EMBRACING THE HISTORIC AND TOXIC LEGACIES OF A SVOCS-CONTAMINATED BROWNFIELD: USING LANDSCAPE INTERPRETATION TO EXPAND THE REDEVELOPMENT OF BOULEVARD CROSSING PARK

by

XURAN ZOU

(Under the Direction of Douglas Pardue)

ABSTRACT

As representative contaminants found at the brownfield sites, Semi-Volatile Organic Compounds (SVOCs) have negative effects on people that exposed to them. This thesis explores the potential of combining landscape interventions and conventional remedial strategies for SVOCs-polluted brownfields to enhance the remediation process while embracing the historic and toxic legacies of these sites. The research analyzes the potential of being combined with landscape interventions of different remedial strategies and provides possible design solutions. Relevant literature and cases are reviewed in this thesis and a conceptual design for Boulevard Crossing Park, a SVOCs-contaminated site, is provided to examine the possibility of such combination.

INDEX WORDS: landscape architecture, brownfield, historic legacies, toxic legacies

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XURAN ZOU

BLA, South China Agricultural University, China, 2012

A Thesis Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment

of the Requirements for the Degree

MASTER OF LANDSCAPE ARCHITECTURE

ATHENS, GEORGIA

2015

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XURAN ZOU

Major Professor: Committee: Douglas Pardue Alfie Vick Umit Yilmaz Ming Zhao

Electronic Version Approved:

Suzanne Barbour Dean of the Graduate School The University of Georgia August 2015

ACKNOWLEDGEMENTS

First, I would like to express the deepest appreciation to my major professor, Douglas Pardue, who guided me through the whole process of writing this thesis and provided illuminating views on a number of issues related to the thesis. I express my warm thanks to Professor Vick for his kindness of being the chair of my reading committee and his help on improving my thesis. I would also like to thank my committee member, Professor Yilmaz, for sharing his wisdom during the course and giving us a wonderful trip in Turkey. I would like to thank my committee member, Ms. Zhao, for sharing expertise, and valuable suggestions towards my thesis.

Most of all, I owe my thanks to my parents for their love and persistent support in my life.

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CHAPTER 1

INTRODUCTION

1.1 Background

Semi Volatile Organic Compounds (SVOCs), originate from manufacturing and agrochemical industries, are typical contaminants and always found in brownfield sites (Wei et al., 2012; Marks, Wujcik, & Loncar, 1994). Brownfields contaminated by SVOCs and common brownfields both have negative effects on the environment, public health, and social and economic environments. Although SVOC's negative effects on human health has received attention, its impact on the indoor environment warrants additional concern. This thesis investigates the site known as Boulevard Crossing Park, which is largely contaminated by SVOCs.

According to information given in the U.S. Environmental Protection Agency (EPA)'s website: there are many remedial strategies developed to deal with the SVOCs on the brownfields. However, most of these strategies only emphasize the cleanup process, which may demolish the toxic legacies and unique site characteristics of each site.

The Boulevard Crossing Park, as a part of the Atlanta BeltLine project, is originally a typical brownfield redevelopment site, whose historic and toxic past has been simply cleaned up for faster future reuse, resulting in the lost of its unique characteristic as a brownfield in the past. The historic and toxic legacies are unique site characteristics of a brownfield site, which deserve to be interpreted in brownfield redevelopment projects. This thesis uses the knowledge of landscape architecture to help create unique greenspace in the redevelopment of the SVOC

contaminated brownfield. More specifically, landscape intervention is used to enhance the performance of conventional remedial strategies while responding to the historic and toxic legacies of the site.

1.2 Research Questions

The main research question of this thesis is: how can landscape design interpret historic and toxic legacies of a SVOCs-polluted brownfield in the context of typical brownfield redevelopment. In order to understand how landscape interpretation can be combined with remedial strategies for SVOCs-contaminated brownfield sites, it is important to understand how remedial strategies specifically work and to evaluate their potential to be combined through landscape interventions. In short, what design potentials exist to combine remedial strategies with landscape interpretation?

Once such elements were decided, the most suitable remedial strategies that could be combined with landscape interventions could be chose. The second specific research question addresses these selected remedial strategies: How may remedial strategies be combined with landscape interventions, and how may historic and aesthetic values be addressed through such landscape interventions?

The third specific research question explores the real-world application of these ideas within the context of an actual SOVC-polluted site. A design solution for Boulevard Crossing Park based on the ideas generated from this research will be provided.

1.3 Limitations and Delimitations

1.3.1 Limitations

The first limitation of this thesis is time. The remedial strategies discussed in this thesis are those developed during the writing. However there are always newer and more advanced remedial strategies being developed all the time, so the remedial strategies discussed in this thesis may be incomplete and outdated.

The second limitation is the effects of the landscape interventions discussed in this thesis. The landscape interventions could help enhance the remedial process and more importantly, interpret the historic and toxic legacies of the site. However, the interventions could not treat site contamination individually. Rather, various landscape interventions that can be used in different contaminated materials are discussed. It is important to remember that sites contaminated with SOVCs do not have all of the aforementioned issues.

The third limitation is the Environmental Site Assessment (ESA) report of the Boulevard Crossing Park. Currently, only ESA I and ESA II reports have been conducted. These reports are limited in scope, as they only confirm the fact that the site is contaminated by SVOCs. They overlook the extent and depth of contamination.

1.3.2 Delimitations

The first delimitation is the type of brownfield sites. Although various brownfields need to be redeveloped, this thesis only addresses one particular type of brownfield—those contaminated by SVOCs- Thus, the strategies discussed in this thesis may not be suitable for other types of brownfield sites.

The second delimitation is the existing condition of the site. Georgia Power transmission lines go through the site, which pose additional danger to visitors. In order to ensure public safety, there must be a specifically designated space for activities beneath the power lines.

1.4 Methodology and Thesis Structure

The main research methods used in this thesis include a literature review, case studies, and a projective design. They are applied throughout different chapters.

Chapter 2 introduces the negative effects of brownfield sites, with an emphasis on those polluted by SVOCs. People's expectations about these brownfields are also introduced in this chapter. All these facts point out the necessity of introducing landscape interventions into the redevelopment process of SVOCs-polluted sites.

Chapter 3 introduces some successful brownfield and landfill redevelopment projects, which address the landscape intervention in different ways. Although these sites are not originally SVOCs-polluted sites, they still provide useful information about the introduction of landscape interventions into SVOC-contaminated sites. Also, the case studies may inform the potential combinations of the remediation strategies and landscape intervention for SVOCs polluted brownfield sites.

Chapter 4 evaluates the potential of combining SVOC with different remedial strategies of landscape interventions. Potential combinations of selected remedial methods and landscape interventions are also provided.

Chapter 5 includes a feasibility study of strategies from chapter 4 that are applied to a concrete design for Boulevard Crossing Park.

CHAPTER 2

BROWNFIELD AND SVOCS

Strategies for brownfield redevelopment projects are often distinctive from other types of landscape projects, due to their contamination. This Chapter will review and analyze specific remediation technologies that are effective in the treatment of SVOC contaminants, according to the EPA's Remediation Technologies Screening Matrix and Reference Guide.

2.1 The Dangers of Brownfield

Brownfields are defined as "the real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant or contaminant"(U.S. EPA, 2015) in EPA's website. This comprehensive definition suggests a complicated and critical relationship between toxicity and development (Yount, 2003). There are over 450,000 brownfields in the U.S. (U.S. EPA, 2015) and they all have negative impacts on both the natural environment and people exposed to them (U.S. EPA, 2012).

The negative impact of brownfields can be observed by assessing safety risks, social and economic problems, and environmental health dangers (U.S. EPA, 2012). Safety risks in brownfield sites are primarily caused by the presence of abandoned structures and equipment on these deteriorated sites (U.S. EPA, 2008). With the absence of proper management and maintenance, there is an increased risk of crime (Berman, Forrester, 2013). Social and economic problems are reflected in the reduction of social capital, local government tax base, property values and social services (U.S. EPA, 2012). Furthermore, these contaminated sites pose environmental health dangers to humans and the natural environment because of the risks

associated with their biological, physical and chemical characteristics. And such dangers on environmental health could be spread both by the contaminants left on site and water like runoff, groundwater that is polluted by them (U.S. EPA, 2012).

For decades, developers and community members have focused on redeveloping these contaminated sites in an attempt to improve health outcomes in human populations and in the natural environment. Various treatment strategies have been created to address contamination problems and enhance the environment.

2.2 Conventional Treatment Strategies for Brownfield

Assessment, cleanup activities, and redevelopment design of brownfield sites are suggested as potential methods to improve environmental health. Cleanup is an important process, which should occur along a continuum, rather than at isolated points in time. The cleanup phase presents diverse factors that deserve attention, and should also incorporate remedial techniques that comply with unique cleanup standards established for the particular type of contaminant (Hollander, Kirkwood, Gold, 2010). Remedial techniques are ideal for solving environmental problems associated with contaminants in brownfields, which could be applied in various ways (Hollander, Kirkwood, Gold, 2010). Remedial techniques could be divided into two categories, based upon contaminant location with respect to brownfield sites: those that deal with contaminants on-site versus those that deal with them off-site of brownfields.

On-site remedial techniques include biological, chemical, and thermal treatment. Generally, on-site treatments are more cost effective than off-site treatments because they do not require excavation and transportation (Marks, Wujcik, & Loncar, 1994). However, the quality of their performance may be less certain, due to the diverse soil and aquifer characteristics (Marks, Wujcik, & Loncar, 1994).

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Biological treatment can be easily implemented, but requires a longer cleanup process in comparison to other types of treatment. Although physical/chemical treatment is time efficient, it requires specific equipment. And thermal treatment is quick, but relatively costly, as it demands additional energy and equipment (Marks, Wujcik, & Loncar, 1994).

According to statistics from the EPA, on-site remedial techniques, like bioventing, enhance bioremediation and phytoremediation, while remaining effective and cost-efficient. However, other strategies exist that have demonstrated effectiveness in specific areas. For example, thermal treatment has exhibited the unique ability to handle halogenated SVOCs, while chemical treatments, such as air sparging and bioslurping, are useful for treating water features.

Although off-site remedial techniques could be considered as biological, chemical, and thermal treatments, they differ in terms of content and application when compared to on-site treatments. Off-site treatments are advantageous because they are efficient in time and are more certain in performance. However, they require excavation of contaminants, which may introduce additional financial burden, equipment and permit requirements, as well as challenges to worker safety (Marks, Wujcik, & Loncar, 1994). When compared to on-site biological treatment, off-site biological treatment generally requires less time and has greater certainty in uniform performance (Marks, Wujcik, & Loncar, 1994). Chemical treatment, which includes chemical extractions, will have better performance in off-site remediation and offers more options for offsite treatment, such as hot gas decontamination, incineration, open burn, and pyrolosis.

Compared with off-site techniques, on-site remedial techniques could better preserve unique characteristics because these remedial methods maximally reserve the site inventory. This increases chances that on-site remedial techniques have for combining with design methods to

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interpret the site history and build the site character. This unique combination of remedial methods and landscape design will be discussed further in Chapter 4.

Conventional treatment technologies for soil-contaminated brownfield and watercontaminated brownfield are summarized in Figure 1 and Figure 2. And according to EPA's Remediation Technologies Screening Matrix and Reference Guide, the evaluations of their effectiveness, development status, treatment train, operating and maintenance intensive, reliability, cost, time are also provided in Table 1.

ed Brownfields				site Chemical Treatment	site Thermal Treatment	f-site Biologial Treatment	f-site Chemical Treatment	f-site Thermal Treatment	untainment	her Treatment	0 1 2 3 4 5 6		
Treatment Technologies for Soil Contamination	Bioventing Enhanced Bioremediation Phytoremediation	Chemical Oxidation Electrokinetic Separation Fracturing Soil Flushing Soil Vapor Extraction Solidification	Thermal Treatment	Biopiles Composting	Landfarming Slurry Phase Biological Treatment	Chemical Extraction	Oxidation	Dehalogenation Saparation	Soil Washing Solidification	Hot Gas Decontamination	Incineration Open Burn Pyrolysis Thermal Desorption	Landfill Cap Landfill Cap Enhancements	Excavation Retrieval Off-Site Disposal

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Figure 1: Treatment technologies for soil-contaminated brownfield

Treatment Technologies for Water Contaminated Brownfields



Figure 2: Treatment technologies for water-contaminated brownfields

	Development Status	Treatment Train	Operation & Maintenance Intensive	System Reliability	Cost							
Treantment Technologies For Soil Contaminated Brownfields												
In-site Chemical Treatment		0	0		3							
In-site Thermal Treatment			0		S							
Off-site Biologial Treatment					5							
Off-site Chemical Treatment		8	\bigcirc		(5)							
Off-site Thermal Treatment		0	0	0	S							
Containment		0	0		3							
Other Treatment					N/A							
Treantment Technologies For Wa	Treantment Technologies For Water Contaminated Brownfields											
In-site Chemical Treatment		0	Ø	0	٢							
Off-site Biologial Treatment			Ø	0	3							
Off-site Chemical Treatment		Ø	0		\bigcirc							
Containment			Ó		S							
Air Emissions	Ø	N/A			(5)							
	Not been fully implemented but has been tested(pilot) and is	COMPLEX (more technologies, media to be treated, generates	LOW degree of O&M intensive	LOW reliability and	LOW defree of gener costs relative to other							
Definition Of Symbols	Promising Has been implemented at full scale but still	excessive waste, etc.) RELATIVE SIMPLE (two-car train or so,	AVERAGE degree of	AVERAGE reliability and	options							
Demilion of Symbols	needs improvements and testing	STAND-ALONE	O&M intensive HIGH degree of O&M	Average maintenance HIGH reliability and	general costs relative other options							
	the final remedy at multiple sites, well documented	(not complex in number of media/ treatment technologies)	• intensive	low maintenance	costs relative to other options							

Table 1: Treatment Technologies Evaluation



2.3 SVOCs-Contaminated Brownfield and Harmfulness

According to the soil assessment provided by Oneida Total Integrated Enterprises (OTIE, 2013), SVOCs constitute the main contaminants for the site focused on by this thesis (OTIE, 2013). An understanding of the characteristics of SVOCs and their potential health risks for the human population could attract attention to the necessity of treating SVOC-polluted fields. Furthermore, these perceptions are also fundamental for choosing suitable treatment techniques of brownfields.

