THE SUCCESSION OF A CONTAMINATED FLOODPLAIN: RECLAIMING THE WEST BOTTOMS

by

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A REPORT

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MASTER OF LANDSCAPE ARCHITECTURE

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Abstract

Kansas City is expecting a 25% growth in population by 2050. This design proposal promotes West Bottoms as a potential area to house some of the new population, and more importantly supply a live and work community for these people. West Bottoms is also home to major industry in Kansas City as well as an up and coming art culture. West Bottoms has great potential for a community that allows the existing and new population to be a part of a live-work-play community with the vacancies in the area.

The projected population growth is expected to promote sprawl, further increasing the average driving time to the city. West Bottoms currently has few connections to the downtown and offers few reasons to come to the area. These connections are mainly major bridges or highways. Another issue West Bottoms faces is flooding problems from OK Creek and Turkey Creek, which lead into the Kansas and Missouri Rivers. Finally, post and present industrial soil contamination threatens the groundwater. When mixed with flooding concerns, this contamination is potentially harmful for the health of downstream cities.

Drawing inspiration from travels, Kansas City charm, plants, art, and water storage, case studies were researched. Themes from each case study were quantified. These themes paired with inventory and analysis of the West Bottoms provided the basis for the design proposed here. The successional design of the area will progress from a contaminated landscape to a landscape that holds floodwater. The final design holds all of the stormwater from the 100 year 1, 2, 3, 6, 12, and 24 hour rain events. The final design incorporates areas of learning, a variety of paths and seating, a live-work-play community, clean and creative industry, and an art culture that sustains the excitement for the timeline of succession. Overtime this landscape will evolve into a new destination for Kansas City using an integrated solution remediating the soil and holding flood waters as an amenity for the new population.

THE SUCCESSION OF A CONTAMINATED FLOODPLAIN:

RECLAIMING THE WEST BOTTOMS

JESSICA KING / FALL 2012 / LAR 700 / TIM KEANE

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ABSTRACT

Kansas City is expecting a 25% growth in population by 2050. This design proposal promotes West Bottoms as a potential area to house some of the new population, and more importantly supply a live and work community for these people. West Bottoms is also home to major industry in Kansas City as well as an up and coming art culture. West Bottoms has great potential for a community that allows the existing and new population to be a part of a live-work-play community with the vacancies in the area.

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LIST OF FIGURES

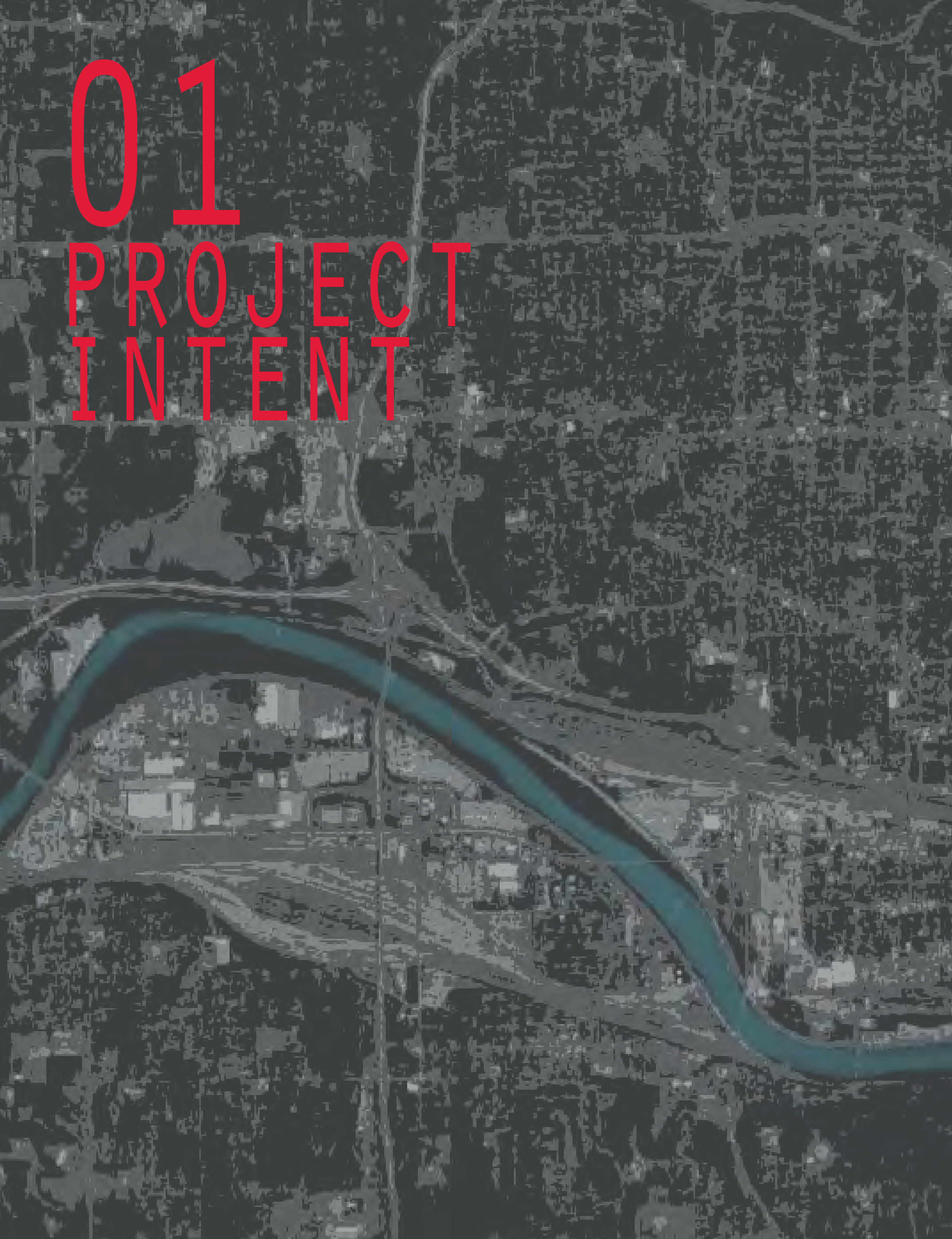
03

LIST OF TABLES

03

TABLE OF CONTENTS

01 PROJECT INTENT



DILEMMA

West Bottoms is disconnected from Kansas City physically, socially, and mentally. Topography and roads physically separate West Bottoms from Kansas City and the site is located within the flood plain of the Missouri and Kansas Rivers. Socially, residents have minimal connection to a live, work, and play network and must commute to work in the district. Mentally, the landscape of West Bottoms lacks growth potential that is needed for the expected 25% population increase by 2050 for Kansas City (MARC, 2012); the area invokes discomfort at a pedestrian scale. The atmosphere is ominous and unwelcoming. This industrial landscape is assumed to be home to contaminated, toxic soils from underground storage tanks, railroad development, and industrial contamination. These sinks of materials threaten the groundwater and must be intercepted to avoid impacts on habitat and biodiversity in the area. FIGURE 1.01

▲ FIGURE 1.01
Disconnect of the West Bottoms to Kansas City. (by Author)

THESIS

How will a phased phytoremediation plan integrated with a flood storage plan reconnect downtown Kansas City to an economically revitalized West Bottoms?

The 150 year succession plan for the West Bottoms integrates phytoremediation with flood storage to reconnect downtown Kansas City to an economically revitalized district. The revived landscape cleanses toxic soils through extraction by plants and uses hydrophytes to cleanse contaminated groundwater. Post remediation, the landscape holds stormwaters in a network of wetlands, ultimately flowing into the Missouri River. FIGURE 1.02

▲ FIGURE 1.02
West Bottoms Connections to Kansas City. (by Author)

INSPIRATION

TRAVEL

While interning at Atelier Dreiseitl, I learned their design and work process and general interests. Their method of designing systems that consider social, flooding, and policy impacts on a landscape, more specifically rivers hold great promise for my works at West Bottoms. Having seen their work process, I know and understand the parameters for how they keep all of their projects within an ecologically and socially conscious design. Their use of cleansing biotopes provides a technique of terraced rain gardens filtering water and allowing for maximum infiltration to recharge the groundwater. Their work lowers the impacts of flooding on urban environments by allowing for more flood storage capacity. Projects and designers at Atelier Dreiseitl know the importance of natural succession and use the concept to allow for a design to run its course in nature. Their use and knowledge of natural systems root designs in natural processes, such as natural succession.

The inspiration for this research and design proposal originated from a travel excursion to the Ruhr River area in northwestern Germany. While this area is traditionally known as a heavily industrialized region, it has transformed in more recent years as places of manufacturing and production are parceled into active public spaces, which serve the community in the form of parks, museums, and galleries. The historical and industrial culture, which snakes through northwestern Germany, awakens to new functions and new understanding in this modern age. This area is also interesting for its use of natural succession in design. The projects below celebrated the natural processes attributing to regrowth within the park. FIGURE 1.03

Zeche Zollverein, a post-industrial park, was adapted from a coal mine to a sculptural landscape with a strong industrial heritage. Plants and railroad tracks populated the park and the transformation of industrial structures into sculpture dominated the space. Zeche Zollverein is located in Essen, Germany. The park was first listed as a UNESCO World Heritage Site in 2001 (UNESCO 2012). FIGURE 1.04

The park, Oberhausen Gasometer, is located adjacent to the river Emscher. The gasometer was designed to incorporate gallery space, including a large photography exhibit. Exhibits in the repurposed gasometer changed regularly, and at the chamber's center stood a giant concrete tree. Lights from the floor illuminated the tree, creating shadows with skylights above the sculpture. Other attractions at the park included climbing the gasometer and riding the elevator to the overlook of the Ruhr region (Zeche Zollverein 2012).

The 180 hectare Landschaftspark Duisburg-Nord is another example of repurposed industrial land. Only after thorough remediation processes, such as capping harmful contaminants and phytoremediating lower levels of pollutants, did the park become active. Through the design of this park, the designers let nature run its course. Spaces were defined by a variety of different activities for social interaction. The people of Germany in the Ruhr valley were used to seeing the visually toxic landscape of industrial structures. Developing this project created controversy because most people wanted it torn down. The park transformed the industrial structures into sculptural pieces to change the thinking from unrest to calming (Landschaftspark Duisburg-Nord n.d.). Walking around the structures, up stairs, around rusty pieces and parts, the abundance of greenery amazed me. I found the range of activities and the scale of the park incredible and inspiring. FIGURE 1.05

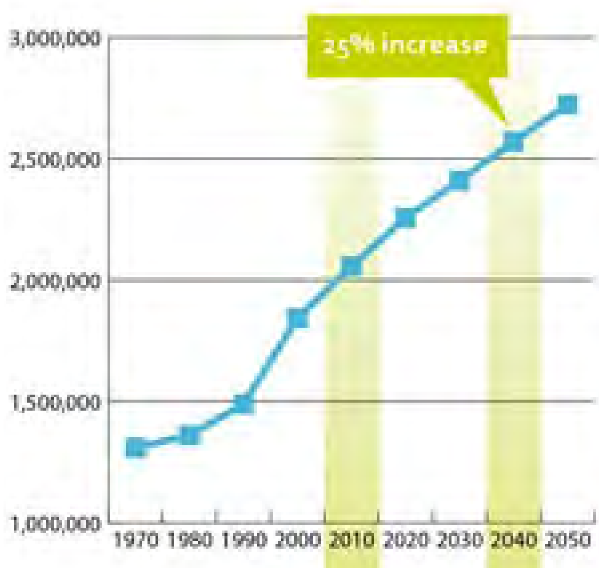
FIGURE 1.03
The Post-Industrial Park of Zeche Zollverein. (by Author)

FIGURE 1.04
Gasometer Art Installation. (by Author)

FIGURE 1.05
Art Installation in Landschaftspark. (by Author)

DESIGN COMMUNITY

Kansas City has a unique charm, which can be harnessed in an ecologically-rooted urban redesign. Potential population growth is estimated at a 25% increase by 2050 and West Bottoms provides an opportune area for redevelopment. Forecasting to 2040, the Mid-America Regional Council (MARC) expects a population increase of 750,000 people in the Greater Kansas City Area, summing to a total 2,750,000 estimated population of the Greater Kansas City Area in 2050 (MARC 2012). FIGURE 1.06 Currently however, the driving culture from the sprawling suburbs dominates the dense urban environment. Expected population growth will increase the average 20-minute drive to the Greater Kansas City Area (MARC 2012). To combat this, city planners desire to promote social interaction and intervention through design, and the residents seem to support this movement. According to MARC, more businesses and residents are reflecting on their impacts and considering a balance to protect future generations' resources (MARC 2012). Examples of community support for planning efforts in Kansas City include Build a Better Block and (Park)ing Day.



▲ FIGURE 1.06
Forcasted 2040 Kansas City Population Increase. (MARC, n.d.)

INDUSTRIAL CHARACTER

The West Bottoms has a distinct character, separate from Kansas City itself and this provides incentive to redevelop and emphasize the culture. Buildings within the West Bottoms have a vintage feel to them, which could encourage a diversity of land-uses and building types. Businesses, boutiques, and galleries are potential repurposing strategies. FIGURE 1.07 Highway overpasses, which are prevalent in the West Bottoms, provide a unique typology challenge in the creation of public space. Bike paths could be used to create regional connections to downtown Kansas City. West Bottoms land-use contains a mix of functioning industry and vacant buildings, which adds another appealing parameter. Functioning industry enables a new strategy of phytoremediating a site before it is vacant to allow for quick redevelopment when the industry is gone as long as there are not too many contaminants. Abandoned buildings open the possibility for gallery spaces, redevelopment, and phytoremediation.

FIGURE 1.07
West Bottoms Industrial and Historic Character. (by Author)

FLOODING

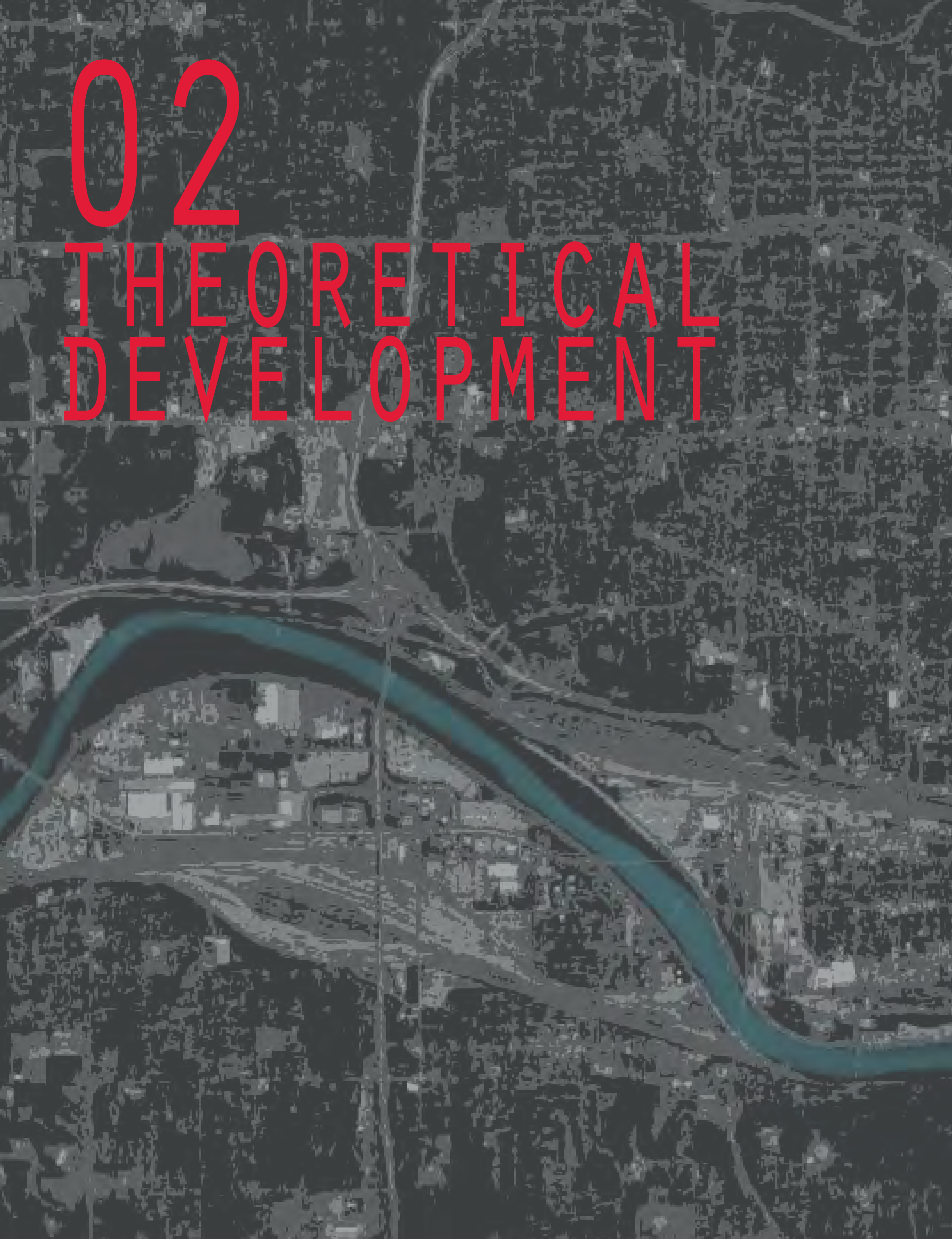
A course in fluvial geomorphology and research of the Kansas River shaped the method components of dealing with flooding landscapes and best management practices. Using Dave Rosgen's (1996) stream classification resources in the course allowed classification of the Kansas River. Classification provides future design strategies to incorporate the natural channel migration and considers the stream gage data. USGS stream gage data offers information valuable for quantifying stormwater flows and flood flows. This information becomes important when calculating the total volume of runoff for the West Bottoms.

Flooding in the West Bottoms in Kansas City provides an intriguing challenge for a regenerative living landscape in the area. The proximity of the Kansas and Missouri Rivers provokes uneasiness for the city residents; however, the rivers also provide a landscape architect the opportunity to establish a living system. The floodplain for the confluence of the two rivers offers the potential for innovative flood storage capacity designs. The use of stormwater best management practices as defined by *Low Impact Development* will promote a higher infiltration rate, a lower peak flood discharge, and the use of flood storage. FIGURES 1.08 AND 1.09

▲ FIGURE 1.08
West Bottoms Flooding. (KCDC, 2010)

▶ FIGURE 1.09
Kansas City Flooding. (KCDC, 2010)

02
THEORETICAL DEVELOPMENT



METHODOLOGY

PROPOSITION

Inspired by my travels through the Ruhrgebiet and internship, I employed a strategy of landscape succession over the next 150 years, starting with phytoremediation and site design for the industrial landuse within West Bottoms to transform it into a regenerated, healthy, economic ecosystem activated by new residents. Succession started with phytoremediation and continued by developing the ecological habitat benefits of storing and slowing storm/floodwater. I studied the influence of phytoremediation on flood storage in a park setting. The study resulted in an understanding of transformed space over time through economic, environmental, and artistic development.

The methodology for this research-based design was case study. Case studies provided evidence to back up design claims and provided information about processes and projects (Francis 2001, 15) – an evidence by design approach. The case studies employed in this work were researched, chosen, qualified and quantified based on themes explained below. The evaluation process of these case studies informed my design decisions for the West Bottoms catchment. Effective case studies were defined by common themes identified by researching each case study. This evidence by design approach was quantified and qualified in a cohesive design for the West Bottoms in Kansas City.

INVESTIGATION

I framed the investigation as evidence based design, investigating successful case studies to evaluate my own design. The case studies stemmed mainly from previously developed driving forces and inspirations. I researched case study sites based on their ability to store floodwaters, provide recreation and environmental learning, remediate contaminated soils, and create a habitat for humans and native species.

STEPS OF INVESTIGATION

The investigation began with researching case studies and beginning the design process with inventory and analysis in ArcGIS. Next, I looked at each case study's quantified ecosystem benefits and compared how they matched up to one another. After finding little correlation, the case studies were then evaluated based on how closely my design goals met the case studies' design strategies. The case studies themes were then identified for design and ecological benefits. These themes were: recreational, experiential, and learning public space, better water quality, conventional remediation or phytoremediation, increased habitat creation and species richness, increased property value, groundwater cleansing, stormwater management, flood storage, bioengineering, slowed velocity, suspended solids removal, and usage of a network wetland terraces. The case study themes informed the design of landscape succession for the West Bottoms. These themes were then quantified from their respective case studies. Once the themes were quantified, they then became design elements, strategies and goals for my own design for the West Bottoms.

PAYOFFS

Once I understood design approaches from case studies, I was able to design for maximum ecosystem services within the West Bottoms. The themes developed and quantified per case study became the foundation for the landscape succession design for the West Bottoms.

VALIDITY OF METHODOLOGY

The use of a case study method allows a unique process of evidence-based design to evaluate old approaches that were successful. The success of the case studies is outlined into smaller categories rating their success. These same categories are then evaluated as potential design themes to quantify ecosystem services.
FIGURE 2.01

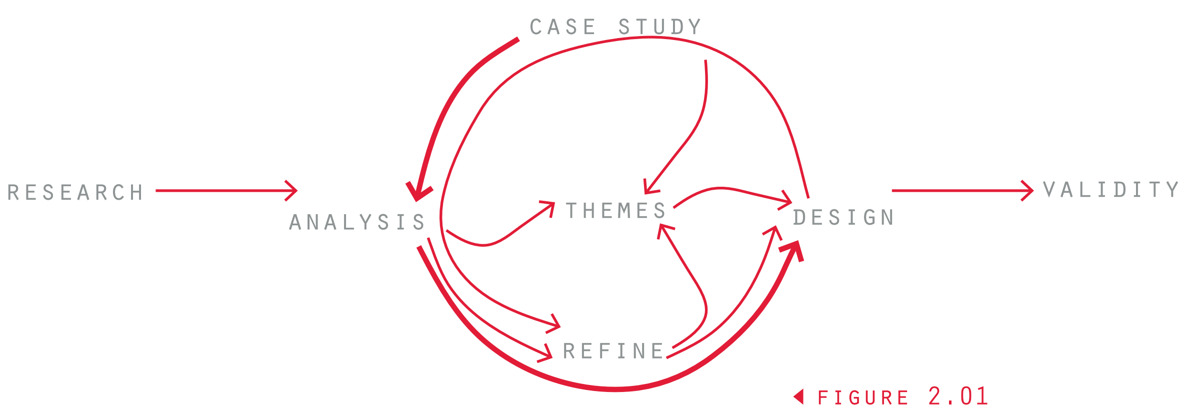


FIGURE 2.01
Methodology Process Diagram. (by Author)

CASE STUDY RESEARCH

METRICS AND CONCEPTS

Once the case studies were chosen, they were evaluated based on each sites' ability to store flood waters, remediate contaminated soils, and provide environmental learning. Concepts that were quantified for these case studies include 'recreational and learning public space', 'better water quality', 'conventional remediation or phytoremediation', 'increased habitat creation and species richness', 'increased property value', 'groundwater cleansing', 'stormwater management', 'flood storage', 'bioengineering', 'slowed velocity', 'suspended solids removal', and 'usage of a network of wetland terraces'. Not all case studies were quantified for each design theme, but when they were applicable, they were quantified. For example, if a case study did not treat water quality, it isn't quantified below.

CASE STUDIES

Case studies were chosen from the Landscape Architecture Foundation's Landscape Performance Series case studies, American Society of Landscape Architecture awards, literature, and through my internship at Atelier Dreiseitl. The case studies include Thornton Creek Water Quality Channel, Bishan-Ang Mo Kio Park, Shanghai 2010 Expo Houtan Wetland Park, Federal Medical Center, the Napa River, Magnusen Park Wetlands, Qunli Stormwater Park, Menomee Valley Redevelopment, and Sydney Olympic Millennium Parklands.

Other case studies that were referenced include Teardrop Park in Chicago, Kresge Foundation Headquarters in Michigan, an oil spill site in Milwaukee, Revival Fields, the Guadalupe River in San Jose, Buffalo Bayou in Houston, Landschaftspark Duisburg Nord in Germany, and Zeche Zollverein also in Germany. Many of these case studies fit the criteria of the identified themes developed from the case studies, but did not have enough information directly relating to the site chosen in Kansas City, Kansas. These sites either had a different program of use or other inputs to the design that were less relevant to the chosen site.

FIGURE 2.02
Thornton Creek Case Study.
(Thornton Creek, 2012)

Thornton Creek Water Channel is located in Seattle. SvR Design designed the channel in 2009. The site is adjacent to a major interstate, contributing to the overall runoff volumes for the area. The site is composed of 2.7 acres and holds runoff from its 680 acre catchment. The design converted a parking lot to a new commercial development. This development drains to the center, where a strand of small terraced pools that function as a natural stream filter the water. Designs for the channel provided a multifunctional open space for the surrounding communities in Northgate Seattle as well as providing filtered runoff before flowing back into the creek. The park was equipped with a riparian buffer, banks were stabilized and native plants were used.

Quantifying the themes developed from researching and synthesis of this case study evaluated the success of this particular project. Evaluating the 'recreational and learning public space' theme, this project increased open space by 50%. 'Increased habitat creation and species richness' was successful based on a returning bird species and the use of native plants. The project 'increased property value' with $200 million in private, residential, and commercial development. 'Stormwater management' was addressed with 78% reduction of impervious surfaces. The channel removed 40-80% of suspended solids from 91% of the average volume of annual stormwater runoff, quantifying the 'suspended solids removal' theme (Thornton Creek, 2012).

FIGURE 2.02

Bishan-Ang Mo Kio Park is located in Singapore, between the Bishan and Ang Mo Kio neighborhoods. Singapore's Public Utilities Board (PUB) popularized the transformation of Singapore to a city of water and gardens. This initiative, 'Active, Beautiful, Clean Waters Program' (ABC Waters) influenced developers and designers to begin finding multifunction in Singapore's water in order to promote social and learning spaces, as well as natural water systems in the urban environment. Atelier Dreiseitl, Singapore's PUB, and the National Parks Board designed the 155 acre park that was completed in 2012. The project transformed the concrete channel of the Kallang River into a natural, stable river. The bank slopes were stabilized using different forms of bioengineering, which were tested for many years before the park opened. The park brings people closer to the natural infiltration and cleansing processes that occur at the park. Cleansing biotopes, or ephemeral wetlands, improve water quality of the runoff in the park through detention ponds filtered with hydrophytes. These cleansing biotopes are similar to rain gardens and allow for filtration and infiltration.

