# DEVELOPING CONNECTIONS + JUNCTION CITY, KANSAS

by

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A REPORT

submitted in partial fulfillment of the requirements for the degree

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# Abstract

This project is of a personal interest to me, because Junction City, Kansas has been my home town since birth. The city is a rapidly growing community with a strong military presence from nearby Fort Riley, Kansas. The project will explore the capacity for effective growth while preventing the degradation of fragile natural resources within the community. It will also provide new amenities for the people of Junction City as well as capitalize on the existing natural amenities.

The project provides stormwater management solutions for an existing retail development and a proposed mixed use development incorporating sustainable practices. Studying the history and progressive nature of Junction City provides an understanding of how to embrace the design within the surrounding landscape.

A model for responsible mixed use retail and residential development in Junction City is provided through this project. Stormwater best management strategies were also implemented to improve the oxbow wetlands by capturing the first flush storm event as well as a 25 year storm event. Finally, the project should continue to shape the history and enthusiasm of Junction City and its people.

# Developing Connections
## Junction City, Kansas

Masters Project and Report

Brett Rolfs | Spring 2009 | Kansas State University

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Its kind of

**FUN** to do the

**IMPOSSIBLE**

- Walt Disney

# Table of Contents

# Appendix Listing

# List of Figures and Tables

**Figures**

Mixed Use Development Design



Master Conclusion



## **Tables**

Concept Studies



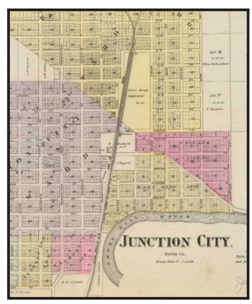
Best Management Practice Retrofit Design



Mixed Use Development Design

# Project Introduction

1



# Project Introduction

**Dilemma** The City of Junction City, Kansas is a community quickly growing due to developmental pressures. When rapid expansion occurs it is important for a community to prevent the degradation of natural resources. Maintaining and promoting natural amenities is important to both residents and tourists.

**Project Thesis** The improvement of existing stormwater management through the use of Best Management Practices (BMPs) will provide educational demonstration sites for the community. Additionally, new sustainable development practices will act as catalysts for future development in and around Junction City. Environmental health, community pride, and unconventional ideas will promote the development of the demonstration and catalyst sites.

## History of the Community

Junction City has a rich, progressive history. In 1854, after the establishment of the Kansas-Nebraska Act, Andrew J. Mead, of the Massachusetts Emigrant Aid Company, started planning a community to be called Manhattan. The proposed town of Manhattan was to be located where Junction City currently exists. (kansastown.us 2009) The Massachusetts Emigrant Aid Company was a transportation agency that carried immigrants to the Kansas Territory during the period referred to as Bleeding Kansas in the 1850's. Bleeding Kansas was a movement to empower the Free-Staters so that Kansas could enter the Union as a free state. (kshs.org 2009)

The steamship Hartford was to deliver the immigrants to the proposed city. Unable to complete the trip as planned due to low waters on the Kansas River, the immigrants settled 20 miles east of their destination and called the settlement Manhattan - as originally Mead proposed for Junction City. The settlement was located where the city of Manhattan, Kansas currently exists.

The community Mead originally planned (currently Junction City) was renamed Millard City in 1855 and then changed to Humboldt in 1857 by local farmers. It was finally renamed Junction City to represent the confluence of the Republican, Smoky Hill, and Kansas Rivers. The community was incorporated as an official city in 1859. (jcks.com 2006)

Junction City marks the confluence of three rivers as well as functioned as a primary railroad stop at the junction of three railroads; the Kansas Pacific (running east-west), the Missouri, Kansas and Texas (running


*Figure 1.1 | Historic Downtown Junction City, September 29, 1894*
*(Kansas Historical Society)*

south), and the Junction City and Fort Kearny (running north). In 1866, the Kansas Pacific depot grounds were marked off and a turn-table was built. Trains ran from Leavenworth, Kansas to Junction City opening a new era for the city. The popularity of the railroad prompted the building of a roundhouse and other workshops at the depot grounds, which drew many settlers to the community, thus helping to establish a town.

In 1879, the grand Bartell Hotel was erected at the entrance to western downtown [Figure 1.1] to support the influx of settlers and tourists who passed through Junction City. The structure was built of red brick blocks with Italianate features and was deemed "emblematical of better time and speedy progress," to the community's development. (United State Department of the Interior 1976) Famous guests of the Bartell Hotel include: Mr. Adolphus Busch, Sally Rand, Gene Tierney, John Phillip Sousa, W.C. Fields, Gloria Vanderbilt, Dan Dailey, and John Wayne.

## Junction City Today

Today, Junction City remains a small Kansas town with a population of 20,082. (dailyu.com 2008) The population continues to rise primarily due to the reinstitution of the Big Red One, 1st Infantry Division at adjacent Fort Riley. (1id.army.mil 2008) The community is blessed with American patriotism, cultural and racial diversity, impressive recreation opportunities, and a town staff that is eager to maintain and embrace the community's assets.

Junction City continues to progress with strong community ambitions and development similar to the western progression that occurred in the late 1800's. However, it has not been progressive in the development of ecological standards for development occurring within city limits. One such example is the historic Smoky Hill River oxbow, a wetland, which has not been viewed as an amenity of the city. The oxbow wetlands has the potential to be a tremendous resource.

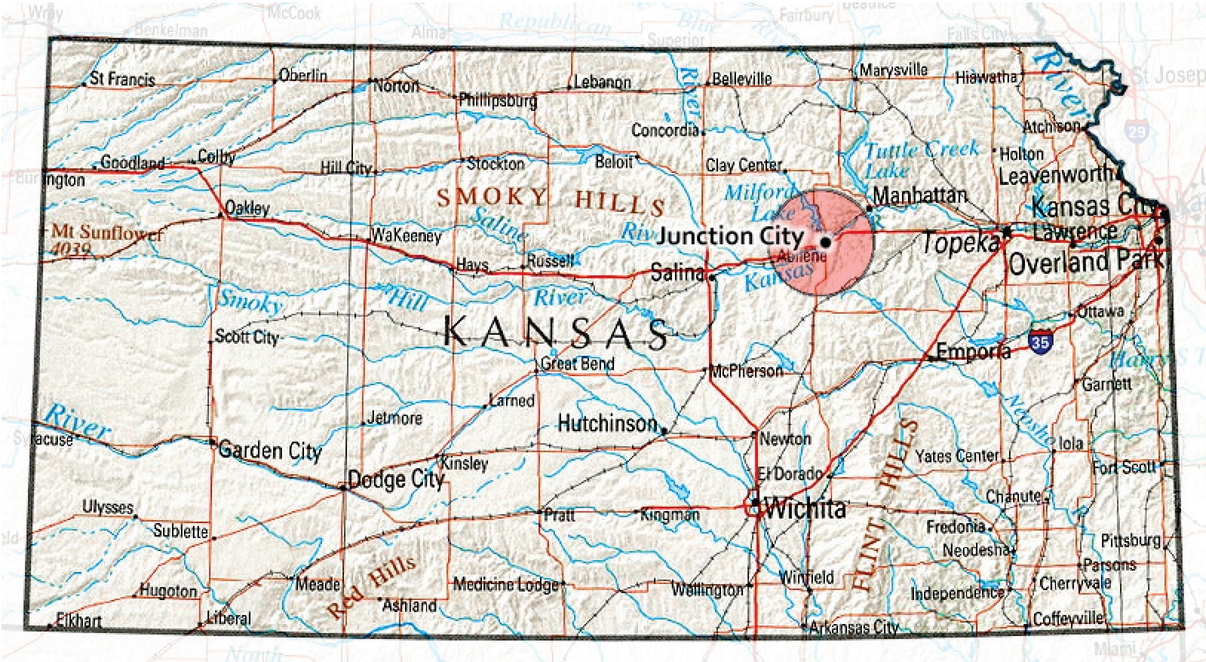



*Figure 1.2 | Regional Location*
*(University of Texas 2001, Rolfs Adaptation 2009)*

**Project Location** Junction City is located along Interstate 70 and at the confluence of the Smoky Hill River, Republican River, and Kansas River in east central Kansas. [See Figure 1.2] The project area is a partially developed landscape adjacent to the Smoky Hill River oxbow. [See Figure 1.3] Having been treated as a stormwater depository, the oxbow wetlands are polluted and in poor condition. Junction City's vibrant and historic downtown is located northwest of the project site by approximately ¼ to one mile. Because of it's proximity to the historic downtown it is important to note that undeveloped agricultural land within the project site is forecasted to become commercial development which could detract from downtown. (Comprehensive Plan, Junction City and Geary County 2007)

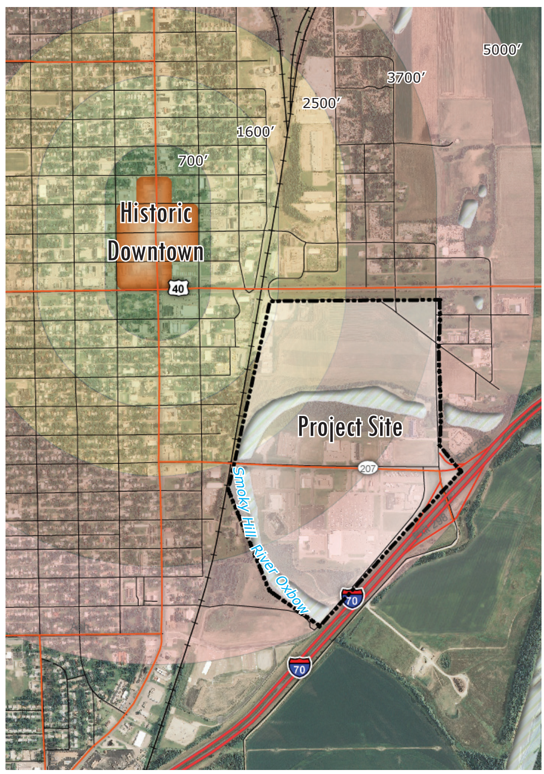



*Figure 1.3 | Project Location*
*(Rolfs 2009)*

**Project Anticipation** The goals for this project were derived from the goals and objectives rosette. [Figure 1.4] The diagram represents goals central to the project with the project objectives along the peripheral. The point at which the line wrapping around the diagram intersects the objective indicates the importance of the objective. The closer the plotted point is to the objective, the greater the importance is in meeting the goal by which it is defined.

The purpose of this work is to retrofit the existing commercial development with stormwater BMPs to improve the water quality of the oxbow wetlands. Retrofitting the existing development with BMPs must serve the community and interstate travelers, primarily through an educational experience.

This project will also provide a model mixed-use development for the undeveloped agricultural land north of the oxbow wetlands. The mixed-use development will entertain the needs of the community and interstate travelers. To demonstrate the importance and effectiveness of sustainable development practices, a series of educational trails and connections will integrate the existing and proposed developments as one cohesive design.

By instituting the goals and objectives, this project suggest changes that create new amenities and implement innovative technologies in order to enhance the

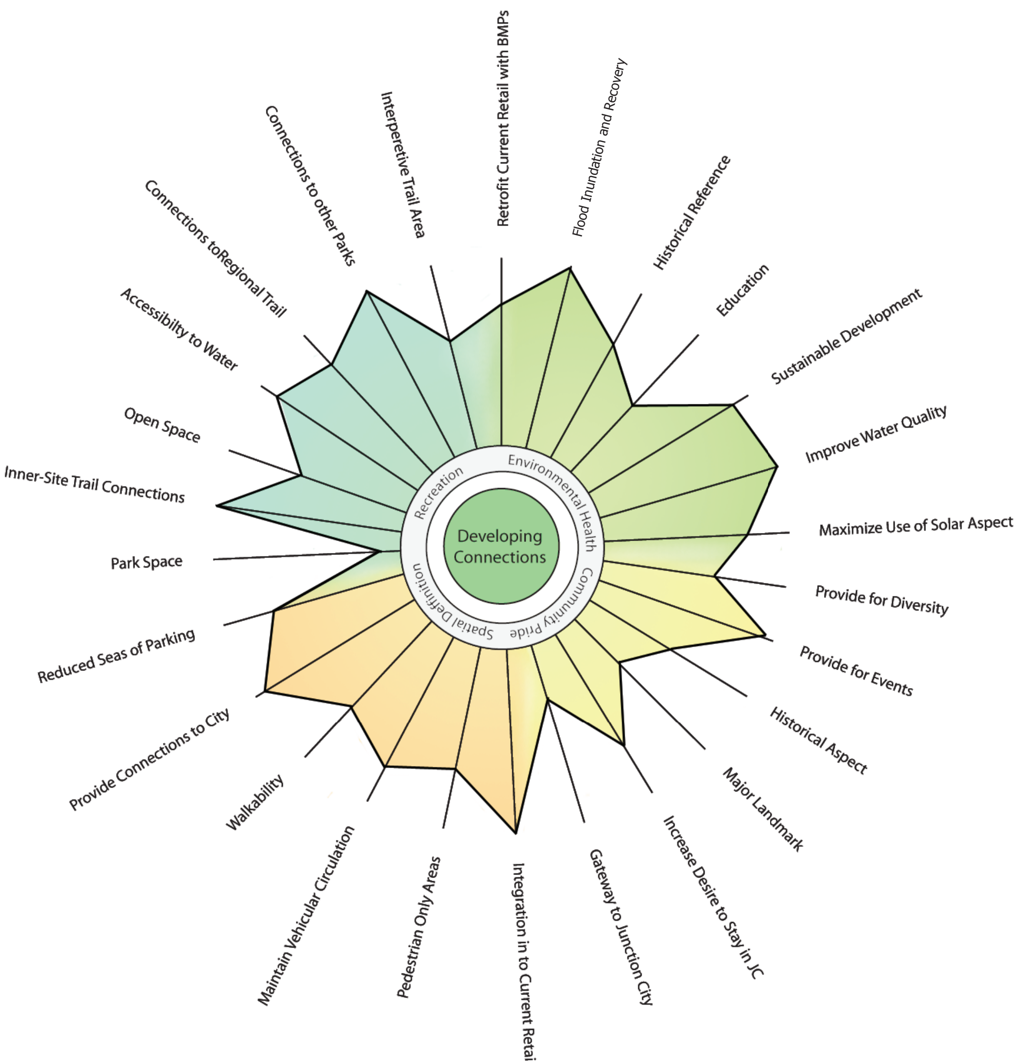



*Figure 1.4 | Goals and Objectives Rosette (Rolfs 2009)*

community image of Junction City. The existing development will be retrofitted with stormwater BMPs to minimize effects on the oxbow wetlands. Sustainable development practices will be demonstrated through a mixed-use development on the existing undeveloped agricultural land poised to be commercial property. Recreation and educational trails will be implemented, on the project site, to provide connections to the Riverwalk Trail and the proposed citywide trail system.

## Philosophy and Methodology

The city staff of Junction City expressed a great deal of interest when asked if they would be willing to provide information for this project study. Interested city officials and employees were invited to the final presentation of the work to learn about the student design process and to provide feedback on the design. It is critical for student work to be recognized by an authoritative organization so the work can inform a selected group of people about new, innovative ideas.

Three overarching themes defined this project study [see Figure 1.5]:

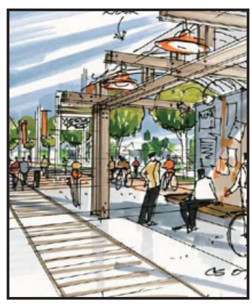
+ Community pride
+ Environmental health
+ Unconventional ideas

Sense of place and community pride was considered to have the greatest significance in the design process, primarily because of Junction City's rich history and cultural diversity. Promoting environmental health was a primary goal in creating a solution that best fit Junction City. Lastly, unconventional ideas were employed to break away from the typical scene already found within the community.


*Figure 1.5 | Philosophy and Methodology Diagram (Rolfs 2009)*

# Concept Studies

2



# Concept Studies

The concept study is a compilation of relevant planning, landscape architecture, and sustainable design documentations that explain the project themes: community pride, environmental health, and unconventional ideas.

**Definition of Place** Junction City is a place that many people, all who have a strong sense of community pride, reside in and call home. In order to effectively design this development project so it becomes a part of the place defined as Junction City - it is necessary to understand the dimensions of place. In his text, *Writing for an Endangered World*, Buell describes his five dimensions of place, which are further explored here. [Figure 2.1]

The first dimension is a central area of affiliation where a person's sense of place decreases as he or she moves away from a central point such as a home, neighborhood, or town. It is at this core level where people are most willing to express their strongest sense of place. It is within this closeness that people maintain the quality of their homes, the historical character of their neighborhoods, the vitality of their social communities, and the viability of natural ecosystems. (Buell 2001)

Random arrangement of points, the second dimension of place, illustrates how places can be very far apart, and yet, share a common identity. Places are parts of systems and environmental pathways that link distant places to one another, disrupting the division between cities and pristine nature. (Buell 2001) The area that Junction City and Fort Riley share is a prime example of the second dimension of place. The two communities are vastly different, yet people are proud to be from one, the other, or both.

The third dimension demonstrates the continual shaping and reshaping of places by internal and external forces. For those who have developed a sense of place, changes in the place or a new physical surface are hidden from them in unseen layers of usage, memory, and significance. (Buell 2001) The progressive nature of Junction City promotes a continually changing landscape. However, long-term residents still see the place as they so desire. This can be potentially harmful when the place is changing negatively and long-time residents are unable to identify change because usage, memory, and significance masks their sense of place.

The fourth dimension of place is in regards to the movement of people into and out of places. This means any one place contains residents with collective memories of the places that have been significant to them over

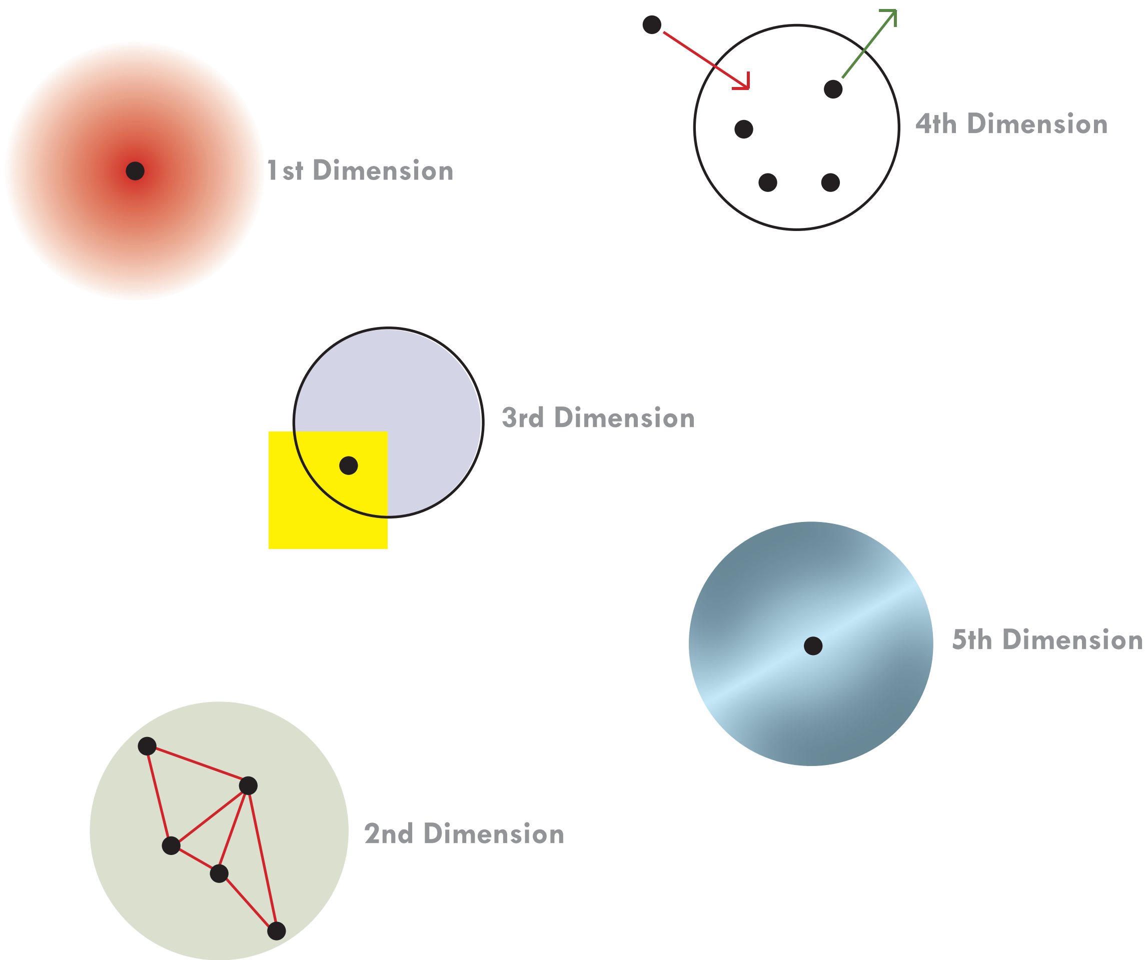



*Figure 2.1 | Diagramatic representation of Buell's 5 dimensions of place. (Rolfs Adaptation 2009)*

time. (Buell 2001) Because the community of Junction City is directly influenced by the arrival and departure of military troops and their families, the community is filled with people that have other perceptions of place.

The final dimension suggests that imaginary or virtual places also matter. This adds a certain fictive quality to contemporary revelations about actual places. (Buell 2001) Roughly 20 years ago, the citizens of Portland, Oregon, chose to pursue innovative development paths. Consequently, when advocates speak of Portland, they proclaim how they have come very close to the ideal place of sustainability. Similarly, the historical plan for Junction City, was a fictive place during the mid-1800s; and Junction City was proposed to be the gateway signifying that one had entered the Wild West.

**Mixed Use Development** Central to the value of mixed use development is the belief that developments contribute to the vitality and attractiveness of town centers - one of the goals of this project. (Department for communities and local government) The term 'vitality' is defined by the life that is represented by people located in and around a development. The vitality of a mixed use development covers a wide band of activity from highly active liveliness to the simple non-active presence; with every variation in-between. The relationship between ground floor uses and street activities is particularly influential in the vitality of a mixed use development. The impact of the street environment, in a mixed use development, is critical in bringing people to the site and allowing them to walk around and enjoying themselves.

Conflicts occur with the residents and patrons of a mixed-use development when the noise and bustle of evening or nighttime activities negatively affects the quality of life for residents within the development. Many regular users of late-night leisure and entertainment venues want the area to be quiet when they come home to sleep or relax. This indicates that privacy is an essential component of a successful mixed-use development. Another issue indicated is the lack of parking that car owners identify as a main source of dissatisfaction.