2.3.1 SVOCs



Figure 3: Model of semi-volatile organic chemicals

(Sources: Image from www.exponent.com)

As representative contaminants detected in brownfields, Semi Volatile Organic Compounds (SVOCs) (Figure 3) are classified as synthetic organic compounds, which are solvent-extractable and primarily formed from carbon and hydrogen atoms (U.S. EPA, 2014). Though SVOCs have a boiling point greater than water (ranging from 240-260°C to 380-400°C), they may vaporize when exposed to above room temperatures (U.S. EPA, 2014), which renders them harmful to people in outdoor environments, such as brownfields. SVOCs encompass a range of chemicals, including phenols (Figure 4), phthalates (Figure 5), and polynuclear aromatic hydrocarbons (PAHs) (Figure 6) (Hollander, Kirkwood, Gold, 2010).



Figure 4: General chemical structure of phenols

(Sources: Image by Padleckas, Cacycle, 2005)



Figure 5: General chemical structure of phthalates

(Sources: Image by Derksen, 2007)



Figure 6: Schematic representation of an important PAH, benzo(a)pyrene

(Sources: Image by Drbogdan, 2010)

Currently, SVOCs are known to exist in the air, water, soil and biota, and they could be introduced into the environment via gaseous airborne chemicals or chemicals absorbed but not bound on surfaces and dust (IAQ-SFRB, 2015).

Current research about SVOCs' impact is limited and chiefly relevant to the indoor environment. Unfortunately, the outdoor environment is often overlooked. This thesis attempts to address this shortcoming by focusing on landscape interventions designed to improve an outdoor brownfield site contaminated by SVOCs. However, experience and knowledge of SVOCs' impact on indoor environments and human health can inform potential threats imposed on the outdoor environment and people nearby.

According to previous studies, humans can be exposed to and affected by SVOCs in various ways, such as through inhaling SVOCs-polluted air, touching SVOCs-coated surfaces, and ingesting SVOCs-contaminated dust or foods (IAQ-SFRB, 2015). The particular chemical characteristics and the nature of exposure to SVOCs impact human health in distinct ways (IAQ-SFRB, 2015). Overall, SVOCs have the capacity to result in adverse health conditions, including cancers, allergies, retarded reproductive development, altered semen quality, endocrine disturbance, lower birth weight, etc (IAQ-SFRB, 2015). Thus, SVOCs pose serious health risks for humans in the outdoor environment that should not remain overlooked. Rather, these risks deserve proper public attention and specific treatment protocol.

2.4 Common Treatment Technologies for SVOCs

According to the EPA's Remediation Technologies Screening Matrix and Reference Guide, the following treatment technologies are the most common and rated "better" for treatment of SVOCs contaminated brownfields. However, choices of technology should be informed by knowledge of specific compounds involved and modified as needed.

2.4.1 For SVOCs Monitored in Soils, Sediments, and Sludges

2.4.1.1. Incineration

Incineration (Figure 7) is defined as the burning of harmful materials, like polluted soil, at a controlled temperature that is high enough to demolish hazardous contaminants (Hollander, Kirkwood, Gold, 2010). Several types of contaminants can be treated by incineration, including soil, sludge, liquids, and gases (U.S. EPA, 2012). During this process, materials are heated inside of an incinerator, at various temperatures for different periods of time, depending on the amount and type of harmful chemicals present (U.S. EPA, 2012). After the chemicals are heated up, they transform into gases, eventually combining with oxygen to become less hazardous gases and steam (Hollander, Kirkwood, Gold, 2010). Following this process, the modified gases are treated by air-pollution-control devices, which produce waste that must be collected and disposed of in a licensed landfill (Hollander, Kirkwood, Gold, 2010).



How an incinerator converts waste into ash and gases.

Figure 7: Diagram of incineration process (Source: Image from U.S. EPA, 2012)

2.4.1.2. On-site Bioremediation (Biodegradation)

Bioremediation (Figure 8) is the process of using biological agents, such as microorganisms or plants, to degrade or eliminate harmful materials in contaminated soil or water (Hollander, Kirkwood, Gold, 2010). These microorganisms can absorb toxic organic contaminants like fuels or solvents, and break them into safe products, including carbon dioxide and water (U.S. EPA, 2012). Meanwhile, the contaminants provide enough energy to stimulate the growth of microbes (U.S. EPA, 2012). Although bioremediation is a non-intrusive, sustainable cleanup technique it requires time, which pose an obstacle for brownfields that require instant remediation. (Hollander, Kirkwood, Gold, 2010). However, bioremediation could be used in the context of landscape intervention because mature landscapes require a long period of time. On-site bioremediation treatment is advantageous for several reasons, as it does not require excavation, it produces less dust, it releases fewer contaminants, and is more cost effective (U.S. EPA, 1996). Furthermore, the EPA emphasizes in situ bioremediation as a treatment that could potentially have the best performance on permeable soil according (U.S. EPA, 1996).



Microbe takes in oil, oxygen, and nutrients and releases gases and water.

Figure 8: Schematic diagram of bioremediation

(Source: Image from U.S. EPA, 2012)

2.4.1.3. Solvent Extraction/ Chemical Extraction

Solvent extraction (Figure 9) is a chemical approach that uses solvents to remove hazardous contaminants (U.S. EPA, 2001). First, soil is dug out and sifted to remove rocks and debris for solvent extraction. Then, the soil is placed in an extractor and mixed with solvent for treatment (U.S. EPA, 2001). The chemicals dissolved by solvent are then diverted into a separator where they can be separated from the solvent. Lastly, the resulting solvent is reused or disposed of in a licensed landfill (U.S. EPA, 2001).



Figure 9: Schematic diagram of solvent extraction

(Source: Image from U.S. EPA, 2001)

2.4.1.4. Excavation, Retrieval, and Off-site Disposal

Contaminated soil excavation, retrieval, and off-site disposal are methods used to remove and transport contaminated soil to permitted off-site treatment or disposal facilities, which are designated by state government's land disposal restrictions and regulations (Marks, Wujcik, & Loncar, 1994). Although excavation and disposal are used extensively in various types of sites, they may be difficult and expensive when soil volumes are large and there are complex hydrogeological environments (Marks, Wujcik, & Loncar, 1994).

2.4.1.5. Thermal Desorption

Thermal desorption (Figure 10) is a physical technology approach that has demonstrated effectiveness in treating organic-contaminated solid mediums by heating them to a certain high temperature, which changes them into gases and separates the organic contaminants from the solid medium. This process can remove both volatile and semi volatile contaminants (Marks, Wujcik, & Loncar, 1994). The excavated and prepared soil is then placed into a thermal desorber that heats the contents to a specifically designated high temperature, based on the properties of the contaminants For example, a temperature between 600 and 1000°F may be used to treat SVOCs contaminated soil (U.S EPA, 2012). Thermal desorption, when combined with other technologies, could more effectively treat contaminants. For example, off-gas treatment could be integrated with thermal desorption on sites where waste has less than 10 percent organics (Marks, Wujcik, & Loncar, 1994). Rather than destructing organic contaminants through a process, such as incineration, thermal desorption volatilizes contaminants and collects the off-gas for further destruction or discharge (Hollander, Kirkwood, Gold, 2010).



Thermal desorber heats contaminated material to evaporate contaminants.

Figure 10: Schematic diagram of thermal desorption process

(Source: Image from U.S. EPA, 2012)

2.4.2 For SVOCs Monitored in Groundwater, Surface Water, and Leachate

Carbon adsorption and UV oxidation are the most common off-site treatment technologies to treat SVOCs in water body (Marks, Wujcik, & Loncar, 1994). Although in-site treatment techniques are not widely used, biological treatment technologies are effective for in site treatment of SVOC-polluted water.

2.4.2.1 UV Oxidation

UV oxidation uses strong oxidizers and irradiation with intense UV light to oxidize and destruct organic and explosive constituents in contaminated water (Marks, Wujcik, & Loncar, 1994). The UV light is utilized as a catalyst for oxidation reactions, converting oxidizing agents like ozone (O_3) and hydrogen peroxide (H_2O_2) into highly reactive hydroxyl radicals, which destruct and transform organic contaminants into relatively harmless materials like carbon

dioxide, water, and salts (Marks, Wujcik, & Loncar, 1994). The UV oxidation process could be configured in batch or continuous flow modes, and additional catalysts may be applied to enhance the system performance if necessary (Marks, Wujcik, & Loncar, 1994).

2.4.2.2 Pump and Treat (Reactor, Carbon Adsorption)

Pump and treat (Figure 11) is a method that pumps groundwater through recovery wells or trenches, sending it to an aboveground treatment system where contaminants are treated by cleanup techniques, using a biological reactor or carbon adsorption (U.S. EPA, 2012).



Figure 11: Working principle of pump and treat system (Source: Image from U.S. EPA, 2012)

Bioreactors

Pump and treat with bioreactors is a long-term technology that takes advantages of microbes to degrade SVOCs in a tank or canister filled with fixed-film media, such as sand or activated carbon (U.S. EPA, 2005). The fixed media provide a place where contaminants can provide the nutrients necessary for the collection and growth of microbes (U.S. EPA, 2005).

Nutrients may be added to bioreactors to maintain the growth of microbes (Marks, Wujcik, & Loncar, 1994).

Carbon Adsorption/ Granulated Activated Carbon (GAC)

In this method, the groundwater would be pumped through columns or tanks that contain GAC (Figure 12) in order to sorb the contaminants from the surfaces of granules (U.S. EPA, 2012). After this process, the exiting water and air will need to be tested to judge whether the contaminants are completely treated or not. If not, they will be processed again until reaching the treatment requirement (U.S. EPA, 2012). Regular replacement or regeneration of GAC is needed to keep the system working (U.S. EPA, 2012).



Figure 12: Working principle of carbon adsorption/ granulated activated carbon (GAC) (Source: Image from U.S. EPA, 2012)

2.4.2.3 On-site Bioremediation: Oxygen Enhancement

In situ groundwater bioremediation is efficient in treating both soil-contaminated and groundwater-contaminated SVOCs sites (U.S. EPA, 1996). There are three parts of an in situ groundwater bioremediation system: the extraction well, which removes groundwater from

underground; the treatment system, which adds nutrients and oxygen to the contaminated water; and the injection wells, which return the "conditioned" groundwater back underground in order to let microorganisms treat with the contaminants (U.S. EPA, 1996).

Oxygen Enhancement through Air Sparging

Air sparging is a common oxygen enhancement method used in situ for groundwater treatment. This process helps to rinse contaminants by pumping air into groundwater and infiltrating the contaminated area (Huling, Bledsoe, & White, 1990). Small-diameter air injection points render easy installation and relative flexibility for design and construction (Marks, Wujcik, & Loncar, 1994).

Oxygen Enhancement through H₂O₂

Oxygen enhancement with hydrogen peroxide (H_2O_2) is another popular method that enhances aerobic bioremediation by injecting a dilute solution of hydrogen peroxide into a contaminated groundwater area (Soesilo, & Wilson, 1997). Hydrogen peroxide injection could not only increase the oxygen content in groundwater but also maximally deliver dissolved oxygen to the petroleum-contaminated area and reduce oxygen loss by volatilization (U.S. EPA, 2003).

2.4.2.4 Passive Treatment Wall

Passive treatment walls (Figure 13) are structures placed underground for contaminated ground water treatment. Such treatment walls are designated in a trench across the flow direction of the contaminated ground water and are selectively filled with different materials designed to treat the present contaminants (U.S. EPA, 1996). This wall could be used to treat contaminants and transform them into safe materials. Afterwards, the clean water could run out of the wall (U.S. EPA, 1996). There are several advantages associated with passive treatment walls,

including cost effectiveness, energy efficiency, and the ability for modification to treat different types of contaminants. These walls are energy efficient because they do not depend on mechanical equipment or an energy source to pump out contaminated water. Moreover, the property can retain a productive function, while undergoing treatment (U.S. EPA, 1996).



Figure 13: Schematic diagram of passive treatment wall

(Source: Image from U.S. EPA, 1996)

According to the information of those treatment technologies provided in EPA's Remediation Technologies Screening Matrix and Reference Guide, evaluations of the effectiveness, development status, treatment train, operating and maintenance intensive, reliability, cost, time are provided in Table 2. Based on the evaluations of these different aspects, the potential for landscape intervention of these treatment technologies are also demonstrated in Table 2. In conclusion, bioremediation, excavation, enhanced bioremediation, and passive treatment wall were selected as with more potential for landscape intervention, since they are relatively simple to operate, with relatively low disruption to the site, and they got features related to landscape elements. Specific landscape intervention strategies for these selected remedial methods will be illustrated later in Chapter 4.

	Effectiveness Halogenated SVOCs	Demonstrated Nonhalogena -ted SVOCs	Development Status	Treatment Train	O&M Intensive	System Reliability	Cost				
			\bigcirc	0			3				
Chemical Extraction					\bigcirc		S				
Incineration	æ				\bigcirc		S	C			
Thermal Desorption							5	C			
Excavation, Retrieval, and Off-site Disposal								C			
Passive Treatment Wall					Ó		5	(
Bioreactors							(5)	(
UV Oxidation	A						S	(
Granulated Activated Carbon			Ø	0	Õ		3	C			
	A HALOGENATED		PILOT	COMPLEX	O LOW	low	S LOW	() s			
Definition of Symbols	LIMITED EFFEC Limited effectiver or full scale		Ø AVERAGE	AVERAGE				۰ 3			
	HALOGENATED Effectiveness der		Ø FULL	STAND -ALONE	() нісн	G HIGH	🜀 нідн	()			
Off-site Biological Treatment		Limited effectiveness demonstrated at pilot or full scale NONHALOGENATED SVOCS EFFECTIVE Effectivenes demonstrated at pilot or full pilot or full scale									
Off-site Physical/ Chemical Treatment Off-site Thermal Treatment	Effectivenes dem pilot or full scale										
	Level of Effectiveness highly dependent upon specific contaminant and its application /design										

Table 2: SVOCs Treatment Technologies Evaluation


2.5 Green Future—People's Opinions Regarding Brownfield Redevelopment

Historically, the proper treatment of such formerly hazardous sites has presented challenging and positive impacts on urban development, the environment of a local area, and the well being of local residents. Brownfield redevelopment could significantly benefit the community and its inhabitants by enhancing environmental quality and residents' health through remediation, stimulating the economy with new development projects.

