LOW IMPACT DEVELOPMENT STORMWATER TECHNIQUES:
LESSONS LEARNED FROM TOPEKA, KANSAS CASE STUDIES

BY

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Abstract

Low Impact Development (LID) is an emerging ecological method for planning and designing stormwater management. The main goal of LID is that post development hydrology mimic predevelopment hydrology or that of the natural land pattern. The difference between LID and conventional end of pipe engineering is that LID is designed for on-site infiltration. LID was developed in Maryland and has since been adapted to other ecoregions. The introduction and background offer a review of the importance of ecological stormwater management and the basic principles and techniques of LID. Ecological stormwater management involves understanding and applying ecoregion factors such as: climate, physiography/ landform, geology, soils, and plant associations.

This thesis begins with a brief overview of the ecoregional factors associated with the Topeka, Kansas (KS) area. Two case studies of LID type stormwater structures are investigated. The case studies, Jackson Street and Hillcrest, are projects of the City of Topeka Water Pollution Control Division (Topeka, KS). The primary topics investigated include: background, political approval process, condition of site before implementation, general project design, stormwater design, soil, plants, LID principles and techniques used, lessons learned, and a critique of each project. Investigation methods include: personal communication with key individuals involved, and a review of site visits, drawings, specifications, and other projects documents.

Table of Contents

List of Figures

List of Tables

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Chapter One: Introduction

Relevance of Stormwater to life-

Stormwater is simply rain that has hit the ground of the surface and is interacting with its surrounding environment. Rain is essential to life for plants, people, animals, and all types of biotic life. Whether you live in Yuma, Arizona which receives 3.2 inches of precipitation or St. Louis, Missouri which receives 37.5 inches, rain nourishes life (ClimateZone.Com). Our drinking water comes from rain after it moves into soils and comes out into springs, wells, or aquifers.

Stormwater is not treated like sewage (although they may combine during large storms). As stormwater flows from roofs, streets, parking lots, and all types of surfaces it carries pollutants and sediments directly into soils, streams and rivers. Pollutants come from typical residential neighborhoods, highways, urban centers, and all types of landscapes. Some of the most common pollutants include engine oil, turf grass fertilizers, anti-freeze, sediments (from construction sites and highway maintenance), and many others. These pollutants can make our ground water un-safe to drink and our rivers and lakes un-safe to swim in. In many different ways people are impacting the water quality of the community in which they live (Ferguson, 1998, 7).

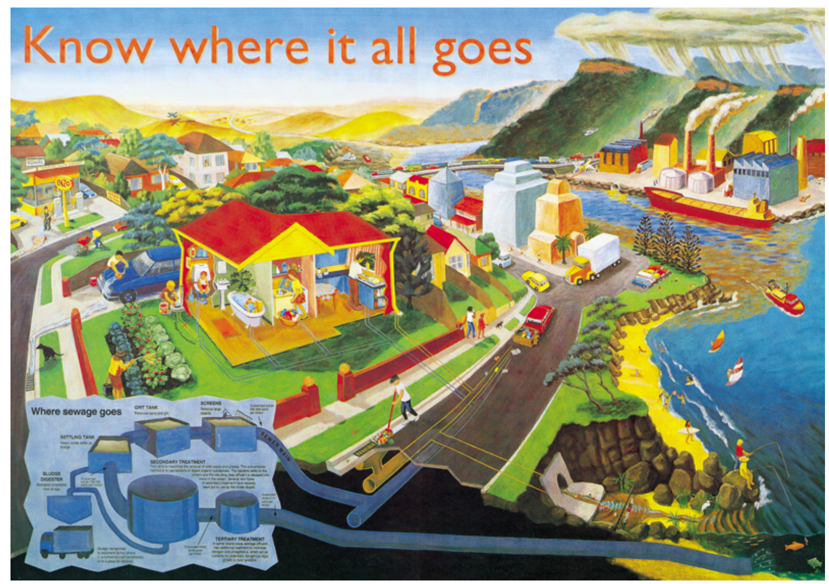


Figure 1-1: Know where it all goes

(http://www.environment.nsw.gov.au/stormwater/whatis/kwiag.htm 4-06-06)

As shown by the Environmental Protection Agency (EPA) illustration "Know where it all goes" (Fig. 1-1), water from homes, streets, lawns, retail stores, factories, and other sources goes to our rivers and lakes. The EPA image shows that in everyday living people affect water quality, for better or worse, without even knowing.

The phrase "out of sight, out of mind" with regard to stormwater in the past may have meant "out of site, out of mind" (or off our site and no longer our concern); however, since the Federal Water Pollution Control Act Amendments of 1972 government laws, programs and professionals have increased efforts to make United States (US) water systems cleaner (Law, 1972). Agencies are now required to pay attention to how rain runoff interacts and impacts receiving streams.

Rain, which provides the precious resource of fresh water, is in some ways a two edge sword. Rain, sun and soil provide the basic requirements for biotic life. Plants provide oxygen for all living organisms. Plants provide food, medicines, and other basic needs for people. Urban living can give the false belief that humans are not part of the ecosystems in which they live. The truth is that humans are a significant factor in ecosystems, whether they live in a wilderness, suburban, rural, or urban environment. Native Americans practiced sustainable ecosystem management for thousands of years. One of example Native American ecosystem management is that of burning the prairies to suppress trees and forbs, while increasing grasses for buffalo, elk, deer, and other herbivores (Pyne, 1996).

