RECLAIMING RIVER ROUGE, MI: AN ECOLOGICAL APPROACH

By

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ABSTRACT

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In this research based design thesis, the relationship between human and non-human ecosystems was explored through the creation of a hypothetical master plan design for the city of River Rouge, MI, USA, to remedy the current problems faced there, specifically the loss of urban density, indigenous habitat destruction, and wasteful stormwater management techniques. The design is presented through a series of plan view schematics, and images from a three-dimensional model. A Post-treatment test was conducted to evaluate the attractiveness via a visual quality analysis comparing current site photographs to created scenes. Scores were compared using an un-paired T-Test. Results show a significant improvement of visual quality when comparing mean values and also the 95% confidence intervals. Means differ by -28.18 ± 5.392 (a lower/more attractive Visual Quality score). The 95% confidence interval found that the original site mean scores falls between 61.18 and 81.21, while the created mean lies within 37.15 and 48.89. The P value for this experiment was found to be less than 0.0001. Treatments utilized within this study prove promising to improve this suffering suburb of Metropolitan Detroit, MI.

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INTRODUCTION

<u>Overview of Problem</u>

Of all the issues facing the design world today, the effects of uninformed decision-making and wasteful development practices is of the most urgent concern (Göçmen 2009). This phenomenon is often described as "Urban Sprawl." Urban Sprawl is responsible for numerous ecological impacts including habitat loss(Berke et al. 2003), ecosystem fragmentation (Brook 2005), decreased bio-diversity (Petersen 2013), air and water pollution (Echols 2008), as well as climatological effects. (Alberti 1999, Göçmen 2009, Pauleit & Golding 2005) Though awareness of these impacts have become widely known, current developmental patterns are doing little to counteract against the negative impacts associated with sprawl(Pauleit & Golding 2005). An increasing number of policies designed to protect and preserve ecosystems and natural areas have been devised (Kaplan et al. 2004, McWilliam et al. 2010), but many decisions are still left to individuals and developers(Alberti 1999, Conway 2006. Göcmen 2009, Thompson 2004). What factors are inhibiting the utilization of the scientific findings(Alberti 1999, Conway 2006, Pauleit & Golding 2005, Thompson 2004) concerning ecological impact to create informed developmental policy? How can developers and individuals be educated and encouraged to make environmentally sensitive decisions in spite of new policy? Can conservation techniques positively influence suburban resident satisfaction? (Brook 2005, Göcmen 2009)

Development trends and sprawl patterns have been a popular area of investigation in the recent decades(Pauleit & Golding 2005). Urban populations have been on the rise, and many suburban areas have also seen dramatic influx in population(Göcmen 2009). More recently, the ecological impacts associated with these patterns have been studied; how this knowledge is passed on and understood by those responsible for and involved in these patterns (Alberti 1999, Conway 2006. Pauleit & Golding 2005, Thompson 2004). Past studies seemed to focus primarily on dense urban environments, but recent studies have also begun looking into the relationship between suburban development and natural ecosystems, specifically definitions of terminology, and environmental attitudes (Weller 2008, Ndubisi 2008, Kaplan 2004, Thompson 2004). Economic aspects have also been frequently addressed. Studies have found significant correlations between preserving natural areas and increased property values (Thorsnes 2002, McWillian et al. 2010. Geoghegan 2002).

Despite the increased amount of study in the problem area, there seem to be substantial deficiencies in the full understanding of the topic. Few studies have identified factors that influence decisions made by real-estate developers, and suburban residents. While some have shown that these populations are aware of environmental benefits of alternative design management, why aren't pro-environmental behaviors more prevalent? How could these practices be marketed to developers? How could ecologically progressive communities be marketed to homebuyers? Further research is needed to address these issues. Policy making could benefit from tried and tested developments, that effectively act against sprawl, and showcase how scientific discovery can be used to inform decision making on the entire scale of land use management.

Purpose of the Study

This study aims to investigate the relationship between human and non-human (natural) ecosystems within an urban residential environment, how they relate currently, and how they can be better integrated, if at all. This information could play a vital role in marketability of ecologically/environmentally sensitive developments. Policy makers on the local, regional, and federal scale could potentially benefit from information on how to better design communities, restore non-human habitats, how to designate land to be preserved, and what to enforce within developmental procedures. However, most importantly this thesis aims to demonstrate the author's abilities and knowledge within the holistic field of Environmental Design; Bridge the gaps between Urban Planning, Ecology and Landscape; and explore the application of personal design philosophy.

Definition of Terms

For a complete list of definitions of terms used throughout this thesis, please refer to the Glossary in Appendix B.

THEORETICAL FRAMEWORK

The Biophilia Hypothesis

The central theory driving this thesis is that of the "Biophilia Hypothesis." This project explores the claims proposed by the "Biophilia Hypothesis" and seeks to create an example of its potential for real world applications.

The "Biophilia Hypothesis" was first suggested by Edward O. Wilson in 1984. The basic idea is that humans have an innate connection to the natural world, because their brains evolved within it. Biophilic Design stems from this principle, suggesting that good design caters to our need for this connection, utilizing patterns and forms found often in nature, specifically the environments in which humans evolved.

> "Humanity is exalted not because we are so far above other living creatures, but because knowing them well elevates the very concept of life." (Wilson 22)
>
> "The one process now going on that will take millions of years to correct is the loss of genetic and species diversity by the destruction of natural habitats. This is the folly our descendants are least likely to forgive us." (Wilson 121)

Exploration Questions

The following questions were foundational to the choice of research fields, design philosophies, and the development of the experimental hypothesis:

Can Biophilic Design be successfully woven into the current urban fabric?

Can indigenous landscapes be successfully restored in the urban fabric?

Can human and non-human ecosystems be integrated in an urban residential setting?

What effects would these integrations have on the lives of residents?

Hypothesis

The theoretical hypothesis for this study is: "Human and non-human ecosystems can be integrated in a mutually beneficial manner, which will provide an attractive setting to increase urban density."

While a testable hypotheses is: "If the selected site of River Rouge, MI is treated through applied Biophilic design, then the resulting product will display lower(more attractive) Visual Quality scores." A testable null hypothesis would be; "If the selected site of River Rouge, MI is treated through applied Biophilic design, then the resulting product's Visual Quality scores will not differ significantly from scores of the existing site."

REVIEW OF LITERATURE

Research Areas

This study seeks to address a problem consisting of many interrelated fields of research/topics. For this reason, multiple disciplines were investigated throughout the course of the review of current literature relevant to the problem at hand. To begin, the literature has been divided into three major areas of research:

-Sustainable Urban Revitalization

-Wetland Reclamation

-Stormwater Management

As these areas of research are interrelated, overlap occurs within every category. It is essential to identify these relationships and synthesize them to accurately understand the direction of current research trends related to the problem.

During the review process, another distinct topic trend was discovered, visual quality and environmental preference of "natural" areas. This topic is very relevant to the other fields of study, and for that reason was chosen as a means for evaluating the success of the final design product.

For the sake of this review of literature the three major research areas will be given their own individual subchapters, along with one devoted to visual quality/environmental preference.

Sustainable Urban Revitalization

Environmental Design, Landscape Architecture and their related disciplines all serve the primary function of providing for human use and well-being. For this reason the author has selected Sustainable Urban Revitalization as the primary field of research for this study.

Urban Sprawl and human development are responsible for habitat loss & fragmentation(Berke et al. 2003,Brook 2005), decreases in bio-diversity(Petersen 2013), and the pollution of air and water (Echols 2008, Pauleit & Golding 2005). Current design practices do little to suit the needs of human and non-human users (Baldwin et al. 2010, Pauleit & Golding 2005, Thompson 2004, Wener and Carmalt 2006). The general public lacks a strong land ethic, a connection to the ecosystem of which they are a part (Thompson 2004).

Throughout the course of human history residential development has occurred in primarily three forms: urban, suburban, and exurban. Of these forms suburban development is most often attributed to the most devastating consequences(Göcmen 2009, Pauleit & Golding 2005). Suburban development has been a trend in the United States beginning roughly at the end of the 19th century; however it wasn’t until after the end of World War II, when the economy was most suitable, that serious outward expansion began, commonly refereed to as “Urban Sprawl,” (Lovejoy et al. 2010). As cities were expanding, the potential negative influences of such development became a great interest to planners, scientists and concerned citizens. In the recent decades suburban development has been placed under increasing scrutiny. Some communities as well as planning and design groups have taken initiative to begin building residential areas using more sustainable approaches(Baldwin et al. 2010, Kaplan et al. 2004, Lovejoy et al. 2010, Pauleit & Golding 2005, Stangl and Guinn 2011). This practice however is still struggling to become the norm; Sprawl is still occurring, and development is not always under the influence of informed decision making. For these reasons, the emerging topic of “Sustainable Urban Revitalization” has become popular within the scientific and professional communities (It is important to note that this term has been chosen by the author to represent the many related design philosophies seeking to address the issues created by Urban Sprawl. Many of these individual philosophies will be explained later on within this review). The major issues surrounding Sustainable Urban Revitalization are: harmful development trends, the discrepancies between terms and definitions, a lack of connection between environmental attitudes and behaviors, ineffective urban compaction, professional irresponsibility, conservation and its economic value, failures to study at multiple scales, few studies of urban ecology, the popular philosophy of New Urbanism, Technology and Landscape, and also the concept of Biophilia.

Development Trends

Currently there is still a trend to build low-density developments, despite the discouragement of the scientific community(Göcmen 2009). Studies have looked into the relationships between residential development and environmental perceptions (Göcmen 2009). Results have shown that the presence of natural areas is among the top reasons that homebuyers choose their home location, which often leads to preference for the low-density trend. These communities result in increased dependency on automobiles and add strain to existing infrastructure and resource distribution. Disastrous effects on air and water quality are among the other impacts of current low-density development. One explanation of these effects reads, "Sprawl increasingly dominates the landscape by converting vast expanses of land into roads, parking lots, roofs, and driveways. These impervious surfaces generate polluted runoff that is recognized as a leading threat to water quality, as well as increase downstream flooding and habitat loss" (Berke et al. 2003). To support the establishment of green suburban theories, consumers must be educated to make more informed decisions about housing location choice. If this is done then there might be enough demand to influence policy and improved development practices. (Göcmen 2009, Kaplan et al. 2004, Thompson 2004)

Studies concerning resident satisfaction within different types of neighborhoods have been increasingly popular in recent years (Lovejoy et al. 2010). Identifying the characteristics important to residents is key to designing attractive developments. Lovejoy et al. 2010 published a paper comparing suburban neighborhoods to traditional environments to determine residential satisfaction. Results suggest that traditional neighborhoods are in fact preferred when compared to the suburban developments typical of sprawl. The article states, "For both types of neighborhoods, the most important predictor of neighborhood satisfaction are resident's perceptions of the attractive appearance and safety of the neighborhoods," (Lovejoy et al. 44). The same study was surprised to find that other factors did not influence satisfaction significantly, for instance, low density or the availability of parking(Lovejoy et al. 2010).

Discrepancy Between Terms

One major issue in the struggle to build greener communities is the discrepancy between term use and their definitions (Kaplan et al. 2004). The professional world and the world of homeowners use different terminology to describe the subdivisions in which they live. Terms such as “conservation”, “sustainability”, “green space” and “open space” are common in the realm of suburban design, but there is little being done to establish a unified standard to aim towards. If progress is to be made, there must be a well-defined framework model for green communities to undertake, and its goals must be understood and supported by those who live there (Kaplan et al. 2004).

There also proves to be significant discrepancy between the different sustainable design philosophies, as well as problems between what individual approaches prescribe and actual implementation (Berke et al. 2003). One such design concept is named New Urbanism. The approach claims to offer social, fiscal and environmental benefits when compared to more often utilized development methods, but problems have arisen while attempting to prove this claim empirically (Berke et al. 2003).

Lack of Connections

Another important concern of researchers is the lack of connection between environmentally conscious attitudes and pro-environmental behaviors (Thompson 2004). Even though residents and developers may be well informed about the impacts of development, they are not making sustainable, green decisions collectively (Thompson 2004). While there is increasing trends to support sustainable development, there is not a strong land ethic shared by the community to foster successful enactment (Thompson 2004). Scientific organizations and design professionals may be advocating better planning practices, but ultimately major environmental impacts are the results of numerous small private-sector decisions (Thompson 2004). Connections must be made between developers, educators, residents, and planners; these connections must be supported with strong community interaction, as well as interaction between the disciplines(Thompson 2004).

Ineffective Urban Compaction

Urban compaction is often seen as a solution to fighting the effects of sprawl and preserving areas of open space and natural vegetation (Pauleit & Golding 2005). Much research has been done on its effectiveness and theory. Urban compaction aims to slow or stop sprawl by revitalizing urban environments to suit the needs of increasing populations, through conscientious planning and density analysis. By using Geographic Information Systems in conjunction with regional surveys, Pauleit and Golding (2005) studied the patterns of growth and development within American cities. Findings have shown that even in compacted developments, green spaces have been lost to development, especially in economically affluent areas. Suggestions have been made to inform policy making about proper ways to permanently preserve natural areas while restricting development. (Pauleit & Golding 2005)

Ecosystem Fragmentation

Connections between preserved natural areas are another concern of contemporary research (Brook 2005, Conway 2006. Göcmen 2009). Current methods of conservation have been shown to be ineffectively addressing the flow of abiotic and biotic features within the environment. Preservation methods are creating islands of habitat disconnected from other ecological systems. Research has shown that public land preservation such as parks and green ways are not capable of advancing sustainability alone; private land must also be worked into the network to truly be sustainable (Conway 2006). Under current policy it is expected that connectivity resistance will continue to rise(Conway 2006). Without proper education, utilization of private and public land will not achieve the necessary levels of conservation to sustain and maintain ecosystem services (Conway 2006). Specific guidelines must be established for homeowners and private developers to facilitate connections between areas of habitat and natural vegetation (Conway 2006, Göcmen 2009). Sustainable development itself is under scrutiny by researchers concerned with its ability to reach the goals the movement has established(Baldwin et al. 2010, Berke et al. 2003, Brook 200, Göcmen 2009, Stangl and Guinn 2011, Thompson 2004, Wener and Carmalt 2006). While the movement attempts to limit the impact on the natural environment and even establish new green connections, it fails to the needs of ecological systems and resources(Baldwin et al. 2010). Those who are responsible for development are not often authorities on ecological systems and development, leading to the inability for human environments to meet the needs of the environment (Göcmen 2009, Thompson 2004). Environmentally sustainable practices are now being implemented by developers, but are often simplified and ineffective. Research has suggested that strong, steadfast communication must be developed between environmental and ecological experts, design professionals, and land developers for sustainable practices to accurately actualize(Göcmen 2009, Thompson 2004). The often overlooked and under-appreciated profession of landscape architecture is considered a potential facilitator between those involved in suburban development (Brook 2005).

Professional Irresponsibility

The role of landscape architects within the suburban realm has also been called into question. Some professionals have concluded that the traditional work performed within the profession is one based on superficiality (Weller 2008). Suburban communities are often misunderstood and understudied if even studied at all by landscape architects, even though they have potential for being working experts in the area (Weller 2008). There are often too many factors contributing to the inability of suburban developments to become sustainable and practice green urbanism theory (Weller 2008). Unless control is gained within the umbrella of suburban development, disconnects will continue to exist between theory and practice (Weller 2008). The many paradigms of development must be unified under a common goal with clear direction, framework and guidelines (Weller 2008).

Economic Value of Conservation

Economic value of preserved lands has been another area of study for landscape researchers. Financial barriers are often considered barriers to green development, but many studies have shown potential monetary gain from implementing conservation techniques (Hardie et al. 2007, Thorsnes 2002). Areas of preserved natural vegetation have a direct effect on the property value of residential homes. For instance, properties that backed up to a forest preserve sold at significantly higher rates and prices than those that did not (Thorsnes 439). Non-monetary value is also attributed to such areas, and is recognized by residents. Thorsnes's research (2002) has found that permanent preserves can offer many benefits to housing communities including flood control, recreational space, wildlife viewing, pollution control, privacy and reduced congestion. (Thorsnes 2002)

A similar study by Hardie et al. (2007) investigated the effects of forest conservation and zoning on subdivision land value. The study features comparison with requirements from the Maryland Forest Conservation Act (FCA) of 1991 and its potential to affect property values. Results from the study, "find that the average values of developed lots per subdivision acre are positively associated with the percentage of the subdivision that developers are required to plant in forest under the FCA," (Hardie et al. 471). In addition, Hardie et al. discovered that zoning regulations have an effect on property values where, "planning associations in Maryland force developers to subdivide into smaller number of large lots than would be privately profitable," (470). The authors suggest that residential land use zoning would benefit from requiring higher density developments by commanding higher average lot values. (Hardie et al. 2007)

The relationship between these benefits and values in comparison to traditional means of development must be further studied. Only if these benefits can be understood and clearly communicated to developers, planners, and politicians will the practice have positive effects in the fight against sprawl.

Scale Failures

The scale at which urban sprawl is addressed is an area of study of contemporary research (Mason 2011, Ndubisi 2008, Wheeler 2009). “Sustainable regionalism” is a method being studied, with focus on its ability to address the many issues of sprawl that cannot be solved on smaller scales (Ndubisi 2008). It is a theory that aims to establish ecological systems within regions experiencing urban growth. Ndubisi(2008)has shown that focusing on the city, and the communities that surround them as separate entities results in incomplete design and planning prescriptions. Sustainable practices must be studied and enacted as a network connecting all forms and scales of development together. Until this is done, far-reaching sustainability is not an accessible goal (Ndubisi 2008).

In 2011, Mason discussed the historical roots and current trends of what he calls, “ecoregional planning.” Ecoregions are defined by natural boundaries, rather than political, such as; topography, hydrology, flora and fauna (Mason 2011). These regions differ in scale, mega- meso- and micro-, of which the latter sees the most activity in planning (Mason 2011). Mason demonstrates how this is a problem, stating, “Environmentalists, bioregionalits, conversation biologists, and many others have long held the view that if we are to properly manage our environmental resources, America must be viewed foremost as a collage of ecoregions, rather than a collection of state and local governments," (408). The paper also posits that ecoregioinal planning will continue to suffer unless economic and political barriers are overcome (Mason 2011). The best solution given by the study is to provide and enforce effective incentive-disincentive programs at the mega- and mesolevel ecoregional scales (Mason 2011).

Urban Ecology

The particular ecology within cities is an area of little study within the realm of landscape architecture and urban planning. There is a complex relationship within cities between socioeconomic structures, ecology within cities, and cities as ecosystems. Some feel that cities are "holes" within the fabric of natural ecosystems, and not much has been studied on this disturbance (Wu 2008). There is consistent encouragement of adopting a new perspective when designing and revitalizing cities, one that focuses on interdisciplinary and trans-disciplinary approaches to integrating human ecology with the rest of the ecosystem. Once patterns of urban growth and development are studied in more detail, then designers and planners can better formulate approaches to designing for the needs of a growing population. If properly planned, development can be switched from the cause of environmental degradation, to the means to achieve sustainability. (Wu 2008)

New Urbanism

New urbanism is a relatively new design approach seeking to provide a beneficial means for low-impact development(Katz 1993; Duany, Plater-Zyberk and Alminana 2003). The theory is defined as, "Neighborhood design trend used to promote community and livability. Characteristics include narrow streets, wide side-walks, porches, and homes located closer together than typical suburban designs," (Farr 2008). Integral to the philosophy is increasing the density of residential dwelling units. "Seven swelling units per acre is a minimum threshold of net density for new urban developments, compared to four dwelling units per acre(or less) for conventional developments," says Berke on page 400 of his study on the effectiveness of the approach. Pedestrian orientation is another key component. New Urbanism designs with the intent of reducing the use and prominence of automobiles within developments. For this reason, an increased amount of pedestrian and bike trails are often created; these trails can actually increase impervious surfaces within green areas and could be seen as a disadvantage. Berke and his fellow authors point out that these trails could trade runoff for improved air quality due to decreased used of motor vehicles for travel. Furthermore, by designing mixed land uses within developments, New Urbanism posits increased attraction, satisfaction, diversity, incomes, and civic bonds within its communities (Berke et al. 2003). An important finding from the Berke study is that within greenfield developments New Urbanism is more effective than conventional developments at incorporating watershed protection. The same study did not find strong evidence to suggest that New Urbanism was as successful in urban infill sites. The authors suggest for this reason that,"New Urban developments in urban core areas should more effectively account for watershed impacts," pg. 410. Providing incentives for New Urbanist infill development would provide for future studies of its effectiveness (Berke et al. 2003).

New Urbanism and LEED-ND were evaluated in a study by Stangl and Guinn in 2011. They state that while LEED-ND portrays itself as tool for meeting the requirements of New Urbanism theory, it actually fails to accurately account for connectivity within neighborhoods. The authors demonstrate several scenarios where neighborhood layouts pass LEED-ND's connectivity test, but feature dramatic connectivity limitations. Also, included in the article is a method for determining route directness as a more objective means to evaluate connectivity and ease of movement in all directions (page 290) and easy solutions to remedying the failures of LEED-ND. It is important for designers to not apply theories, such as New Urbanism, but to verify that principles and techniques within these theories in fact achieve the goals they set out to reach. (Stangl and Guinn 2011)

Technology and Landscape

Key to a review on literature regarding sustainable urban revitalization is the 1994 text *Gray World, Green Heart: Technology, Nature, and the Sustainable Landscape,* by Robert Thayer. The book outlines human-landscape phenomenons such as technophilia, technophobia, topophilia, landscape guilt, deep ecology and the Gaia Hypothesis. The main premise of the book is that humanity innately loves both nature and technology, however the presence of the two together often creates cognitive dissonance, resulting in landscapes that are not sustainable (Thayer 1994).

Thayer also discusses dilemmas within landscape management and planning practices concerning the aforementioned phenomenons. His particular style os sustainability includes 5 main characteristics:

"1. Use primarily renewable, horizontal energy at rates which can be regenerated without ecological destabilization.

2. Maximize the recycling of resources, nutrients, and byproducts and produce minimum "waste," or conversion of materials to unusable locations or forms

3. Maintain local structure and function, and not reduce the diversity or stability of the surrounding ecosystems

4. Preserve and serve local human communities rather than change or destroy them

5. Incorporate technologies that support these goals. In the sustianable landscape, technology is secondary and subservient, not primary and dominating," (Thayer 243).

Of these characteristic, the fifth seems to be of strongest emphasis throughout the book. Thayer asserts that technology within a sustainable landscape must be transparent, and genuine, displaying its true nature to the public, whether negative or positive. Also, technology needs to add complexity without creating contradiction; with one example being that air conditioning must not afford some a pleasurable climate, while ultimately resulting in the suffering of others (Thayer 313). This vision may result in a post-postmodern world with, "the style of no style,"(315) that departs from traditional aesthetics and adheres to ecological functionality of form (Thayer 1994).

Biophilia

One particular design philosophy that attempts to remedy many of the aforementioned issues with sustainable design, is Biophilia. Developed by Edward O. Wilson in 1984 it has been investigated and adapted by many other researchers. According to Kellert et al. (2008),"The goal of Biophilic design is to integrate social and natural sciences to produce human living environments that sustain a human-nature connection; i.e., provide psychological benefits," (Baldwin et al. 2010).