Evaluating the park's success based on the themes, 'recreational and learning public space' is successful in that the park has been designed to use 42 acres of floodplain as multifunctional space; the additional space also 'increases habitat creation and species richness'. Because of the addition of this open space, the park has seen a 30% increase in biodiversity. Further evaluating the site, a system of cleansing biotopes treats 171,183.5 gallons of water per day, allowing for 'better water quality'. The design slows water velocity by 50% using a cleansing biotope system. These cleansing biotopes and bioengineering techniques increase biodiversity in the area, economic value, and environmental stewardship. Use of a natural system and public interaction, the park has been able to bring together two rivaling neighborhoods together. The joining of these two neighborhoods created an 'increased property value'. 'Stormwater management' for the park is successful because it is a pilot project for Singapore, which promotes active, beautiful, and clean water. Bishan-Ang Mo Kio Park is successful at 'flood storage' by increasing carrying capacity by 40%. 'Bioengineering' for the site is measured through the transformation of the concrete channel to a natural channel using planted gabions. The project 'slows water velocity' by 50% using a naturally meandering channel and the gabions to interrupt the flow of water. "Usage of wetland terraces' is evaluated with using cleansing biotopes that cleanse the water. and catches 40% more stormwater than before. (Atelier Dreiseitl, 2012). FIGURE 2.03

▲ FIGURE 2.03
Bishan-Ang Mo Kio Park's Outdoor Learning. (Atelier Dreiseitl, 2012)

The Houtan Park is 34.5 acres of reclaimed industrial landscape adjacent to the Huangpu River in Shanghai, China. Designed for the green Expo in Shanghai in 2010, the design incorporated flexible spaces for increases and decreases in visitors. The Expo was used to showcase new technology and green energies. Turenscape designed the Shanghai Houtan Park in China. The site was also designed to withstand heavy pedestrian traffic for the first few years and minimal visits after the expo.

The park had successful 'recreational and learning public space' in the design with the incorporation of terraces and pathways that include learning signage. 634,000 gallons of water are cleansed per day through an aeration and microbial process for 'better water quality' along the Hangpu River. The preexisting landfill, steel factory, and shipyard were 'remediated' using plants to absorb the heavy metals. 200 species were observed in total, providing an 'increased habitat creation and species richness'. 'Flood storage' was quantified as holding water from a 20 year to a 100 year flood event. 'Bioengineering' stabilized slopes by using riprap instead of the previous concrete floodwalls. The naturalized system 'increased habitat creation and species richness'. A 'slowed velocity' was achieved using terraces to slow the water. 'Usage of wetland terraces' cleansed the water through aeration while trapping pollutants (Shanghai Houtan Park, 2012). FIGURE 2.04

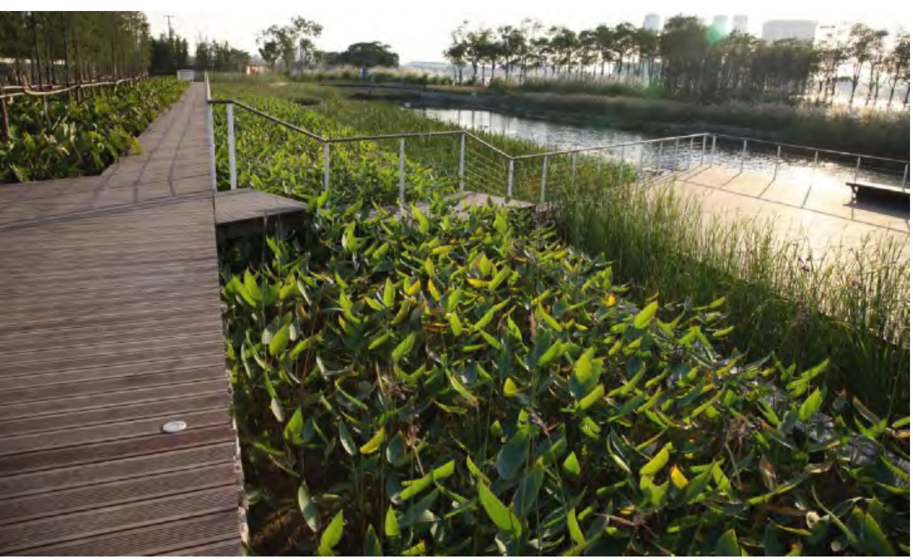


FIGURE 2.04
(2 Photos) Houtan Park in Shanghai, Designed with Lush Native Vegetation and a Variety of Experiences. (Shanghai Houtan, 2012)

The Fort Devens Federal Medical Center is a case study located in Massachusetts. The site design featured detention basins that increased water quality, decontaminated soils, and increased biodiversity. Carol R. Johnson Associates designed the site, including the 55 acre catchment. The stream incorporated detention basins within the channel to provide an ecological and fully bioengineered amenity.

The project had 'better water quality' through the implementation of three basins that eliminated toxins by 70% through biological treatment. New species and landform provided biodiversity, and 'increased habitat creation and species richness'. The 'flood storage' aspects alleviated storms up to the 100 year flood volumes and stored 65% of peak flows. Infiltration increased by 60% by increasing the opportunity for absorption. 'Bioengineering' was achieved through natural stabilization of slopes. Fiber rails and the 'usage of wetland terraces' helped to 'slow velocity' of the water, allowed for infiltration, increased habitat, and cleansed water (Goldsmith, 2001).

The Napa River runs from Mount St. Helena to the San Pablo Bay. The city of Napa experienced frequent inundation, totaling to about twenty major floods before action was taken. The river drains a 426 square mile watershed. Napa's citizens took action with the city to redesign the channel to allow for natural floodplain function. With many meetings and design solutions from the Army Corps of Engineers, the City of Napa disagreed with the flood walls and concrete channelization and wanted their river to become a naturally meandering channel. Paired with several landscape architects, the City of Napa designed a system that mitigated floodwaters, provided habitat, incorporated flex space, remediated contaminated industrial sites, and designed a social amenity.

'Remediation' for the Napa River valley project removed 170,000 cubic yards of soil from the industrial area, which was eventually used for mudflats. Marshlands promoted 'increased habitat creation and species richness'. 'Increased property value' in result of the social and natural amenities raised the commercial real estate by 20%. 'Flood storage' for the design connected 600 acres of floodplain back to the Napa River. 'Slow velocity' was achieved with a naturally meandering channel design. Marsh plains were used for inundation and 'wetland terraces', which provided more area for infiltration and filtration. FIGURE 2.05

◀ FIGURE 2.05
Napa River Valley Natural Channel.
(Viani, 2012)

Magnuson Park, once Sand Point Peninsula was a reclaimed Naval Air Station. The natural wetlands and hilly forest landscape was converted into flat land for the air station. Most runoff and any wetland water movement was piped underneath the air station. The Berger Parnership PS in Seattle, Washington designed the Magnuson Park Wetlands. The site is 154 acres of converted flat land to wetlands, athletic fields that absorb runoff, and reconstructed forestland. The design incorporated constructed paths and a variation of experience for park visitors as well as learning signage unveiling the site's natural past.

Magnuson Park Wetlands as an 'learning public space' had many volunteers and learning opportunities as well as signage for visitors. 3000 people helped with maintenance and data collection for the wetland habitats. The site used repurposed concrete from the naval air station for the design and remediated the compacted soils, which fulfilled the 'remediation' theme. 'Increased habitat creation' was measured in the increase of frog and dragonfly species from native plants. 'Stormwater management' was achieved by a cut and fill balanced natural stormwater collection, as opposed to the subsurface pipes. 'Flood storage' held 5 million gallons of water within the wetlands. 'Suspended solids removal' was at 94% removal, and there were 10 acres of 'wetland terraces' to filter and infiltrate runoff (Magnuson Park Wetlands, 2012). FIGURE 2.06

▼ FIGURE 2.06
(2 Photos) Educational Programs for the Wetlands at Magnusen Park. (Magnusen, 2012)

Qunli Stormwater Park was designed to compliment a new urban district in Heilongjiang Province, China. The urban district was to be developed into 7907 acres of building, expecting a population of about 33,000 people. The 84 acre wetland design for the new development became the main greenspace to collect the runoff from the impervious urban district. Qunli Stormwater Park in China was designed by Turenscape. The design controlled the new development by incorporating an extensive network of mounds and wetlands to hold and cleanse runoff and groundwater. An outer filtration ring used forest hydrophytes to contain and absorb contaminated runoff from the new development.

A variety of uses and pathways in Qunli Stormwater Park promoted 'recreational and learning public space'. 'Better water quality' was achieved by filtering stormwater in the outer ring of forest hydrophytes and mounds before it entered the wetland network. The wetlands had varied depths from mounded earth and wetland depressions, creating 'increased habitat creation and species richness'. 'Stormwater management' was achieved through filtered and cleansed stormwater in the filter ring before it entered the wetlands. The 'usage of wetland terraces' was composed of a necklace of ponds using cut and fill techniques (ASLA, 2012).
FIGURE 2.07

FIGURE 2.07
(4 Photos) Post-Industrial Path Network within Qunli Stormwater Park. (ASLA, 2012)

The Menomonee Valley Redevelopment plan is located in Milwaukee, Wisconsin. The 140 acres of redevelopment was designed by Wenk Associates, Inc. Menomonee Valley was home to many abandoned industrial sites. The river experienced erosion and loss of habitat from the industrial landuse. Overall, the Menomonee Valley redevelopment focused on making the area pleasant for investors, visitors, nearby citizens, and for habitats. Recreation in the area was lacking and most of the area was unused. The redevelopment sparked investment, public interest, habitat creation, and learning efforts in the area.

Menomonee Valley Redevelopment was successful at creating 'recreational and learning public space' by using bike trails linked to the city, incorporating an urban ecology center linked with schools, and learning programs involved in the redevelopment process. Menomonee Valley also acted as a student laboratory for nearby schools. The design had 'better water quality' and treated the stormwater caught on site. All 140 acres were remediated to protect the watershed and any further bank erosion. 'Remediation' consisted of piling 300,000 yards^3 of soil and debris for landforms, capping contamination. The stabilization of the riverbanks 'increased habitat creation and species richness'. The site 'increased property value' with more development and an increase of 1400% in 7 years. 'Stormwater management' was achieved from use of native plants, which allowed for better absorption. Collection and cleansing of stormwater occurred within the center of the site. 'Flood storage' was achieved through the storage of 100 year flood volumes for the 100 acre basin (Menomonee, 2012). FIGURE 2.08

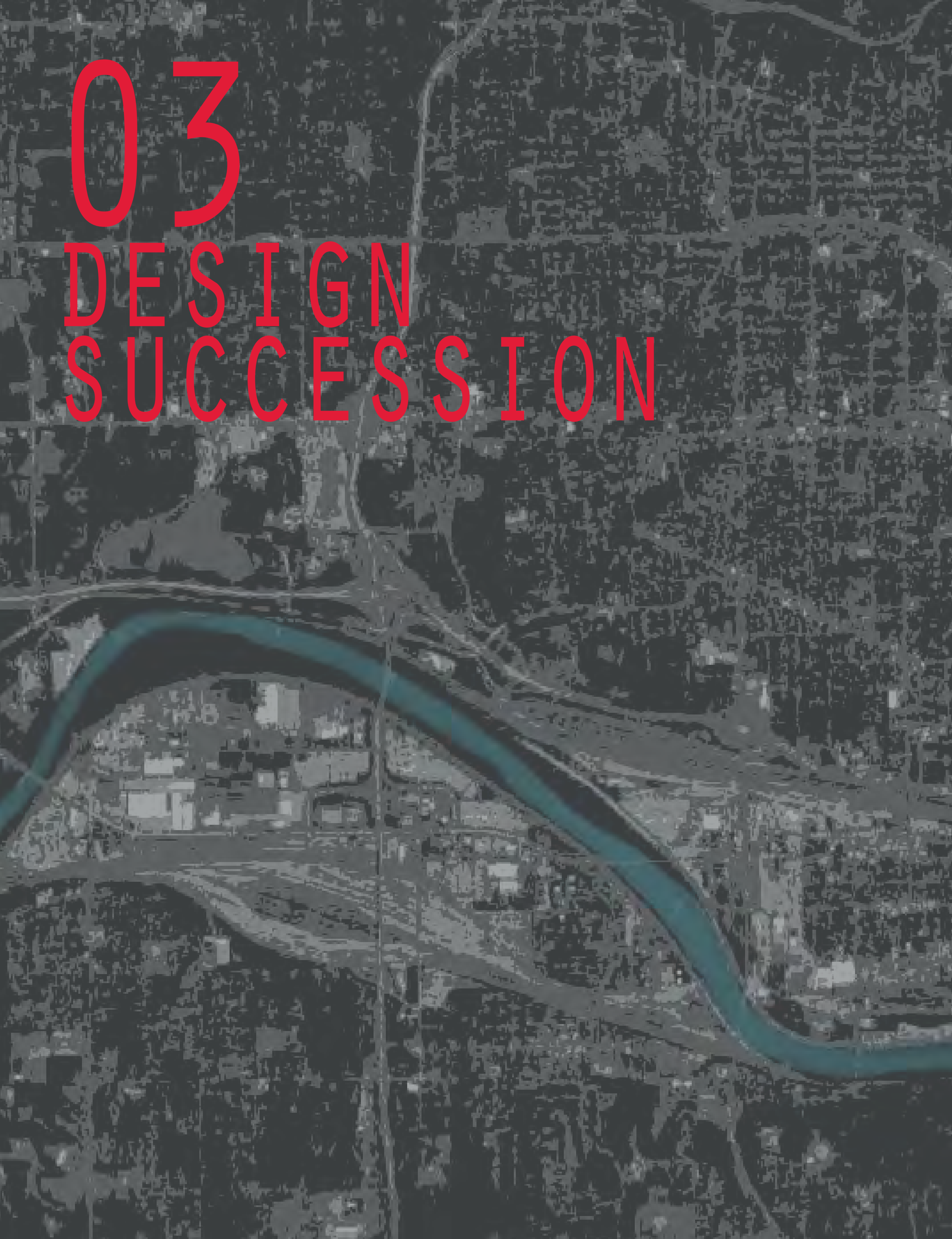
FIGURE 2.08
(2 Photos) Menomonee Valey Redevelopment Recreational Education. (Menomonee, 2012)

PWP Landscape Architecture designed the Sydney Olympic Millennium Parklands in Australia in 2000. The design was over 1000 acres of brownfield site turned into a nature park for the 2000 Sydney Olympics. Learning signs along the trail network and programs were developed to inform the public of the natural processes taking place there. Bioremediation ponds were used to cleanse contaminated soils and groundwater and also provided habitat.

The site provided 'recreational and learning public space' for around 2.5 million people per year and held education programs for schools. Trail systems and parking lots were used to enhance the learning programs. 'Better water quality' was achieved through bioremediation ponds, which provided gray water for irrigation for the parklands. Treatment of 65% contaminant saturated soils, 123,601 cubic feet of leachate, and collection of contaminated soils used for capped landforms successfully 'remediated' the site. 'Increased habitat creation and species richness' occurred from reestablishment of mangroves and ultimately their unique habitat. 180 native bird species and frog species were found in the area. 1653.5 pounds of hydrocarbons and 948 pounds of benzene were degraded through the use of the bioremediation ponds that 'cleansed groundwater'. 'Bioengineering' was achieved through restoring the creek that leads into the major river. The 'usage of wetland terraces' was successful in using remediation ponds (Sydney Olympic Millennium Parklands, 2012). FIGURE 2.09

▼ FIGURE 2.09
(2 Photos) Soil Remediation using Water in the Olympic Millenium Parklands. (Sydney Parklands, 2012)

03
DESIGN SUCCESSION



BOUNDARIES

PHYSICAL BOUNDARY

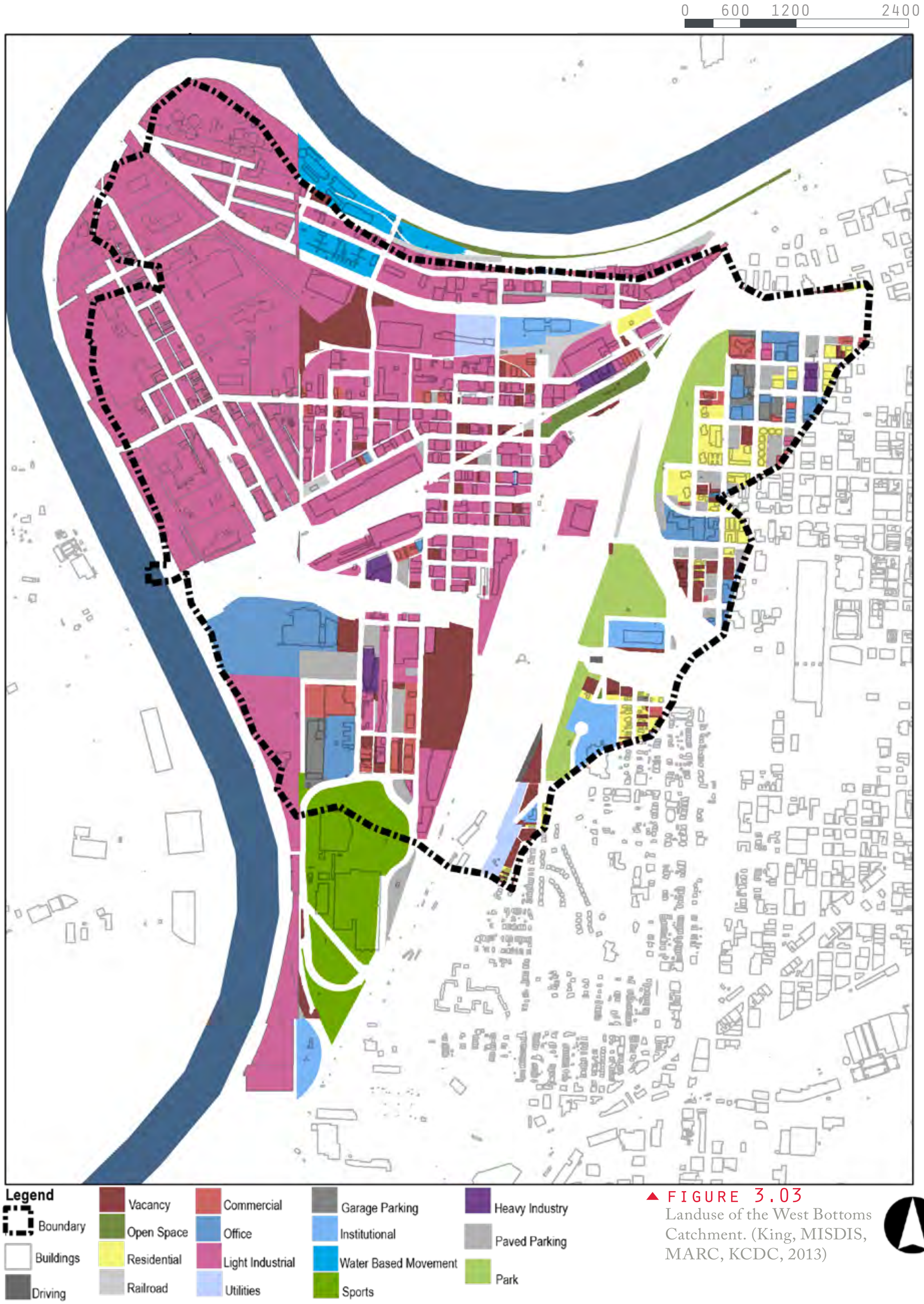
West Bottoms is located on the Missouri and Kansas state line in Kansas City. The catchment is 919 acres, including part of the downtown. The catchment boundary used in this project is from the hydrologic unit code (HUC) from the Mid-America Regional Council (MARC). West Bottoms is topographically cut off from downtown Kansas City to the east and from the confluence of the Missouri and Kansas rivers by a levee to the southeast. West Bottoms is located within the floodplain of these two rivers. The West Bottoms is primarily industrial landuse and provides a palette for phytoremediation, active public space, and flood storage.
FIGURE 3.01 AND 3.02

PHYSICAL ANALYSIS

The topography of the West Bottoms generally collects water from the Turkey Creek watershed to the south of the site. From there, the water drains north, along the eastern edge of the West Bottoms. This eastern edge contains steep slopes up to the city of Kansas City. To the northwest, there is a highpoint, which drains to the center of the site. There are two major highways into the site, creating interruptions of views. The main access points into the area are split into two categories. First, vehicular access points running east-west are Interstate 70, Interstate 670, West 12th Street, Old Highway 32, and 23rd Street to the south. Other local east connections include Forrester Road, Union Avenue, and Woodsweather Road. A local connection to the west is North James Street.
FIGURE 3.02-3.06

FIGURE 3.01
Map of Kansas City and its Surrounding Neighborhoods. (King and Google, 2013)

FIGURE 3.02
Basemap of the West Bottoms Catchment. (King, KCDC, and MARC, 2013)



▲ FIGURE 3.03
Landuse of the West Bottoms Catchment. (King, MISDIS, MARC, KCDC, 2013)

FIGURE 3.04
Topography of the West Bottoms Catchment. (King, MISDIS, MARC, KCDC, 2013)

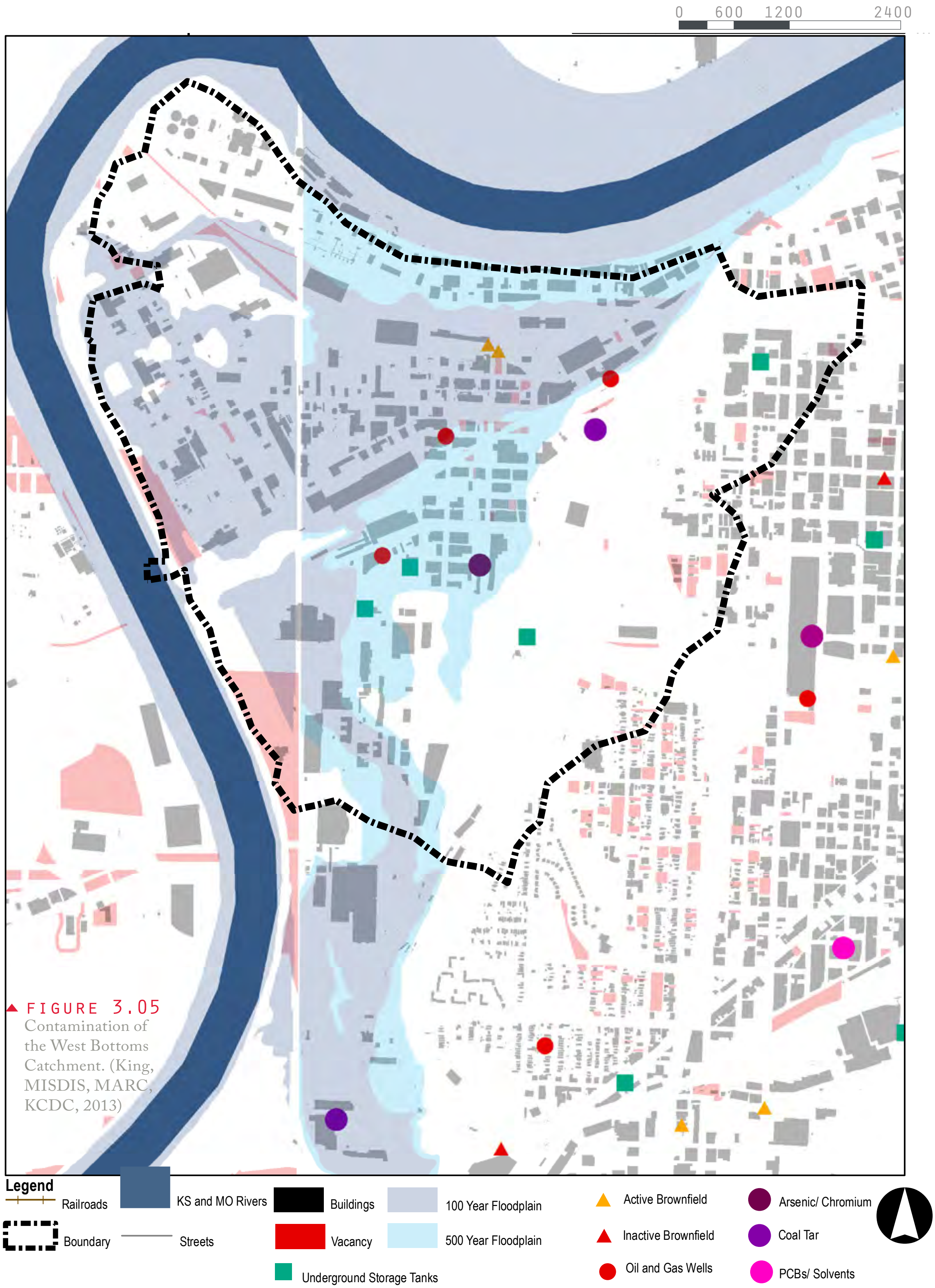


FIGURE 3.05
Contamination of the West Bottoms Catchment. (King, MISDIS, MARC, KCDC, 2013)

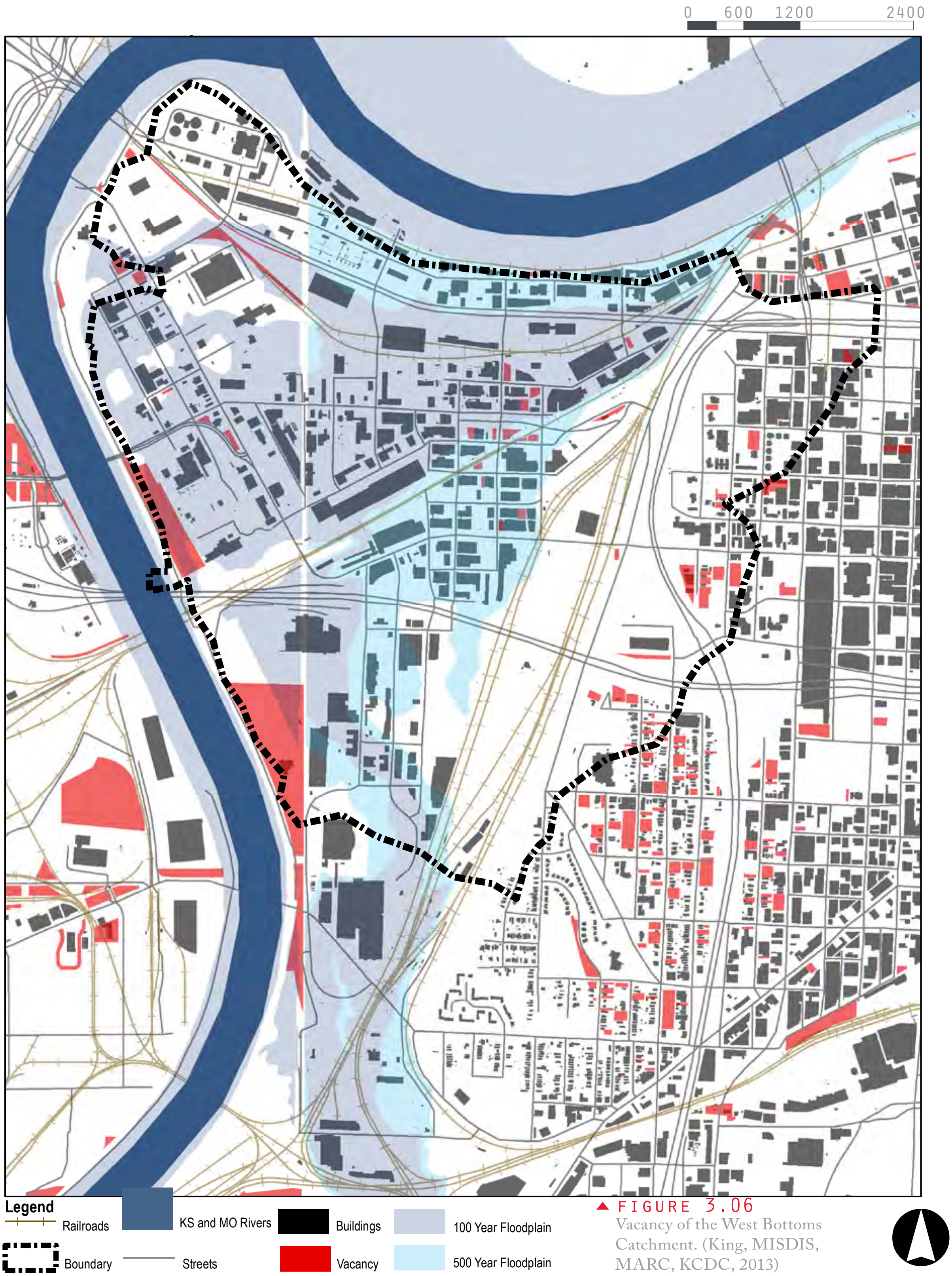


FIGURE 3.06
Vacancy of the West Bottoms Catchment. (King, MISDIS, MARC, KCDC, 2013)

FOUNDATIONAL ANALYSIS

Kansas city historical analysis

Redeveloping Industrial Sites by Carol Berens covers the history of industrial sites. Most often, industry settled near the river and began shaping cities based on the access to water. Transporting goods through water travel was important to the developing cities. The laborers lived nearby. Cities developed around the industrial riverfronts. After World War II, modern technology created a high demand for industry, further impacting environmental damage. Industrial impacts on the city contributed to urban sprawl, ultimately closing many industrial sites. The architectural style of industrial buildings was based on efficiency instead of status (Berens, 2011).

