen must be available in the soil or groundwater. Information revealed in Table 2 and the soil inventory (Figure 46) shows that this technique can be used on the sites chosen for this project. This is important due to the fact that these conditions are necessary for the microbes to perform their job. If conditions are not right the process will take longer to or they will eventually die off. To elude this situation air, nutrients or other substances can be pumped underground. Other techniques used to induce bioremediation include soil mixing, pumping groundwater into tanks for remediation, pumping nutrients and air into wells (biosparging) or soil (bioventing), etc.

Parameters	Optimum Levels
Available Soil Water	25-85% holding capacity
Oxygen	Aerobic >0.2 mg/l DO Anaerobic: O_2 < 1%
Redox Potential	Aerobes & Facultatives: > 50mv Anaerobes: < 50mv
pH	5.5-8.5
Nutrients	C:N:P of 120:10:1
Temperature	15-45° C (Mesophiles)

Table 2: Normal microbial requirements for bioremediation

(Hazen, Bioremediation: The Hope and the Hype, 2012)

Bioremediation is a safe approach to brownfield remediation because the microbes used naturally occur in the environment (EPA, A Citizen's Guide to Bioremediation, 2001). They pose no threat to people in the surrounding area. No dangerous chemicals are used during the process and most of the nutrients added are common fertilizers (nitrogen and phosphorus) used on lawn and gardens. Large amounts of equipment are not needed and the application is fairly inexpensive when compared to other forms of remediation. It can be used as in-situ treatment (on site) or ex-situ (off site) technique. The only setback to bioremediation is the amount of time it can take. Depending on site conditions the process can take several months up to several years for satisfying results (EPA, A Citizen's Guide to Bioremediation, 2001). Even though this technology is considered fairly new, many brownfield sites today have been revitalized using bioremediation.

One example of bioremediation is land farming. Land farming is defined as biologically treating uncontained soil by utilizing farming methods (Hazen, 2012). This includes aeration of the soil (tilling) and applying fertilizer and/or organisms. This can be an on or off site treatment. On site treatment is limited to relatively shallow layers of soil where reasonable oxygen levels can be obtained. On site land farming usually involves excavating the contaminated soil over an impermeable material in a cleared area for treatment. This could be used to teach people farming skills that they could utilize in other ways around their neighborhood.

Common soil contaminants that have been treated via land farming include but are not limited to:

- Petroleum Hydrocarbons
- Gasoline / BTEX
- Diesel, Jet Fuel, and Heating Oil

- Crude Oil and Bunker C
- PAHs
- Chlorinated Solvents

Table 1: Microorganisms having biodegradation potential for xenobiotics.

Organism	Toxic chemicals	Reference
Pseudomonas spp	Benzene, anthracene, hydrocarbons, PCBs	Kapley *et al.*, 1999; Cybulski *et al*, 2003
Alcaligenes spp	Halogenated hydrocarbons, linear alkylbenzene sulfonates, polycyclic aromatics, PCBs	Lal and Khanna, 1996
Arthrobacter spp	Benzene,hydrocarbons,pentachlorophenol, phenoxyacetate, polycyclic aromatic	Jogdand, 1995
Bacillus spp	Aromatics, long chain alkanes, phenol, cresol	Cybulski *et al.*, 2003
Corynebacterium spp	Halogenated hydrocarbons, phenoxyacetates	Jogdand, 1995
Flavobacterium spp	Aromatics Aromatics Naphthalene, biphenyl	Jogdand, 1995 Jogdand, 1995 Jogdand, 1995
Azotobacter spp	Aromatics, branched hydrocarbons	Jogdand, 1995
Rhodococcus spp	benzene,cycloparaffins	Dean-Ross *et al.*, 2002
Mycobacterium spp	Hydrocarbons	Sunggyu, 1995
Nocardia spp	Aromatics Aromatics Hydrocarbons, polycyclic hydrocarbons	Park *et al.*, 1998 Jogdand, 1995 Jogdand, 1995
Methosmus sp	Phenoxyacetate, halogenated hydrocarbon diazinon	Jogdand, 1995;
Methanogens	PCBs, formaldehyde	Ijah, 1998
Xanthomonas	PCBs, polycyclic aromatics, biphenyls	Jogdand, 1995

Table 2: Microbes utilize the heavy metals:

Microorganism	Elements	References
Bacillus spp.	Cu, Zn	Philip *et al.*, 2000; Gunasekaran *et al.*, 2003
Pseudomonas aeruginosa	U, Cu, Ni	Sar *et al.*, 1999; Sar and D`Souza, 2001
Zooglea spp.	Co, Ni, Cd	Gunasekaran *et al.*, 2003
Citrobacter spp.	Cd, U, Pb	Yan and Viraraghavan, 2001; Gunasekaran *et al.*, 2003
Chlorella vulgaris	Au, Cu, Ni, U, Pb, Hg, Zn	Pearson, 1969; Gunasekaran *et al.*, 2003
Aspergilus niger	Cd, Zn Zn, Ag, Th, U	Guibal *et al.*, 1995; Gunasekaran *et al.*, 2003
Pleurotus ostreatus	Cd, Cu, Zn	Favero *et al.*, 1991
Rhizopus arrhizus	Ag, Hg, P	Gunasekaran *et al.*, 2003
Stereum hirsutum	Cd, Pb, Ca	Gabriel *et al.*, 1994 and1 996
Phormidium valderium	Cd, Co, Cu, Ni	Gabriel *et al.*, 1994 and 1996
Ganoderma applanus	Cd, Pb Cu, Hg, Pb	Gabriel *et al.*, 1994 and 1996
Volvariella	Zn, Pb, Cu	Purkayastha &

Table 3: Different microorganisms/microbes and chemicals that they treat

(Kumar, Bisht, Joshi, Dhewa, Review on Bioremediation of Polluted Environment: A Management Tool, 2010)

Bioremediation and Phytoremediation

There are many examples of bioremediation and phytoremediation being used simultaneously to remediate contaminated sites. Both techniques can be used simultaneously to treat polluted soil, air and water. An example of this is included in the appendix.

Capping

Capping involves placing a cover over contaminated material such as the waste buried at a landfill (EPA, A Citizen's Guide to Capping, 2001). Such covers are called "caps." Caps do not clean up the contaminated material. Instead they hold them in place so it will not come into contact with people or the environment.

Sometimes digging up and removing contaminated material can be difficult or expensive. Instead, a cap will be placed over it to keep it in place. A cap works in three main ways:

1. It stops rainwater from seeping through the hazardous material and carrying the pollution into the groundwater, lakes or rivers.

2. It stops wind from blowing away the hazardous material.

3. It keeps people and animals from coming into contact with the contaminated material and tracking it off the site.

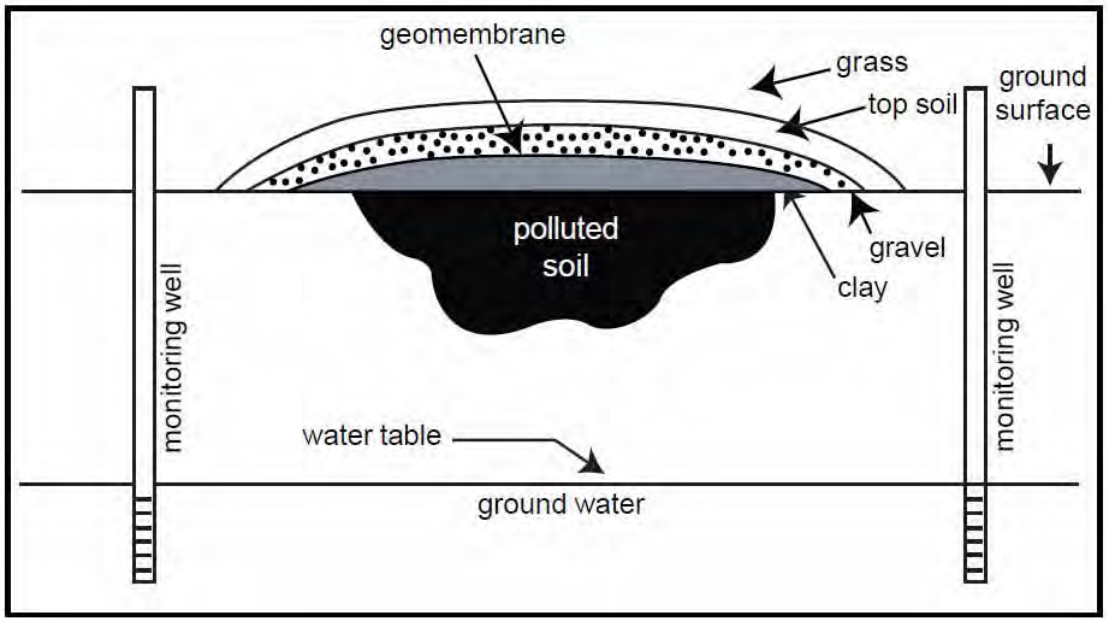

Figure 58: Diagram of capping technique (epa.gov)