Designers of supposedly green and sustainable developments often overlook the means necessary to truly provide habitat suitable for a diverse range of organisms, as well as human well-being (Baldwin et al. 2010). However these authors suggest that Biophilic design could remedy this problem based on support that,"an abundance of research has revealed that ecosystems with a full complement of interacting species have significant utilitarian value to humans by providing dividends for human health," (Baldwin et al. 2010). Some of the benefits discovered include: reduced crime; reduced pain, stress and depression; enhanced physical and mental resilience; improved childhood development, attention, academic performance and productivity (Baldwin et al. 2010).

Important to the philosophy of Biophilia are the six approaches to design outlined by Kellert in his 2008 book *Biophilic Design: The Theory, Science and Practice of Bringing Buildings to Life*. Those approaches are "environmental features" such as psychologically significant plants, animals and landforms; "natural shapes and forms" including imitation of natural features, organic forms, and motifs; "natural patterns and processes" that represent growth and change, self-similarity, scale repetition, and sensory variability; "light and space" with special regard to natural light, sequential spaces and transitional indoor-outdoor spaces; "place-based relationships" such as connections to place with the use of indigenous materials and motifs; and finally "evolved human relationships to nature" especially prospect and refuge, order and complexity, innovation and security (Baldwin et al. 2010). Baldwin recommends that these approaches be used to link human development with approaches for conservation. He makes an intriguing and innovative assertion that, "If we choose to provide the infrastructure for sensitive species first, the ideal infrastructure for long-term sustainability can follow in the 'negative space'." This view is very different from traditional planning which provides for human use first, and then may choose to devote leftover spaces for conservation.

A European researcher published a paper in 2007 making a case for, and listing several examples of Biophilic architecture. The author agrees that research in the area supports that human created environments could be designed to improve emotional and cognitive functioning (Joye 2007). The author posits that, "by architecturally mimicking natural forms and structural organizations of natural setting, these beneficial effects can be tapped in the built context,"(Joye 305). Joye provides an excellent narrative explaining the many hypotheses that support Biophilia. Important to the article are Joye's suggestions on how to actually go about incorporating the ideas of Biophilia in the environment. He mentions the Savannah Hypothesis, that humans having evolved in a savannah setting prefer them to other biomes, and provides a strategies that, "include creating wide open spaces; making variations in the architectural topography; integrating clusters of real or symbolic trees (e.g. collumns); integrating a water feature (e.g. fountain) or even a small fire,"(311). Furthermore, mentions the idea of amplification, simplification, or abstractions of natural features and forms, to increase their biophilic responses (pg 314). Joye compares this idea with the success of architectural works by Gaudi and Calatrava. (Joye 2007)

A short review on the subject was written by Elizabeth Molthrop in 2011. In the paper she discusses many of the aforementioned principles, specifically the historical evidence supporting Biophilia and also the fractal forms prevalent in the design theory. However, the author emphasizes that, "the rates of technological progress have far exceeded rates of psychological evolution, leaving us ill-equipped to cope with our lifestyle," (37). While technology is made to improve our lives, it also is a source of much stress. The author believes that biophilic design seeks to remedy this dilemma by creating environments that facilitate good mental health. She even identifies two recent building projects that were executed with biophilic design in mind. One is the Adam Joseph Lewis Center for Environmental Studies at Oberlin College, Ohio and the other is the University of Guelph Humber Building in Ontario, Canada.(Molthrop 2011)

In summary, the relationships of sprawl and the many influences of development have been a matter of frequent study within the world of research. Trends in research have suggested a need for better integration between the many study areas, and those who participate in development. Education and discussion are integral to facilitating change in the current paradigms. Studies must be done to help link these areas together, to complete a comprehensive solution.

Wetland Reclamation

Wetlands have often been labeled as critically important and extremely fragile ecosystems (Harrison et al. 2011, Mitsch et al. 1998). In the United States efforts to protect, restore, and reclaim these landscapes have become increasingly more frequent. Wetlands have great potential to support biodiversity, provide ecosystem services, and foster human interest and recreation (Harrison et al. 2011, Mitsch et al. 1998, Mitsch et al. 2012). Some of the popular topics in the literature on wetland reclamation are: their effectiveness for detention and retention, wetland design methodologies, nutrient removal, wildlife conservation, pest problems, microbial biomass, and methane gas and greenhouse gas emissions.

Wetlands Effectiveness for Detention/Retention

A topic of much concern within the area of wetland reclamation is whether they can successfully detain/retain the large quantities of stormwater runoff from urban land uses. Constructed wetlands are often designed with the goal of managing stormwater in a sustainable fashion, but doubt that these sensitive ecosystems can tolerate dramatic hydrologic fluctuations exists.

This topic was studied in 2009 by Millhollon et al. The researchers looked into a constructed wetland that aimed to detain stormwater from a 162 hectare site consisting of cultivated cropland and pasture. Calculations were made to determine the volumes of water that would have come off the land in its original forested state and this was used to size the constructed wetland(The Soil Conservation Service [AKA Natural Resource Conservation Service] Curve Number method was used). Final size was set at only 1.9% of the total site area (pg 2466). During the study period Hurricane Rita dumped above-average rain fall unto the site, and the constructed wetland was able to detain the water for 11 to 12 days after the event. The authors have determined this rate to be successful.(Millhollon et al. 2009)

Wetland Design Methodology

During this literature review, many interesting articles on the topic of wetland design strategies were found that were written by William J. Mitsch from Ohio State University.

Mitsch published a paper in 1994 that discussed a wetland restoration project at a former missile base within the Great Lakes Basin. The paper discusses 10 potential design approaches and postulates the most appropriate technique, "evaluated for their contribution to local ecology, research, education and wildlife, ease of maintenance, and probability of success," page 31 (Mitsch et al. 1994). Out of the many options, recommendations were given toward a design that restores the site back to original conditions, with a wetland open to the adjacent Gibralter Bay because it will provide the most potential value to the ecosystem. Mitsch also recommends passive recreational facilities on site to allow for human use and interest with the restoration project. Connecting the restored marsh to nearby existing hydrologic systems is vital. The team suggested that diked wetlands designs not be used as they would isolate hydrologic functions(Mitsch et al 1994). This study is particularly important to the topic of this thesis because it lies in close proximity to the chosen project location, and exists under similar conditions. The site of the Mitsch study is now a member of the Detroit River International Wildlife Refuge (Domashevich, 2011).

In 1998 he published a study discussing the procedure and effectiveness of self-design for creating and restoring wetlands (Mitsch et al. 1998). Mitsch posits, "In the context of ecosystem restoration and creation, self-design means that if an ecosystem is open to allow "seeding," through human or natural means, of enough species' propagules, the system itself will optimize its design by selecting for the assemblage of plants, microbes, and animals that is best adapted for existing conditions," page 1020. This concept is quite different than traditional approaches used by designers to restore and create wetlands who tend to select for specific species and use them as an evaluation of the project's success(Mitsch et al. 1998). The research team investigated self-design within an experiment at two 1 ha wetland basin sites, one planted, one left unplanted after construction. Results found that, "The planted and unplanted wetlands apparently converged within 3 years in most of our indicators of ecosystem function," page 1027. The researchers concluded that planting a wetland is not necessary, or even optimal, for restoring or creating a well-functioning wetland ecosystem. If the system is connected to hydrologically open systems, self-design will occur from the continual introduction of plant, animal, and microbial species. (Mitsch et al. 1998)

In 2012 Mitsch and fellow researchers published a follow-up study and the same wetland project to determine the long-term effects of self-design. Results from the investigation found, “Wetland plant richness increased from 13 originally planted species to 116 species overall after 15 years, with most of the increase occurring in the first 5 years,” page 237(Mitsch et al. 2012). The team also determined that the originally unplanted wetland became the most productive ecosystem and provided the most ecosystem services.

Nutrient Removal

Nitrogen and Phosphorus are two nutrients often studied in relation to wetland reclamation due to the devastating impacts they can have on ecosystems.

In 2010 a paper was published by Ardón et al. concerning the Phosphorus export within restored wetlands in relation to fluctuations in water levels. Researchers were concerned that restoring wetlands in land that served formerly as agricultural fields would result in the harmful release of legacy fertilizer nutrients (Ardón et al. 2010). Their study did in fact find increased levels of soluble reactive phosphorus leaving the study site after periods of increased flooding. They concluded that this increased export of phosphorus could continue up to 16 years in this wetland restored on agricultural lands. As this nutrient increase would affect downstream ecosystems, the researchers suggest that, ”timing of restoration and active management of water levels might help alleviate these problems in future wetland restoration projects.” This recommendation could create problems when placing wetland projects, and especially for designers and developers that seek a simple, maintenance-free solution to deal with wetland requirements, nutrient removal, and stormwater management. (Ardón et al. 2010)

Harrison et al. (2011) investigated denitrification processes in urban wetlands. Denitrification offers a permanent method for removing nitrogen from water bodies. The study determined that within urban areas, “created oxbow wetlands have been shown to be net sinks for N and P on an annual basis,” pg 640. They concluded that forested wetlands provide the greatest opportunity for denitrification due to the abundance of leaf litter that provides carbon required for the chemical reactions of converting nitrogen. Water residence time was another factor described by the study as a significant contributor to denitrification efficiency. Concerns often arise that denitrification trades water quality for increased greenhouse gas pollution.

However, the authors of this study conclude that the urban wetlands studied, “could not be considered to be a significant source of Nitrous Oxide in regional greenhouse gas inventories,” pg 644. The authors suggest that urban stream management could benefit from creating wetlands to remove nitrogen from urban watersheds year round (Harrison et al. 2011).

Wildlife Conservation

Wetland reclamation has been a proven means to wildlife conservation; wetlands often host a diverse array of animal life, and by reclaiming these ecosystems designers can protect and even attract these important organisms (Kreuger 2001, Petersen 2013, Rozas and Minello 2001).

Kreuger published a paper in 2001 describing wetland reclamation projects in Houston, TX. Material was dredged when a port channel was widened and deepened, this material was used to restore and create several wetland marshes and islands along the channel. Designers of the project expect the islands to be homes to over 15 species of important water birds. To insure longevity of these islands, limestone blocks were arranged around their perimeters to slow erosion from passing ship traffic. (Kreuger 2001)

Rozas and Minello published in 2001 a paper on the subject of marsh terracing as a means to restore wetland fishery habitat to sub-tidal/soft-bottom areas. Terracing uses dredged material to create artificial marsh ponds within deeper water systems. The study concluded that, "terrace fields support higher standing crops of most fishery species compared with shallow marsh ponds of similar size," (Rozas and Minello 327). The authors posit that this terracing technique can be used to improve fishery populations in ares where natural marsh cannot easily establish. This is due to the discovery that, "terracing appears to reduce fetch, wave energy, and shoreline erosion within coastal water bodies,"(Rozas and Minello (340).

A paper on the bird use of wetlands near developed areas was published in 2013 by Petersen et al. Wetland and their surrounding land cover were studied in several locations near Minneapolis/St. Paul Minnesota. The researchers found that, "bird species richness and diversity in these suburban wetlands were positively associated with the cover of trees and nontree vegetation within a few hundred meters of the wetland boundaries, whereas richness, diversity and total detections were negatively associated with human constructed aspects of land cover," (Petersen 224). Also determined by the study was that, "land cover closest to the wetlands seemingly had less influence on bird metrics than that within with 500-m buffer as a whole," (224). These two findings together demand that developments near or seeking to create wetlands, minimize the presence of roads and buildings not only on land adjacent to wetlands, but also within the vital non-wetland vegetative land covers nearby (Petersen 2013).

Pest Problems

One problem often associated with wetland reclamation within/near human settlements is the idea that such areas increase the presence of pests. Mosquitos and other insects could create problems in urban areas, if wetlands did in fact increase their presence. Much research has been conducted to investigate possible eco-friendly techniques to limit this threat, and the resulting effects such as blood-transmitted diseases.

Chatterjee et al. 2007 investigated the use of a dragonfly nymph introduction in wetlands as a bio-control agent. Results found the nymph effective at reducing mosquito larvae populations, significantly more than previously used fish predators. The authors declared that more research is needed to discern if such introduction would have negative ecological impacts, but the method seems promising. (Chatterjee et al. 2007)

A Swedish research team conducted a long term study on the use of biological mosquito larvicide, *Bacillus thuringiensis israelensis* (Bti). They were worried that such a control mechanism would have adverse effects on the ecosystem by decreasing populations of other insect species essential to the food-web (Lundström et al. 2009). However, their study concluded that, "the Bti-based control of flood-water mosquitos does not cause any major direct negative effects on chironomid production, and therefore does not seem to induce any risk for indirect negative effects on birds, bats or any other predators feeding on chironomids," page 117. This discovery suggests that biological control agents have potential to control pests often associated with wetlands and standing water, without harming ecosystems. (Lundström et al. 2009)

Microbial Biomass

Wetland research has also often studied comparisons between natural and constructed wetlands in terms of microbial biomass conditions. Certain levels of microbial biomass are necessary for wetlands to function. If constructed wetlands are unable to meet similar levels of microbial biomass as natural wetlands, the feasibility of such construction is bound to have limitations.

A study by Duncan and Groffman in 1994 investigated this dilemma. Specifically they studied, "microbial biomass C, soil respiration, denitrification enzyme activity (DEA), and potential net N mineralization and nitrification," (Duncan 1994. pg 298). In the study they found that, "levels of these parameters in the constructed wetlands fell within the range of variability observed in the natural wetlands," pg 298. It is important to notice that the constructed wetlands they studied utilized soils for construction that were high in organic substrates, allowing for aggressive establishment of vegetation. When these wetlands we constructed, sediments from a nearby pond dredging were mixed in the soils used on site (pg 304). These results support the idea that constructed wetlands can be used successfully to cycle nutrients and treat water sources.

Methane and Greenhouse Gas Emissions

During this review of literature a common topic was found concerning the potential negative effects of wetland creation, methane gas and other greenhouse gas emissions. In a 2012 study, Mitsch et al. Discovered that methane emissions were nearly twice as high from self-design/natural/unplanted wetlands than those that were created. However, when ratios of carbon sequestration and greenhouse gas emissions were compared, the researchers concluded that planted wetlands function as a sink of climate-radiative forcing, and the unplanted wetland functioned as a source(Mitsch et al. 2012). This holds true with other reports that suggest wetlands as one of the largest non-anthropogenic sources of greenhouse gasses. Montzka et al. 2011 presented a review of natural and anthropogenic sources of non CO2 greenhouse gases. The review posits that anthropogenic sources are responsible for the largest contribution of greenhouse gases, likely 2 or 3 times more than wetland sources. The authors attribute this to the constantly increasing demand for energy and food in human society (Montzka et al. 2011). For this reason, it can be assumed that the creation of wetlands should not be hindered by their potential to release harmful gasses, because, when compared to human sources, wetland emission is negligent. Mitigation techniques should instead be concentrated on anthropogenic sources, specifically energy and agriculture, a topic not discussed within this thesis.

In summary, wetland reclamation offers many solutions to mitigating the problems that arise from negligent development techniques. Although, the process itself is not free of problems, through the continuing use and study of wetland reclamation insight can be gained on its true effectiveness and the proper ways to install and manage these complex ecosystems.

Stormwater Management

Improper stormwater management procedures continue to deteriorate our most precious resource, water (Echols 2008, Hurley and Forman 2011, Whitaker et al. 2002). Many fundamental differences exist between the currently used techniques and researched philosophies. This dilemma results in much confusion, waste, and the slow recovery of resources. For these reasons, many researchers have been conducting studies comparing both traditional and avant-garde methods to determine their effectiveness and cost. Some of the popular topics in the realm of stormwater management include: treatment design shapes and forms, biofiltration, and low-impact design.

Treatment Design Shapes and Forms

In 1999, *Civil Engineering* published a short expose on the potential use of meandering wetlands for stormwater runoff treatment. The article claims that such a design would increase pollutant uptake and decrease installation costs, when compared to traditional management designs. "If we can support a more dense area of vegetation, we can get the same nutrient removal in a smaller area," (Anonymous 1999). By meandering a stormwater treatment stream the installations will require less land area. This method could be particularly useful in areas with high land prices, or limited amounts of available space for stormwater treatment. Meandering a treatment channel allows for more flexibility in design implementation (Anonymous 1999).

Whitaker et al. 2002 wrote a piece describing an 8 acre stormwater management system designed for a manufacturing facility. The design featured a combination of bioretention planting strips, extended dry detention basins, and a mitigated wetland connected in sequence. Flows off parking areas are first collected in catch basins to remove sediments, then enter the planting strips that function to relieve water loads downstream and serve as aesthetic vegetation. The article mentions that 65% of total phosphorus was retained by these planting strips during initial tests (77). The design also included ways to mitigated small and large storms independently with small storms discharging through perforated piping, and large storms onto vegetated spillways. The authors posit that the most important aspect of the project was the careful attention given to hydrograph reports to determine proper elevations for specific plant communities, and the salvaging of organic topsoils vital to the success of plant growth. (Whitaker et al. 2002)

An interesting topic in the design of stormwater management systems is Split-flow theory (Echols 2008). This theory, "proposes to systematically split runoff into three volumes and evaporate, infiltrate and discharge; and manage these volumes in ways that emulate natural hydrological site processes, thereby creating stormwater management systems that are more ecologically based," (205). This theory offers solutions to the problems that typically result from traditional methods of conveyance, detention, and retention practices. Echols states that conveyance treatment, "speed runoff downstream, increase flood risk to downstream properties, discharge first-flush pollution, increase excess runoff frequency, and fail to emulate natural landscape hydrology," (206). Detention which is designed to slowly release stormwater downstream, are effective for this purpose, but fail to emulate natural hydrologic functions such as evapotranspiration and infiltration. Retention systems are often designed to treat the flaws of detention, but according to Echols also fail to address the diversity of stormwater events that may occur on site. (Echols 2008)

Split-flow theory actually combines these methods in a way that better emulates natural landscape hydrology, for a balanced water management effect. The theory suggests use of, "a combination of retention facilities, overflow structures, proportional flow splitters, and infiltration and discharge systems," (207) to divide stormwater into separate volumes that will evaporate, infiltrate and discharge in proportions similar to natural settings (Echols 2008). Specifics of split-flow systems will not be discussed here, but research shows it as a promising and feasible method for ecologically managing stormwater.

In 2011 Hurley and Forman published a paper that investigated the necessary sizing and configuration of stormwater systems to meet targeted nutrient removal levels. The authors found that, “the target of 65% P-reduction was only achieved with designs that treated 100% of urban land with a pond or bio-filter,” (Hurley and Forman 850). This requirement was met at the 200 acre study site with a single pond representing 5% of the total land area, and with a multi-pond design ranging from 5%-10% of coverage. They conclude that a combination of these two methods could provide for adequate treatment of stormwater from 100% of developed urban landscapes with relatively low land allocation for stormwater systems. (Hurley and Forman 2011)

Biofiltration

The ability of stormwater management techniques to filter out harmful pollutants is one of the approaches most beneficial mechanisms. Much research in the field has concerned the effectiveness of biofiltration in different settings and circumstances.

Pollutant removal efficacy was studied in 2002 by Mallin et al. Three wet detention ponds were investigated, and of the three one, “Achieved significant reductions in total nitrogen, nitrate, ammonium, total phosphorous, orthophosphate, and fecal coliform bacterial counts,”(Mallin et al. 654). The researchers believe that this is due largely to this pond’s high length to width ratio, the fact that most of the input water was into the upper area of the pond, and that it contained a diverse community of aquatic macrophyte vegetation. Such a design allows for maximized contact between pollutants, sediments and plants. The study also advises use of forebays to increase primary settling in the bioretention system, and construction of a shallow shelf at the edge of the ponds to encourage rooted macrophyte growth. (Mallin et al. 2002)

McNett and Hunt (2011) evaluated the toxicity of forebay sediments in stormwater wetlands. Forebays are often installed to encourage sedimentation so that pollutants can be captured before entering wetlands in mass quantities. Forebays alleviate the difficult task of removing sediments for larger, more vegetated ponds (McNeyy and Hunt 2001). The study found that routine forebay sediment removal was necessary to meet aquatic health standards. However, due to the low toxicity of metals tested in the sediment, they determined that forebay spoils could be safely applied to adjacent land as a cost-effective disposal method. Moreover, the authors, "recommend that forebay sediments be tested, near time of excavation and prior to land application, for bioavailable nitrogen, phosphorous, calcium, and potassium, to ensure adequate plant growth, and thus prevent erosion of sediments and associated contaminants," (537). The findings from this study provide a method of ensuring that stormwater wetlands operate effectively and can be managed ecologically. (McNeyy and Hunt 2001)

A study by Dietz on the subject found that bioretention systems were able to significantly reduce levels of nutrients such as copper, lead, zinc, Kjeldahl-nitrogen, and ammonia-nitrogen. Nitrate-nitrogen was not well contained, and total phosphorus export from the bioretention systems was a problem, however. The author suggests a design to combat phosphorus export, to only use underdrains when soil in the bioretention system drains poorly, and to direct the outfall of this drain into a grassy or wooded area. To address the nitrate concentrations, the author encourages experimentation with raised drains, to create a saturation area in retention basins that would allow for denitrification reactions to occur. (Dietz. 2007)

A study in 2011 by Blecken et al. posited that while biofilters, "can remove up to 80%, or 90% of total metals found in stormwater,"(303), winter operation has been a concern. Despite concerns, however, their findings report that, "Temperature did not affect Cc, Pb, and Zn removals in general, but Cu removals increased with decreasing temperatures," (303). These findings support the notion that biofilters can indeed be implemented in regions with significant periods of low temperatures, and still serve the purposed of sequestering harmful environmental metals. (Blecken et al. 2011)

A study published by Hogan and Walbridge in 2007 wrote on the topic of nutrient retention from urban stormwater. In the article stormwater detention basin best management practice (SDB-BMP) were compared to the more traditional stormwater detention basing flood control (SDB-FC) technique. SDB-BMPs are designed not only to detain stormwater, but to function ecologically and ameliorate the negative downstream affects of stormwater. Results from the study suggest that SDB-BMPs result in greater soil phosphorus removal than SDB-FCs and operate at levels similar to natural riparian wetlands. These results were identified to be dependent on SDB-BMP's ability to retain sediments with nutrients that increase phosphorus sorption capacity (such as iron and aluminum). SDB-BMPs also, "direct inflow waters across the entire basin, increasing retention time and maximizing contact between urban runoff and soils," (392). Designing to include these factors of SDB-BMPs would prove useful in urban stormwater management practices. (Hogan and Walbridge 2007)

Low-Impact Design

Stormwater management techniques have been a mandatory requirement for most development projects for many years now (Dietz 2007). However, the methods utilized in traditional stormwater management is arguably not the most sustainable. For this reason, researchers and designers have been experimenting with new techniques to improve the sustainable aspects of stormwater management. One such methodology is known as Low-Impact Design (LID). The primary goal of LID, "is to preserve as much of the site in an undisturbed condition, and where disturbance is necessary, reduce the impact to the soils, vegetation, and aquatic systems on site,"(Dietz 352). Winter function was also supported by the Dietz study (354).