Although brownfields are a relatively new concept, there are a number of studies expressing positive opinions about brownfield redevelopment. For example, proponents of brownfield redevelopment favor converting abandoned spaces into more ambient, publically accessible greenspaces, like parks, rather than industrial facilities, like warehouses (Greenberg, & Lewis, 2000). Similar opinions are echoed in another interview conducted by De Sousa (Sousa, 2006). Furthermore, a research investigation conducted by a team at IUAV University, which surveyed 400 individuals in the Municipality of Venice, determined that the majority of respondents strongly supported the revitalization of brownfields into public parks, sports fields and recreational areas, and acknowledged that the redevelopment would produce positive health outcomes for the population (Tonin, & Turvani, 2011). Additionally, this study demonstrated the fact that proximity to contaminated sites positively impacts people's attitudes and beliefs about redevelopment, as well as their willingness to support such endeavors. In another study conducted by Wernstedt and Siikamäki pointed out that numerous neighborhoods in American has been affected by the deserted brownfields and also suffering from lacking greenspace like parks at the same time (Siikamäki, & Wernstedt, 2008). This research also pointed out that transforming these brownfields into greenspace is a solution to solve both problems in physical environment and human environment around these neighborhoods (Siikamäki, & Wernstedt,

2008). Moreover, remediating brownfields for greenspace use like parks is less difficult and expensive than for housing use (Harnik, & Donahue, 2011) while it could serve more people and broader neighborhood.

Despite the potential negative environmental and public health impact associated with brownfields, the public still has high expectations for its transformations—greenspace. Such 'green expectations' require that the redevelopment process remediate environmental issues and provide opportunities for outdoor activity. Landscape interventions would be a perfect choice for satisfying people's green expectations, as they remediate the environment, while introducing quality green space.

2.6 How Could Landscape Help

Based on people's expectations of brownfield redevelopment—greenspace, it is important to find methods that combine remediation strategies and landscape interventions. Although each SVOCs treatment technique has advantages and disadvantages, the selection of a particular approach demands decisionmaking, informed by factors, such as the type of contaminant and level of contamination.

In conclusion, bioremediation, passive treatment wall and excavation have the greatest potential to be combined with landscape interventions and involve the least engineering, while remaining energy efficient. Other treatments are far more complex to use alongside landscape interventions because they require very particular processes, equipment, and possibly permits, and they utilize more energy. Such treatments include incineration, thermal desorption, chemical extraction, pumping treatment and UV oxidation. Furthermore, the environmental impact measured in terms of pollution must be considered in this decisionmaking process. It is important to conduct a diligent cost-benefit analysis, because technologies vary in complexity and environmental impact. Although certain technologies combine more easily with landscape intervention, they may produce higher levels of pollution. Therefore, it may be more ethically sounds to choose a strategy that combines with landscape interventions in a more complex manner, so as to reduce negative impacts on the environment.

Some brownfield redevelopment projects attempt to take into consideration the dual importance of remedial treatments and landscape intervention. Chapter 3 will present case studies of these projects and highlight their usefulness. Potential combinations of the remediation strategies and landscape interventions for SOVCs-polluted brownfield sites will be discussed in Chapter 4.

CHAPTER 3

CASE STUDIES

This chapter will review brownfield and landfill redevelopment projects from three main aspects: remediation strategy, interpretation of site historic and toxic legacies, and aesthetic approach of landscape intervention. All of the projects included in this chapter are relatively small in size but brilliant in performance regarding interpretation of site historic and toxic legacies. These cases will be arranged in ascending order based on their accessibility and impact on people, according to site locations.

The first project is Byxbee Park, a recreational public park proposed on a reclaimed landfill in Palo Alto, California. It locates on the edge of the bay area of San Francisco, and produced significant changes to the natural system of the bay area. In the 1980s, Palo Alto city withdrew the site and it was no longer used as part of the city garbage dumps (Rijsberman, 2005). Later, from 1988 to 1991, the City of Palo Alto collaborated with Hargreaves Associates and artists Michael Oppenheimer and Peter Richards, to reclaim the abandoned city dump and transform it into a health city park. The main challenges of this project involved working with the existing garbage dump and restoring the Bay's ecosystems, while providing recreational spaces and artistically interpreting the site characteristics of the San Francisco Bay. The design team decided to cap the dump with clean earth and impermeable clay, sculpting the material into abstract mounds and hills. Meandering trails were open for bicycle and jogging. Various pieces of environmental art were placed to increase the public's awareness of the Bay's natural characteristics (Rainey, 1994). All of Byxbee Park constitutes land art, naturally existing alongside the shores of the San Francisco Bay. The site is an example of an integrative approach, as it combines reclaiming a landfill and artistic expression.

The second case is Chattanooga Renaissance Park, a 23.5 acre urban brownfield redevelopment project located in the waterfront area of Downtown Chattanooga, which also has a growing neighborhood. In 1969, the EPA declared Chattanooga the most polluted city in the U.S because of the ubiquitous presence of heavy manufacturing plants throughout the city. Chattanooga Renaissance Park was originally an enamel manufacturing plant that was closed and abandoned in 2002 (Spielberg, 2009). In 2008, it was declared Chattanooga's city park (National Geographic Society, 2011). The project team was a collaboration of landscape architects, engineers, city agencies and community members. The main problem associated with this project was the contamination leaching from the former capped waste cells. The waste cells were located in the site's 100-year flood plain and the leaching contamination would run into the groundwater, thereby presenting a serious risk to the Tennessee River (Collett, & Taylor, 2014). The design team resolved to excavate contaminated soils and relocate them to a level higher than the 100year flood plain, and sealed them to prevent further pollution (Collett, & Taylor, 2014). Additionally, the team created elevated iconic landforms from the elevated pile of soils and provided spaces for recreation (Collett, & Taylor, 2014). Renaissance Park provides an example of combining the treatment of leaching contaminants in groundwater and contaminated soil with artistic expression in riverfront redevelopment projects.

The third case is Steel Yard, a non-profit organization with a focus on displaying industrial art built from a former steel fabrication facility. The site is located in Olneyville, a blighted neighborhood of Providence, Rhode Island. The previous steel fabrication plant was closed in 2001 and left the site with vacant steel fabrication facilities and polluted industrial lots (Patten,

2011). Later in 2002, the site was bought and redeveloped into a site for a non-profit organization that features industrial art by two local artists (Hollander, Kirkwood, & Gold, 2010). The main challenge for this project surrounded the pollution and existing industrial legacies. The lead contaminated soil was excavated and treated off-site. The industrial legacies were kept and reused on site as a landmark to invoke people's awareness of the site's industrial history. The Steel Yard gives us a model for transforming a distressed neighborhood with industrial debris into a vital and healthy community, while simultaneously serving as an industrial arts education center.

The final case is the Alumnae Valley Restoration in Wellesley College, Massachusetts, which is a restoration project that transformed a former parking lot over a toxic brownfield into an ecological campus green space. The site formerly functioned as a physical plant and a natural gas pumping station, which resulted in a contaminated brownfield. In 1997, Michael Van Valkenburgh Associates proposed a restoration plan to redevelop the site into its original glacial valley landscape. Due to the previous industrial activities, the original scene of glacial valley landscape was destroyed and the soils and groundwater on site were polluted, which challenged redevelopment efforts. The design team designated three main strategies of remediation to address the environmental degradation --- excavate and remove the heavily contaminated soils for off-site treatment, cap and seal the mildly contaminated soil on site with clean fill and geosynthetic clay, and periodically pump the contaminated groundwater out of the site through constructed wells and certain pumping infrastructure for further off-site treatment (Michael Van Valkenburgh Associates, 2015). In addition to integrating ecological approaches, such as the construction of wetlands and basins, into their plan, the team also sought to manage stormwater issues and create aesthetic landforms that resembled the original glacial valley. Therefore, the

Alumnae Valley Restoration is a good example of preserving site characteristics and reclaiming fields, while incorporating ecological principles.

3.1 Case One—Byxbee Park, Palo Alto, California

Project Name: Byxbee Park

Location: 2375 Embarcadero Road, South shore of San Francisco Bay

Size: 29 acres

Former use: Garbage dumps, landfill

Current use: Park

Client: City of Palo Alto

Design Team: Hargreaves Associates, artists Peter Richards and Michael Oppenheimer

3.1.1 Project Background

Byxbee Park (Figure 14) is a 29 acre public park situated on top of a reclaimed landfill site, on the shore area of the San Francisco Bay. "It is a highly artificial, sculptural landscape (Kirkwood, 2010)." The park presents a unique combination of art and landscape architecture, as a result of the collaboration between landscape architects of Hargreaves Associates and artists Peter Richards and Michael Oppenheimer (Rainey, 1994).



Figure 14: Site plan of Byxbee Park

(Source: image Hargreaves Associates, 2015)

3.1.1.1 Site Histories:



Figure 15: Timeline of Byxbee Park

3.1.1.2 Site Contamination: Leachates and methane from garbage

3.1.2 Design Approach

3.1.2.1 Remediation Strategy





The site was historically used as a landfill, but was closed in 1980 (Figure 15). Notably, there are numerous adjacent landfills around the Bay area, some of which have been converted into parks, while others continue to operate in their original capacity. The site's previous use as a landfill resulted in contamination originating from existing tons of garbage stored on site. The landfill also presented a threat to water quality (Fred, & Jones, 1991). When waste was saturated with water or received artificial irrigation, it had the capacity to produce leachate and methane gas, which could result in potential ground water pollution that would harm human health (Pedersen, & Johnson, 1997). In order to address these threatening factors, hills and mounds of waste were creatively constructed on site. The hills consisted of 60 feet of garbage, covered by a one-foot thick impervious clay layer with two feet of soil on top (Hargreaves Associates, 2015). They were then covered with native grasses, wild flowers and small shrubs instead of tall trees in order to keep the clay cap from being disturbed or broken (Figure 16). No irrigation was provided, in order to prevent groundwater from being polluted by the leachates from the landfill.



Figure 16: Diagram of capping

Garbage under the hills produced methane gas for decades, which negatively impacted the environment, as many greenhouse gases do (Horii, 2000). However, designers decided to make use of the methane, rather than ignore it. A keyhole-shaped waste gas burner (Figure 17) was

added on site to address problems associated with the methane gas. This project was named "Keyhole" (Horii, 2000).



Figure 17: Methane gas burnoff facility "Keyhole"

(Source: image from http://www.abag.ca.gov, image redrawn by the author)

The site location heavily influenced the natural system of the bay as well as the improvement of the quality of the environment. The use of native vegetation and creation of bay marshes provided a good habitat for endemic animals and plants, which could also provide additional protection of the Bay's complex ecosystems. Concrete chevrons were introduced to slow down runoff and create moist habitats for native wildflowers (Rainey, 1994).

3.1.2.2 Interpretation of Site Historic, Toxic Legacies

The mounds (Figure 18) and paths were established to reflect site history: the mounds on site were arranged as a metaphor of the mounds of Ohlone Indians who first inhabited the area about 2000 years ago (Rainey, 1994). Trails made of crushed oyster shells gathered from the former landfill and a flare burning off excess methane gas served to remind visitors of the site's use as a landfill (Kirkwood, 2001).



Figure 18: Hills and mounds built up from landfills

(Source: image from www.rhorii.com, image redrawn by the author)

3.1.2.3 Aesthetic Approach of Landscape Intervention

Hargreaves Associates took a highly artistic approach in their design. They created series of aesthetic abstractions to arouse people's awareness of site characteristics and natural beauty. Earthworks and installations were used to create land art. For example, they represented the existing topography by creating a pole forest made from 72 evenly spaced wooden telephone poles (Figure 19) with different heights. The poles functioned like a gigantic sundial, casting shadows as the sun traversed the sky (Rainey, 1994). Furthermore, there is a 30 foot high 'wind wave piece' (Figure 20) that reflects the wind's orientation, while emphasizing visitors' experiences of the Bay area's natural character (Rainey, 1994).



Figure 19: Pole field

(Source: image from www.flickr.com, image redrawn by the author)



Figure 20: Wind wave piece

(Source: image from www.flickr.com, image redrawn by the author)

Although the wooden poles and wind wave piece constitute an aesthetic approach for the interpretation of site character, it would be even more meaningful if the installations were placed relative to site history or contamination.

The rhythmic landforms were designed according to site topography, wind orientation, and vision. Various small hillocks lined the top of the hills and had crushed oyster shells paths

(Figure 21) winding through them (Horri, 2000). Chevrons (Figure 22) were set to visually connect the runway of the adjacent airport to the site (Rainey, 1994).



Figure 21: Bird eye view of the small hillocks and curving trails

(Image: Hargreaves Associates, 1991, image redrawn by the author)



Figure 22: Chevrons pointing to the airport runway

(Image: Hargreaves Associates, 1991, image redrawn by the author)

3.1.3 Lessons Learned

Byxbee Park is an excellent example of how a landfill redevelopment project can enhance the living environment through a cost effective environmental approach (Rainey, 1994). It also demonstrates how art can beautify a site when it is combined with landscape design. In addition to pleasant landscape, Byxbee Park provides both passive and active opportunities for activity to visitors. The park displays native vegetation and wildlife of the Bay area and provides spaces for recreational activities, like jogging, biking, bird watching, and other more contemplative activities (Rainey, 1994). The park is a lively component of the surrounding environment and it successfully addresses site characteristics (Rainey, 1994).

Byxbee Park stands out from conventional landfill-converted parks because it contains an art demonstration, i.e. the mounds, and also includes the remediation facility 'Keyhole.' In comparison, conventional landfill-converted parks are created only to provide active recreation fields for golf, soccer, and other activities. Hence, Byxbee Park is unique.