Water is essential all ecosystems and life. What would happen if water was taken out of any ecosystem or community? There would be ecosystem failure. By sending stormwater downstream in a pipe, water is taken out of one ecosystem or area and sent to another. In effect when rain water does not infiltrate into the ground, it is taken out of one ecosystem and transferred (often rapidly) to another.

On the other side of the two-edged sword, stormwater can be a destructive force. Improper planning and high rainfall causes flood damage to buildings, roads, bridges, soils and vegetation. Urban areas often have more than 80 percent impervious land surfaces, causing exponentially high amounts of runoff making flood control more difficult. As result, urban streams are more prone to flooding and erosion than rural or undisturbed streams due to higher run-off.

Figure 1-2 shows a Kansas State University (KSU) apartment building experiencing flooding from a 2-5 year storm interval. The site grading directs stormwater towards the building, without allowing for overflow or a natural drainage channel. The scene of buildings, roads, and landscapes flooding is common throughout urban developments. Proper planning and design focuses on infiltrating stormwater as well as preserving natural drainage channels and floodplains.

The disciplines of landscape architecture, urban and regional planning, watershed planning, civil engineering and others direct the manner in which we build our cities, roads, communities, and environments. Every plan and most construction documents include instructions and procedures for stormwater management. Stormwater design is concerned with planning where the water or runoff goes in the environment and

Figure 1-2: KSU Apt., Results of a Typical 2 Yr. Storm (Author)

the processes it encounters during its journey. The planning and design of stormwater management must be done, from the perspectives of both the site scale and the watershed scale.

If a professional were to design a parking lot for a retail center in downtown Manhattan, Kansas, the designer must recognize that if the plan provides infiltration on site then the design will contribute to the protection of the watershed. However, if the designer chooses not to treat stormwater on-site then the design is adding pollution to the local and regional watershed. The conventional design for stormwater (end of pipe method) is to drain storm runoff to a curb inlet, which is connected to a storm pipe. The pipe accelerates the velocity of runoff and efficiently conveys pollutants, which are emptied into receiving fluvial systems. The increased velocity and volume causes stream erosion. When landscape architects and civil engineers grade landforms they are influencing where the stormwater will run and the processes it will encounter along the way.

Conventional stormwater management

Stormwater management methods have evolved significantly over the past 100 years. Pre-automobile era roads were primarily paved with cobbles and bricks, which allows for some permeability and slows runoff. "Minor residential streets had no curbs; they were flanked by swales or ditches that kept streets drained during moderate rainfalls. Undersized culverts at driveways and intersections typically caused the swales to store the watershed equivalent of a half inch of runoff" (Ferguson, 1998, 4).

The automobile completely changed how cities are built and connected: including the infrastructure to deal with runoff. In 1916 the United States government passed the Federal Road Act, which "promoted the building of paved roads between cities to facilitate travel and commerce" (Encarta, 2003). The road improvements connected the major cities, but everything was still two lane roads.

"The passage of the Federal-Aid Highway Act of 1956 was perhaps the most significant event in U.S. road-building history" (Encarta, 2003). The act approved and funded the construction of more than 43,000 miles of interstate highways (Encarta, 2003). The new highway system provided independence for vast travel across the United States; however, it also established a dependence of Americans on roads and automobiles. The reliance upon oil, cars, and roads has had a tremendous impact on natural resources and ecological systems. Each year the United States paves or re-paves more than half a million acres of land (Ferguson, 1996), which is .0217% of the total 2.3 billion acres (Committee on Resources 2004).

Cities have been planned, zoned, and designed to accommodate the car. Ferguson states "Citizens moved from farms to metropolitan areas, and from the central sections to the suburbs. Businesses abandoned the old urban cores and relocated near suburban highway exits. In the suburbs, parking lots became essential adjuncts to stores." (Ferguson, 1998, 4). Nearly all land development in the U.S. revolves around the automobile.

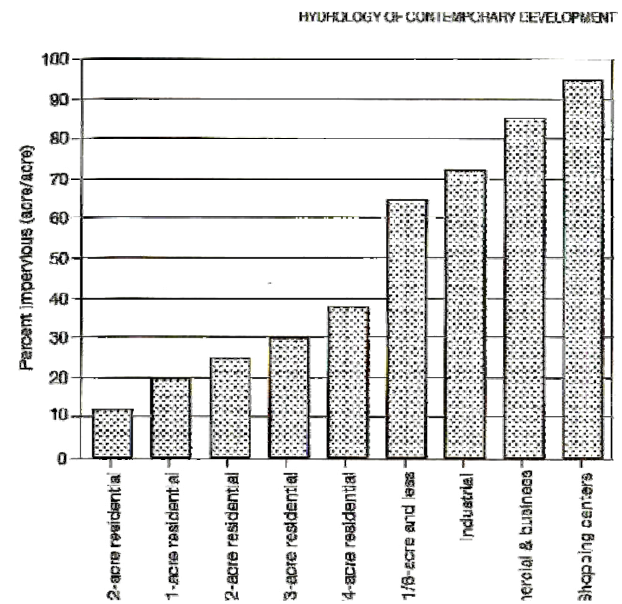


Figure 1-3: Hydrology of Contemporary Development (Ferguson, 1998, 5)

The result of an auto dependent society is a high percentage of impervious land cover in cities, towns, and the highways connecting all types of land uses. Figure 1-3 shows the levels of impervious land according to the development type. Impervious materials include: asphalt, concrete, roofs, highly compacted soils and others. The amount of stormwater runoff is often increased by more than 80-90 percent in urban areas, when compared with undisturbed land (Day, 2005).