The West Bottoms was first used for trading grounds between the French Trappers and Kansas Indians. The area developed into a hub for trade from the Missouri River and Mexico via the Santa Fe Trail. With the building of the railroads, stockyards were established in 1871. City life quickly filled in, but with the flood of 1903, investment moved elsewhere. Other industry in the West Bottoms was responsible for Landing Craft Tank production in World War II. Stockyards remained in the West Bottoms, accounting for most of the economic growth of Kansas City until after World War II and finally moved with the flood of 1951. The economy crumbled within 5-6 years, with 50,000 lost jobs. The Kemper Center was built in 1974 by the American Royal to revitalize the West Bottoms (West Bottoms Business District Association, 2012).

Kansas City is home to many parks that are unused by their immediate population. These parks are part of George Kessler's original parks and boulevard system for the city. The West Bottoms lacks open space as well as connections to the city's park system.

Kansas City's overflow control plan

In the 1960s, Rachel Carson wrote *Silent Spring*, which initiated a policy based water revolution in 1970 with the Water Pollution Control Act and the Clean Water Act of 1972. This law encouraged rivers and streams to be clean by 1983. Current water systems are still inadequate and continue to allow depletion, flooding, and poor quality. The Kansas City sewer system was built 150 years ago and in some places, hasn't changed since. The Overflow Control Plan seeks to tend to sewers in need of repair and separate the 58 miles of combined sewers. Combined sewers within Kansas City carry minimal amounts of waste and stormwater during low flow, yet during high flow, the system exceeds capacity and empties into the rivers. This emptying is protected under the National Pollutant Discharge Elimination System permit for the city. Separate sewers function during low flows, but combine during high flows, flowing into the rivers. The combination at high flow is not covered under the National Pollutant Discharge Elimination System permit for the city, and is high priority for change with this plan (Franklin, 2009).

Currently, the Kansas River, Missouri River, Blue River, and Brush Creek are the receiving river systems of the sewer overflow. 127,000 people use the system. Within the Central Industrial District basin, the basin area is 5,415 acres for the catchment, serving the 25,836 population for the area. A complaint from the EPA was filed for issues of sewage outputs into the river. According to the complaint, 4.6 million gallons have been emptied into the river systems in Kansas City. The complaint extends to include discharge of sewage and dirty water onto public property. To comply with the clean water law and regulations, all discharges must be reported and the output water should not be hazardous to humans (Franklin, 2009).

The current Turkey Creek and Central Industrial District (CID) watersheds have an overflow volume of 2.66 billion gallons annually, and capture 11% of stormwater flow. For the CID watershed, there are two diversion structures in place. The basin's annual combined sewer overlow is 128 million gallons and has a 54% annual capture efficiency during precipitation events. The CID watershed is 79% efficient for basin-wide capture. The CSO plan suggests an increase in in-line storage by adding more storm sewers in the western section of the CID watershed, allowing 1.6 million gallons of storage, capturing 77% of wet weather flow (Franklin, 2009).

The goals of the Overflow Control Program reduce impacts of flooding, improve water quality, and maximize economic, social, and environmental benefits. The Triple Bottom Line (people, prosperity, and planet) is the push for this proposal (Franklin, 2009). The sewer systems should be a combination of living systems and man-made infrastructure. Management is of utmost importance to satisfy the Triple Bottom Line and to sustain over time. Performance evaluations will regulate success (Franklin, 2009).

Planning initiatives like the August 2008 stream setback ordinance will help to move the plan along. Sewers will undergo repairs, integrating living infrastructure systems supported in public and private development codes to fulfill low impact development and separating the 88% of stormwater flow from sewers. Updating the sewer system will decrease the need for flood storage. Urban forestry will be included to promote and restore biodiversity and improve quality of life. Maintenance will keep the sewer system and related infrastructure current. Efforts will be made to increase learning within the Kansas City community, to promote rain gardens through incentives, and create $5 million in jobs (Franklin, 2009).

WATER CALCULATIONS AND DATA FOR CATCHMENT

The TR-55 manual method was used to calculate stormwater runoff volume for the West Bottoms. To find volume, the Soil Conservation Service (SCS) runoff curve number (CN) method was used. As the curve number increases based on site conditions (i.e. landuse, soil type, rainfall intensity for the city), the runoff volumes increase. The equation used was $Q = ((P-I_a)^2) / ((P-I_a) + S)$. Q is equal to runoff in inches, P is equal to rainfall in inches, S is the potential maximum retention after runoff begins in inches, and I_a is equal to initial abstraction in inches. I_a can also be described as any immediate infiltration due to blocked flow or evaporation. To accurately calculate I_a, the equation $I_a = 0.2S$. The end equation used was $Q = ((P - 0.2S)^2) / (P + 0.8S)$. To find S, the equation, $S = (1000 / CN) -10$ can be used (USDA, 1986).

In my analysis of West Bottoms surface flow, I found different rainfall intensity values, or P values for the region. Regional rainfall intensities are values that are developed for each region based on inches of rainfall over a period of time. These intensities included one year, two year, five year, ten year, twenty-five year, fifty year, and one hundred year rain events for the one hour, two hour, three hour, six hour, twelve hour, and twenty-four hour rain events. Each paired year-hour rain event for the region was used for the P value in the equation above. To better explain the process, see example below (USDA, 1986). TABLE 3.01 AND 3.02

To find a weighted curve number, a weighted analysis based on area of different land uses was completed. The catchment area for the West Bottoms is 919 acres. Using percentages for residential, open space, parking and streets, commercial, and industry, a weighted curve number was calculated. Assuming most of the soil in the developed area of West Bottoms experienced compaction through development, especially with a strong industrial land use, the 'D Soil' category for finding landcover was used. There were 52 acres of residential land, 139 acres of open space, 245 acres of pavement, 134 acres of commercial, and 349 acres of industry. Each landuse was given an overall percentage of the catchment and multiplied by the curve number per landuse. Summing all of the final numbers per land use produces a weighted curve number of 94. For a better explanation, see example below (USDA, 1986). TABLE 3.03 AND 3.04

Residential land makes up 5% of the total area, when multiplied by the curve number for residential of 92, there is a 5.21 total. Open space makes up 12% of West Bottoms with a curve number of 89, which produces a number of 10.27. Paved areas are 12% of the total at a curve number of 98, producing a 11.41. Commercial land is 15% of the total with a 95 curve number, generating a 13.85. Industry is 56% of West Bottoms with a curve number of 93 and a total of 52.60 (USDA, 1986).

I used a one-year, one-hour rainfall, which has an intensity, or P of 1.45 inches. Second, I used a two-year, one-hour rainfall with P = 1.7 inches. P = 2.15 inches in the five-year, one-hour rainfall event, and P = 2.55 inches in the ten-year, one-hour rainfall event (USDA, 1986).

To find the S value for the overall equation, I used the weighted curve number from above, 94.
$S = (1000/94) - 10$
$S = 0.6383$

To find Q for a one-year one-hour rainfall, the rainfall intensity, P = 1.45, as stated above. To find the volume of rainfall, the Q value will be multiplied by the total volume of 919 acres.
$Q = (1.45 - 0.2 (0.6383))^2 / (1.45 + 0.8(0.6383))$
Q = 0.892 inches x 919 acres
Stormwater Volume = 819.604 acre inches or 68.30 acre feet

▸ TABLE 3.01

Weighted Curve Number Calculations and Storage Calculations for the Existing Conditions. (USDA, 1986) (Hershfield, 1961)

LANDUSE	ACRES	PERCENTAGE	CN	CN BY %
INDUSTRY	349	0.38	93	35.34
OPENSPACE	139	0.15	89	13.35
IMPERVIOUS	245	0.27	98	26.46
RESIDENTIAL	52	0.05	92	4.60
COMMERCIAL	134	0.15	95	14.25
				94

Before

Year	Hour Rainfall	P	S	Acres	Inches to Feet	Equals
1	1	1.45	0.64	919	12	68.30
2	1	1.70	0.64	919	12	85.65
5	1	2.15	0.64	919	12	117.72
10	1	2.55	0.64	919	12	146.82
25	1	2.90	0.64	919	12	172.58
50	1	3.30	0.64	919	12	202.25
100	1	3.70	0.64	919	12	232.11
1	2	1.70	0.64	919	12	85.65
2	2	2.10	0.64	919	12	114.12
5	2	2.60	0.64	919	12	150.49
10	2	3.00	0.64	919	12	179.98
25	2	3.90	0.64	919	12	247.09
50	2	3.50	0.64	919	12	217.16
100	2	4.30	0.64	919	12	277.13
1	3	1.85	0.64	919	12	96.24
2	3	2.20	0.64	919	12	121.33
5	3	2.90	0.64	919	12	172.58
10	3	3.30	0.64	919	12	202.25
25	3	3.80	0.64	919	12	239.60
50	3	4.30	0.64	919	12	277.13
100	3	4.75	0.64	919	12	311.04
1	6	2.15	0.64	919	12	117.72
2	6	2.60	0.64	919	12	150.49
5	6	3.40	0.64	919	12	209.70
10	6	3.90	0.64	919	12	247.09
25	6	4.50	0.64	919	12	292.19
50	6	5.10	0.64	919	12	337.48
100	6	5.70	0.64	919	12	382.89
1	12	2.50	0.64	919	12	143.16
2	12	3.10	0.64	919	12	187.39
5	12	3.90	0.64	919	12	247.09
10	12	4.60	0.64	919	12	299.73
25	12	5.30	0.64	919	12	352.60
50	12	6.00	0.64	919	12	405.63
100	12	6.80	0.64	919	12	466.37
1	24	2.50	0.64	919	12	143.16
2	24	3.50	0.64	919	12	217.16
5	24	4.50	0.64	919	12	292.19
10	24	5.30	0.64	919	12	352.60
25	24	6.10	0.64	919	12	413.22
50	24	6.90	0.64	919	12	473.98
100	24	7.75	0.64	919	12	538.64

LANDUSE	ACRES	PERCENTAGE	CN	CN BY %
INDUSTRY	255.13	0.28	93	25.82
OPEN SPACE	326.75	0.36	89	31.64
IMPERVIOUS	151.13	0.16	98	16.12
RESIDENTIAL	52	0.06	92	5.21
COMMERCIAL	134	0.15	95	13.85
TOTAL	919			92.64

TABLE 3.02
Weighted Curve Number Calculations and Storage Calculations for the 50 Year Succession Plan. (USDA, 1986) (Hershfield, 1961)

PLAN 1

YEAR	HOUR RAINFALL	P	S	ACRES	INCHES TO FEET	EQUALS
1	1	1.45	0.80	919	12	61.19
2	1	1.70	0.80	919	12	77.85
5	1	2.15	0.80	919	12	108.96
10	1	2.55	0.80	919	12	137.42
25	1	2.90	0.80	919	12	162.72
50	1	3.30	0.80	919	12	191.96
100	1	3.70	0.80	919	12	221.46
1	2	1.70	0.80	919	12	77.85
2	2	2.10	0.80	919	12	105.45
5	2	2.60	0.80	919	12	141.01
10	2	3.00	0.80	919	12	170.00
25	2	3.90	0.80	919	12	236.28
50	2	3.50	0.80	919	12	206.68
100	2	4.30	0.80	919	12	266.05
1	3	1.85	0.80	919	12	88.09
2	3	2.20	0.80	919	12	112.49
5	3	2.90	0.80	919	12	162.72
10	3	3.30	0.80	919	12	191.96
25	3	3.80	0.80	919	12	228.86
50	3	4.30	0.80	919	12	266.05
100	3	4.75	0.80	919	12	299.69
1	6	2.15	0.80	919	12	108.96
2	6	2.60	0.80	919	12	141.01
5	6	3.40	0.80	919	12	199.31
10	6	3.90	0.80	919	12	236.28
25	6	4.50	0.80	919	12	280.99
50	6	5.10	0.80	919	12	325.95
100	6	5.70	0.80	919	12	371.10
1	12	2.50	0.80	919	12	133.83
2	12	3.10	0.80	919	12	177.30
5	12	3.90	0.80	919	12	236.28
10	12	4.60	0.80	919	12	288.46
25	12	5.30	0.80	919	12	340.98
50	12	6.00	0.80	919	12	393.73
100	12	6.80	0.80	919	12	454.21
1	24	2.50	0.80	919	12	133.83
2	24	3.50	0.80	919	12	206.68
5	24	4.50	0.80	919	12	280.99
10	24	5.30	0.80	919	12	340.98
25	24	6.10	0.80	919	12	401.28
50	24	6.90	0.80	919	12	461.78
100	24	7.75	0.80	919	12	526.23

TABLE 3.03
Weighted Curve Number Calculations and Storage Calculations for the 100 Year Succession Plan. (USDA, 1986) (Hershfield, 1961)

LANDUSE	ACRES	PERCENTAGE	CN	CN BY %
INDUSTRY	170.08	0.19	93	17.21
OPEN SPACE	369.25	0.40	89	35.76
IMPERVIOUS	108.63	0.12	98	11.58
RESIDENTIAL	94.52	0.10	92	9.46
COMMERCIAL	176.52	0.19	95	18.25
TOTAL	919.00			92.27

Plan 2

Year	Hour Rainfall	P	S	Acres	Inches to Feet	Equals
1	1	1.45	0.84	919	12	59.38
2	1	1.70	0.84	919	12	75.85
5	1	2.15	0.84	919	12	106.69
10	1	2.55	0.84	919	12	134.96
25	1	2.90	0.84	919	12	160.12
50	1	3.30	0.84	919	12	189.24
100	1	3.70	0.84	919	12	218.63
1	2	1.70	0.84	919	12	75.85
2	2	2.10	0.84	919	12	103.21
5	2	2.60	0.84	919	12	138.53
10	2	3.00	0.84	919	12	167.37
25	2	3.90	0.84	919	12	233.41
50	2	3.50	0.84	919	12	203.90
100	2	4.30	0.84	919	12	263.09
1	3	1.85	0.84	919	12	85.99
2	3	2.20	0.84	919	12	110.19
5	3	2.90	0.84	919	12	160.12
10	3	3.30	0.84	919	12	189.24
25	3	3.80	0.84	919	12	226.01
50	3	4.30	0.84	919	12	263.09
100	3	4.75	0.84	919	12	296.66
1	6	2.15	0.84	919	12	106.69
2	6	2.60	0.84	919	12	138.53
5	6	3.40	0.84	919	12	196.56
10	6	3.90	0.84	919	12	233.41
25	6	4.50	0.84	919	12	277.99
50	6	5.10	0.84	919	12	322.86
100	6	5.70	0.84	919	12	367.93
1	12	2.50	0.84	919	12	131.39
2	12	3.10	0.84	919	12	174.64
5	12	3.90	0.84	919	12	233.41
10	12	4.60	0.84	919	12	285.45
25	12	5.30	0.84	919	12	337.86
50	12	6.00	0.84	919	12	390.53
100	12	6.80	0.84	919	12	450.93
1	24	2.50	0.84	919	12	131.39
2	24	3.50	0.84	919	12	203.90
5	24	4.50	0.84	919	12	277.99
10	24	5.30	0.84	919	12	337.86
25	24	6.10	0.84	919	12	398.07
50	24	6.90	0.84	919	12	458.49
100	24	7.75	0.84	919	12	522.87

LANDUSE	ACRES	PERCENTAGE	CN	CN BY %
INDUSTRY	85.04	0.09	93	8.61
OPEN SPACE	429.25	0.47	89	41.57
IMPERVIOUS	48.63	0.05	98	5.19
RESIDENTIAL	137.04	0.15	92	13.72
COMMERCIAL	219.04	0.24	95	22.64
TOTAL	919.00			91.72

TABLE 3.04
Weighted Curve Number Calculations and Storage Calculations for the 150 Year Succession Plan. (USDA, 1986) (Hershfield, 1961)

Plan 3

Year	Hour Rainfall	P	S	Acres	Inches to Feet	Equals
1	1	1.45	0.90	919	12	56.83
2	1	1.70	0.90	919	12	73.02
5	1	2.15	0.90	919	12	103.44
10	1	2.55	0.90	919	12	131.42
25	1	2.90	0.90	919	12	156.39
50	1	3.30	0.90	919	12	185.31
100	1	3.70	0.90	919	12	214.54
1	2	1.70	0.90	919	12	73.02
2	2	2.10	0.90	919	12	100.00
5	2	2.60	0.90	919	12	134.97
10	2	3.00	0.90	919	12	163.58
25	2	3.90	0.90	919	12	229.24
50	2	3.50	0.90	919	12	199.89
100	2	4.30	0.90	919	12	258.80
1	3	1.85	0.90	919	12	83.00
2	3	2.20	0.90	919	12	106.90
5	3	2.90	0.90	919	12	156.39
10	3	3.30	0.90	919	12	185.31
25	3	3.80	0.90	919	12	221.88
50	3	4.30	0.90	919	12	258.80
100	3	4.75	0.90	919	12	292.24
1	6	2.15	0.90	919	12	103.44
2	6	2.60	0.90	919	12	134.97
5	6	3.40	0.90	919	12	192.59
10	6	3.90	0.90	919	12	229.24
25	6	4.50	0.90	919	12	273.64
50	6	5.10	0.90	919	12	318.36
100	6	5.70	0.90	919	12	363.31
1	12	2.50	0.90	919	12	127.89
2	12	3.10	0.90	919	12	170.80
5	12	3.90	0.90	919	12	229.24
10	12	4.60	0.90	919	12	281.08
25	12	5.30	0.90	919	12	333.32
50	12	6.00	0.90	919	12	385.85
100	12	6.80	0.90	919	12	446.13
1	24	2.50	0.90	919	12	127.89
2	24	3.50	0.90	919	12	199.89
5	24	4.50	0.90	919	12	273.64
10	24	5.30	0.90	919	12	333.32
25	24	6.10	0.90	919	12	393.38
50	24	6.90	0.90	919	12	453.68
100	24	7.75	0.90	919	12	517.96

WASTEWATER TREATMENT PLANTS

Wastewater treatment plants exist in the West Bottoms on either side of the state line. For the Kansas side, the wastewater treatment plant is located in the farthest northwestern part of the West Bottoms and is called 'Kaw Point Wastewater Treatment Plant'. To the east of that, across the state border, the Missouri wastewater treatment plant is called 'Westside Wastewater Treatment Plant'. Primary treatment within a wastewater treatment plant is defined as settling of suspended solids and sludge. Secondary treatment within a wastewater treatment plant is the process of breaking down contaminants through several filtrations, settling basins to allow for aeration, or settling and breakdown using plants. Tertiary treatment is used as a final filter before it enters into the river. FIGURE 3.07

In an email from Jim Larkin of the Water Pollution Control Division of the Unified Government of Wyandotte County, Kansas City, Missouri, he stated that Kaw Point Wastewater Treatment Plant has the ability to treat 48 million gallons of water per day, using four trains, or systems. The process of treatment first mixes the sludge in oxygen basins and settles. Next, water goes through a final clarifier where sludge sinks to the bottom and is returned into the oxygen basins. The treated effluent, or cleansed water is then put directly into the Missouri River. By 2014 the plant will be using a low pressure UV disinfection for effluent before entering the Missouri River. On average in 2012, influent wastewater was 16.4 million gallons per day, and effluent flows, on average, were 17.7 million gallons treated per day.

In an email from Sherri Irving from the Wastewater Treatment Division of Kansas City Missouri Water Services Department, she stated that Westside Wastewater Treatment Plant treated 15.4 million gallons per day. The plant first takes the sludge and mixes it with liquor in a tank. Then the aeration begins and then settles for thirty minutes. The sludge then is returned into the first phase of the process whereas the cleansed water is then treated in the same manor two more times.

These two wastewater treatment plants currently do not have a tertiary treatment for the effluent. Therefore, the design for a wetland network in the West Bottoms catchment will partially serve as final filtration before returning to the river. This process will use wetland hydrophytes species to cleanse the water. The wastewater treatment will continue to function as is until a more resilient approach is presented to the city. Research on the topic of alternative wastewater treatment suggests that wetland networks can provide a similar result to wastewater treatment plants, however in a floodplain area such as the West Bottoms, wastewater wetlands would be subject to flooding. Projecting out to the days when the wastewater treatment plants will no longer be needed, it seems that an area such as the West Bottoms would benefit from the primary treatment of wastewater in a downsized plant. Secondary and tertiary treatment however could potentially be functional in a wetland network such as the network proposed.