LID has been experimenting with many new technologies often overlooked by traditional stormwater management. These methods include, bioretention, green roofs, and permeable pavements. LID uses cluster layouts of vegetated swales, rain gardens and bioretention areas to intercept and treat stormwater volumes created by development and impervious surfaces. This study posits that green roofs can intercept 60-70% of stormwater (Dietz 356) and suggests the use of this method in areas where space is limited or current sewer systems are often overloaded. LID prescribes the use of many permeable surface materials including, concrete blocks and grids, plastic grids, pervious asphalt, and pervious concrete. Each material offers its own benefits and concerns, but all have proven as promising alternatives to traditional surfaces. (Dietz 2007)

In summary, there are many different potential applications for stormwater management, each with their own benefits and pitfalls. Conducting more tests that combine and compare these various techniques will bring the scientific community and design professions one step closer to eliminating practices that offer more harm than good, and also improve efficiency and our ability to protect vital water resources.

Visual Quality/Environmental Preference

For several decades the topic of environmental preference has been an intriguing research field for scientists and designers alike. Many researchers have conducted work with an attempt to discern what characteristics within the physical environment appeal to the human mind, and the reasons behind these preferences (Aks and Sprott 1996, Burley 1997, Burley et al. 2011, Hagerhall et al. 2004, Kaplan and Kaplan 1989, Steinitz 2000, Taylor et al. 2005).

Carl Steinitz summarized the general beliefs for current evaluation models in a short essay written in 2000. He claims that most, "are normally attributed to landscapes within some combination of less 'development', more distant views, more varied terrain, the presence of water, and a more engaging ('mysterious') sense of involvement," (Steinitz 283). However, disagreement arrises between most researchers in which of these factors is most influential (Steinitz 2000).

Key to an understanding of environmental preference is the work of Rachel and Stephen Kaplan. One study taken from their vast array of work within the field was published in 1989 and investigates particular variables of the physical environment thought to correlate with preference. The four domains they chose were, landcover, informational, perceptual, and physical variables, with 20 independent variables divided among those domains. Results from the study showed some surprising relationships, “Smoothness” was the strongest positive predictor, and “Mystery” also had strong effect. While “Openness”, “Weedy Fields”, and “Scrubland” correlated negatively with preference. The Kaplans concluded from this study that environmental predictors are a complex field of study, and have inspired an alarming number of subsequent studies. (Kaplan and Kaplan 1989)

One such study was published in 1996 by researchers at the University of Wisconsin, Aks and Sprott. They attempted to quantify the preference humans have for chaotic patterns. They discovered how,“aesthetic preferences correlate with the fractal dimension (F) and the Lyapunov exponent (L) of the patterns,”(Aks and Sprott 1). The researchers defined F as, “the extent that space is filled,” within an image of a scene and L as, “the unpredictability of the dynamical process that produced the pattern," (2). Their results showed that participants preferred images with F and L values that were very close to the values shared by many natural objects and forms (1.26 and 0.37 respectively) such as coastlines, clouds and mountain ranges. Another interesting finding from the study was the correlation between F and L preference and self-reported declarations of participant creativity. They found results suggesting, "that self-reported creative individuals have a marginally greater preference for high F patterns and self-reported scientific individuals preferred high L patterns," (1). This discovery is interesting because it suggests that generalization of human preference is limited to the personal characteristics of individuals. (Aks and Sprott 1996)

In 2004 Hagerhall et al. investigated the idea of fractal geometry's correlation with preference. The researchers decided to study the fractal dimension of silhouette outlines of landscape scenes and test it against user preference. Results from the study suggest that fractal geometry may be a large part of the basis for visual preference, and could explain the correlation between preference and "naturalness" as "natural" patterns are often fractal in form. It is interesting to note that images with water bodies or hilly topography were removed from the results of this study due to confounding effects in the comparison between silhouette and preference. (Hagerhall et al. 2004)

Fractal geometry as a factor for preference was investigated again by Taylor et al. in 2005. This specific study analyzed the paintings of Jackson Pollock alongside the fractal dimension of natural shapes, forms and patterns. The researchers discovered results similar to early studies, that "participants in visual perception tests display preference for fractals with mid-range fractal dimensions," (Taylor et al. 1). The most preferred fractals (whether natural images, paintings or computer-generated images) range from 1.3-1.5 (page 6). Interestingly, the study found that an artistic interpretation of a savannah scene (1.4 fractal dimension) reduced psychological stress of observers more so than a photograph of a forest scene (1.6 fractal dimension). This finding suggests that "natural" features may not always be the most preferred, while simplified (mid-range fractal) versions could be.(Taylor et al. 2005)

In 1997 Burley conducted a study to develop a, "perception-based visual quality predictive equation," that could be used by planners and designers to evaluate natural and designed scenes. The study tested many natural and human landscape variables for their predictive power that resulted in a predictive model capable of explaining 67% of the variance in participant preference for visual images of scenes. Burley discovered certain variables that had a greater power than others, such as: perimeter of foreground vegetation, area of distant non-vegetation, vehicles, humans, wildlife, utilities, openness and mystery. A predictive model such as this could prove useful when determined how to build more attractive physical environments. (Burley 1997)

Another study on the topic of Visual Quality mentions that observers, "prefer environments with animals, plants, and geological features; most man-made features are not preferred," (Burley et al. 50). This particular study investigated the Visual Quality of an adapted Frank Lloyd Wright's "Broadacre City" (a low density living environment, mixed with agriculture and preserved natural spaces) against images from Detroit, MI during it's most prosperous times. Results show that the FLW plan proved to be the more visually appealing of the two designs and supports the notion that incorporation of natural elements within urban fabrics as a way to increase the attractiveness of the urban environment. (Burley et al. 2011)

Further insight into Visual Quality was gained with a study conducted by Mo et al. in 2011. The formula developed by Burley (1997), was tested by Mo et al. to determine its effectiveness within French, Portuguese and Chinese populations. The article makes many astute conclusions about the topic of visual quality, one being, "Aesthetics, ecology, function, economics, and culture are not separate issues in the view of the respondents. When the landscape is observed and evaluated, the respondents utilize all of these values in the evaluation of landscape," (Mo et al. 550)." However, the most profound result from the study was that, "the Chinese response is quite different than equations that explain Western landscape preference where the equations can predict much more of the variance," (549). This finding suggests that there is likely no general set of features that most humans prefer in the physical environment, but rather Visual Quality is influenced by different cultural perceptions (Mo et al. 2011).

Another paper published in 2009 by Chen et al. studied the aesthetic quality of urban green spaces. In the author's investigation of related studies Chen et al. found that, "landscape aesthetic perception is a product of multi-sensory stimuli, the integration of other senses like olfactory, auditory, and tactile to visual aspect of perception..." (76). This led them to incorporate testing of these factors in their own study. Standardization of photos taken from their chosen Hangzhou Flower Garden in China was key to the study, which attempted to devise a method for scientifically evaluating an environment based on photographs. The study found that olfactory factors were a strong predictor of environmental preference with, "natural fragrance from flowers, leaves and rivers were held highly among respondents," (80). They also found that urban green spaces have the ability to mask unpreferred sounds while conserving preferred sounds for positive results, which concurs with other studies researched by Chen et al 2009. This article on the study did not explain how photos were rated, provide the photos along with their scores, or explain what visual variables led to higher or lower scores (although they did claim to have analyzed photos for "viable open sky, water, canopy/vegetative cover and paved area," pg 79).

In summary, Visual Quality and Environmental Preference are complex, multi-variable phenomena. Although much is still unknown about the topic, the techniques discussed above offer the design professions great tools for quantifying the success of their designs. By designing with these approaches in mind development will be able to distance itself from subject dogma and progress further into a realm of applied science.

Summary of Literature

Each of the researched fields of study, and their respective texts have provided a valuable database of information with potential for application within holistic environmental design. Through synthesis, individual findings from urban revitalization, stormwater management, wetland reclamation and visual quality studies can be combined to develop particular treatment strategies for particular design problems. This process will be described in detail within the subsequent chapters of this thesis.

METHODS

Research Design

This study will utilize a mixed methods approach, to combine the qualities of both qualitative and quantitative research in procedure and analysis. A mixed methods approach will allow for exploration of the problem through qualitative inquiry, to be built upon later by quantitative investigation. The process of developing an ecologically sensitive master plan for the city of River Rouge, Mi is a complex dynamic, and requires the synthesis of both methods for a proper and complete understanding (Creswell 2003, Tashakkori & Teddie 2003).

A sequential exploratory strategy will be conducted for this study. The first stage of inquiry will consist of secondary research methods of both qualitative and quantitative nature. This stage will involve synthesis of empirical information discovered within the aforementioned literature review, and the application of design techniques found in similar projects. The second stage of this study will be to generate a comprehensive hypothetical master plan to address the problems faced at River Rouge. Design decisions in this stage shall be justified by the initial research. The third and final stage of this study will be the truest form of quantitative data gathering. The hypothetical master plan will be evaluated for success by means of Visual Quality analysis as conducted by Burley 1997, comparing images from the hypothetical design to actual images of the current site conditions. Through this strategy potentially biased design decisions and qualitative findings can be analyzed and supported by more concrete empirical evidence.

Stage 1 Qualitative data collection and analysis

As mentioned before, this stage of research is mostly represented within the Review of Literature chapter of this thesis. Specific applications of the secondary research findings will be referenced within the Design chapter.

Stage 2 The design process

The design methodology used in this thesis is based upon stages 1 through 4 of the eight-stage site planning cycle outlined by Kevin Lynch in 1986. The cycle itself finds its roots in the scientific method. The stages of his model used are:

1. Defining the problem
2. Programming and the analysis of site and user
3. Schematic design and the preliminary cost estimate
4. Developed design and detailed costing

(Lynch 1986)

These stages have been modified to suit the needs of a hypothetical master plan. Summary of these steps and their products are presented in the Design chapter of this thesis. Explicit procedures of each design stage will not be given in this narrative.

<u>Stage 3 Quantitative data collection and analysis</u>

This stage of research is the most scientific of all approaches and strives to objectively evaluate the hypothetical solution to the focus problem with a simple test, to test the attractiveness of the created design through Visual Quality analysis as described by Burley 1997.

Please recall the hypothesis, "If the selected site of River Rouge, MI is treated through applied Biophilic design, then the resulting product will display lower(more attractive) Visual Quality scores." A testable null hypothesis would be, "If the selected site of River Rouge, MI is treated through applied Biophilic design, then the resulting product's Visual Quality scores will not differ significantly from scores of the existing site."

The first step to applying Burley's Visual Quality test is to apply a 6.35 mm by 6.35 mm grid of 30 rows and 38 columns to each image that is to be tested. This was done using an overlay layer in Adobe Photoshop CS6 and importing each image in beneath. Next, each image is evaluated for the presence and quantity(in units of grid squares) of the independent variables/landscape components as defined in Table 1 (note: Burley identified many more variables in his 1997 paper, but only those included in his predictive equation have been presented). These values were recorded using an Apache Open Office 3 spreadsheet.

Variable	Description
Health	Table 2
X1	perimeter Immediate vegetation
X2	perimeter Intermediate non-vegetation
X3	perimeter distant vegetation
X4	area of intermediate vegetation
X6	area of distant non-vegetation
X7	area of pavement
X8	area of building
X9	area of vehicle
X10	area of humans
X14	area of wildflowers in foreground
X15	area of utilities
X16	area of boats
X17	area of dead foreground vegetation
X19	area of wildlife
X30	open landscapes: X2+X4+(2*(X3+X6))
X31	closed landscapes: X2+X4+(2*(X1+X17))
X32	openness:= X30-X31
X34	mystery:=X30*X1*X7/1140
X52	Noosphericness: = X7+X8+X9+X15+X16

Table 1. Independent Variables

The Health score for each image must be determined before all the independent variable scores can be inserted into the predictive formula. This health score is found by tallying qualities found in Table 2. Once found, these values can be used within the following equation to determine the Visual Quality score for each image:

$$Y = 68.30-(1.878*HEALTH)-(0.131*X1)-(0.064*X6) +(0.02*X9) +(0.036*X10)+(0.129*X15)-(0.129*X19)-(0.006*X32) +(0.00003*X34)+(0.032*X52)+(0.0008*X1*X1)+(0.00006*X6*X6)-(0.0003*X15*X15)+(0.0002*X19*X19)-(0.0009*X2*X14)-(0.00003*X52*X52)-(0.0000001*X52*X34)$$

Interpretation of the resulting scores is straightforward; Burley (1997) states that,"scores in the forties indicate images with exceptional scenic beauty. Scores in the nineties and hundreds indicate exceptional nonscenic images," (56).

A	purifies air	+1 0 -1
B	purifies water	+1 0 -1
C	builds soil resources	+1 0 -1
D	promotes human cultural diversity	+1 0 -1
E	preserves natural resources	+1 0 -1
F	limits use of fossil fuel	+1 0 -1
G	minimizes radioactive contamination	+1 0 -1
H	promotes biological diversity	+1 0 -1
I	provides food	+1 0 -1
J	ameliorates wind	+1 0 -1
K	prevents soil erosion	+1 0 -1
L	provides shade	+1 0 -1
M	presents pleasant smells	+1 0 -1
N	presents pleasant sounds	+1 0 -1
O	does not contributed to global warming	+1 0 -1
P	contributes to the world economy	+1 0 -1
Q	accommodates recycling	+1 0 -1
R	accommodates multiple use	+1 0 -1
S	accommodates low maintenance	+1 0 -1
T	visually pleasing	+1 0 -1
	Total Score	

Table 2. Environmental Quality Index

Scores for each image tested, and the statistical findings of the data are reported in the Results chapter of this thesis.

Validity approaches

To ensure validity within the third stage of research several preventative actions will be taken. Sample populations will be selected to represent a normal distribution. Photographs taken from the existing site, and scenes created to represent the end product will both aim to show the full variety of landscape scenes found across site. Although a large sample collected and analyzed by multiple researchers would prove the most accurate method, time and resource limitations have prevented this. Photographs used will be standardized to some degree because they were taken on the same day, during the same time of day, with the same camera and settings, and by the same photographer. Scenes created have also been made to the same size and resolution, by the same designer, using the same computer programs.

Sampling size is limited by time constraints, to capture and test every possible view within the untreated and treated site would be nearly impossible. The results of this study could potentially be unrepresentative of the actual conditions occurring on site. Diversity in representation is therefore imperative. Additional experiments must be conducted to confirm any findings. Constant repetition of similar studies are required to maintain validity of any findings when applied to future locations.

Though time will pass during the course of this study, and external events could influence end results, it is unlikely to significantly affect the validity of this project. It is assumed that the information presented in the review of literature is the most current, and accurate, thus best for application within the design phase. Although developments in the researched fields are evolving constantly, this has not been considered by the author. Maturation is unlikely to be a threat in this study because no human or nonhuman participants will be studied. Only the maturation of the author/researcher could affect the results, but this cannot be avoided.

Accuracy in determining the visual quality score of each image poses the strongest threat to validity. This is due to error that may arise during the variable quantity/counting process, and also the actual input of values into the test equation. However, all evaluations were conducted using the same method, and by the author and therefore any error should be standardized. Use of a spreadsheet to record values, calculate partial sums, and the final score will also reduce threats to validity.

DESIGN

Introduction

The following narrative describes the design approach employed to address the problems facing River Rouge, MI. The chapter begins with fact-finding background research, then schematic master plan designs, and finishes with site details in the form of perspective scenes. Unless otherwise stated, all images were created by the author with the aid of Adobe Photoshop CS6 and Google Sketchup 8.

Assumptions

It has been assumed for the sake of this project that the industrial land currently occupied on site is free for redevelopment.

There is also no defined time-frame for the beginning or end of this project. Significant time and money would be required to transform much of the chosen site to a state suitable for development, however this phase of preparation is not outlined, therefore it is assumed to have been completed prior to installation of this master plan.

Inventory & Analysis

Site Selection:

The site selected for this project is River Rouge, Michigan. The site also happens to be located along one of the world’s largest freshwater coastal marshes, the Lake St. Clair and Lake Erie system. According to a published master plan developed by United States Steel (a current landowner of much of the study site) in 2010, much of this important ecosystem was destroyed by human settlements and agriculture via cut and fill, with the last fill taking place in the 1930s or 1940s (Nativescape 2010).

The Rouge River is the largest watershed in Southeastern Michigan, and makes this site an excellent location to study the effects of urban stormwater management techniques. The fact that this river connects to the Detroit River and Lake Erie strengthens the locations importance to ecology. Size was another determining factor of site selection. To accomplish successful restoration of a coastal wetland, significant land area is necessary. A large area is also necessary to implement the stormwater management techniques used in this study. This site is approximately 1,000 acres in size. The City of Detroit and its suburbs are in drastic need of revitalization projects to retain and attract residents, especially River Rouge. Projects of a similar nature have been occurring recently along the Detroit River, making this project ideal for creating habitat corridor linkages. Lastly, this location was chosen based upon its convenience for the researcher as the area is very familiar.

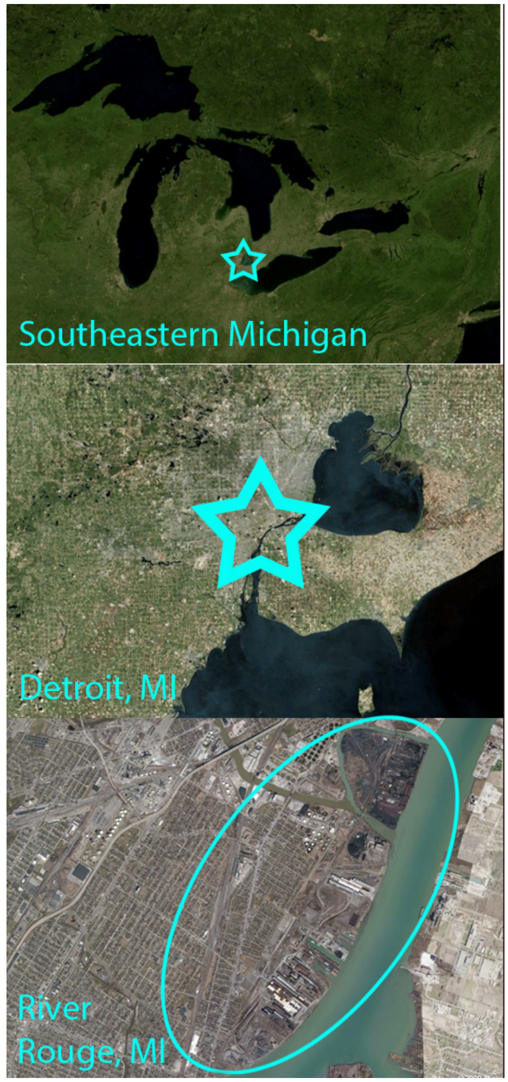

Figure 1. Selected site location. FlashEarth/Bing Maps/Microsoft Corporation. Annotations by Rory Hyde 2013.

For interpretation of the references to color in this and all other figures, the reader is referred to the electronic version of this thesis.

Figure 1 was taken from Flash Earth and shows the site location in relation to the state of Michigan, and also Metropolitan Detroit. Figure 2 is a plan view image of the entire site prior to treatment. The image was taken from Flash Earth on March 23, 2013 and therefore represents site conditions existing at that date with the assumption that nothing has changed since the time the photographs were taken and the access date.

Figure 2. Selected site of River Rouge, MI along Detroit River. FlashEarth/Bing Maps/Microsoft Corporation.

Inventory:

Prior to human settlement the site was located within a coastal wetland, specifically a shrub swamp/emergent marsh (shown in Figure 3) ecosystems adjacent to the site were an Oak-Hickory Forest (light pink) and a Beech-Sugar Maple Forest (dull pink)(Albert 2008). These ecosystems will be important to understanding how to restore an indigenous landscape on site. The majority of plant species used within the new development will be taken from plant lists from one of these ecosystems assuming actual implementation of this project, however none have been specified in this thesis.

Currently the site is located entirely within active industrial land uses. Adjacent to the site are the cities of River Rouge and Ecorse, mostly composed of single family residential parcels with scattered commercial enterprises and a main commercial corridor along W. Jefferson Avenue. Many studies have been conducted targeting specific corporations located here for their environmental and human health concerns(Hawk 2012).

The current city layout does not agree with many of the founding principles of sustainable urban design practices (Beatley 2000). For example, there is little variety in housing stock, poor accessibility to commercial districts and park/recreational space, and development is auto-oriented opposed to

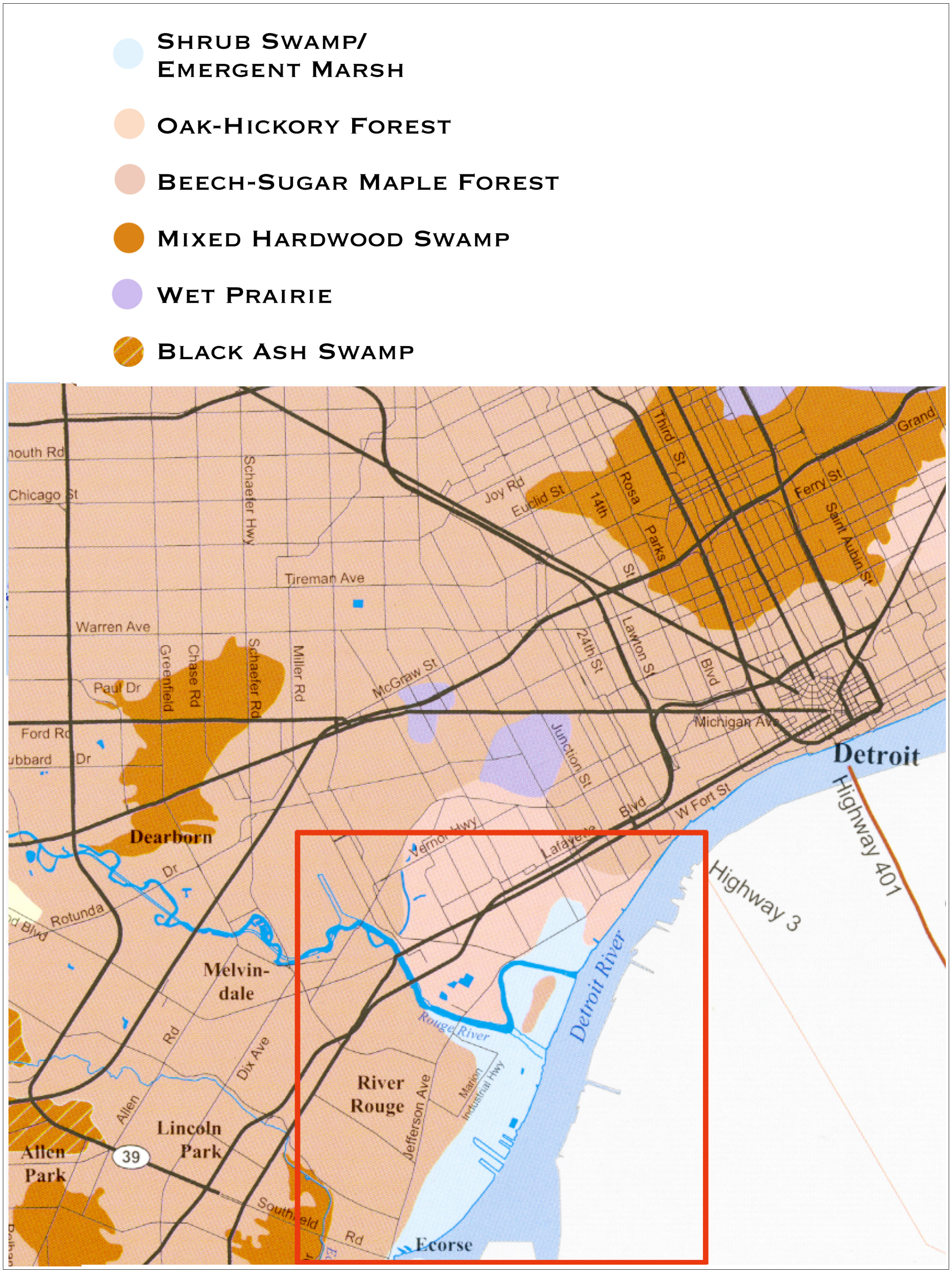

Figure 3. Prior Landcover on site, circa 19th century. Scale not given. Albert 2008.

people-oriented.