The most prevalent method of managing stormwater in the 20th century has been using curbs and gutters to send stormwater runoff into storm-drains. Other types of inlets are used as well, but the concept of sending the water directly to a pipe is the same. The storm drainage system transports water directly into the nearest channel, ditch, stream, or pond.

Detention and retention ponds are used to slow or contain the runoff, but rarely do they contribute to improving water quality. As water conveys to ponds through pipes, ditches or swales it is deprived the opportunity to pass through plant communities and soils, which can clean stormwater.

"A field study of 15 stormwater ponds and one natural wetland in Guelph and the Greater Toronto Area, Ontario, was performed in 1997 and 1998" (Bishop, 2000). The findings were that "sediments from all ponds contained concentrations of at least one contaminant that exceeded the "lowest effects level" (LEL) of the Guidelines for the Protection and Management of Aquatic Sediment in Ontario" (Bishop, 2000). Ponds control runoff and prevent runoff; however the total volume of runoff is increase and as shown in the study by Bishop they often contain pollutants.

Wildlife and fowls are attracted to ponds, which can be detrimental if the ponds contain contaminated water. A fence may prevent a child from swimming in a detention pond, but it is more difficult to prevent fowls and wildlife from entering.

The practice of draining stormwater off site through a pipe and then holding it in a pond or directly into receiving fluvial systems is also called "end of pipe". Reasons why the conventional methods are not working include: increase in potential flooding and erosion due to increase in runoff volume, increase in pollutants due to lack of treatment (through plants and soil), missed opportunities to increase natural landscapes in urban settings (by day lighting channels), and loss of aquifer recharge.

It has become the common perspective for the public that stormwater is bad (primarily because of the potential for flooding) in urban or suburban settings. Conventional engineering teaches that runoff must be controlled with channels or ditches (usually concrete or grass), pipes, and ponds or holding basins. The described conventional end-of-pipe methods have been used for more than 50 years and are still being used today

In 1974 two engineering and surveying companies in Manhattan, Kansas prepared a Design Criteria and Procedures for Storm Drainage for the City of Manhattan, Kansas. The entire 63 page manual is devoted to calculating and sizing engineering structures for storm drainage. The manual is not unique in fact. It says, "The design charts, graphs, and data presented in this manual are not original; they are a compilation of useful information readily available in a variety of publications, collected together for the convenience of persons working to alleviate or prevent flooding in the City of Manhattan" (Schwab-Eaton, Inc 1974). This 1974 approach to stormwater management involving highly structured engineering; was, and is, common throughout much of the United States. In recent years the author has witnessed the common use of end-of-pipe stormwater management in both newly constructed landscapes and older landscape, while living and traveling in the Mountain west, Midwest, and Mid-Atlantic regions. While it is important to understand the engineering behind conventional stormwater management, this approach should be the method used if more natural oriented systems and techniques will not work.

The current cultural and political mindset of stormwater management using end-of-pipe method must be enlightened, stormwater is a valuable resource and should be treated as such. The achilles heel of planning and engineering is that man believes he can control nature, when in reality it is best to design and plan using natural processes.

The current engineering practices as described previously are for the most part decreasing the water quality of streams by sending contaminants into receiving waters. Research has shown that bioretention "has the potential to improve stormwater quality from developed areas… Investigations using pilot-plant projects laboratory bioretention systems and two existing bioretention facilities documented their effectiveness at removing low levels of lead, copper, and zinc from synthetic stormwater runoff" (Davis, 2003, abstract). Stormwater management using bioretention has a number of positive environmental contributions.

"As authorized by the Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Point sources are discrete conveyances such as pipes or man-made ditches" (http://cfpub.epa.gov/npdes/, viewed May 25, 2006). Residential homes or sites are not required to have an NPDES permit, however, "industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. In most cases, the NPDES permit program is administered by authorized states. Since its introduction in 1972, the NPDES permit program is responsible for significant improvements to our Nation's water quality" (http://cfpub.epa.gov/npdes/, viewed May 25, 2006). Bioretention facilities and other ecological stormwater management practices can help industrial, municipal, and other facilities achieve clean runoff. Proper planning and design will help achieve NPDES permits.