Successful mixed use developments can be found in individual buildings, a series of buildings grouped together, or as predominant characteristics across from urban areas. These are identifiable by a mix of functions that jointly activate the built form. Mixed use developments are successful when uses visibly activate the ground floor level of buildings and the street environment in a positive and integrated manner as seen in figure 2.2. If a development is successful, it can also enhance the economic and social-well being of an area. Mixed use developments also enhance the vitality of an area, thus generating a strong sense of place and an attractive and sustainable environment.


*Figure 2.2 | A well articulated Mixed Use Development Streetscape in British Columbia (da-architects.ca 2009)*

Experiencing nature in mixed use developments is important to viability. Direct experience with nature in a mixed-use development involves physical contact with natural settings and nonhuman species. Activities associated with this type of experience are largely non-planned and non-directed. Indirect experience also involves physical contact with nature but in more restricted, programmed, and managed contexts, such as within a rural park. Contact with natural settings and species is the result of regulated or contrived human activity. Nature is often the product of deliberate and extensive human manipulation. A vicarious or symbolic experience with nature lacks any physical contact and instead is experienced through representations that are sometimes realistic and sometimes not. (Corbett 2006)

## BMP and Big Box Retail

Implementing green infrastructures provides an opportunity for new development to occur in a more environmentally efficient manner. It can also rehabilitate existing developed areas. A green infrastructure is an interconnected network of waterways, wetlands, woodlands, wildlife habitats, and other natural areas that maintain natural ecological processes. Installing a green infrastructure means preserving, creating, or restoring vegetated areas and natural corridors, like greenways, parks, conservation easements, and riparian buffers. When these lands are linked together in an urban environment they provide Best Management Practices (BMPs) similar to natural undeveloped systems. (Kloss and Calausse 2006)

BMPs can be accomplished through green infrastructure use by managing water naturally. Vegetated BMPs are the best way to restore natural processes in an urban environment and in impervious areas. Restoration of natural water movement processes can be initiated by capturing and retaining rainfall, infiltrating run off, and reducing stormwater runoff volumes.

Evaluation of the existing site is necessary to determine whether stormwater BMPs can be met. This includes the consideration of every area as a potential contributor to stormwater management goals and is essential when establishing BMPs. Stormwater management controls should be located as close as possible to the source of potential impacts. Small-scale site planning strategies create small-scale watersheds and can be designed to address specific management issues. (UFC 2004)

Implementing stormwater BMPs on a site, primarily developed with big box retail centers, is a challenge. Big box retailers require an enormous area for parking, vehicular circulation, pedestrian routes, and building footprints. These large sections of impervious areas increase stormwater runoff and pollutant loads. The goal is to reduce the effect of development on natural processes, minimize stormwater runoff volume, and preserve existing drainage patterns. In order to achieve a more sustainable development the design and retrofit of development BMPs must be established.

Four of the most common BMP principles which can be applied to the development of Junction City, follow:

1. Disconnect impervious areas and downspout runoff from linked impervious surfaces. (LIDC 2005) Once run off has been exposed to an impervious surface, such as a parking lot, it typically flows directly to a stormwater collection system with no possibility of infiltration to the soil. The runoff from impervious drainage areas increases volume, peak runoff rates, and pollutant loads.

2. Minimal site disturbance techniques are practices that minimize ground disturbance by identifying the smallest possible land area to be disturbed during site development. (LIDC 2005) Minimizing the amount of clearing and grading on a site also reduces the overall hydrologic impacts of site development by maintaining natural drainage patterns and reducing soil compaction, thus reducing the rate of infiltration. When using BMPs to collect water on site it is important to maintain or improve the natural rate of soil infiltration.

3. Increasing time of concentration slows the velocity of runoff. Time of concentration is the amount of time water has to infiltrate, or reduce in velocity, before exiting the watershed. By increasing time of concentration, erosion can be reduced and the potential for infiltration can be increased. This improvement will increase the time it

| BMP | New Development | Retrofit |
|---|---|---|
| Cisterns | ● | ● |
| Conservation (Vegetation) | ● | ○ |
| Downspout Disconnection | ○ | ● |
| Filter Strips | ● | ● |
| Infiltration Beds/Trenches or Dry Wells | ● | ⦿ |
| Pocket Wetlands | ● | ● |
| Porous Pavement | ● | ⦿ |
| Rain Gardens | ● | ● |
| Reforestation (Vegetation) | ● | ● |
| Sand Filters | ● | ● |
| Soil Amendments | ● | ● |
| Tree Box Filters | ● | ● |
| Vegetated Roofs | ● | ● |
| Vegetated Swales | ● | ● |

Key: ● Highly Suitable ⦿ Moderately Suitable ○ Not Suitable

*Table 2.1 | Suitability of BMPs for Land Development Types (LIDC 2005)* takes for runoff to flow across a site to the drainage point or a stormwater BMP.

4. Pollution prevention is a management action that reduces or eliminates pollutants before they are disposed downstream. (LIDC 2005) The objective of pollution prevention is to keep nonpoint source pollutants out of runoff and fragile ecosystems. Implementing several smaller BMPs nearest to the source of runoff will greatly reduce the number of pollutants in the runoff water. It is important to identify suitable locations for stormwater BMPs when establishing a site plan.

Selecting the proper stormwater BMP for a specific location is critical and must be addressed during design for a new development. It also must be looked at carefully when retrofitting an existing development. The suitability for stormwater BMPs regarding new development and retrofit alternatives can be seen in Table 2.1. (LIDC 2005)

**Summary** As noted previously, Junction City is a place that people are proud to call home. It is most important to develop the project as a place for the residents of the community. Junction City was founded and expanded by entrepreneurs willing to take risks and try alternative methods of development. Mixed-use development can bring a certain energy back to the city and primarily to historic downtown. Establishing a model of sustainable development, with connections to the natural oxbow and downtown, will promote minimal maintenance design. Even though the city currently has no innovative stormwater guidelines, the same attitude will allow city officials to pursue something of which they can be proud.

The use of innovative stormwater management strategies will improve the wetlands oxbow. A higher quality of water will be the first step in recognizing the oxbow wetlands as a valuable resource for the community. The reduction of pollutants, quantity of water, and minimal disturbance design is the first step in improving the water quality of the oxbow. The use of attractive BMPs to cleanse runoff, as well as allow people interaction through recreation or education, will establish the project site and oxbow wetlands as a cohesive place.

# Project Site Study

3

## Project Site Study

**Community Influence** It is important to understand the municipal fabric that defines Junction City as a place of historical significance and innovation. Understanding this context is central to the successful development of this project. The site in a newly developing area  which seems to disconnected from the community as a whole.

Figure 3.1 identifies important developments and historical structures that define Junction City's downtown community as a place. The primary landmarks identified include brief synopses of their significance. Notable commercial and retail businesses define the primary transportation corridors through Junction City. Public open spaces and parks are also identified. Open space areas are important because their connectivity is a key element of green infrastructure. Two electrical substations, and the livestock sale barn among other sites, are identified as degrading and require careful consideration when developing the project design because of the negative connotations that people associate with them.

It is also important to explore the downtown dimension. Figure 3.1 also represents downtown Junction City as a place that functions as the town's revisited center. The core of downtown is within walking distance of the project site. Several schools are also in close proximity to downtown and the site.

Connections in Junction City are primarily transportation-based with some secondary pedestrian connections relying on straight-line sidewalks. As illustrated in the history of Junction City, the existing railway was a critical component to the community's growth, progress, and, ultimately, it's success. Today, Interstate 70 is the modern day railway that feeds tourists and cross-country travelers into the heart of Junction City. To house all of these visitors, several hotels and a first class convention center are located adjacent to the oxbow on the site.

Junction City is currently planning and developing parts of a trail system to wrap around the outer edge of the city. (Barnes & Lazer 2009) The general location of components of the trail system is also identified in figure 3.1. Possible access to the Kansas River is identified as an important consideration in determining the route of the recreational trail system. It is important to link the project site to the proposed citywide trail system. The trail system will connect with the Riverwalk trail that follows the Republican River north to Milford Lake, and possibly to Kansas River access.

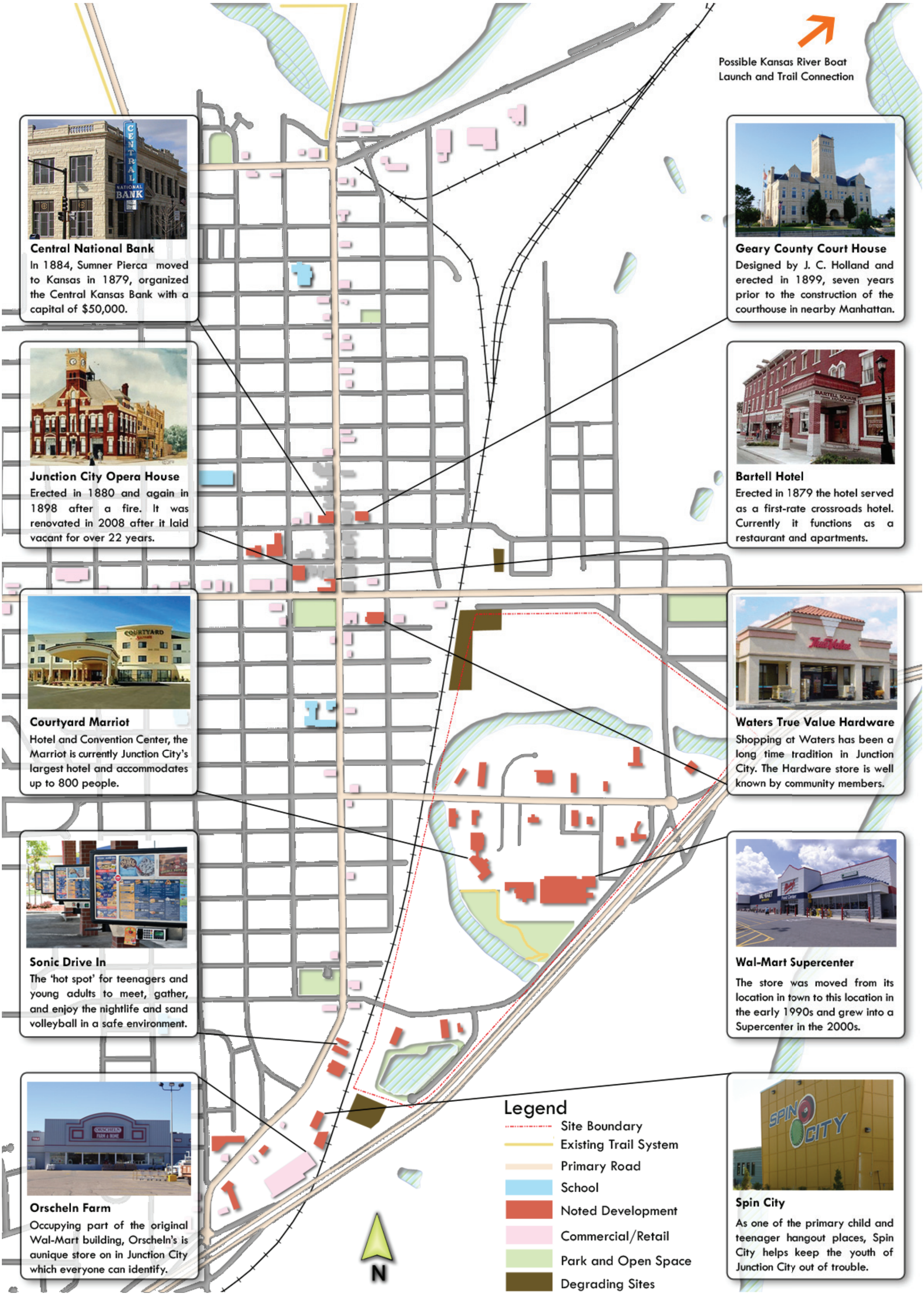



*Figure 3.1 | Community Influence*
*Rolfs*

**Development Patterns** The project site has been evolving over the past 17 years. Figure 3.3 shows the relative methods of development that have occurred in recent times and includes their respective areas. Year-by-year layers are overlaid to demonstrate the changes in development patterns. Through time, the amount of low-intensity development has decreased while the amount of high-intensity development has nearly doubled. [Figure 3.2] Surface parking has also grown at an alarming rate.

It is important to understand the past development patterns of the landscape within the site boundary and just as important to study proposed developments outside the site boundary. The Smoky Hill Marketplace [appendix A3.1] designed by D.J. Christie, Inc, is a 340-acre, mixed-use development that includes retail, entertainment, sport, and tourist venues. It has been planned to occupy the south side of interstate 70, between interstate 70 towards the Smoky Hill River. The project to date is currently on hold. The programming information provided for the project reveals what the city staff and other developers perceive as necessary development for the future of Junction City. The Smoky Hill Marketplace is also in the plans—to be developed directly across Interstate 70 from the location of the site.

In addition to the Smoky Hill Marketplace project, the northern agricultural field adjacent to JC Livestock is zoned for commercial use (Geary County and Junction City Comprehensive Plan 2007) and is currently for sale as commercial land. Even though it is within the floodplain, it is destine to be developed commercially.

## Site Opportunities

Since the project site primarily consists of retail center developments, it is no surprise that less than three residences can be found on the site. [appendix A3.2] The current development is not conducive to residential living.

The population of Junction City is known to have been one of the most racially diverse communities in the state of Kansas. [appendix A3.2] Currently, this generally includes whites and blacks. Hispanics follow as the third greatest population.

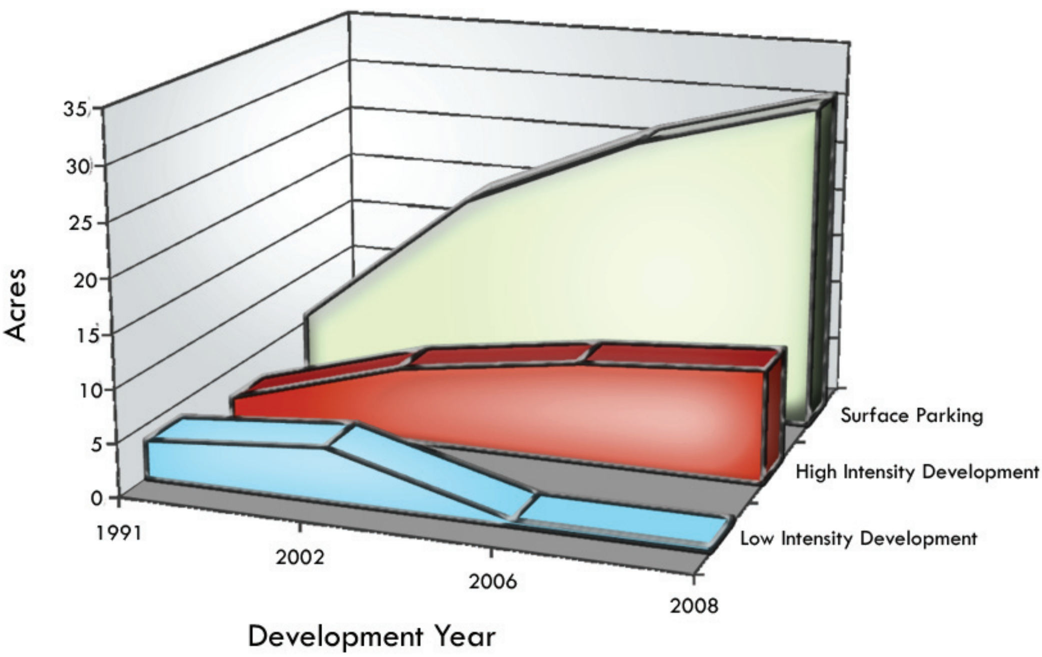



*Figure 3.2 | Development Inventory (Rolfs 2009)*


*Figure 3.3 | Development Inventory*
*(Rolfs 2009*

**Site Inventory** Site elements at the ground level will greatly influence the design and must be considered. A photographic inventory of the project site can be seen in Figure 3.4.

The northern part of the site is currently a producing agricultural field at photography location (4). It is important to note that the land currently used in agricultural production is for sale as commercial property. This tract of land also has direct views to Junction City's "J-Hill", as seen from photography location (9).

The existing wetlands park is found at photography locations (1) and (2). This park allows visitors to come in contact with the present ecosystem. By bringing park visitors to the water's edge and the middle of the oxbow wetlands, visitors are immersed in a wild environment that, from the retail shops, is not apparent. Allowing visitors to escape the rigors of structured development is a very important concept of this project.

Stormwater Best Management Practices (BMPs) are best placed where drainage patterns and grading currently exist. (LIDC 2005) The images at photography locations (3), (5), (7), and (8) depict possible locations for BMPs. The existing drainage and grading patterns are suitable for a BMP retrofit. The locations are also highly visible providing an opportunity for demonstration of the use of BMPs to the community of Junction City. Not only do the BMP retrofit locations provide an opportunity to capture stormwater, they also can be used as part of a naturally linked trail system through the development that connects to existing pedestrian corridor as seen from photography location (9).

Infrastructure influencing the project site can be found in appendix A3.2. Utilities buried underground are important to note because they are expensive to move and should not be placed beneath BMPs due to the increase in ground moisture content. High voltage power lines are strung across the site from north to south, connecting two major electrical substations for Junction City. Due


*Figure 3.4 | Photography Inventory*
*(All Photography by Rolfs 2009)*


*Figure 3.5 | Washed away railroad after 1903 Flood. Location: near project site (Kansas Historical Society)*

to electrical easements, no structure may be placed 50' on either side of the electric line. The locations of storm drain inlets, outlets, manholes, and pipes are also critical to the placement of BMPs. It is important to capture water, in the upper reaches of the watershed, upstream from a drain inlet.

**Flood Considerations** Junction City was built at the confluence of three railway lines as well as three rivers; the Smoky Hill River, Republican River, and the Kansas River. The site is also located on the historic floodplain of the Smoky Hill River. The oxbow wetlands, ecologically considered in this project, were once a part of the Smoky Hill River channel. Although notorious for causing flooding issues with 100year storm events, the Smoky Hill River is detained behind a levee system, which protects western developments of the community.

The first major flood to affect Junction City was in 1903. It washed away part of the railway line. [Figure 3.5] Floodwaters


*Figure 3.6 | Annotated FEMA Flood Map (FEMA 1987)*

encompassed the land from the railroad tracks eastward to the river channel. A flood in 1951 inundated the river valleys once again and put the project site underwater. Milford Dam and Reservoir were built to control flooding of the Republican River basin following the flood of 1951. (usase.gov 2009) This preceded the construction of Interstate 70, in the late 1950s (ksdot.org 2004), as well as the levee system which helps protect lower Junction City from major flood events. Prior to the 1951 flood, the Smoky Hill River occupied the current oxbow until the floodwaters cut the current channel below "J-Hill".

The construction of the levee system opened up a huge portion of land to be developed. One may debate the ethical aspects of building in an historic floodplain. It is important to consider these ethical concerns when designing. [Figure 3.6] This project aims to demonstrate how more sustainable development can be created where development is forecasted to happen. (Comprehensive Plan, Junction City and Geary County 2007) In order to create a development suitable for living, the minimum flood elevation of 1077' must be met for the first floor elevation of buildings on the site. (FEMA 1987) Maintaining first floor elevation has the greatest effect on public health and safety, but is not the only element to consider. It is also important to design the area as a floodable landscape and consider damage and safety concerns of the public.

**Water Quality Testing** Water quality testing was performed by Brett Rolfs with an Industrial Test Systems, Inc Water Quality Test Kit on October 30, 2008 (purchased from FilterWater.com, on October 20, 2008). Sampling occurred on two sites south of the Wal-Mart Supercenter; one in the oxbow off the dock, and the second adjacent to the wetland system along the shore. No harmful nutrients or metals were found and the only change in test outcome was the wetland sample, which had more chloride and a lower pH. The only unsafe result was the bacteria test, which failed. See appendix A3.3 for detailed findings and results as well as a location map. Testing was not conducted on the northern oxbow wetlands, as this property is not open to the public. The results are anticipated to be the same with slightly more nitrogen because the oxbow wetlands are adjacent to agricultural land.

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# Best Management Practice Retrofit Design

4

# BMP Retrofit Design

**Design Concept** A stormwater best management practice (BMP) retrofit is applied to the existing retail development on the project site in Junction City. BMP retrofits are designed to capture the first flush runoff in order to protect the oxbow wetland ecosystem of harmful pollutants generated by existing retail development. By utilizing the stormwater runoff as an amenity for the site, the BMP retrofits are accessible via an education trail system and act as demonstration sites for emphasis of stormwater management. The BMP educational trail links the existing hotels and existing wetlands park with one another and is highly visible to the people of Junction City along the primary transportation corridors.

**Program of Elements** This section of design focuses on the BMP retrofit of the existing commercial retail center with approximately 30 acres of surface parking and circulation systems and approximately 10 acres of building foot prints. In order to begin improving the water quality of the oxbow wetlands a series of stormwater BMP's will be implemented to capture, at minimum, a 'first flush' rain event. The first flush will remove most of the pollutants attributed to surface parking and large building footprints. Capturing the first flush is considered to be 80 percent of a one-hour, two year storm event. (Keane 2009) For Junction City, this is 1.37 inches of rainfall. The capability of BMPs to remove pollutants from stormwater run off will influence their placement and selection. The following BMPs are deemed suitable for use of a retrofit design. (LIDC 2005)

+ Pocket Wetlands
+ Vegetated Bio-retention

Integrating interactive site features as part of the BMP retrofit design provides an opportunity to bring citizens and community leaders in direct contact with the BMPs. An educational trail system will demonstrate the effectiveness of BMPs. It will also create a more efficient, sustainable development with a trail system linking hotels and park space, which prevent reliance on automobiles for movement about the site.

**Retrofit Analysis** Finding locations suitable for BMP retrofits required several layers of information to be analyzed. Because the direction and flow of stormwater runoff is highly dependent on the topography of a site, the first layer of information analyzed is the topography of the site. [Figure 4.2] For proper functionality, BMPs are to be placed adjacent to major waterways, ditches, or

*Figure 4.1 | Integrating people with the landscape (dctc.edu 2009, Rolfs Adaptation 2009)*

swales as the BMP can be washed away. (Dodds 2007) Flat areas, or areas with slopes of less than two percent slope, have lower stormwater velocities and are areas suitable for BMP placement. The low areas of the site are also important to note because they are susceptible to stormwater runoff collection providing an opportune environment for BMPs. The treatment of stormwater runoff is best suited at the source of runoff.

The excessive stormwater runoff on the project site is created by impervious surfaces that consist of building rooftops, surface parking lots, and roadways. Impervious surfaces are an important layer to be analyzed because they emit the most pollutants in stormwater runoff. (Dodds 2007) By keeping BMPs adjacent to the impervious surfaces they will capture runoff further up the watershed, decreasing stormwater runoff. They also reduce the minimum size of BMPs, at the end of the watershed, before the runoff enters the oxbow wetlands or storm drainage system.