Topography on site is rather flat, as the natural flood-plain has been filled to allow for development.

There has been a decline in population and housing occupation within the city over recent years. Between the 2000 and 2010 census there was a 20.3 percent decrease in population. Also, the 2010 census found that only 77.6% of houses were occupied (U.S. Census Bureau).

Design Inspiration

Shanghai's Houtan Park:

This park design was chosen as a model for several key elements of the River Rouge site. Houtan Park uses artificial wetland terraces to clean 634,000 gallons of water daily.

Specific features include:

16-100 ft. wide

1 mile long

650 ft. waterfall

850 ft. to trap heavy metals

820 ft. for nutrient removal

820 ft. cascades for aeration

980 ft. sand filtration

18 ft. grade change

[Turenscape 2007]

Concept

To guide the forms and design decisions of this development on overarching concept has been selected, Patterns in Nature: Fractal Geometry and Fluid Evolution. Nestled shapes and the gradual growth of forms from simple toward complex is the driving force of this design. Connections to nature will foster the evolution of this urban community from human-centered into a sustainable habitat.

Fractal geometry, as mentioned before, is found in the principles of Biophilia. Fractal geometry has potential to cater to mankind's in-born affinity toward patterns found in nature. Nestling shapes and evolving patterns of forms add coherent complexity to the environment. This bio-mimicry will aid in the integration of man-made and natural elements within the landscape. Simple rules will be applied to the division of spaces and decoration of elements.

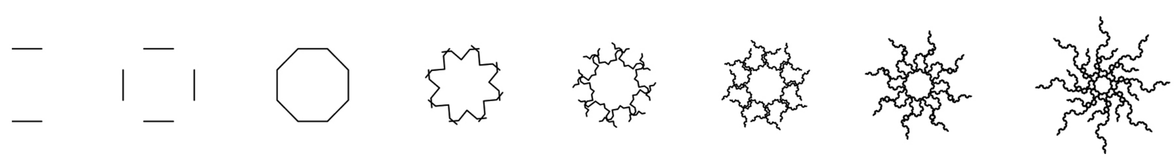

Figure 4. Generation of a fractal snowflake. Rory Hyde 2013.

Program

A project of this magnitude would require an extensive program. Therefore the scope of this work was kept at a rather conceptual and schematic level. The program elements for the River Rouge site include:

Restore natural qualities to riverfront regions

Create artificial wetlands both diked and open to river

Develop terraced treatment channels

Designate ares for multiple settling tanks and ponds

Orient building stock to maximize passive and active solar use

Orient building stock to maximize exposure to views of natural areas

Develop a river-adjacent mixed use corridor

Develop marshes for freshwater fish hatchery

Provide areas for public scenic outlooks

Develop non-motorized trails across site

Designate an area for Great Blue Heron Rookery

Utilize Fractal-like patterns throughout the design, at various scales

Functional Relationships

Before program elements were placed on site a study of functional relationships was conducted. It was important to generate model for the ideal way to organize necessary elements. Figure 5 shows relationships between the proposed developments, stormwater treatment stages, and proposed wetlands. This model was used to assist decision-making as the design transformed from ideal, to site-specific.

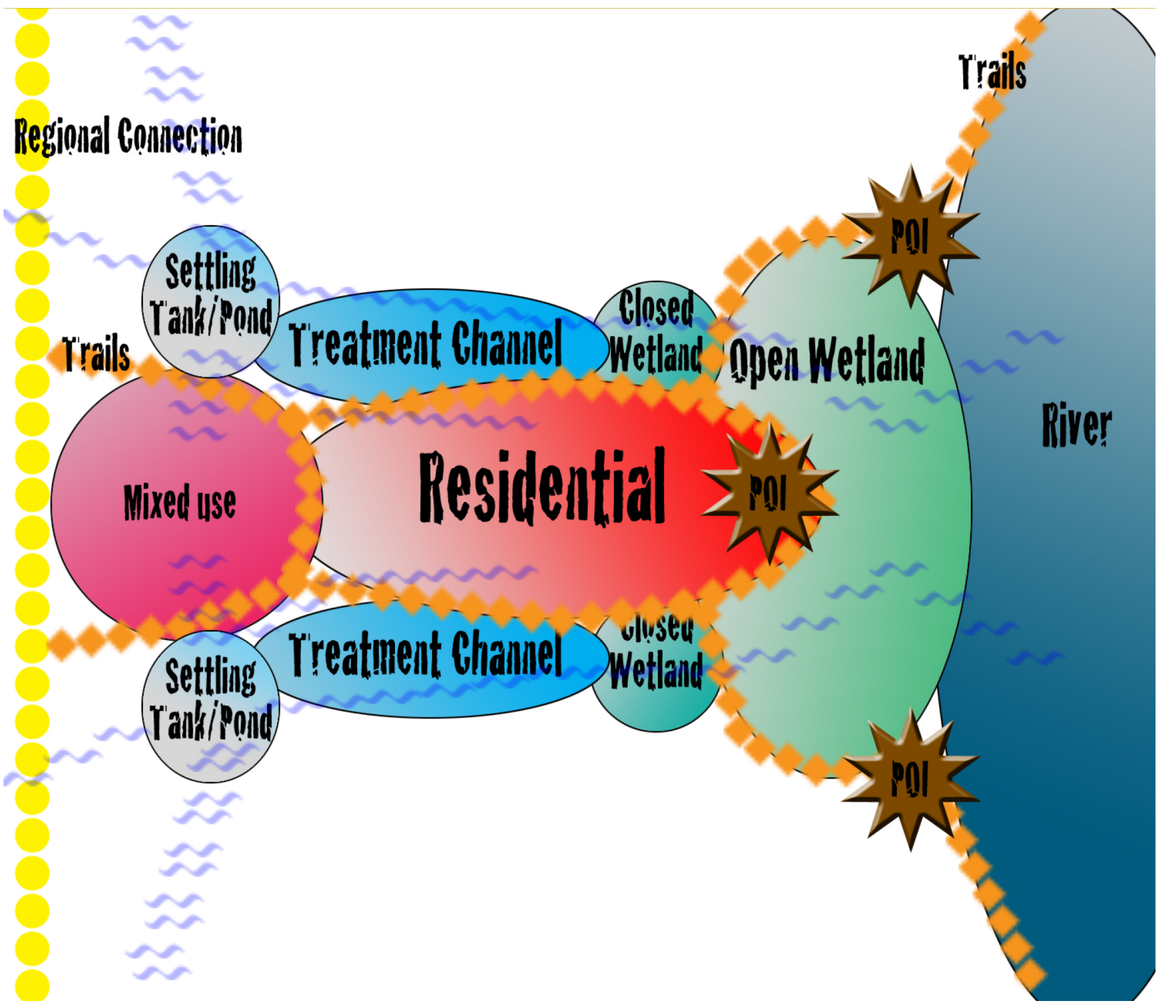

Figure 5. Schematic Functional Use Diagram. Rory Hyde 2013.

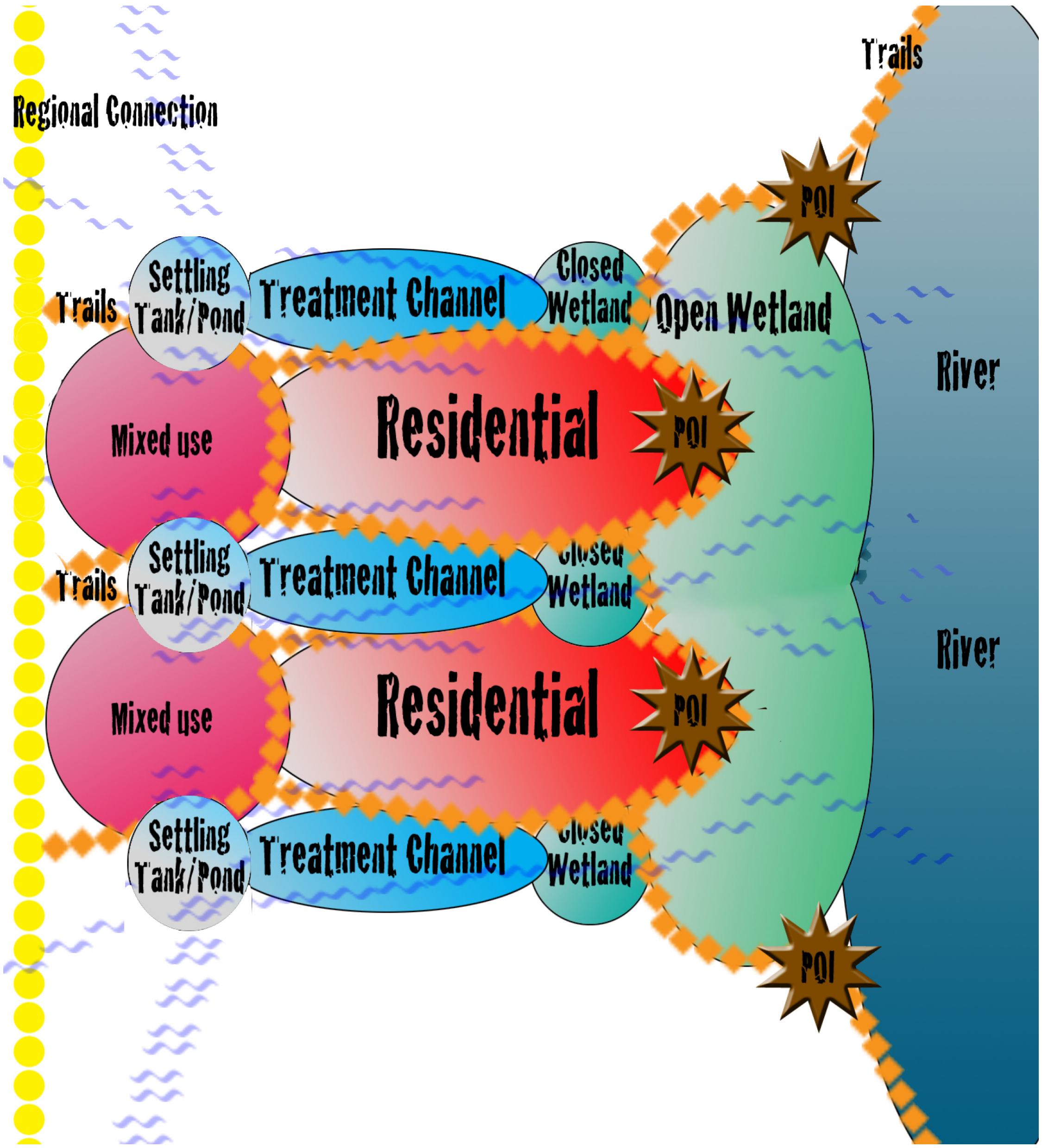

Figure 6. Schematic Functional Use Diagram #2. Rory Hyde 2013.

To further evolve the schematic functional use of the new elements on site, Figure 6 was made. Here the ideal building blocks were stacked to develop a rudimentary neighborhood pattern. However, the result at this stage was still too linear, and not natural. To meet the requirements of Biophilic design, the coastline must integrate with residential areas, protect wetlands, and incorporate fractal forms.

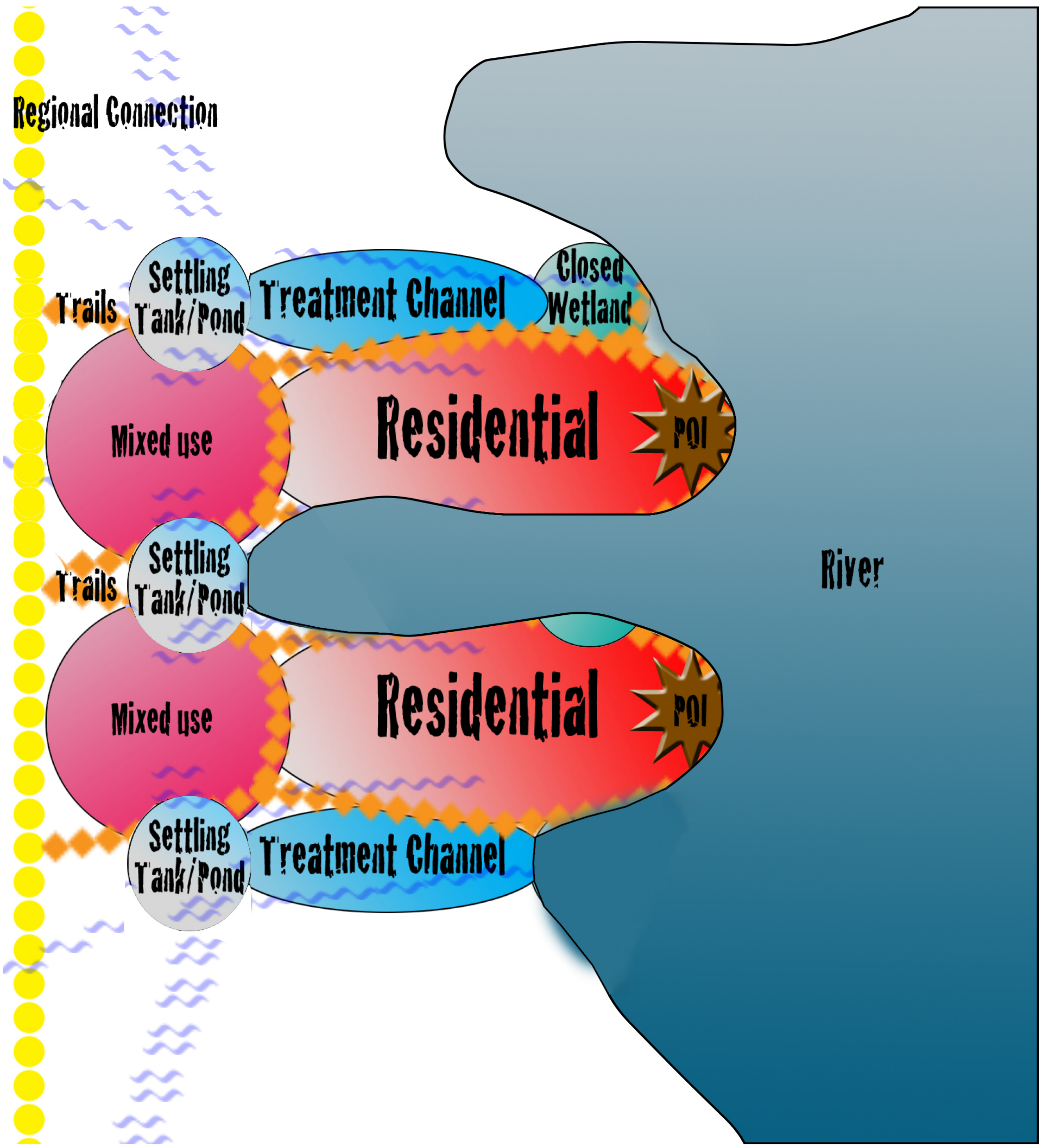

Figure 7. Schematic Functional Use Diagram #3. Rory Hyde 2013.

To address this issue, Figure 7 was created. This image represents a rough schematic of how to better integrate the human and non-human interfaces, maximize residential exposure to wetlands, all the while protecting them from river currents and traffic.

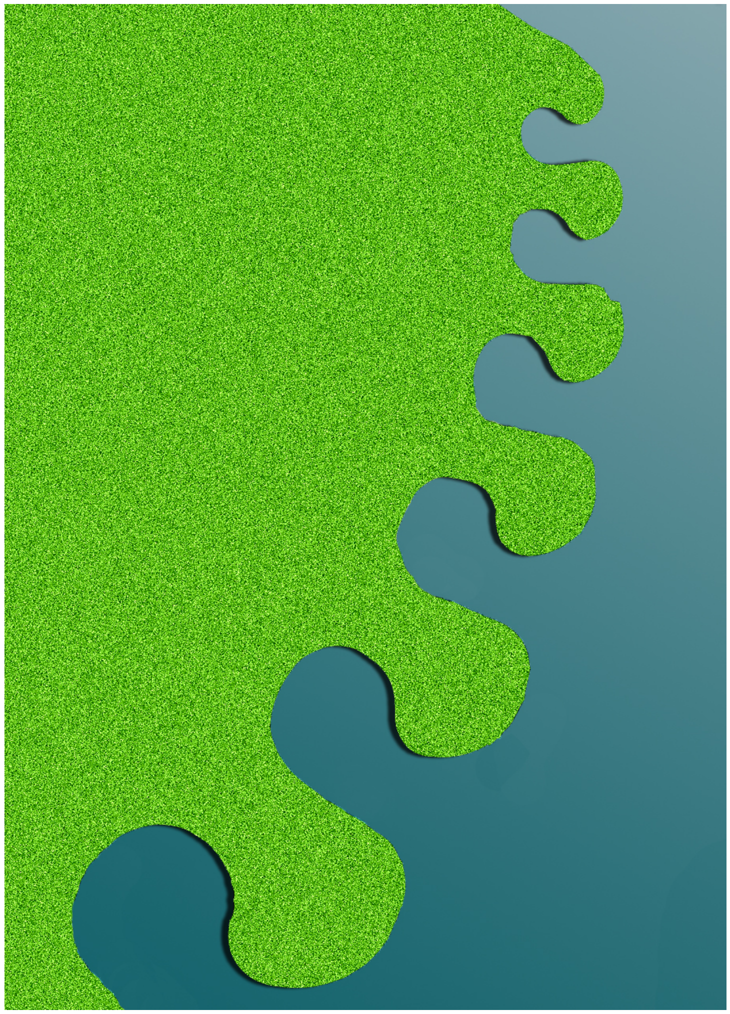

Figure 8. Schematic Fractal Coastline. Rory Hyde 2013.

Finally, a plan view, site-specific schematic of the proposed coastline was drawn, shown by Figure 8. A basic shape was applied to the current coastline and repeated with augmentation. This figure, in conjunction with the previous schematics, formed the basis for the final master plan.

Master Plan

Figure 9 shows the final master plan for the River Rouge site. At this Landscape Scale, it is important to notice how the original coastline was transformed to create a repetitive, and evolving series of inlets. This fractal coastline was essential in restoring the wetlands that once existed on site, and protecting them from rough river conditions(as recommended by Mitsch 1994). The decision to shape the coast in this manner also remedies part of the problem of the post-industrial soil. By removing large quantities from the existing earth, contaminants can be prevented from causing further harm to residents and the ecosystem.

The new housing blocks were developed within the peninsulas created near the coastline to maximize human exposure to the indigenous landscape character. These blocks are oriented in an east-west manner to take advantage of passive solar effects. The northern portion of the site has been devoted to an alternative, green energy, bio-fuel facility(C in figure 9), to supply the surrounding area with an ecologically sensitive replacement for the current power options. Specific considerations for this facility will not be given, but would feature high-yield crops such as flax, safflower, sunflower, wheat, hemp (pending legalization) and algae. This facility also has potential for wind power generation within crop fields. At the southern end of the site is a large coastal wetland preservation (G in Figure 9), designed to remain undeveloped to engender establishment of a complete ecosystem with highly-fluctuating water levels. In contrast to current condition, there is no longer an industrial presence on site in its place is new river-adjacent green zone.

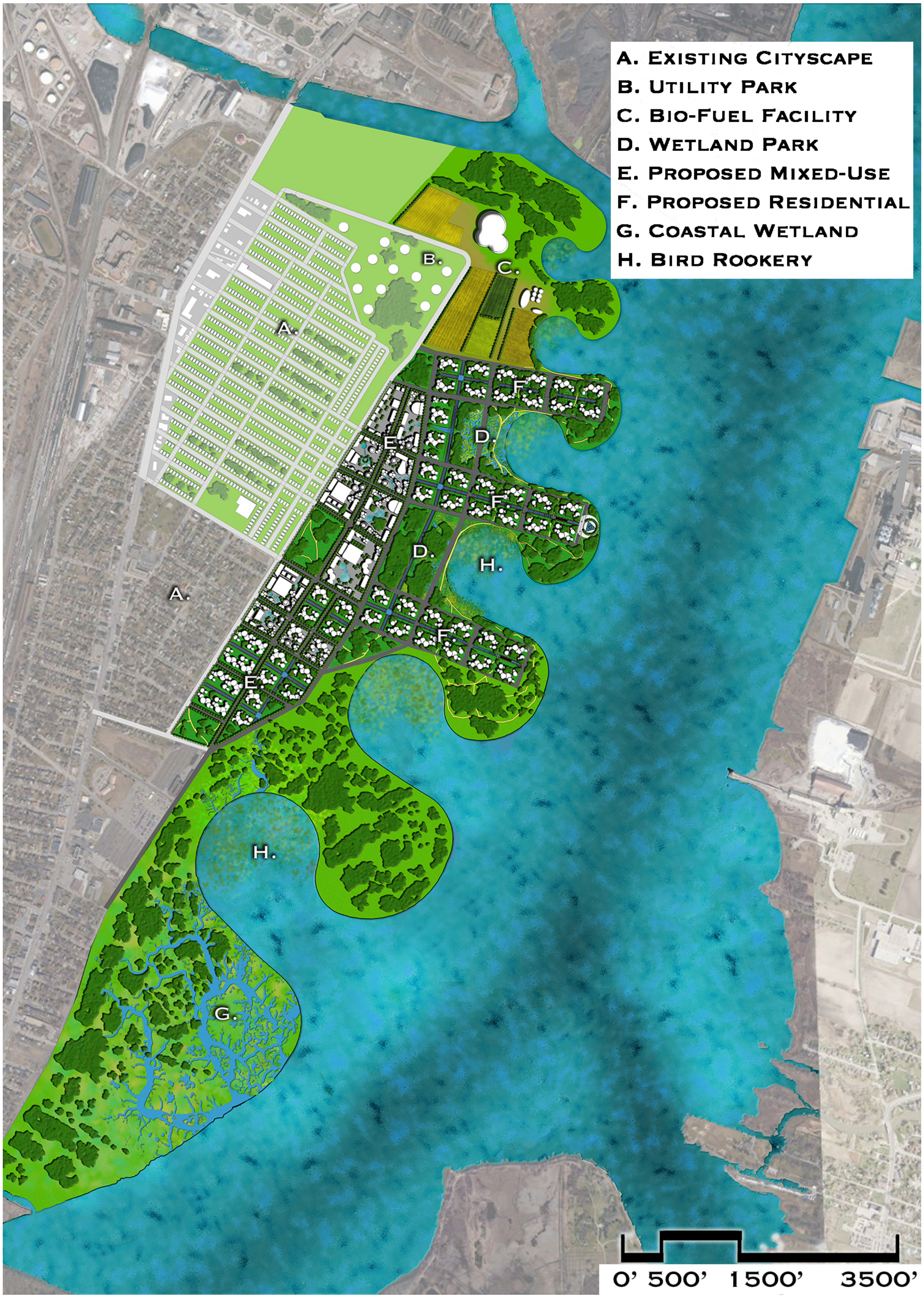

Figure 9. Proposed Master Plan, Landscape Scale. Rory Hyde 2013.