Hydrologic Cycle

Watershed-

Stormwater planning and design is done at the site scale, but always within the context of the larger watersheds. A watershed is also known as a catchments area, drainage basin, or catch basin (usually neighborhood size or smaller areas). A watershed is defined as "an area in which all water, sediments and dissolved materials flow or drain from the land into a common body of water such as a river, lake, stream, bay or oceans" (Green Streets, Metro, 2002). A watershed is "land area that contributes runoff (drains) to a given point in a stream or river. Synonymous with catchment and drainage or river basin" (Ward and Trimble, 2004, 443).

Watersheds are delineated by the USGS into geographic areas called Hydrologic Unit Codes (HUC). "The hydrologic units are arranged within each other, from the smallest (cataloging units) to the largest (regions). Each hydrologic unit is identified by a unique hydrologic unit code (HUC) consisting of two to eight digits based on the four levels of classification in the hydrologic unit system" (USGS). The EPA says that "many water quality and ecosystem problems are best solved at the watershed level rather than at the individual waterbody or discharger level" (USGS).

Decisions made by planners, engineers, and designers affect the runoff and hydrology the watershed(s), whether or not they are aware of it. Each watershed is unique and has its own set of issues regarding impairments and others. The EPA provides a website called surf your watershed http://www.epa.gov/surf/ . The website provides data concerning size of watershed, up and down stream watersheds, impairments, links to local groups working for the benefit of the watershed, and other specific information according the watershed. This information, along with consulting hydrologists and GIS specialist will help planners, engineers, and designers make good environmental decisions. Every decision implemented into construction (or policy such as a buffer ordinance) can have either a positive or negative impacts on the watershed and its hydrologic cycle.

Hydrologic Cycle-

The hydrologic cycle has been defined by the Illinois State Geological Survey as "the vast and complex circulation of water between the earth and the atmosphere…rain falls from the atmosphere and lands on land or water, most of which returns directly through evaporation. Water also returns to the atmosphere by transpiration, the water taken up by the plants from the soil through their roots and released through their leaves as water vapor" (Illinois State Geographical Survey, 2004).

As rain falls it is passes through "canopies, stems, grass blades, and vegetative litter bed", the small but significant amount which is intercepted and retained is called interception (Ward and Trimble, 2004, 86). Water that is held on vegetation begins to

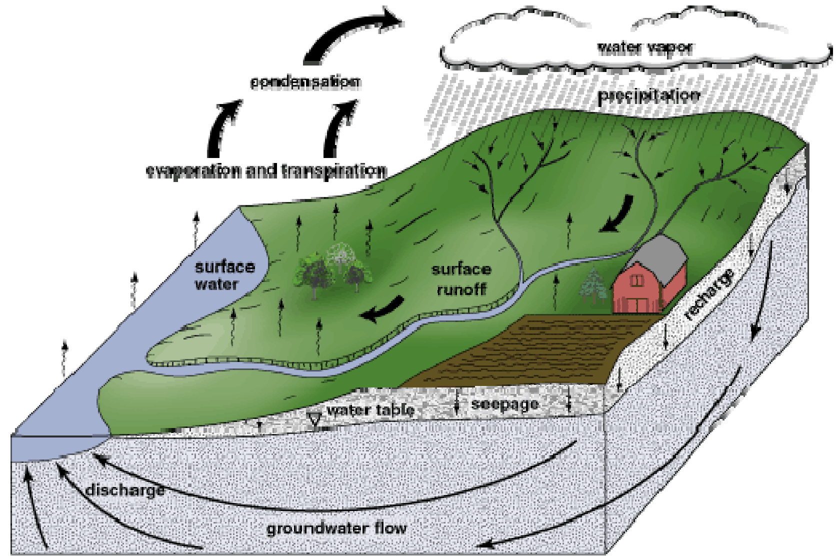


Figure 1-4: Hydrologic Cycle

evaporate during the storm and after. Vegetation has a greater capacity than impervious material (such as concrete) to hold and slow water runoff. In urban and suburban environments vegetation is minimal, which changes the hydrology of an area by decreasing interception, evaporation, evapotranspiration, and increasing runoff.

Rainwater that hits ground surface either runs off, evaporates, or infiltrates into the soil. Roots of plants "aid infiltration by acting as pathways for water flow. Fibrous roots absorb large amounts of water" (Shaw, 2003, 24. As explained in more depth in Chapter 5 Ecoregion, "Roots of prairie grasses can extend deep into the ground and aid infiltration and evapotranspiration". The "Dense root networks stabilize and minimize erosion" (Shaw, 2004, 25). As water infiltrates into the soil, the dense prairie root can act as a sponge holding water, until in evapotranspirates or percolates downward.

Water that is not intercepted flows across the land to streams and rivers as surface runoff. The remainder percolates downward through the ground to the saturated zone where available openings in the earth materials are filled with water. It is important to note "The rate at which water infiltrates depends on soil properties such as soil water content, hydraulic conductivity, (permeability), and porosity" (Ward and Trimble, 2004, 5). Conditions that negatively affect infiltration and percolation are compacted surfaces and impervious surfaces. Plants and organisms have a major role in aerating the soils and helping water percolate to aquifers or moving laterally as subsurface flows. Groundwater flows under the influence of pressure and gravity and eventually discharge at the surface as springs or as seepage into streams, rivers, lakes, or wetlands.