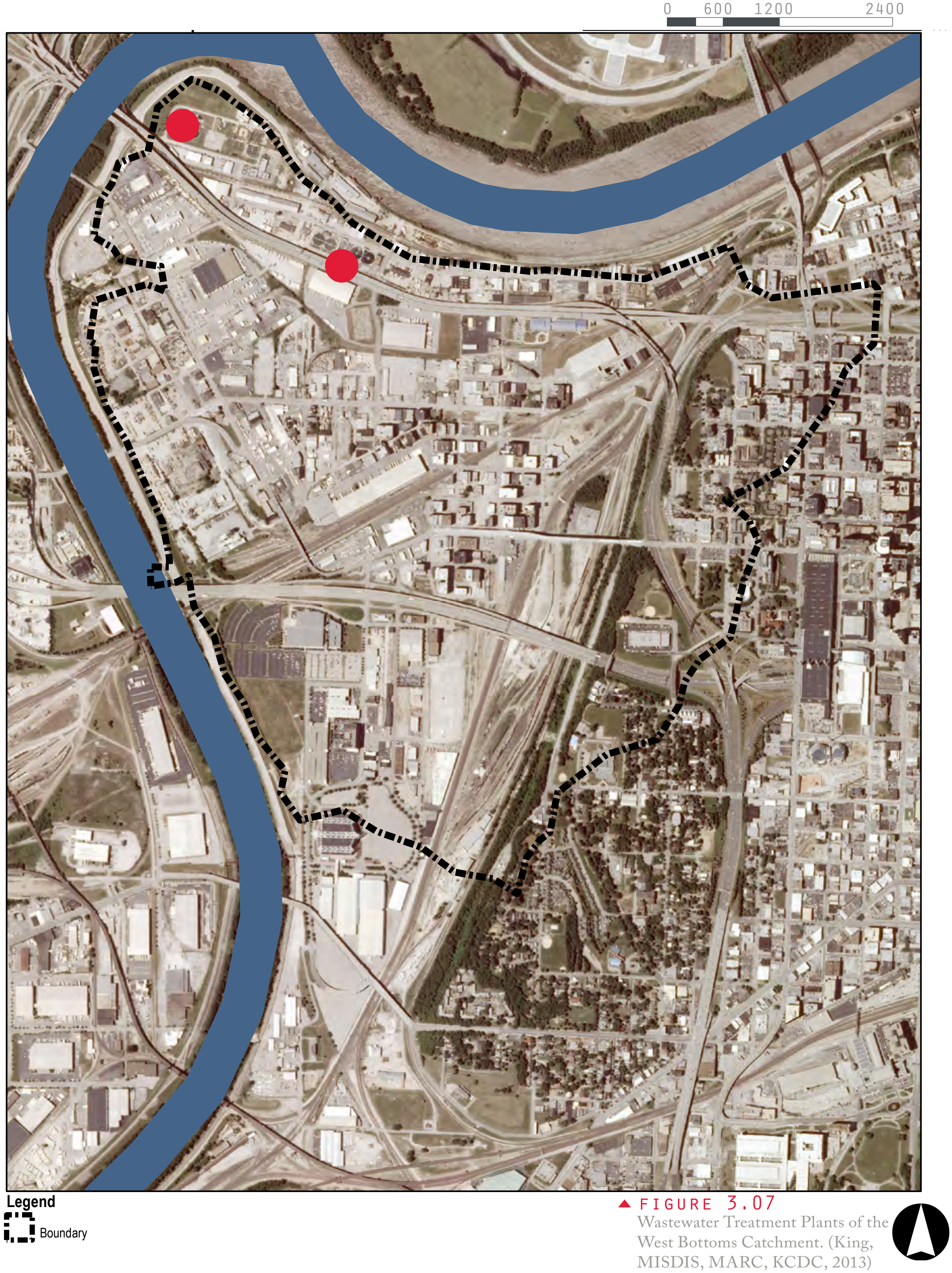


FIGURE 3.07
Wastewater Treatment Plants of the West Bottoms Catchment. (King, MISDIS, MARC, KCDC, 2013)

FLOOD STORAGE PLANS

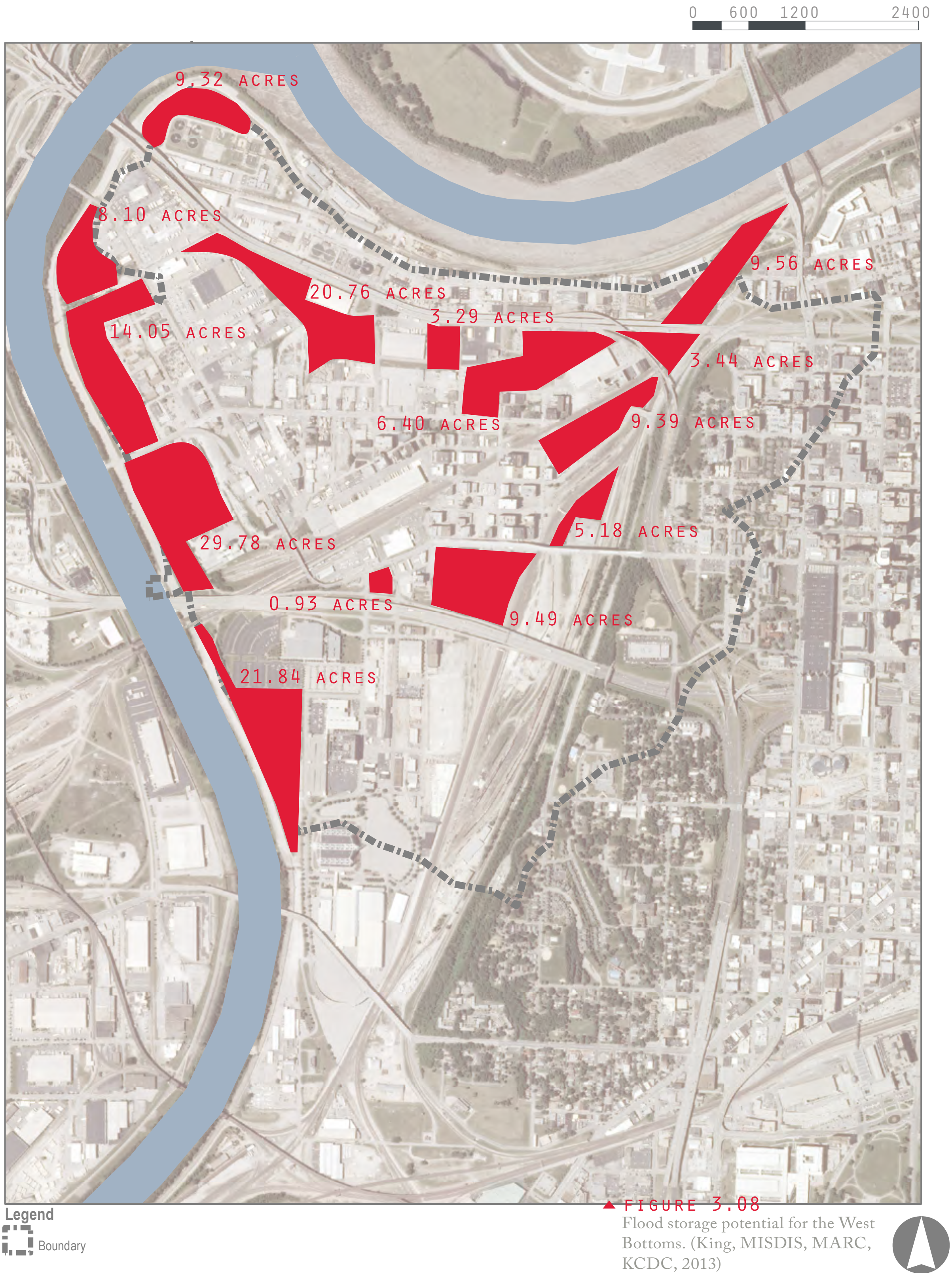
ANALYSIS OF FLOOD STORAGE POTENTIAL

With a highpoint to the northwest, most of the water to the west flows south along the western edge of the West Bottoms, or heads toward the middle of the catchment. To the south, drainage is collected from the Turkey Creek watershed and heads north toward the middle and along the east and western edges. Most of the water flowing into the catchment from the east comes from Kansas City and heads north along the bluff. The flow network analysis was done using Google SketchUp and topography maps generated in ArcGIS and AutoCAD. Mapping a flow network in other tools such as ArcHydro does not provide accurate enough flow patterns due to the flatness of the catchment.

Analysis conducted for storage potential included a site visit exploring the area and potential open spaces. Next, mapping of areas within the catchment that had potential contaminated sites uncovered areas where phytoremediation could be helpful. Google Earth, Google Maps, and Google Street View allowed me to look at possible areas that were dilapidated, were primarily used for storage, had great views, had connections to other potential flood storage areas, and provided a need for improvement. After identifying areas using Google's programs, I pulled my analysis to date into ArcGIS with generated topography from a Light Detection and Ranging (LIDAR) file, which had a 2 meter resolution. The analysis ended by looking at vacant parcels and landuse in the area, which determined areas of little challenge to obtain. FIGURE 3.08

CALCULATING STORAGE FOR PARCELS

Using a simple calculation for the entire network of parcels, stormwater storage volume was quantified. The depth of a typical wetland is about a foot and a half to three feet. For this area, most of the wetlands will be an average of two feet in depth at high flow. I calculated the flood storage potential for these parcels as a whole network by adding the area of each wetland together, then multiplying it by two feet for depth. The totaled area for the flood storage parcels equaled 152.18 acres. This area multiplied by a two foot depth equaled 304.36 acre feet of storage. If all of these initial analysis parcels were used to hold surface flow, the design for the West Bottoms catchment would hold all the water up to a 100 year one hour rainfall, up to a 100 year two hour rainfall, up to a 50 year three hour rainfall, up to a 25 year six hour rainfall, up to a ten year twelve hour rainfall, and up to a five year 24 hour rainfall. These calculations from above were used as a test run for the TR55 runoff calculations for the designed wetland network.



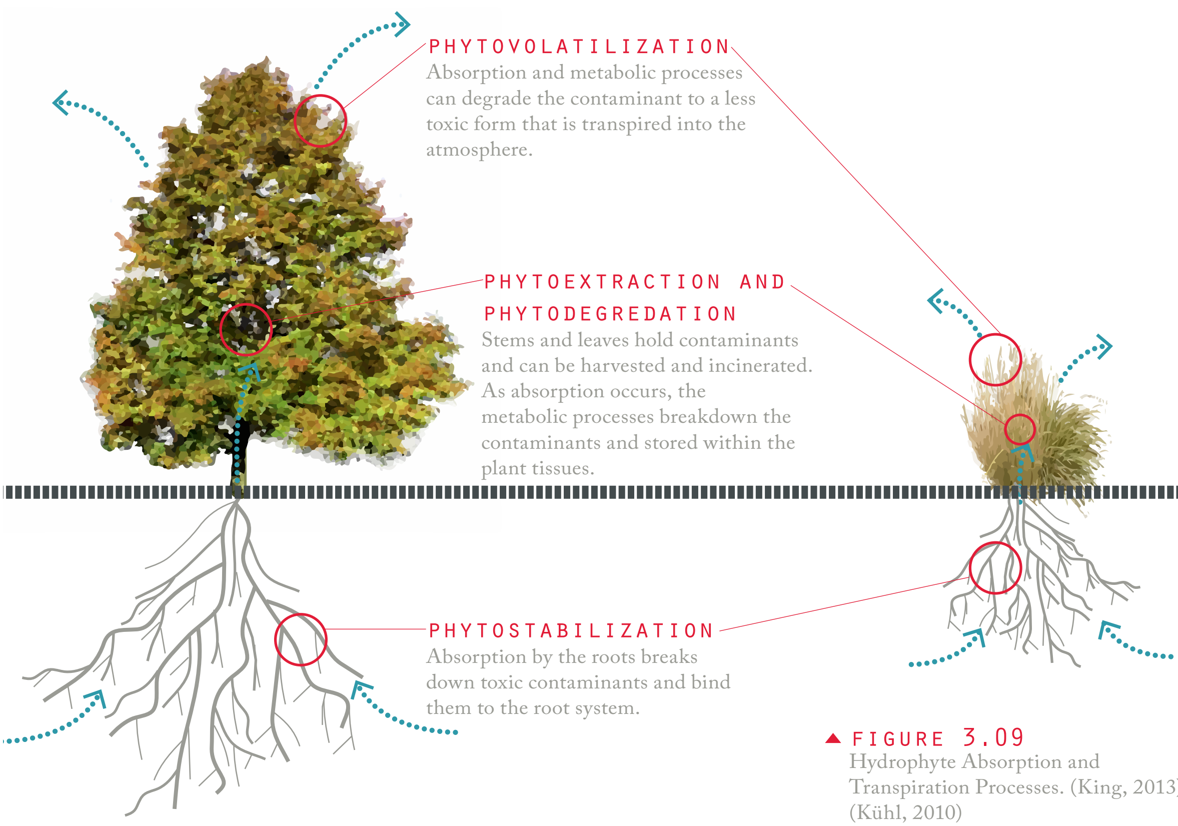
▲ FIGURE 3.08
Flood storage potential for the West Bottoms. (King, MISDIS, MARC, KCDC, 2013)

DESIGN ELEMENTS

HYDROPHYTES

As stated, the West Bottoms is host to many potential and possible soil and groundwater contaminations from the industrial landscape. The design for the wetland network integrates flood storage and phytoremediation. These two elements require cleanup before allowing storage of stormwater because of the potential seepage into the groundwater. Contaminated soils must be removed through phytoremediation prior to flood storage. In the future succession for the area, the industrial landuse will be cleansed through the use of hydrophytes within the wetland and hydrophytes cleansing the groundwater. Hydrophytes are tolerant of wet conditions and have high transpiration rates, which proves that these species can be used in the process of phytoremediation and the cleansing of groundwater.

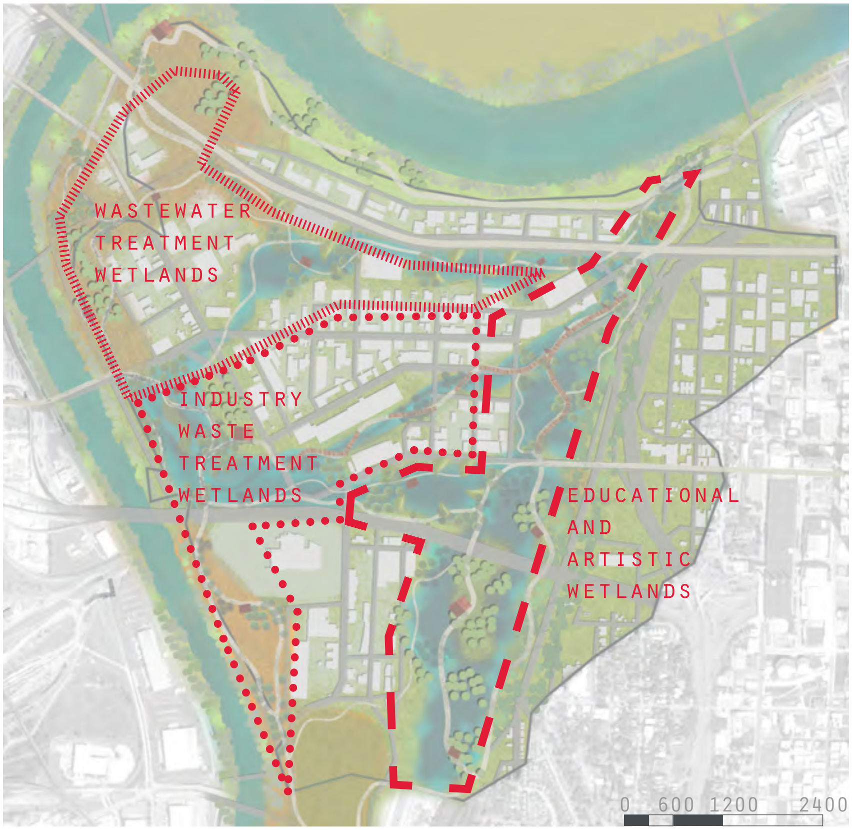
The design incorporates hydrophytes as buffers and filters for groundwater in wooded wetland buffers. Hydrophytes used in the design are valued for deep roots to tap into the groundwater, the ability to live and survive in high flow conditions as well as no flow conditions, aesthetics, quick growth, and for filtration of soil and water purposes. The selected hydrophytes include willows (*Salix spp.*), cottonwoods (*Populous deltoides*), silver maples (*Acer saccharinum*), and sycamores (*Platanus spp.*). These species are planted around the edges of the wetlands before water flows to the next wetland in order to filter any contaminated groundwater from the industrial landuse. The hydrophytes also provide a change of experience around the wetlands. Groupings of forest wetland trees provide multi-function of filtration and experience. FIGURE 3.09



▲ FIGURE 3.09
Hydrophyte Absorption and Transpiration Processes. (King, 2013) (Kühl, 2010)

WETLAND DISTRICTS

The network of wetlands are developed for three separate tasks in the design for the West Bottoms catchment. Each of these wetland types will change along with landuse during the succession. To the northwest, two wastewater treatment plants function without significant tertiary treatment of the water. In result, the design for the wetland network beginning at the far northwestern portion of the catchment and feeds into the wetlands in the central area to the north are designed to treat the wastewater in its tertiary treatment phase. This strand of wetlands is very different from the wetlands to the east and lower-middle portion of the catchment. These wetlands will serve as open space for residents, business owners, stormwater management, and recreation. These wetlands function primarily as runoff capture and experience for visitors and residents. The wetlands to the west primarily function as cleansing of industrial landuse contamination. These industries will undergo a change in regulation of wastewater and contamination, forcing a cleaner approach to industry. These wetlands will filter outputs from the industry and return the water to a state acceptable of acceptable effluent to the river. While these separate types and functions of wetlands change along with landuse during the succession, they will each maintain the appropriate management strategy and undergo the same data collection and tests to ensure they are still functioning. Looking further along the succession timeline, it is assumed that as the wetlands grow, fluctuate, and become ephemeral wetlands or wet meadows that wastewater treatment plants will no longer be an important part of society. Once new systems dealing with wastewater are adapted, these wastewater treatment wetlands will become an extension of the experiential and recreational wetlands. FIGURE 3.10



▶ FIGURE 3.10
Wetland Districts Within the West Bottoms. (King, 2013)

GREEN INDUSTRY

As the wetland network is developing and contracting, the landuse will be affected by the flux. The majority of the landuse in the West Bottoms is light industrial, which continues the cycle of contamination and presents an issue for future generations. In order to plan with succession of the wetland system, industry in the area will transform to use green technology and industry techniques. These techniques manage use of water, wastewater, consumer products, shipping and transportation, waste, materials, and product packaging. Adopting a more resilient way of manufacturing goods eliminates excessive resource use, excess waste, and overuse of water.

As an example, the Aveda Corporation strives to close the circuit of energy, consumption, and waste within the company. To do this, the corporation uses all natural products by eliminating harmful chemicals and dyes that affect the waste produced. Packaging and some products use recycled materials from the interior of their corporation as well as outsourced materials. The company strongly promotes an introspective approach for updating their earth and community care by setting goals every two years and reporting findings or results every two years. This maintenance program for the corporation keeps goals in check and develops research projects to have new forms of resilient manufacturing techniques.

LIVE-WORK-PLAY NETWORK

During the succession of the West Bottoms, a transition from primarily industrial to a live and work system will occur. The industry will slowly transition into creative industry with live above spaces. The clean industries will be art studios and simple manufacturing. These industries are designed to be within residential and commercial landuses to provide a walkable district. Within walking distance, residents will be able to enjoy nature, get coffee, shop for groceries, and go to work. This living style in the West Bottoms provides a variety of activity and the ability to be close to nature.

Artspace is a developer that is working on establishing live and work buildings. Their developments are co-owned with artists. The developer works to promote art efforts in the city and art for strengthening the community. Each project Artspace helps with has different goals ranging from helping with economic revitalization, racial issues, historic preservation and reuse, visions and ideas at a city scale, and art activism. For the West Bottoms, using this kind of developer has the potential to integrate art, nature, living spaces, and the workplace. I imagine it would include live above art studio or creative industry renovated from existing buildings, as well as a community art building that becomes an advocacy for community art programs and art education in the area.

SUCCESSION DESIGN

Designing for a succession over 150 years must incorporate flexible planning and fluctuating networks of wetlands, social and political aspects, as well as future technology. Planning for a detailed understanding of each of these changes over time is impossible. Most of the assumptions made to plan for 150 years from now are currently underway in research and planning efforts. In this instance and for the purposes of this project, the catchment of West Bottoms is entirely adaptable. For detailed design purposes, the ephemeral quality of the wetland network has to be seen as adaptive open space. These wetlands have been calculated to hold up to a certain storm event, and even beyond. When there is low flow, the design needs experiential qualities and learning opportunities in signage for each design stage focus to keep interest.

Stated above, I have designed the wetlands to have three primary functions based on location, and as a final phase, two primary functions. Learning within the wetland network will play a huge role in the success of the project at low flow, and increasingly important in the wetlands that function as wastewater treatment for the clean industry. The path network throughout the wetlands will promote activity and experiential learning. In the eastern portion of the site, learning paired with experience promotes use of the network even at low flow. The eastern wetlands will serve as spillover space from the crossroads and provide creative industries space to showcase work throughout. Open space in the West Bottoms will have a variety of experiences from the woodlands to the wetlands, seating and path access is possible. Gathering spaces for events are placed to further promote learning and provide residents and workers an area to share with one another. Contemplative paces occur within the entire wetland network to allow workers in the industries to the west areas to relax, and give residents and artists area to be inspired. The 150 year succession is illustrated in a time line focusing on phytoremediation, flood storage, education and development. Each of these stages throughout the next 150 years is illustrated following the time line.
FIGURE 3.11 AND FIGURES 3.12-3.20

50 YEARS

DEVELOPMENT

The succession during stage five provides better connections to throughout the wetland network. Path hierarchy is formed to enable people to experience the entire wetland network. Also, development changes and increase in commercial and residential landuses will start a new identity for the West Bottoms.

FLOOD STORAGE

The succession through stages three and four end the fifty year mark of succession and begin the next phase of maintenance. These two stages offer the opportunity to educate the residents on how the West Bottoms stores floodwaters and begins to connect into a network of wetlands.

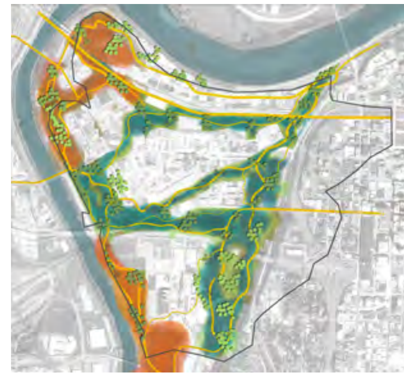
EDUCATION

The succession through stages one and two focus on phytoremediation. The importance of education through these first two stages is critical in the success of the designed succession. Education will provide a learning atmosphere of the history and future of the West Bottoms. These stages prepare the West Bottoms for storage of stormwater.

PHYTOREMEDIATION

100 YEARS

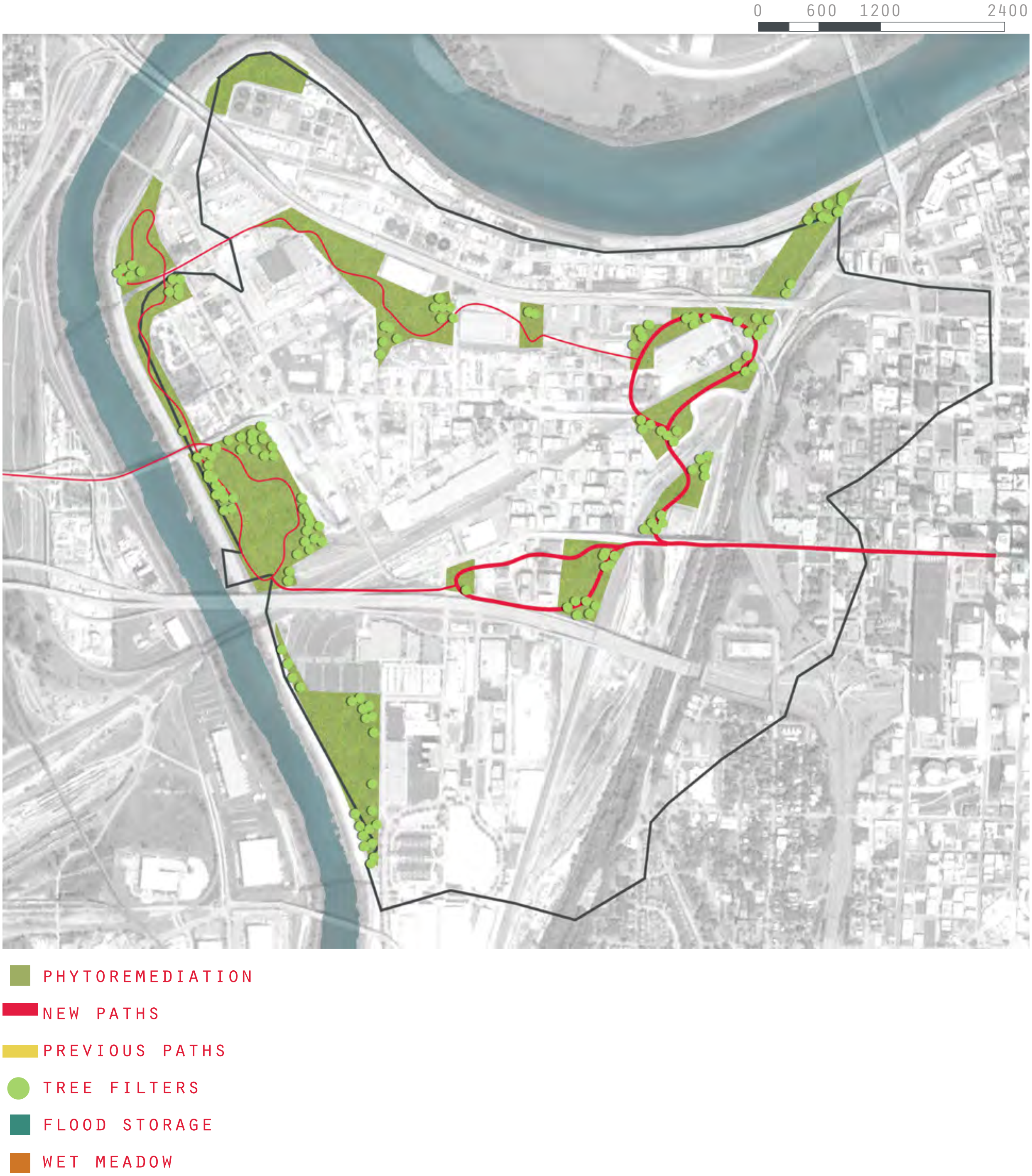
The last stage of the 150 planned succession includes a full network of connected wetlands. Wet meadows are the final stage of succession and completes new development. The new landuse finishes the idea of the West Bottoms as a live-work-play network.



Succession stages seven and eight begin the last stage of the planned succession. These plans increase connectivity throughout the site and increase flood storage. Education is key to allow residents to experience the ecological benefits of the designed and natural succession.

Succession stage six focuses on new open space for flood storage. The new areas are first phytoremediated. These new areas must have education on the process and previous landuses.