Building Use:

Figure 10 illustrates the existing and proposed uses within the final design. Decisions for this arrangement was a synthesis of recommendations from New Urbanism, Green Urbanism, Sustainable and Biophilic Design. Proposed residential uses (purple) were kept along the river. Pure commercial buildings (red) have been located on the western edge of the site. A mixed-use corridor was developed in the space between(blue-green). This gradient serves to transition the existing neighborhood into the new. Building forms also follow this gradient, transitioning from rectilinear on the western edge, into circular/organic nestled forms (also see later 3D figures). Residential buildings shall easily meet a minimum of 7 dwelling-units per acre (if not more), as prescribed by Berke et al. 2003. Core parking structures (yellow), as well as on-street parking will service the proposed mixed-use and commercial areas, instead of traditional surface lots.

Figure 10. Proposed building use. Rory Hyde 2013.

Local Connections:

River Rouge already has great potential for connectivity. W. Jefferson Avenue and the Fisher Freeway connect the city with Downtown Detroit and other communities downriver. Coolidge Highway leads west toward Dearborn. This design caters to this connectivity by creating access points along the existing grid (as shown by the red arrows in Figure 11). Rail lines (grey dotted line) also exist in this area, and with redevelopment River

Rouge could become an excellent location for transit-oriented-design. With the aid of light-rail, efficient bus routes, car-shares, and bike-shares, River Rouge could take advantage of the local connections and attract a significant population increase. This design will also serve as a green corridor, connecting with the green spaces to the south (delineated by the green arrow).

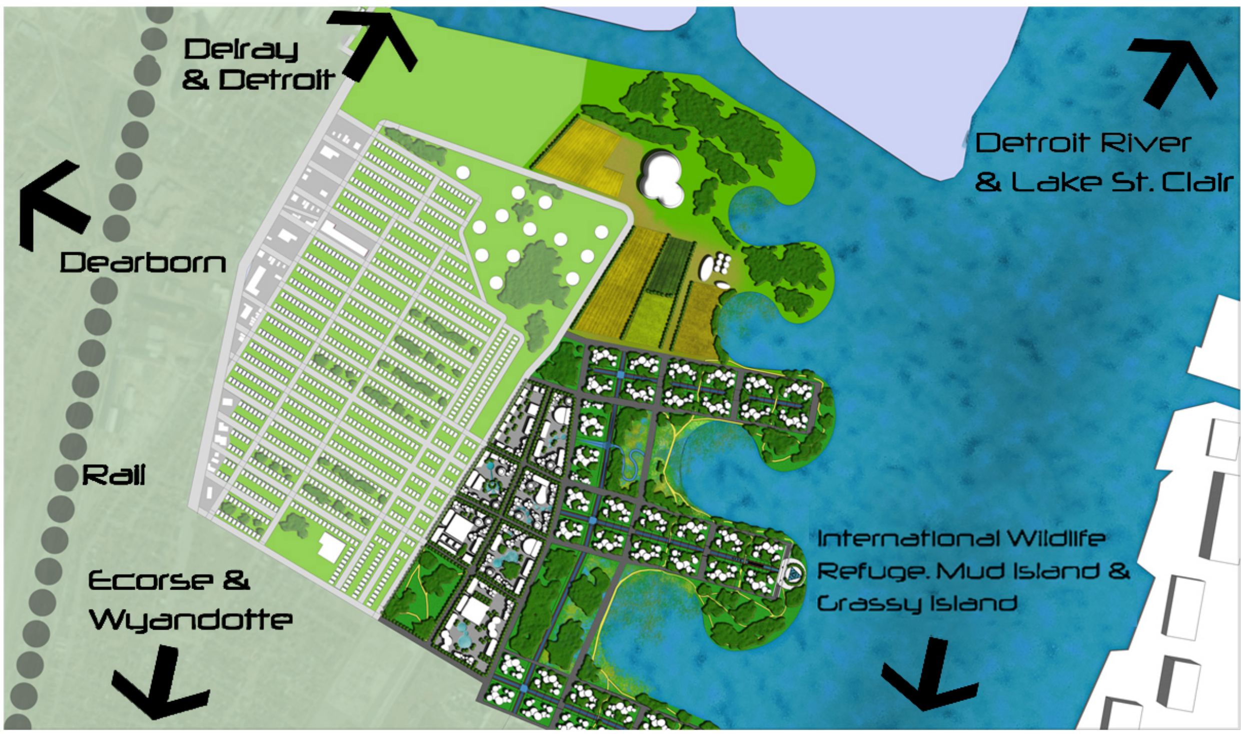

Figure 11. Proposed neighborhood connectivity. Rory Hyde 2013.

Hydrology:

Significant earthwork is required to execute the goals of this project. Existing land must be removed to create the river inlets. Earth from this procedure will be used to raise the peninsulas above grade. A slight incline will slowly direct stormwater from the peninsulas toward the mainland through terraced filtration channels. As the water travels it will be treated before its release into the wetlands and the river. Stormwater from the existing city infrastructure, the proposed development, and land upstream will also be directed through filtration channels and into the wetlands.

In periods of low-rain, water from the either of the rivers could be taken up and used to fill the treatment channels which are intended to serve both functional and aesthetic purposes. Filtration channels are depicted in a linear fashion in Hydrology Schematic (Figure 12), however developing the network into a series of meandering streams could be a potential design alternative(see *Civil Engineering*'s article Anonymous. 1999). This consideration would enhance the design’s Biophilic properties as well as increase the time stormwater remains on site and thus can be treated. Pursuit of this concept would be vital to the project development phases, if this master plan were actualized.

Figure 12. Hydrology schematic. Rory Hyde 2013.

Neighborhood Scale Land Use:

Figure 13 takes a closer look at how land uses relate at the neighborhood level. Both the residential and mixed-use areas are bounded by green spaces of significant size. The mixed-use area contains vegetation of traditional urban nature, as seen by the tree-lined streets. While, the residential areas feature planting patterns designed to mimic natural processes.

The proposed road network seeks to reduce automobile use across site. Roads connect to the existing grid pattern, but the depicted linear fashion shown in the figures is not the only option. Streets with a slight meandering character could enhance the scenic quality of the new development, create a variety of spatial shapes, and also slow vehicular speeds. However, such a design must not decrease the walkable nature of any road network.

To maximize walkability, pedestrian orientation, and reduce run-off, greenways have been developed between housing blocks, and along the filtration channels. These highly vegetated paths are lined with trails paved with pervious materials. These greenways alienate block length/intersection distance problems without creating unnecessary paved roads. In most cases, distances between intersections within the new design range from 150-400ft, falling well below the limits described by Farr 2008. Non-motorized trails run throughout the site, connecting residential areas with the greenspaces (shown in yellow).(Berke et al. 2003)

The orange stars represent ideal locations to create wildlife viewing areas for non-residents. These would be in the form of traditional road-side pull-offs and a brief walk to a disguised/minimally-destructive observation areas, that aim to limit the human-centered appearance of the intended use. Non-motorized trails also link to these points of interest.

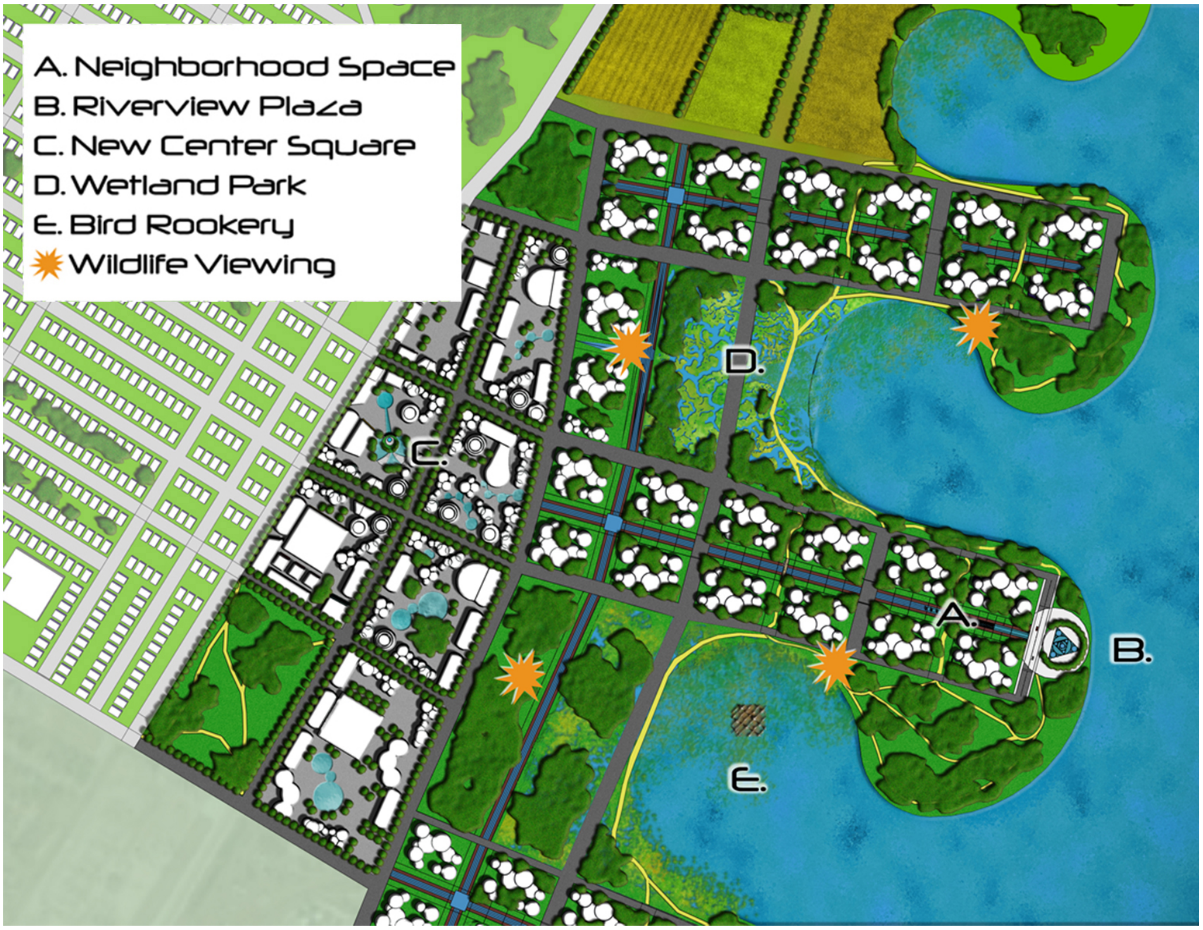

Figure 13. Neighborhood scale Proposed Land Use. Rory Hyde 2013.

Site Details

The following series of images depict three-dimensional views of the proposed site. Figure 14 is an image of an aerial view looking from the terminus of one of the residential peninsulas toward the mixed used area. It is important to notice how the orientation of the housing units maximizes southern exposure. To incorporate the Fractal concept at this scale, dwellings are self-similar in form, and stacked to allow for ample views of the surrounding environment. This decision also provides an interesting street frontage with a variety of spaces to incorporate plantings, gardens, courtyards and patios.

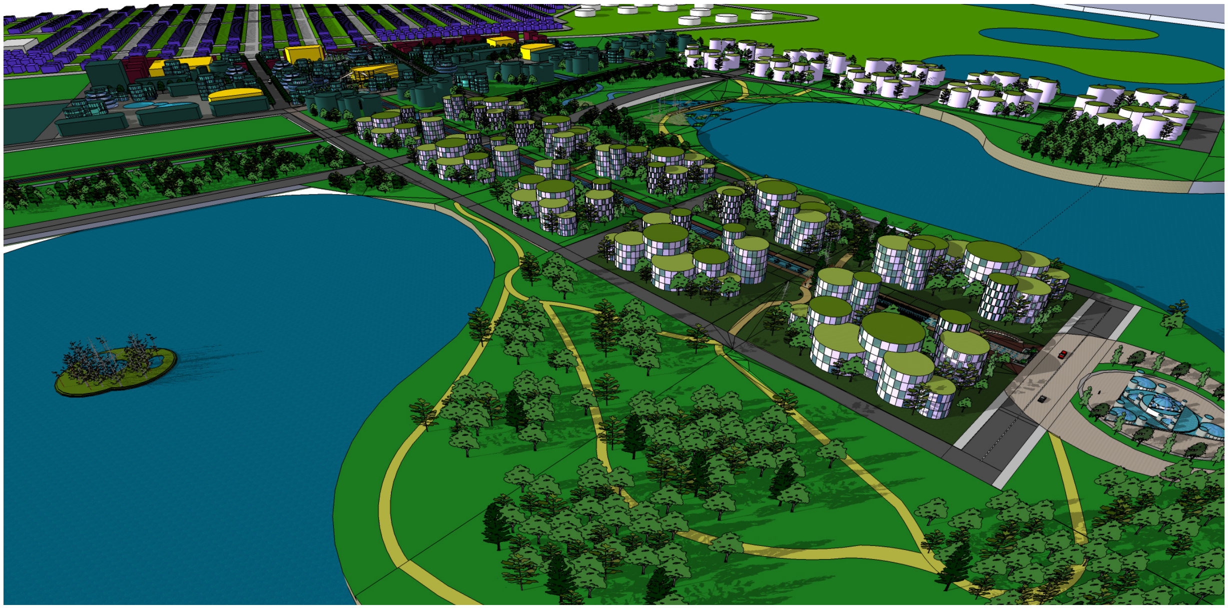

Figure 14. Aerial view of proposed residential peninsula. Rory Hyde 2013.

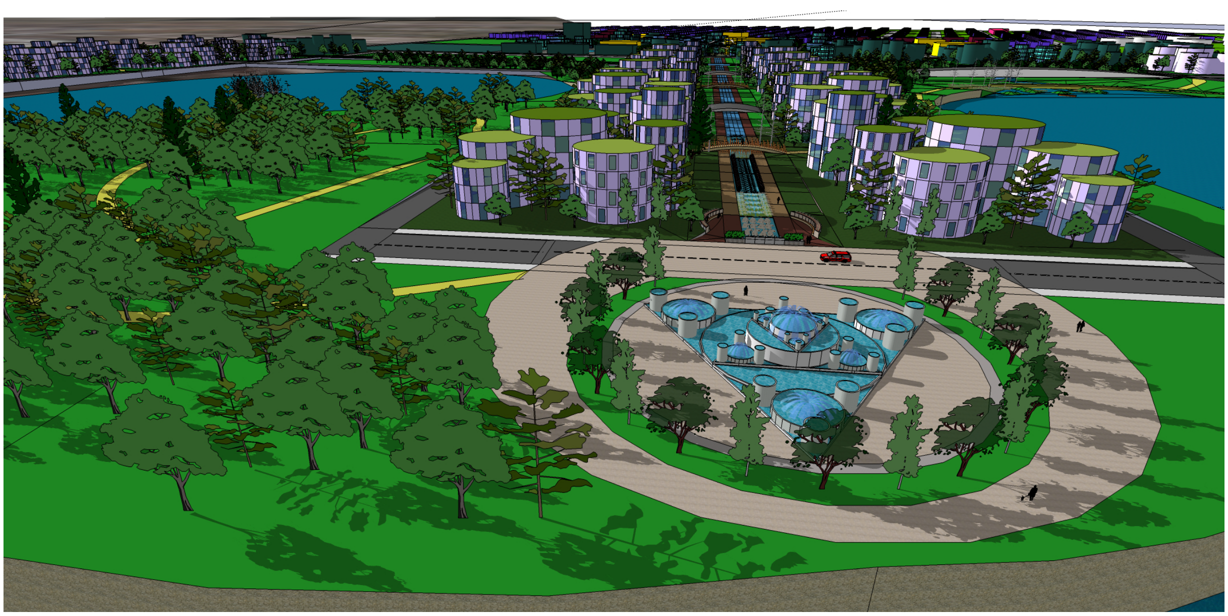

Figure 15. Aerial view of Riverview Plaza. Rory Hyde 2013.

A heavily forested park stands at the terminus of this feature, to provide residents with space for recreation and relaxation, while also creating habitat for upland species.

Both roads and the centralized filtration channel terminate at the large Riverview Plaza(Figure 15). This public space features a large fountain serving to emphasize the use of water on site, and is built using fractal designs. Residents and visitors alike may use the plaza for what its name implies: to gain perspective of the Detroit River and the new wetland environment created by this design.

A perspective of Riverview Plaza is shown in Figure 16. This perspective looks out from the filtration channel centered within the residential area. Sitting within or strolling between the residential blocks users will be exposed to the stormwater treatment process through a sequence of artificial wetlands. This image only shows a few of the treatment stages: settling (in tanks below ground), water cascades for aeration, and a wetland of plants selected to remove heavy-metals. The remainder of the stages, (as used in Houtan Park's design) exist further downstream.

Figure 16. Riverview Plaza perspective. Rory Hyde 2013.

Figure 17 depicts another perspective within the filtration channel. This image shows how the channel and adjacent non-motorized path continue throughout the residential blocks. Once again in the foreground the terrace for heavy-metal removal is shown, followed by the pathogen removal terraces. The mid-ground of this figure shows where the greenway connecting the perimeter roads transverses the channel. It is important to notice the spaces created adjacent to the channel. These semi-public areas provide opportunities to create spaces of partial enclosure ideal for picnic/BBQ areas, community gardens, or even small playgrounds.

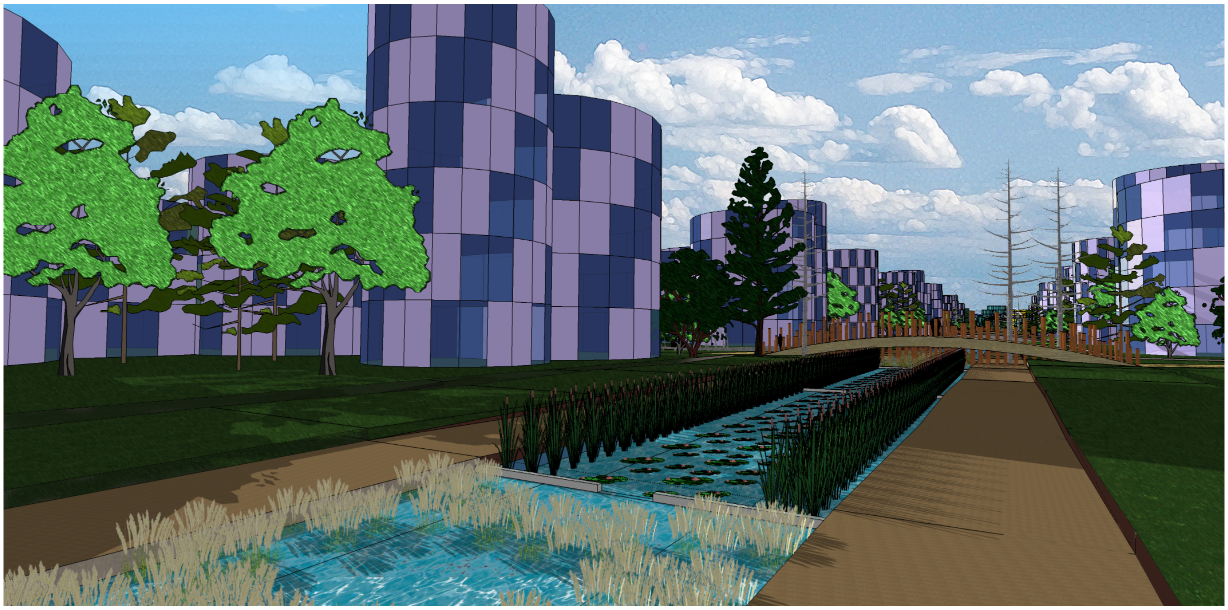

Figure 17. Residential interior treatment channel. Rory Hyde 2013.

Figure 18 is a perspective of the treatment channel again, this time shown looking out from a window of one of the residential towers. Residents taking in this view may will enjoy watching wildlife and passersby within the shady, vegetated corridor. The design shown here is reminiscent of the canals of European cities, such as Amsterdam. However, scale has been slightly modified: building heights average 45-60ft while right of way is ~130ft, creating a 1:2 ratio, while the canals of Amsterdam are closer to 1:4(estimated with Google Earth). Once again, the spaces along the treatment channel provide opportunities to be further designed, thus increasing the appeal of the residential views.

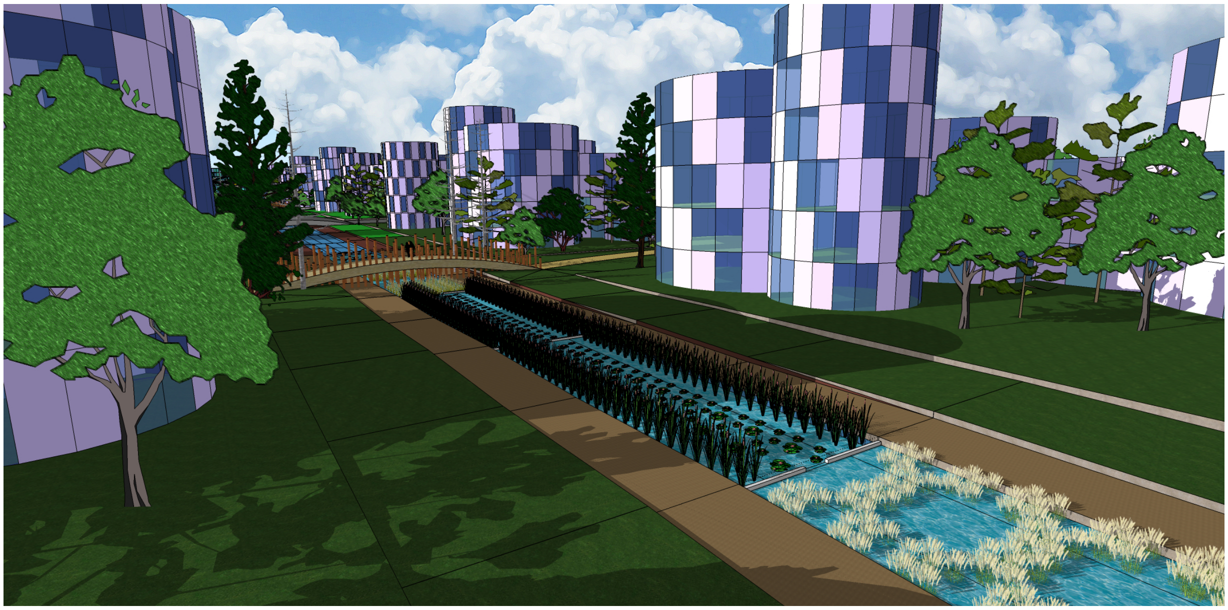

Figure 18. Residential interior treatment channel seen from apartment window. Rory Hyde 2013.