In order to maintain the oxbow wetlands ecosystem, limiting any development within 50 feet to 200 feet from the oxbow wetlands is important. (SSI 2008) Preventing any development in this area reduces wetland sediment loading and will preserve wetland vegetation. The placement of BMPs will not occur where vegetation is to be preserved and must be at least 200 feet from the oxbow wetlands. While most of the layers studied in this analysis prevent BMPs from being placed in a certain locations, the accessibility and visibility to areas where BMPs may be constructed, is particularly important.

The consideration of all analysis layers yields a final layer of information, which indicates the most suitable locations for BMP retrofits. These will capture the first flush storm event and are the locations which will be considered for BMP selection and design.

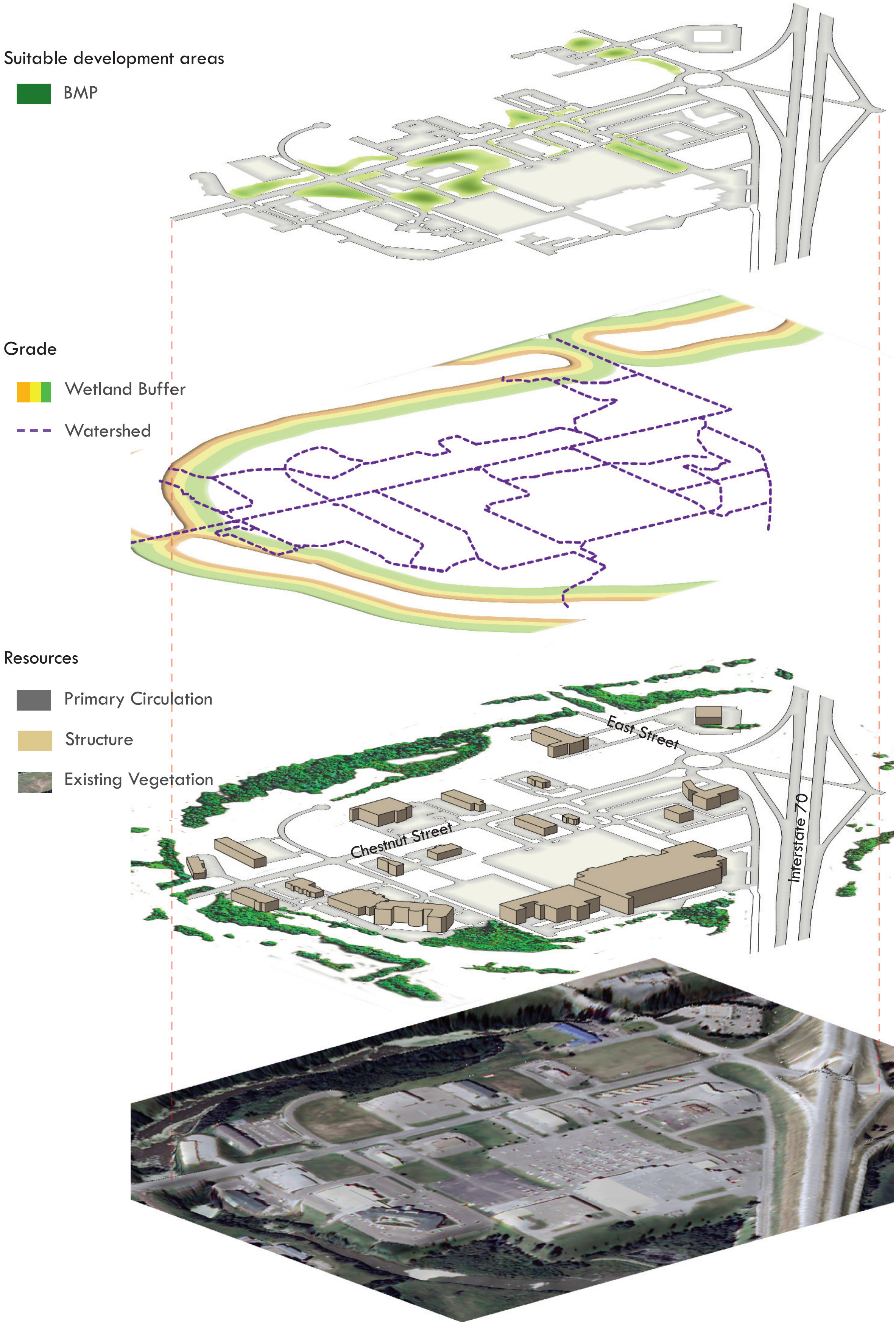



*Figure 4.2 | Layered Analysis*
*(Rolfs 2009)*

## BMP Selection and Design

The location and type of BMPs selected for this stormwater retrofit were derived through site analysis (figure 4.2) and a detailed study of existing watersheds and drainage patterns on site that can be seen in figure 4.3. The quantity of stormwater travelling across impervious paving is the primary determining factor for BMP selection. [appendix A4.2-10] The two BMPs deemed suitable for this retrofit, pocket wetlands and vegetated bio-retention cells (rain gardens), are capable of treating vast quantities of water. (LIDC 2005)

to maintain a consistent water level, which supports various plants and animals. The constructed wetlands act as a stormwater depository. Unlike natural wetlands, their use is intended to collect stormwater runoff and will not degrade when used as a stormwater depository.

## Educational Trail system

The site analysis in figure 4.2 identified locations for BMP retrofits that are highly visible to members of the Junction City community. Not only are the optimum

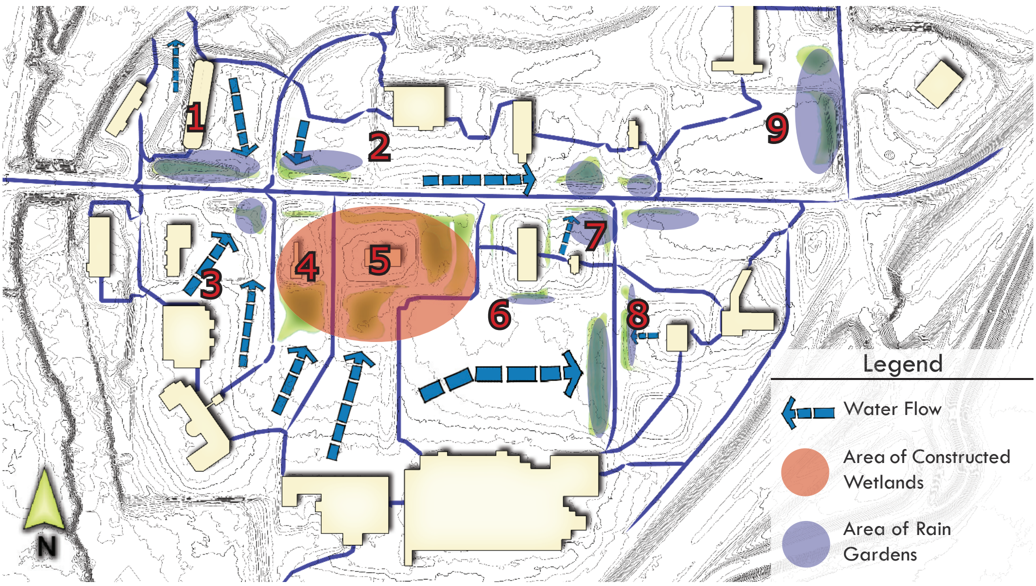



*Figure 4.3 | Watershed Diagram (Rolfs 2009)*

It is important to know that rain gardens are typically used in applications where they are not placed in line with a drainage corridor. (Dodds 2007) While rain gardens infiltrate water extremely fast, their construction yields a relatively weak composition when exposed to water quickly moving through them. Rain gardens are positioned throughout the watersheds to capture smaller quantities of point source pollutants and runoff. They do not maintain water levels during dry weather.

Constructed pocket wetlands are located at the end of a watershed, in line with a drainage corridor. The pocket wetlands are designed

locations for BMPs selected by their visibility from roadways and existing sidewalks, the visibility from possible trails linking the hotels on the site. The BMP retrofit development supports unconventional ideas by promoting education and a positive sense of place in a strictly retail and commercial environment.

The educational trail system is integrated in the rain garden and pocket wetland design scenarios that follow. Understanding how the educational trail system relates to the represented BMP system is important because it shows the human relationship.

## Vegetated Bio-Retention

*(Rain Garden)*

The vegetated bio-retention areas, also known as rain gardens, are located thoughout watersheds one, two, six, seven, eight, and nine. As seen in table 4.1, the combined watersheds are successful at capturing 2.38 acre-feet of water, which is above the 2.31 acre-feet required to capture the first flush (80 percent of a 2 year, 1 hour storm event).

Minimal site grading is needed to achieve capturing the first flush event through the retrofit of rain gardens. The selection of sites for rain gardens, as seen in figure 4.4, take into account the existing grade to utilize sites that naturally have a shallow depression, such as in a small slope, swale, or ditch. These locations also typically include an existing storm drain that can be retrofitted to provide emergency overflow drainage in the event that a rain garden overfills during a heavier storm event. With any stormwater collection method, an emergency overflow is critical to establish for preventing flooding of walkways, streets, or structures. [figure 4.5]

The position and placement of rain gardens must be carefully considered. They must be placed in the higher reaches of watersheds to collect point source runoff that contains urban stormwater runoff pollutants. (Dodds 2007)

Although identified as a vegetated buffer in some instances, the rim of the rain garden consists of low growing native grasses, like Buffalo Grass. Native grasses slow overland flow and allow the stormwater runoff to decrease carrying capacity, thus dropping solids before they enter the rain garden. The rain garden itself is planted with tall, native vegetation that is drought tolerant and can be inundated by water for short periods of time.

By establishing a series of rain gardens along the existing pedestrian corridors and vehicular corridors, the residents of Junction City, and tourists visiting the community, will experience a new place of which they can be proud. [Figure 4.6] Rain gardens are highly visible and provide a sense of enjoyment

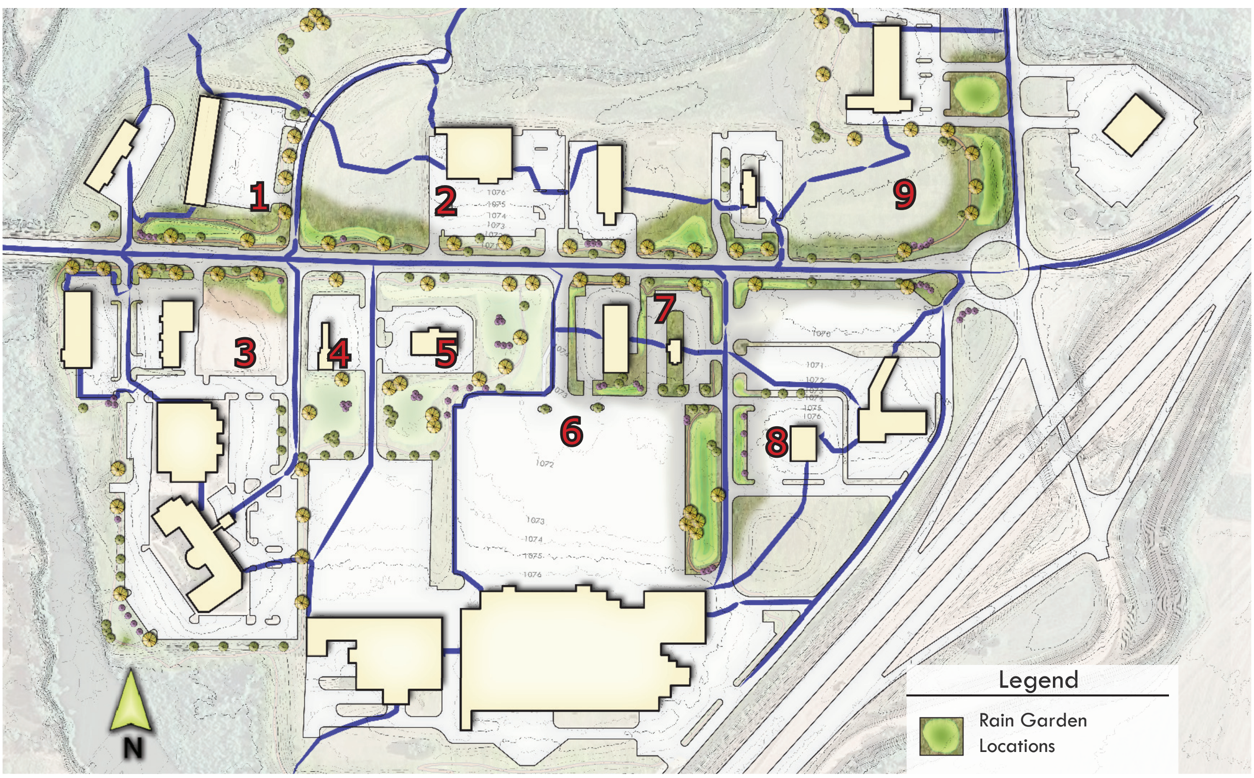



*Figure 4.4| Watershed and Rain Garden Mapping (Rolfs 2009)*

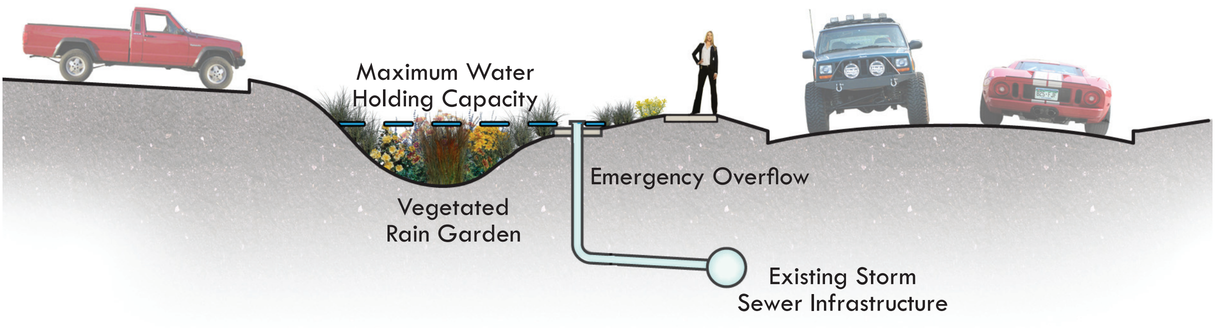



*Figure 4.5 | Typical Rain Garden Section Representation*
*(Rolfs 2009)*

and connectivity to the natural systems of the world. Because rain gardens are easily seen from the road side or sidewalk, they are excellent sites to promote and demonstrate the uses and effectiveness of rain garden BMP development. Educational signage along the existing sidewalk informs pedestrians of the benefits of rain gardens to inspire visitors and residents to practice similar strategies on their own property.

| | Area | 1st flush quantity | Bio Retention Area | | | Quantity retained on site | |
|---|---|---|---|---|---|---|---|
| Watershed | *Acres* | *inches* | *Acre-Feet* | *Gallons* | *Sf-Feet* | *Square feet - feet* | *Acre-Feet* |
| 1 | 2.86 | 2.65 | 0.22 | 72,062 | 9,633 | 10,175 | 0.23 |
| 2 | 6.72 | 5.60 | 0.47 | 152,143 | 20,339 | 21,133 | 0.49 |
| 6 | 9.61 | 11.20 | 0.93 | 304,017 | 40,641 | 40,700 | 0.93 |
| 7 | 2.00 | 2.13 | 0.18 | 57,847 | 7,733 | 8,500 | 0.20 |
| 8 | 1.05 | 2.18 | 0.18 | 59,245 | 7,920 | 7,950 | 0.18 |
| 9 | 5.92 | 3.97 | 0.33 | 107,764 | 14,406 | 15,102 | 0.35 |

*Table 4.1 | Watershed and Stormwater Calculations and Conclusions*
*(Rolfs 2009)*


*Figure 4.6| Rain Garden Interaction*
*(Rolfs 2009)*

## Constructed Wetlands

In addition to rain gardens, constructed wetlands provide aesthetically pleasing stormwater BMPs retrofits. They are located in watersheds three, four, and five of the existing retail development. [Figure 4.7] The constructed wetlands have a combined wetland retention area of 1.66 acre-feet as seen in table 4.2. The minimum volume necessary to retain the first flush storm event is 1.3 acre-feet indicating that the program goal was exceeded.

The constructed wetlands are located in depressed areas toward the end of the watershed, along proposed trails, and in close proximity to primary circulation corridors. Unlike naturally occurring wetlands, constructed wetlands are designed to function properly when used as a stormwater retention basin and are built in line with the drainage corridors. The constructed wetlands function much like rain gardens the exception being that constructed wetlands maintain a pool level to support a variety of plant and animal species. Because the constructed wetlands are located in an urban area, an emergency overflow drain is adapted to the existing storm drainage infrastructure in place on the site. [Figure 4.8]

Constructed wetlands contain more variety of plant species than rain gardens. Their undulating ground level allows for plants with different moisture needs to thrive in a variety of growing conditions. Providing for a variety of vegetation, establishes the constructed wetland as a special place where natural expression can thrive in the city. Residents and visitors can experience and enjoy natural processes that improve water quality and the health of the development.

Since the location of the constructed wetlands was derived from the site analysis, they are highly visible to those moving through the site along the existing roadways and sidewalks. The wetlands are also interactive through the use of the educational trail system, which is ADA accessible, and traverses the middle of the wetlands. Allowing community members and visitors the area to closely interact and

| Watershed | Area *Acres* | 1st flush quantity *inches* | Bio Retention Area *Acre Feet* | *Gallons* | *Sf Feet* | Quantity retained on site *Square feet - feet* | *Acre-Feet* |
|---|---|---|---|---|---|---|---|
| 3 | 3.91 | 5.02 | 0.42 | 136,418 | 18,236 | 21,133 | 0.49 |
| 4 | 0.64 | 3.74 | 0.31 | 101,435 | 13,564 | 15,800 | 0.36 |
| 5 | 7.74 | 6.86 | 0.57 | 186,285 | 24,903 | 35,500 | 0.81 |

*Table 4.2 | Watershed and Stormwater Calculations and Conclusions (Rolfs 2009)*

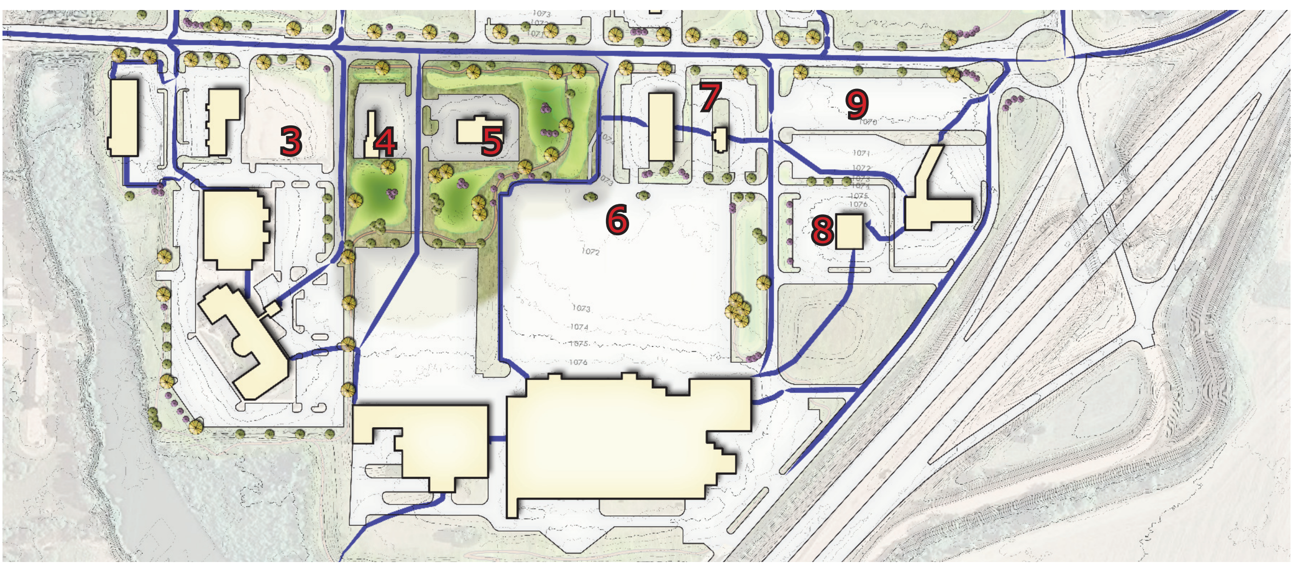



*Figure 4.7 | Watershed and Constructed Wetlands Mapping (Rolfs 2009)*


*Figure 4.8 | Typical Constructed Wetlands Representation*
*(Rolfs 2009)*

experience such a wild landscape connects them to the natural environment surrounded by big box retailers.

Once fully immersed in the landscape, educational signage along the trail, and sidewalks, paint a picture of the importance and necessity of the constructed wetlands in, and around, a retail development. The educational trail easily ties into the existing sidewalk with an inviting array of plants, educational signage, and changing of pathway materials. During storm events that cause the constructed wetlands to reach maximum water holding capacity, the educational trail remains accessible by everybody who desires to experience the space.


*Figure 4.9 | Constructed Wetland Interaction and Trail System*
*(Rolfs 2009)*

## BMP Retrofit Conclusion

New development ideas and patterns promote ideas typically not found in Junction City. Stormwater best management practice retrofits are applied to the existing retail development site in Junction City. The BMP retrofits, rain gardens and constructed wetlands, are designed to capture, at minimum, the first flush runoff, which is 80 percent of a two year, one hour storm event. Capturing and treating stormwater runoff protects the oxbow wetland ecosystem from harmful pollutants generated by existing retail development.

Minimal site grading makes the BMP retrofit more attractive to parties interested in implementing them. Utilizing the existing storm drainage infrastructure provides emergency overflow drainage in the event that a rain garden over fills in a heavier storm event. In any stormwater collection method, an emergency overflow is critical to establish in preventing flooding of walkways, streets, or structures.

A variety of retrofits improves the aesthetics of the site and promotes a stronger sense of community and place. By utilizing the stormwater runoff as an amenity for the site, the BMP retrofits are accessible through the education trail system and act as demonstration sites of the effects of stormwater management. The BMP educational trail links existing hotels and the wetlands park with one another and is highly visible to the people of Junction City along primary transportation corridors.

# Mixed Use Development Design

5

# Mixed Use Development Design

**Design Concept** More sustainable development practices can help Junction City preserve existing natural resources in and around the city. The northern development site prescribes a mixed use development that retains all runoff generated by a 25 year storm event on site. Views of "J-Hill" are preserved, enhanced, and framed through the integration of open space and careful building massing. As in the southern portion of the site, all innovative stormwater solutions are accessible through the education trail system, which links all of the proposed development, downtown Junction City, and existing development on the southern site component. This sustainable development is a demonstration, which focuses on a new type of development for Junction City.