3.2 Case Two—Chattanooga Renaissance Park, Chattanooga, Tennessee

Project Name: Chattanooga Renaissance Park

Location: 100 Manufacturers Road, Chattanooga, Tennessee

Size: 23.5 acres

Former use: Roper Enameling Plant

Current use: Waterfront park

Client: River City Company for Chattanooga Downtown Redevelopment Corporation Design Team: Hargreaves Associates

3.2.1 Project Background

Renaissance Park (Figure 23) is a 23.5 acre redeveloped urban park transformed from a former industrial site. The park locates on the North Shore of Chattanooga, and it plays a significant role in encouraging the development the North Shore neighborhood. Several capped waste cells were left inside a 175 acre watershed of a periodic stream on site, whose pollutants were a threat to the surrounding environment and the water system of Tennessee River (Hargreaves Associates, 2015). The contaminants were SVOCs and overland leakage produced

heavy metal leaching from the buried waste cells, which ran into the river and groundwater. The capped wastes were removed and treated by chemical and geotechnical approaches. The reclaimed soils were brought back to the site for future utilization as fill for creating landforms and stand as an interpretation of the toxic legacies. In addition to celebrating site history and toxins, Renaissance Park also has designated spaces for social engagement, environmental education, and historical reflection.



Figure 23: Site plan of Renaissance Park

(Source: image from Hargreaves Associates)

3.2.1.1 Site Histories



Figure 24: Timeline of the Chattanooga Renaissance Park

3.2.1.2 Site Contamination

Due to its previous industrial use, several different contaminants permeated the soil, resulting in varying degrees of contamination (Collett, & Taylor, 2014). Contaminations (Figure 25) include but not are limited to: PCBs, VOCs, SVOCs and heavy metals (Collett, & Taylor, 2014). The main problem on this site was a combination of 12,000 cubic yards of contaminated soil and enamel frit (Collett, & Taylor, 2014). Furthermore, capped waste cells on site within the 100-year flood plain were leaching SVOCs and heavy metal contaminants into groundwater, which posed a risk to the Tennessee River.

3.2.2 Design Approach

3.2.2.1 Remediation Strategy



Table 4: Remedial strategy for Chattanooga Renaissance Park

Because the site was previously a manufacturing facility (Figure 24), there were varying degrees of contaminated soils located throughout the site (Collett, & Taylor, 2014). Also, capped waste cells containing industrial waste presented the main environmental problem. The Phase II Environmental Site Assessment of Renaissance Park confirmed SVOCs and heavy metals as

contaminants that were leaching from the capped waste cells (Collett, & Taylor, 2014). The effluent polluted groundwater and the surrounding environment would threaten the environmental and public health.



Figure 25: Site contamination study

(Source: image from Hargreaves Associates)

Treatment strategies were created to address these challenges. First, buried industrial waste was relocated. 34,000 cubic yards of polluted soil was excavated and relocated above the 100-year flood plain. Wetland systems with native vegetation were constructed in the place of former waste cells to absorb and clean runoff on site (Collett, & Taylor, 2014). The team built iconic landforms (Figure 26) out of the material and used more than two feet of clay and clean soil to cap them. Second, wetlands (Figure 27) were used as natural filters for runoff on site, gathering and filtering the water. However, seeing that the runoff could have been polluted by leaching contaminants from the waste cells, it also served as a potential threat to the water system of the

Tennessee River. Furthermore, the site was cut by a periodic stream, which made the riverbank unstable and sensitive. Thus, revetment systems such as gabions, rip rap and root wads were proposed to handle the erosion and to stabilize the stream bank in a sustainable manner (Hargreaves Associates Webpage). This water feature was not only a component of the beautiful landscape, but also served an important role in rehabilitating the environment: it enhanced the floodplain storage capacity by 9.32 acre-feet, enriched the wildlife habitat and also protected the water system of the Tennessee River from being polluted (Collett, & Taylor, 2014). Lastly, an underground drainage system was used to treat lingering leachate before it reached the sanitary sewer system (Collett, & Taylor, 2014).



Figure 26: Iconic landforms with contaminated soils underneath (Source: image from Hargreaves Associates, image redrawn by the author)



Figure 27: Constructed wetlands and stabilized stream bank (Source: image from Hargreaves Associates, image redrawn by the author)

3.2.2.2 Interpretation of Site Historic and Toxic Legacies

Originally, there was an 110,000 square-foot Roper enameling plant located on this site, which was closed in 2002. The remaining site was a brownfield with blighted buildings and empty lots (Spielberg, 2009) (Figure 28).

In this project, the site's history was communicated to the general public via interpretive signage, which illustrated history and the runoff treatment process. Signage was interspersed to educate visitors about the site's heritage as a critical location during the Civil War (Collett, & Taylor, 2014). However, the site history presented was very limited, as signs only interpreted the Civil War era. Signage overlooked site productivity history as an industrial location that had an enameling plant.



Figure 28: Renaissance Park before and after redevelopment

(Source: photographs by John Gollings, 2014)

The construction of artistic landforms and wetlands celebrated site toxicity history, which were the major elements of Renaissance Park.

3.2.2.3 Aesthetic Approach of Landscape Intervention

A portion of the existing riparian floodplain forest was preserved and new vegetation was added to form viewing corridors and gathering spaces (Figure 29). This indicates that designers synthesized their ideas about conservation of the natural environment and public recreation when developing this site.



Figure 29: Circular gathering space cleared among former flooded forest

(Source: image from Hargreaves Associates, image redrawn by the author) Iconic landforms and constructed wetlands were built to provide beautiful views and open spaces for recreation and relaxation. In addition, artistic sculptures (Figure 30) were placed to strengthen a sense of place.



Figure 30: Artistic sculpture

(Source: image from Hargreaves Associates, image redrawn by the author)

3.2.3 Lessons Learned

Renaissance Park provides a great illustration of how to incorporate ecological and historical education into brownfield redevelopment. The park used wetlands as a filter to handle runoff, and also provided a stormwater treatment showcase for public education. The park applied interpretive signage and sculpture to share and preserve the historical and cultural richness of the site. However, the installations overlooked the site's productive and toxic history, which is a shortcoming that could be addressed in the future.

The park also offers a possible solution for treatment of contaminants in a waterfront brownfield, which it has demonstrated by removing contaminated soil from a floodplain and sealing it in a location of higher elevation. The park shows how contaminated soil can be used to construct creative landforms that could provide additional landscaping opportunities and recreational spaces, while keeping the public mindful of pollution. Overall, the preservation of the wooded area in the floodplain reflects an excellent balance between urban revitalization and conservation of natural resources.

3.3 Case Three—The Steel Yard, Providence, Rhode Island

Project Name: The Steel Yard
Location: 27 Sims Ave, Providence, Rhode Island
Size: 3.5 acres
Former use: Steel fabrication facility
Current use: Artist studios, Industrial arts educational center
Client: The Steel Yard
Design Team: Klopfer Martin Design Group

Project Background

The Steel Yard, located in Olneyville, an industrial valley district of Providence, Rhode Island, was once a prosperous industrial center for metal manufacturers, textile, and jewelry (Patten, 2011) (Figure 33). However, in the wake of economic downturn, it became a distressed neighborhood with vacant steel fabrication facilities and contaminated industrial lots (Patten, 2011) (Figure 31). In 2002, two local artists purchased the site, and eventually transformed it into a base for their art-based non-profit organization (Hollander, Kirkwood, & Gold, 2010). Today, the Steel Yard (Figure 32), constitutes a successfully redeveloped brownfield site that has reestablished a healthy environment, while preserving industrial history. The project has reestablished community acceptance and strengthened both local and urban revitalization, while using art to provide economic and educational opportunities (Klopfer Martin Design Group, 2015).



Figure 31: Existing conditions plan (Source: image from Klopfer Martin Design Group) Figure 32: Site plan (Source: image from Klopfer Martin Design Group)

3.3.1.1 Site Histories



Figure 33: Timeline of the Steel Yard

(Data credit: Drake Patten, The Steel Yard)

3.3.1.2 Site Contamination

Lead and chromium were detected in the soils on site, as a result of its former industrial use. Thus, serious environmental risks were present.

3.3.2 Design Approach

3.3.2.1 Remediation Strategy



Table 5: Remedial strategy for Steel Yard

Between 1902 and 1934, a steel shop called the Providence Steel and Iron Company, occupied the site. A painting company, PS&I, was involved with painting outdoor beams on site and allegedly polluted soils by overspraying lead-based paint (Hollander, Kirkwood, & Gold, 2010). According to environmental remediation standards, soil with lead contamination higher than 10,000 ppm was required to be excavated and treated by licensed facility, while soil with lead contamination from 4,000 ppm to 10,000 ppm was treated on site and then placed back on site for further use, like building landforms. Designers also decided to cap 12 inches of clean soil or pavements for the entire site (Hollander, Kirkwood, & Gold, 2010) (Figure 34).



Figure 34: Remediation strategy

(Source: image from Klopfer Martin Design Group)

3.3.2.2 Interpretation of Site Historic and Toxic Legacies

There were several prominent existing industrial legacies on site, namely three vacant industrial buildings, five sets of overhead gantry cranes, and several scrap steel sheets and cubes (Klopfer Martin Design Group, 2015) (Figure 35). Such existing structures gave this site unique character, which designers used to their advantage. They kept the three existing industrial buildings on site, but transformed them to perform new functions (Figure 36). The two two-story brick buildings were transformed into artist workspaces, a café, commercial rental spaces and Steel Yard administrative space, while the long building was reorganized into workshop areas.



Figure 35: The original site in 2003---before remediation

(Source: image from http://www.rimonthly.com)



Figure 36: Preserved long building and gantry cranes—after redevelopment (Source: image from Klopfer Martin Design Group, image redrawn by the author) Additionally, they repainted five notable gantry cranes and kept them on site as historic landmarks. They also recycled and reshaped scrap steel sheets and cubes into metal bale retaining walls (Figure 37) (Klopfer Martin Design Group, 2015).





Figure 37: Recycled metal bale retaining wall

(Source: image from Klopfer Martin Design Group, image redrawn by the author)

3.3.2.3 Aesthetic Approach of Landscape Intervention

The site's proximity to the Narragansett Bay watershed challenged landscape interventions to address the issue of runoff potentially reaching this water system. The implementation of pervious surfaces and bio-retention systems was proposed as a sustainable solution. The bio-retentions could hold and filter rainfall on site and prevent contamination from leachate, while simultaneously improving the landscape (Hollander, Kirkwood, & Gold, 2010). On the other hand, recycled materials and water-loving plants in the bio-retention added unique characteristics to the site.

3.3.3 Lessons Learned

The Steel Yard project's success was largely due to the integration of different strategies based on the existing site conditions and the reuse of industrial legacies. The industrial legacies were preserved on site with new functions to inform people of the industrial history on site. Innovative use of recycled materials, such as the wasted industrial metal sheets and cubes, devices, and debris, gave voice to the site's former history. Pervious pavements and bioretentions played important roles in solving the problem of runoff, which also created a healthy neighborhood environment. Furthermore, the Steel Yard expanded opportunities for art education and demonstrations in a reclaimed urban landscape, which produced a more active, engaged community.

3.4 Case Four—Alumnae Valley Restoration, Wellesley, Massachusetts

Project Name: Alumnae Valley Restoration

Location: Wellesley College, Wellesley, Massachusetts

Size: 13.5 acres

Former use: Parking lot over toxic brownfield

Current use: Campus green space

Contaminant: Contaminated soil from former coal gasification plant and landfill

Client: Wellesley College

Design Team: Michael Van Valkenburgh Associates, Inc.

3.4.1 Project Background

The Alumnae Valley Restoration (Figure 40) is a brownfield redevelopment project located on a 13.5 acre parking lot of Wellesley College campus. It is a typical case of transforming a contaminated brownfield into a sustainable landscape and an ecological campus.

3.4.1.1 Site Histories



Figure 38: Timeline of the Alumnae Valley Restoration

In 1902, Frederick Law Olmsted Jr. surveyed Wellesley College and found the campus possessed distinct characteristics, including glacial topography, valley meadows and native plant communities, which were all worthy of preservation (Michael Van Valkenburgh Associates, 2015). During the first several years of campus development, the valley was neglected, although it was a remnant of the original glacial landscape. However, as the campus expanded, the valley was developed into a site for a physical plant, a natural gas pumping station and eventually, a parking lot, all seated atop a contaminated brownfield (Michael Van Valkenburgh Associates, 2015). A new parking garage was constructed off site, which alleviated the site's burden as a car stock, and allowed for redevelopment (Figure 38).

In 1997, the site was functioning as a parking lot situated over a contaminated brownfield. Michael Van Valkenburgh Associates proposed a plan that would restore the valley, making it part of the natural hydrological system of Wellesley College campus (Michael Van Valkenburgh Associates, 2015) (Figure 39). The project was completed in 2005, with scenery of lush wetlands displaying the original glacial valley landscape.



Figure 39: Layout of Alumnae Valley (Source: image from www.mvvainc.com)



Figure 40: The restored Alumnae Valley (Source: photograph from: www.mvvainc.com)

3.4.1.2 Site Contamination

This site contained contaminated soil beneath the existing parking lot from the former coal gasification plant and a landfill.

3.4.2 Design Approach

3.4.2.1 Remediation Strategy



Table 6: Remedial strategy for Alumnae Valley Restoration

Polluted soils found underneath the parking lot and dense non-aqueous phase liquid beneath the aquifer layer, caused by former industry activities, presented challenges for redevelopment. This project relied on both off-site and on-site treatment of contaminants. Heavily contaminated soil was excavated and removed off-site for treatment; the mildly contaminated soil was capped with clean fill on site and used as fill material for meadow-planted and drumlin-like mounds (Michael Van Valkenburgh Associates, 2015). Newly constructed deep wells and a pumping infrastructure collected and pumped out dense non-aqueous phase liquid left by former industrial processes, periodically removing it off site for further treatment (Michael Van Valkenburgh Associates, 2015) (Figure 41).