The perspective shown by Figure 19 is of the greenway that cuts across the treatment channel to connect the perimeter roads. Here non-motorized transit may cross the cross the channel. This feature is essential to maintain the walkability/connectivity of the neighborhood. The bridge shown in the figure is intended to resemble the forms of tree-trunks within an inundated marsh and is to be constructed with reclaimed logs of various sizes. This decision seeks to emphasize the natural quality of the greenway through bio-mimicry.

Figure 19. Greenway traversing residential blocks. Rory Hyde 2013.

Figure 20 illustrates a perspective looking out from a residential unit window toward one of the wetland inlets found between the residential peninsulas. The foreground of the image exhibits the rooftop of one of the shorter towers. Greenroofs have been installed on all residential towers to assist in stormwater management, energy savings, roof protection, and aesthetic appeal/biophilic response (Dietz 2007, Kellert et al. 2008). These spaces have opportunity to be designed as intensive or extensive greenroofs and thus could allow resident use for small gardens, patios, and viewing platforms.

The mid-ground of the figure shows how residents would be looking out over a canopy of trees lining their street. These trees will be planted based upon fractal patterns, or natural growth models instead of arbitrary geometric constraints.

The background of this figure shows the distant mixed-use area (blue-green buildings) and also the public wetland park.

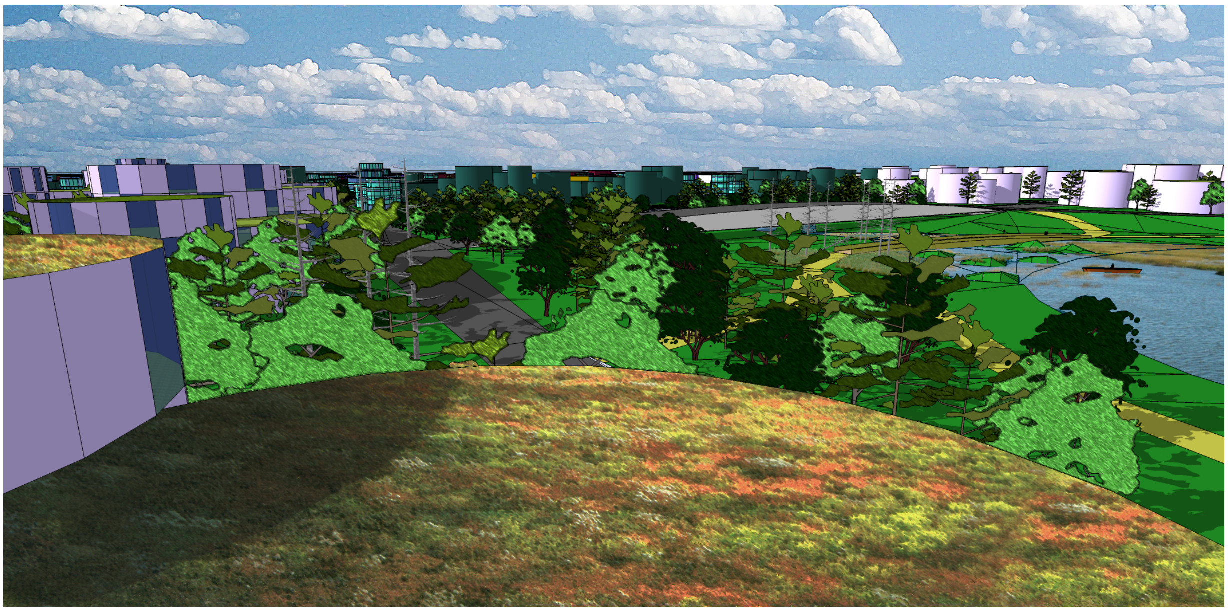

Figure 20. Exterior view of residential peninsula from apartment window. Rory Hyde 2013.

Figure 21 shows an aerial view of the mixed-use corridor. A variety of building forms have been utilized. Those nearest the existing neighborhood are traditional in form, while those nearest the new neighborhoods will be designed with Biophilia and Fractals in mind. Parking in this area is either on-street or within core parking structures (shown in yellow), (not sur- face lots) allowing for maximized building frontage, as well as internal space for pedestrian plazas, stormwater treatment pools and greenspaces. A linear pattern was used for this part of the design, however trees could be planted with a slight meander to add appeal and variety to the streetscape. Plantings are intended to be more humanistic and structured than residential and natural areas.

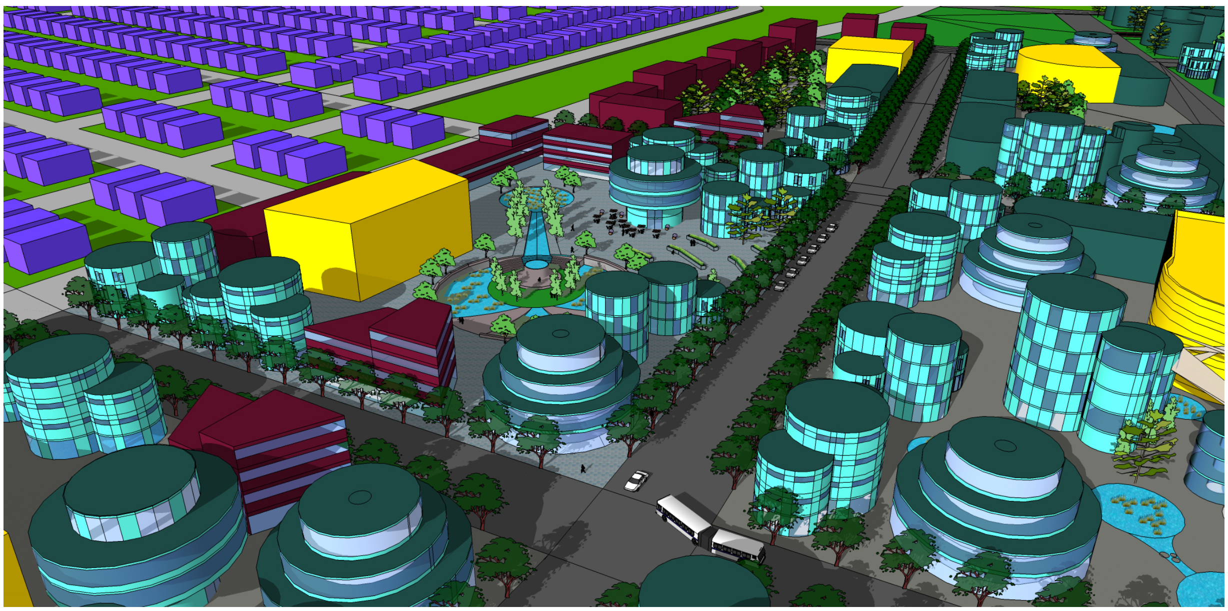

Figure 21. Aerial view of proposed Mixed-Use corridor. Rory Hyde 2013.

Figure 22 portrays an eye-level perspective example of a streetscape found within the mixed-use corridor. At this intersection the self-similar forms of the buildings can be seen. Facades of these buildings are designed to maximize visibility of building contents, especially on the ground level. The high density of street trees creates a shaded pedestrian corridor.

Streets are wide enough to allow two lanes of traffic and on-street parking, but not affect the ideal minimum building-height: street width ratio (1:3). The streetscape would benefit from further design to include vegetated tree lawns, rain gardens, lighting, signage, and other amenities, but has not been developed in this project.

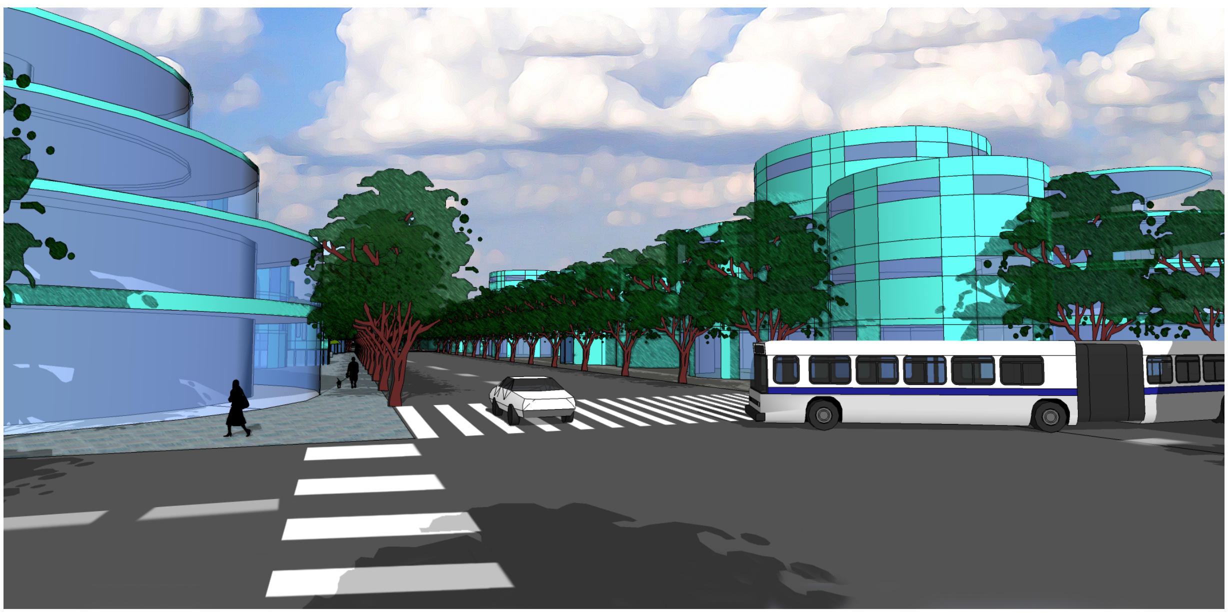

Figure 22. Streetscape of proposed Mixed-Use area. Rory Hyde 2013.

Figure 23 depicts how one of the interior spaces within a mixed use block could be designed. New Center Square will serve the community's many need. Visitors will have a place to gather, preform, socialize, relax and dine. All the while they will be experiencing sustainable stormwater management techniques, and also aesthetic plantings of vegetation that echo back to the area's indigenous landscape. Water collected in these pools comes from the surrounding paved surfaces, and also from intercepted storm sewers on and off site. These pools form a network across the mixed-used areas aimed at capturing 100% for urban stormwater, and then directing it toward the filtration channels before entering adjacent wetlands and the Detroit River proper.

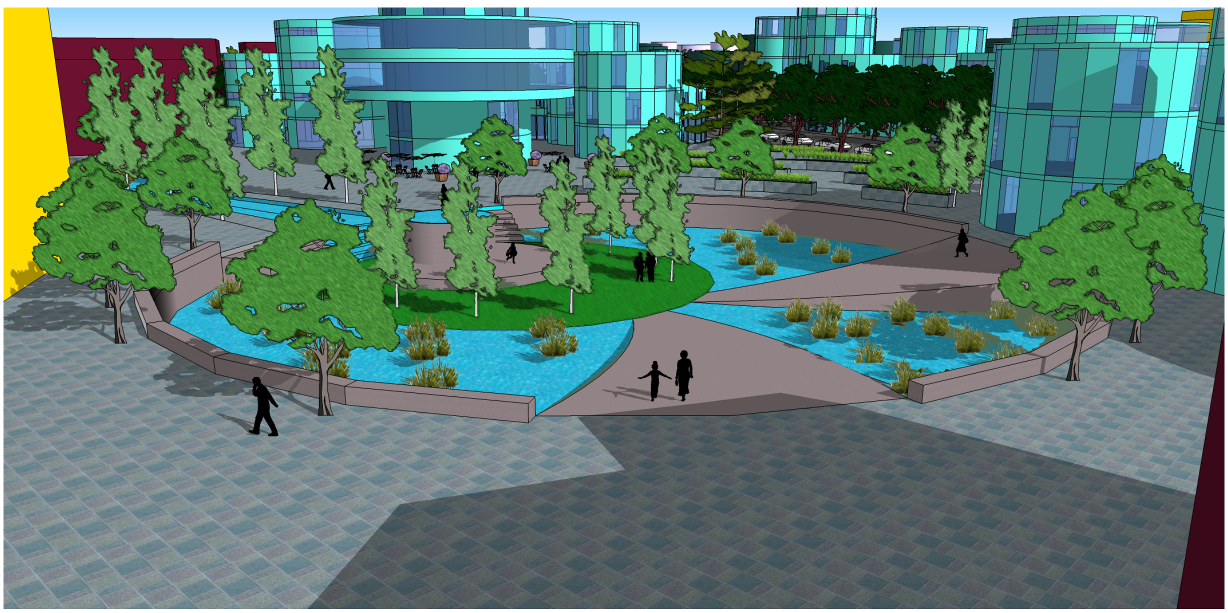

Figure 23. New Center Square. Rory Hyde 2013.

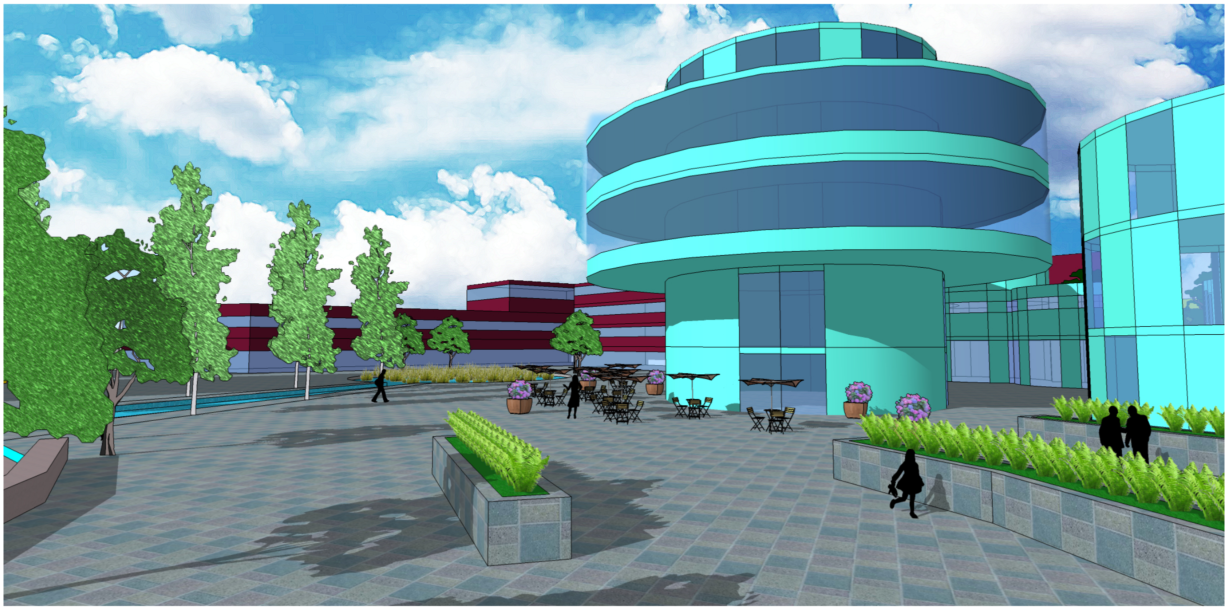

Figure 24. New Center Square cafe perspective. Rory Hyde 2013.

Figure 24 portrays another view of New Center Square, featuring a small cafe located beneath the awning of a mixed-use building. Raised planting beds are used to further divide space between buildings, facilitate movement across site, and provide for easy maintenance.

Close to New Center Square is another block interior demonstrating the character of this new mixed-use development, shown by Figure 25. Here an indoor-outdoor space has been created using tensile fabric overhangs between buildings. This feature creates a shaded corridor between buildings, but also allows for the use of vegetation. Such design will encourage pedestrian traffic into and through the block interiors.

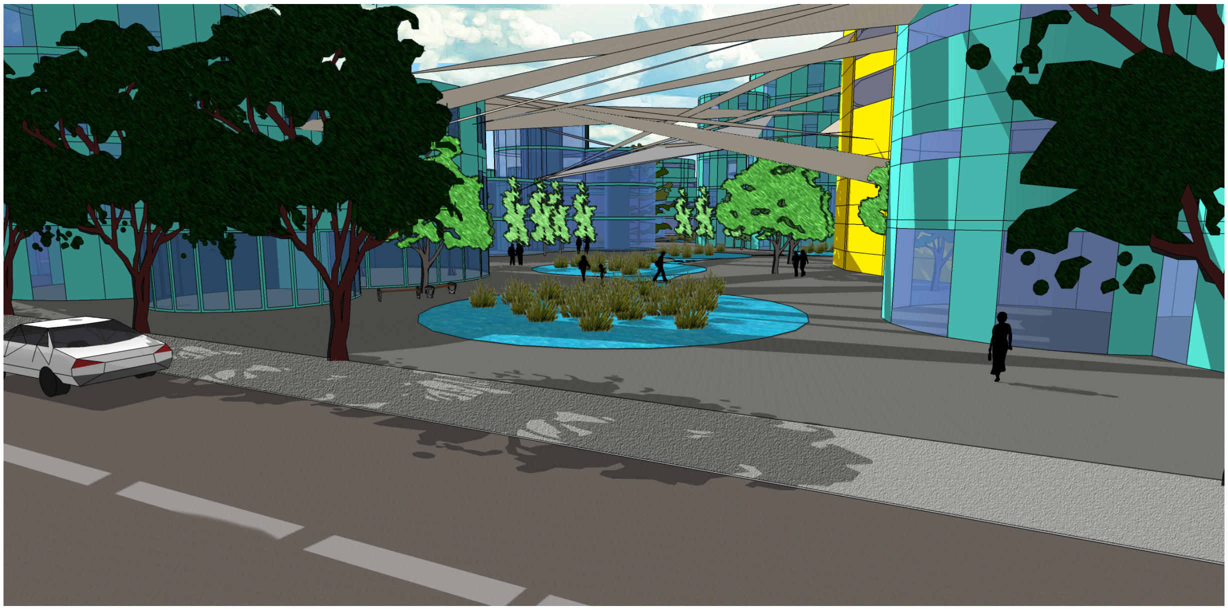

Figure 25. Alleyway with fabric canopy. Rory Hyde 2013.

An interior perspective of this covered corridor is displayed in Figure 26. The design concept for this area is an idealized Savannah oasis. Shallow circular pools fill the space with aquatic plants and white noise while detaining stormwater. Trees have been scattered across the site to divide up the spaces and cater to the biophilic response of users. This manicured space allows for all-weather use by retail shoppers, office employees, and other daily visitors.

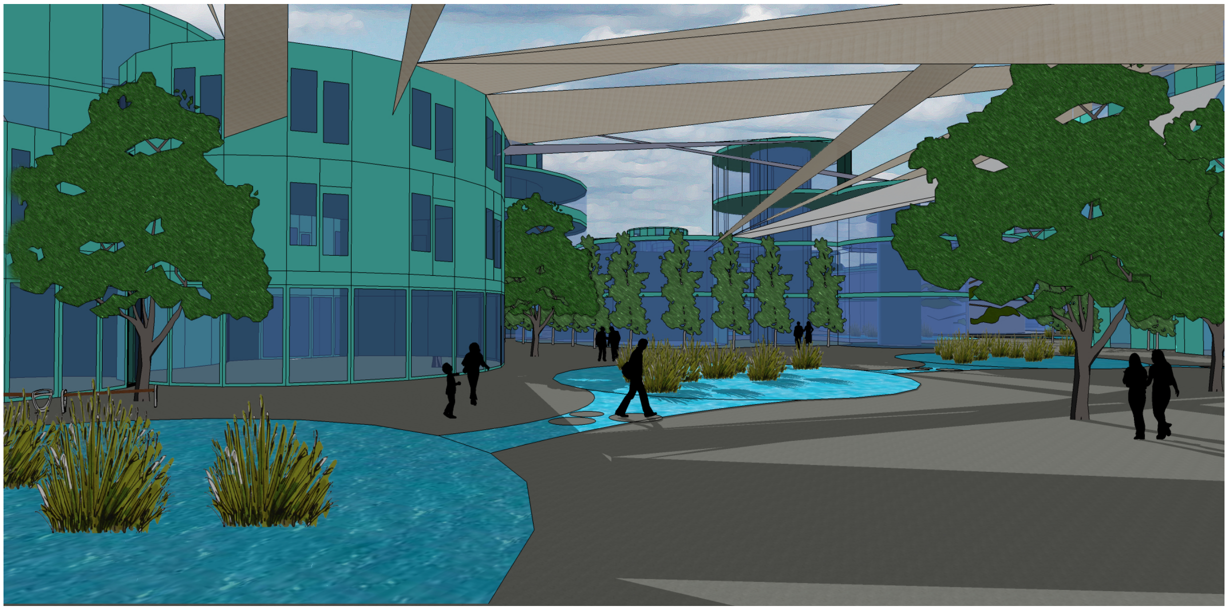

Figure 26. Interior view of covered alleyway. Rory Hyde 2013.

Figure 27 is a perspective of this site's primary wetland park located between the residential peninsulas, and adjacent to the mixed-use corridor. Trails coming from other locations will connect users with this restored indigenous landscape and allow for passive recreational uses. This park is where all stormwater collected by the various filtration channels is emptied before being released directly into the river. The flow of water is controlled to create an emergent marsh with many islands of vegetation bisected by meandering fractal-like streams. This particular image shows how a trail can span one of the streams atop a levy to allow for controlled release of water. Here design potential exists to allow for fish hatcheries, but is not explicit in this project.

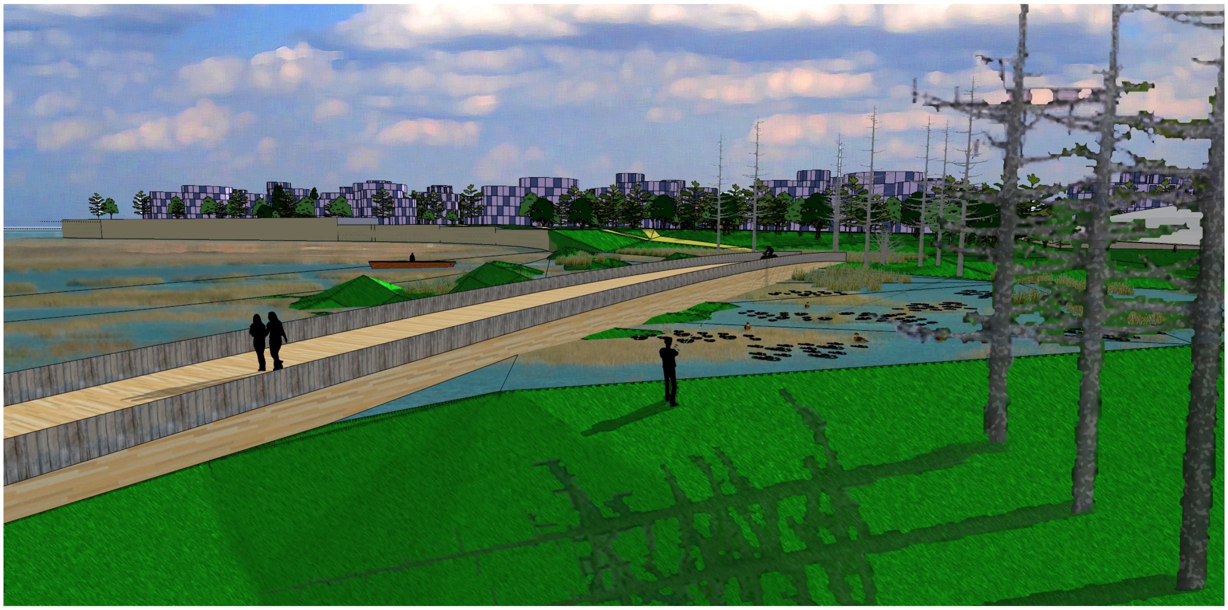

Figure 27. Wetland Park. Rory Hyde 2013.