Caps have been used at hundreds of sites because they are an effective method for keeping waste contained. Caps are a part of a cleanup remedy. Building a cap could take several days or up to a few months. Once installed, frequent maintenance should be conducted to ensure that the product used to cap is doing its job.

Examples of materials used for capping are concrete, asphalt and vegetation or turf (phyto-capping) (EPA, A Citizen's Guide to Capping, 2001).

The particular site chosen for this project can utilize this technique because buildings foundation, roads, sidewalks, vegetation etc. will be implemented. These different items can serve a dual purpose of being utilized for whatever needed on site and capping chemicals. Once again, routine maintenance should be conducted to make sure these systems are well maintained.

Phase 2 Summary

The processes chosen for remediation are capping, phytoremediation and bioremediation. While capping can be an instant solution, the other two categories could take longer depending on how severe the site is contaminated. Using bioremediation and phytoremediation together can be an effective method because it can speed up the process of plant growth and remediation. Combinations of bioremediation and phytoremediation have been proposed for certain areas of the site.

- Phytoremediation & Bioremediation
    - Can be used to establish a riparian buffer
    - Cleans up a wide variety of contaminants
    - Is an on-site treatment
    - The surrounding communities can get involved and learn from experience
    - There is potential for city and UT to get aid from the government to conduct tests
    - Is cheaper than other methods

Individually, based on information gathered from the case studies that were conducted on using phytoremediation and bioremediation, these processes could take anywhere from 2 to 20+ years to successfully remediate the soil.

- Capping

Capping has been proposed in other areas due to the cities plans to implement buildings and other forms of urban infrastructure in the area. Other benefits include:

- It is quick solution for soil contamination
- It is an on-site treatment
- It contains the hazardous materials
- A wide variety of materials can be used for this purpose (asphalt, concrete, turf, etc.) (EPA, A Citizen's Guide to Capping, 2001)

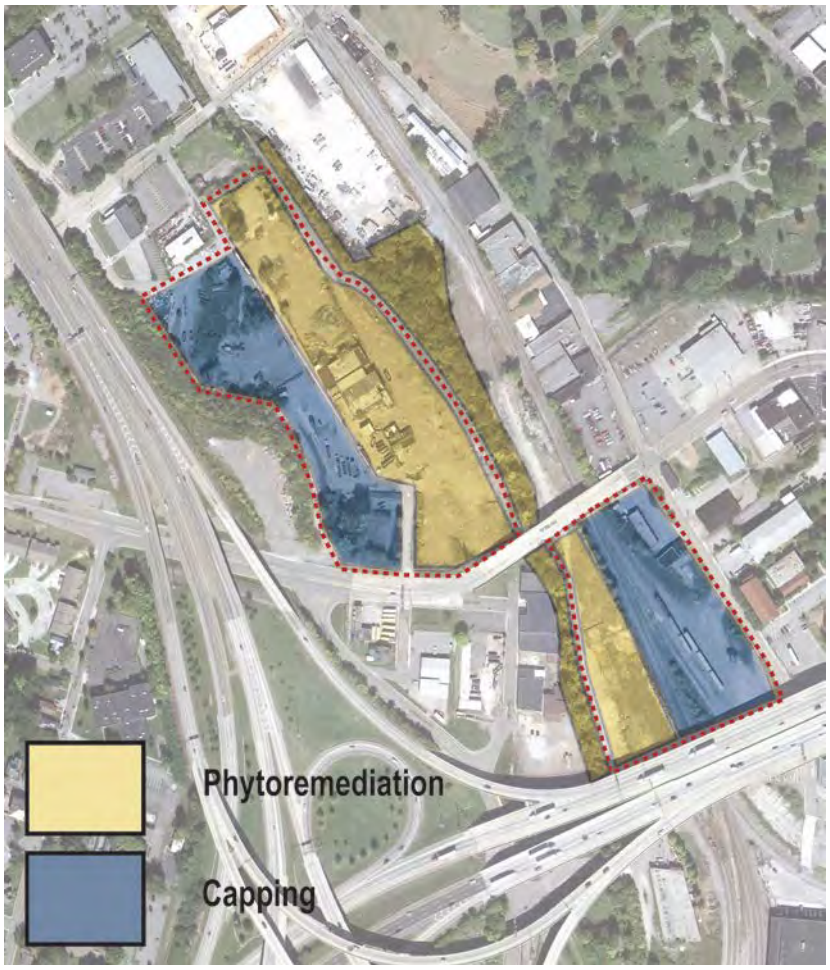

Figure 59: Map showing locations of remediation techniques

Figure 60: Section through Phillip's Metal site showing remediation phase

Phase 3 – Redevelopment

After contamination on the site is reduced to levels low enough to allow human activity, the redevelopment phase can be start. If certain spaces within the brownfield site have low contamination levels then redevelopment and remediation can take place simultaneously. From the various case studies, the amount of time it takes for pollution levels to deteriorate depends on what pollutants are present, how much is present and the remediation technique chosen. If the right remediation technique is chosen for a given circumstance then it would decrease the wait time. This process can take anywhere from 6 months to 20+ years.

Redevelopment involves designing the site and installing what is needed for the recommended use. For this site, we acknowledged the city's plan of expanding the downtown area (Knoxville Community Development Corporation, Proposal to the EPA for Brownfields Grant Fund, 2010). Based upon studies conducted throughout the project Knoxville needs affordable housing, green space, a riparian buffer zone for the 2nd Creek watershed and spaces that encourage recreational activity (The University of Tennessee College of Social Work Office of Research and Public Service, Nine Counties. One Vision. Focus Group Results and Final Needs Analysis, 2004).

CHAPTER VIII

PROJECT NARRATIVE

This chapter explains the process of how the remediation and redevelopment techniques will be applied to the Phillip's Metal and G-36 sites. The specific steps needed for these applications are showcased along with their expected outcomes. At the end of the chapter the potential that this transformation provides for the upliftment of local citizens (in form of affordable housing, recreational space, improved forms of transportation, etc.) is explained.

Riparian Restoration

Figure 61: Pictures of debris along 2nd Creek corridor

The 2nd Creek watershed is one of the most impaired water systems in Knoxville due to the fact that its drainage basin includes the industrial corridor and surrounding neighborhoods. The contaminants found within the neighboring sites wash into the creek which destroys the natural environment that it once supported. Before the site can be used for human purposes such as housing and recreation, the condition of the soil and creek must be addressed.

To repair the damaged water body, a riparian buffer must be implemented and maintained. This buffer will establish a structured stream bank system as well as filter the storm water and enhance water quality. The land that surrounds the creek must be restored.

A 3-zone riparian buffer system using restoration strategies appropriate for Tennessee streams was recently developed for Beaver Creek, an urban stream also located in Knox County. This system will also be applied to this project along the 2nd Creek corridor.