THE MIXED USE DEVELOPMENT PROJECT SITE IS LOCATED BEHIND THE SMOKY HILL RIVER LEVEE SYSTEM AND IS STILL REGARDED AS BEING PART OF THE FLOODPLAIN SYSTEM. THE GEARY COUNTY AND JUNCTION CITY COMPREHENSIVE PLAN (2007) HAVE IDENTIFIED THE SITE ZONED FOR COMMERCIAL USE. THE SITE IS CURRENTLY 'FOR SALE' AS COMMERCIAL PROPERTY. DEVELOPMENT ON THE SITE WITHIN THE FLOODPLAIN IS INEVITABLE. THIS HIGH DENSITY MIXED USE DEVELOPMENT PROVIDES THE LEAST INVASIVE WAY TO DEVELOP THE LAND MINIMIZING THE PLACEMENT OF FILL IN THE FLOODPLAIN.

**Program of Elements** The purpose of the mixed use development design is to provide a stark contrast to the existing development which was retrofitted with stormwater BMPs. This sustainable mixed use development will be an extension of downtown Junction City and provide an example for how future developments should be explored. This model of mixed use development is not guided by stringent rules and regulations as a New Urbanist development might require. (Figure 5.1)

The program for the mixed use development is specific to the particular site in Junction City, Kansas. All of the programming elements are designed to support and embrace the thriving historic downtown in Junction City. The program also includes the existing and proposed zoning regulations, which identifies the project site for commercial use. Some of the selected commercial and retail uses proposed for the site include:

+ Corner Store
+ Small Boutique Stores
+ Clothing Store
+ Specialty Outdoor Equipment
+ Branch Bank
+ Restaurants

People are critical to the success of any mixed use development. (Department for communities and local government 2002)

*Figure 5.1 | Integrating people with the landscape (dctc.edu 2009, Rolfs Adaptation 2009)*

Residential apartments and lofts will be integrated with the proposed retail system and will also be included as stand alone units.

Public open spaces and civic development play an important role in the shaping of this development. A train depot museum, public park, and a recreation trail system are amenities to be integrated into the fabric of the mixed use development.

In addition to structures to be placed on the site, the mixed use development is to retain 100 percent of stormwater runoff from a 25 year, 1 hour storm event on site. A series of stormwater best management practices (BMPs) will be used to capture runoff close to the generating source, reducing runoff velocities and quantities. (Dodds 2007)

The layout of the development will resemble the historic grid layout while allowing for minimal grading and natural drainage corridor preservation. Connections to the existing road system are critical.

**Site Analysis** The most critical preexisting condition on the site is to consider the possibility of flooding. (Figure 5.2) As with the BMP retrofit, the mixed use development structures will need to have a finished floor elevation at least one foot above the base line flood elevation. (Junction City Ordinance

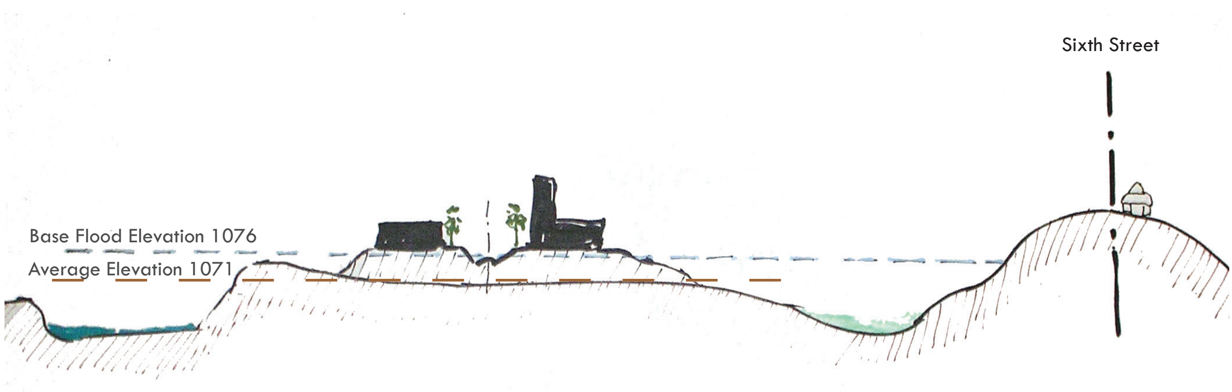



*Figure 5.2 | Diagrammatic Flood Analysis Section (Rolfs 2009)*

460) The base line flood elevation for the mixed use development site is 1076 feet above sea level. (FEMA 1987) Any built elements on the site can be placed below the 1076 feet base line flood elevation if they meet the following requirements during a flood event:

+ May not be swept away
+ No danger to life or property
+ No erosion
+ Does not negatively impact the proposed development
+ Emergency vehicles have access to the development
+ Minimal maintenance or repair following the flood event

(Junction City Ordinance 460)

Understanding the dynamic of the site as it relates to the implementation of a mixed use development is important. All though the site is currently a producing agricultural field, with only nine feet of elevation relief, other aspects and influences of the site need to be studied. A site analysis, containing layer of the aspects that influence in the mixed use development, can been seen in figure 5.3.

The existing road infrastructure provides excellent vehicular connections to the site. Adjacent to the northern site boundary line, four lane 6th street leads directly to the historic downtown of Junction City. Another primary vehicular circulation path is along East Street, which that runs south towards existing retail and commercial development that will be  which was retrofitted with BMPs. Not only do the roads  surrounding the site provide excellent vehicular connections, they also introduce primary view corridors into the site. The JC livestock facility is an auction house and must be considered if it is to remain at its current location, adjacent to the site. An existing park and ball field are located northeast of the project site and establish a pedestrian node linking to the mixed use development site.

Certain areas of the site must be avoided when establishing a mixed use development. Two, 100 foot electrical easements are found on the site and must be avoided for possible structure locations as well as dense vegetation.  In order to protect the oxbow wetlands ecosystem, a minimum 200 foot buffer must be implemented around the oxbow wetland. (SSI 2008) Preventing construction within the oxbow wetland buffer exhibits the practice of minimal site disturbance and is encouraged by the Sustainable Sites Initiative. The tract of land that the JC Livestock facility resides on is considered part of the mixed use development project. However, it is important to note that the facility may not vacate the property and should only be considered as a location for a program element that will not be critical to the design of the mixed use development.

Topography is the final, and perhaps, most important layer of information to consider when locating opportune areas for development. As previously mentioned, and demonstrated in figure 5.2, the site has potential as a flooding hazard and requires special attention. Additionally, the elevation relief of the ground plane must be studied. Because the site is currently used for agricultural production, there are no slopes greater than three percent that could cause issues in the placement of structures or road systems. Approximately 85 percent of the site drains toward the northeast, away from the oxbow wetlands, due to a continuous high point along the edge of the wetlands oxbow. This was probably created  by the years of agricultural production on the site. The pre-existing low points on the site are opportune locations to develop large scale, constructed wetlands to be used to treat excessive stormwater runoff that may not be treated within the mixed use development.

The most suitable locations for large scale stormwater BMPs and the establishment of a mixed use development are identified at the top layer of figure 5.3.  These are locations that avoid the no-build area, buffers, and take into account the existing vehicular circulation patterns as well as existing ground level elevation. The tan locations are where the core development areas are located and green areas are where large scale stormwater BMPs are located.

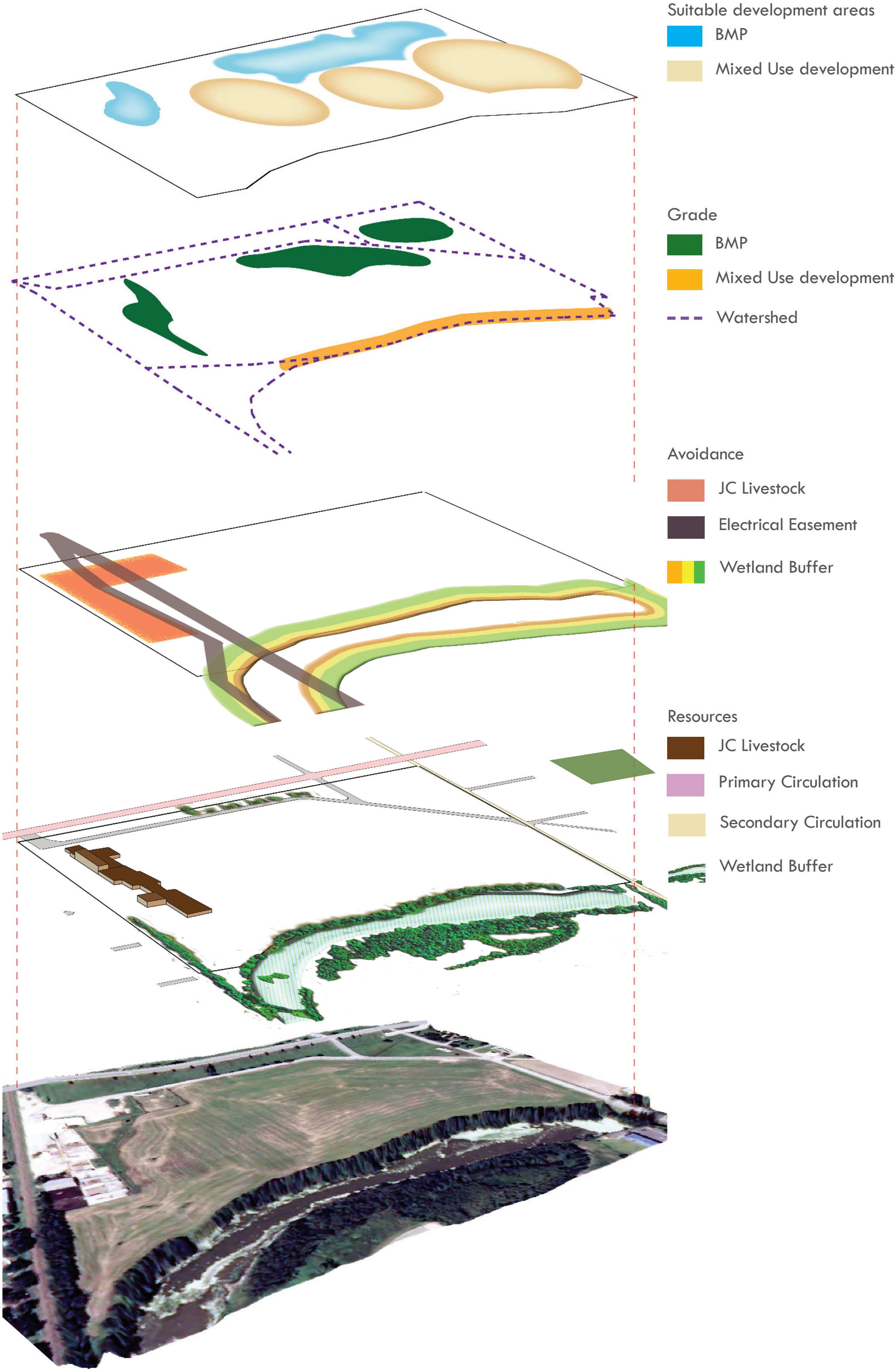



*Figure 5.3 | Layered Mixed Use Development Analysis (Rolfs 2009)*


*Figure 5.4 | Mixed Use Development Site Plan (Rolfs 2009)*

## Unconventional Ideas

This mixed use development proposed for is to be a demonstration site for Junction City. [Figure 5.4] It provides an example of how future development should occur as the community continues to grow. Unconventional ideas are used to demonstrate how an economically effective development can be aesthetically pleasing, protect the surrounding ecosystems, and even provide a refuge for people and animals.

Located along interstate 70, the development provides an opportunity for the city to embrace all of its amenities and assets. Tourists exiting the interstate will find desired conveniences in one mixed use development. The site will contain a corner store, a number of restaurants, a bank, shopping, and a number of interactive recreation opportunities. From the roadway, just enough of the site is visible to draw attention of passersby. Because it will be a catalyst site in Junction City, the visitor can establish a sense of community, innovation, and well-being. For the tourist, this development can be the place to stop and stay a while.

A resident of Junction City will experience the site much differently as they spend more time there, some may even establish it as their home. The development contains over 45 residential dwelling units. Integrating people amongst retail and commercial outlets creates a dynamic landscape that is welcoming and interesting.

Unlike typical suburban development patterns, mixed use development utilizes shared parking principles. By condensing surface parking, for many businesses, into a few centrally located lots, the density of the mixed use development increases as does the amount of open space intended for public use. In addition to the 593 parking stalls found in condensed surface parking and along streets, 300 parking stalls are located in the three level parking garage attached to a mixed use building structure. [Table 5.2]

Integrating a variety of building uses creates a space desirable by many. Although most of the site plan is dedicated to mixed retail and commercial use, strictly residential high density structures surround the proposed urban park space as seen in table 5.1 and figure 5.5. In addition to strictly residential development, public use facilities enhance use diversification within the proposed mixed use development. Promoting retail uses that support the desires of the project are also important. A 10,000 square foot sports and outdoor store is proposed on the site to promote interaction with the amenities offered within the project and community of Junction City. The farmers market brings people into the site and positions them close to the heart of the development. A train depot museum is proposed on the JC Livestock tract of land. In addition to the farmers market pavilion, the train depot museum will attract people and bring them further into the site. It is important to draw people into the site for reasons other than retail and commercial. Once people have reached their desired destination in the development, they can effectively move through out the entire site without needing to drive a car. Green corridors are integrated within the development to provide places for comfortable linking paths between the uses provided on site. The integrated green space corridors link comfortable and attractive streetscapes with one another. [Figure 5.6 and Figure 5.7] Integrated green space within the mixed use development introduces more destination possibilities within the site, such as trails and interactive educational experiences.

**Environmental Health** In addition to providing the community of Junction City with a model mixed use development, this project aims to promote innovative stormwater management solutions in a

| | | |
|---|---|---|
| | Residential | 23,500 sf |
| | Loft Residential and Mixed Retail | 105,000 sf |
| | Retail and Commercial | 50,000 sf |
| | Public Use Facilities | 17,400 sf |
| | Urban Park | 90,000 sf |

*Table 5.1 | Land Use Square Footage (Rolfs 2009)*

| Use | Requirement | Minumum | Provided |
|---|---|---|---|
| Residential | 2 per Unit | 90 | 99 |
| Commercial | 1 per 300sf | 167 | 201 |
| Mixed Use | 1 per 300sf | 350 | 479 |
| Public Use | 1 per 200sf | 87 | 114 |
| Total | | 694 | 893 |

*Table 5.2 | Parking Allotment (Rolfs 2009)*

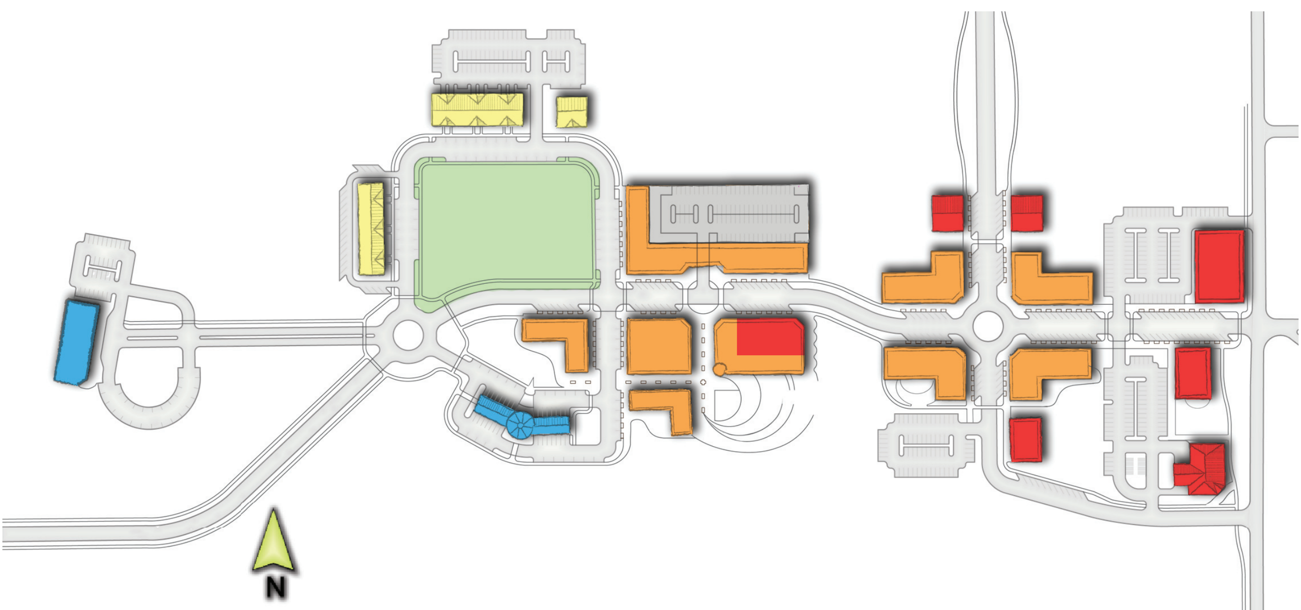



*Figure 5.5 | Land Use Relationship Diagram (Rolfs 2009)*

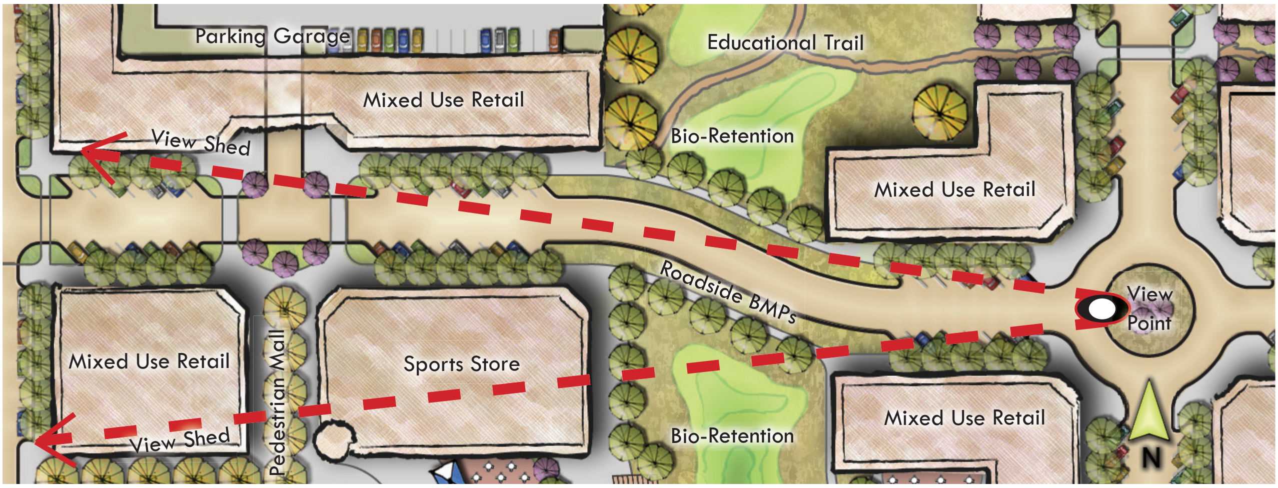



*Figure 5.6 | Mixed Use Streetscape Enlargement Plan (Rolfs 2009)*


*Figure 5.7 | Mixed Use Development Streetscape*
*(Rolfs 2009)*

community that has few. While the existing retail and commercial development south of this proposed site was retrofitted with stormwater best management practices to retain and cleanse the first flush rain event, this mixed used development is integrated with BMPs to capture and cleanse the run off of a 25 year storm event, on site.

Achieving zero runoff is accomplished by integrating small scale BMPs within the development and along the green pedestrian linking corridors. [Figure 5.8] These small scale BMPs will capture the first flush event as achieved in the BMP retrofit. (Dodds 2007) The small scale BMPs are very effective in the removal of pollutants that are, by nature, generated when structures and automobiles are introduced to the landscape.

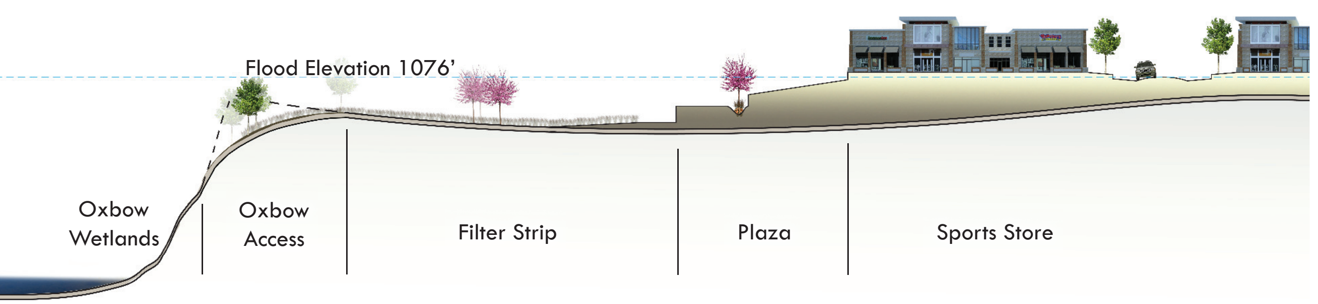
In addition to small scale BMPs, that capture the first flush storm event, excessive stormwater run off is captured and stored in a series of bio-retention areas. Large scale bio-retention areas are constructed on the existing grade, or close to it, in order to maintain the natural drainage patterns existing on the site. [Figure 5.9] Because the small scale BMPs capture localized pollutants, stormwater runoff that is captured by the bio-retention areas is generally cleaner meaning these areas can support a variety of plant and animal life.

The proposed mixed use development and landscape generates 62.81 inches of stormwater runoff that needs to be stored in 5.24 acre-feet of BMP and bio-retention areas. [Table 5.2] The mixed use development design will be successful in capturing and cleansing 5.43 acre-feet of stormwater runoff. The landscape surrounding the mixed use development and stormwater BMPs is planted with native prairie grasses. These native grasses provide superior filtering and infiltration of water as it runs off the landscape. The native grasses reconnect Junction City to the prairies of the Flint Hills which seem to have been forgotten. The use of native prairie plants on a large scale greatly reduces the need for irrigation thus making the development more sustainable.

## Community Pride

The history of Junction City is a full of people who were proud to be from the region and strived to make to make their home a better place. The residents of Junction City are proud of their heritage and continuously strive to make their hometown a better place that is enjoyable by all. That is why it is critical that the mixed use development supports the community and establishes its self as a place for the people.

Centrally located, and essential, to the mixed use development is a pedestrian mall as seen in figure 5.10 and figure 5.11. The pedestrian mall connects the farmers market and parking structure with a pedestrian avenue. Terminating the pedestrian mall at the south is a plaza that overlooks the oxbow wetlands and capitalizes views toward Junction City's 'J-Hill'.