Once on the surface, the water can evaporate. When water vapor cools, it condenses into clouds from which precipitation falls to the earth, completing the cycle (Illinois State Geographical Survey, 2004). Figure 1-4 is an illustration of the processes exhibited by the hydrologic cycle.

The effects of urbanization or development on a watershed can be extremely negative on the local ecosystem and disrupt the hydrologic cycle. Much of the natural vegetation and land is replaced with impervious cover such as concrete or asphalt. As the percentage of impervious land cover increases the amount of stormwater infiltration into the groundwater decreases and the runoff into curb and gutter and pipes increases. The significant change in the local hydrologic cycle of the land will decrease the ecosystem's health.

A hydrograph displays the amount of water (usually cubic feet per second) discharging over a period of time. Figure 1-3 shows the relationship between communities of different stormwater strategies and their respective hydrograph.

According to Andrew Ward "More than 50% of the population (US) depends on groundwater as the primary source of drinking water. Approximately 75% of American Cities derive their supplies totally or partially from groundwater" (Ward and Trimble, 2004, 6). Unless aquifers are recharged we will eventually run out of water to drink. Aquifer recharge takes years and most commonly aquifers are being depleted faster than they are recharged. This shows a specific connection between stormwater management and the condition of the hydrology of watersheds.

Infiltration-

Infiltration is essential to groundwater recharge and is part of the hydrological cycle. "Infiltration is defined as the passage of water through the surface of the soil, via pores or small openings, into the soil profile. Water infiltrating into the soil profile is a necessity for vegetative growth, contributes to under-ground water supplies that sustain dry-weather stream flow, and decreases surface runoff, soil erosion and the movement of sediment and pollutants into surface water systems" (Ward and Trimble, 2004, 55).

In order to mimic the hydrology of predevelopment conditions or natural land patterns within an ecoregion the post development infiltration rates must be roughly equal to those of similar ecosystems or vegetative communities within local landscapes.

When infiltration is eliminated from the hydrologic cycle by using impervious materials such as asphalt and concrete then groundwater aquifers are not recharged, perennial streams do not continue their natural base flow, and plants have minimal amounts of water from which to draw.

Water moves downward in soil by forces of tension and gravity. Then tension forces are also called matric, suction, or capillary forces. "The term suction is often used because water is sucked or pulled into the pores. A common example of capillary flow (flow due to tension forces) occurs when a person's finger is pricked, and a blood sample is taken. The blood sample is drawn into the thin sample tube due to capillary forces. To illustrate water movement due to tension forces, dip a dry blotter or paper towel into and note how quickly water is sucked into the dry material against the pull of gravity" (Ward and Trimble, 2004, 58).

Soil is a combination of air, water, and particles (or peds). The voids or spaces in soil are called pores. "When the pores are completely filled, the soil is described as saturated" (Ward and Trimble, 2004, 59). "Porosity is an important property in problems involving water volumes or water or water movement. It is commonly used in calculations made by hydrologist, soil scientist, and agricultural engineers" (Ward and Trimble, 2004, 58). When soil has a high degree of saturation infiltration rates are low. "When water is present, soil air is displaced from the pores, the soil water content increases, and the soil tension decreases. This results in decreased infiltration rates" (Ward and Trimble, 2004, 58). In designing for stormwater techniques such as Bioretention cells or naturalized detention areas (sometimes called raingardens) it is important to design some type of overflow outlet, case the bioretention cell or like structure is saturated. The overflow can be a drainage swale that is connected to a larger drainage swale or stream, or as a last resort to an inlet into a pipe.

Small pores fill first due to surface tension force, followed by larger pores. The larger pores containing water begin to drain until equilibrium between gravity pulling down and the attraction of the   As water moves in soil there is a "tug-of-war" between gravitational and suction forces (Ward and Trimble, 2004, 59-63). Following the wetting of the ground surface, there is "redistribution of soil water, and pores will drain to capillary and gravity flow" (Ward, 2004, 59). In applying this soil principle to stormwater management we learn that water entering an infiltration pond or cell will redistribute as it is infiltrating into the soil. "When gravity flow becomes negligible, the soil water content of the profile will be at field capacity" (Ward and Trimble, 2004, 59). It is important for stormwater structures such as an infiltration pond to have a stormwater inlet or natural overflow outlet for when the soil of the structure reaches field capacity.

"A similar tug-of-war occurs when the roots of a plant tries to extract water from a pore. The plant has to apply sufficient pulling force to overcome the opposition pulling force due to tension in the pore" (Ward and Trimble, 2004, 59). Generally as prolonged dry periods occur plant roots of drought tolerant plants go deep into the soil in search of water. The extension root structures into the soil give drought tolerant plants their hardiness.