Another example of large-scale recreational land use found within this design is that of the Utility Park (Figure 28). Centrally located on the North end of the site, this park stands where large petroleum storage tanks are currently held. However, the new design has transformed these structures into skeletons of their former selves, with the intent to allow for landscape art installation. A portion of the site's prior character re-mains within this design, but now serves a different purpose. The white walls of the tanks have been transformed into murals and/or blank canvases for graffiti-style art, while the insides have been refitted to house sculptures and other art forms that would not fair as well in the park grounds. Inspiration for this design came from actual murals and children's cartoon characters that were found on the neighborhood-facing side of the concrete walls enclosing the existing site. Instead of a foreboding, private parcel, this park now invites residents and guests to play, wander, and investigate an outdoor art-gallery housed in-side a recreated upland forest. It is essential to note that the green terrain shown in these figures does not always represent turf-grass, but groundcover vegetation in general.

Figure 28. Utility Park. Rory Hyde 2013.

The final image of this series depicts one of the bird rookeries proposed (Figure 29). This feature is located within the larger of the created river inlets to provide space that buffers sensitive species from human disturbance. Construction of the rookery consists of reclaimed trees and nesting platforms fixed within a raised island. The rookery is essential to providing space to house a full spectrum of species and aid in development of a complete food-web for the coastal wetland eco-system. This feature will also create an interesting wildlife viewing opportunity for residents and visitors.

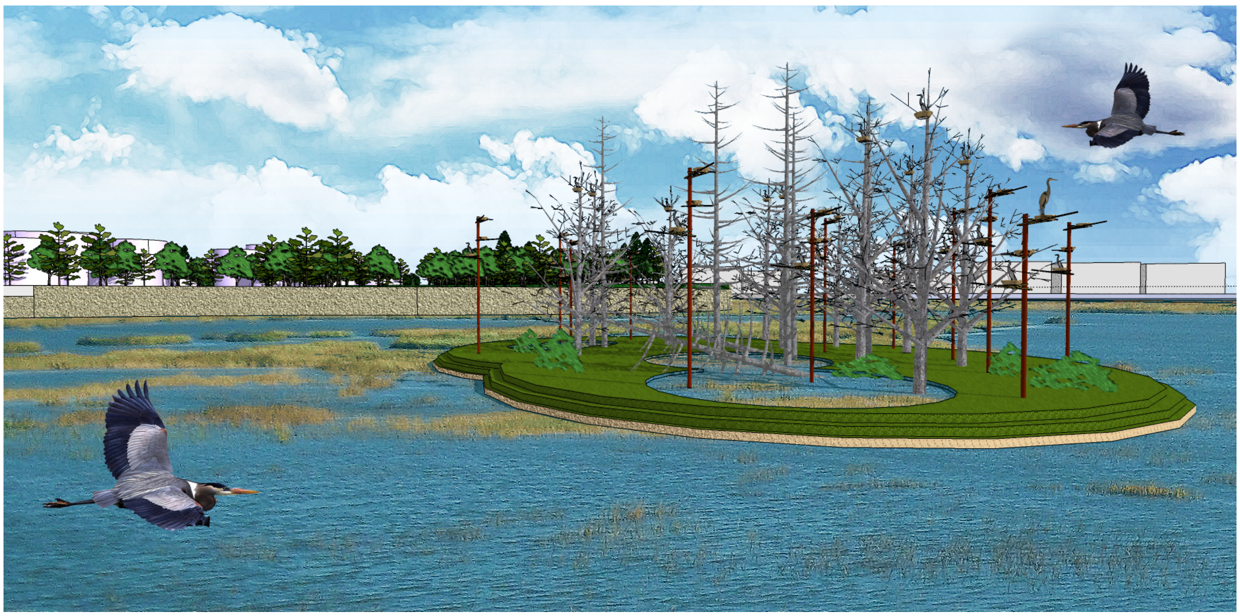

Figure 29. Proposed bird rookery. Rory Hyde 2013.

Reflection/Summary

While maintaining a focus on ecological restoration and stormwater management, sustainable urban revitalization of River Rouge, MI was possible. In place of a hazardous and unattractive industrial complex, proposed is an appealing riverfront community framed by a new landscape founded on fostering man's inborn affinity toward nature.

The proposed plan managed to address all of the initial program elements. The natural quality of the riverfront parcels were restored using indigenous vegetation within a non-linear formation. Closed artificial wetlands were created in close proximity to residential and mixed use areas (e.g. Wetland Park), and have the potential to serve as essential fish hatcheries/habitats. Wetlands open to river were also devised within the river inlets. Terraced treatment channels were developed within residential and mixed-use corridors to manage stormwater on site, with settling tanks below ground, and many surface ponds of aesthetic and functional nature. The building stock on site was oriented to maximize passive and active solar use as also maximize exposure to views of natural areas. The river-adjacent mixed use corridor will encourage public interest of the restored landscape character, and also provide opportunities for economic resurgence. Non-motorized trails and public scenic outlooks have also been established across site to allow for low-impact interaction with the wetland ecosystem. The largest two river inlets afforded the installation of Great Blue Heron Rookeries, essential to the food-chain goals of the project. Lastly, Fractal-like patterns were implemented throughout the design, at the landscape, neighborhood, and site scales.

To truly accomplish the goals of this project, extensive research and planning would be necessary. This design only strived to demonstrate the potential applications of the hypothesis discussed. LEED-ND or a similar evaluation method should be used to determine the sustainable nature of this design. Computer models could be run to determine the exact sizes, formations, and function of stormwater installations necessary to achieve water treatment goals. Once that is complete, this design could be assessed for success. The same could be done to determine ecological value. Models of ecosystem/habitat restoration could be used to determine if this design will in fact promote and protect biodiversity, and connect ecosystems and habitats. This design certainly increased the urban density of the area, but success of the revitalization project is impossible to determine at this stage. Studies must be conducted concerning this design's ability to attract residents. Focus groups or design charettes must be conducted to gain resident input on refining this design. Architecture across site must also be developed further. Although even at this schematic level, architectural layout will have a direct influence on the property value of lots(Thorsnes 2002), their desirability(Baldwin et al. 2010), and their ability to expose residents to the therapeutic effects of viewing nature (Kaplan and Kaplan 1989, Molthrop 2011), further attention should be given to ensure and maximize these effects. For example, the fractal nature of building and streetscape silhouettes could be studied in a manner similar to the Hagerhall et al. 2004 study, to determine if current arrangements rank as more attractive than traditional city views. Transit-Oriented-Development is vital to the success of this design. Locations of transit centers, stops, and routes must be further refined with the aid of transportation planners.

Despite the room for improvement, this design is bound to inspire evolution of a conscious land ethic within the surrounding community; transitioning from human-centered development to one of harmony with habitat.

RESULTS

Results

This chapter presents a summary and brief analysis of the third and final stage of study. Resulting data from the Visual Quality analysis of both pre-test existing photographs and post-test created scenes are presented in Table 3 (rounded to the fourth decimal place). To view these images refer to Appendix A.

Image Number	Existing	Created
1	89.9251	47.4307
2	88.4687	46.1186
3	78.4775	49.8697
4	104.9569	45.7644
5	65.7812	25.3915
6	83.3501	65.3177
7	54.3923	36.5401
8	51.6525	49.8853
9	46.2751	39.1209
10	42.7517	36.3944
11	52.8279	33.6186
12	78.3410	42.4850
13	75.9868	41.2927
14	78.6558	N/A
15	77.0124	N/A

Table 3. Visual Quality Scores

To determine whether the resulting scores were statistically significant or not an unpaired t-test was conducted using the computer program GraphPad Prism 6. This test was chosen because analyzing the mean of the existing and created image visual quality scores is an appropriate method of testing the hypothesis. The mean score of each data set represents the expected score of any random image taken on site and if the mean of the created scenes is statistically different from the mean score of the existing photographs then the null hypothesis (that design treatment will have no effect on the Visual Quality of the sample/the means will not change significantly) can be rejected. This finding would also support the experimental hypothesis that: If the selected site of River Rouge, MI is treated through applied design, then the resulting product will display lower(more attractive) Visual Quality scores.

Before a t-test could be run on the data, first a normality test was conducted to determine if the data represented a normal or Gaussian distribution. A D'Agostino and Pearson omnibus normality test was used for this purpose and the results are reported in Table 4. The test showed that the data was normally distributed and thus would be appropriate for a t-test.

An unpaired t-test was used because the two sets of scores, existing and created, are exclusive. Image 1 of set A does not correspond to image 1 of set B. Welch's correction was used during this unpaired t-test to account for the lack of identical standard deviations between the two groups. While a one-tailed P value could have been used for this test (treatment is expected to have a one-directional, positive influence on the mean score), a two-tailed P value was chosen as they are more conservative in nature, and help offset errors made during statistical analysis. (GraphPad Software Inc, 2013)

GraphPad posits that their two-tailed P value answers the question, "Assuming the null hypothesis is true, what is the chance that randomly selected samples would have means as far apart as (or further than) you observed in this experiment with either group having the larger mean?" (GraphPad Software Inc, 2013)

According to this t-test, the P value was found to be less than 0.0001, a very small value. This result can be interpreted to mean that: Random sampling from identical populations would lead to a difference smaller than observed in 99.99% of experiments, and larger than observed in 0.01% of experiments. It should be concluded that the difference between the means of the existing and created images should not be attributed to chance, but rather effect of the treatment (Biophilic Design).

This same conclusion can be drawn from simple comparison of the 95% confidence intervals (CI) of the data. According to GraphPad, "It is correct to say that there is a 95% chance that the confidence interval you calculated contains the true population mean." Therefore the true population mean of the existing site is likely to be between 61.18 and 81.21, while the created mean lies within 37.15 and 48.89. This means that even at the most similar end of the intervals, the two means would still differ by 12.29, thus suggesting that treatment results in the minimum improvement of 12.29 Visual Quality points for any randomly selected image found within the design. However, assuming that the calculated mean is true, this adjustment would be closer to -28.18 ± 5.392.

Statistical Distribution		
	Existing (A)	Created (B)
Number of values	15	13
Minimum	42.75	25.39
"25% Percentile"	52.83	36.47
Median	77.01	42.49
"75% Percentile"	83.35	48.65
Maximum	105.0	65.32
Mean	71.20	43.02
"Std. Deviation"	18.09	9.710
"Std. Error of Mean"	4.671	2.693
"Lower 95% CI of mean"	61.18	37.15
"Upper 95% CI of mean"	81.21	48.89

"D'Agostino & Pearson omnibus normality test"		
K2	0.5044	2.674
"P value"	0.7771	0.2626
"Passed normality test (alpha=0.05)?"	Yes	Yes
"P value summary"	ns	ns

Table 4. Statistical Analysis

Table 4. (continued)

"Unpaired t-test with Welch's correction"	
	Existing (A) vs. Created (B)
"P value"	"< 0.0001"
"P value summary"	****
"Significantly different? (P < 0.05)"	Yes
"One- or two-tailed P value?"	Two-tailed
"Welch-corrected t, df"	"t=5.227 df=22.02"
"How big is the difference?"	
"Mean ± SEM of column A"	"71.20 ± 4.671 N=15"
"Mean ± SEM of column B"	"43.02 ± 2.693 N=13"
"Difference between means"	"-28.18 ± 5.392"
"95% confidence interval"	"-39.36 to -17.00"
"R squared"	0.5537
"F test to compare variances"	
"F,DFn, Dfd"	"3.471, 14, 12"
"P value"	0.0370
"P value summary"	*
"Significantly different? (P < 0.05)"	Yes

Results from these tests suggest statistical and scientific significance for the studied sample. This can be interpreted to mean that, in fact, design techniques utilized within this thesis have a measurable and actual improvement effect on the visual quality and attractiveness of environments previous developed through other methods.

DISCUSSION

Limitations

Some limitations exist within this study, within the research, design, and test stages. Most of these issues are situations of potential human error, and time and budgetary constraints. Firstly, It was assumed that the author/researcher accurately interpreted and applied the findings discovered in the initial stage of secondary research. No other persons were asked to include their own suggestions of how findings should or could be applied during the second phase of this project. The author did not meet with city officials, local residents, or other designers or planners to gain insight on current site conditions and future recommendations. Therefore, only information from published sources, online databases, and personal site visits were considered. Information from the researched articles and texts if misinterpreted and misapplied could surely limit the studied effects of such application within this design, and other related projects. Secondly,the non-random selection of River Rouge as the test site could potentially have skewed results as the site might have certain preexisting conditions that predispose it to result in a particular outcome. This study did not test multiple selections, therefore validly is a concern when extrapolating results to similar and dissimilar potential treatment locations. Thirdly, certain design decisions fall within realms outside the author’s personal expertise and therefore may be limited in the accuracy and appropriateness of techniques. These limitations could include, but are not limited to: exact sizes and forms of architectural elements; sizes and forms of stormwater management installations, including the actual output volumes from city storm sewers, and precipitation and runoff volumes as they were only estimated; feasibility of earthwork and soil treatment; infrastructure and utility requirements; precise demographic, resident occupancy, and building stock/quality analysis; and also environmental engineering requirements to meet the needs of the desired design. Lastly, and arguably the most significant limitation is that of money and time. As this study was academic in nature, it was intended to be completed at virtually no cost, and in a relatively short period of time. An actual project of this magnitude certainly requires a much larger investment of time and money than one researcher/designer could provide. This limitation may be most evident in the test stage of this study. Only a small sample of existing and created images were tested and may not actually represent the two populations. Also, only the author performed the visual quality calculations, and could have made mistakes, preventable if others were hired to assist and corroborate data.

Recommendations

To fully understand if the city of River Rouge was influenced by this design, and whether or not the hypothesis stated holds any prescriptive power, more tests are required. Biophilic design, and sustainable design in general, aims to influence much more than just the attractiveness/visual quality of an environment. The proposed design has potential to meet these goals, but was not tested empirically by this study.

As one of the primary goals of this study was to lend support to ecologically sensitive design techniques, tests to determine the effects of the chosen design on non-human ecology is imperative, with specific regard for biodiversity, biological health, and habitat creation and conservation. This would require fairly complicated modeling, the creation of experimental plots in an outdoor laboratory, or even a longitudinal study of actual application on site. Baldwin et a. 2011 provides an introduction on how to approach designing for non-human and human habitats simultaneously. This idea should be discussed with ecological and urban planners. A simple application of the Shannon-Wiener index on chosen plant lists, introduced species, and species targeted through habitat restoration, could give preliminary results on biodiversity.

More tests would be necessary to determine if the proposed master plan actually managed to promote sustainability development techniques. A LEED and LEED-ND scoring system could meet this requirement, however, as mentioned in the literature review these methods do not necessarily account for a true measure of sustainability. Alternatives to consider include: Green Globes by the Green Building Initiative, or SITES by the Sustainable Sites Initiative. The use of such a system as a guide when designing the more detailed aspects of architecture and neighborhood layouts would be an excellent way to ensure that sustainability requirements are met. Developing a plan for construction material recycling and sourcing would be a way to ensure sustainable practices. Recommendations for amending local laws to make room for green ordinances and rezoning considerations, that could be given to city officials is strongly suggested to make certain that the sustainability goals of this project are maintained and promoted during occupation.

Conducting focus groups, or design charrettes to understand and meet the needs of current and potential residents is strongly suggested. Testing for the marketability of the proposed design, and any subsequent more detailed designs, would provide a great deal of information on the effectiveness of the design methodology and hypothesis.

Testing to determine if the design succeeds in providing clean water resources is another recommendation. The master plan intends to treat stormwater, and has the potential to assist in river decontamination as well. Soil, water, and biomass toxicity and quality tests should be conducted on existing and post-treatment conditions to analyze and make adjustments for improvement goals.

The only aspect of the hypothesis that was tested, attractiveness, would also benefit from additional testing. Additional experiments must be conducted to confirm the findings of this study. Constant repetition of similar studies is required to maintain validity of any findings when applied to future locations. This did not test multiple locations, therefore validly is a concern when extrapolating results to similar and dissimilar potential treatment locations. Applying the design techniques used in this study on other sites, and then testing them for attractiveness would provide useful information. (One example of a project that does test a design with multiple metrics was the 2012 MSU thesis by Yun Wang,"Context Sensitive Design: A Non-Transportation Example in Michigan.")

Most importantly, for a project of this nature, significant collaboration between design disciplines and research fields is necessary to ensure accuracy, efficiency, and thoroughness of development and management techniques. If able, future studies should work with professionals from a multiple of sciences to address the challenges of large-scale site planning and environmental design.

The techniques used in this design have potential for use in other areas across the country. Many other former wetland sites could benefit from indigenous landscape restoration, and sustainable Biophilic design. Examples elsewhere in the Great Lakes region include: Maumee River, Saginaw River, Grand River and the Muskegon River. Each of these areas feature large watersheds emptying into the Great Lakes basin via existing or formerly existing wetland marshes adjacent to urban development (Albert 2008, MNFI 2013). Salt water estuaries include San Francisco Bay, Long Island Sound, Charlotte Harbor, Sarasota Bay, Mississippi Delta, and the Hudson River. Many of these locations are currently being improved through aid of the National Estuary Program (NEP 2012). The nature of these locations differ dramatically from the site selected in this thesis, but general treatment theories could be applied successfully with adjustment for large, tidal, wetland ecosystems.

Conclusions and Significance

Despite the aforementioned limitations and recommendations for improvement, this study itself holds strong merit as an example of applied science exploration within the field of environmental design. This thesis has demonstrated how human and non-human environments can be combined effectively through thoughtful design, in a manner that does not sacrifice aesthetics for environmentalism. In fact, results from the post-treatment test suggest that design of this nature enhances the attractiveness of a development. Many potential design solutions from varying professional disciplines were explored within this study, some based upon tested real-life precedent projects and others based on theoretic philosophies, resulting in a unique synthesis of holistic design. This project has strong potential to be extrapolated as a potential solution to other areas across the country (and potentially the world) suffering from similar problems. Placed in the hands of a well-rounded, multi-discipline design and planning team, this schematic design would serve as an excellent guide for addressing the complexity of struggling urban areas and their mutualistic relationships with non-human ecosystems.

APPENDICES

APPENDIX A: Tested Images

Figure 30. NE corner of Marion Industrial Hwy, looking South.

Figure 31. NE corner of Marion Industrial Hwy, looking East.

Figure 32. NE corner of Marion Industrial Hwy, looking Northeast.

Figure 33. NE corner of Marion Industrial Hwy, looking West.


Figure 34. Belanger Park, at river looking North.


Figure 35. Belanger Park, looking North.


Figure 36. Belanger Park, playground looking.


Figure 37. Belanger Park, looking South.


Figure 38. John Dingell Park, looking North.


Figure 39. John Dingell Park, looking East at Mud Island.


Figure 40. John Dingell Park, looking South.


Figure 41. Abbott Street, looking West.


Figure 42. Walnut and Genessee, looking East.


Figure 43. Walnut and Genessee , looking West.

Figure 44. Jefferson Ave and Henry St, looking Southeast.


Figure 45. Riverview Plaza, looking East from housing block.

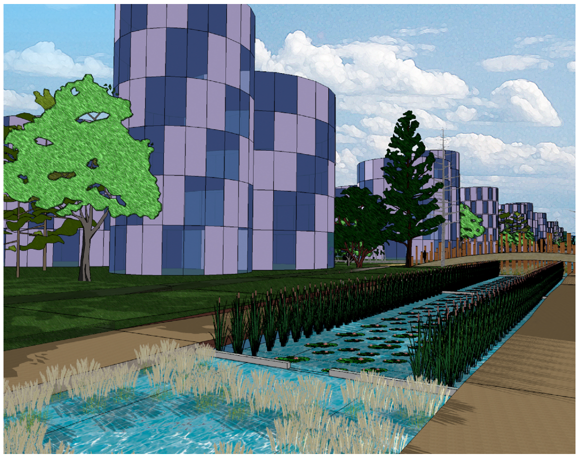
Figure 46. Housing block near Riverview Plaza, looking West.

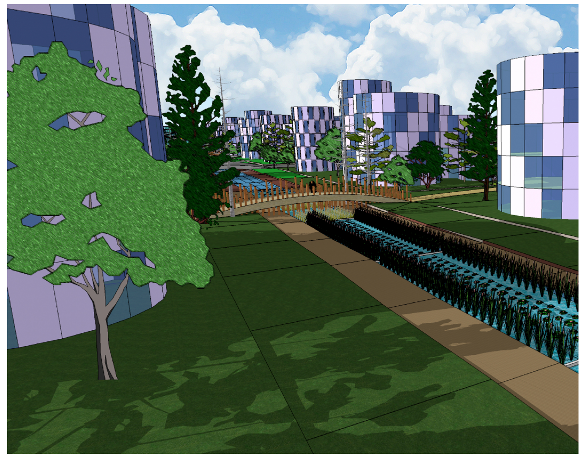
Figure 47. Housing block near Riverview Plaza, looking West from Apartment window.

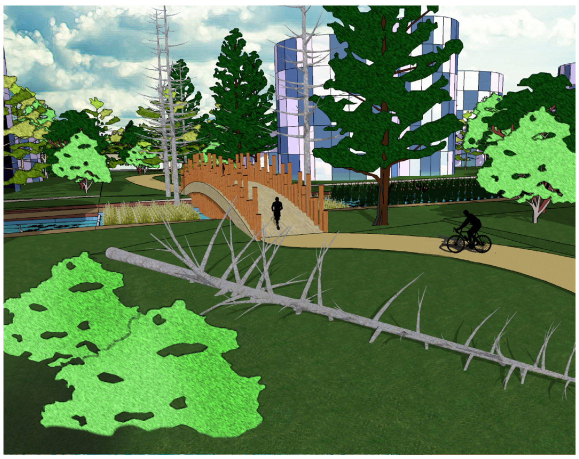
Figure 48. Greenway traversing residential block, looking North.


Figure 49. Exterior view of residential peninsula, looking Northwest.