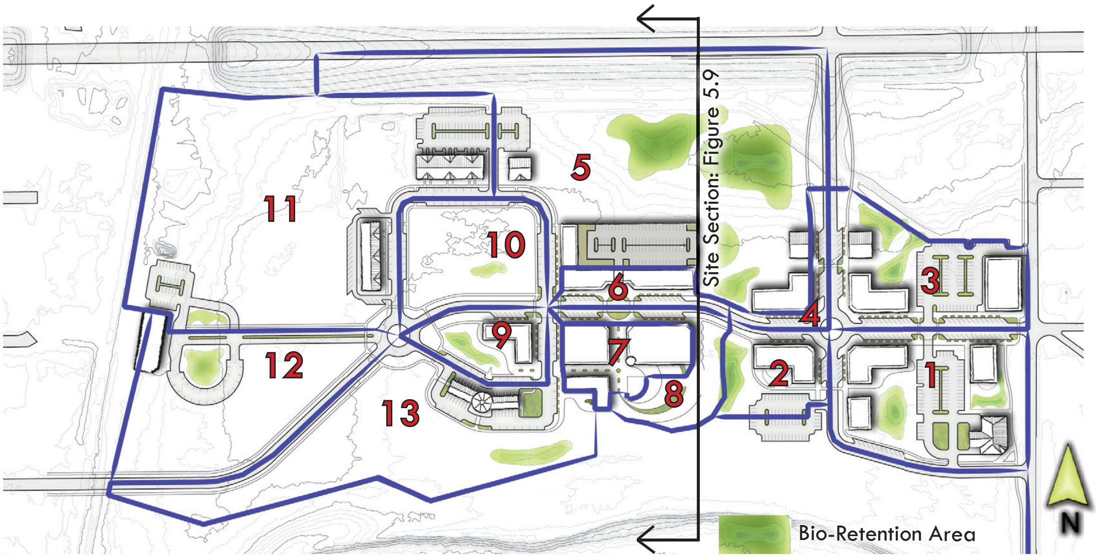



*Figure 5.8 | Watershed Diagram*
*(Rolfs 2009)*

| Watershed | Area | 25yr storm quanity | Minimum Bio-Retention Volume | | | Quantity retained on site | |
|---|---|---|---|---|---|---|---|
| | *Acres* | *inches* | *Acre-Feet* | *Gallons* | *Sf-Feet* | *Square feet - feet* | *Acre-Feet* |
| 1 | 4.43 | 7.58 | 0.63 | 205,791 | 27,510 | 28,023 | 0.64 |
| 2 | 1.20 | 2.25 | 0.19 | 61,108 | 8,169 | 8,316 | 0.19 |
| 3 | 3.44 | 6.28 | 0.52 | 107,644 | 22,812 | 23,319 | 0.54 |
| 4 | 0.64 | 1.10 | 0.09 | 29,804 | 3,984 | 4,231 | 0.10 |
| 5 | 13.29 | 13.45 | 1.12 | 365,126 | 48,810 | 50,055 | 1.15 |
| 6 | 0.98 | 2.20 | 0.18 | 59,676 | 7,977 | 8,517 | 0.20 |
| 7 | 1.40 | 2.83 | 0.24 | 76,800 | 10,267 | 10,515 | 0.24 |
| 8 | 1.05 | 1.07 | 0.09 | 29,077 | 3,887 | 3,900 | 0.09 |
| 9 | 1.41 | 2.11 | 0.18 | 57,277 | 7,657 | 7,699 | 0.18 |
| 10 | 2.76 | 2.75 | 0.23 | 74,733 | 9,990 | 10,170 | 0.23 |
| 11 | 11.60 | 10.63 | 0.89 | 288,693 | 38,593 | 41,161 | 0.94 |
| 12 | 4.96 | 5.51 | 0.46 | 149,673 | 20,008 | 21,722 | 0.50 |
| 13 | 4.90 | 5.05 | 0.42 | 137,140 | 18,333 | 19,061 | 0.44 |
| Totals | 52.60 | 62.81 | 5.24 | 1,642,542 | 227,997 | 236,689 | 5.43 |

*Table 5.3 | Mixed Use Development Bio Retention Volume*
*(Rolfs 2009)*

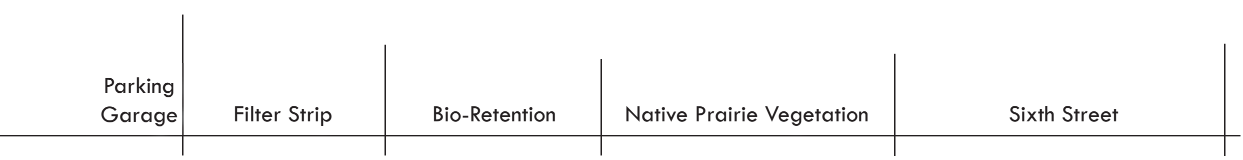



*Figure 5.9 | Mixed Use Development Site Section (see figure 5.8)*
*(Rolfs 2009)*

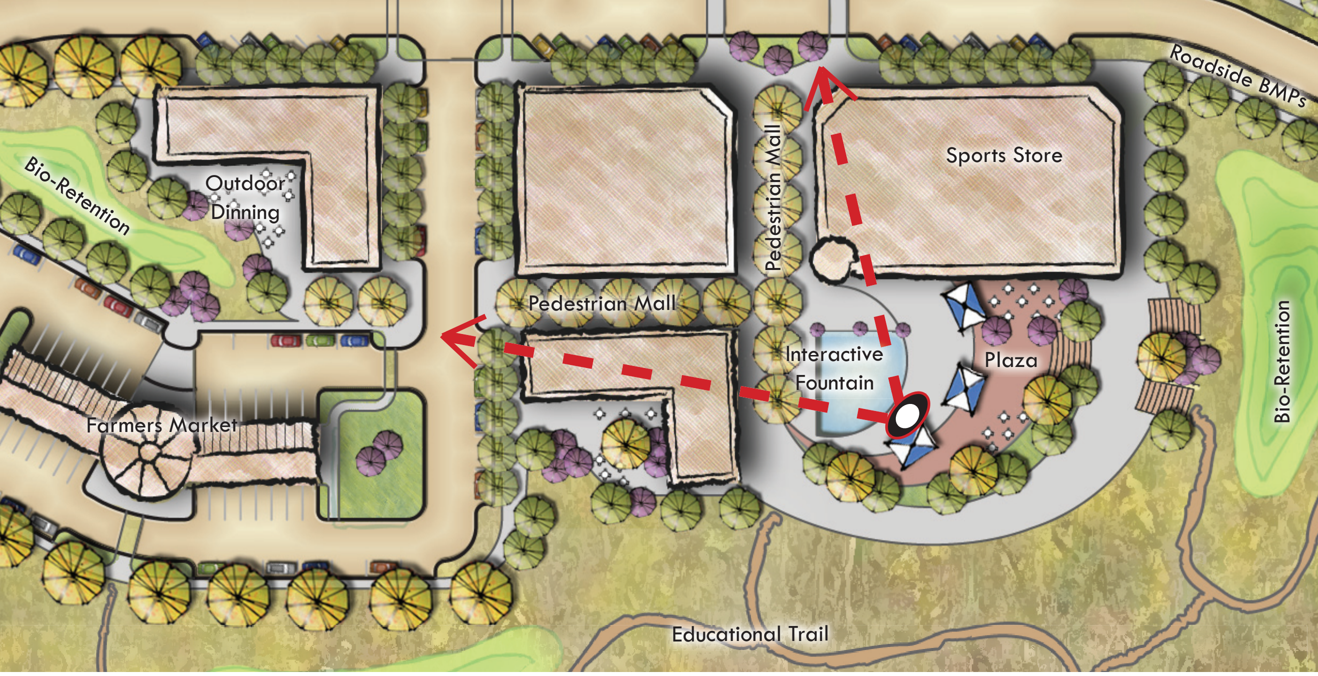



*Figure 5.10 | Pedestrian Mall Enlargement Plan (Rolfs 2009)*

*Figure 5.11 | Pedestrian Mall*
*(Rolfs 2009)*

Although the pedestrian mall is an urban element in the project, it should be made of porous paving. The pavement allows water to percolate it and be stored for later use. The stormwater collected by the porous paving is treated and stored for use in the interactive plaza fountain. Located at the terminus of the pedestrian mall is an interactive fountain. The interactive fountain feature provides site visitors a refuge on hot summer days at the south end of the mall. It is surrounded by shops, restaurants, and a multi use, large plaza.

The plaza space integrates a stormwater BMP. It also ramps and steps down to the existing ground level, below the base flood elevation the buildings are required to meet. As the final terminus point of the pedestrian mall, the plaza is designed to accommodate public events where shade tents or booths can be set up, for example, as an extension of the farmers market if it grows in popularity.

Through circulation and pedestrian paths, the mixed use development is connected with the historic downtown of Junction City. This is important to notice as a primary objective of this project in order to prevent competition with downtown Junction City.

Integrated within the design of the mixed use development and stormwater management practices is an educational trail system. This trail system is designed to supply a connection with oxbow wetlands and bio-retention areas. Educational signage and experiences demonstrate how effective design and stormwater management practices provide an aesthetically pleasing, yet productive, development that can fit the model of sustainability.

## Mixed Use Conclusion

Sustainable development practices will help Junction City improve environmental health by preserving existing natural resources and implementing stormwater best management practices. The mixed use development retains all water generated by a 25 year storm on site. The stormwater solutions are accessible through the education trail system, which demonstrates a new type of development in Junction City. Higher Density commercial development does not detract from historical importance of and influence on the project.

# Conclusion

6

# Conclusion

## Comprehensive Master Plan

Junction City is a small Kansas town blessed with a diverse community, spectacular recreation opportunities, and town staff who are eager to maintain the community's amenities. The design project overcomes polluted stormwater runoff and prescribes a more sustainable style of development. Integrating the development into the community's history, social fabric, and natural resource base was essential to the development of the master plan.

More sustainable development practices will help Junction City preserve existing natural resources in and around the city. The northern development site calls for a mixed use development that retains all runoff generated by a 25 year storm event on site. A stormwater best management practice (BMP) retrofit is applied to the existing retail development in the southern part of the project site. The BMP solutions are designed to capture the first flush runoff of harmful pollutants that otherwise would find their way into a fragile ecosystem.

Unlike the existing southern development, the proposed mixed use development north of the oxbow wetlands is tightly compacted, high density landscape. This is essential because the site, yet behind a levee system, is located within the Smoky Hill River Floodplain. The compact design reduces the amount of fill placed in the floodplain, defines the development as a place, and provides open space amenities for the community. In retrospect, the preexisting southern development site had previously been filled and developed with a loosely linked array of structures and parking lots.

By utilizing stormwater runoff as an amenity for the project, an education trail system, and demonstration site for the effects of stormwater management can be emphasized. The BMP educational trail links existing hotels, the wetlands park, and the mixed use development with one another. The trail system and features are highly visible to the people of Junction City along primary transportation corridors. All innovative stormwater solutions are accessible through the education trail system linking all of the proposed development, downtown Junction City, and the existing development on the southern part of the site.

The integration of people is critical to the success of any development. Public open spaces and civic development played an important role in the shaping of this project. A train depot museum, public park, and a recreation trail system are amenities integrated into the fabric of both the mixed use development and retrofit aspects of the project.

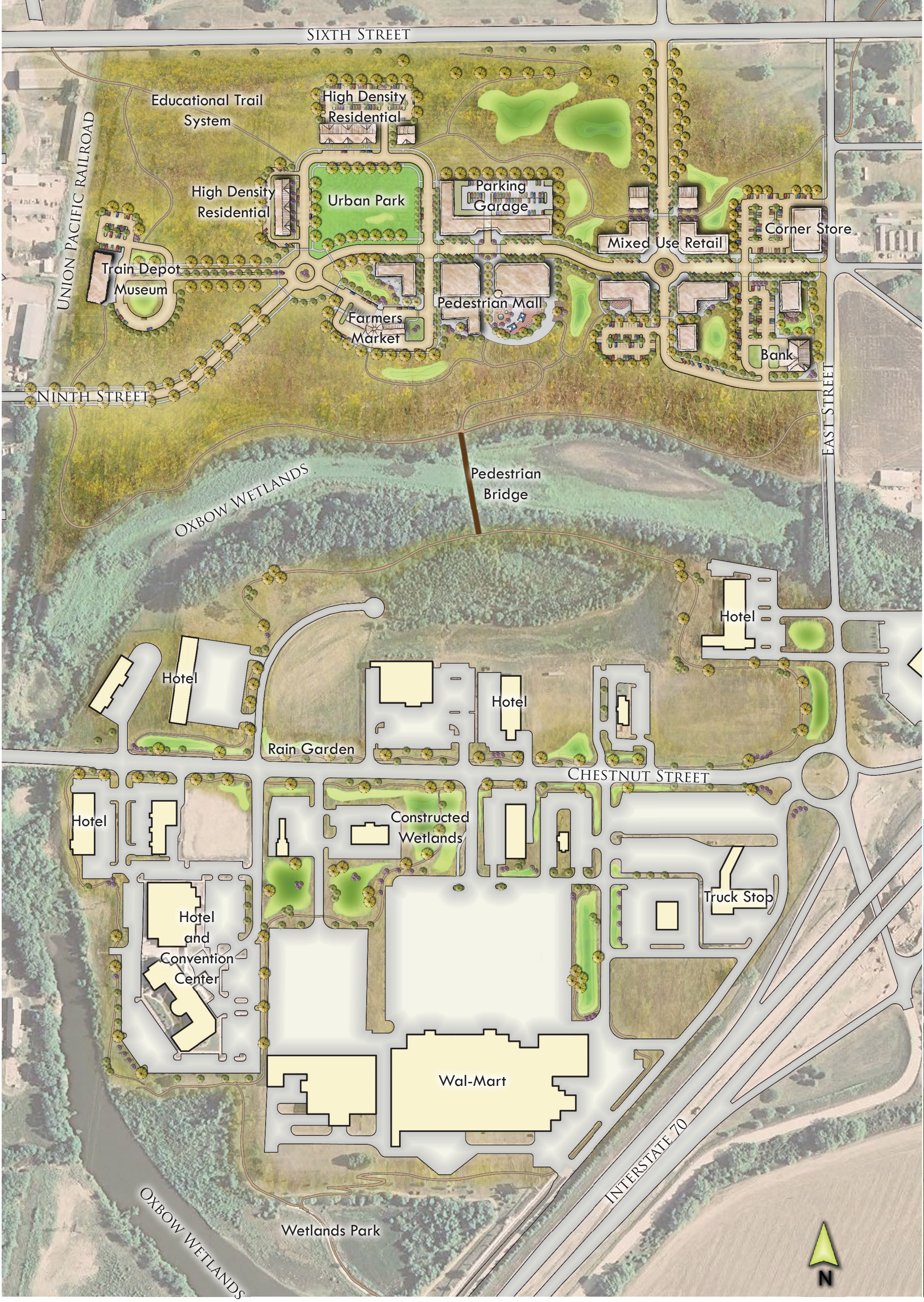



*Figure 6.1 | Comprehensive Master Plan (Rolfs 2009)*

## Anticipated Future

It is a known fact that Junction City will continue to grow. In fact, with the Big Red 1 in the process of moving back to Fort Riley, the community of Junction City has swelled very quickly. Even without military influence, Junction City has the potential to be a remarkable place that anyone would be proud to call home.

How Junction City continues to grow and prosper is up to citizens and town staff. With a growing population and fantastic interstate frontage, the community will soon be targeted by businesses and developers as a place to build. How Junction City responds to the requests and demands of these people will define the future.

Junction City is in a unique position for growth and development. The community can continue on its path of solitary developments not integrated with one another as many communities have done. It is only a matter of time until those existing developments will need to be retrofitted with BMPs and public space due to environmental concerns (water quality and water quantity) or the citizens desire. Curently, the city has the opportunity to implement green technology and be on the forefront of innovative development and community design. [Figure 6.2]


Possible Future

Current

*Figure 6.2| Possible Future Compared to Current Situation (Rolfs 2009)*

# Further Information

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# Glossary

**Best Management Practices (BMPs)** - *Effective, practical, structural or nonstructural methods which prevent or reduce the movement of sediment, nutrients, pesticides and other pollutants from the land to surface or ground water, or which otherwise protect water quality from potential adverse effects of human activities. (state.hi.us 2008)*

**Evapotranspiration** – *the loss of water from the ground by evaporation and transpiration. (UFC 2004)*

**Grading -** *Altering a land surface by cutting, filling and/or smoothing to meet a designated form and function (SSI 2008)*

**Infiltration -** *The penetration of water through the ground surface into subsurface soil (SSI 2008)*

**Low Impact Developmen**t – *A stormwater management strategy concerned with maintaining or restoring the natural hydrologic functions of a site to achieve natural resource protection objectives and fulfill environmental regulatory requirements. (UFC 2004)*

**Nitrogen** - *The total nitrogen in water is comprised of dissolved inorganic and organic nitrogen and particulate organic and inorganic nitrogen, minus N2 gas. Phytoplankton and bacteria contribute to the amount of dissolved inorganic nitrogen content. Decomposition of aquatic life adds both dissolved organic and particulate organic nitrogen to water; while sewage runoff, erosion, and watershed increases particulate inorganic nitrogen levels in water. (ISU)*

**Native plants** - *Plants native to the EPA Level III ecoregion OR known to naturally occur within 200 miles of the site (SSI 2008)*

**Pollutant load -** *The amount of polluting material that a transporting agent, such as a stream, a glacier, or the wind, carries at a given time. (SSI 2008)*

**Phosphate** - *Required by every living plant and animal cell. Deficiencies in available P in soils are a major cause of limited crop production. Phosphorus deficiency also is probably the most critical mineral deficiency in grazing livestock. (Encarta 2005)*

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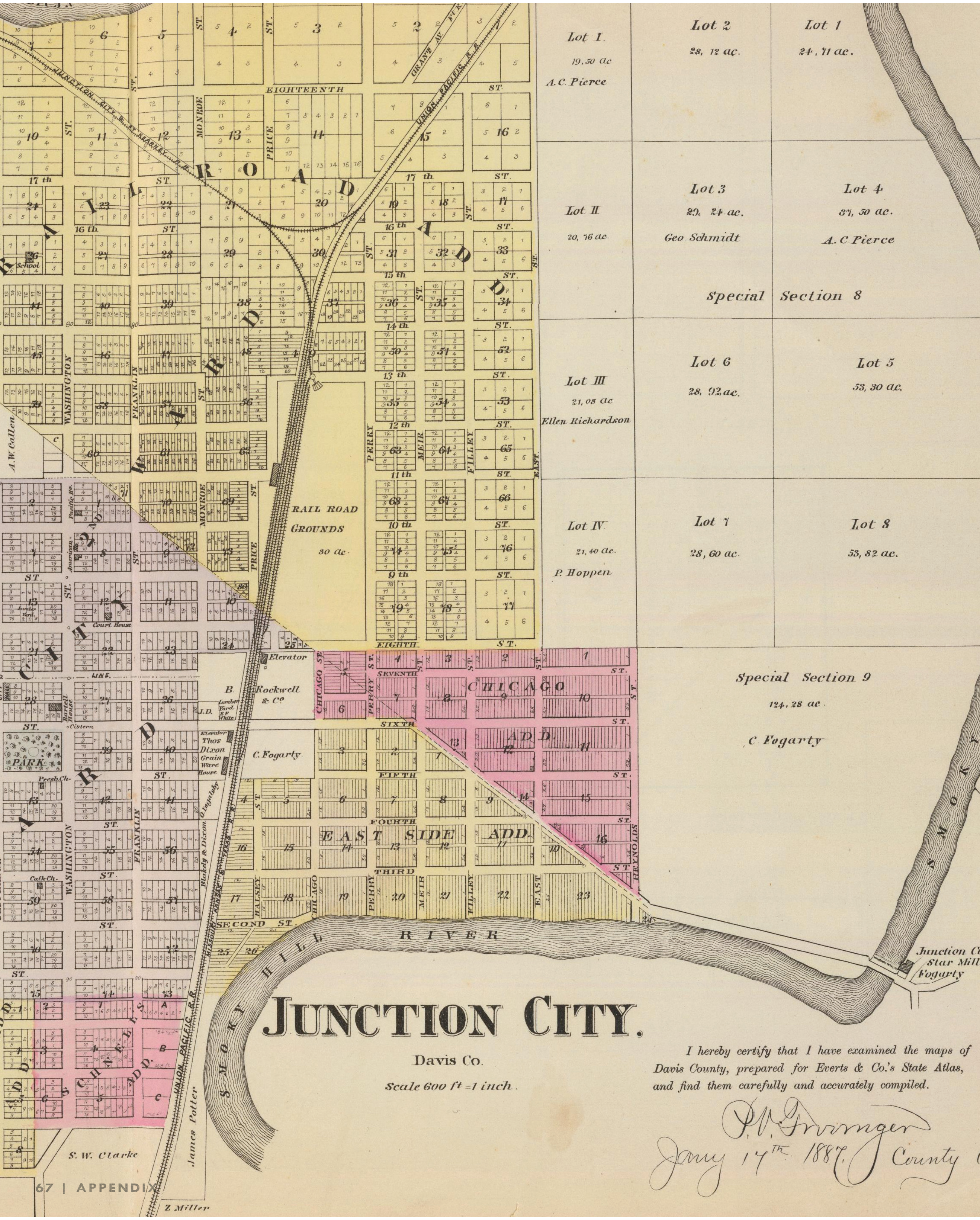
# Appendix

# Appendix One | Supplemental Introduction

## A1.1 Historical Map

*Historical 1887 Map of Junction City, Kansas | Project site and Downtown Region*
*(Philadelphia: L.H. Everts & Co. www.davidrumsey.com)*



# Appendix Two | Supplemental Concept Studies

## A2.1 Lagoon Park

### Project Location

University of California, Santa Barbara
Van Atta Associates, Inc., Santa Barbara, California


*The project site*
*Google Earth 2008 | Adapted by Rolfs 2008*

### Project Background

The California Coastal Commission denied the university's planned residence halls to be built adjacent to the project site because a plant named tarweed, that indicates the presence of a wetland habitat, was found within and around the site to be replaced by the residence halls. The potential wetland areas, along with 100 feet wide buffer zones, had to be preserved in order for the university to build their residence halls. Initially the university simply envisioned six acres of valuable coastal bluff land locked behind chain link fence and barbed wire to protect the wetland habitat. (ASLA 2008)