FIGURE 3.11
Successional Stages of the West Bottoms in the Different Parts of Succession. (King, 2013)



▲ FIGURE 3.12
Stage One Focuses on an Educational Pathway Through the Area of Phytoremediation. (King, 2013)

PHYTOREMEDIATION

NEW PATHS

PREVIOUS PATHS

TREE FILTERS

FLOOD STORAGE

WET MEADOW

▲ FIGURE 3.13
Stage Two Expands the Educational Pathway Through the Area of Phytoremediation and Includes the Start of Flood Storage. (King, 2013)

PHYTOREMEDIATION

NEW PATHS

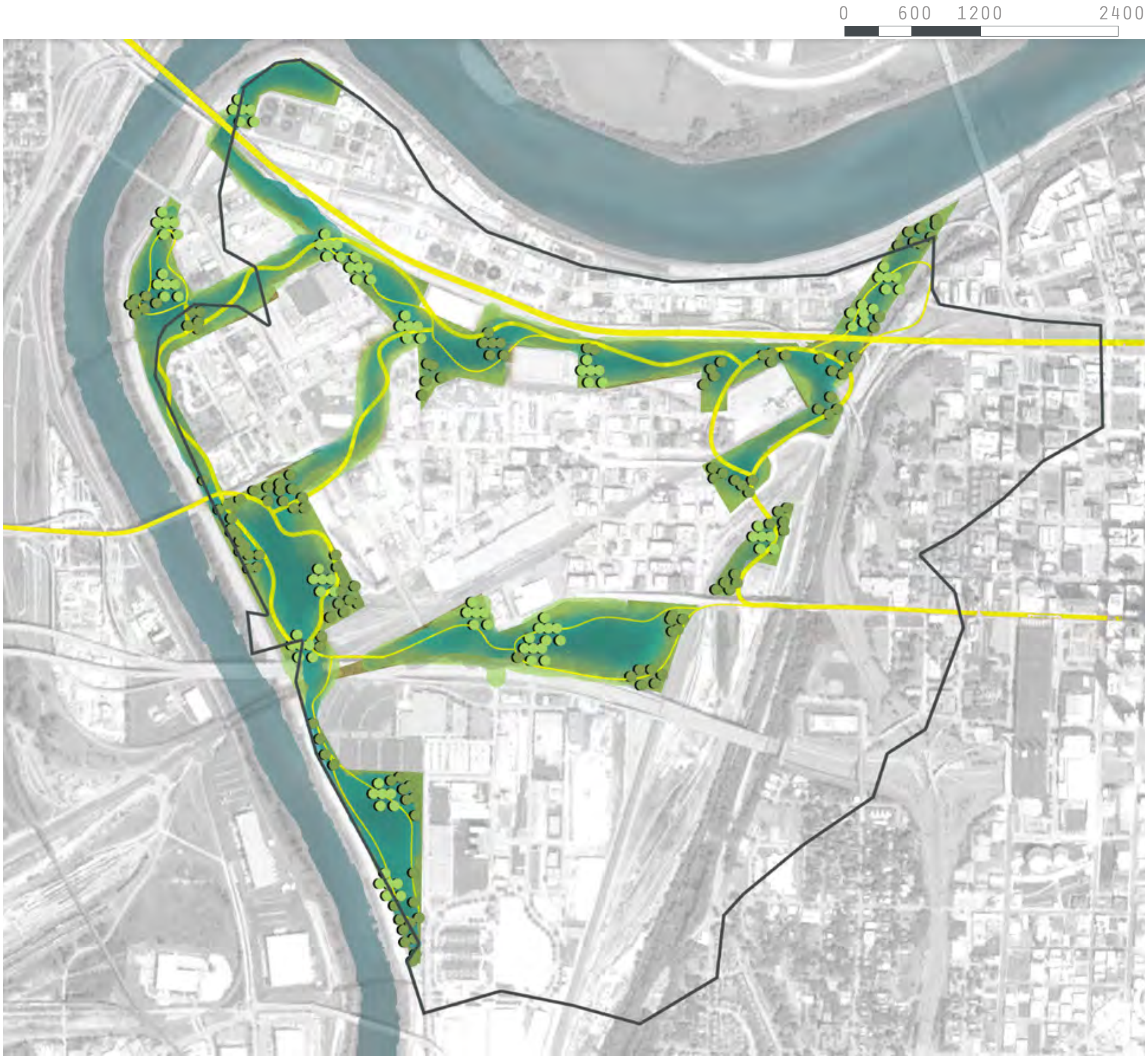
PREVIOUS PATHS

TREE FILTERS

FLOOD STORAGE

WET MEADOW

▲ FIGURE 3.14
Stage Three is at the Fifty Year Mark. This Plan Focuses on an Education Through the Flood Storage Wetlands. A Regional Bike Path Connects to Kansas City. (King, 2013)



PHYTOREMEDIATION

NEW PATHS

PREVIOUS PATHS

TREE FILTERS

FLOOD STORAGE

WET MEADOW

▲ FIGURE 3.15
Stage Four Expands and Connects the Pathway Through the Flood Storage Wetlands. (King, 2013)

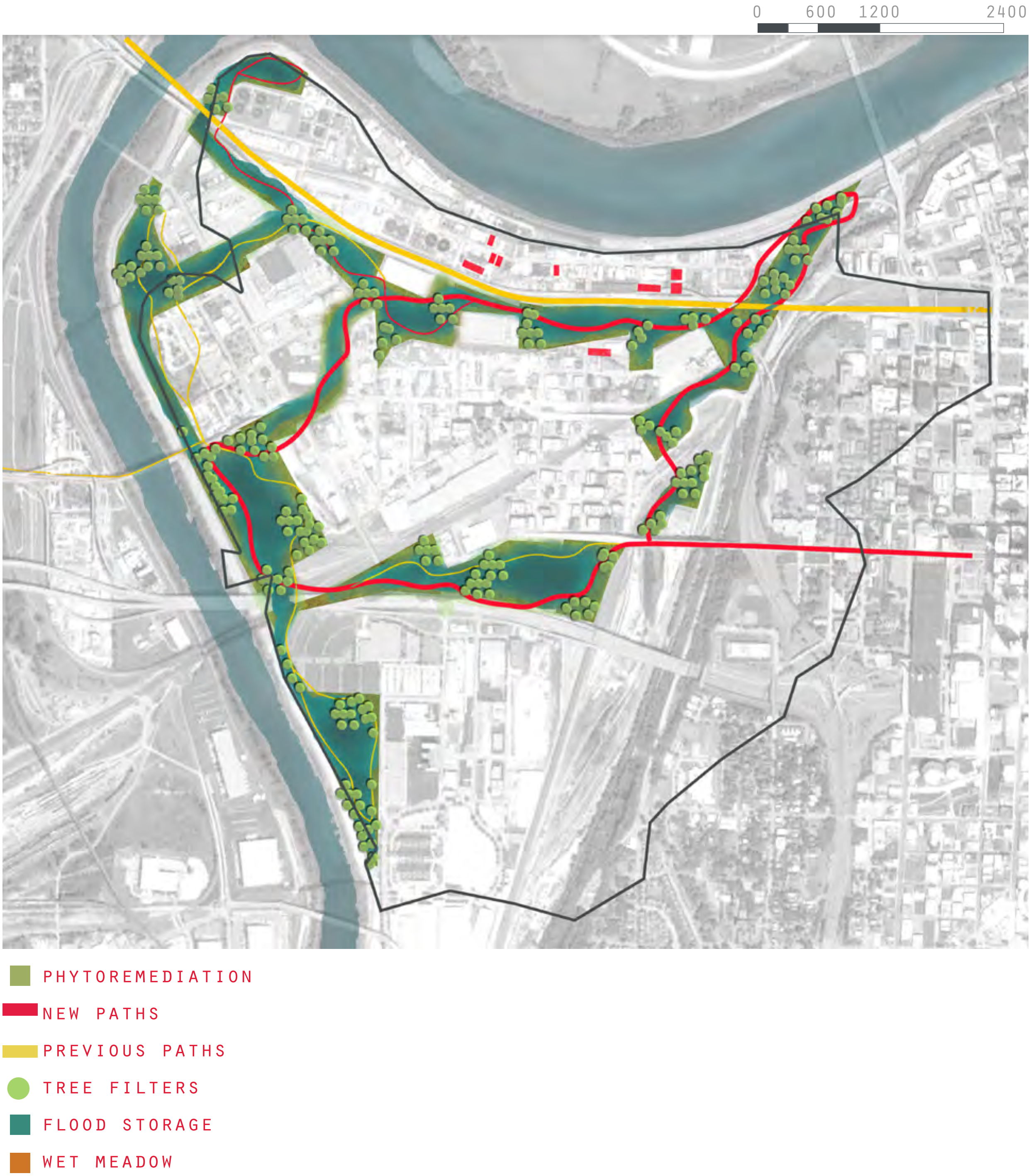
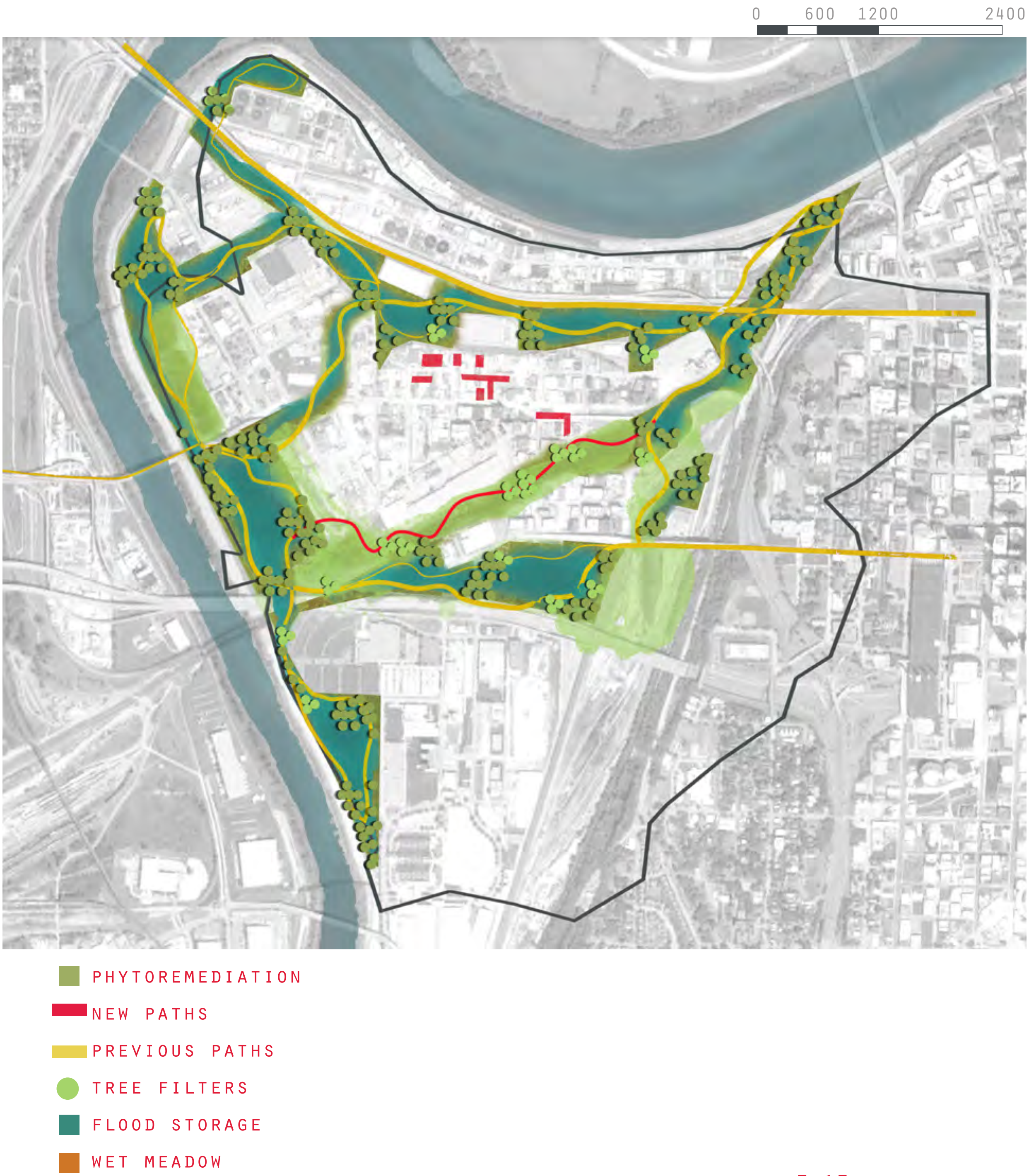
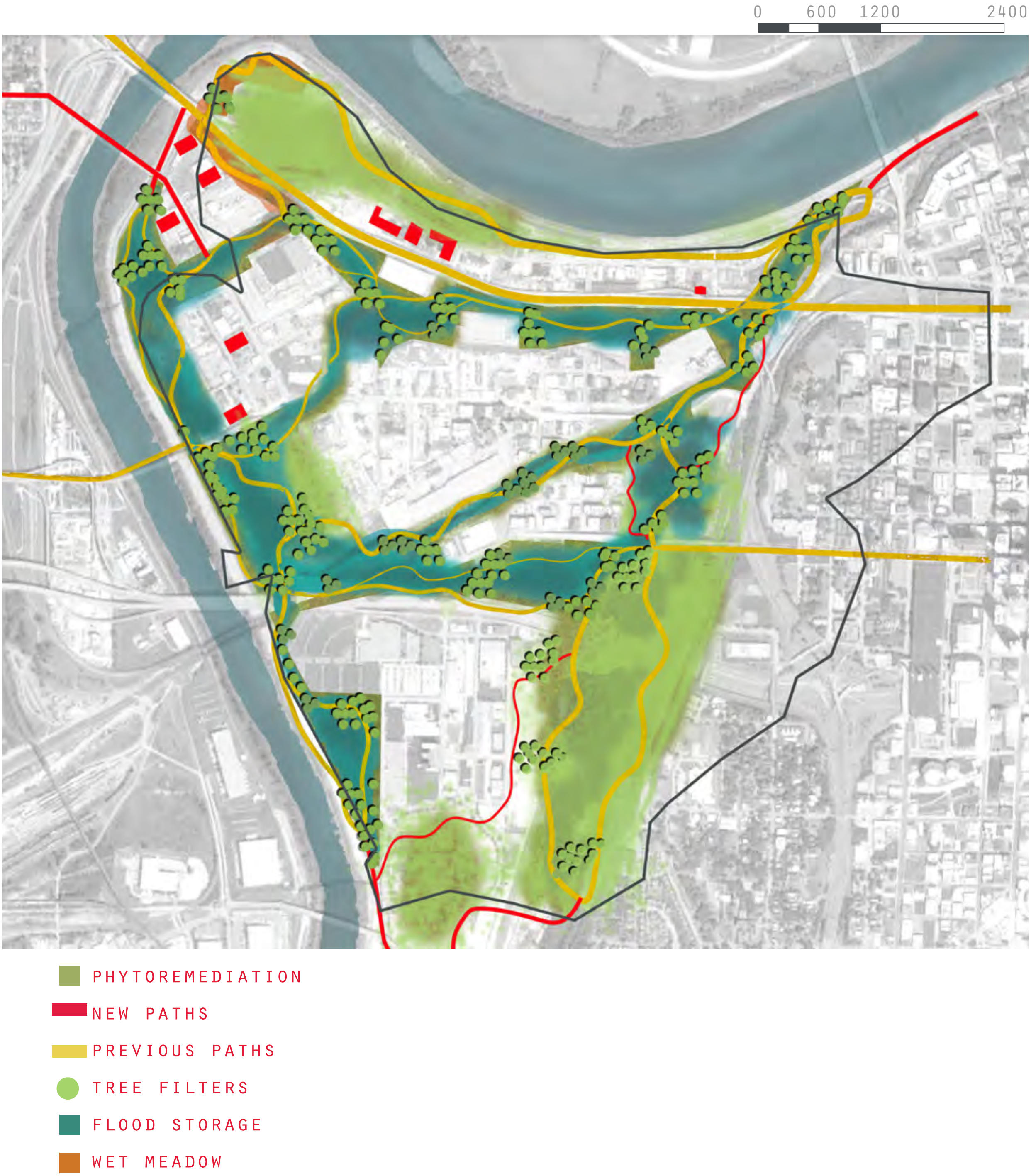


FIGURE 3.16
Stage Five Forms a Connective Loop Around the Wetlands to Allow for Education and Recreation. (King, 2013)

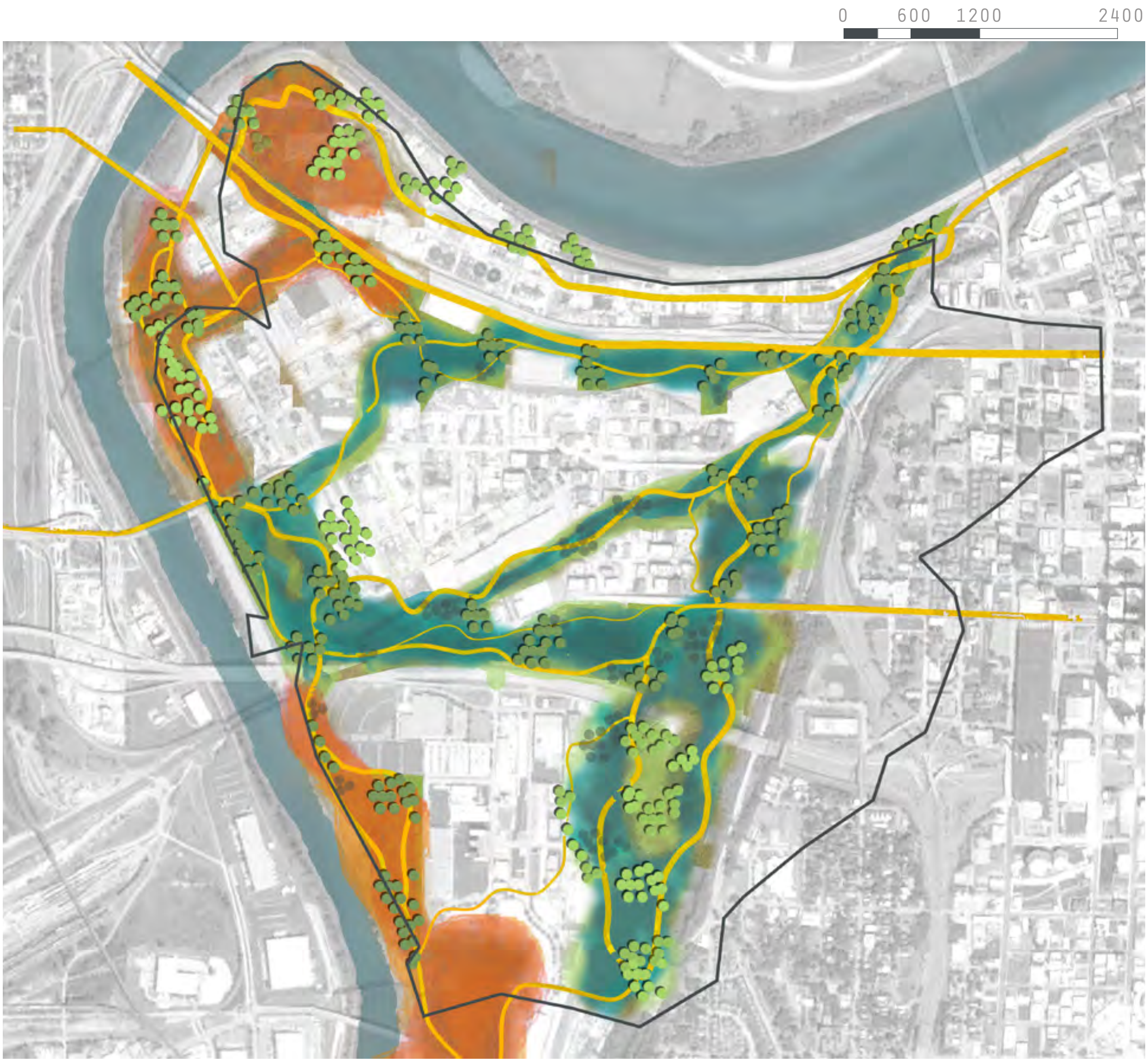


▲ FIGURE 3.17
Stage Six Expands the Area of Phytoremediation to Make Further Connections Through the Wetland Network. New Clean and Creative Industries Continues to Develop in the Area. (King, 2013)

▲ FIGURE 3.18
Stage Seven Marks the 100th Year of Succession. Phytoremediation Continues in the Railway Right of Ways and Development Forms a Live-Work-Play District. (King, 2013)



▲ FIGURE 3.19
Stage Eight Connects Pathways and Fills in Development in Areas that are Lacking. (King, 2013)



PHYTOREMEDIATION

NEW PATHS

PREVIOUS PATHS

TREE FILTERS

FLOOD STORAGE

WET MEADOW

▲ FIGURE 3.20
Stage Nine Marks the 150th Year of Succession. The Wetlands to the West Have Become Wet Meadows and are Used for Overflow Purposes. (King, 2013)

DESIGN STAGE ONE

SUCCESSION

Fifty years from now, the West Bottoms will be in the midst and at the end of phytoremediation cleanup and the beginning stages of flood storage enhancement. Focusing on establishment, measures will be taken to reconstruct contaminated soil if necessary. Detritus will be used to encourage microbes in the soil. The soil that cannot be phytoremediated will be removed and or capped if necessary. Soil will be reconstructed to allow for new plant growth.

The landscape of the catchment will be sculpted to allow for floodwater flow and storage. Surface water wetlands will be fragmented and the beginning stages of connecting these parcels underway. Connections to Kansas neighborhoods to the west, such as Riverview, and connections to the east to downtown Kansas City are made. Vegetation is well established and hydrophyte tree filters are expanding. Contaminated vegetation has been incinerated. Wetland hydrophyte species are establishing, as water is stored. Industry and wastewater treatment plants become used less. The sewer systems are under reconstruction to separate waste from stormwater. More efforts in the downtown have been made to alleviate the pressure on the storm sewers through natural detention systems. FIGURE 3.21

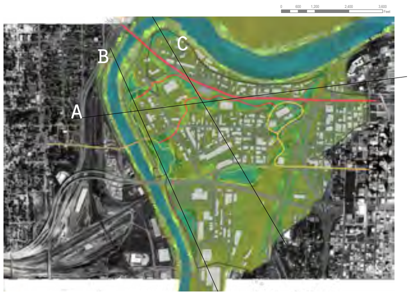
The wetland network is experienced through a trail system, heading north around the perimeter of the wetlands. To encourage access into the West Bottoms, a regional bike path is included underneath the I-70 viaduct. Circulation focuses on the eastern portion of the West Bottoms to educate people on the phytoremediation occurring in the east, where the most contamination potential is located. Circulation continues throughout the site in a loop that runs through to the west, to the south and back to the east. There are a few crossings of roads and pedestrian bridges for better circulation. Roads currently cross over many of the connections of the wetlands. A range of experiences occurs through the forested areas and along the wetland edge. Mounds have been developed for interest during all seasons and low flow. Small platforms sit just above the water level to engage people with the water. Larger platforms are found throughout for larger gatherings and classes. FIGURES 3.22-3.26

FIGURE 3.21
Landscape Experience and Informal Learning Opportunities at Successional Stage One: 50 Years. (King, 2013)

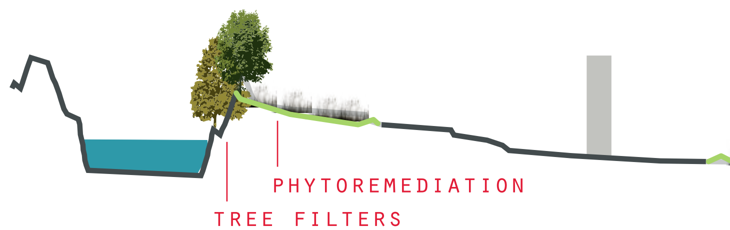
▸ FIGURE 3.22
Design for the Succession at 50 Years. (King, 2013)

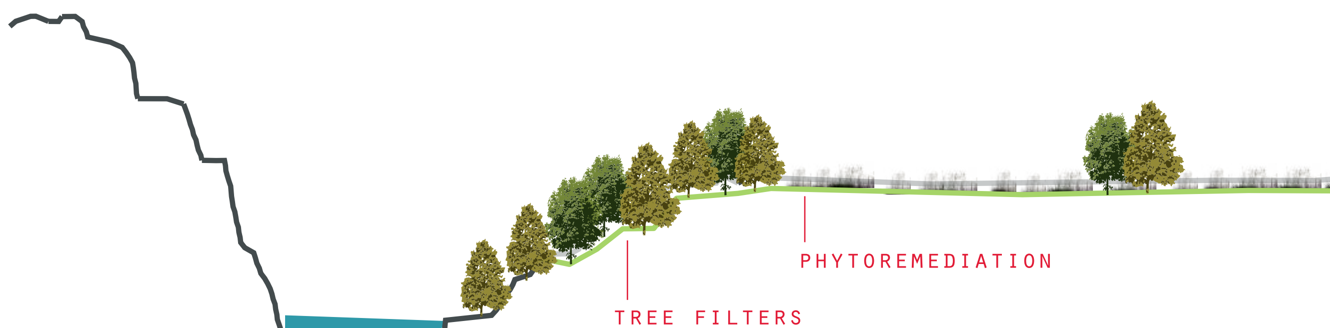
Imagine a park with a system of phytoremediation taking place in some areas, and flood storage in other areas. The plants are absorbing contaminated groundwater and contamination in the soils while people walk along the pathway. They stop to learn about the land that will soon collect water and how overtime, the land will heal and grow through succession. Continuing along the path, residents come across wetlands that are functioning to store stormwater and cleanse it before recharging the groundwater through infiltration. Walkers, runners, families, and school groups are all intrigued by the wetland habitats. Birds return to the area, insects are enjoying the native grasses, and frogs are jumping. Tree filters are established and providing habitat for bird species. The wetlands to the north, the people learn, is focused on cleaning wastewater in its final stage of cleansing before returning to the Missouri River. The loop of wetlands connects to Kansas City, Kansas and Missouri, serving a variety of neighborhoods. Walking along the loop gives a variety of spaces that serve those looking for lunch spaces, joggers, families, leisurely walks, ADA accessible pathways, and play spaces. Within the urban context, this is a place for learning, observing, playing, and relaxing. FIGURES 3.27 AND 3.28

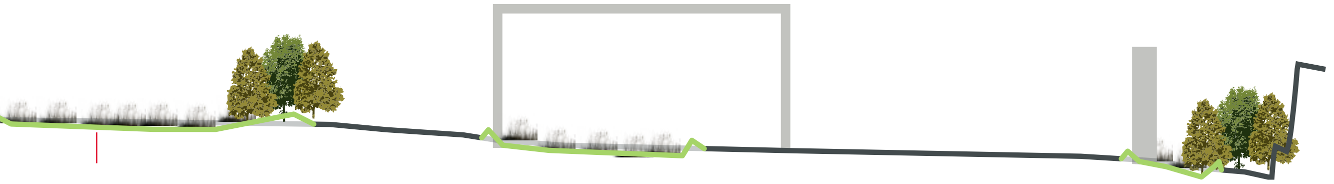
▼ FIGURE 3.27
The Montage Shows how Residents are Using the Area and How the Design and Natural Succession Create a Destination for the Network. (King, 2013)



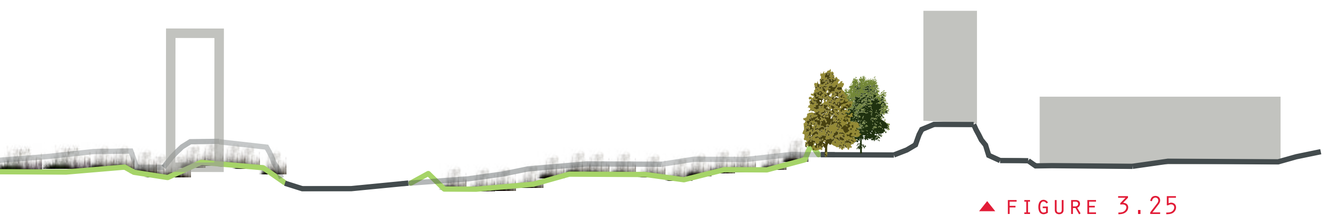
▶ FIGURE 3.23
Sections for the 50 Year Succession.
(King, 2013)