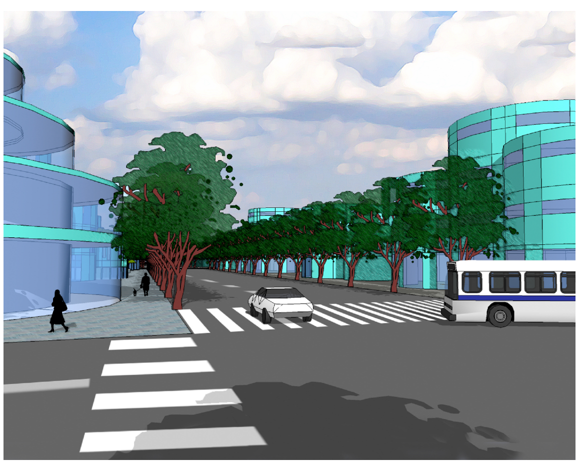
Figure 50. Mixed use streetscape, looking North.


Figure 51. New Center Square, looking Northeast from office window.

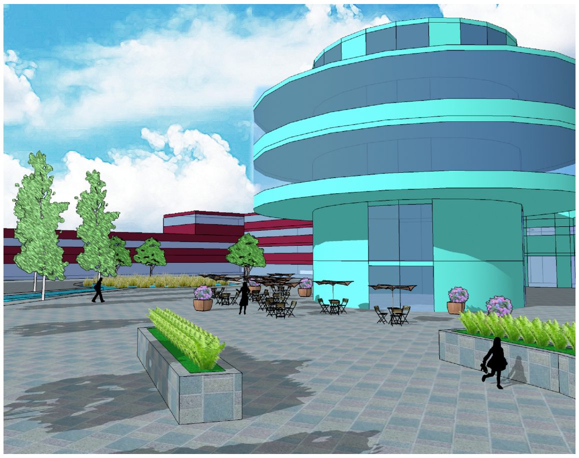

Figure 52. New Center Square cafe, looking West.

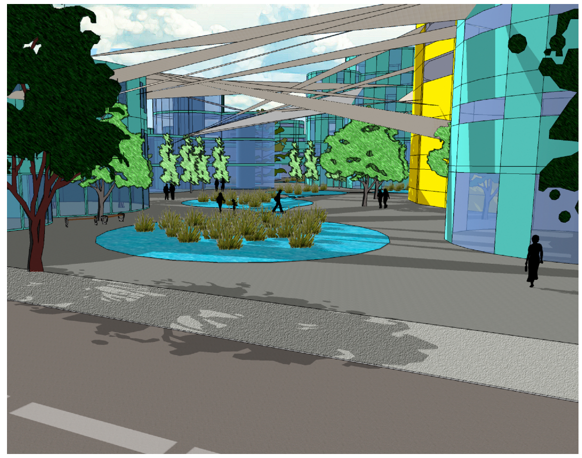

Figure 53. Covered alleyway, looking West.

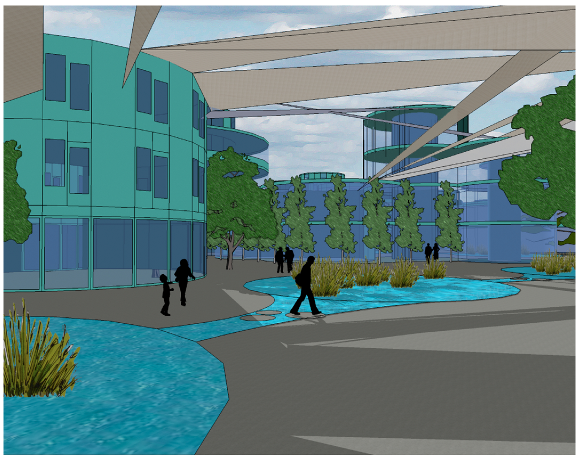

Figure 54. Covered Alley interior, looking Southwest.

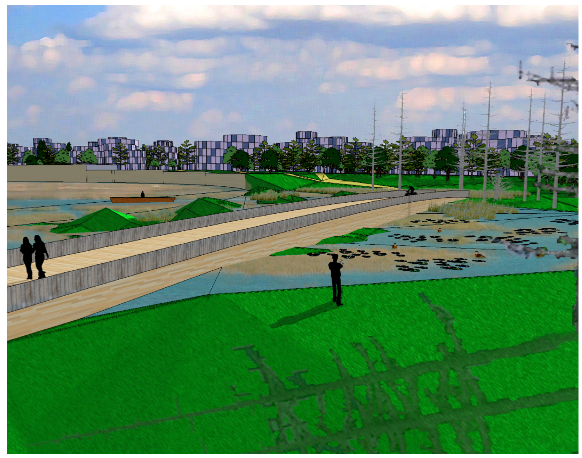

Figure 55. Wetland Park, looking Southeast.

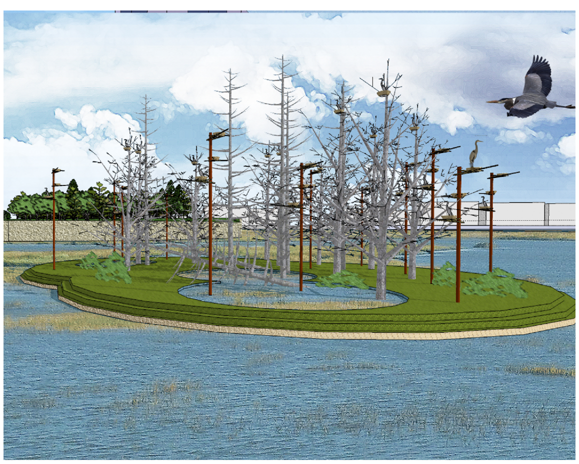

Figure 56. Bird rookery, looking East.

Figure 57. Utility Park, looking South.

APPENDIX B: Glossary

All definitions taken directly from Merriam-Webster online, unless otherwise stated. Accessed May 7, 2013. <http://www.merriam-webster.com/>.

"*" denotes the author's interpretation of terms, assembled from multiple sources and personal use.

Aeration - n. from Aerate - v. to supply or impregnate (as the soil or a liquid) with air.

Aesthetic - adj. responsive to or appreciative of what is pleasurable to the senses.

Best Management Practices (BMPs) - n. management practices and procedures used to prevent or reduce the pollution of surface waters (EHS 2012).

Biodiversity - n. The variety of life, at all levels of organization, classified both by evolutionary (phylogenetic) and ecological (functional) criteria(Colwell 2009). See also: Species Diversity

Bio-filtration - n. the act of absorbing, removing, breaking down, or sequestering contaminants and pollutants from stormwater and soil using plants. See: Phytoremediation, Rain Garden, Sequestration. *

Biomass - n. 1. the amount of living matter (as in a unit area or volume of habitat); 2. plant materials and animal waste used especially as a source of fuel.

Bio-mimicry - n. the close resemblance of a design or process to an actual organism or ecological process. *

Biophilia - n. a hypothetical human tendency to interact or be closely associated with other forms of life in nature.

Bio-retention - n. the act of retaining stormwater with the assistance of plants. See: Rain Garden, Retention, Retention Basin. *

Block - n. a usually rectangular space (as in a city) enclosed by streets and occupied by or intended for buildings; the distance along one of the sides of such a block.

Blueway - n. A linear water body/waterway; a corridor composed of water. Blueways can be used to create connected networks of water that include natural and artificial water bodies; may feature access points for non-motorized water transit. See: Greenway *

Brownfield - n. A site that is underutilized or not in active use, on land that is either(Farr 2008); a tract of land that has been developed for industrial purposes, polluted, and then abandoned. Contrast: Greenfield.

Buffer - n. something that serves as a protective barrier.

Charrette - n. a period of intense design, usually collaborative and schematic, may involve design professionals, lay persons and clients working together to generate ideas and solutions. *

Cognitive dissonance – n. psychological conflict resulting from simultaneously held incongruous beliefs and attitudes (as a fondness for smoking and a belief that it is harmful)

Community - n. a group of people with a common characteristic or interest living together within a larger society. Contrast: Ecological Community.

Connectivity - n. measure of connectedness (Stangl, Paul, and Jeffery M. Guinn 2011)

Conservation - n. a careful preservation and protection of something; especially : planned management of a natural resource to prevent exploitation, destruction, or neglect.

Conveyance - n. the act of moving stormwater from an impervious surface directly into a natural waterbody, via drains or pipes * from Convey - v. to bear from one place to another; especially : to move in a continuous stream or mass. Contrast: Detention, Retention.

Core Parking - n. off-street parking for automobiles, usually a parking garage/structure; located within dense urban developments; may be hidden/disguised with intention to reduce the perceived presence of automobiles in the area or actual horizontal space required for said vehicles. *

Deep ecology – n. an ecology guided by a deep sense of normative philosophical values. e.g. a sense of self indistinguishable from and united with the natural world (Thayer 1994).

Denitrification - n. the loss or removal of nitrogen or nitrogen compounds; specifically : reduction of nitrates or nitrites commonly by bacteria (as in soil) that usually results in the escape of nitrogen into the air.

Detention - n. the act or fact of detaining or holding back;a period of temporary custody. See Detention Basin. Contrast: Retention.

Detention Basin/Pond - n. an area surrounded by an embankment. . .designed to temporarily hold stormwater long enough to allow solids to settle. It reduces local and downstream flooding (Farr 2008).

Development - n. a developed tract of land; especially : one with houses built on it.

Discharge - n. a measure of the amount of water flow at a particular point, e.g. the flow of water in a stream or in a pipe (EHS 2012). v - to release stormwater downstream. *

Discipline - n. a field of study.

Dwelling Unit - n. from Household - n. a social unit composed of those living together in the same dwelling.

Eco-friendly - adj. not environmentally harmful.

Ecological - adj. from Ecology - n. a branch of science concerned with the interrelationship of organisms and their environments.

Ecological Community - n. an interacting population of various kinds of individuals (as species) in a common location. Contrast: Community.

Ecoregion – n. areas of the environment defined principally by topography, hydrology, flora, fauna and other natural boundaries, rather than political. e.g. a watershed that crosses multiple state lines (Mason 2011).

Ecosystem - n. the complex of a community of organisms and its environment functioning as an ecological unit.

Ecosystem Fragmentation - n. see Habitat Fragmentation.

Environment - n. the complex of physical, chemical, and biotic factors (as climate, soil, and living things) that act upon an organism or an ecological community and ultimately determine its form and survival.

Environmental Attitude – n. The beliefs and ideas a person, or group of persons have concerning their environment and their role within it. * (Thompson 2004)

Environmental Behavior – n. The actions of a person, or group of persons that have direct influence on their environment, specifically the ecological health. * (Thompson 2004)

Environmental Design - n. the ordering of the large-scale aspects of the environment by means of architecture, engineering, landscape architecture, urban planning, regional planning, etc., usually in combination (Dictionary.com)

Environmental guilt – n. guilt about what technological development has done to the landscape, to "nature," and to the earth (Thayer 1994).

Environmentalism - n. advocacy of the preservation, restoration, or improvement of the natural environment; especially : the movement to control pollution.

Exurban - adj. from Exurb - n. a region or settlement that lies outside a city and usually beyond its suburbs and that often is inhabited chiefly by well-to-do families.

Eutrophication - n. the process by which a body of water becomes enriched in dissolved nutrients (as phosphates) that stimulate the growth of aquatic plant life usually resulting in the depletion of dissolved oxygen.

Evapotranspiration - n. loss of water from the soil both by evaporation and by transpiration from the plants growing thereon.

First-flush - n. the initial volume of stormwater during a stormwater event, consisting of higher concentrations of contaminants (taken from impervious surfaces). * See: Impervious surface.

Food Chain - n. an arrangement of the organisms of an ecological community according to the order of predation in which each uses the next usually lower member as a food source. See: Ecological Community.

Food-web - n. the totality of interacting food chains in an ecological community. See: Food Chain.

Fractal - n. any of various extremely irregular curves or shapes for which any suitably chosen part is similar in shape to a given larger or smaller part when magnified or reduced to the same size.

Gaia hypothesis – n. Earth's climate and surface environment are controlled by the plants, animals, and microorganisms that inhabit it. . .the planet behaves not as an inanimate sphere of rock and soil. . .but as a biological superorganism. . .that adjusts and regulates itself (Thayer 1994).

Grade - n. the degree of inclination of a road or slope; a datum or reference level; especially : ground level.

Green Building - n. Building design that yields environmental benefits, such as savings in energy, building materials, and water consumption, or reduced waste generation (Farr 2008).

Greenhouse Effect - n. warming of the surface and lower atmosphere of a planet that is caused by conversion of solar radiation into heat in a process involving selective transmission of short wave solar radiation by the atmosphere, its absorption by the planet's surface, and reradiation as infrared which is absorbed and partly reradiated back to the surface by atmospheric gases.

Greenfield - n. Newly developed real estate on what was previously undeveloped open space (Farr 2008); land not previously developed or polluted. Contrast: Brownfield.

Greenhouse Gas - n. any of the gases whose absorption of solar radiation is responsible for the greenhouse effect, including carbon dioxide, methane, ozone, and the fluorocarbons (Dictionary.com). See: Greenhouse Effect.

Green Roof - n. a roof covered with vegetation, designed for its aesthetic value and to optimize energy conservation (Dictionary.com). May be Extensive (shallow soil, supports light plant/weights, only accessed for maintenance) or Intensive (deeper soil, supports heavy plants, even trees, allows for regular access). *

Green Space - n. a plot of undeveloped land separating or surrounding areas of intensive residential or industrial use that is maintained for recreational enjoyment. (Kaplan 2004)

Green Urbanism - n. ...”emphasizes that our old approaches to urbanism. . .are incomplete and must be substantially expanded to incorporate ecology and more ecologically responsible forms of living and settlement." (Beatley 2000).

Greenway/Green Corridor - n. A linear open space; a corridor composed of natural vegetation. Greenways can be used to create connected networks of open space that include traditional parks and natural areas (Farr 2008); may feature non-motorized trails, blueways and water bodies. See: Blueway. *

Habitat - n. the place or environment where a plant or animal naturally or normally lives and grows.

Habitat Fragmentation - n. The division of large tracts of natural habitat into smaller, disjunct parcels (Farr 2008).

Heavy Metal - n. any metal with a specific gravity of 5.0 or greater, especially one that is toxic to organisms, as lead, mercury, copper, and cadmium (Dictionary.com)

Hydrograph - n. a graph of the water level or rate of flow of a body of water as a function of time, showing the seasonal change (Dictionary.com).

Hydrologic - adj. from Hydrology - n. a science dealing with the properties, distribution, and circulation of water on and below the earth's surface and in the atmosphere.

Hypothesis - n. a tentative assumption made in order to draw out and test its logical or empirical consequences.

Immobilization - n. from Immobilize - v. to convert into organic form. Contrast: Mineralization.

Impervious Surface - n. from Impervious Cover - n. Anything that stops rainwater from soaking into the ground, including roads, sidewalks, driveways, parking lots, swimming pools, and buildings (Farr 2008). Contrast: Pervious Surface.

Infill - n. the planned conversion of empty lots, underused or rundown buildings, and other available space in densely built-up urban and suburban areas for use as sites for commercial buildings and housing, frequently as an alternative to overdevelopment of rural areas (Dictionary.com). Contrast: Urban Sprawl.

Infiltration - n. from Infiltrate - v. to cause (as a liquid) to permeate something by penetrating its pores or interstices. See: Interstices, Pervious Surface.

Infrastructure - n. the system of public works of a country, state, or region; also : the resources (as personnel, buildings, or equipment) required for an activity.

Interstices - n. a space that intervenes between things; especially : one between closely spaced things.

Land Ethic - n. A person's or group of persons' impression of connection to the land/environment/nature that they are a part of, whether or not they feel obligated and/or inclined to protect it. (Thompson 2004) see Environmental Attitude

Landscape Architecture - n. from Landscape Architect - n. a person who develops land for human use and enjoyment through effective placement of structures, vehicular and pedestrian ways, and plantings.

Landscape Design - n. he development and decorative planting of gardens, yards, grounds, parks, and other types of areas. Gardening and landscape design is used to enhance the settings for buildings and public areas and in recreational areas and parks. It is one of the decorative arts and is allied to architecture, city planning, and horticulture (Dictionary.com).

Landscape guilt – n. see Environmental guilt.

LEED/L.E.E.D. - n. Leadership in Energy and Environmental Design is a voluntary, consensus-based, market-driven program that provides third-party verification of green buildings (USGBC).

LEED-ND - n. LEED for Neighborhood Development integrates the principles of smart growth, urbanism and green building into the first national system for neighborhood design(USGBC).

Low-density - adj. having low concentration (Dictionary.com)

Macrophyte - n. a member of the macroscopic plant life especially of a body of water. See: Macroscopic.

Macroscopic - adj. observable by the naked eye.

Master Plan - n. to develop or improve (land, a community, a building complex, or the like) through a long-range plan that balances and harmonizes all elements (Dictionary.com).

Mineralization - n. from Mineralize - v. to convert into mineral or inorganic form. Contrast: Immobilization.

Mixed-Use (MU) - adj. used or suitable for several different functions. n. A development that combines residential, commercial, retail, and/or office uses, either in a vertical fashion (in a single building) or a horizontal fashion (adjacent buildings); A neighborhood urban center that allows a variety of residential types (condos, apartments, townhouses) and commercial, and retail uses clustered together in a development of less than 40 acres (Farr 2008).

Natural - adj. having or constituting a classification based on features existing in nature. See also: Non-human.

New Urbanism - n. Neighborhood design trend used to promote community and livability. Characteristics include narrow streets, wide sidewalks, porches, and homes located closer together than typical suburban designs (Farr 2008).

Non-human - adj. classification based on features not related to or created by man. *

Open space - n. undeveloped land that is protected from development by legislation (Dictionary.com). (Kaplan 2004)

Outfall- n. the point where a sewer or drainage discharges into a receiving waterway (EHS 2012).

Pathogen - n. a specific causative agent (as a bacterium or virus) of disease.

Pervious Surface - n. anything that allows rainwater to soak into the ground through its pores or Interstices. See: Infiltration. *

Phytoremediation - n. a process of decontaminating soil or water by using plants and trees to absorb or break down pollutants (Dictionary.com). See: Bio-filtration.

Plan-view - n. a drawing made to scale to represent the top view. . . of a structure or a machine, as a floor layout of a building (Dictionary.com).

Plaza - n. a public square in a city or town; an open area usually located near urban buildings and often featuring walkways, trees and shrubs, places to sit, and sometimes shops.

Preservation - n. to keep safe from injury, harm, or destruction.

Private Sector - n. the area of the nation's economy under private rather than governmental control (Dictionary.com). See Public Sector.

Program - n. a brief. . .outline of . . . the features to be presented; a plan or system under which action may be taken toward a goal.

Progressive - adj. making use of or interested in new ideas, findings, or opportunities.

Public Sector - n. the area of the nation's affairs under governmental rather than private control (Dictionary.com).

Rain Garden - n. a garden with functional purpose to detain, or retain stormwater, may or may not use bio-filtration as well; not necessarily an aesthetic/ornamental garden, but rain gardens may serve this purpose as well as their functional roles. *

Reclamation – n. the act or process of Reclaiming - v. to rescue from an undesirable state; also : to restore to a previous natural state; to make available for human use by changing natural conditions.

Retention - n. from Retain - v. to hold secure or intact. See Retention Pond. Contrast: Detention.

Retention Basin/Pond - n. a storage site similar to a detention basin but the water in storage is permanently obstructed from flowing downstream (Dictionary.com).

Revitalization - n. from Revitalize - v. to give new life or vigor to

Runoff - n. the water that flows off the surface of the land, ultimately into streams and bodies of water, without being absorbed into the soil (Farr 2008).

Sediment - n. the matter that settles to the bottom of a liquid.

Sequestration - n. the combining of metallic ions with a suitable reagent into a stable, soluble complex in order to prevent the ions from combining with a substance with which they would otherwise have formed an insoluble precipitate, from causing interference in a particular reaction, or from acting as undesirable catalysts (Dictionary.com).

Species Diversity - n. A measure composed of both Species Richness and Species Evenness (Colwell 2009).

Species Evenness - n. A measure of the homogeneity of abundances in a sample or a community (Colwell 2009).

Species Richness - n. The number of species in a community, in a landscape or marinescape, or in a region (Colwell 2009).

Streetscape - n. the appearance or view of a street.

Stormwater - n. an abnormal amount of surface water due to a heavy rain or snowstorm (Dictonary.com). see also Runoff

Stormwater management - n. anything associated with the planning, maintenance, and regulation of facilities which collect, store, or convey stormwater(EHS/University of Virginia 2012).

Substrate - n. the base on which an organism lives.

Suburban - adj. from Suburb - n. a smaller community adjacent to or within commuting distance of a city.

Sustainable Regionalism - n. A design/planning philosophy that, "seeks to create, revitalize, and restore the ecological region in metropolitan areas through the physical design and planning of neighborhoods, villages, and cities within a region from a regionally-based sustainable perspective." (Ndubisi 2008)

Sustainability - n. from Sustainable - adj. of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged.

Swale - n. a low-lying or depressed and often wet stretch of land.

Technophilia – n. the hard-wired human predisposition to invent tools and use them creatively to solve problems (Thayer 1994).

Technophobia – n. the suspicion, fear, and aversion to certain technologies and their physical manifestations (Thayer 1994).

Tensile - adj. of, relating to, or involving tension; taut.

Theory - n. a plausible or scientifically acceptable general principle or body of principles offered to explain phenomena.

Topophilia – n. the affective bond between people and place or setting. (Thayer 1994)

Transit-Oriented-Development/Design (TOD) - n. A form of development that emphasizes alternative forms of transportation other than automobile – such as walking, cycling, and mass transit – as part of its design. TOD locates retail and office space around a transit stop. This activity center is located adjacent to a residential area with a variety of housing options. . .(Farr 2008).

Urban - adj. of, relating to, characteristic of, or constituting a city.

Urban Compaction - n. act of restricting development to a certain area (usually within existing city limits); intended to utilize existing infrastructure and reduce urban sprawl. See: Infill. Contrast: Urban Sprawl.*(Paulete & Golding)

Urban Ecology - n. from Urbanology - n. a study dealing with specialized problems of cities (as planning, education, sociology, and politics).

Urban Planning - n. the activity or profession of determining the future physical arrangement and condition of a community, involving an appraisal of the present condition, a forecast of future requirements, a plan for the fulfillment of these requirements, and proposals for constructional, legal, and financial programs to implement the plan (Dictionary.com).

Urban Sprawl - n. the spreading of urban developments (as houses and shopping centers) on undeveloped land near a city. Patterns of urban growth that include large acreage of low-density residential development, rigid separation between residential and commercial uses, leapfrog development in rural areas away from urban centers, minimal support for non-motorized transportation methods, and a lack of integrated transportation and land use planning (Farr 2008). Contrast: Infill, Green Urbanism, New Urbanism, TOD

Walkability - n. the components that make up a place and by its overall look and feel (Farr 2008). from Walkable - adj. capable of being traveled, crossed, or covered by walking (Dicitonary.com); often used a measurement of design quality and desirability of a development. *

Wetland - n. land where part of the surface is covered with water or the soil is completely saturated with water for a large majority of the year. . .provide an important habitat for many different types of plant and animal species. . .natural stormwater control areas. . .(EHS 2012).

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