The project became a place where students are immersed in nature and encouraged to appreciate the subtle beauty of natural ecosystems. Native Coastal Sage Scrub vegetation and amenities such as surf showers, bike racks and outdoor study areas protect the wetlands from trespass. Access to the coastal beach was enhanced with ramps and stairs. The new wetlands create habitat for birds, invertebrates and other animals, while plants remove pollutants from runoff on its way to the Lagoon. (ASLA 2008)

### Lagoon Treatment

Just as the oxbow wetlands were protected by the use of BMPs, the Lagoon Park project has a direct influence on Lagoon ecosystem and its ability to function and be maintained. Water is filtrated through a series of constructed and preserved wetlands, coastal scrub vegetation, and through a native planted bioswale. To understand how the design Van Atta Associates Inc. had on the water quality of the Lagoon, a study was conducted to compare the water quality of a continuous deflection separator, a typical storm drain pipe, and the bioswale. (Herr 2007)

### Nutrient Study

The lagoons total nitrogen : phosphate ratio indicates it is nitrogen limited. This means plant growth is dependent on the amount of nitrogen not the amount of phosphate in the lagoon. However, the stormwater drains have total levels of nitrogen that are above the maximum in dry weather and during storm events. The bioswale has the least amount of nitrogen during dry time or after storm events. It is interesting to note that the lagoon has nitrogen levels below the EPA maximum during dry weather, but during storms level is slightly higher than the maximum. Nitrogen in the stormwater runoff creates more suitable environment for excessive plant growth after


*University of California, Santa Barbara Lagoon Park*
*Van Atta Associates*

storm events.(Herr 2007)

## Metals Study

Copper, zinc, and nickel are the metals studied in this case study. Copper is used in a variety of enzymes and in electron transport and is essential to all plants and animals although high levels of copper are toxic. Zinc is essential for the survival of organisms and is toxic at high levels. Nickel is only known to be toxic and not an essential metal for ecosystem survival. The bioswale is successful at taking up some of the metals as they consistently have the lowest concentrations of copper, zinc, and nickel during dry weather and during each of the storms. Some native plants are known to absorb unusually large concentrations of metals and organically treat them. The nickel and copper samples followed the same pattern with the highest concentrations in the lagoon and less at the bioswale. (Herr 2007)

## Bacteria Study

Enterococci and total coli form, bacterias of fecal matter, are found in the lagoon and meet EPA health standards during dry weather conditions but not during storm events. The most probable number (MPN) of enterococci at which a beach is closed is 104. (Herr 2007) All samples had an MPN that was higher than 104 during storm events. However, the lagoon had MPNs that were below 104 during the dry events demonstrating the need to filter stormwater further up the watershed. There were extremely high levels of bacteria in the bioswale at all times. The bioswale is made of plants and soil (biomass), which is a good environment for bacteria, while the other drains are made of cement. (Herr 2007)

## A2.2 Avon's Big Box Oasis

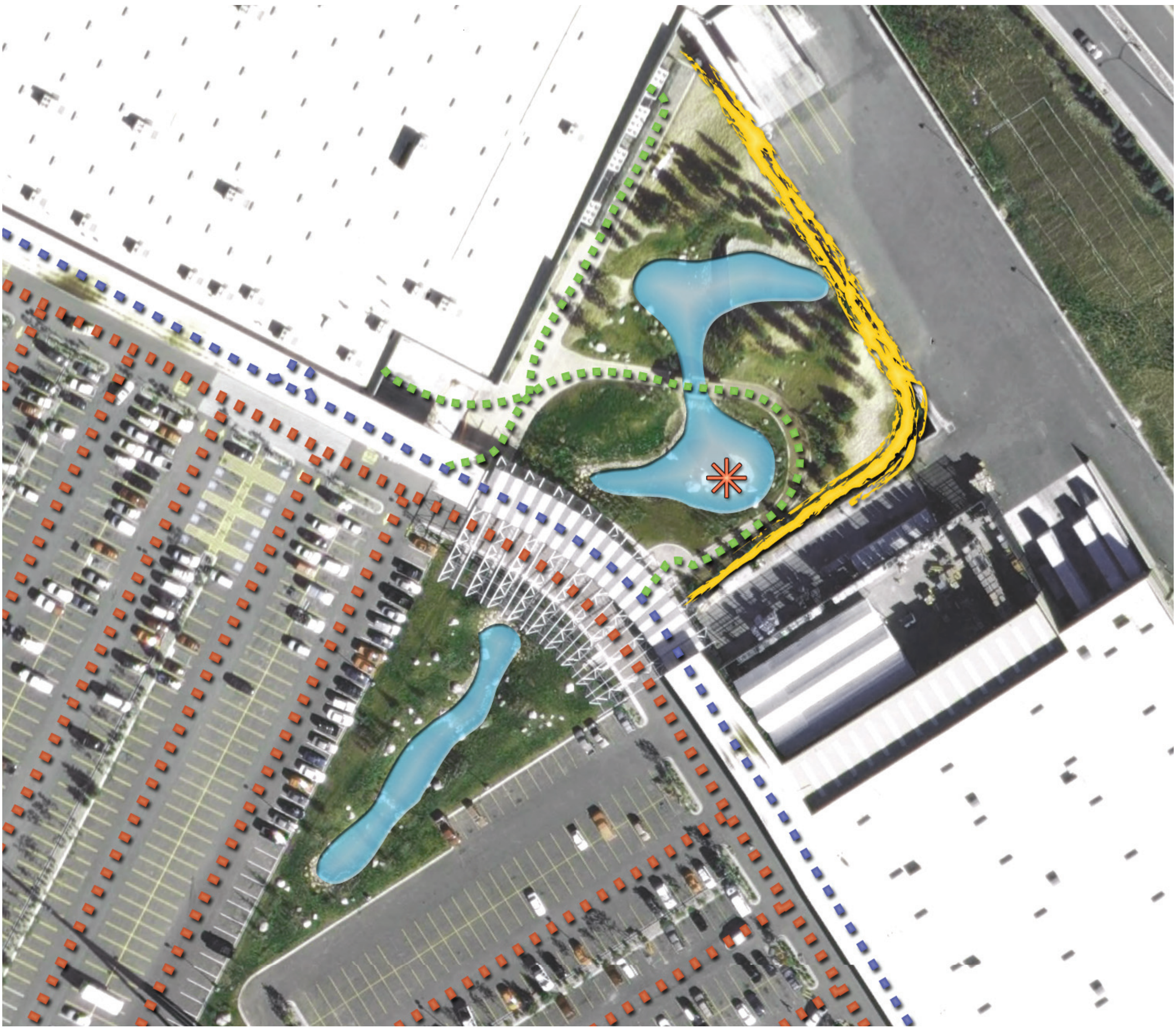
### Project Location

Wal-Mart and Home Depot in the Traer Creek Plaza Avon, Colorado
VAg, Inc. Architects and Planners, Vail, Colorado

### Project Description

This is a minimal maintenance design project located between the Wal-Mart and Home Depot stores in Avon, Colorado. A landscape designed for pedestrian use in a generally unfriendly environment that uses stormwater as an asset to improve the aesthetics of the site. The 1.9 acre project area integrated stormwater management systems with an uncomplicated pedestrian oriented landscape. Approaching the site, by car or foot, an array of industrial overhead planes constructed of the same material of the Wal-Mart and Home Depot facades greet the visitor. A huge rock is the central feature of the site raising itself out of the consistent water level more than 15 feet. Interest is drawn to the site because of its open design with the only obstruction being a visual and sound buffer from Interstate 70 and the truck loading docks.


*The Project Site*
*Google Earth 2008 | Adapted by Rolfs 2008*



*Site Elemants Plan*
*Image by: Google Earth, Rolfs adaptation*

## Project Importance

This project is like an oasis within a typical sea of parking for the big-box retailers is more than a visually interesting site. As you approach the site, rather it be by car or foot, you are greeted by an array of industrialized overhead planes constructed of the same material of the Wal-Mart and Home Depot facades. The central piece is a huge rock, marked in red as a strong visual landmark raising itself out of the consistent water level more than 15 feet. Interest is drawn to the site because of its open design with the only obstruction being a visual and sound buffer from Interstate 70 and the truck loading docks.

The water features use recycled stormwater runoff to supply the visual linkage of the two spaces. A soothing waterfall feature helps distort any Interstate noise that may have filtered through the rear buffer. During Avon's long winter season, the water features become a depository for sidewalk snow removal as the large parking lots are cleared of snow which is then hauled away.

# Appendix Three | Supplemental Site Study

## A3.1 Smoky Hill Marketplace

The Smoky Hill Marketplace designed by D.J. Christie, Inc, is a development a 340 acre mixed use development that includes retail, entertainment, sports, and tourist venues. It is planed for the south side of Interstate 70 towards to the Smoky Hill River and has been put on hold. Although the development was put on hold, the programming information provided by the project reveals what the city staff and other developers perceived as necessary development types for the future of Junction City.

### Personal Goals and Objectives

600,000 SF of retail to include
- 130,000 SF home improvement retailer
- 100,000 SF Department / soft good retailer
- Three 20,000 to 40,000 SF Jr. box retailers
- 40,000 to 55,000 SF furniture retailer
- 70,000 to 100,000 SF of small shop retail
- 65,000 SF of highway inline retail

Site access via two interstate interchanges
- Chestnut St. exit on the east side
- Washington St. exit on the west side

1.6 miles of interstate frontage with 17 outparcels (all with interstate frontage)

2 acre lake with 3 lakefront restaurant pods adjacent to arena with interstate visibility

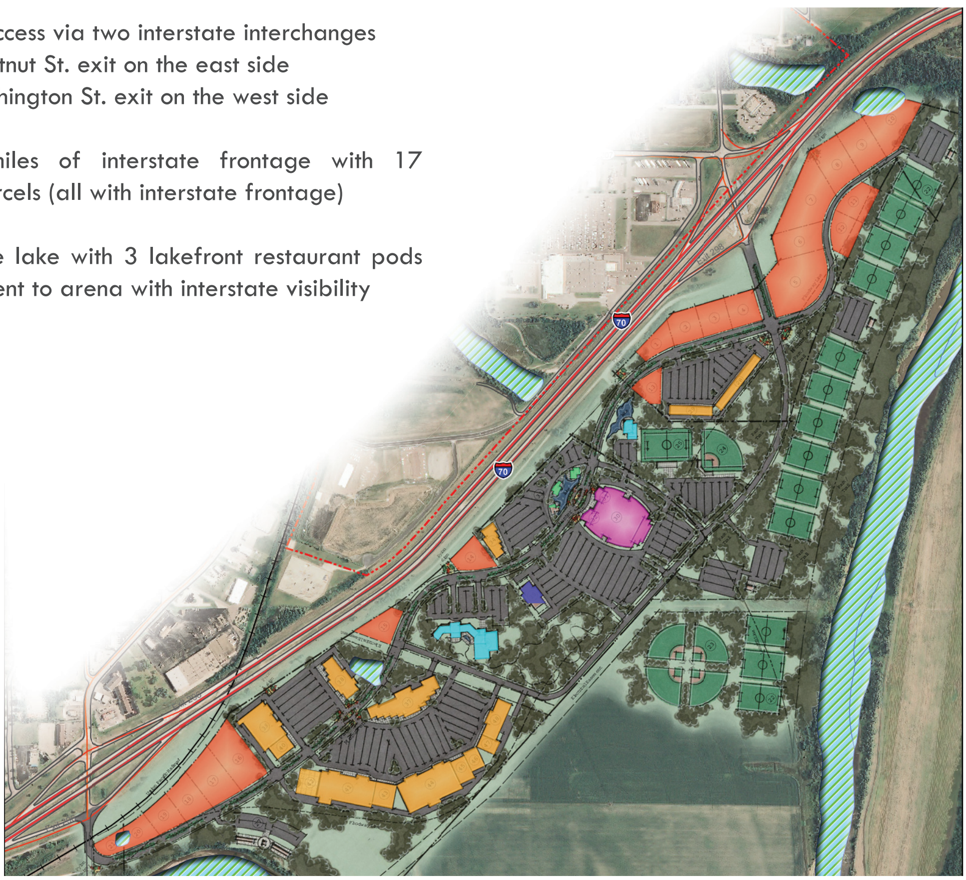
85,000 SF 4,500 seat multi-use arena (primary use is minor league hockey)

10 acre, 36,000 SF 12 screen Dickinson Movie Theatre

25 acre, 140 room Roaring River Water Park and hotel (similar to Great Wolf Lodge concept in Kansas City)

Athletic fields with 13 soccer fields, 4 baseball/softball fields, and a soccer and baseball complex with large amount of permanent stadium seating. Also including a city operated park/trail system including playground areas 3 roundabouts, each with a large bronze monument of a Big Red 1General/War Hero

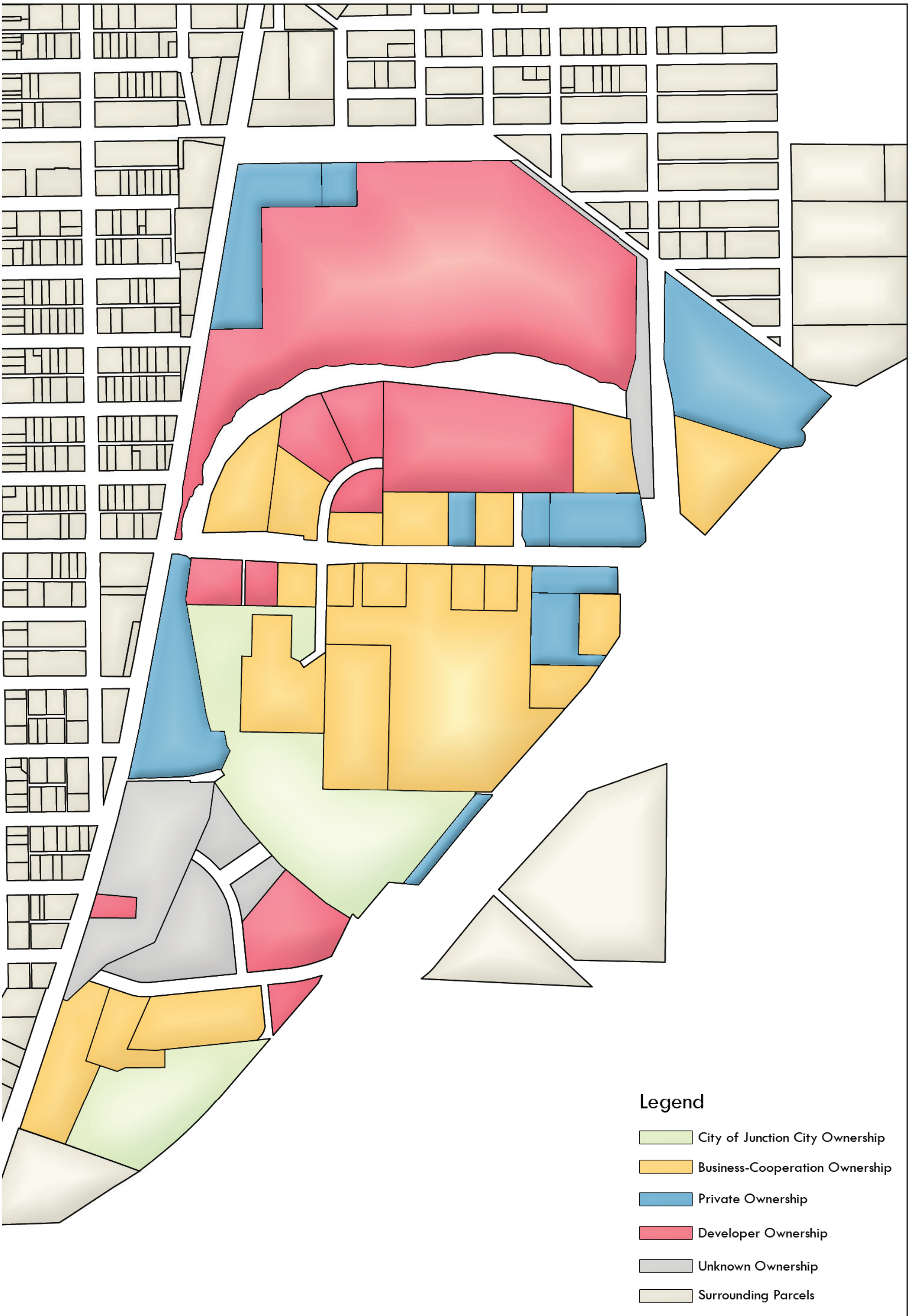
Farmer's market with tower feature and paved court area



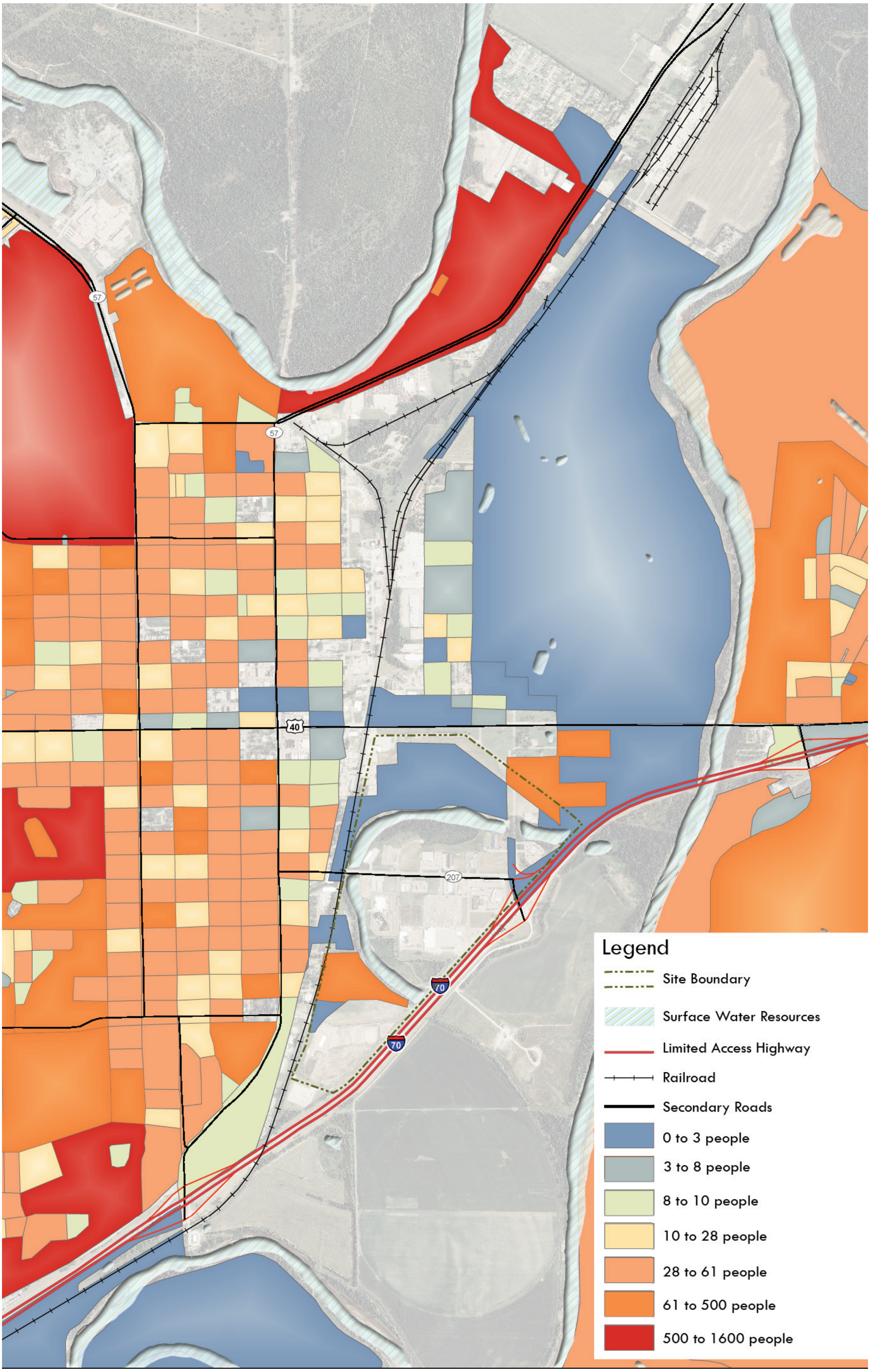
*Smoky HIll Marketplace*
*D.J. Christie, Inc*