Method: Beaver Creek Riparian Restoration Zoning

Using guidelines referenced from the TN MS-4 Working Group Water Quality Buffer Zone Policy and The EPA Aquatic Buffer Model Ordinance, the Beaver

Creek Task Force along with other government agencies created a standard for riparian restoration that the state of Tennessee is highly in favor of.

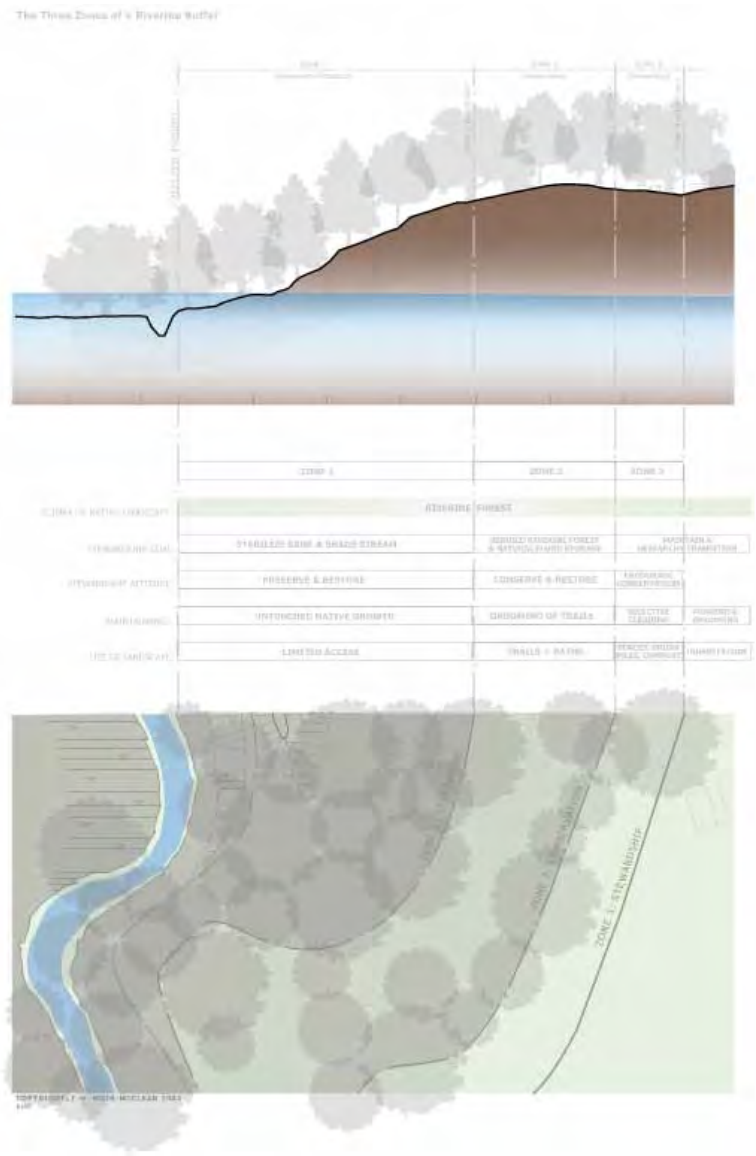

Figure 62: Diagram of guidelines for Beaver Creek riparian restoration

(Source: http://ww2.tdot.state.tn.us)

The plan uses different zones and establishes how each one can be used to satisfy the needs of the environment and people who want to interact with the creek. In the Beaver Creek riparian restoration zoning method the floodplain was incorporated into Zone 2 (Conservation Zone). For this thesis project it is important to minimize human contact within this zone therefore the floodplain will be incorporated in Zone 1 (Preservation Zone). The altered zoning system is described in the following text.

Description of Zones: Beaver Creek Riparian Zone Best Practices (2006)

Goals For:	*Zone 1*	*Zone 2*	*Zone 3*	*Developed Land*
Local Habitat	Riverine Forest			Groomed Woodland
Stewardship	Stabilize bank, shade stream	Rebuild riverine forest & natural flood storage	Healthy transitions from conserved places to developed places	
Flood Mitigation	Stabilize banks Reduce contaminant loads	Store floodwater	-Reduce imperviousness -Increase stormwater filter, treatment	
Stewardship Attitude	Preserve & restore	Conserve & restore	Encourage conservation	
Maintenance	Untouched native growth	Grooming of trails	Selective clearing	Mowing & grooming
Use of Landscape	Limited access	Trails and paths	Fences, hedgerows, compost	Human use & activities

Table 4: Goals for Beaver Creek riparian corridor

Zone 1

The first zone is labeled the Preservation Zone, and it measures from the edge of the creek's floodway. The goal of this zone is to stabilize erosion prone slopes and banks next to the stream, and to preserve and restore wetlands, vegetation, and high-value habitat adjacent to the stream. Minimum width of this zone is 25 ft. and it expands to include steep slopes, and riparian habitat like wetlands adjacent to the bank identified by NWRA or other agencies as requiring preservation.

Zone 2

The second zone is a labeled the Conservation Zone. This zone measures from the Preservation Zone boundary. Minimum width is established by the order of the stream and the FEMA floodplain boundary. Second Creek is a first-order stream, so minimum width is 50 ft. plus FEMA floodplain areas that extend beyond this minimum width. Either the 100-year or 500-year FEMA flood-way boundary is used to establish the furthest extend of this zone. In watersheds like Second Creek, where flooding is an issue and development increases the amount of impervious surface, the use of the 500-year FEMA floodway boundary is strongly recommended. The Conservation Zone conserves and restores floodplain areas that receive storm water during floods, while encouraging greenway corridor and passive recreation.

Zone 3

The final zone, zone 3, is labeled the stewardship zone and it serve as a buffer between the designated riparian restoration zone and any adjacent urban infrastructure. Including landscape elements that encourage stewardship, enrich experiences of habitat, filter or treat storm water, and provide privacy buffers between private and shared uses are encouraged in this zone.

Project Application: Second Creek Riparian Restoration

Due to the success of Beaver Creek restoration efforts, this zoning system was chosen as a guide for the adaption of a similar system within the sections of the 2nd Creek watershed found on the Phillip's Metals and G-36 Brownfield sites. However, the Beaver Creek riparian zone didn't address remediation issues so the zoning system had to be altered to achieve the goals of this project. The changes that were made include:

1. Changing the overall use of Zone 2

2. Inserting a separate greenway corridor to accommodate the greenway use removed from Zone 2

Zone 1: Preservation Edge

- Stabilizes stream bank
- Heavy activity in this area is not allowed but the creek's edge will be approachable once it is stabilized and contamination levels are suitable for use

Zone 2: Conservation

- Rebuilding natural flood storage capacity
- Remediation zone that is restricted to human use until contaminations levels are suitable for use

Greenway Corridor

- Allows for safe passage through the site
- Contains plants that help capture and remediate storm water

Zone 3: Stewardship

- Acts as a barrier between riparian zones (including greenway corridor) and urban infrastructure (roads, buildings, etc.)