Figure 41: Contaminants issues and remediation techniques

(Source: image from Michael Van Valkenburgh Associates, Inc.)

3.4.2.2 Interpretation of Site Historic and Toxic Legacies

The site's historical functions include a glacial valley, industrial ground, and a parking lot (Michael Van Valkenburgh Associates, 2015). However, the original glacial valley landscape was severely damaged as a result of the site's later use as an industrial ground and parking lot. The site's most precious features are contained in the glacial valley, which, unfortunately, suffered the greatest destruction. In order to strengthen this valuable site character, designers tried to recover it through various techniques: confronting the pollution history and treating the contaminants with proper techniques; restoring the original glacial valley landscape and

enhancing the landscape experience by taking advantages of topography and the hydrology system (Figure 42).



Figure 42: The Valley's hydrologic system

(Source: image from Michael Van Valkenburgh Associates, Inc.)

3.4.2.3 Aesthetic Approach of Landscape Intervention

With the help of landscape interventions, the site was restored to its original character. The valley was again picturesque, with wetlands and basins, containing plants like forbs and sedges to help hold and infiltrate site runoff before it ran into Lake Waban (Figure 43). The team introduced a geosynthetic clay layer to seal contaminants and prevent water from permeating into the groundwater. Landforms in the project were abstracted from the glacial topography,

which restored the site's unique characteristics. Trails were created over and around the artistic landforms (Figure 44), guiding people's movement and addressing the scene of the landscapes (Michael Van Valkenburgh Associates, 2015).



Figure 43: Wetlands and basins

(Source: photograph by Mottern, 2006, image redrawn by the author)



Figure 44: Landforms abstracted from glacial topography (Source: photograph by Mottern, 2006, image redrawn by the author)

3.4.3 Lessons Learned

The Alumnae Valley project was integrated with multiple environmental remediation approaches and sustainable stormwater management to regain its initial picturesque scenery and finally became a living part of the contemporary campus. The iconic landforms and weltands constructed with meadow were great approaches for interpreting the site's historic and toxic legacies. This project provided visitors with the rich opportunity to experience the site's unique geological characteristics by using an ecological landscape system to treat pollution. Lastly, the Alumane Valley project presents an approach for strengthening the most valuable feature on site to activate brownfield redevelopment.

Summary of Case Studies				
Project Name	Byxbee Park	Renaissance Park	Steel Yard	Alumnae Valley Restoration
Project Location	Palo Alto, California	Chattanooga, Tennessee	Providence, Rhode Island	Wellesley, Massachusetts
Project Size	29 acres	23.5 acres	3.5 acres	13.5 acres
Design, Cleanup, and Construction Time	1988-1991	2003-2006	2003-2010	2001-2005
Cost	\$1.4 million	\$8 million	\$1.2 million	\$4.5 million
Former Land Use	Garbage dumps/landfill	Appliance manufacturing and enameling facility	Steel fabrication facility	Parking lot over toxic brownfield
Contaminant	GarbageLeachatesMethane	 Capped waste cells PCB's, heavy metals, cyanide, VOCs, SVOCs, contaminated soil SVOCs, heavy metal contaminated groundwater 	Lead and chromium contaminated soil	 Polluted soils underneath the parking lot Dense non-aqueous phase liquid underneath the aquifer layer
Comparison of Size, Cost, a	ind Time among Cases			

3.5 Summary of Case Studies (Table 7)

Table 7: Summary of Case Studies



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Studies
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Project Name	Byxbee Park	Renaissance Park	Steel Yard	Alumnae Valley Restoration
Current Land Use	Park	Waterfront park	 Artist studio Industrial arts educational center 	Campus green space
Site History and Characteristics	 Landfill Bay shore 	 Waste cells Blighted buildings and empty lots River shore with flooded forest Critical location during the Civil War 	 Vacant steel fabrication facilities (three industrial buildings, five sets of overhead gantry cranes) Contaminated industrial lots 	 The site once had glacial topography, valley meadows, and native plant communities in 1902 Parking lot over toxic industrial land
Key Challenges	 Responding to the landfill conditions while protecting the complex ecosystems Collaborating with artists in the park design 	 Dealing with the contaminated postindustrial waste leaching toxic contaminants into the groundwater within the 100- year flood plain 	 Dealing with the contamination Dealing with the site's unique existing steel fabrication facilities' legacy Improving the site's functionality and obtaining public intervention 	 Dealing with polluted soils underneath the parking lot and dense non-aqueous phase liquid underneath the aquifer layer caused by former industrial activities Restoring the original valley system
Remediation Strategy	 The existing garbage was capped by a one-foot thick impervious clay layer with two feet of soil on top The methane gas was burned off by certain facilities 	 The contaminated soil was excavated and removed to containment cells that sit above the 100-year flood elevation An underground drainage system was used to treat leachate before it ran into the sewer system Toxic runoff was filtered by constructed wetlands, which also enhanced the river shore habitat 	• The contaminated soil was treated with a binder and capped with 12 inches of clean fill or pavement across the whole site	 Mildly contaminated soil was treated onsite and capped with a three-foot layer of clean fill Heavily toxic soil was excavated and removed offsite for treatment Contaminated dense non- aqueous phase liquid was pumped out through constructed deep wells or removed from the site for further treatment
	Alumnae Valley Restoration	 Figure A] Landforms were abstracted from the glacial topography to gave the unique characteristic back to the site Figures B&C] The most valuable legacy of the original glacial valley landscape was restored and enhanced by taking advantage of the topography and the hydrology system 		
--------------	----------------------------	---		
Case Studies	Steel Yard	 [Figure A] The prominent existing industrial legacies were preserved and transformed into historic landmarks and new functional space as a visual identity for the site functional space as a visual space as a visual identity for the site and cubes were recycled and reshaped into metal bale retaining walls [Figure B] Former scrap steel sheets and cubes were recycled and reshaped into metal bale retaining walls introduced as an approach to redevelop the site and demonstrate the site's character Native plants were introduced to create a native and under the site and demonstrate the site's character 		
	Renaissance Park	 [Figure C] Signs were placed to highlight the site's heritage as a critical location during the Civil War [Figure D] Existing riparian floodplain forest was partly preserved to create a landscape scene Concrete from a former building floor was reused as construction material 		
	Byxbee Park	 [Figures A&B] Mounds and paths were built as a metaphor for the Ohlone Indians' first inhabitation on the site 2,000 years ago years ago [Figures D&E] Artworks (telephone poles, wind wave piece) were placed to strengthen the site's natural character [Figure F] Chevrons were placed to the runway of the adjacent airport Natural bay habitat was preserved and improved by using native vegetation and bay marshes 		
		① Interpret site historic legacy		
Summary of C	Project Name	Landscape Intervention		
		61		

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of Coco	OI Case
Cummony	y minime

Alumnae Valley Restoration	 [Figure A] Reclaimed soil was used as fill material for meadow-planted and drumlin-like mounds [Figure B] Wetlands and basins were built to infiltrate site runoff Monitoring wells were installed under the marsh to treat the toxic contamination and prevent leaching
Steel Yard	 A pervious surface and a bio-retention system were implemented to treat runoff on site to avoid leachate contamination Reclaimed soil was placed back onsite to build various landforms
Renaissance Park	 [Figure A] Constructed wetlands with native plants wetlands with native plants were created in the place of former waste cells (excavated void), to treat runoff while standing as a showcase of the toxic treatment Expension
Byxbee Park	 [Figure C] A methane gas burn off facility was established as a reminder of the site's landfill history Land art was created with an abstractive earthwork over reclaimed soils, as an acsthetic expression of the toxic legacy
	(2) Interpret toxic legacy
Project Name	

Specific landscape intervention approaches in case studies are extracted and summarized in Figure 45.



Figure 45: Landscape intervention approaches in case studies

CHAPTER 4

"BROWNFIELD LANDSCAPE"

- A COMBINATION OF LANDSCAPE INTERVENTION AND BROWNFIELD TREATMENT

4.1 Landscape Intervention in the Brownfield Redevelopment

Brownfield redevelopment requires the collaborative intervention of various disciplines, like engineering, planning, and landscape design, due to the complexity of pollution (Kirkwood, 2001). Nonetheless, landscape design provides a critical role in this process, through the interpretation of toxic and historic legacies. This chapter highlights how landscape intervention can be applied to benefit brownfield redevelopment.

4.1.1 Limitations of Conventional Brownfield Redevelopment

Many brownfields are being redeveloped in urban areas because of their historically valuable industrial locations: close to the city center, well connected to infrastructure, and relatively affordable due to their polluted histories (UIC Sustainable Brownfields Consortium, 2013, Pennsylvania Department of Environmental Protection, 2015). The critical locations of these brownfields and the increasing lack of available non-contaminated land for urban development indicate the growing importance of brownfield sites to future urban character (Kirkwood, 2001). The practice of redeveloping abandoned and blighted brownfields for diverse urban use has been approved and implemented for years. However, economics and urban development often primarily drive this process and underemphasize the importance of history, ecology, and social engagement (Sousa, 2003).

In recent years, brownfield redevelopment is increasingly informed by essential environmental, historical, and social concerns (Sousa, 2003). Two specific sites discussed in chapter 3 support this statement. Alumnae Valley at Wellesley College, Massachusetts, places a primary emphasis on ecological aspects, as evidenced by the renewal of a polluted parking lot on campus, which is converted into a sustainable, eco-friendly green space on the campus. The Steel Yard in Rhode Island illustrates a design approach that treats and embraces the site's industrial history, rather than discarding it. It also includes, rather than excludes, community concerns in the redevelopment process.

According to the U.S. Environmental Protection Agency (EPA), the reuse of brownfields typically involves several phases (U.S EPA, 2009). The first phase identifies the redevelopment idea; the second conducts the environmental site assessment (Phase I ESA, Phase II ESA); the third develops a remedial action plan; the fourth conducts a cleanup; the fifth intervenes in development; and the last step performs long-term property management. Usually, a property is considered ready for redevelopment after reaching certain assessment and cleanup requirements set by the U.S. EPA (U.S. EPA, 2009). Future use of a site determines its specific cleanup standards. For example, industrial use standards are less strict compared to standards for residential use (Environmental Law Institute, 2015). The compact and preliminary sequencing of remediation and redevelopment processes put the reuse of brownfield in a passive position, separated from design, which is constrained by remediation outcomes. Landscape design interventions introduced in the remediation process of brownfield redevelopment may render contaminated sites more accessible for people.

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4.1.2 Potential Benefits of Landscape Intervention in Brownfield Redevelopment

Landscape intervention in brownfields provides many general benefits, such as improving the natural environment, public health, and community quality, as well and increasing property values of surrounding neighborhoods. However, it could also provide active and passive activities for people and restore the environment, while strengthening remediation effects. Lastly, landscape interventions that address historic and toxic site legacies can reframe and expand the aesthetic value of brownfield sites.

4.1.2.1 Preserve and Strengthen the Remediation Effects

Landscape can be utilized both in the remediation and redesign processes to improve brownfield redevelopment and enhance remediation processes and effects. For example, the methane gas burn-off facility in Byxbee Park, Chapter 3, successfully combined the remedial process with landscape design. Similarly, contamination treatment technologies like bioremediation and phytoremediation that utilize plants and microbes as a media to treat contaminants on site could be more extensively utilized during remediation processes. Landscape interventions like those not only help the treatment process achieve better remediation performances, but also improve the landscape with a sensual experience of brownfield redevelopment (Sleegers, 2010). And, the Alumnae Valley project used wetlands to infiltrate the runoffs and installed monitoring wells under the marsh to treat toxicity and prevent leaching (Michael Van Valkenburgh Associates, 2015).

An underground laboratory (Figure 46) that exhibits plant root growth of green infrastructure in Rhizotopia, Hamburg demonstrates this expanded role, showing how remediation infrastructure not only restores environment, but also educates and enriches the experience of a polluted site (Samimi, & Wang, 2007; Sleegers, 2010). However, when using technology like phytoremediation, "hot-spots" of contamination treatment may need to be fenced in and blocked by dense planting, which will prevent people from being affected by the toxic plants (Kirkwood, 2001).



Figure 46: Underground laboratory

(Source: image by Samimi and Wang, 2007)

4.1.2.2 Reframe and Expand Aesthetic Value of Brownfield Sites through Attention to

Their Historic and Toxic Legacies

Integrating landscape design early in the brownfield redevelopment process could help reframe and expand the aesthetic value of brownfield sites through historic and toxic legacies. After all, the unique historic and toxic legacies distinguish brownfields from other types of land. Brownfield landscape could be introduced to express the unique characteristics of a brownfield site. The Alumnae Valley illustrates the unique and valuable legacy of the glacial topography and ecology through ecological restoration techniques and hydrological design (Michael Van Valkenburgh Associates, 2015). Byxbee Park presents an example of combining capping technology with artistic landforms, to simultaneously restore and cap contamination, while sealing the landfill. This reveals a connection between remediation technologies and design, based on the morphology of the site's historic and toxic legacies. In this case, remediation technologies could be taken as inspiration, and aesthetic clues used to stimulate design ideas (Kirkwood, 2001). In the Renaissance Park project, the big hole created during the excavation process to remove contaminated cells was replaced with newly constructed wetlands.

Historic structures or industrial relics left on a brownfield site could be preserved and renewed as landmarks of the site. The Steel Yard demonstrates successful reuse of industrial legacies and recycling of wasted industrial material. The remedial soil could be reused as fill to rebuild iconic landforms on site. The Alumnae Valley used remedial material as fill for meadowplanted and drumlin-like mounds. Additional art installations could be added to express particular site characteristics, such as slope, wind orientation, wildlife habitat, site history, etcetera. The Wind wave piece, pole field, and chevrons of Byxbee Park constitute artistic pieces that preserve such unique site characteristics.

4.2 Process of Introducing Landscape Intervention into Brownfield Redevelopment

Landscape interventions play a critical role in brownfield redevelopment, as they can improve environmental health, interpret toxic and historic legacies, address people's needs in the outdoor environment, and synthesize environment, function, art, and science. The specific process of introducing proper landscape interventions consists of analyzing the site characteristic; selecting proper remediation strategies; and combining landscape interventions with selected remedial strategies.