## A3.2 Inventory Layers

### Ownership Inventory

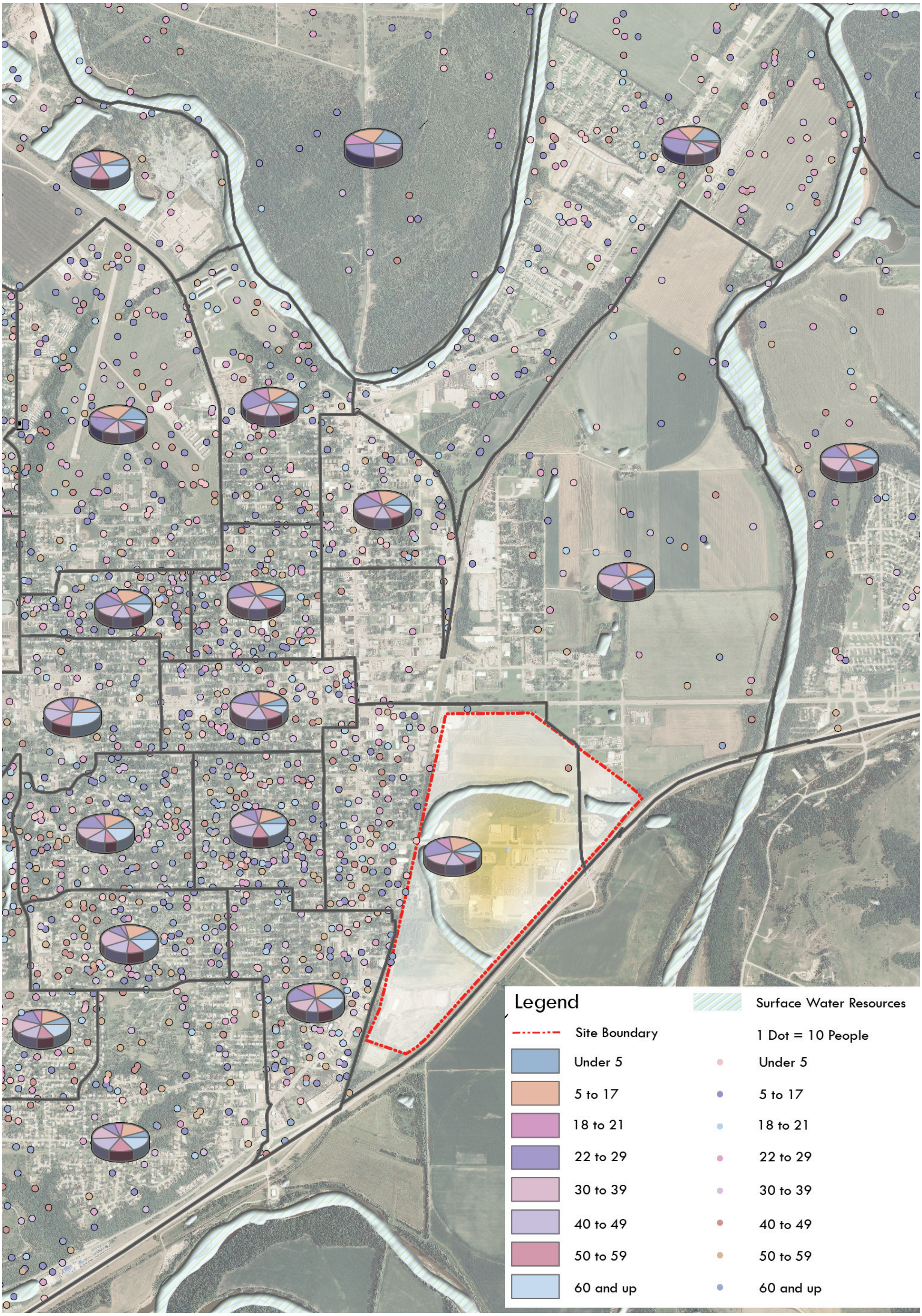


## Census Block Population Inventory

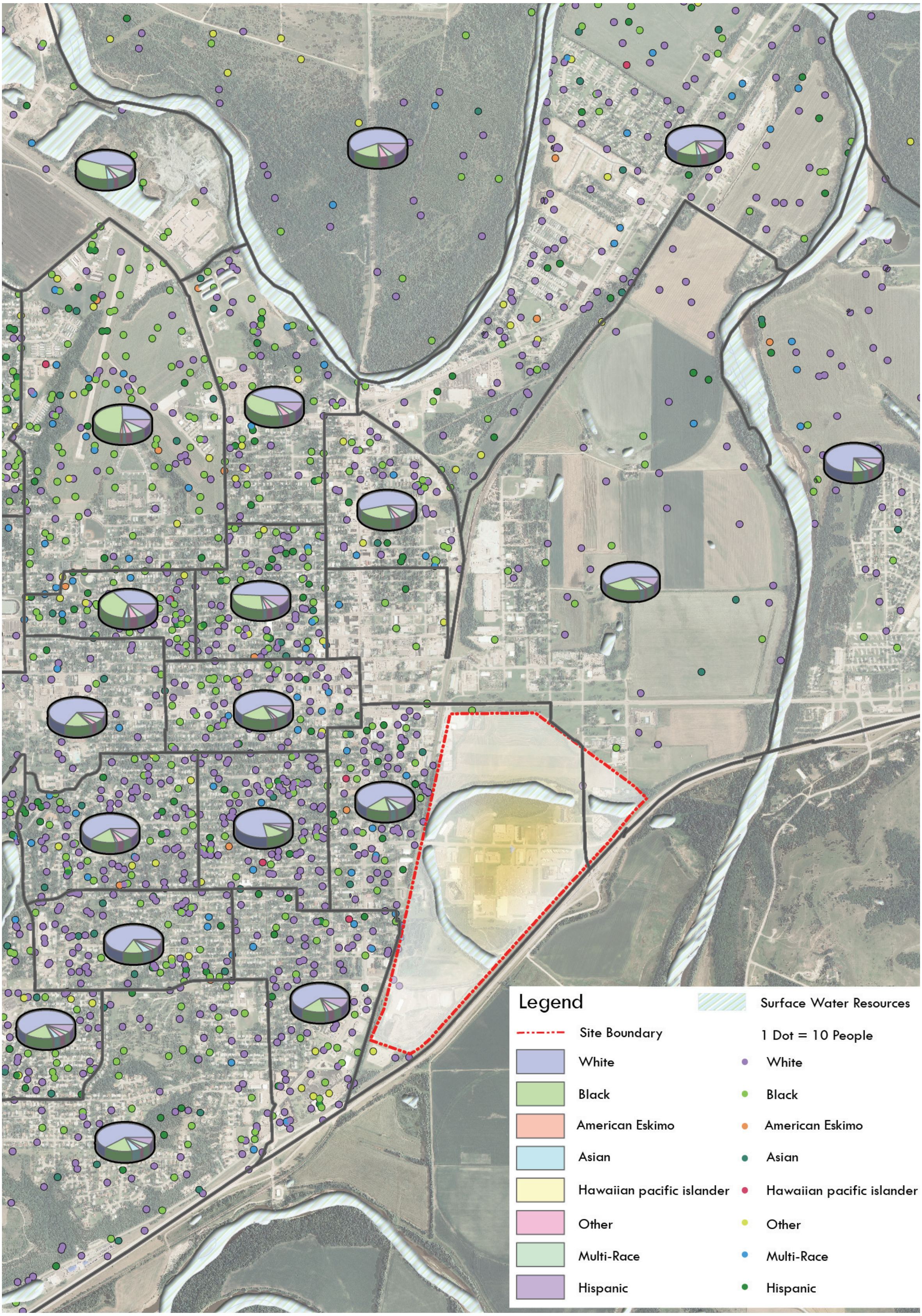


## Infrastructure Inventory

## Age Distribution Inventory



## Race Distribution Inventory

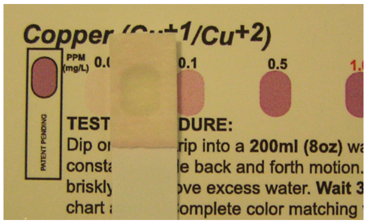


## A3.3 Water Quality Testing

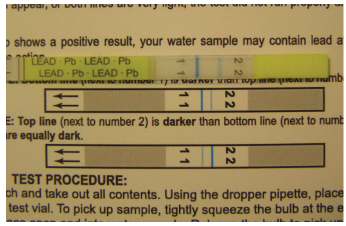
### Main Body Sample Results

Free Chlorine

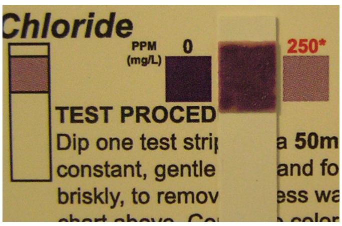

Copper



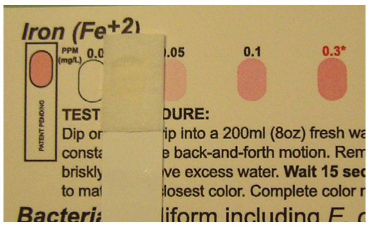

Lead



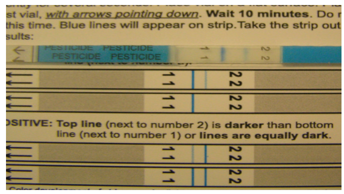

Chloride



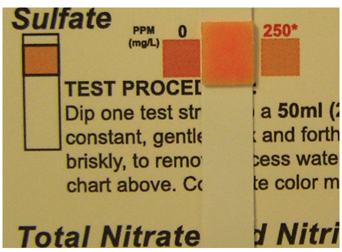

Iron



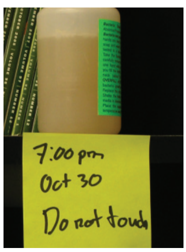

Pesticide

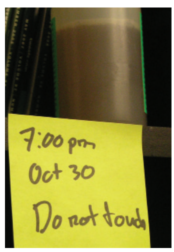



Sulfate

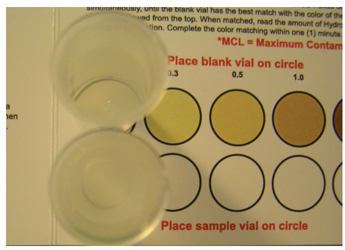



Bacteria

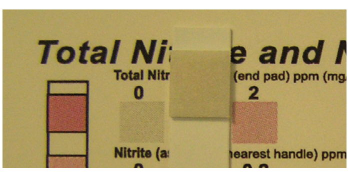


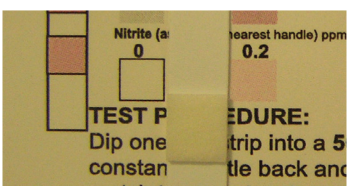

Hydrogen Sulfide

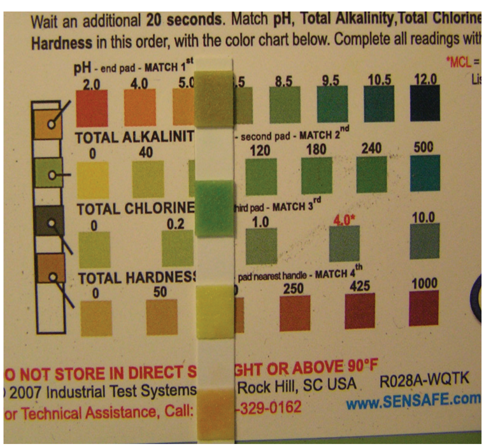



Nitrate




Nitrite




pH

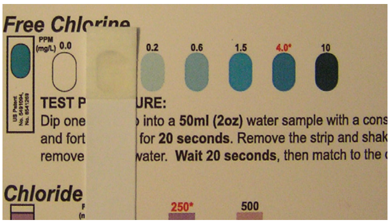
Chlorine

Hardness

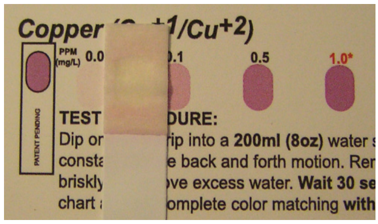
Alkalinity

## Shallow Water Sample Results

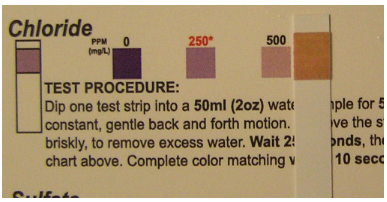
Free Chlorine



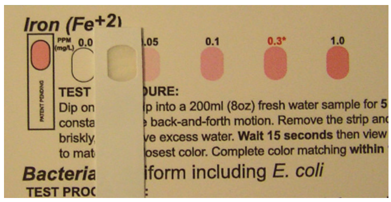

Copper



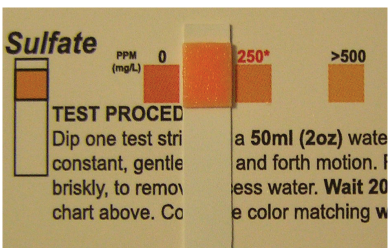

Chloride



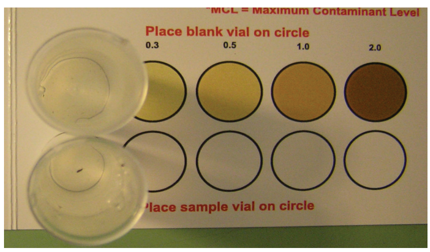

Iron



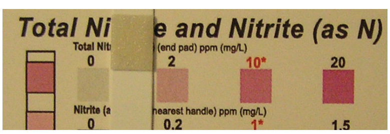

Sulfate



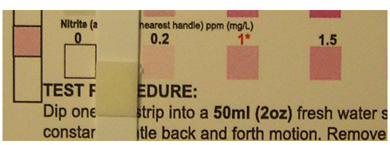

Hydrogen Sulfide

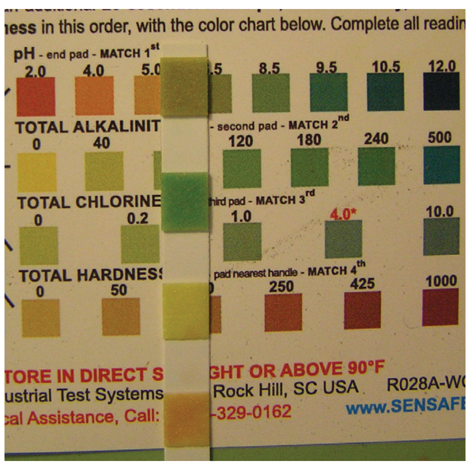



Nitrate




Nitrite




pH

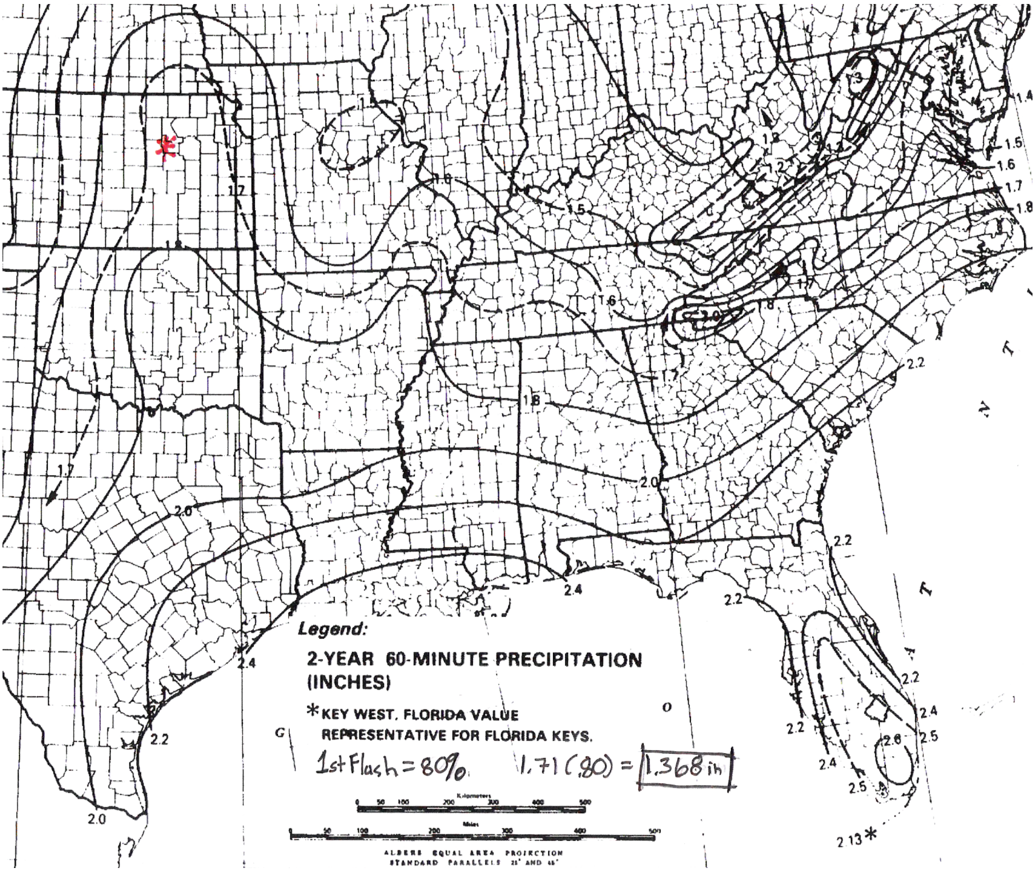
Chlorine

Hardness

Alkalinity

# Appendix Four| Supplemental BMP Retrofit

## A4.1 | HYDRO-35 Rainfall Map




## A4.2 | Watershed 1 Calculations

Watershed 1.S

Area 124,696 sf 2.86 acres

| | Area | | Runoff | Adjusted Area | Adjusted Area | Storm Event | Total Water | Bio Retention Area | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Surface Type | *Sf* | *Acres* | Coefficient | *Sf* | *Acres* | *80% 1hr-2yr Rain* | *inches* | *Acre Feet* | *Gallons* | *Sf Feet* |
| Building | 7,618 | 0.17 | 1.00 | 7,618 | 0.17 | 1.37 | 0.24 | 0.02 | 6,506 | 870 |
| Parking and Roads | 64,059 | 1.47 | 0.95 | 60,856 | 1.40 | 1.37 | 1.91 | 0.16 | 51,973 | 6,948 |
| Open Space | 53,019 | 1.22 | 0.30 | 15,906 | 0.37 | 1.37 | 0.50 | 0.04 | 13,584 | 1,816 |
| Totals | | | | | | | 2.65 | 0.22 | 72,062 | 9,633 |

| *Bioretention* | | Rain garden | |
|---|---|---|---|
| 10175 | 0 | 0 | |
| 0 | 0 | 0 | |
| 0 | 0 | 0 | |
| 10175 | 0 | 0 | 10175 |

# A4.3 | Watershed 2 Calculations

Watershed 2.S

Area 292,736 sf 6.72 acres

| Surface Type | Area *Sf* | Area *Acres* | Runoff Coefficient | Adjusted Area *Sf* | Adjusted Area *Acres* | Storm Event *1hr-25yr Rain* | Total Water *inches* | Bio Retention Area *Acre Feet* | Bio Retention Area *Gallons* | Bio Retention Area *Sf Feet* |
|---|---|---|---|---|---|---|---|---|---|---|
| Building | 17,523 | 0.40 | 1.00 | 17,523 | 0.40 | 1.37 | 0.55 | 0.05 | 14,965 | 2,001 |
| Parking and Roads | 120,095 | 2.76 | 0.95 | 114,090 | 2.62 | 1.37 | 3.59 | 0.30 | 97,436 | 13,025 |
| Open Space | 155,118 | 3.56 | 0.30 | 46,535 | 1.07 | 1.37 | 1.46 | 0.12 | 39,742 | 5,313 |
| Totals | | | | | | | 5.60 | 0.47 | 152,143 | 20,339 |

| *Bioretention* | | Rain garden | |
|---|---|---|---|
| 4444 | 0 | 4378 | |
| 6090 | 0 | 1320 | |
| 2989 | 0 | 1412 | |
| 500 | 0 | 0 | |
| 14023 | 0 | 7110 | 21133 |

# A4.4 | Watershed 3 Map and Calculations

Watershed 3.S

Area 170,411 sf 3.91 acres

| Surface Type | Area *Sf* | Area *Acres* | Runoff Coefficient | Adjusted Area *Sf* | Adjusted Area *Acres* | Storm Event *1hr-25yr Rain* | Total Water *inches* | Bio Retention Area *Acre Feet* | Bio Retention Area *Gallons* | Bio Retention Area *Sf Feet* |
|---|---|---|---|---|---|---|---|---|---|---|
| Building | 28,730 | 0.66 | 1.00 | 28,730 | 0.66 | 1.37 | 0.90 | 0.08 | 24,536 | 3,280 |
| Parking and Roads | 107,395 | 2.47 | 0.95 | 102,025 | 2.34 | 1.37 | 3.21 | 0.27 | 87,132 | 11,648 |
| Open Space | 96,600 | 2.22 | 0.30 | 28,980 | 0.67 | 1.37 | 0.91 | 0.08 | 24,750 | 3,309 |
| Totals | | | | | | | 5.02 | 0.42 | 136,418 | 18,236 |

| *Bioretention* | | Rain garden | |
|---|---|---|---|
| 15700 | 0 | 0 | |
| 3020 | 0 | 0 | |
| 0 | 0 | 0 | |
| 18720 | 0 | 0 | 18720 |

# A4.5 | Watershed 4 Calculations

Watershed 4.S

Area 28,000 sf 0.64 acres

| Surface Type | Area *Sf* | Area *Acres* | Runoff Coefficient | Adjusted Area *Sf* | Adjusted Area *Acres* | Storm Event *1hr-25yr Rain* | Total Water *inches* | Bio Retention Area - 1ft dept *Acre Feet* | Bio Retention Area - 1ft dept *Gallons* | Bio Retention Area - 1ft dept *Sf Feet* |
|---|---|---|---|---|---|---|---|---|---|---|
| Building | 3,975 | 0.09 | 1.00 | 3,975 | 0.09 | 1.37 | 0.13 | 0.01 | 3,395 | 454 |
| Parking and Roads | 99,850 | 2.29 | 0.95 | 94,858 | 2.18 | 1.37 | 2.98 | 0.25 | 81,011 | 10,830 |
| Open Space | 66,586 | 1.53 | 0.30 | 19,976 | 0.46 | 1.37 | 0.63 | 0.05 | 17,060 | 2,281 |
| Totals | | | | | | | 3.74 | 0.31 | 101,465 | 13,564 |

| *Bioretention* | | Rain garden | |
|---|---|---|---|
| 14000 | 0 | 1800 | |
| 0 | 0 | 0 | |
| 0 | 0 | 0 | |
| 14000 | 0 | 1800 | 15800 |

# A4.6 | Watershed 5 Map and Calculations

Watershed 5.S

Area 336,986 sf 7.74 acres

| Surface Type | Area *Sf* | Area *Acres* | Runoff Coefficient | Adjusted Area *Sf* | Adjusted Area *Acres* | Storm Event *1hr-25yr Rain* | Total Water *inches* | Bio Retention Area *Acre Feet* | Bio Retention Area *Gallons* | Bio Retention Area *Sf Feet* |
|---|---|---|---|---|---|---|---|---|---|---|
| Building | 7,500 | 0.17 | 1.00 | 7,500 | 0.17 | 1.37 | 0.24 | 0.02 | 6,405 | 856 |
| Parking and Roads | 171,970 | 3.95 | 0.95 | 163,372 | 3.75 | 1.37 | 5.14 | 0.43 | 139,523 | 18,652 |
| Open Space | 157,516 | 3.62 | 0.30 | 47,255 | 1.08 | 1.37 | 1.49 | 0.12 | 40,357 | 5,395 |
| Totals | | | | | | | 6.86 | 0.57 | 186,285 | 24,903 |

| *Bioretention* | | Rain garden | |
|---|---|---|---|
| 19000 | 0 | 0 | |
| 16500 | 0 | 0 | |
| 0 | 0 | 0 | |
| 35500 | 0 | 0 | 35500 |

# A4.7 | Watershed 6 Calculations

Watershed 6.S

Area 418,511 sf 9.61 acres

| Surface Type | Area *Sf* | Area *Acres* | Runoff Coefficient | Adjusted Area *Sf* | Adjusted Area *Acres* | Storm Event *1hr-25yr Rain* | Total Water *inches* | Bio Retention Area *Acre Feet* | Bio Retention Area *Gallons* | Bio Retention Area *Sf Feet* |
|---|---|---|---|---|---|---|---|---|---|---|
| Building | 6,800 | 0.16 | 1.00 | 6,800 | 0.16 | 1.37 | 0.21 | 0.02 | 5,807 | 776 |
| Parking and Roads | 347,181 | 7.97 | 0.95 | 329,822 | 7.57 | 1.37 | 10.37 | 0.86 | 281,676 | 37,655 |
| Open Space | 64,530 | 1.48 | 0.30 | 19,359 | 0.44 | 1.37 | 0.61 | 0.05 | 16,533 | 2,210 |
| Totals | | | | | | | 11.20 | 0.93 | 304,017 | 40,641 |

| *Bioretention* | | Rain garden | |
|---|---|---|---|
| 23000 | 0 | 1700 | |
| 11000 | 0 | 300 | |
| 4700 | 0 | 0 | |
| 0 | 0 | 0 | |
| 38700 | 0 | 2000 | 40700 |