Figure 63: 2nd Creek Riparian Zone map

Beaver Creek Riparian Restoration Zoning

Phillips Metals / G-36 2nd Creek Riparian Restoration Zoning

Figure 64: Comparison of the Beaver Creek riparian restoration zone & the 2nd Creek riparian restoration zone

Description of Zones: Phillip's Metals / G-36 2nd Creek Riparian Zone

Goals For:	*Zone 1*	*Zone 2*	*Greenway Corridor*	*Zone 3*
Local Habitat		Riverine Forest		
Stewardship	Stabilize bank, shade stream	Rebuild riverine forest & natural flood storage	Provide safe, non-vehicular corridor for the community	Healthy transitions from conserved places to developed places
Flood Mitigation	Stabilize banks Reduce contaminant loads	Store floodwater	Increase storm water filter, treatment	-Reduce imperviousness -Increase storm water filter, treatment
Stewardship Attitude	Preserve & restore	Conserve & restore	Encourages conservation	Encourage conservation
Maintenance	Untouched native growth	Remediation planting	Grooming of trails	Selective clearing
Use of Landscape	Limited access	*No access or paths	Trails and paths	Fences, hedgerows, compost

***Access to this site can be allowed once contamination levels are low enough for human use**

Table 5: Goals for Phillip's Metal / G-36 2nd Creek corridor

Zone 1

The first zone is labeled the Preservation Zone, and it measures from the edge of the creek's floodway. The goal of this zone is to stabilize erosion prone slopes and banks next to the stream, and to preserve and restore wetlands, vegetation, and high-value habitat adjacent to the stream. Minimum width of this zone is 25 ft. and it expands to include steep slopes, and riparian habitat like wetlands adjacent to the bank identified by NWRA or other agencies as requiring preservation. On this segment of 2nd Creek, located on the Phillip's Metals and G-36 sites, there are no steep slopes, wetlands or habitats that expand the boundary so Zone 1 is the minimum of 25 ft. wide across the site.

Zone 2

The second zone is a labeled the Conservation Zone. This zone measures from the Preservation Zone boundary. Minimum width is established by the order of the stream and the FEMA floodplain boundary. Second Creek is a first-order stream, so minimum width is 50 ft. plus FEMA floodplain areas that extend

beyond this minimum width. Either the 100-year or 500-year FEMA flood-way boundary is used to establish the furthest extend of this zone. In watersheds like Second Creek, where flooding is an issue and development increases the amount of impervious surface, the use of the 500-year FEMA floodway boundary is strongly recommended. The Conservation Zone conserves and restores floodplain areas that receive storm water during floods. Unlike the Beaver Creek riparian corridor, Zone 2 of this proposed riparian corridor will primarily serve as remediation zones. During the remediation phase no contact is allowed in this area. When contamination levels are reduced and considered safe, this zone can become a place for passive recreation.

Greenway Corridor

Due to the fact that greenways are not a recommended use in Zone 2, it is necessary to insert a greenway corridor on the Phillip's Metal and G-36 site. This corridor will be 25 ft. wide to implement a greenway and plantings that encourage floodwater mitigation and storm water filtration.

Zone 3

Zone 3 is labeled the stewardship zone and it serve as a buffer between the designated riparian restoration zone and any adjacent urban infrastructure. Including landscape elements that encourage stewardship, enrich experiences of habitat, filter or treat storm water, and provide privacy buffers between private and shared uses are encouraged in this zone.

Riparian Plantings

To maximize the performance of the phytoremediation process, the proper plants must be chosen. To succeed in this task the chemicals affecting the site must be identified and plants native and/or can adapt to the weather conditions in that particular region (USDA Zone 7 in this case) should be used. The plants must be able to handle the chemical intake.

Frequent maintenance should be conducted to the chosen plants are able to handle chemical intake. Dead plants should be inspected to verify if the chemicals are too overwhelming for the plants. Maintenance also involves watering, weeding, adding fertilizer and/or microbes to the soil, etc. to aid the plant in the phytoremediation process since chemical intake can potentially cause high levels of stress within the plant. These necessary tasks can provide jobs for the people in the surrounding neighborhoods.

This was done for the brownfield sites in this project. The plants chosen are listed below. The plant names listed in red are native to the area.

Figure 65: 2nd Creek Riparian Zone 1 section

Stream Bank

Trees	
Scientific Name	**Common Name**
Acer Rubrum	Red Maple
Acer saccharinum	Silver maple
Betula nigra	River Birch
Carpinus caroliniana	Ironwood
Fraxinus pennsylvanica	Green Ash
Gleditsia triacanthos	Honey Locust
Liquidambar styraciflua	American Sweet Gum
Liriodendron tulipifera	Tulip Poplar
Platanus occidentalis	Sycamore
Quercus rubra	Northern Red Oak
Salix nigra	Black willow

Shrubs	
Scientific Name	**Common Name**
Alnus serrulata	Alder
Arundinaria gigantean	River Cane
Calycanthus floridus	Sweetshrub
Cephalanthus occidentalis	Buttonbush
Lindera benzoin	Spicebush
Physocarpus opulifolius	Ninebark
Sambucus canadensis	Elderberry

Grasses, Sedges & Ferns	
Scientific Names	**Common Name**
Carex cherokeensis	Cherokee Sedge
Carex plantaginea	Plaintain–leaved sedge
Polystichum acrostichoides	Christmas fern
Tripsacum dactyloides	Eastern Gammagrass

Red Maple

Contaminant Treated:
Leachate, Hydrocarbons

Silver Maple

Contaminant Treated:
VOCs

River Birch

Contaminant Treated:
Herbicide bentazon

Green Ash

Contaminant Treated:
PAHs

Honey Locust

Contaminant Treated:
Lead

Northern Red Oak

Contaminant Treated:
Hydrocarbons

American Sweet Gum

Contaminant Treated:
Perchlorate

Black Willow

Contaminant Treated:
Perchlorate

Plaintain-Leaved Sedge

Contaminant Treated:
Petroleum Hydrocarbons, BTEX, VOCS, Heavy Metals

Tulip Poplar

Contaminant Treated:
Petroleum Hydrocarbons

Cherokee Sedge

Contaminant Treated:
Petroleum Hydrocarbons
BTEX, VOCS, Heavy Metals

Figure 66: Zone 1 - Stream Bank Plant List

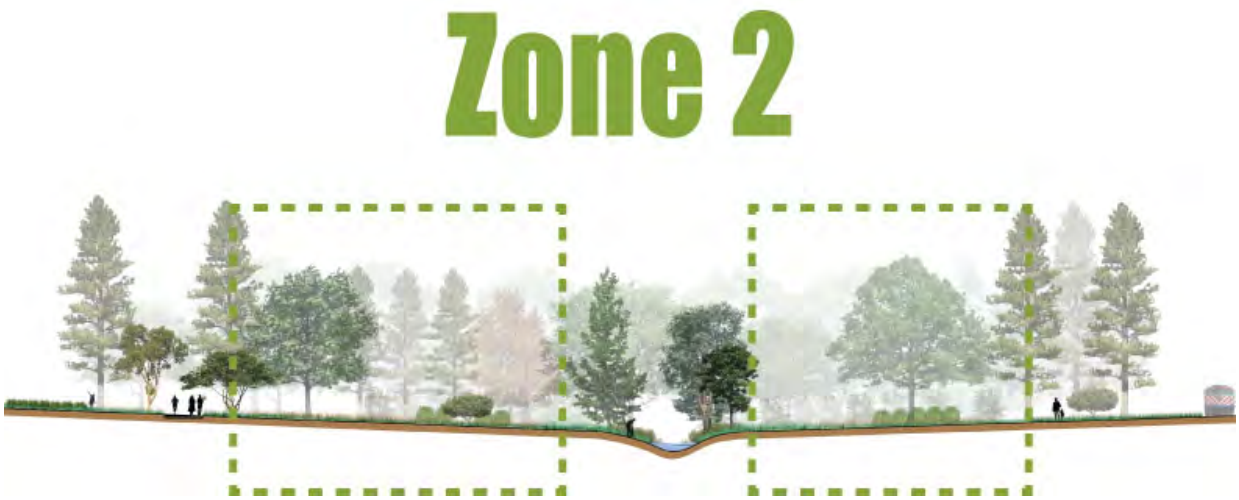

Figure 67: 2nd Creek Riparian Zone 2 Section

Flood Plain - Wetland Meadow

Trees	
Scientific Name	**Common Name**
Asimina triloba	Paw Paw
Crataegus mollis	Hawthorn
Ilex opaca	American Holly
Morus rubra	Red Mulberry
Quercus phellos	Willow Oak
Viburnum prunifolium	Northern Blackhaw
Viburnum rufidulum	Southern Rusty Blackhaw