4.2.1 Analyze Site Characteristic (History, Culture, Contamination)

Site analysis is an essential process of information gathering that familiarizes one with a site's problems or potential. Environmental site assessments analyze brownfield site contaminations and are divided into two phases: phase I determines whether or not a site is

contaminated; if contamination is detected, then phase II ensues, which identifies the details of contamination and the impact on the environment, public health, economic growth, and other factors (ASTM, 2015). Besides providing such a core analysis of the contaminated conditions, general site analysis could also offer a better understanding of site characteristics, such as site location, circulation, natural resources, site history, site culture, and user analysis. Analysis of site characteristics is an essential process that allows one to prepare for the synthesis of crucial site information and the future design process.

4.2.2 Choose Proper Remediation Strategies

It is important to select proper remediation strategies based on the type of contamination and degree of pollution. Such determinations must be informed by the contamination information contained in environmental assessments. This includes a review of the current site conditions, potential risks, hazardous history, etc. from phase I (ASTM, 2015); chemical and metal contamination information found in the sample testing from phase II (AAI Environmental Corporation, 2015). Different remediation strategies could result in different redevelopment processes, as demonstrated by cases presented in chapter 3. A remediation plan could be simultaneously conducted with landscape interventions, like the capping strategy applied in Byxbee Park and Chattanooga Renaissance Park. However, other remedial strategies will need to be completed before other activities occur.

4.2.3 Combining Landscape Intervention with Remedial Strategies: Adding Aesthetic Values to Remediation Strategies

Landscape intervention could be used to strengthen the effects of and add aesthetic values to remediation strategies. These aesthetic values could be embodied in three main aspects— enhancing the environment; creating public space for social engagement that offers people

opportunities to interact with environment and experience sustainable practices and lifestyles; and preserving the site historic legacy with respect to cultural, social, and toxic history.

4.2.3.1 Enhancing the Environment

Landscape intervention could help restore the environment and enhance good results from the remedial process. This process could occur on redeveloped brownfield sites in various ways: sustainable green infrastructures, like bio-swales, constructed wetlands, and various restored ecosystems. They could treat the stormwater and potential leachates from contaminations on site and provide possible habitat for wildlife. These landscape intervention efforts could continually improve the quality of the site even once the remedial process is over.

Besides the remedial benefits above, landscape intervention could also play important roles in educating people about the environmental problems on a brownfield site as well as the ecological dynamics of a brownfield site. It could even enhance people's awareness about environmental protection and respect. Furthermore, sculptures, environmental installations and artistic earthworks from these landscape interventions could add more aesthetic values to the brownfield sites.

4.2.3.2 Creating a Social Space

The public space and additional site programs created by landscape interventions could also address the aesthetic values of brownfield sites. Landscape intervention in the redeveloped brownfield sites could provide an opportunity for people in surrounding communities to become aware of site history. Blighted spaces, like brownfield sites, are proven to influence people's health through the shaping of broader environmental conditions (McIntyre, Tyler, Wall, & Wang, 2013). A more friendly relationship between these sites and people are needed. Landscape interventions on the redeveloped brownfield sites could increase the number of interactions between people and the sites. Landscape interventions can bring liveliness and sustainability to redeveloped brownfield sites, as previously demonstrated in the successful cases mentioned in chapter 3.

4.2.3.3 Celebrating the History

Celebrating the site history is another important aspect that could help address the aesthetic values of a brownfield site. Historic structures and buildings left on site, contaminations found on site, and the cultural, social and economic histories of a site can all reflect site history. Landscape intervention is an approach that could reveal and reutilize the site history during redevelopment. It could also strengthen site characteristic and its unique aesthetic value. This may occur in the following ways: Firstly, adaptive reutilization of the existing structure, especially structures with post-industry features, could show the history of the site as an industrial place. An example is Steel Yard, where designers reclaimed the former structures into attractive icons. Secondly, reuse of the remedial soil to build landforms on site could demonstrate the site toxic history and previous contamination, like the mounds in the Byxbee Park. Lastly, display of proper remediation strategies on site could demonstrate knowledge of environmental problems and their potential solution for the neighborhood. For example, the wetland showbox in Chattanooga Renaissance Park present the remedial process to people.

4.3 Specific Landscape Intervention Strategies for a SVOCs-polluted Site

In addition to the general brownfield redevelopment strategies presented in section 4.2, SVOCs-polluted brownfields have unique challenges. Based on the analysis of different treatment strategies for SVOCs, discussed in Chapter 2, and the real experience gained from case studies in Chapter 3, this chapter will offer possible solutions for combining landscape interventions with treatment strategies. Chapter 2 classified possible SVOCs treatment strategies into two categories--those with either a high or medium potential for landscape intervention. These classifications were based upon analysis of factors including cost, time, system reliability, operation, and maintenance intensiveness.

4.3.1 For the Treatment Strategies for SVOCs-polluted Brownfield Sites with High Potential for Landscape Interventions

Efficient remedial strategies for SVOCs-polluted soil include bioremediation, chemical extraction, incineration, thermal desorption and excavation, retrieval, and off-site disposal. Bioremediation (biodegradation), excavation, retrieval, and off-site disposal, and passive treatment wall have more potential for landscape interventions than the other listed remedial strategies. Bioremediation (Figure 47) uses microorganisms and plants to cleanup the contaminated soil and water, which are both necessary and available in healthy landscapes. These two processes could develop together and benefit each other.



Figure 47: Concepts of landscape intervention approach for bioremediation

Another remedial strategy that could be combined with landscape intervention is excavation (Figure 48). The holes left on the ground from the excavation process could be reclaimed into different landscapes to serve as a visible reminder of the site's pollution history.



Figure 48: Concepts of landscape intervention approaches for excavation, retrieval and off-site disposal

Finally, another remedial strategy for the SVOCs-contaminated water could be used in combination with landscape interventions— a passive treatment wall (Figure 49). These walls are set underground to help clear the SVOCs-contaminated underground water and could be combined with landscape to increase both visibility and people's awareness.

Passive treatment wall



Figure 49: Concepts of landscape intervention approaches for passive treatment wall

4.3.2 For the Treatment Strategies for SVOCs-polluted Brownfield Sites with Medium Potential for Landscape Interventions

Some remedial strategies were rated with a medium potential for being combined with landscape intervention because they require too much mechanical or chemical effort (Figure 50). These include chemical extraction, incineration, thermal desorption, and UV oxidation, amongst other remedial processes. However, these strategies could be very effective for some polluted sites. Although it is difficult to introduce landscape interventions to these chemical and mechanical processes, these strategies may still have the potential to play important roles in the future development of brownfields. They could be organized as education models to help make a more educational space.



Figure 50: Concepts of landscape intervention approaches for other strategies

4.3.3 Comparison of Those Selected Remedial Strategies

Table 8 shows a comparison of the selected remedial strategies (Figure 47-50) on time, disturbance, cost, and visibility. This will provide a reference for the selection of remedial strategies for the design application.



Table 8: Comparison of Those Selected Remediation Strategies

CHAPTER 5

DESIGN APPLICATION

Based on actual site conditions and knowledge of landscape interventions in Chapter 4, this chapter will analyze the potential of 'brownfield landscape' and provide possible design solutions in a selected SVOCs-polluted site—Boulevard Crossing Park. An analysis of the inventory, the history, the contamination, and the topography of the site will be analyzed in preparation of the latter design. And the design (Figure 71& Figure 72) will pay attention to three main aspects: the treatment of contamination, the landscape interpretation of site historic and toxic legacies, and the introduction of community desired program.

5.1 Site Description



Figure 51: Site location map

(Source: map from www.mapbox.com)

Boulevard Crossing Park, the site chosen or design application, is located at Englewood Avenue and Boulevard SE in southeast Atlanta (Figure 51), Georgia, and was formerly used as an industrial site. According to the U.S. EPA's brownfield property progress profile, this 22-acre site consists of two soccer fields and unused property (Figure 52). The site was first developed into industrial land in the 1960s and has been used for industrial purposes until about 2008 (OTIE, 2013). Former industrial use included varying degrees of automotive storage and maintenance purposes (OTIE, 2013).



Figure 52: Site aerial photo in 2015

(Source: map from Google Maps, 2015)

The site was later identified as an abandoned sanitary landfill and underwent a Targeted Brownfield Assessment (OTIE, 2013). Boulevard Crossing Park was redeveloped into a park as a part of the Atlanta BeltLine project in 2011.

5.2 Site Inventory and Analysis

Site inventory and analysis includes a review of site history and an analysis of the existing conditions, such as topography, hydrology, view, utilities, soils, and contamination.

5.2.1 History

Historic information (Figure 53-54) about the site is available via Atlanta Sanborne maps, historical aerial photos of the site, and redevelopment proposals from the Atlanta BeltLine. Industrial development first occurred on the site in 1960, continued from the 1970s until about 2007. However, the east corner of the site has always remained undeveloped. The site's industrial uses include diverse automotive activities, which range from auto repairing, to vehicle towing, and auto device distribution (OTIE, 2013). Notably, a part of the site was also recognized as junkyard (Ecos Environmental Design, Grice & Associates, Smith Dalia Architects, & Dovetail Consulting, 2009).

In the late 2000's, industrial development declined, which caused environmental problems and criminal activities around the site. The Atlanta BeltLine, Inc. aimed to redevelop the site as a part of the overall BeltLine project in the early 2010s: former industrial buildings on site were demolished and underground storage tanks from a former automotive repair facility were removed (Phase I ESA conducted by Peachtree Environmental, Inc.). These efforts cleared the site of any surface evidence that would reveal its past uses. Two new soccer fields were added onto sites where buildings had been formerly located, as a temporary measure to get people using the site. However, other parts of the site remained untreated and undeveloped well into the future.

Site Aerial Photographs from 1940 to 2015 Sources: The Georgia Aerial Photographs database; Google Earth



Images of Former Industrial Buildings by Ecos Enviroinmental Design, Grice & Associates, Smith Dalia Architects, and Dovetail Consulting for Atlanta BeltLine Inc., 2007

Images of Newly Built Sports Fields by Atlanta BeltLine Inc., 2015

Figure 53: Site development from 1940 to 2015 (Image redrawn by the author)



Figure 54: Site evolution timeline

5.2.2 Topography

The site has an elevation ranging from 880' to 1000' (green to pink in the elevation analysis map), with the lowest points on the eastern and northern edges of the site, and the highest point on the western edge (Ecos Environmental Design, Grice & Associates, Smith Dalia Architects, &Dovetail Consulting, 2009) (Figure 55). The steepest slope (red in the slope analysis map (Figure 56) occurs on the western and northern border of the site, as well as in the central part of the property, which indicates a big drop in elevation on three main parts of the site. There are also several flat areas (yellow in the slope analysis map), but these are separated into different elevations on the map.



(Source: map from City of Atlanta Geographic Information Systems)





Figure 56: Slope and elevation analysis

(Source: image by Ecos Environmental Design, Grice & Associates, Smith Dalia Architects,

and Dovetail Consulting, 2009)

The steep slope (Figure 57) is challenging for designers, as it separates the site into several sections with large differences in elevation. This also makes it hard to connect the relatively flat areas on site. However, it may offer opportunities to create isolated spaces for other activities without disturbing surrounding areas.



Figure 57: Site photos showing the big drop in elevation on site

5.2.3 View from the Site

A major advantage for redeveloping this area into a quality recreational space with beautiful scenery lies in Atlanta city skyline's visibility (Figure 58) from the northwestern area of the site, which is also the highest point on the entire site.



Figure 58: Site Photo showing a good view of Atlanta city skyline from a high point on site

5.2.4 Hydrology

The hydrology map (Figure 59) shows an existing stream (Intrenchment Creek) running through the site, along its eastern boundary. The portion of Intrenchment Creek running through the site, in addition to stormwater and sanitary sewer water, was piped through a combined sewer system underground (Ecos Environmental Design, Grice & Associates, Smith Dalia Architects, &Dovetail Consulting, 2009).



Figure 59: Hydrology analysis (Image redrawn by the author)

(Source: image from Ecos Environmental Design, Grice & Associates, Smith Dalia Architects, and Dovetail Consulting, 2009; City of Atlanta Geographic Information Systems, Atlanta Regional Commission Open Data, 2015)

5.2.4 Utility Easements

According to the utility map in the Atlanta Beltline's Master Plan proposal for Subarea 3 Boulevard Crossing in 2009, there are two easements (Figure 60) located inside the site boundary. A Georgia Power transmission line (Figure 61) crosses the site, while a sanitary sewer line runs along the eastern border. Both of these easements may limit redevelopment and design processes in the future.



30' Sanitary Sewer Line Easement





Figure 61: Site photo showing the Georgia Power transmission line crossing through the site **5.2.5 Soils**

According to the soil analysis map (Figure 62) generated by NRCS Web Soil Survey online, the site contains soil classified as 100 percent urban land. Urban land is defined as any area that is influenced and altered by human activities, and that also experiences soil disturbance in the process of urbanization (USDA, &NRCS, 2008; Craul, 1991). Due to the disturbance and displacement of urban land, urban soil may present with limited aeration and water drainage, low organic matter, and possibly with contaminants (Craul, 1991).

As a brownfield site, the soils on-site were presumed to be contaminated, due to prior industrial use. A Phase II ESA was conducted to determine the soil contamination on-site.