Different soil types have different water holding capabilities. Clay soils have higher water holding capacity due to tension, small pores, and high amount of surface area. Sandy

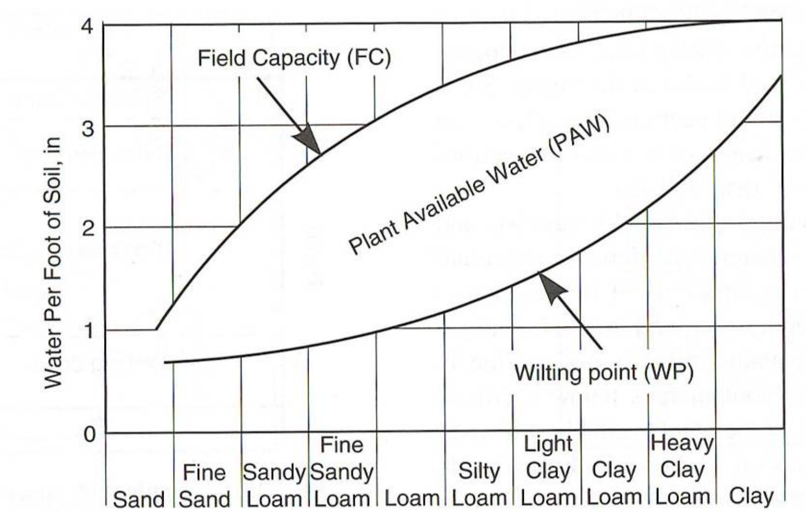


Figure 1-5: Soil water holding capacity (Ward and Trimble, 2004, 59)

soils have a low water holding capacity due to large pores. LID techniques used in the mid-Atlantic region call for more sandy soils to allow for high infiltration rates, yet due to lower amounts of precipitation mid-West regions would do better to have a Fine Sandy Loam to a Light Clay Loam soil. Midwest and West regions receive less precipitation and it is important for soils to hold water for the drier plant communities.

Precedents of Stormwater Management

The Woodlands-

One of the earnest and most striking examples of hydrological analysis and stormwater management taking central role in development is **The Woodlands** community, a thoughtfully planned suburb north of Houston, Texas. In the 1960's George Mitchell a developer began making plans for a large land tract north of Houston. Initially the development was conventional in layout and design, but Mitchell sought environmental planning assistance. In 1970, following a recommendation of his planning and director, Robert Hartsfield, Mitchell read Ian McHarg's Design with Nature. Subsequently in 1971, the firm Wallace, McHarg, Roberts and Todd (WMRT) was selected to complete an environmental plan for the Woodlands (Forsyth, Ann 2005).

George Mitchell "indicated that his most important move was to employ McHarg. Although the WMRT work was refined and revised by subsequent consultants" (Forsyth, 2005, 172).

Figure 1-6: Vegetated Swale, The Woodlands, TX (Forsyth, Landscape Architecture, 2005)

WMRT set the stage for the environmental planning for the Woodlands. WMRT's approach to planning and design at The Woodlands progressed "logically from ecological data inventory to interpretation, assessment of landscape tolerance, design synthesis, guidelines, and plans" (Forsyth, 2005, 173).

The Woodlands was flat, and thus naturally held a great deal of water at or near the surface. The site was dominated by pine forest. One third of the site was within the 100-year floodplain and "the WRMT team saw this issue of hydrology, the water system including drainage and aquifer recharge, as the most critical natural system" (Forsyth, 2005, 175).

The hydrology of The Woodlands was respected and made the centerpiece of the development in order to preserve the forested ecosystem, groundwater recharge, and the natural aesthetics of the site. One planner noted: "The pines are not particularly special, but the rest of the trees like the big live oaks and magnolias, are really beautiful trees. The problem is, if you