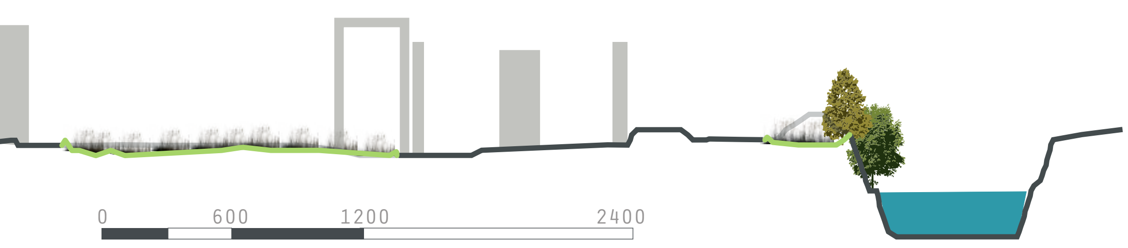


▲ FIGURE 3.24
Section Cut A is Cut Through the Kansas River and the Phytoremediation Areas and Development in Figure 3.21. (King, 2013)



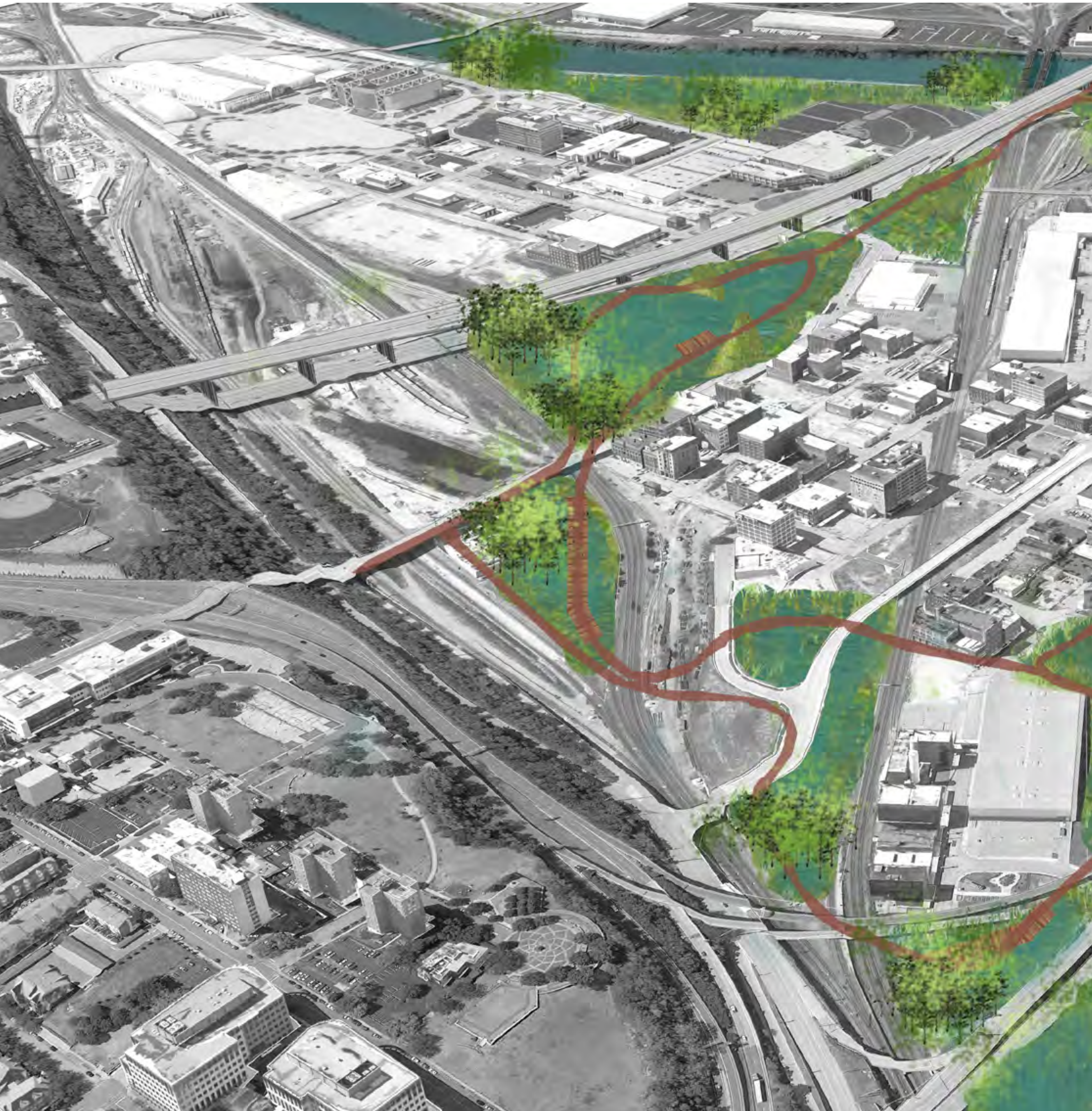
▲ FIGURE 3.25
Section B is Cut Through Kansas River and the Phytoremediation Areas to the West, Showing the Succession of the Wetland Network. (King, 2013)

▼ FIGURE 3.26
Section C is Cut Through the Phytoremediation Areas and New Development. It Also Shows the Slope Up to Kansas City and the Kansas River. (King, 2013)



Imagine a park with a system of phytoremediation taking place in some areas, and flood storage in other areas. The plants are absorbing contaminated groundwater and contamination in the soils while people walk along the pathway. They stop to learn about the land that will soon collect water and how overtime, the land will heal and grow through succession. Continuing along the path, residents come across wetlands that are functioning to store stormwater and cleanse it before recharging the groundwater through infiltration. Walkers, runners, families, and school groups are all intrigued by the wetland habitats. Birds return to the area, insects are enjoying the native grasses, and frogs are jumping. Tree filters are established and providing habitat for bird species. The wetlands to the north, the people learn, is focused on cleaning wastewater in its final stage of cleansing before returning to the Missouri River. The loop of wetlands connects to Kansas City, Kansas and Missouri, serving a variety of neighborhoods. Walking along the loop gives a variety of spaces that serve those looking for lunch spaces, joggers, families, leisurely walks, ADA accessible pathways, and play spaces. Within the urban context, this is a place for learning, observing, playing, and relaxing. FIGURES 3.27 AND 3.28

▼ FIGURE 3.27
The Montage Shows how Residents are Using the Area and How the Design and Natural Succession Create a Destination for the Network. (King, 2013)



▲ FIGURE 3.28
The Aerial Showing the West Bottoms During Succession Stage One at Fifty Years (King, 2013)

PERFORMANCE THEMES

Themes from the case study research were also evaluated for the successional timeline, first focusing on establishment. The themes show the ecological, aesthetic, and economic performance benefits and services of the design. These themes would be monitored over the succession timeline.

- Recreational and learning public space- Path networks and varied seasonal interest create recreation and learning for the design. This phase is important in that people need to understand the process of phytoremediation and the process of the landscape over the last 50 years and over the next 100 years. The importance of learning in this fifty-year succession is to gain interest and involvement in the community. Events and programs will be held to gain public interest in the project as well as establish task forces for future maintenance and care plans.

- Better water quality- Hydrophytes have been planted and established to cleanse groundwater, while other plants geared toward phytoremediation are in the process of extracting heavy metals, chromium, and ammonium. Wetland plants cleanse surface flow from storm events and water from wastewater treatment plants.

- Conventional remediation or phytoremediation- Phytoremediation is the extraction method used. Plants used are cottonwoods, silver maples, sycamores and willows to provide natural succession and native plant interest. 326 acres are remediated in this 50-year succession. Volunteer plant communities are beginning to establish.

- Increased habitat creation and species richness- Habitat is increased with open space and biodiversity from the wetlands. The network of wetlands incorporates a variety of experiences from forest wetland to upland prairie to open water wetlands, attributing to new species and habitat. Open space increased by 135%.

- Increased property value- Property value increases with new open space. Plans for future industrial use and a new district bring in excitement for the community.

- Groundwater cleansing- Hydrophyte tree filters (as part of the wooded wetland areas) work to extract groundwater contamination and stabilize it before reaching the river.

- Stormwater management- Collection of stormwater through site grading and storage begins to take the load off of the storm sewers, and in result the entire sewer system for Kansas City.

- Flood storage- The addition of 375.5 acre feet of flood storage through wetlands that are not fully connected to create a network yet.

- Slowed velocity- Velocity of the water is slowed through hydrophyte tree filters in the wooded wetland areas and through the series of wetlands.

- Suspended solids removal- Cleansing the secondary effluent of the wastewater treatment plants within the wetlands will function as suspended solids removal.

- Usage of a network of wetland terraces- The design incorporates wetlands, not yet linked to form a network in this successional phase.

STORAGE CALCULATIONS

Over the fifty years of establishment, the West Bottoms catchment is 28% industry, 35.5% open space, 16.5% impervious surface, 5.5% residential, and 14.5% commercial. These landuses produce a weighted curve number for runoff calculations of 93. Within 50 years, storage has the potential to alleviate the stormwater produced from a 100 year one hour rainfall, a 100 year two hour rainfall, a 100 year three hour rainfall, a 100 year six hour rainfall, a 25 year twelve hour rainfall, and a ten year 24 hour rainfall. FIGURE 3.29

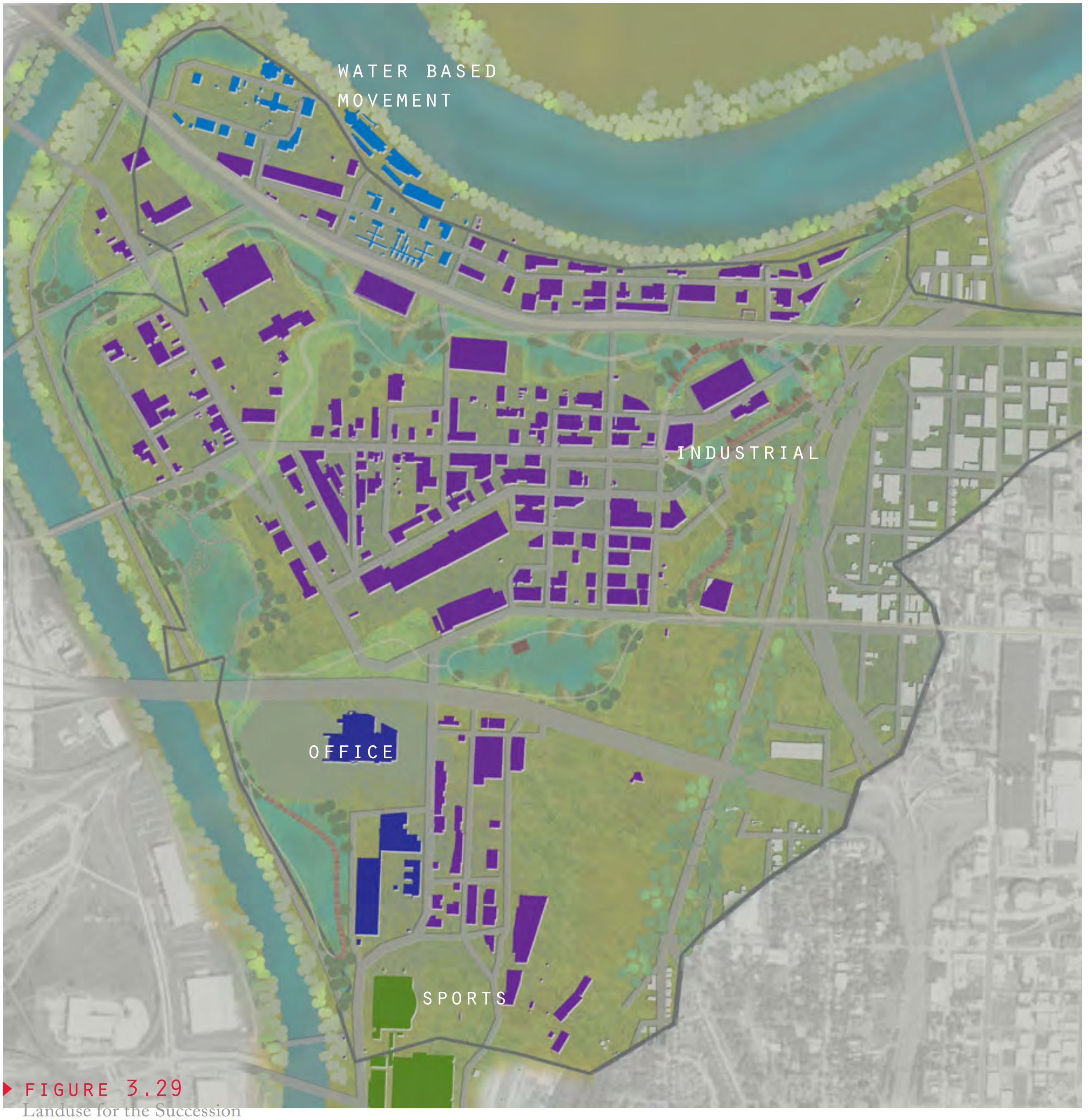


FIGURE 3.29
Landuse for the Succession at 50 Years. (King, 2013)

DESIGN STAGE TWO

SUCCESSION

One hundred years from now, the succession of the West Bottoms will be focused on maintenance. Habitat, biodiversity, learning programs, native plants, floodwaters, wetlands, and trail networks will all be in the maintenance phase. This means that the people of Kansas City will need to maintain interest in the project by using learning programs and public awareness. Plant communities will be maintained to ensure that growth and volunteer species are continuing to promote the most ecosystem benefits possible for the area. Tests will be run as part of the learning programs to make certain that the storage system and phytoremediated soils are performing.

It is expected that railroads will become obsolete, with the use of high-speed trains, and more efficient means of shipping. The remediation process for the railroad right of ways will be taking place. Flood storage will be actively holding surface flow, and maintain habitat and ecosystem services. The flow patterns of the wetlands are now connected through railroad right of ways and along previously vacant lots. Roads that run through the wetlands are now either bridges or only crossable at low flow. Development nearest the river is now transformed into an extension of the Richard L. Berkley Riverfront Park. Connections to the outer neighborhoods are still maintained. More woodland wetland areas filter the groundwater. Wastewater treatment is no longer the major water treatment and the plants are in the process of downsizing to treat only for primary stages of treatment. Secondary and tertiary treatment has shifted to wetlands filtration. Sewer systems have become separated for stormwater and sewage. The downtown has researched and implemented more living infrastructure systems, alleviating the need for storm sewers. FIGURE 3.30

The wetland network is experienced through the trail system, weaving through the wetlands. Circulation focuses on the central loop, bringing people through the connected wetlands that cleanse industrial waste, the wetlands near the I-670 viaduct, and back up through to the northeast. New circulation to the southeast is within the railroad corridor and educates people on phytoremediation and history of landuse. Other circulation paths educate visitors on flood storage and wooded wetland groundwater filtration. Road crossings are bridged or crossable during low-flow. Pedestrian boardwalks through the wetlands have been installed and bridges to have a wider range of experience. Hydrophyte forests are established along the wetland edges and in the connections. Mounds, small platforms, and larger platforms are now equipped with more seating and learning signage. A few pavilions have been built for learning programs and events. FIGURES 3.31-3.35

▶ FIGURE 3.30
Landscape Experience and Informal Learning Opportunities at Successional Stage Two: 100 Years. (King, 2013)

▶ FIGURE 3.31
Design for the Succession at 100 Years. (King, 2013)

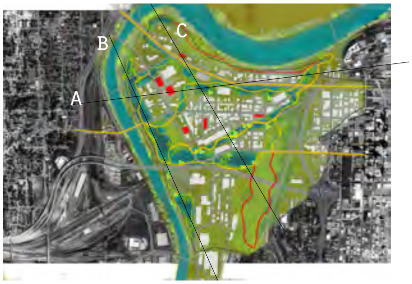
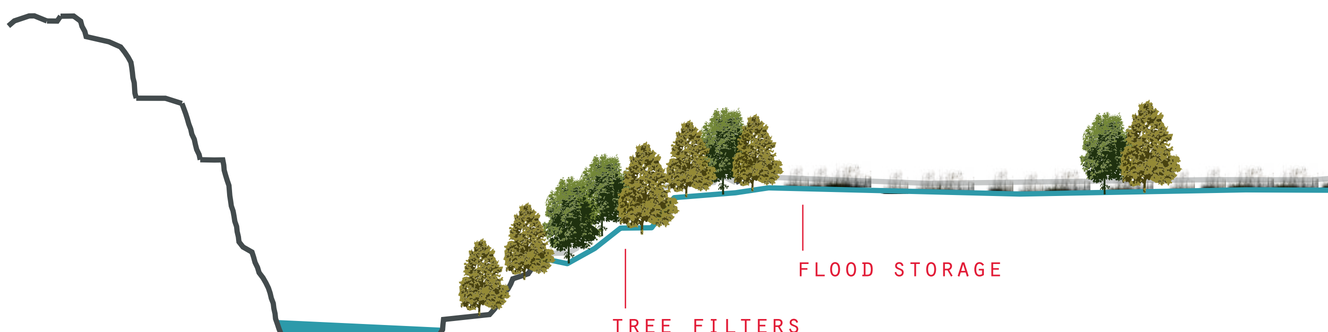
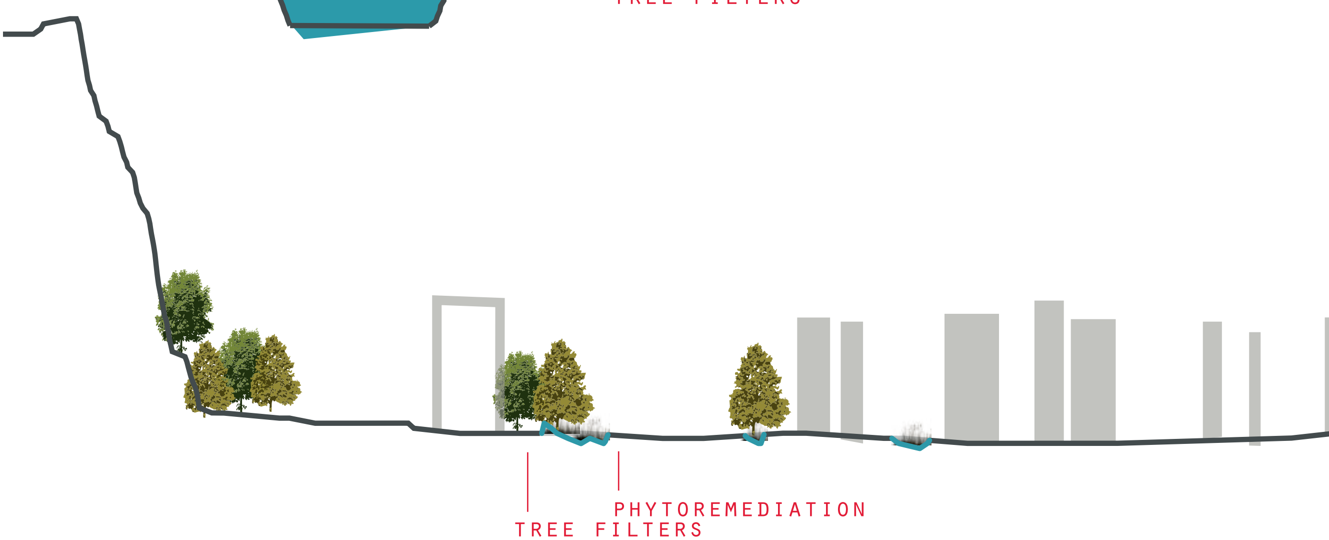
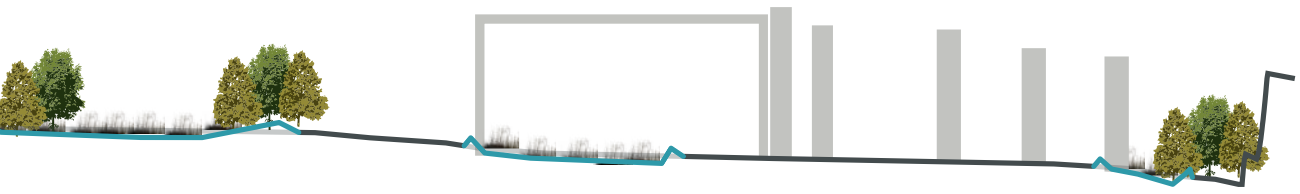


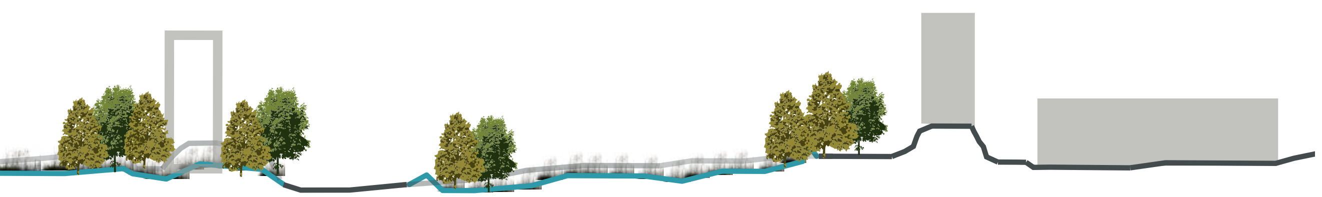
FIGURE 3.32
Sections for the 100 Year Succession.
(King, 2013)





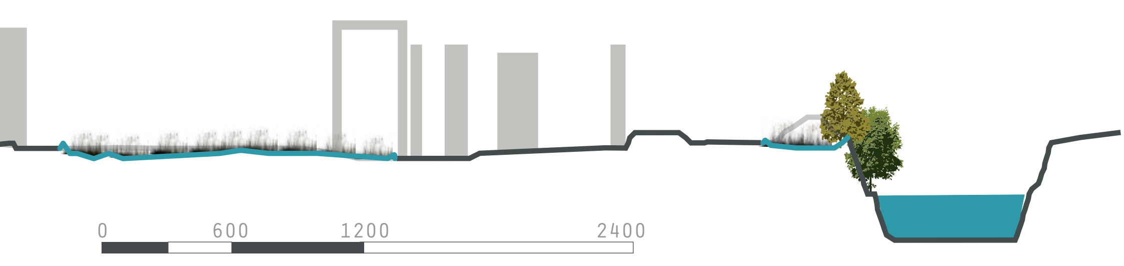


▲ FIGURE 3.33
Section Cut A is Cut Through the Kansas River and the Wetlands and Development in Figure 3.29. (King, 2013)



▲ FIGURE 3.34
Section B is Cut Through Kansas River and the Wetlands to the West, Showing the Succession of the Wetland Network. (King, 2013)

▼ FIGURE 3.35
Section C is Cut Through the Wetlands and New Development. It Also Shows the Slope Up to Kansas City and the Kansas River. (King, 2013)



Imagine a community organization working together to fix up the pathway, remove volunteer and invasive species, and lead walking tours of the open space/wetland network. A park that is now holding more water from higher intensity rainfalls is transforming into a cohesive yet functional oasis from the city life. Visitors come from the greater Kansas City area to see the transformation from an old industrial district. Children play in the water while parents relax on the docks and mounds. School groups gather to look at the tadpoles in the water while joggers run past. The sounds of succession include birds chirping, tree leaves rustling, frogs croaking, and grasses swaying in the wind. Children's laughter, feet running along a gravel path, and families chatting can all be heard within the network. As cleansing is taking place within the wetlands, children are learning through active exploration. This park showcases people who are excited about succession and invested in their community open space network. As stewards, the community participates in cleanup while researchers collect data and samples to ensure the function of the park. New areas for phytoremediation have expanded with the unused railway corridor. The main path focuses on the central loop, yet allows for contemplative lunch spaces for working people. FIGURES 3.36 AND 3.37

▼ FIGURE 3.36
The Montage Shows how Residents are Learning From Experience of the Natural Succession and How the Wetlands are an Amenity. (King, 2013)

▲ FIGURE 3.37
The Aerial Showing the West Bottoms During Succession Stage Two at 100 Years (King, 2013)

PERFORMANCE THEMES

Themes from the case study research were also evaluated for the successional timeline, second focusing on management. The themes show the ecological, aesthetic, and economic performance benefits and services of the design. These themes would be monitored over the succession timeline.

- Recreational and learning public space- Path networks have been expanded to give more experience and exposure to the wetlands. Education programs will benefit from getting close and getting to know the species. Historical signage outlines the process for phytoremediation and the use of wooded wetland species as groundwater filtration. Signage also includes information on wastewater treatment and industrial waste treatment. Maintenance happens through learning programs and community involvement help to keep interest in the long-term succession of the West Bottoms.

- Better water quality- More hydrophytes have been planted and established to cleanse groundwater, and railroad right of ways are in the process of phytoremediation in order for it to hold surface flow. Wetland plants continue to cleanse stormwater and wastewater from industry. Wastewater that was treated by the treatment plants is now being treated in its primary stages within the treatment plants and all secondary and tertiary treatment becomes filtered through the wetlands running east west in the north.

- Conventional remediation or phytoremediation- Phytoremediation is the extraction method used to remediate the transformed railroad right of way in the southeast. Plants used are cottonwoods, silver maples, sycamores and willows extract contaminants and provide native habitat. 42.75 acres have been added to the remediated open space system.

- Increased habitat creation and species richness- Habitat has increased again with the addition of 42.75 acres of open space for habitat. Potential habitat has increased 13% in the last 50 years.

- Increased property value- Property value increases with new open space. Plans for future clean industry and a new creative live-work-play district maintain in excitement. Commercial business has increased by 31.7% from fifty years ago.

- Groundwater cleansing- Wooded wetland filters continue to extract groundwater contamination and stabilize it before reaching the river.

- Stormwater management- Through flood storage, detention wetlands also capture and filter stormwater before infiltration occurs.

- Flood storage- The addition of 85 acre-feet of flood storage increases flood storage by 22.6%. Flood storage wetlands are now fully connected to create a network.

- Slowed velocity- Velocity of the water is slowed through established tree filters and paths double functioning as check dams. Mounds also help to slow velocity.

- Suspended solids removal- Cleansing of secondary effluent from the waste water treatment plants removes any leftover suspended solids.

- Usage of a network of wetland terraces- The design incorporates a fully connected wetland system.