Soils Analysis Map

Sources: NRCS Web Soil Survey



Legend

- Site Boundary
- ReD -- Rion sandy loam, 10-15% slopes
- CrA -- Congaree-Cartecay complex, 0-2% slopes, occasionally flooded
- 🛑 Ub -- Urban land
- UfC2 -- Urban land-Cecil complex, 2-10% slopes, moderately eroded
- UrE -- Urban land-Rion-Louisburg complex, 10-25% slopes, bouldery

Figure 62: Soil analysis

(Source: information from NRCS Web Soil Survey, 2015, image redrawn by the author)

5.2.6 Contamination

A phase I and partial Phase II Environmental Site Assessment (ESA) was conducted in 2005 to address the risk of possibly contaminated storage tanks located underground, beneath former truck and automotive repair facilities on site (Ecos Environmental Design, Grice & Associates, Smith Dalia Architects, and Dovetail Consulting, 2009). The toxic tanks were later removed and managed by Environmental Technology Resources, Inc. in 2006 (Ecos Environmental Design, Grice & Associates, Smith Dalia Architects, and Dovetail Consulting, 2009). Based on phase I ESA results, a phase II ESA was conducted on the site by OTIE Company. The assessment used random samples (Figure 63&Table 9) from the site, collected both from surface and subsurface soils. Results from the final analysis suggested that the contamination issues were mainly located in surface soils (0 to 2 feet below ground surface) (OTIE, 2013). This field survey investigated the following contaminations: -PCB, TPH, TAL metals, TCL VOC, and TCL SVOCs. The final results indicated that arsenic, cobalt, lead and manganese exceeded the Regional Screening Level values (RSLs) in a few samples; however, PCBs and VOCs were not threats to the site. Notably, most of the samples (eight of nine) (Figure 64) analyzed for SVOCs exceeded the RSLs (OTIE, 2013).

In general, the major issue on site concerns SVOC presence in the surface soils, which is correlated with activities like vehicle maintenance, solvent degreasing, and dumping (OTIE, 2013).

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Soil Sample Locations Map (Data Sources Boulevard Crossing Park Phase II ESA Report, 2013)

Figure 63: Soil sample locations

Footprint of Former Building

SB - Soil Boring

SS - Soil Sample

(Source: OTIE, 2013, image redrawn by the author)

							tal Metals (6010/7471)	H (8015 DRO/GRO)	sticides (8081)	B (8082)	DC (8260)	OC (8270)
Sample Number	Location	Latitude	Longitude	Sample Date	Matrix	SampleType	P	đ	Pe	ЪС	2	SV
HAB-1	HAB1	-84.36961881	33.72284644	5/15/2013	Soil	Field Sample		Х				
HAB-2	HAB2	-84.36942272	33.72300657	5/15/2013	Soil	Field Sample	X	Х	Х			
HAB-3	HAB3	-84.36972933	33.72305105	5/15/2013	Soil	Field Sample	X	Х		Х		
SB01 (10-12)	SB01	-84.37216183	33.72293974	5/14/2013	Soil	Field Sample				Х		Х
SB02 (28-30)	SB02	-84.37127294	33.72295605	5/13/2013	Soil	Field Sample	X	Х	Х			
SB03 (13-15)	SB03	-84.37176968	33.72323601	5/13/2013	Soil	Field Sample				Х	Х	Х
SB04 (28-30)	SB04	-84.37206379	33.7234453	5/13/2013	Soil	Field Sample	X	Х	Х			
SB05 (28-30)	SB05	-84.37176968	33.72366003	5/13/2013	Soil	Field Sample				Х		Х
SB06 (28-30)	SB06	-84.371401	33.723451	5/13/2013	Soil	Field Sample	Х	Х	Х		Х	
SB07 (18-20)	SB07	-84.37214223	33.72381496	5/13/2013	Soil	Field Sample						Х
SB08 (8-10)	SB08	-84.37167164	33.72443739	5/14/2013	Soil	Field Sample		Х		Х		
SB-09 (8-10)	SB09	-84.3710235	33.72459002	5/15/2013	Soil	Field Sample	Х	Х	Х		Х	
SB-10 (8-10)	SB10	-84.3710235	33.72502294	5/15/2013	Soil	Field Sample		X				
SB11 (13-15)	SB11	-84.37236118	33.72207267	5/14/2013	Soil	Field Sample	X			Х		Х
SB12 (18-20)	SB12	-84.37247556	33.72212431	5/14/2013	Soil	Field Sample		Х	Х	Х		
SB13 (13-15)	SB13	-84.37237425	33.7221977	5/14/2013	Soil	Field Sample	Х				Х	
SB14 (18-20)	SB14	-84.37248536	33.72227109	5/14/2013	Soil	Field Sample						Х
SB15 (13-15)	SB15	-84.3723383	33.72232273	5/14/2013	Soil	Field Sample	X	Х				
SB16 (18-20)	SB16	-84.37246575	33.72262172	5/14/2013	Soil	Field Sample		Х			Х	
SB17 (13-15)	SB17	-84.37224353	33.72271142	5/14/2013	Soil	Field Sample		Х	Х			
SB18 (10-11)	SB18	-84.37243308	33.72291256	5/14/2013	Soil	Field Sample	X					Х
SB-19-BG (3-4)	SB19	-84.37218144	33.72318708	5/14/2013	Soil	Field Sample	X	Х	Х	Х	Х	Х
SB-20-BG (3-4)	SB20	-84.37279183	33.72472049	5/15/2013	Soil	Field Sample	X	Х	Х	Х	Х	Х
SS-01	SS01	-84.37172941	33.72291168	5/13/2013	Soil	Field Sample	Х	Х				
SS-02	SS02	-84.37144419	33.72319635	5/13/2013	Soil	Field Sample			Х	Х		Х
SS-03	SS03	-84.37227845	33.72343357	5/13/2013	Soil	Field Sample	Х	Х				
SS-04	SS04	-84.37203601	33.723653	5/13/2013	Soil	Field Sample			Х			Х
SS-05	SS05	-84.37232836	33.72375975	5/13/2013	Soil	Field Sample	Х	Х				
SS-06	SS06	-84.37235688	33.72407406	5/13/2013	Soil	Field Sample		Х		Х		
SS-07	SS07	-84.37214297	33.72399697	5/13/2013	Soil	Field Sample	Х					Х
SS-08	SS08	-84.37229984	33.72431721	5/13/2013	Soil	Field Sample		Х	Х			
SS-09	SS09	-84.37167236	33.72387836	5/13/2013	Soil	Field Sample	X	Х				
SS-10	SS10	-84.37133723	33.72363521	5/13/2013	Soil	Field Sample				Х		Х
SS-11	SS11	-84.37120889	33.72476793	5/14/2013	Soil	Field Sample		Х		Х		
SS-12	SS12	-84.37087376	33.72456036	5/14/2013	Soil	Field Sample	X					Х
SS-13	SS13	-84.37185062	33.72459002	5/14/2013	Soil	Field Sample	X	Х				
SS-14	SS14	-84.37130871	33.72425198	5/14/2013	Soil	Field Sample			Х			Х
SS-15	SS15	-84.3694049	33.72271004	5/13/2013	Soil	Field Sample	Х	Х				
SS-16	SS16	-84.36904838	33.7228761	5/13/2013	Soil	Field Sample	X					X
SS-17	SS17	-84.36884873	33.7225855	5/13/2013	Soil	Field Sample		Х	X			
SS-18	SS18	-84.36885586	33.7220636	5/14/2013	Soil	Field Sample				Х		
SS-19-BG	SS19	-84.37054576	33.72327344	5/14/2013	Soil	Field Sample	Х	Х	Х	Х	Х	Х
SS-20-BG	SS20	-84.37279183	33.72472049	5/15/2013	Soil	Field Sample	X	X	X	X	X	X

Table 9: Summary of Collected Soil Samples and Sampling Locations

(Source: OTIE, 2013)

SVOCs Detected Soil Sample Locations Map

(Data Sources: Boulevard Crossing Park Phase II ESA Report, 2013)



- Site Boundary
- Soil Sample Location
- Soil Sample detectd for SVOCs and exceeded RSL value
 - Footprint of Former Building

Notes: HAB - Hand Auger Boring SB - Soil Boring SS - Soil Sample

Figure 64: SVOCs-detected soil sample locations

(Source: OTIE, 2013, image redrawn by the author)

A total of nine surface soil samples were analyzed for SVOCs, and eight were identified as being dangerous in terms of human contact, because of high RSLs (OTIE, 2013). However, results also indicated that the subsurface soil was safe.

The shaded area shown in the Table 10 indicates the specific type and value of SVOC contaminants that were identified as being above the RSLs. The orange area indicates the highest concentration of each SVOC contamination in the eight samples. The specific SVOCs detected in the surface soil samples include Benao(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene (OTIE, 2013).

	RSL	SS-02	SS-04	SS-07	SS-10	SS-14	SS-16	SS-19- BG	SS-20- BG	Average
SVOC(ug	/kg)									
Benzo(a)anthra cene	150	1680	1300	156	487	1860	504	370	267U	908.1
Benzo(a)pyrene	15	1590	1450	203	467	1600	413	338	44.8	763.2
Benzo(b)fluoran thene	150	2620	2390	310	820	2690	670	550	267U	1435.7
Dibenzo (a,h)ant hracene	15	297	380	47.1	107	248	99.1	59.4	267U	176.8
Indeno(1,2,3- cd)pyre ne	150	910	1160	133	316	733	259	166	267U	525.3
Notes: RSL - Regional Screening Level for residential soil U - Not detected above the sample quantitation limit Shaded - Analyte concentration exceeds the associated RSL for Contact with Reside Soil Orange - Highest concentration Sources: Phase II ESA Report, 2013									sidential	

Summary of SVOC contaminated soil analytical results (detected above respective RSL)

Table 10: Summary of SVOCs Contaminated Soil Analytical Results

(detected above respective RSL)

(Data sources: OTIE, 2013, table reorganized by the author)

The chart below (Figure 65) is made based on the data from the Table 10, showing a comparison of the sample recorded level and the RSL level (ug/kg).



Figure 65: Comparison of the sample recorded level and the RSL level

(Image drawn by the author)



Table 11: Summary of SVOCs Concentration Level (Image drawn by the author) This chart (Table 11) uses green circles to represent the RSL value of SVOCs. The recorded values of the SVOC contaminated soil samples are represented as colors ranging from yellow, to green, and red. The sizes and redness of these circles are determined by the recorded values of the samples: the bigger the recorded value is, the larger the circle is and the darker the color is.
SVOCs Concentration Level Map

Footprint of Former Building

(Data Sources: Boulevard Crossing Park Phase II ESA Report, 2013)



Figure 66: SVOCs concentration map (Image drawn by the author)

Individual analyses are conducted for different types of SVOCs, and those different layers of circles that represented different types of SVOC are synthesized in the map above (Figure 66). The size and darkness of the circles above could suggest the composite SVOCs contaminant concentration level of each soil sample.

While the area containing the existing soccer fields has been cleared of contamination, the rest of the site is identified as brownfield, with soils mainly contaminated by SVOCs. This issue

of how to best clean up the contaminated soil on site using proper remediation techniques poses a serious challenge for the redevelopment process. Furthermore, when designers prepare a redevelopment plan for the brownfield site, they must consider how to integrate the treatment process into the design process, so that they sufficiently address site characteristics and site history. Different remedial strategies would affect the interpretation of site history in design. For example, although excavation and removal of contamination from the site without any reflection is efficient, it can neglect and erase site characteristics and history. On the contraire, good preservation and interpretation of the site's historic and toxic legacies could offer people an opportunity to experience the developing process of the site from past to present.

5.2.6 Existing Programs on Site

The existing soccer fields and two pavilions are the only redeveloped functional elements currently on site. The soccer fields create a strong atmosphere for active recreation on site, and attract many people. However, the scope of programs offered on the site is still limited, especially those for children, and could be expanded in the future to more comprehensively address community needs (Figure 67). Developers could take more functions into consideration during the latter portion of the redevelopment process to address this issue.













Figure 67: Site photos showing the type of activities exist on site

5.3 ECOS's Plan



Figure 68: ECOS's master plan for Boulevard Crossing Park

(Source: image by ECOS, 2009)

A design company, ECOS Environmental Design, Inc., proposed a concept design (Figure 68) for this site in 2009. However, their plan was never implemented. Rather, developers built two new soccer fields. According to the local staff of Atlanta BeltLine, Inc., a major issue is the

shortage of redeveloping funding. Although this plan didn't pay enough attention and respect to the site's history of contamination, it still provided some good programming ideas based on communication with the local residents.

The 2009 plan addressed the five following issues: circulation, active recreation, passive recreation, arts, and environment (Table 12). It also suggested combining corresponding programming ideas. Walkways with different widths and walking experience were programmed for the on-site circulation system. Skate parks, basketball courts, and children's playgrounds were proposed for active recreation activities on site. Furthermore, planners proposed the concept of installing life-fitness stations along different walkways to increase opportunities for physical activity. The main programs for passive recreation included picnic shelters and dog-parks. In addition to these programs, which mainly address recreational activities, developers also emphasized art and environmental issues.

Programs	Circulation	Active recreation	Passive recreation	Arts	Environment
	Pedestrian paths (Paved walks, boardwalks)	Sports facilities (skate park; basketball courts)	Picnic shelters	Artistic design (artistic installations)	Stormwater management
	Multi-use trails (walking, jogging,)	Large playgrounds	Dog-park	Educational arts (restored habitat demonstration)	Sustainable material (local plants and produced compost, recycled mulch)
	Gateways	Large open space (big lawn, plaza)	Community garden	Art festivals	Restore habitat
		Life-fitness stations (along the trails)			

Design Programs from ECOS's Plan

Table 12: Design Programs from ECOS's Plan

Following public review of the plan, a follow-up survey was conducted, which suggested that the playground, multi-experience trails, dog-park and open-multiuse fields are the most

popular programs. Although the toxic legacies of this former brownfield received insufficient attention, the plan sufficiently addressed community needs relative to greenspace.



Evaluation diagram of ECOS's Plan

Figure 69: Evaluation of ECOS's plan

A diagram (Figure 69) was developed to evaluate the concept plan of ECOS in terms of environmental conservation, brownfield toxins and productive legacies interpretation, function consideration, and the balance and synthesis of multifaceted issues. This evaluation diagram provides an integrated framework to assess the contribution of each aspect in a design. The radius represents the importance of each element in the whole plan. The larger radius is, the greater the performance of a specific element is. In general, ECOS's plan did well on addressing people's needs and healing the environment. However, it relatively overlooked the interpretation of site characteristic and synthesizing different elements in a whole plan.

5.4. Proposed Design Programs

New design programs need to be agreed upon that take into consideration the existing condition of the site, appreciated design programs by residents in ECOS's plan, and lessons

learned from the case studies. This chapter analyzed the existing conditions of the site and ECOS's plan. Chapter 3 will discuss lessons learned from the case studies.