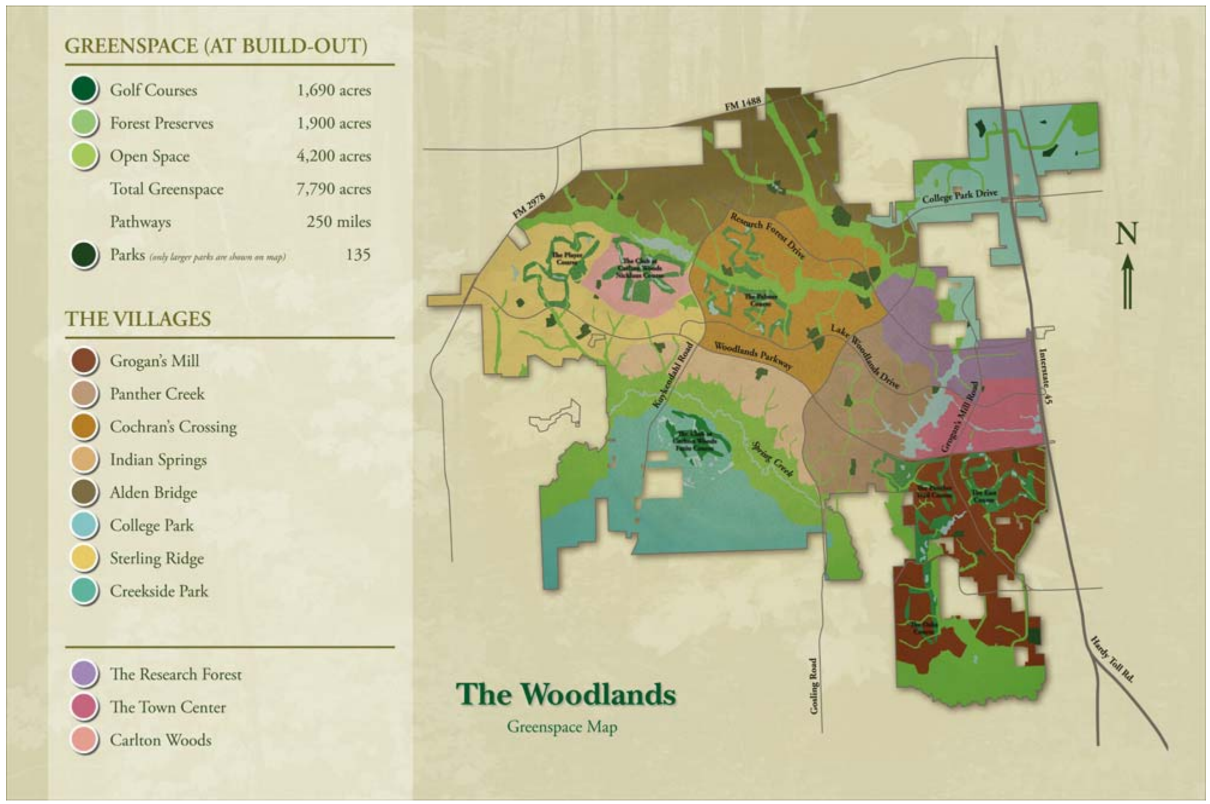


Figure 1-7: Map of Green Space and Streams (http://www.thewoodlands.com/ 4-6-06)

change the hydraulic regime even the slightest bit, what happens is virtually all of the broad-leaved evergreens die; you end up with pines" (Forsyth, 2005, 175). The planners knew if they dropped the water table then plant associations would change resulting in the loss or decline of the current ecosystem.

WMRT's role in The Woodlands included "planning and design as well as analyzing geology, hydrology, soils, plant ecology, wildlife, and climatology" (Forsyth, 2005, 174). WMRT's analyzed the major site and ecoregion factors (including hydrology) and then applied this knowledge as locations for streets, lots and other development features were proposed.

As part of the process "the WMRT team delineated areas where development would have less impact because of soils, slope, drainage, water recharge, erosion, wildlife areas, and opportunities for recreation and open space. This included limits on clearing of building lots, the design of open space, and changes to drainage design (Forsyth, 2005, 175). Wooded areas remained as the prominent aesthetic feature of the development and supported the natural hydrology. The Woodlands changed the site's hydrology; however it was intended "to increase peak flows by only about one-third of the increase in comparable new developments" (Forsyth, 2005, 175).

The Woodlands is an excellent example of ecological planning and design, but due to economic restraints and political factors the development has deviated some from the original environmental planning ideas. "The development has largely

Figure 1-8: Perennial stream at The Woodlands (Forsyth, Landscape Architecture, 2005)

controlled runoff, is a striking forest area, has a variety of parks, and boasts a path system of over one hundred miles. However, a number of environmental activists have complained that in some areas only a "veneer of woods" or "a forest façade" remains and that the focus on hydrology has detracted from the attention paid to maintaining corridors for wildlife" (Forsyth, 2005, 202-203).

The role of hydrology in any development should be top priority if communities are to be sustainable. The Woodlands shows that hydrology, development, and ecology can all be combined to create ecologically and economically sustainable developments.

Village Homes-

Another sustainable community example is Village Homes, Davis, CA. In the early 1970s a grass roots effort to organize, plan, and design a sustainable community was led by architect Michael Corbett. The evolution of the community or green village was an organic process involving local citizens, fellow graduates of the Ecology program at University of California, Davis, and newly elected city council members. During this time Davis's new city council voted to place a "moratorium on all growth until the city's general plan could be rewritten" (Corbett, 2000, 25). The City of Davis wanted to change suburban sprawl and the proposed Village Homes was offered a sustainable community.

The Village Homes total site is 70 acres, 240 single family detached homes and 20 apartment units. The community's sustainable practices include (Village Homes Website, unknown publication date):

- Homes oriented for passive solar heating
- Minimizing impervious surfaces by narrowing street widths
- Pedestrian, Bike paths encouraging recreation and non motorizing travel
- Natural drain system of creek beds, swales, and infiltration ponds

- Edible landscaping, with a variety of fruit trees and other edible plants cared for and used by residents
- Common green space owned by residents (40% of total site acreage)

The **hydrology of Village Homes** is different from conventional developments in that the grading drains water from roofs and lots to the rear of lots rather than the front or street storm drains. The runoff is sent to "attractive, meandering, creeklike shallow swales that run through the greenbelts. They are landscaped like seasonal streambeds, with rocks, bushes, and trees" (Corbett, 2000, 44). Small check dams using "pieces of wood" were placed in the channels to slow runoff and increase percolation (Corbett, 2000, 44).

"In light rains, this surface drainage system allows all the water that falls to be absorbed into the ground. In heavier rains, the system empties some water into the city's storm drains, but not nearly the amount a typical subdivision would" (Corbett, 2000, 44-45). Village Homes stormwater management plan has proven effective by holding 90% of runoff on-site and as the "tree's continue to make the soil more porous, the land's capacity to hold and absorb runoff increases" (Corbett, 2000, 45).