Hawthorn

Contaminant Treated:
Hydrocarbons

American Holly

Contaminant Treated:
PAHs, PCBs

Shrubs	
Scientific Name	**Common Name**
Cephalanthus occidentalis	Button Bush
Cornus amomum	Silky Dogwood
Hypericum prolificum	Shrubby St. John's Wort
★ *Itea virginica*	Virginia Sweetspire
Viburnum dentatum	Arrowwood Viburnum

Red Mulberry

Contaminant Treated:
Cadmium

Silky Dogwood

Contaminant Treated:
Hydrocarbons

Grasses, Sedges & Ferns	
Scientific Names	**Common Name**
★ *Andropogon gerardii*	Big Bluestem
Andropogon virginicus	Broom Sedge
Chasmanthium latifolium	River Oats
Elymus canadensis	Canada Wild Rye
Eupatorium dubium	Joe-Pye Weed
Helianthus maximilianii	Maximillian Sunflower
★ *Panicum virgatum*	Switch Grass
★ *Sorghastrum nutans*	Indian Grass
Vernonia altissima	Tall Ironweed

Big Bluestem

Contaminant Treated:
PAHs

Maximillian Sunflower

Contaminant Treated:
Heavy Metals, PAHs

Broom Sedge

Contaminant Treated:
Petroleum Hydrocarbons, BTEX, VOCS, Heavy Metals

Switch Grass

Contaminant Treated:
Hydrocarbons, PAHs

Canada Wild Rye

Contaminant Treated:
Hydrocarbons, PAHs

Figure 68: Zone 2 - Flood Plain - Wetland Meadow Plant List

Forested Meadow

Flowering Dogwood

Contaminant Treated:
Halogenated Hydrocarbons

Indigo Bush

Contaminant Treated:
Lead

Mapleleaf Viburnum

Contaminant Treated:
Heavy Metals

Hop Sedge

Contaminant Treated:
Petroleum Hydrocarbons, BTEX, VOCS, Heavy Metals

Trees	
Scientific Name	**Common Name**
Aesculus flava	Yellow Buckeye
Carya ovate	Shagbark Hickory
Cercis canadensis	Redbud
Cornus florida	Flowering Dogwood
Diospyros virginiana	Persimmon
Halesia carolina	Carolina Silverbell
Juglans nigra	Black Walnut
Juniperus virginiana	Red Cedar
Pinus taeda	Loblolly Pine
Rhamnus caroliniana	Carolina Buckthorn
Rhus glabra	Smooth Sumac

Shrubs	
Scientific Name	**Common Name**
Amorpha fruticosa	Indigo Bush
★ *Hypericum frondosum*	Golden St. John's Wort
★ *Rhus aromatic*	Fragrant Sumac
Symphoricarpus orbiculatus	Coralberry
★ *Viburnum acerifolium*	Mapleleaf Viburnum

Grasses, Groundcovers & Flowers	
Scientific Names	**Common Name**
★ *Asclepias tuberosa*	Butterfly Weed
★ *Carex lupulina*	Hop Sedge
Osmunda cinnamomea	Cinnamon Fern
Polygonatum biflorum	Solomon's Seal
Tradescantia virginiana	Spiderwort
Scripus cyperinus	Woolgrass
★ *Scirpus validus*	Softstem Bulrush

Figure 69: Zone 2 - Forest Meadow Plant List

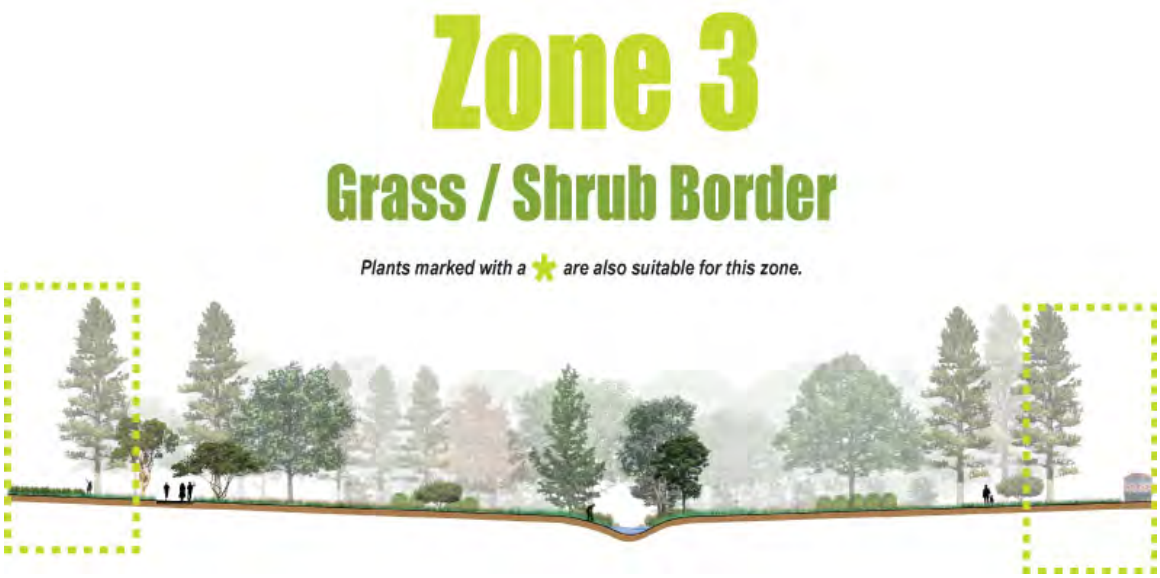

Figure 70: 2nd Creek Riparian Zone 3 section

That plants that are marked with a green asterisk in Figures 66, 67 and 68 are suitable for this zone as well as those along the greenway corridor.

Urban Infrastructure

Based on studies conducted throughout the project, Knoxville is in need of affordable housing, green space and landscapes that encourage recreational activity (The University of Tennessee College of Social Work Office of Research and Public Service, Nine Counties. One Vision. Focus Group Results and Final Needs Analysis, 2004). All of these were implemented in the proposed design.

Masterplan

Figure 71: Final masterplan

This masterplan reveals the overall scheme of the reclaimed Phillip's Metal site and the G-36. Along with the riparian zone and greenway there are mixed use

buildings, a new road system, sidewalks wide enough for pedestrian flow, open spaces for recreation and more.

Remediation Program

Figure 72: Diagram showing where phyto/bioremediation is used

The areas where phytoremediation and bioremediation are taking place makes up the majority of the site. These areas are not limited to those purposes. One of the most important aspects of the large masses of plants is that it offers much more to the surrounding communities and the entire city. Not only are the plants aesthetically pleasing as they help beautify the area but they help create jobs in several ways. Phytoremediation is a new technique and research is necessary to find what plants are capable of handling chemical exposure. The plantings will have to be monitored and maintained. This can help create jobs for people in the neighborhoods. Not only will they have the potential to gain employment but they will learn about their natural environment in the process. The plantings provide the opportunity for the local neighborhoods and city to get involved in community

gardening/planting. After contaminations levels are safe for human use, gardening plots can be set up for different neighborhoods and organizations (school groups, churches, community centers, etc.) to tend to and take care of. This has the potential to provide the citizens (mainly those living in the low income neighborhoods) something to cherish and take pride in thus restoring the since of community.

Figure 73: Diagram showing where capping method is used

Capped sites include roads, paving and building foundations. This method seals the contaminants in place not eliminating the possibility people coming into contact with any hazardous material. The site should be monitored every 5 years to ensure that the capping system is functioning properly.