5.4.1 Lessons Learned from Case Studies

The Table 13 includes lessons learned from case studies and a review of the existing site conditions in six different approaches of potential landscape interventions for Boulevard Crossing Park. A comparison of site existing conditions and ECOS's plan are shown in lateral columns. Corresponding recommended actions are listed according to their priority, based on lessons learned from case studies and an evaluation of site existing conditions and ECOS's design.

Lessons learned from Case Studies						
Landscape Intervention (Design Approaches)	Example from Case Studies					
1. Aesthetic expression of site characteristics and history	 Byxbee Park: Mounds and paths were built as a metaphor for the Ohlone Indians' first inhabitation on the site 2000 years ago. Art works (telephone poles and wind wave piece) were placed to strengthen the site's natural character. Renaissance Park: Signs were placed to highlight the site's heritage. Steel Yard: Art was introduced to redevelop the site and demonstrate the site's characteristics. Alumnae Valley Restoration: Landforms were abstracted from the glacial topography that gave the site its unique characteristics. 					
2. Take advantage of remediation process	 Byxbee Park: A mathane gas burn off facility was built as a remediation approach and as a reminder of the site's landfill history. Land art was created using abstract earthwork over the capped and reclaimed soils. Renaissance Park: Wetlands with native plants were constructed in place of former waste cells (excavated void) to treat runoff while illustrating toxic treatment. Alumnae Valley: Reclaimed soil was used as fill material for meadow-planted and drumlin-like mounds. Monitoring wells were installed under the marsh to treat toxins and prevent leaching. 					
3. Add additional site programs	• Steel Yard: Exterior spaces (paved space and large lawn) and interior spaces (work studio and shop) are provided, allowing people to visit, relax, work and learn.					
4. Manage stormwater	 Steel Yard: Pervious surfaces and a bio-retention system were implemented to treat runoff on-site to avoid leachate from contaminants. Alumnae Valley Restoration: Wetlands and basins were built to infiltrate site runoff. 					
5. Restore ecosystem	 Alumnae Valley: The original glacial valley landscape was restored and enhanced using ecological restoration techniques, and topography and hydrology design. Byxbee Park: The natural bay habitat was preserved and improved by using native vegetation and bay marshes. 					
6. Reuse material	 Steel Yard: Scrap steel sheets and cubes were recycled and reshaped into metal-bale retaining walls. Renaissance Park: Concrete from former building floor was reused for construction material. 					

Table 13: Lessons Learned from Case Studies

5.4.2 Conclusion of Proposed Design Programs

According to the new plan, this thesis proposes developing the site into a community park that could provide necessary passive and active recreations in the remediated area, while also restoring on-site ecosystems, woodlands, and water systems.

The proposed design programs (Table 14) are based on this idea and have considered the existing site conditions, case studies, and ECOS's plan.

In addition, the proposed design would involve interpretations of site toxic and historic legacies based on the chosen remediation technologies, in order to create a sense of "brownfield landscape."

Suggested design ideas for Boulevard Crossing Park								
Landscape Intervention (Design Approaches)	Example from Case Studies	Site's Existing Condition	ECOS Plan	Recommended Action	Priority			
1. Aesthetic expression of site characteristics and history	 Byxbee Park: Mounds and paths were built as a metaphor for the Ohlone Indians' first inhabitation on the site 2000 years ago. Art works (telephone poles and wind wave piece) were placed to strengthen the site's natural character. Renaissance Park: Signs were placed to highlight the site's heritage. Steel Yard: Art was introduced to redevelop the site and demonstrate the site's characteristics. Alumnae Valley Restoration: Landforms were abstracted from the glacial topography that gave the site its unique characteristics. 	• The existing park lacks an on-site aesthetic expression of the site's characteristics.	 Although ECOS proposed placing art installations in gateways and providing space for performance art, the plan did not combine these with the site's characteristics. 	• Art could be introduced to help address the unique characteristics and history of the site in various aspects, such as abstracted landforms, art installations, and thematic signage related to the site characteristics.	****			
2. Take advantage of remediation process	 Byxbee Park: A mathane gas burn off facility was built as a remediation approach and as a reminder of the site's landfill history. Land art was created using abstract earthwork over the capped and reclaimed soils. Renaissance Park: Wetlands with native plants were constructed in place of former waste cells (excavated void) to treat runoff while illustrating toxic treatment. Alumnae Valley: Reclaimed soil was used as fill material for meadow-planted and drumlin-like mounds. Monitoring wells were installed under the marsh to treat toxins and prevent leaching. 	• The existing park offers no on-site interpretation of the former remediation process.	• ECOS's plan did not take advantage of the remediation process. Their plan was based on the hypothesis that the site would be remediated.	• Landscape design could be introduced earlier into the brownfield redevelopment process, and integrated with the remediation process. In addition, landscape design could take advantage of the remediation process to address the site characteristics.	****			
3. Add additional site programs	• Steel Yard: Exterior spaces (paved space and large lawn) and interior spaces (work studio and shop) are provided, allowing people to visit, relax, work and learn.	 The site's existing offerings are limited to two soccer fields and two pavilions with picnic tables. 	 ECOS's plan provided many new programs at the site for active and passive recreation. The surrounding communities highly appreciates some of these programs, so they are helpful to the new plan. 	• Both active and passive recreation should be introduced to the site, but people's activities should be limited to the remediated area.	****			
4. Manage stormwater	 Steel Yard: Pervious surfaces and a bio-retention system were implemented to treat runoff on-site to avoid leachate from contaminants. Alumnae Valley Restoration: Wetlands and basins were built to infiltrate site runoff. 	 No on-site stormwater management is offered. 	• Wetlands and stormwater ponds have been constructed for on- site stormwater management.	• Stormwater management should be applied at the site because the stormwater might be contaminated.	****			
5. Restore ecosystem	 Alumnae Valley: The original glacial valley landscape was restored and enhanced using ecological restoration techniques, and topography and hydrology design. Byxbee Park: The natural bay habitat was preserved and improved by using native vegetation and bay marshes. 	• A heavily wooded area, which may be preserved, is located at the eastern area of the site.	 ECOS's plan applies a hierarchy of preservation, conservation and regeneration to restore the ecosystem. The woodlands are proposed to be revitalized to create a habitat for urban wilderness. 	• Restore the on-site woodlands and water system using bioremediation and passive treatment walls.	****			
6. Reuse material	 Steel Yard: Scrap steel sheets and cubes were recycled and reshaped into metal-bale retaining walls. Renaissance Park: Concrete from former building floor was reused for construction material. 	• The former buildings on site were demolished by the City of Atlanta in 2007. Only a few abandoned tires, concrete debris, and pieces of timber are left at the site.	• ECOS's plan did not use the recycled material from the site.	• Recycled material was not available on-site. However, recycled material could be collected from other similar industrial locations.	****			

Table 14: Suggested Design Ideas for Boulevard Crossing Park

Additionally, evaluation diagrams (Figure 70) are made to campare the site exisitng condition, ECOS's plan, and proposed plan in four aspects: improvement of the environment, interpretation of site historic and toxic legacies, addresses on people's need, and synthesis of various factors through landscape design.



Figure 70: Evaluations of site existing condition, ECOS's plan and proposed plan The proposed plan aims to take advantages of ECOS's plan while integrating the conclusion of former chapters, in order to develop a progressive brownfield redevelopment plan for the Boulevard Crossing Park. Environmental problems, functional needs, and artistic interpretation of site characteristics are addressed in the new plan that is relatively balanced than the former plans.



Figure 71: Proposed site plan for Boulevard Crossing Park





Figure 72: Layers of the proposed site plan

5.5.1 Environmental Treatment

According to the ESA Phase II Report, the main environmental threat currently on site is the SVOCs contaminated surface soils. Furthermore, SVOCs contaminants may have migrated into the groundwater via the flushing of stormwater, which previously occurred on site.

Chapter 2 concluded that the most efficient remedial strategies for SVOCs polluted brownfields include bioremediation, chemical extraction, incineration, thermal desorption, excavation, and passive treatment walls. Based on an evaluation of effectiveness, operation and maintenance intensity, cost, time, and the potential of being integrated with landscape design, the following SVOCs remedial strategies are selected (Table 15): thermal desorption, excavation and off-site disposal, bioremediation, and passive treatment wall.



Table 15: Proposed remedial strategy for Boulevard Crossing Park

The idea is to apply thermal desorption to the areas with the greatest intensity for use (i.e. the southwest area, which features an urban landscape with lawns and grid planting trees). This method is selected because of its demonstrated effectiveness and efficiency for treating SVOCs soils. It would also allow people to have safe spaces for social and recreation in the first part. In addition, the treated soil will be reused to fill in the excavated area or create mounds on site. For the middle part (meadow area), excavation and off-site disposal are proposed to treat the SVOCs-contaminated surface soils, while a passive treatment wall is suggested along slope area and depressed area to handle the potential contaminated runoff and groundwater. Since excavation is the most efficient way to deal with high levels of contaminant, excavation is

selected to handle the middle part of site, which is known to have the highest concentration of SVOCs on site (Figure 65). These passive treatment walls and excavated area together will function as an eco-filter in the site. Bioremediation would be the main remedial strategy for the east-north area (restored woodland), since this part of site would have the least intensity of use. Although bioremediation is more time consuming, it is less costly and provides better opportunities for blending into the background of the preserved woodland because of its use of natural processes and with least disruption to the existing environment. In order to prevent the negative impact of the industrial land in the north, the site limit is expanded in this direction. This could better clean the site and prevent the site from contaminated by the north untreated industrial land outside of boundary.

5.5.2 Site Interpretation (historic and toxic legacies)

First, the big idea is to use 'cracks' (rust metal board) to symbolize environmental harm caused by contaminants. Lush vegetation will serve as a metaphor for 'hope,' which in this case, is healing the wounds caused by environmental harm. Furthermore, this will provide an interpretation of healing (Figure 73).



Figure 73: Concept analysis

Secondly, the design takes advantage of the remediation process and integrates landscape design to interpret site historic and toxic legacies. For example, the excavation of contaminated soils and capping with clean soils would create various landforms, such as mounds and pits, which could be used as a way to interpret the most contaminated spots on site. Meandering paths are proposed to connect these spots and provide a loop for access. Passive treatment walls are proposed along the slope area and depressed area that would collect runoff on site. Moreover, the passive treatment walls would be brought above the ground as an illustrative feature wall to interpret the remedial process of SVOCs-contaminated water. Meadows will be planted along the easement area of the Georgia Power Line, in order to make use of the limited space beneath the power line, and to function as eco-filters that absorb and filtrate the runoff. Furthermore, such eco-filters could also provide habitat for plants and wildlife. The woodland ecosystem will be

restored as once characterized on site. However, due to former bioremediation in the woodland area, fencing will be used to prevent people from touching any toxic plants that may have been contaminated. Root barrier will be added to the area where trees locate over the existing sewer line, to keep the sewer safe.

Lastly, vertical elements like poles and frames, made of rusty metal, will be installed as a visual connection between the contaminated spots. In addition, the rusty metal is used to reflect the former industrial activities on site. Due to safety concerns, vertical elements below the power line would be 9 feet tall (no more than 14 feet).

5.5.3 Site Program

The site is mainly comprised of three areas, defined by the presence of three kinds of landforms: neat lawns with grid planting trees, wave meadow, and prosperous woodland area (Figure 73). They are arranged from the most intensity of use to the least intensity of use (Figure 74). The program includes active recreation and passive recreation. Active recreation programs, such as a basketball court, skate park, children's playground, and life fitness equipment are primarily set along Englewood Ave. Passive recreation programs, including a dog park, picnic areas, large lawns, viewing platforms, and multi-use paths are located within the middle area of the site (Figure 75).



Figure 74: Analysis of intensity of use



Figure 75: Perspective of view from the entrance

CHAPTER 6

CONCLUSION

The thesis aimed to explore possible methods for integrating landscape design into the remediation process in the SVOCs-polluted brownfield redevelopment, in order to create a better brownfield landscape with an emphasis on interpretation of brownfield site's historic and toxic legacies. The author's research about the causes and impact of SVOCs brownfields, the relevant cleanup technologies for SVOCs and lessons learned from case studies, has lead to a conclusion about possible strategies for landscape intervention in SVOCs polluted brownfield redevelopment and apply them in the design for the Boulevard Crossing Park in Atlanta, Georgia.

Brownfield redevelopment is a complex topic, which would involve the collaboration of diverse disciplines due to the complicated issues surrounding pollution. The brownfield redevelopment process could be lengthy, due to the phased work of Phase I, Phase II Environmental Site Assessment (ESA), related environmental clean-up actions, site redevelopment proposal, and construction. The most crucial work in this thesis concerns the synthesis and balancing of various issues raised in the brownfield redevelopment. This thesis first researched the existing Phase II ESA report of Boulevard Crossing Park to determine the specific type of contaminant. Then possible treatment technologies for the detected contaminant (SVOCs) are identified. After examining the literature, feasible design approaches that address site character preservation and site historic and toxic legacies interpretation were provided. Lastly, this thesis provides suggestions of applicable landscape intervention approaches for Boulevard Crossing Park, based upon a synthesis of site conditions analysis, the community's

desired programs, and former studies. However, there are constraints regarding the proposed clean up strategies and design approaches, due to the limited information available from the existing Phase II ESA report (i.e. confirming only the presence of SVOCs contaminants on site, not the extent of contamination). Additional systematic sampling would be required to determine the extent of SVOCs contamination, such as volume and area, which could also entail a supplemental site assessment.

A potential future study direction of brownfield redevelopment could incorporate a multidisciplinary team from the very beginning. This could provide multiple perspectives about brownfield issues and may promote a greater role for landscape architecture in the production of more comprehensive and satisfied brownfield redevelopment projects. Furthermore, it would be helpful to apply adaptive management to brownfield redevelopment, which could include monitoring and assessing the effectiveness of the integration of landscape intervention and remediation techniques. These processes could occur early in the process of brownfield redevelopment. Results from this comparison could be used to improve brownfield redevelopment processes in the future.

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