STORAGE CALCULATIONS

Over the last 100 years, the West Bottoms catchment has transformed to incorporate 18.5% industry, 40% open space, 12% impervious surface, 10.25% residential, and 19.25% commercial. These landuses produce a weighted curve number for runoff calculations of 92. Within 100 years, storage has the potential to alleviate the stormwater produced from a 100 year one hour rainfall, a 100 year two hour rainfall, a 100 year three hour rainfall, a 100 year six hour rainfall, a 100 year twelve hour rainfall, and a fifty year 24 hour rainfall. FIGURE 3.38

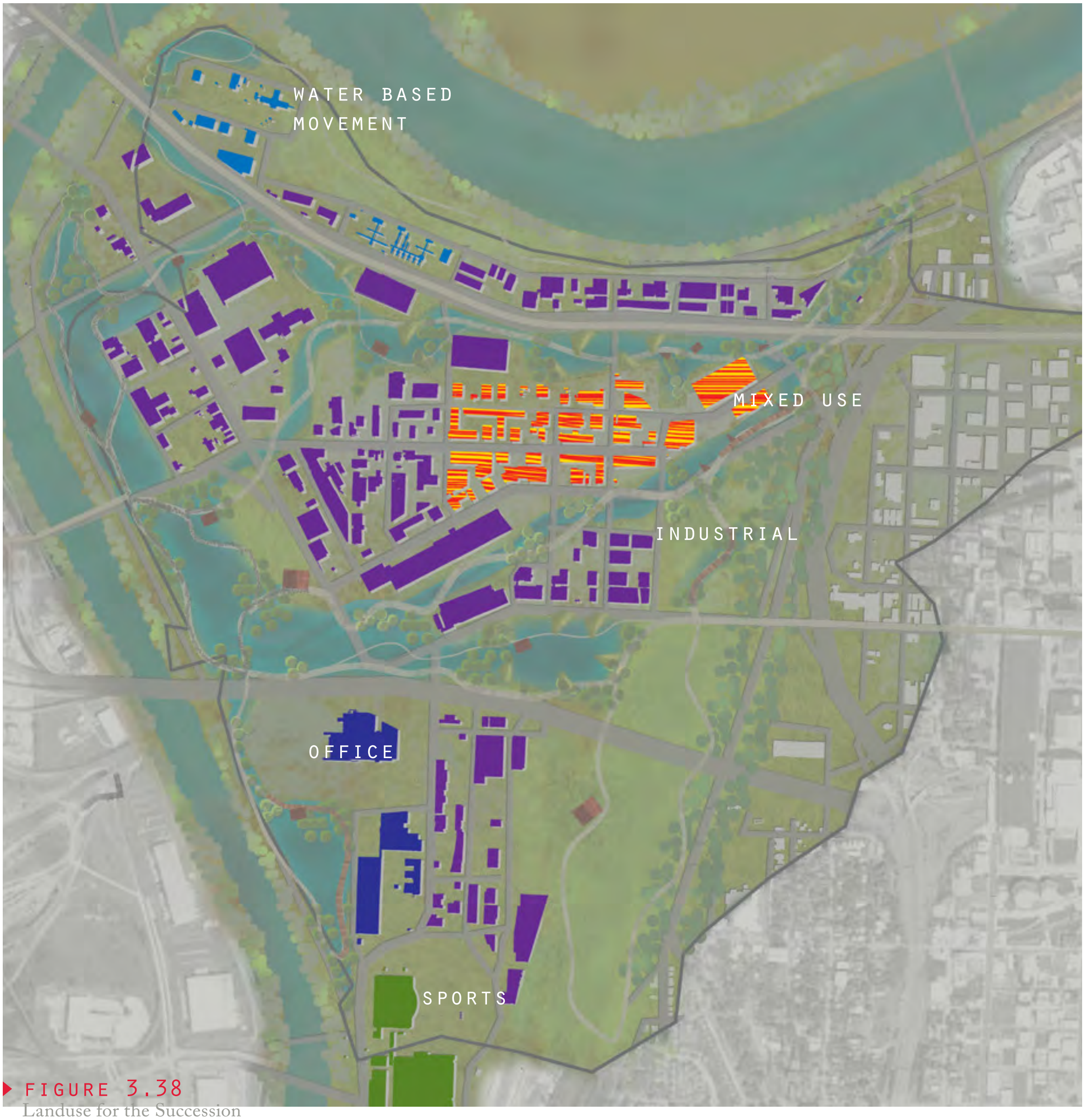


FIGURE 3.38
Landuse for the Succession at 100 Years. (King, 2013)

DESIGN STAGE THREE

SUCCESSION

One hundred and fifty years from now, succession will continue at its own pace. The focus of this plan shows the ecosystem and social benefits of the previous 100-year succession success. Socially, the plan allows people to experience the established open space network and gives Kansas City another destination. The iconic wetland network has full habitat benefits such as groundwater filtering, storing of floodwaters, natural succession of wetlands to wet-meadows, species richness and a truly biodiverse environment. The system will be able to filter stormwater before infiltration, and all of the problems in the system have been improved during the maintenance succession phase.

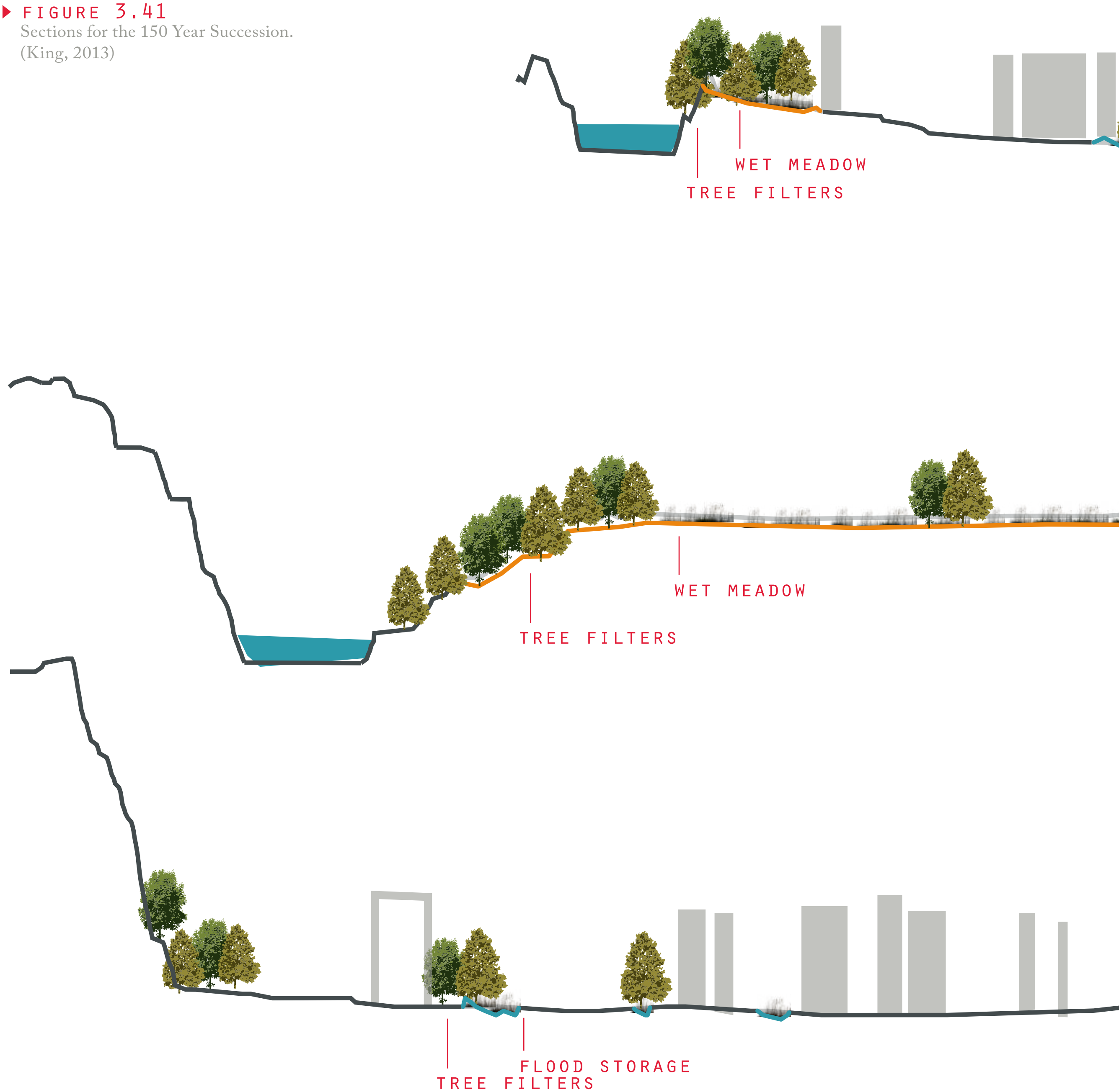
Remediation will be complete for the West Bottoms and flood storage has taken place in the previous railroad right of way. Northwestern wetlands have transformed into upland prairie and wet meadows. The succession of these previous wetlands is on the highest point of the site, and therefore have transformed into upland prairie and wet meadows. The flow patterns of the wetlands are connected to the northern wet meadows for overflow purposes. Development nearest the river is now transformed into a mixed use commercial and residential strip. Connections to the outer neighborhoods are still maintained and promoted through a regional pathway and bike path underneath the Interstate 70 viaduct. Hydrophyte tree filters continue to develop in new wetland territory. Wastewater treatment is used for primary stages of treatment and secondary and tertiary treatment occurs in the wetlands. Most surface flow and stormwater is dealt with in living infrastructure systems allowing for infiltration and reuse of water. FIGURE 3.39

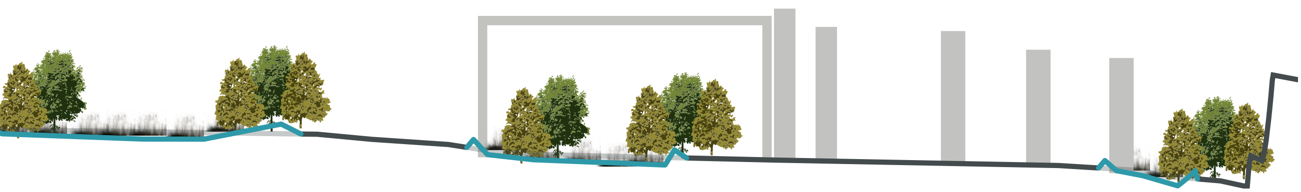
The trail system incorporates terminating platforms and spaces that overlook the wetlands and bring people closer to the water. Large boulders are used in some areas as crossings, and mounds are used for seating and climbing. Wooden reclining chairs and hammocks are incorporated in the forest wetland areas for a different experience. The path hierarchy is now focused on the north-south corridor to the east and the east-west path along the riverfront to the north. Paths to potential sports facilities in the south are also more prominent than in the last 100 years. FIGURES 3.40-3.44

▶ FIGURE 3.39
Landscape Experience and Informal Learning Opportunities at Successional Stage Three: 150 Years. (King, 2013)

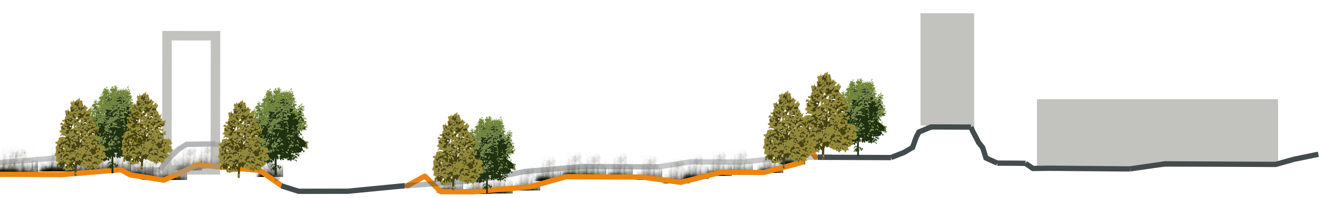
▶ FIGURE 3.40
Design for the Succession at 150 Years. (King, 2013)

▸ FIGURE 3.41
Sections for the 150 Year Succession.
(King, 2013)



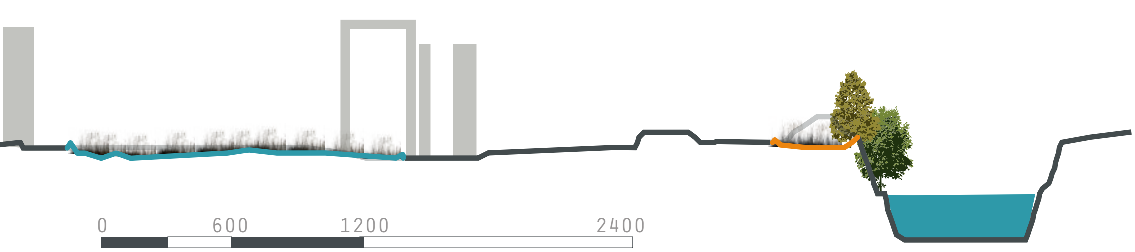


▲ FIGURE 3.42
Section Cut A is Cut Through the Kansas River and the Wet Meadows and Development in Figure 3.37. (King, 2013)



▲ FIGURE 3.43
Section B is Cut Through Kansas River and the Wet Meadows to the West, Showing the Succession of the Storage Network. (King, 2013)

▼ FIGURE 3.44
Section C is Cut Through the Wetlands and New Development. It Also Shows the Slope Up to Kansas City and the Kansas River. (King, 2013)



Imagine parents showing their child about succession and telling the story about when they were young, when the network was still growing and developing. They let their child play in the grasses and forbs, understanding the connection between them and the ecosystem within. The family continues to teach their child about the water and its quality. In an open space system like the one in West Bottoms, the people get close to the water, touching, feeling its calming nature. It is this type of interaction with the system that truly binds person to nature, creating a bond to care for their environment. Dogs and their owners walk by, enjoying the wildlife. Close by on the adjacent street, a group of industry workers get out of work for a nice lunch in the sun. They lay out near the wet meadows for a serene break before going back to work. The streets are bustling with people for shopping around in the galleries and creative boutiques. The transformation of the industrial area provides clean air and water for users. Dragonflies zip past the ducks in the open water while a woman lies in a hammock watching the interactions. This observation of natural systems generates an understanding of the importance of this living infrastructure system. A lunchtime yoga group sets up by one of the wetlands for a peaceful environment. Across the way, children try to catch frogs and run from the geese while a woman in a wheelchair sits on the dock, observing her environment. Tree filters provide shelter for the birds and small animals as well as an oasis of shade for a family. People are engaged in the ecosystem and know the processes taking place to make their environment better.
FIGURES 3.45 AND 3.46

▼ FIGURE 3.45
The Montage Shows how Residents are Enjoying the Benefits of Design and Natural Succession and How the Wetlands are an Amenity. (King, 2013)

FIGURE 3.46
The Aerial Showing the West Bottoms During Succession Stage Three at 150 Years (King, 2013)

PERFORMANCE THEMES

Themes from the case study research were also evaluated for the successional timeline, third focusing on benefits. The themes show the ecological, aesthetic, and economic performance benefits and services of the design. These themes would be monitored over the succession timeline.

- Recreational and learning public space- Path networks allow for experiential learning and getting close to the water and understanding the wetland and wet-meadow ecosystems. Signage explains the natural succession, phytoremediation, hydrophyte tree filtration, and historical and social changes through the succession.

- Better water quality- Hydrophytes tap into the groundwater, cleaning the contamination. Wetland plants are used to clean the stormwater and allow for more infiltration. Wastewater is cleansed from the clean industrial area and wastewater can be treated in the wetlands also.

- Conventional remediation or phytoremediation- Phytoremediation continues through the wetlands and tree filters. Plants used are cottonwoods, silver maples, sycamores and willows extract contaminants from groundwater and surface water in a native habitat. 60 acres have been added to the remediated open space system.

- Increased habitat creation and species richness- Habitat has increased with the addition of 60 acres of open space. Potential habitat has increased overall by 208.8% and increased from the last plan by 16.25%.

- Increased property value- Property value increases with new open space. Plans for future industrial use and a new district bring in excitement. Commercial business has increased by 24% from fifty years ago.

- Groundwater cleansing- Hydrophytes continue to extract groundwater contamination as well as cleanse water before entering the next wetland.

- Stormwater management- Through flood storage, detention wetlands also capture stormwater.

- Flood storage- The addition of 120 acre feet of flood storage, increases flood storage by 26%. Flood storage wetlands are now fully connected to create a network, connecting to the northwestern wet meadows as necessary during large storms.

- Slowed velocity- Velocity of the water is slowed more thoroughly through established hydrophytes, and the connections between wetlands. Mounds and boulders also help to slow velocity.

- Suspended solids removal- Cleansing of tertiary effluent from the wastewater treatment plants removes any leftover suspended solids.

- Usage of a network of wetland terraces- The design incorporates a connected wetland system.

STORAGE CALCULATIONS

STORAGE CALCULATIONS

Over the last 150 years, the West Bottoms catchment has transformed to incorporate 9% industry, 47% open space, 5% impervious surface, 15% residential, and 24% commercial. These landuses produce a weighted curve number for runoff calculations of 92. Within 100 years, storage has the potential to alleviate the stormwater produced from a 100 year one hour rainfall, a 100 year two hour rainfall, a 100 year three hour rainfall, a 100 year six hour rainfall, a 100 year twelve hour rainfall, and a 100 year 24 hour rainfall.
FIGURE 3.47

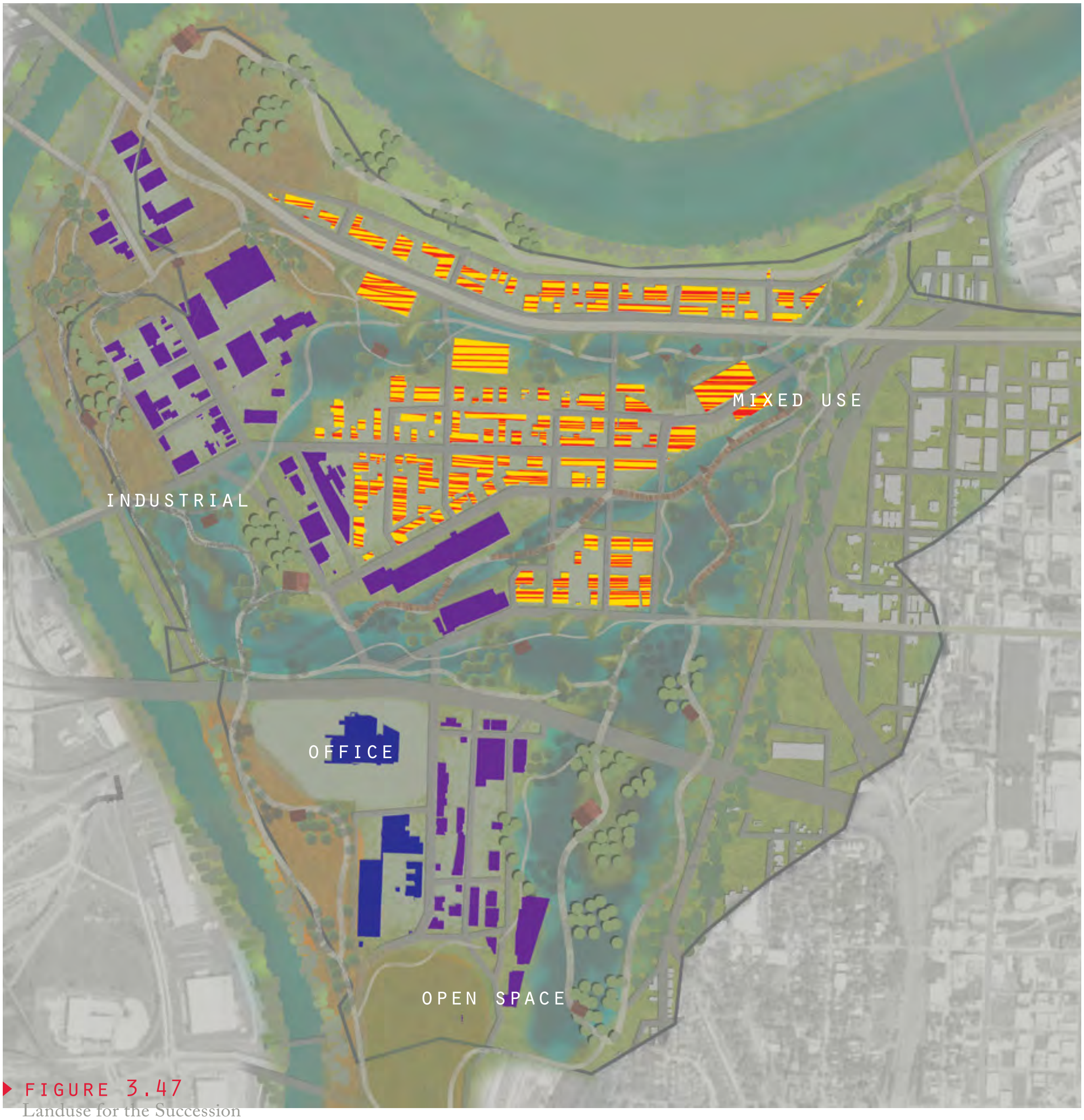
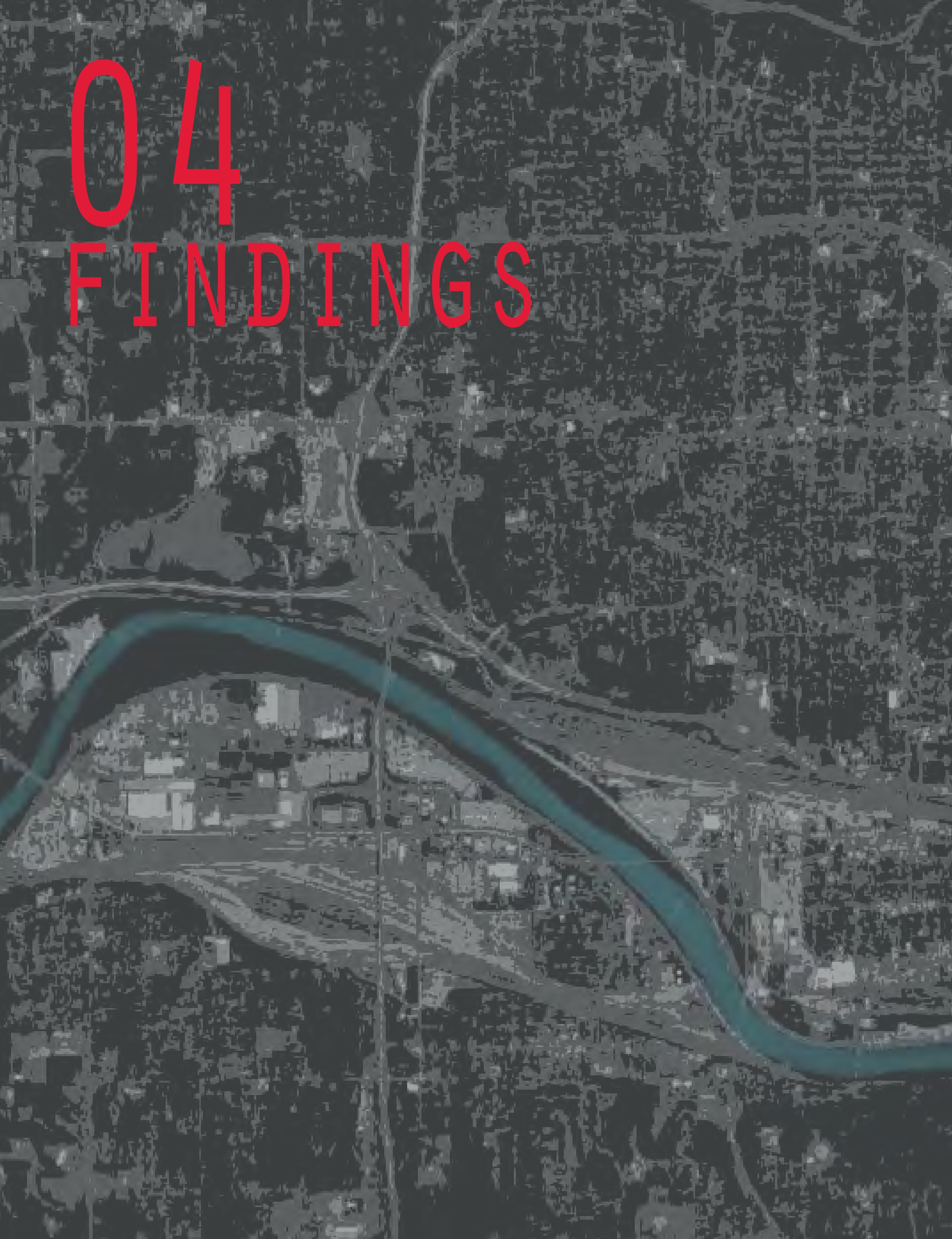


FIGURE 3.47
Landuse for the Succession at 150 Years. (King, 2013)

04 FINDINGS



FINDINGS

PERFORMANCE THEMES

- Recreational and learning public space- Paths throughout the wetland allow for experiential learning and getting people closer to the water. The ecosystem in place within the phytoremediated wetlands has a process of succession that is explained through learning signage. Historical landuse and the succession are described during each process that is underway. Pathways vary between wetland types and provide a variety of different seating experiences. Within the wooded wetland areas, hammocks are provided for an experience that puts people close to tranquility within nature. Crafted benches will be placed along the wetland edges to push people close to experiencing the wetland ecosystem. Mounds of earthwork that double function as slowed velocity checks become play or sitting mounds during low flow.

- Better water quality- Planting of hydrophyte trees that soak up contaminated groundwater is estimated to cleanse most of the groundwater flow in the area. Cottonwoods, silver maples, sycamores, and willows will buffer the wetlands to prevent contaminated groundwater flow. Wastewater from the clean industry will also be cleansed through the wetlands, and with the tree filters in the groundwater. Secondary and tertiary wastewater treatment occurs within the wetland system, cleansing contamination from the primary treatment effluent.

- Conventional remediation or phytoremediation- Cottonwoods, silver maples, sycamores, and willows provide a native habitat of phytoremediation through tree filters. Wetland plant communities filter captured stormwater as well as wastewater from the clean industry and wastewater treatment effluent.

- Increased habitat creation and species richness- Open space for habitat increased by 208%, allowing for more species richness. Besides pathways and road crossings, the increased open space is all pervious surface.

- Increased property value- The increase in open space provides incentives for new development in the area.

- Groundwater cleansing- Hydrophytes such as cottonwoods, silver maples, sycamores, and willows are grown to absorb groundwater, eliminating a contaminated effluent.

- Stormwater management- The wetlands store floodwaters and capture stormwater.

- Flood storage- The wetland network has a total of 580.5 acre feet of storage, increasing flood storage overall for the area above ground instead of below ground. This surface flow storage takes the stress off of the storm sewer system in Kansas City.

- Slowed velocity- Mounds, boulder crossings, and tree filters act as a check dam to slow the velocity of the water in high-flow events.