Site Use Program

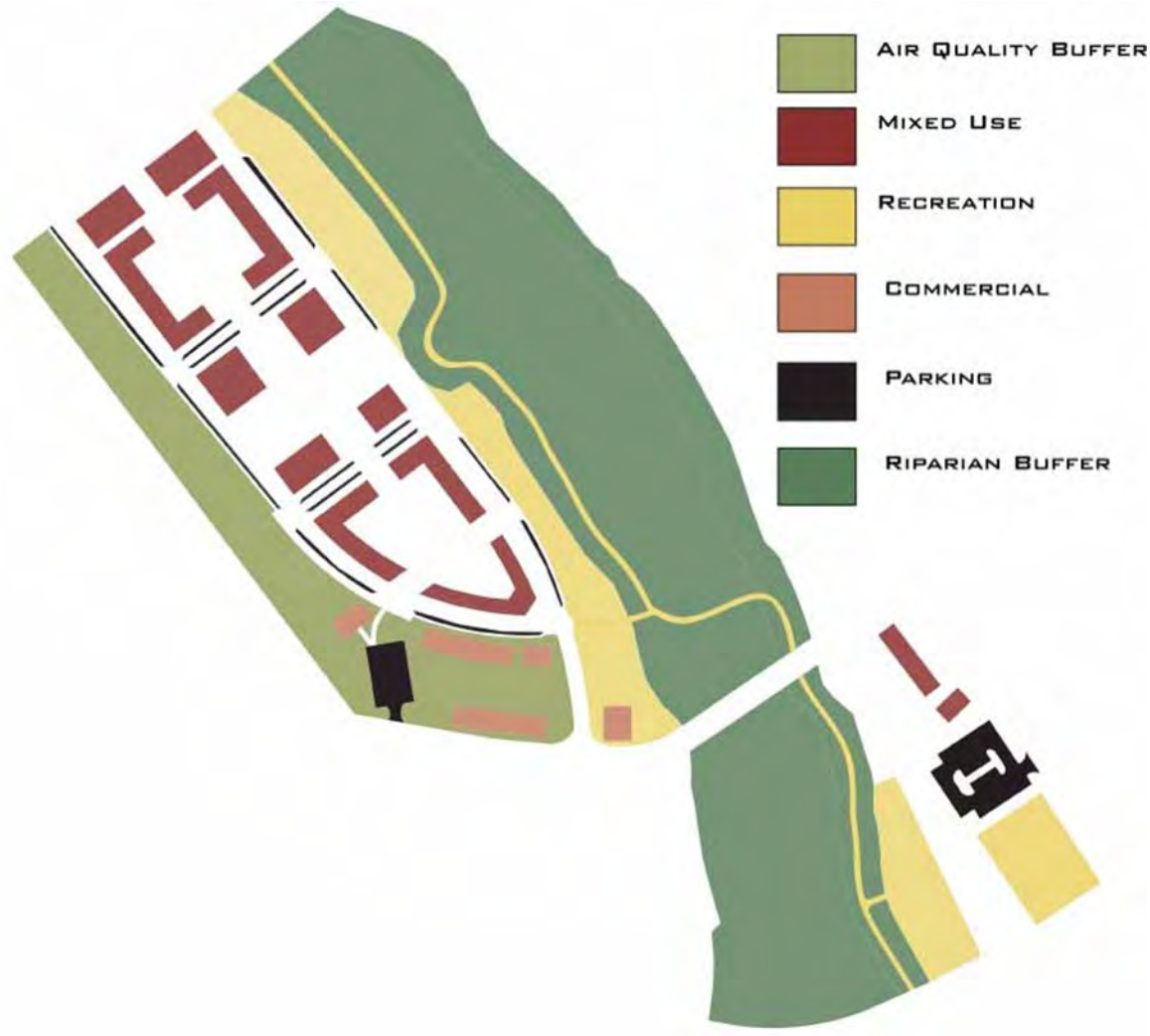

Figure 74: Diagram of site programming

This diagram reveals site programing. The majority of the site is utilized for the riparian and air quality buffer.

Figure 75: Section showing the different uses of the site

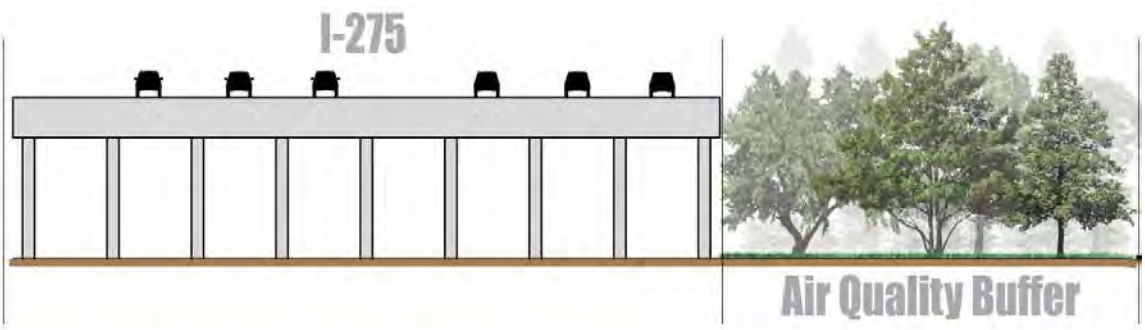

Figure 76: 1-275 and Air Quality Buffer Section

Although the primary function of the air quality buffer is to help decrease the amount of air pollution and providing a noise barrier against the existing I-275 corridor, it provides aesthetic beauty to the site as well.

Figure 77: Riparian Buffer Section

Zone 2 of the riparian buffer allows for a greenway to run through it. Open recreational spaces are located within the landscape (including Zone 3 of the riparian buffer) which promotes the practice of different activities. This includes the greenway, open fields and a small sports field.

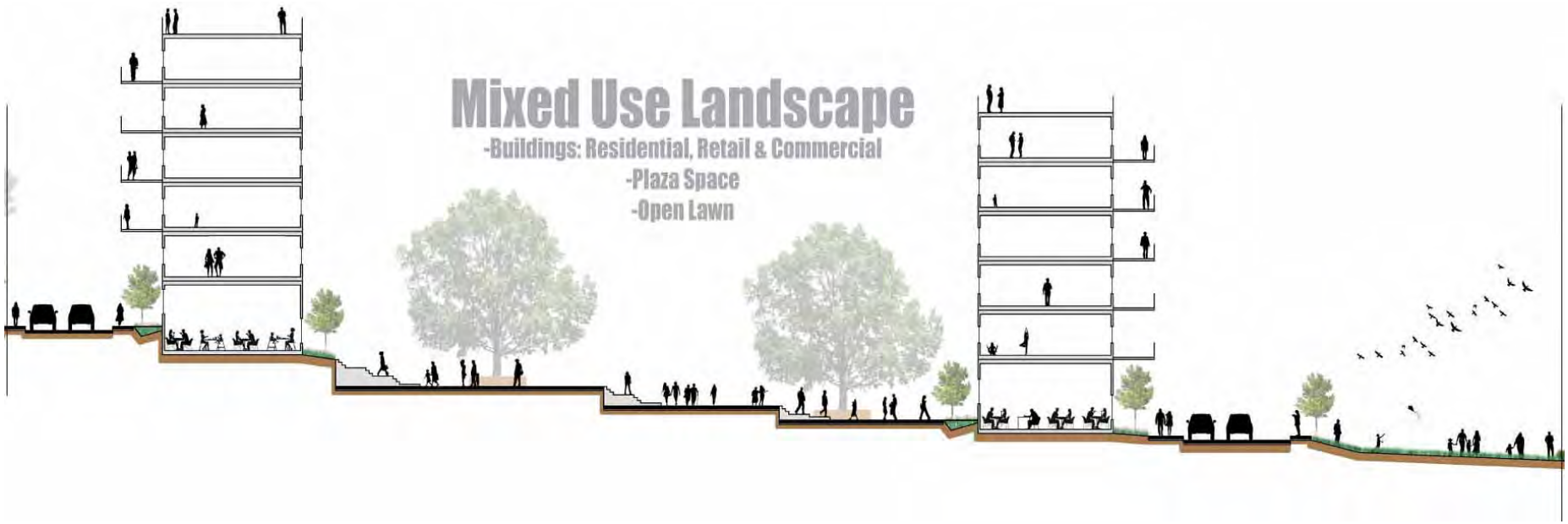

Figure 78: Developed (residential, retail & commercial buildings) section

The mixed used buildings create an open market space with large plazas in between the buildings. The buildings are a mix of commercial and residential. The shops and stores will be located on the bottom floor while the affordable living spaces will be on the upper levels. This gives the occupants the opportunity to overlook the landscape.