# A4.8 | Watershed 7 Calculations

Watershed 7.S

Area 87,052 sf 2.00 acres

| Surface Type | Area *Sf* | Area *Acres* | Runoff Coefficient | Adjusted Area *Sf* | Adjusted Area *Acres* | Storm Event *1hr-25yr Rain* | Total Water *inches* | Bio Retention Area *Acre Feet* | Bio Retention Area *Gallons* | Bio Retention Area *Sf Feet* |
|---|---|---|---|---|---|---|---|---|---|---|
| Building | 6,500 | 0.15 | 1.00 | 6,500 | 0.15 | 1.37 | 0.20 | 0.02 | 5,551 | 742 |
| Parking and Roads | 57,030 | 1.31 | 0.95 | 54,179 | 1.24 | 1.37 | 1.70 | 0.14 | 46,270 | 6,185 |
| Open Space | 23,522 | 0.54 | 0.30 | 7,057 | 0.16 | 1.37 | 0.22 | 0.02 | 6,027 | 806 |
| Totals | | | | | | | 2.13 | 0.18 | 57,847 | 7,733 |

| *Bioretention* | | Rain garden | |
|---|---|---|---|
| 0 | 0 | 3730 | |
| 0 | 0 | 2000 | |
| 0 | 0 | 1170 | |
| 0 | 0 | 1600 | |
| 0 | 0 | 8500 | 8500 |

# A4.9 | Watershed 8 Calculations

Watershed 8.S

Area 45,530 sf 1.05 acres

| Surface Type | Area Sf | Acres | Runoff Coefficient | Adjusted Area Sf | Adjusted Area Acres | Storm Event 1hr-25yr Rain | Total Water inches | Bio Retention Area Acre Feet | Gallons | Sf Feet |
|---|---|---|---|---|---|---|---|---|---|---|
| Building | 3,150 | 0.07 | 1.00 | 3,150 | 0.07 | 1.37 | 0.10 | 0.01 | 2,690 | 360 |
| Parking and Roads | 64,345 | 1.48 | 0.95 | 61,128 | 1.40 | 1.37 | 1.92 | 0.16 | 52,205 | 6,979 |
| Open Space | 16,980 | 0.39 | 0.30 | 5,094 | 0.12 | 1.37 | 0.16 | 0.01 | 4,350 | 582 |
| Totals | | | | | | | 2.18 | 0.18 | 59,245 | 7,920 |

| *Bioretention* | | Rain garden | |
|---|---|---|---|
| 0 | 0 | 5350 | |
| 0 | 0 | 2400 | |
| 0 | 0 | 200 | |
| 0 | 0 | 7950 | 7950 |

# A4.10 | Watershed 9 Calculations

Watershed 9.S

Area 258,014 sf 5.92 acres

| Surface Type | Area Sf | Acres | Runoff Coefficient | Adjusted Area Sf | Adjusted Area Acres | Storm Event 1hr-25yr Rain | Total Water inches | Bio Retention Area Acre Feet | Gallons | Sf Feet |
|---|---|---|---|---|---|---|---|---|---|---|
| Building | 9,550 | 0.22 | 1.00 | 9,550 | 0.22 | 1.37 | 0.30 | 0.03 | 8,156 | 1,090 |
| Parking and Roads | 64,760 | 1.49 | 0.95 | 61,522 | 1.41 | 1.37 | 1.93 | 0.16 | 52,541 | 7,024 |
| Open Space | 183,704 | 4.22 | 0.30 | 55,111 | 1.27 | 1.37 | 1.73 | 0.14 | 47,066 | 6,292 |
| Totals | | | | | | | 3.97 | 0.33 | 107,764 | 14,406 |

| *Bioretention* | | Rain garden | |
|---|---|---|---|
| 9200 | 0 | 5902 | |
| 9200 | 0 | 5902 | 15102 |

# Appendix Five | Supplemental MUD

## A5.1 | Watershed 1 Calculations

Watershed 1.N

Area 192,855 sf 4.43 acres

| | Area | | Runoff | Adjusted Area | Adjusted Area | Storm Event | Total Water | Bio Retention Area | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Surface Type | *Sf* | *Acres* | Coefficient | *Sf* | *Acres* | *1hr-25yr Rain* | *inches* | *Acre Feet* | *Gallons* | *Sf Feet* |
| Building (west) | 21,800 | 0.50 | 1.00 | 21,800 | 0.50 | 2.8 | 1.40 | 0.12 | 38,051 | 5,087 |
| Building (east) | 15,400 | 0.35 | 1.00 | 15,400 | 0.35 | 2.8 | 0.99 | 0.08 | 26,880 | 3,593 |
| Parking and Roads | 66,094 | 1.52 | 0.95 | 62,789 | 1.44 | 2.8 | 4.04 | 0.34 | 109,596 | 14,651 |
| Open Space | 74,561 | 1.71 | 0.20 | 14,912 | 0.34 | 2.8 | 0.96 | 0.08 | 26,029 | 3,480 |
| Walkway (porous paving) | 15,000 | 0.34 | 0.20 | 3,000 | 0.07 | 2.8 | 0.19 | 0.02 | 5,236 | 700 |
| Totals | | | | | | | 7.58 | 0.63 | 205,791 | 27,510 |

| *Bioretention* | | Rain garden | |
|---|---|---|---|
| 1519 | 0 | 1000 | |
| 4319 | 0 | 580 | |
| 5163 | 0 | 400 | |
| 355 | 0 | 3981 | |
| 10706 | 0 | 0 | |
| 22062 | 0 | 5961 | 28023 |

## A5.2 | Watershed 2 Calculations

Watershed 2.N

Area 52,300 sf 1.20 acres

| | Area | | Runoff | Adjusted Area | Adjusted Area | Storm Event | Total Water | Bio Retention Area | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Surface Type | *Sf* | *Acres* | Coefficient | *Sf* | *Acres* | *1hr-25yr Rain* | *inches* | *Acre Feet* | *Gallons* | *Sf Feet* |
| Building | 12,500 | 0.29 | 1.00 | 12,500 | 0.29 | 2.8 | 0.80 | 0.07 | 21,818 | 2,917 |
| Parking and Roads | 19,400 | 0.45 | 0.95 | 18,430 | 0.42 | 2.8 | 1.18 | 0.10 | 32,169 | 4,300 |
| Open Space | 13,200 | 0.30 | 0.20 | 2,640 | 0.06 | 2.8 | 0.17 | 0.01 | 4,608 | 616 |
| Walkway (porous paving) | 7,200 | 0.17 | 0.20 | 1,440 | 0.03 | 2.8 | 0.09 | 0.01 | 2,513 | 336 |
| Totals | | | | | | | 2.25 | 0.19 | 61,108 | 8,169 |

| *Bioretention* | | Rain garden | |
|---|---|---|---|
| 3835 | 0 | 450 | |
| 0 | 0 | 1261 | |
| 0 | 0 | 1096 | |
| 0 | 0 | 1674 | |
| 0 | 0 | 0 | |
| 3835 | 0 | 4481 | 8316 |

## A5.3 | Watershed 3 Calculations

Watershed 3.N

Area 150,000 sf 3.44 acres

| | Area | | Runoff | Adjusted Area | Adjusted Area | Storm Event | Total Water | Bio Retention Area | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Surface Type | *Sf* | *Acres* | Coefficient | *Sf* | *Acres* | *1hr-25yr Rain* | *inches* | *Acre Feet* | *Gallons* | *Sf Feet* |
| Building (west) | 16,800 | 0.39 | 1.00 | 16,800 | 0.39 | 2.8 | 1.08 | 0.09 | 29,324 | 3,920 |
| Building (east) | 14,000 | 0.32 | 1.00 | 14,000 | 0.32 | 2.8 | 0.90 | 0.07 | 24,436 | 3,267 |
| Parking and Roads | 57,500 | 1.32 | 0.95 | 54,625 | 1.25 | 2.8 | 3.51 | 0.29 | 95,345 | 12,746 |
| Open Space | 49,490 | 1.14 | 0.20 | 9,898 | 0.23 | 2.8 | 0.64 | 0.05 | 17,276 | 2,310 |
| Walkway (porous paving) | 12,210 | 0.28 | 0.20 | 2,442 | 0.06 | 2.8 | 0.16 | 0.01 | 4,262 | 570 |
| Totals | | | | | | | 6.28 | 0.52 | 170,644 | 22,812 |

| *Bioretention* | | Rain garden | |
|---|---|---|---|
| 6666 | 0 | 1100 | |
| 616 | 131 | 1338 | |
| 6700 | 0 | 2522 | |
| 2796 | 0 | 0 | |
| 1450 | 0 | 0 | |
| 18228 | 131 | 4960 | 23319 |

# A5.4 | Watershed 4 Calculations

Watershed 4.N

Area 28,000 sf 0.64 acres

| Surface Type | Area Sf | Area Acres | Runoff Coefficient | Adjusted Area Sf | Adjusted Area Acres | Storm Event 1hr-25yr Rain | Total Water inches | Bio Retention Area - 1ft dept Acre Feet | Gallons | Sf Feet |
|---|---|---|---|---|---|---|---|---|---|---|
| Parking and Roads | 15,300 | 0.35 | 0.95 | 14,535 | 0.33 | 2.8 | 0.93 | 0.08 | 25,370 | 3,392 |
| Open Space | 4,825 | 0.11 | 0.20 | 965 | 0.02 | 2.8 | 0.06 | 0.01 | 1,684 | 225 |
| Walkway (porous paving) | 7,875 | 0.18 | 0.20 | 1,575 | 0.04 | 2.8 | 0.10 | 0.01 | 2,749 | 368 |
| Totals | | | | | | | 1.10 | 0.09 | 29,804 | 3,984 |

| *Bioretention* | | Rain garden | |
|---|---|---|---|
| 3581 | 0 | 650 | |
| 0 | 0 | 0 | |
| 3581 | | 650 | 4231 |

# A5.5 | Watershed 5 Calculations

Watershed 5.N

Area 579,115 sf 13.29 acres

| Surface Type | Area Sf | Area Acres | Runoff Coefficient | Adjusted Area Sf | Adjusted Area Acres | Storm Event 1hr-25yr Rain | Total Water inches | Bio Retention Area Acre Feet | Gallons | Sf Feet |
|---|---|---|---|---|---|---|---|---|---|---|
| Building (west) | 44,750 | 1.03 | 1.00 | 44,750 | 1.03 | 2.8 | 2.88 | 0.24 | 78,109 | 10,442 |
| Building (east) | 16,800 | 0.39 | 1.00 | 16,800 | 0.39 | 2.8 | 1.08 | 0.09 | 29,324 | 3,920 |
| Parking and Roads | 58,832 | 1.35 | 0.95 | 55,890 | 1.28 | 2.8 | 3.59 | 0.30 | 97,554 | 13,041 |
| Open Space | 444,513 | 10.20 | 0.20 | 88,903 | 2.04 | 2.8 | 5.71 | 0.48 | 155,175 | 20,744 |
| Walkway (porous paving) | 14,220 | 0.33 | 0.20 | 2,844 | 0.07 | 2.8 | 0.18 | 0.02 | 4,964 | 664 |
| Totals | | | | | | | 13.45 | 1.12 | 365,126 | 48,810 |

| *Bioretention* | | Rain garden | |
|---|---|---|---|
| 40427 | 0 | 350 | |
| 6100 | 0 | 162 | |
| 0 | 0 | 2116 | |
| 0 | 0 | 900 | |
| 0 | 0 | 0 | |
| 46527 | 0 | 3528 | 50055 |

# A5.6 | Watershed 6 Calculations

Watershed 6.N

Area 42,550 sf 0.98 acres

| Surface Type | Area Sf | Area Acres | Runoff Coefficient | Adjusted Area Sf | Adjusted Area Acres | Storm Event 1hr-25yr Rain | Total Water inches | Bio Retention Area Acre Feet | Gallons | Sf Feet |
|---|---|---|---|---|---|---|---|---|---|---|
| Building | 21,360 | 0.49 | 1.00 | 21,360 | 0.49 | 2.8 | 1.37 | 0.11 | 37,283 | 4,984 |
| Parking and Roads | 11,455 | 0.26 | 0.95 | 10,882 | 0.25 | 2.8 | 0.70 | 0.06 | 18,994 | 2,539 |
| Open Space | 3,325 | 0.08 | 0.20 | 665 | 0.02 | 2.8 | 0.04 | 0.00 | 1,161 | 155 |
| Walkway (porous paving) | 6,410 | 0.15 | 0.20 | 1,282 | 0.03 | 2.8 | 0.08 | 0.01 | 2,238 | 299 |
| Totals | | | | | | | 2.20 | 0.18 | 59,676 | 7,977 |

| *Bioretention* | | Rain garden | |
|---|---|---|---|
| 5505 | 0 | 500 | |
| 0 | 0 | 868 | |
| 0 | 0 | 1644 | |
| 0 | 0 | 0 | |
| 0 | 0 | 0 | |
| 5505 | 0 | 3012 | 8517 |

# A5.7 | Watershed 7 Calculations

Watershed 7.N

Area 60,800 sf 1.40 acres

| | Area | | Runoff | Adjusted Area | Adjusted Area | Storm Event | Total Water | Bio Retention Area | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Surface Type | *Sf* | *Acres* | Coefficient | *Sf* | *Acres* | *1hr-25yr Rain* | *inches* | *Acre Feet* | *Gallons* | *Sf Feet* |
| Building | 39,800 | 0.91 | 1.00 | 39,800 | 0.91 | 2.8 | 2.56 | 0.21 | 69,469 | 9,287 |
| Open Space | 750 | 0.02 | 0.20 | 150 | 0.00 | 2.8 | 0.01 | 0.00 | 262 | 35 |
| Walkway (porous paving) | 20,250 | 0.46 | 0.20 | 4,050 | 0.09 | 2.8 | 0.26 | 0.02 | 7,069 | 945 |
| Totals | | | | | | | 2.83 | 0.24 | 76,800 | 10,267 |

| *Bioretention* | | Rain garden | |
|---|---|---|---|
| 9540 | 0 | 625 | |
| 0 | 0 | 350 | |
| 0 | 0 | 0 | |
| 9540 | 0 | 975 | 10515 |

# A5.8 | Watershed 8 Calculations

Watershed 8.N

Area 45,530 sf 1.05 acres

| | Area | | Runoff | Adjusted Area | Adjusted Area | Storm Event | Total Water | Bio Retention Area | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Surface Type | *Sf* | *Acres* | Coefficient | *Sf* | *Acres* | *1hr-25yr Rain* | *inches* | *Acre Feet* | *Gallons* | *Sf Feet* |
| Parking and Roads | 10,070 | 0.23 | 0.95 | 9,567 | 0.22 | 2.8 | 0.61 | 0.05 | 16,698 | 2,232 |
| Open Space | 3,810 | 0.09 | 0.20 | 762 | 0.02 | 2.8 | 0.05 | 0.00 | 1,330 | 178 |
| Walkway (porous paving) | 31,650 | 0.73 | 0.20 | 6,330 | 0.15 | 2.8 | 0.41 | 0.03 | 11,049 | 1,477 |
| Totals | | | | | | | 1.07 | 0.09 | 29,077 | 3,887 |

| *Bioretention* | | Rain garden | |
|---|---|---|---|
| 1866 | 0 | 0 | |
| 1239 | 0 | 700 | |
| 95 | 0 | 0 | |
| 3200 | 0 | 700 | 3900 |

# A5.9 | Watershed 9 Calculations

Watershed 9.N

Area 61,500 sf 1.41 acres

| | Area | | Runoff | Adjusted Area | Adjusted Area | Storm Event | Total Water | Bio Retention Area | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Surface Type | *Sf* | *Acres* | Coefficient | *Sf* | *Acres* | *1hr-25yr Rain* | *inches* | *Acre Feet* | *Gallons* | *Sf Feet* |
| Building | 8,300 | 0.19 | 1.00 | 8,300 | 0.19 | 2.8 | 0.53 | 0.04 | 14,487 | 1,937 |
| Parking and Roads | 18,500 | 0.42 | 0.95 | 17,575 | 0.40 | 2.8 | 1.13 | 0.09 | 30,676 | 4,101 |
| Open Space | 21,300 | 0.49 | 0.20 | 4,260 | 0.10 | 2.8 | 0.27 | 0.02 | 7,436 | 994 |
| Walkway (porous paving) | 13,400 | 0.31 | 0.20 | 2,680 | 0.06 | 2.8 | 0.17 | 0.01 | 4,678 | 625 |
| Totals | | | | | | | 2.11 | 0.18 | 57,277 | 7,657 |

| *Bioretention* | | Rain garden | |
|---|---|---|---|
| 5047 | 0 | 600 | |
| 1877 | 0 | 175 | |
| 6924 | 0 | 775 | 7699 |

## A5.10 | Watershed 10 Calculations

Watershed 10.N

Area 120,330 sf 2.76 acres

| Surface Type | Area Sf | Area Acres | Runoff Coefficient | Adjusted Area Sf | Adjusted Area Acres | Storm Event 1hr-25yr Rain | Total Water inches | Bio Retention Area Acre Feet | Bio Retention Area Gallons | Bio Retention Area Sf Feet |
|---|---|---|---|---|---|---|---|---|---|---|
| Parking and Roads | 25,000 | 0.57 | 0.95 | 23,750 | 0.55 | 2.8 | 1.53 | 0.13 | 41,454 | 5,542 |
| Open Space | 87,747 | 2.01 | 0.20 | 17,549 | 0.40 | 2.8 | 1.13 | 0.09 | 30,632 | 4,095 |
| Walkway (porous paving) | 7,583 | 0.17 | 0.20 | 1,517 | 0.03 | 2.8 | 0.10 | 0.01 | 2,647 | 354 |
| Totals | | | | | | | 2.75 | 0.23 | 74,733 | 9,990 |

| *Bioretention* | | Rain garden | |
|---|---|---|---|
| 2100 | 0 | 6000 | |
| 0 | 0 | 1720 | |
| 0 | 0 | 350 | |
| 2100 | 0 | 8070 | 10170 |

## A5.11 | Watershed 11 Calculations

Watershed 11.N

Area 505,300 sf 11.60 acres

| Surface Type | Area Sf | Area Acres | Runoff Coefficient | Adjusted Area Sf | Adjusted Area Acres | Storm Event 1hr-25yr Rain | Total Water inches | Bio Retention Area Acre Feet | Bio Retention Area Gallons | Bio Retention Area Sf Feet |
|---|---|---|---|---|---|---|---|---|---|---|
| Building | 20,700 | 0.48 | 1.00 | 20,700 | 0.48 | 2.8 | 1.33 | 0.11 | 36,131 | 4,830 |
| Parking and Roads | 63,703 | 1.46 | 0.95 | 60,518 | 1.39 | 2.8 | 3.89 | 0.32 | 105,631 | 14,121 |
| Open Space | 413,597 | 9.49 | 0.20 | 82,719 | 1.90 | 2.8 | 5.32 | 0.44 | 144,383 | 19,301 |
| Walkway (porous paving) | 7,300 | 0.17 | 0.20 | 1,460 | 0.03 | 2.8 | 0.09 | 0.01 | 2,548 | 341 |
| Totals | | | | | | | 10.63 | 0.89 | 288,693 | 38,593 |

| *Bioretention* | | Rain garden | |
|---|---|---|---|
| 23000 | 0 | 3540 | |
| 6790 | 0 | 900 | |
| 0 | 0 | 1531 | |
| 0 | 0 | 1000 | |
| 0 | 0 | 4400 | |
| 29790 | 0 | 11371 | 41161 |

## A5.12 | Watershed 12 Calculations

Watershed 12.N

Area 216,250 sf 4.96 acres

| Surface Type | Area Sf | Area Acres | Runoff Coefficient | Adjusted Area Sf | Adjusted Area Acres | Storm Event 1hr-25yr Rain | Total Water inches | Bio Retention Area Acre Feet | Bio Retention Area Gallons | Bio Retention Area Sf Feet |
|---|---|---|---|---|---|---|---|---|---|---|
| Building | 10,000 | 0.23 | 1.00 | 10,000 | 0.23 | 2.8 | 0.64 | 0.05 | 17,455 | 2,333 |
| Parking and Roads | 46,000 | 1.06 | 0.95 | 43,700 | 1.00 | 2.8 | 2.81 | 0.23 | 76,276 | 10,197 |
| Open Space | 155,200 | 3.56 | 0.20 | 31,040 | 0.71 | 2.8 | 2.00 | 0.17 | 54,179 | 7,243 |
| Walkway (porous paving) | 5,050 | 0.12 | 0.20 | 1,010 | 0.02 | 2.8 | 0.06 | 0.01 | 1,763 | 236 |
| Totals | | | | | | | 5.51 | 0.46 | 149,673 | 20,008 |

| *Bioretention* | | Rain garden | |
|---|---|---|---|
| 7600 | 0 | 11600 | |
| 0 | 0 | 585 | |
| 0 | 0 | 1937 | |
| 0 | 0 | 0 | |
| 0 | 0 | 0 | |
| 7600 | 0 | 14122 | 21722 |

# A5.13| Watershed 13 Calculations

Watershed 13.N

Area 213,250 sf 4.90 acres

| Surface Type | Area Sf | Area Acres | Runoff Coefficient | Adjusted Area Sf | Adjusted Area Acres | Storm Event 1hr-25yr Rain | Total Water inches | Bio Retention Area Acre Feet | Bio Retention Area Gallons | Bio Retention Area Sf Feet |
|---|---|---|---|---|---|---|---|---|---|---|
| Building | 7,400 | 0.17 | 1.00 | 7,400 | 0.17 | 2.8 | 0.48 | 0.04 | 12,916 | 1,727 |
| Parking and Roads | 40,000 | 0.92 | 0.95 | 38,000 | 0.87 | 2.8 | 2.44 | 0.20 | 66,327 | 8,867 |
| Open Space | 154,350 | 3.54 | 0.20 | 30,870 | 0.71 | 2.8 | 1.98 | 0.17 | 53,882 | 7,203 |
| Walkway (porous paving) | 11,500 | 0.26 | 0.20 | 2,300 | 0.05 | 2.8 | 0.15 | 0.01 | 4,015 | 537 |
| Totals | | | | | | | 5.05 | 0.42 | 137,140 | 18,333 |

| *Bioretention* | | Rain garden | |
|---|---|---|---|
| 7767 | 0 | 3325 | |
| 3289 | 0 | 700 | |
| 0 | 0 | 810 | |
| 0 | 0 | 3170 | |
| 0 | 0 | 0 | |
| 11056 | 0 | 8005 | 19061 |