- Suspended solids removal- The effluent from the wastewater treatment plant is cleansed to remove suspended solids, and wetlands provide a capture system for leftover suspended solids removal.

- Usage of a network of wetland terraces- As outlined above, the system uses wetlands and check dams to create a cohesive system that cleanses groundwater, stormwater, and store floodwater.

STORAGE CALCULATIONS

Over the 150 years of succession, the West Bottoms catchment increased open space by 47% to allow for floodwater storage to hold 580.5 acre feet of water within the wetland network. The wetlands hold all of the 100 year 1, 2, 3, 6, 12, and 24 hour rain events.

BROADER OUTCOMES

The use of natural succession provides an open space network that many people can enjoy. Succession permits nature to work on a site in a way that does not hurt the social and natural systems occurring. This type of design strategy allocates learning and engaging opportunities with natural habitats and native species. Learning through experience gives residents and visitors a sense of place while presenting opportunities to understand natural process in the interaction between people and an ecosystem.

The design of a live-work-play district within the West Bottoms provides a series of amenities within walking distance to where residents live. Closing the need to commute promotes a higher quality of life by allowing people to get fresh air, experience nature, relax more, and walk or bike to places as needed. This constant exposure to nature reaps the benefits of the ecosystem services and contributes to a healthier work atmosphere. Living in a live-work-play district gives more incentive to value the community that the residents live in.

Using clean industry techniques and making sure that maintenance strategies are upheld, removes industrial waste and contamination issues. Clean industry will potentially provide the ability to close the circuit of waste. When few harmful chemicals are used in the industrial district and the effluent can be cleansed through the wetlands, it allows the circuit of production-consumption-waste to remain within the West Bottoms.

The aesthetic performance of the wetlands is successful because of the variety of spaces that can be experienced. The aesthetic of the wetlands is a naturalized feel. Native plants and species that grow naturally during succession provide the general aesthetic for the area. Mounds keep the water within the wetlands as well as provide seating for residents walking through the wetland network. Tree filters that cleanse the groundwater allow for a different and shaded experience.

The use of native plants and wetland species offers a rich plant texture aesthetic and visual interest year round. Wetlands are aesthetically pleasing with the use of trees, floating wetland plants, and herbaceous plants that make up several different plant communities and habitats.

Before the implementation of the wetland network, the area was not aesthetically valued. After the 150-year succession, the value of the West Bottoms will increase because the area is iconic and is going to become a significant multifunctional open space network for the city of Kansas City. The wetlands are a unique piece to Kansas City.

Kansas City's wetland and open space system potentially can become a precedent for cities in similar situations and locations as Kansas City. Cities that have a rich industrial area and are located along a river can use this type of strategy to understand the possibilities of natural succession. The importance of natural succession is a lesson many cities can learn from and use once industry and railroad right of ways are unused. Cities such as Omaha, Nebraska, and St. Louis, Missouri are examples of cities in a similar situation to Kansas City and this design proposal.

RELEVANCE

CASE STUDY THEMES

The use of a case study method allows a unique process of evidence-based design to evaluate old approaches that were successful. The success of the case studies is outlined into smaller categories rating their success. These same categories are then evaluated as potential design metrics.

FLOODING LANDSCAPES

Flooding landscapes provide a new typology of park design. The ability for parks to hold flood storage, as discussed as a Low Impact Development strategy, has potential for a new subfield within landscape architecture.

PHYTOREMEDIATION

Phytoremediation is still a fairly new approach in landscape architecture. It is proposed within design strategies, but it is not always fully researched or utilized. The cost effectiveness of the technique provides incentive for using phytoremediation, but it does not always work for sites with a lot of contaminants (Ulam 2012, 54), and it does take a significant amount of time to reach its full potential. The proposition of a phased landscape requires the development of layers of design and remediation processes. A phased phytoremediation landscape will provide the progression and reform of a contaminated site to a healthy place.

INDUSTRIAL BROWNFIELD REGENERATION

The economic and culturally artistic benefits of industrial brownfield regeneration should be studied further. Landscape architecture has few precedent studies on this technique, and the inclusion of an evaluation based on a specific criteria matrix allows for a new understanding based on measures to quantify and qualify the effectiveness of industrial brownfield regeneration. The detoxification of industrial landscapes can utilize the multidisciplinary knowledge of landscape architects, engineers, and biologists to address the contaminants in the soil and the challenges they present. This process can provide new or restructured habitats for existing and future species (Jackson 2001, 35).

NATURAL SUCCESSION

Natural succession is an important part of this design because it addresses the social and cultural changes over the next 150 years. The result of this design strategy truly looks at understanding natural process guided by a design plan. The vision of this plan is to prove that guided nature can become a tool in the design process. More specifically, it has the ability to clean up a brownfield site and hold floodwaters. This multi-functional space gives residents, the city, and government the ability to understand the natural processes through experience.

The open space network that is undergoing the succession gives incentive for new development in the area. It is also incentive for residents to begin caring about their open space to the extent that they will help maintain the habitat within the overall visionary plan for the West Bottoms. The learning associated with this type of plan allows people and generations to see the changes of the West Bottoms over time while feeling connected to its growth. Through learning, people will be able to understand the impacts that development have on a site. This solution addresses many of the issues that we usually solve through more complex and harmful ways, in ways that use nature and time as tools for renewal.

This type of project and plan is valuable to me because it provided an opportunity to join my design process with natural succession. It is important to note the research-based design approach as a design tool that should be used for every design. Phytoremediation is a fairly new tool used within landscape architecture and has the potential of becoming a more important part of the design phases with brownfield sites. The plan considers Kansas City and its need for a visionary idea for the West Bottoms. Many of the previous plans break the area down into pieces to be dealt with separately, especially with the state line running through the West Bottoms. The benefit of using natural succession brings a new approach to solving the dilemmas that occur in the area by allowing nature to clean up and reclaim the West Bottoms socially and naturally. It is also a revolutionary idea because it has the ability to quantify and qualify the benefits achieved while using natural succession.

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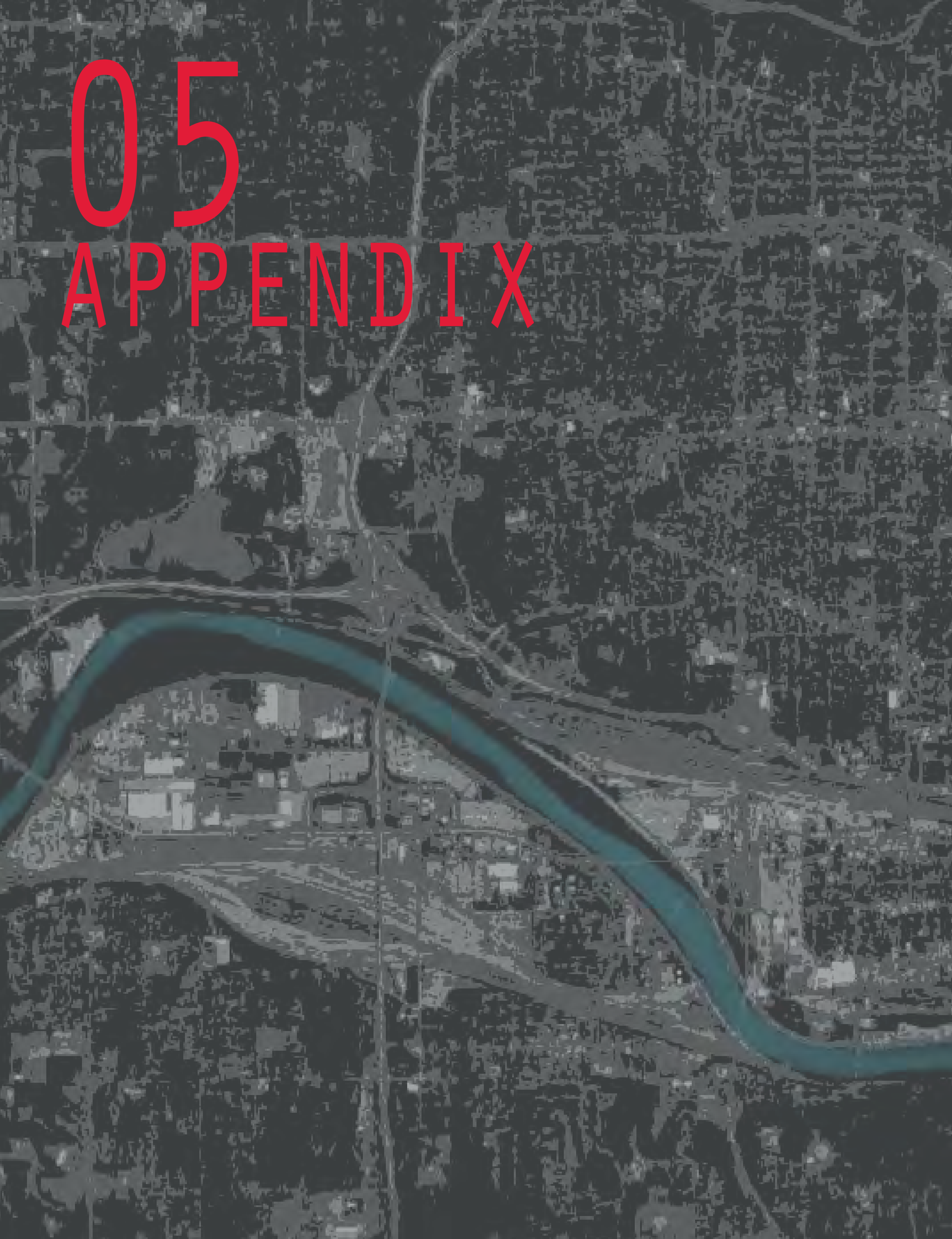
05 APPENDIX



LITERATURE REVIEW

INTRODUCTION

The literature review is broken into four research categories: green infrastructure and urban ecology, economy and art, soil contaminant remediation, and flood storage capacity. These categories represent the four topical interests and defining inspirations for my research design project. Green infrastructure and urban ecology research pertains to the overarching theme or umbrella topic for my project. This research lays the foundation for design parameters and research limitations. Economy and art literature looks at the localized entrepreneurial approach to urban developments. This topic also defines the level of art to be used for design. Through economic and art research, my design process is strengthened. Remediation discusses the technical aspects and feasibility of my project. The research describes the various approaches to remediate a site. To fit in with the green infrastructure and urban ecology research, the research narrows to phytoremediation and bioremediation strategies. Lastly, I include flood storage research, which I will continue to grow and develop for my project. Using research for fluvial systems and more specified research on the Kansas River, research and analysis will be fleshed out over time. [figure 11]

METHOD

While researching, I designed a worksheet to aid in comprehension of the major points of the reading. These points included a summary, relevance, proper citation, themes, and notes. This process created a lens to be applied while reading. Each topic was then generated based on the common and overlapping themes and topics. [figure 12]

green infrastructure and urban ecology

Frederick Steiner's paper, "Landscape Ecological Urbanism: Origins and Trajectories" in *Landscape Urban Planning* discussed the combination of landscape urbanism and landscape ecology. He maintained that landscape urbanism should join design and ecology, while urban ecology is more research based. Steiner challenged designers to use new approaches to deal with population growth in cities and its impact on resources and space (Steiner 2011, 333). Forerunners in this new approach utilized Ian McHarg's notions of designing with nature and Richard Forman's research on habitat patches and corridors. Field Operations and StossU, Landscape Architecture firms at the forefront of testing green infrastructure technologies, have tested the combination of these ideas and the emerging concept of landscape ecological urbanism (Steiner 2011, 333-335).

Mohsen Mostafavi and Gareth Doherty's chapter, "Why Ecological Urbanism" in the book, *Ecological Urbanism,* considered new innovations in landscape architecture to be ecosystem development and reconnection of fragile habitat patches. Ecological urbanism as a new approach focused towards a multidisciplinary planning process could play an integral role in habitat restoration, the ecology of a city, and human interaction by repairing the damages and reconnecting habitats to built environments (Mostafavi 2010, 17-30).

The paper, "Biodiversity and Urban Design: Seeking an Integrated Solution" in *The Journal of Green Building* by Kevin Connery took an approach to stormwater management rooted in living infrastructure. Connery discussed researching global stormwater systems and applying it at the local scale (Connery 2009, 24). The use of a localized living system composed of large patches and riparian buffers lowers the impacts of flooding and allows for growth and movement within patches (Connery 2009, 24).

Jean Rogers' excerpt from *Manufactured Sites* stressed the need for new green infrastructure technologies in buildings. Remediation of damaged sites is a long process and can be prevented through implementation of new building technologies. Using low-impact development strategies could cut the long-term contamination from industrial sites. Including wetlands to cleanse contaminants on site and stabilize compounds is a simple design solution that takes care of contamination before it affects a site. Another green practice Rogers mentioned is maintaining and monitoring sites to make sure leaks and contamination are at a minimum (Rogers 2001, 106-113).

Researching foundational work in green infrastructure and urban ecology provides a framework for design for new growth in cities. Researching and designing through Steiner's standards promotes a combination of Mostafavi's work in ecological urbanism and Connery's living system and green infrastructure research. Understanding processes that can be used to eliminate harmful chemicals before contamination of water and soil, provides a proactive approach to design. The combination of these processes and research topics can result in a rich, layered design addressing urban industrial regeneration.

ECONOMY AND ART

Literature that has not been cited or consulted yet includes Udo Weilacher's *Between Landscape Architecture and Land Art* and Julie Czerniak and George Hargreaves' book *Large Parks*. This literature will enhance the concept, strategy, and process for designing the landscape within the West Bottoms.

Rebecca Krinkle's chapter in *Manufactured Sites* reflected on Robert Smithson's work of making sculpture out of industrial parts. His approach does not fake nature; nature is the progression that occurs between industry and sculpture (Krinkle 2001, 128).

Researching Landschaftspark Duisburg-Nord in *Manufactured Sites*, Peter Latz described the remediation process of the culture and the site. A layered, integrated design approach of prevention, art, and remediation was the foundation for the themes within the park design: physical nature and utilization. Physical nature consisted of industrial sculptural elements and the use of vegetation in swathes. Social activation occurred through the emotional and physical interaction with the industrial sculpture (Latz 2001, 150-151). Latz believed the park was a way for people of the industrial revolution within Germany to accept the past and see it in a new light. The controversy surrounded by the transformation resulted in a balance of urban nature and industrial sculpture. To promote usage, renovations to the buildings were made to incorporate a concert hall, play rooms, art installations, workshops, and sports facilities (Latz 2001, 151-143).

Phil Hubbard and Malcom Miles' chapter in *The Entrepreneurial City* articulated the importance of a city's identity through local business investment. Hubbard and Miles conveyed that the focus of the art within cities should be on the public. A city is rich in culture will be diverse residents and investors (Hubbard 1998, 203). Hubbard and Miles discussed art rooted in historical values of the city. They also warn readers to avoid art without a common good to society, as it can cause gentrification (Hubbard 1998, 219). Public art should be a process benefitting the community over the client. The chapter identified two successful forms of urban art: showing an urban contradiction, and art that is interactive (Hubbard 1998, 222-224).

Krinkle's report on Robert Smithson's work shares a new approach to an artistic remediation process. Fake nature as a new take on nature as a process provides a new understanding of remediation. In addition to the process, Peter Latz offers another piece of advice: the layered approach to the remediation of social and toxic contamination is allowing a phased healing process; a transformation of once harmful structures into beautiful sculptural, physical 'nature'. Hubbard and Miles put art into an economic approach for the transformation of toxins. Art can also be the development of economic strategies to increase art in the urban environment.

REMEDIATION

Alex Ulam's article, "Phyto Your Life" in *Landscape Architecture Magazine* validated the process of phytoremediation and its need in landscape architecture. Ulam described phytoremediation as the uptake and absorption of toxins through their roots and evapotranspiration through their leaves (Ulam 2012, 52-54).

Lucinda Jackson's chapter in *Manufactured Sites* talked about the multidiscipline process of cleaning post-industrial landscapes and its benefit to the local habitat (Jackson 2001, 35). The importance of phytoremediation to detoxify brownfields can only be realized through public interest. Educating people on human health and ecological risks by testing soils and groundwater promotes public awareness to reshape policy (Jackson 2001, 39).

In *Manufactured Sites*, Eric Carman stated that phytoremediation strategies were less expensive and could be combined with conventional remediation efforts. New technologies and plant adaptations are being researched to develop a unique planting palette. Extraction of contaminants from soil, sediment, and water is stored in the rhizosphere through root absorption and is transpired out of the leaves. Phreatophytes change the impact of contaminants on the ground by creating plumes. Carman articulated the process of phytoremediation as a low cost, , a less intrusive, slower process remediation process; the inconsistent results, maintenance requirements, and incineration needs after remediation (Carman 2001, 43-46). Eric Carman talked about the habitat benefits of phytoremediation versus conventional remediation. The creation of habitat and limited vegetation systems provides a new research topic to evolve the planting palette past poplar and willow trees (Carman 2001, 46-50).

Steven Rock's chapter in *Manufactured Sites* elaborated on the interdisciplinary approach to phytoremediation. The cost affective solution often had an aesthetic and an ecological gain. The art of planting was considered as a proper layered landscape of re-growth. Early on in the remediation process, a plant comes in contact with contamination, either dying, ignores it, or breaks down the compound and confuses it for a nutrient. Metals are stored in the roots and stay in the leaves or fruit. Metals are incredibly harmful to humans and to plants. The benefits of phytoremediation include erosion control, aesthetics, creation of plumes in the groundwater, and a natural cap solution (Rock 2001, 53-55). Rock explained the process of degradation to allow plants to establish microbial populations. The plant process absorbs the contaminants and drops the leaves to eventually be detritus for the soil. The soil then uses the organic matter to take in more water, breaking up compounds and making enzymes to break down compounds further(Rock 2001, 55).

Rebecca Krinkle's excerpt from *Manufactured Sites* expressed the effects of toxins other than on soil and water; it becomes harmful to many different species in the food chain. In the 1960s, the concept of limited resources wasn't much of an issue; therefore, contamination also wasn't of major concern (Krinkle 2001, 126). Krinkle described Duisburg park as a model for economic redevelopment of an industrial brownfield. Within the Ruhr area, Landschaftspark Duisburg-Nord had a layered approach to remediation and design (Krinkle 2001, 126-136). Topography was used to remediate and added higher pH to the soils to avoid metal migration into the groundwater (Krinkle 2001, 128).

The work of Peter Latz on Landschaftspark Duisburg-Nord from *Manufactured Sites* showcased a remediation process of the cultural values as well as the site. This layered landscape of integrated design used prevention, art, and remediation to form connections theoretically and physically. Another layer of the park, water, ran through an open sewer system directly into the river Rhine. The water was another layer to design and transported by overhead troughs that overflow and water vegetation (Latz 2001, 153-156). The highly contaminated soils and sludge was capped and buried in the bunkers. Uncontaminated stones were separated and recycled within the soil or walkways (Latz 2001, 156-158).

Justin Hollander, Niall Kirkwood, and Julia Gold's book *Principles of Brownfield Regeneration* evaluated the methods of remediation and their affect on the soil. The term brownfield was from the 1990s. The EPA developed the concept of regeneration for these properties. Brownfields were important lands to remediate and can be used as green space. The book addressed the benefits of brownfield regeneration as economic boosts, cultural understanding and stewardship, educational gains, and habitat restoration (Gold et al 2010, 1-4). Gold et al suggested having a multidisciplinary team structure to avoid error. Once a common group goal was established, the authors stressed the importance of a community outreach plan that allowed feedback from the community (Gold et al 2001, 8-12).

Many programs provided grants and support such as the EPA, Department of Housing and Urban Development, HUD's Community Development Block Grant, and the use of local environmental cleanup agencies (Gold et al 2001, 12-16). The authors stressed the problem of contaminants mixing within the soils. This soil mixture can affect up to 50-60 feet of depth, but most often it has only reached 18 inches of depth. Ground and surface water were very easily contaminated (Gold et al 2001, 22-26). Contaminants within the soil included synthetic organic chemicals with high vapor pressure (VOCs and SVOCs), petroleum products (asphalt, oil, gas, and kerosene), pesticides and herbicides, polychlorinated Biphenyls (electrical equipment and coolants), and metals (Gold et al 2001, 28-30).

Principles of Brownfield Regeneration described three types of remediation: established treatment technologies, innovative alternative treatment technologies, and emerging alternative treatment technologies. Established treatment technologies were said to include air sparging, bioventing, encapsulation, excavation, incineration, permeable reactive barriers, pump and treat, and soil vapor extraction (Gold et al 2001, 31-36). Innovative alternative treatment technologies were used on limited occasions and included bioremediation, natural attenuation, soil washing, and thermal desorption (Gold et al 2001, 31-36). The emerging alternative-treatment technologies were identified as land farming and phytoremediation. Land farming occurred in the upper soil zone and was tilled for aeration, whereas phytoremediation used plants to uptake or neutralize contaminations, soil fertility, pH, drainage, water supply, and microclimate must be considered (Gold et al 2001, 31-35).

Phase I of the remediation process involved an interdisciplinary process that held an intense review of the site to be remediated. The authors suggested holding interviews, conducting a historical analysis and inventory, looking at photos, plans, sanborn maps, flood documents, leases and deeds. They recommended professionals understand the wastes, topography, proximity to residential land and institutions, soil types, and groundwater conditions (Gold et al 2001, 41-42). Phase II consisted of a site assessment to further understand the contaminants in the soil as well as an inventory map of where monitoring wells were monitoring hydrogeology, geophysical processes, contamination conductivity, and remote sensing (Gold et al 2001, 43-48).

All of the authors emphasized an interdisciplinary remediation process. Ulam's article defined phytoremediation and its process and Lucinda Jackson outlined the benefits and approaches to using the remediation process. Eric Carman's article outlined the exact path that contamination takes and summarized the ecological benefits of phytoremediation. Rock explained the struggles plants have growing in harmful contaminants and talked about the benefits of phytoremediation such as erosion control, aesthetics, plumes, and natural caps. Rebecca Krinkle's article shared the impacts of contaminated soil and water on the rest of the ecosystem and described an economic model for brownfield regeneration: Landschaftspark Duisburg-Nord. The precedent was again mentioned in Peter Latz's writing about the design and ecological features that remediated the social and physical aspects of the site. Hollander, Kirkwood, and Gold showcased the entire process of phytoremediation and the different approaches for remediation. This research provided strategies and processes for how a similar project could do a remediation process.

FLOOD STORAGE

Kiran Curtis and Jonathan Cooper's document *Designing for Flood Risk*, explained the differences between the types of flooding. The most crucial flood type for the region of Kansas City was fluvial flooding. This type of flooding was said to occur when blockages from debris were created and increased in precipitation. The manmade sewer system and infrastructure system also caused flooding; separate sewer systems were a better approach. Other infrastructure systems were subject to failure in flooding (Curtis et al 2009, 4-5). The level of predictability, the rate of onset of a flood, the speed and depth of the water, and the duration of the flood were identified as important determining affects by the authors. Flood defense systems limited the amount of discharge from a river and disconnected rivers from their floodplains. The reconnection of these systems was vital to the future health of a stream. The self-sufficiency and stability factors of raising the flood plain created problems down stream and were only a short-term solution (Curtis et al 2009, 7-9).

Floodplain management, by Ann L Riley in *Restoring Streams in Cities*, took a crucial look at the flow of streams, land use change affects on stream flow, floodplain boundaries, velocity of floods, stream flow data, weather data, flood frequencies, and historical data (Riley 1998, 262-263). Identifying the ways urbanization impacted the overall watershed is important. The volume of storm water runoff, peak flood discharge, flood stage elevations, and valley area that will be flooded were important inventory analysis pieces to consider when looking at flood storage capacity (Riley 1998, 268-269). Riley discussed the affects of urbanization on a watershed. An increased peak discharge occurred during storm events. Cutting down the riparian buffer gave a higher peak discharge because there was less infiltration capacity (Riley 1998, 273-274).

Kiran Curtis, Jonathan Cooper, and Ann L Riley examined the role of a floodplain and the inputs that affected peak discharge in a stream event. Both readings discussed the infrastructural affects of urbanization on the floodplain and stresses on a river system. Knowing the specific calculations and numbers for determining flood affects, inventory analysis, and the importance of riparian stream buffers was said to be vital to altering the patterns that streams flood.

The relationships between the literature groups can be seen in my literature map. Strong correlations occur between all of the categories and the green infrastructure and urban ecology category. Currently, there are little to no connections from flood storage to any of the other categories. Linkages occur between art and remediation and art and economy. I have identified these topics of research in order to research for a purpose. When researching, the themes were clear using this framework and it outlined key messages.

ENVIRONMENTAL EDUCATION

Paul Gobster's article *Nature Experiences* discusses the history of user's park needs. In the mid 1800s, nature was included in the park system. An example of this would be Central Park. This type of park used the form of 'naturalism' that had been a romantic idea adapted from 18th century Europe. This highly visual revolution to park design is exemplified in Central Park. Olmstead was unsure how people would use the park, and would have opted for a manual for the park users on how to use the park. Museumification is the misnomer of nature is part of parks. Many of our past and current 'naturalistic' designs are nowhere close to bridging the gap between education through experience and true habitats.

As Jens Jensen and O.C. Symonds began using natives in urban designs, a more accurate marriage of ecological naturescape and urban park design occurred. Management is an important part of every design and is often overlooked. When restoration became popular during the 1970s and 1980s, conservation became an important idea. Finally with Galen Granz and Michael Boland's ecological parks, a social aspect of a park was used. Social ecology provides a better cohesive design solution. This solution should be more about experiential qualities to design and avoid too much labeling and exclusive monitoring. The more fragile a landscape, the more diverse of ecosystem, making it more of a manicured park. Paul Gobster urges for ecological parks to become experience driven, allowing for social disturbance. This unstructured nature exploration will provide a balance between nature and culture.

Ruyu Hung's article *Educating for and Through Nature: A Marleau-Pontain Approach* discusses the importance of participatory learning. Nature is Greek for 'vegetative' and Latin for 'to be born'. "Nature is what has a meaning, whitout this meaning being posited by thought: it is the autoproduction of a meaning. Nature is thus different from a simple thing. It has an interior, is determined from within; hence the opposition of 'natural' to 'accidental'. Yet nature is different form men: it is not instituted by him and is opposed to custom, to discourse."

Berman, Jonides, and Kaplan's article, *The Cognitive Benefits of Interacting with Nature* discusses the benefits of nature on attention. Directed attention and moods have improved by increasing the amount of nature.