Accessible Transportation

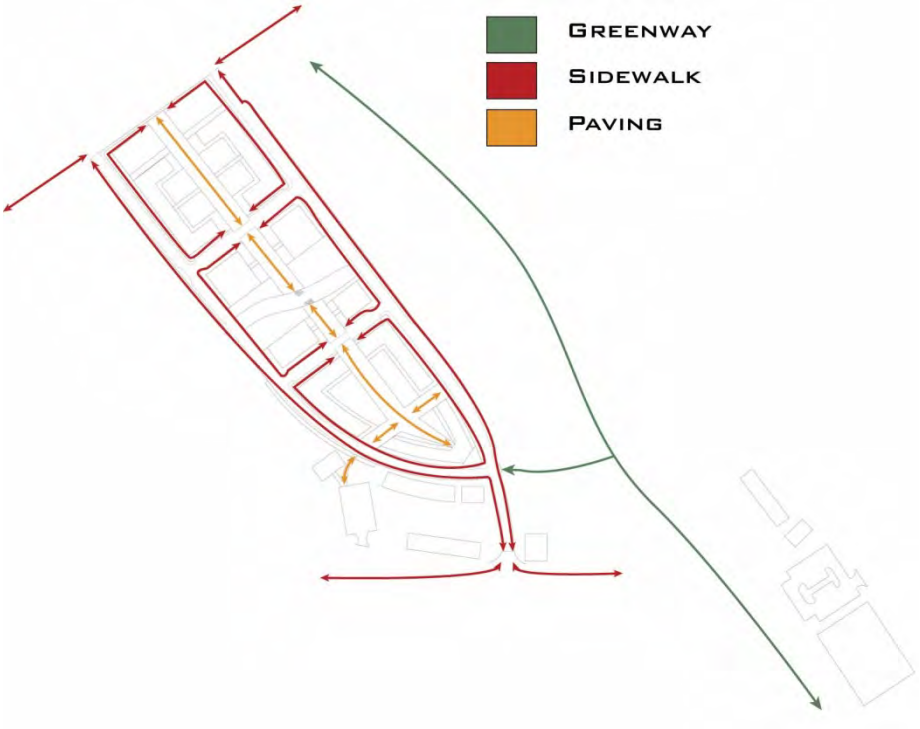

Figure 79: Diagram showing pedestrian / bike circulation

Adequate pedestrian transportation was one of the main concerns throughout the entire project. This proposed design offers pedestrian-friendly avenues for people to enjoy (see Figure 24 for sidewalk improvement suggestions).

The sidewalks are wide enough to encourage people to walk around the property when they can. They are also wide enough to allow for biking, walking, running, etc. while being used by multiple people.

The greenway coming through the area is an improvement as it offers a bicycle and pedestrian connection to other sections of the city. Now people from the less fortunate neighborhoods have safe access to one another, all the resources offered by the downtown area and the university without having to rely on a vehicle. This has the potential to create a more socially connected city.

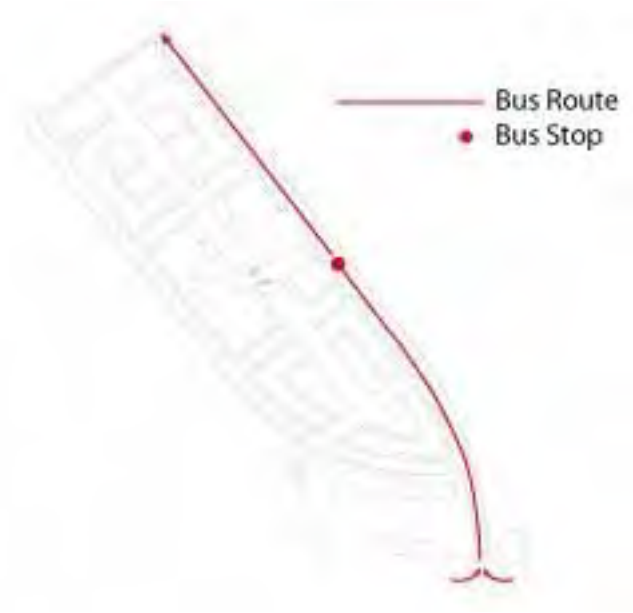

Figure 80: Diagram showing proposed bus route

To encourage more people to ride the bus and the implementation of more bus stops in the area a bus pick up and drop off point was added. This would create more ways of getting to and from the site.

The bus route altered in the map above is bus route # 12 (see Figure 30). This route passes through and has stops within the Lonsdale, Beaumont and Mechanicsville neighborhoods. Some of the most popular destinations throughout the route include Knoxville College, Malcolm Martin Park, the L.T. Ross Building, Murphy Branch Library and the 640 Plaza Shopping Center. This is appropriate since these neighborhoods are some of the most burdened with financial obligations and other means of transportation may be difficult to obtain.

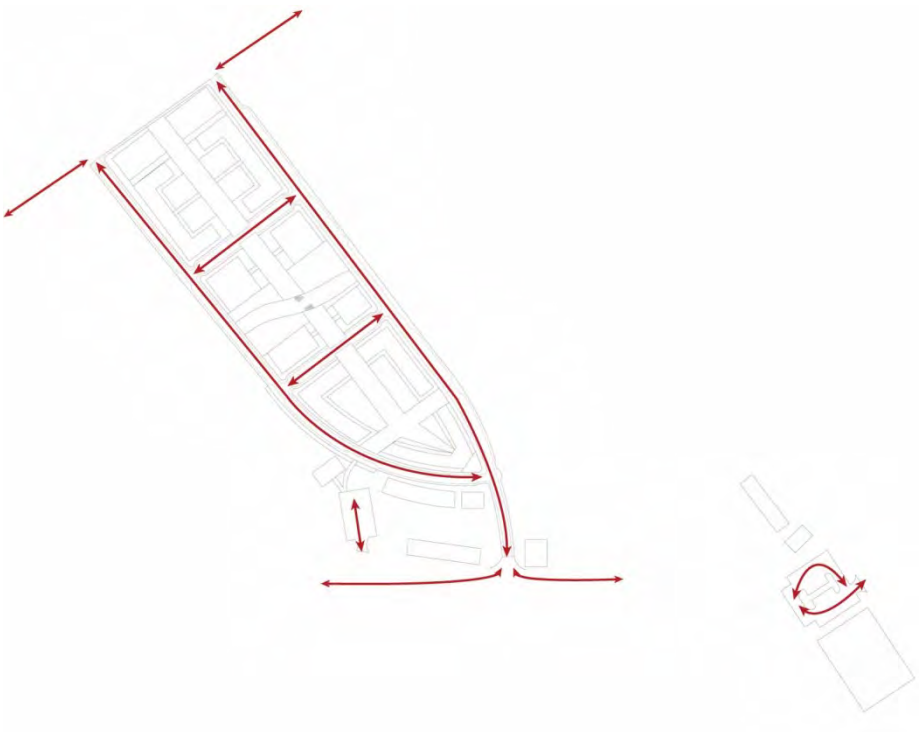

Figure 81: Diagram showing vehicular circulation

The proposed design offers sufficient vehicular transportation so that the site becomes more supportive of the different user groups that may visit on a daily basis. As shown earlier in Figure 15 there is adequate vehicular transportation throughout the project area. This make the proposed site accessible to potential users located throughout the city that will have to rely on vehicular transportation.

Figure 82: Before and after pictures of site (1)

Figure 83: Before and after pictures of site (2)

CHAPTER IX

CONCLUSIONS & RECOMMENDATIONS

The purpose of this thesis is to investigate if socio-economic revitalization can be achieved through brownfield reclamation. From the late 19th century to the early 20th century, the core of major cities in the United States witnessed a tremendous growth in population size and industrial infrastructure. After the Great Depression and suburbanization, many industrial sites were abandoned and left to become undesirable locations.

Today these forgotten brownfield sites are a handicap to the environment because they have been ignored. Most of them are too hazardous to allow human contact within a certain vicinity. As the structures that once housed workers and manufacturing products crumble to the ground, more chemicals and pollutants seep into the soil and local water bodies. The quality and state of the environment degrades in the process. This has devastating effects on the health of local citizens, ecosystems and neighborhoods if not rectified.

This is unfortunate for individuals who have no other option but to live near said locations. As in the case of the I-275 Industrial Corridor in Knoxville, TN, some of the most impoverished neighborhoods in the city are within close proximity to land and water bodies affected by chemicals that originated from brownfield property. This can impair the progression of the neighborhoods as economic constraints placed on the citizens grow due to diminished land and housing values. In certain situations tax dollars are invested in expanding nicer areas of the city instead of making improvements where it is needed the most.

The design proposal offered in this text showcases many ways that the Phillip's Metals and G-36 site can be utilized for the socio-economic benefit of both the local neighborhoods and entire city. First and foremost, a clean and safer environment is created. Even if all that was done to the site was eliminating the debris and contaminant sources, it would still provide improvements to the area. The soil would be more stable to sustain plant life and the water that flows in 2nd Creek would become suitable to support wildlife.

The forms of bioremediation chosen for this site (phytoremediation and bioremediation) would assist in the rehabilitation of the environment. The plants will aid in cleaning the soil, air and water while the nutrients added in the soil would assist the plants in establishing themselves in the harsh environment. The plant material also provides an aesthetic value to the area if it is properly maintained. With the proper plants in place the damaged ecosystem within the 2nd Creek watershed will start to naturally rehabilitate itself. Once the riparian

zone is established it will continue to protect the creek from stream bank erosion and contaminated runoff.

In this project bioremediation serves a dual purpose. Since land farming is a form of bioremediation it can become a teaching tool to educate people in the neighboring communities and throughout the city on farming techniques. Even though it is unlikely that this notion would motivate individuals to conduct farming on a grand scale, it could inspire people to start small home gardens or even community gardens. If these communities were given further guidance on how to grow and maintain crops it could promote scenarios where people could make financial gains by selling their produce. These ideas could potentially stimulate the community socially since it would take a collective effort (communication amongst the members) to take care of the gardens. A step further and the idea of creating jobs and/or incentives for the citizens could come into fruition. Children can even get involved to witness natural processes in their environment therefore better connecting them to the natural world.

Placing new infrastructure (buildings, roads, etc.) on a site usually requires manual labor. An intense amount of effort would go into the construction and maintenance of the proposed site which would generate several jobs in the process. As in the case of Al-Azhar in Cairo, Egypt, certain jobs can be set aside for individuals in the neighboring communities. A task of this proportion would require skilled professionals such as landscape architects, engineers, architects, chemists, horticulturalists, etc. to achieve the goal of redeveloping on these brownfields. Once the infrastructure is operating a new wave of economic opportunities is presented.

In the proposed design, the implementation of mixed-use buildings is a key component. This will create a unique setting where affordable housing and commercial units fuse into one festive market space that offers many experiences (similar to that of Market Square in Downtown Knoxville). The affordable housing would allow residents to save money while the owners of the businesses make economic gains. The city would benefit from tax money newly redeveloped land would generate. The current state of the property is actually costing the city environmentally and economically since it is not being used or maintained.

Another component of the proposed design that presents beneficial opportunities for the city is the 2nd Creek greenway. With the city of Knoxville making plans to expand its greenway network, the addition of the 2nd Creek greenway will help link several key locations. This includes the proposed site, the University of Tennessee and the downtown area. The greenway could become a bridge that connects several distinct groups of people together. Students from the University of Tennessee, business people from the downtown area and the determined citizens from underprivileged neighborhoods now have a positive way of

interacting with each other. One example of this is a businessman from the downtown area meeting someone from the Beaumont neighborhood and their conversation leads to the individual from Beaumont learning about a potential job offered downtown.

The greenway will also offer a safe North-South route for users to walk, run, bike and participate in other forms of pedestrian friendly activity. This could potentially reduce the number of motor vehicles used as well as the pollutants that they create. If greenway users rely on it as a main source of transportation it will also cut down on the amount of gas that has to be purchased. These forms of recreational activity and exercise promote healthy lifestyles decisions. The open space adjacent to the riparian zone along with the small sports field will provide users with opportunity to get involved in recreational activities.

Providing users with alternative means of reaching the site is important. By using the improvements suggested in this paper, the proposed landscape can be enjoyed by everyone in the city. The improved streets and sidewalks will provide friendlier vehicular routes and pedestrian routes through the project. This has the possibility of further promoting people to bike, skate, run, walk, or jog to their destinations. The bus route and bus stop provided by the design promotes a safer environment by eliminating the usage of motor vehicular and their emissions.

The final product provided by this thesis document presents viable solutions to environmental, social and economic concerns in Knoxville, TN. With large amounts of brownfield land available to reclaim it would benefit the city to not only expand the downtown areas but provide its citizens with a unique experience in the process. Taking into account the people living in disadvantaged neighborhoods, there are ways to involve them in the process. Their environment could potentially become a tool used to deliver them from all of the harsh conditions. Landscapes, such as the one proposed in this text, can do just that.

Figure: Map showing potential of brownfields being transformed into useable land

Hopefully the ideas shared in this document can lead to decisions helpful for positive urban growth. What would be ideal is that this project would become a catalyst or blueprint for the reclamation of the remaining brownfield land. This would offer the city of Knoxville more land to create spaces that can be used to uplift the people and the environment in many ways.

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APPENDIX

Case Study - Athens, GA (Using Bioremediation and Phytoremediation Simultaneously)

On May of 1997, a gasoline spill occurred 1 mile outside of Athens, Ga. The gasoline flowed across the ground surface and into a ravine that carried water to a wetland on the banks of Bear Creek. The environmental staff of the pipeline company implemented a phytoremediation system but failed to prepare the soil prior to the installment. This led to many of the new trees dying within the first growing season.

Members of PLANTECO Environmental Consultants, LLC were contacted to find a more suitable method for this problem. They redesigned a phytoremediation system that could treat hydrocarbons in soils and groundwater on site. Deep planted bare root trees (willows and cottonwoods) were used on the ravine while local wetland plants (wooly bull rush, rush, native sedge and cattail) and white willows were planted in the wet contaminated soils. The deep rooted plantings encouraged rhizodegradation in the contaminated soils and aquifer. A 6 ft. security fence was set up around the test area to prevent animals and humans from entering the site.

To help fuel this system, aged compost made of nitrogenous peanut shell and cow manure was placed in the holes before planting. This provides nutrients required for proper soil conditions and stunted activity in the rhizosphere. The presence of algae on the soil surface indicated that conditions were right for vigorous plant growth. Irrigation was delivered to the site through a pumping system set up along Bear Creek. The flow of the creek was slowed using rock and wooden gabions and the pumping system delivered water to the plants. The gabions also prevented soil erosion and helped accumulate water during rainstorms that assisted the wetland plants to flourish.

After 2 growing season the trees were nearly 20 ft. in height. There were also significant changes in the amount of contaminates found in the soil and groundwater samples. Low levels of BTEX were found in the soil and water with 85% of the original content being eradicated in the two growing seasons. After three growing seasons over 90% was gone. Samples from plant material was taken and later showed that VOC’s were taken up by the plants and were either phytodegraded to non-phytotoxic material and/or evapotranspired. This mixed system of phytoremediation and bioremediation proves that these methods can be cost effective as well as a rapid solution to hydrocarbon contamination.

VITA

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