The Village Homes stormwater management plan "was one of the most difficult innovations to get approved. Despite the fact that such a system seemed so serviceable, the city's Planning and

Figure 1-9: Village Homes, (5-06-06 http://www.lgc.org/freepub/images/vh_arial.jpg)

Building Department and Public Works Department were adamantly against it, and the FHA refused to approve it" (Corbett, 2000, 45-47). Public officials believed that the stormwater plan would not work, despite this Village Home received the proper approval and was built according to the plan.

The benefits of a natural drainage system for Village Homes are: reduction in infrastructure costs, lower risk of flooding, increased amount of open space and wildlife habitat, reduced maintenance costs, increased aesthetics of ephemeral streams, and reduced need of irrigation (Corbett, 2000, 43-47). Village Homes offers a time tested example of a stormwater plan that preserved the natural hydrology of the site and in return adds to the character of the community.

Design Research

Introduction-

Perhaps the most effective long-term method to manage stormwater is to imitate the processes of hydrology in healthy ecological systems. Whether the natural land cover is woodlands, mountain forests, meadows, or prairies rainwater begins to infiltrate on contact with well developed, vegetated soils. Various native land covers have different runoff rates, but the common denominator is typically high infiltration which leads to groundwater recharge and continual supply of water to streams through seepage and springs. Steep slopes, high clay soils, and compacted soils offer lower infiltration rates.

Upon a review of background literature (Appendix A) the author based the thesis research on the following critical principles of stormwater management:

1. Stormwater should infiltrate as close to the point of ground impact as possible.

2. Post-development runoff should be close to pre-development runoff. If the site is disturbed then the runoff goal is to mimic that of the natural land pattern.

3. The water quality at the point of receiving streams must be acceptable to the standards set by government agencies and retain the water quality needed to maintain proper aquatic habitats.

4. Plants interacting with soil provide the essential biological process to clean and infiltrate water. The use of native plants is preferred.

5. All stormwater management methods must minimize hazardous flooding.

6. Ecoregion characteristics (such as soil, climate, and plants associations) influence the planning and design of stormwater management.

7. The design should be both aesthetically pleasing and ecologically functional.

8. Previous ecological stormwater approaches should be reviewed and incorporated in order to learn from the past and build on the ideal of ecological stewardship.

During the literature review of stormwater management Low Impact Development (LID) was found to incorporate all of the principles listed previously. LID is a holistic; system based method of treating stormwater and will be the starting point of the research.

Design Research-

LID is a stormwater management program developed and implemented by the Department of Environmental Resources, Prince George's County, Maryland (DER PGC). The LID program was developed in the context of suburban and urban sprawl occurring in the greater Washington D.C. region. The Chesapeake Bay, Mid Atlantic Region (including Maryland) watershed had been experiencing impaired watershed conditions for some time and even implemented Best Management Practices (BMPs), such as detention ponds were not effectively addressing the problem of water pollution (Hager, 2003).

This thesis provides a summary of LID principles, techniques, and purposes. It will help the reader come to a basic understanding of LID and the adaptation of LID principles and practices in Topeka, KS (KS). It is crucial that the planner, engineer, and landscape architect understand the characteristics of the ecoregion which affect the stormwater and hydrology.

In following the model of how to prepare for stormwater planning and design the thesis will provide a basic understanding of the characteristics of the Topeka, KS. The core of the thesis research will involve two case studies of two LID-type stormwater techniques implemented in Topeka, KS. Each case study will involve personal communication with city planners and engineers, site visits, photographs, assessment of vegetative success, and a review of lessons learned from design, construction, and ongoing management.

Chapter 2 Low Impact Development Design Strategies

Origin of LID-

Prince George's County, Maryland faces stormwater management issues similar to most of the country's urban and suburban areas; including ground water recharge, poor water quality, high levels of surface runoff and flooding. The Department of Environmental Resources (DER) began exploring alternative stormwater techniques in the late 1980s and early 1990s. Larry Coffman, associate director of Programs and Planning, Environmental Resources in Prince George's County (DER PGC) developed natural bio-retention, "the process of capturing pollutants in bacterial and plant biomass" (Hager, 2003, 3).

Water quality was the main reason for DER to look at alternative stormwater techniques; however "One of the engineers on the bioretention project noted that the effort was going to alter runoff on the project site" (Hager, 2003, 3). Coffman realized the potential of bioretention and recommended this "tool" as a method to restore site hydrology and store water for possible re-use. In speaking of stormwater management Coffman said "we can control all of it and we don't need a lot of space." (Hager, 2003, 3).

LID publications-

Under the encouragement and support of the US Environmental Protection Agency (EPA), DER PGC published the <u>Low-Impact Development Strategies: An Integrated Design Approach</u> in June 1999. In the preface Larry Coffman states that "Low-Impact development (LID) is a radically different approach to conventional stormwater management. It is our belief that LID represents a significant advancement in the state of art in stormwater management. LID enhances our ability to protect surface and ground water quality, maintain the integrity of aquatic living resources and ecosystems, and preserve the integrity of receiving streams" (DER PGC, 1999, ix). This LID publication is also called the LID National Manual because it was adapted to have a general application for all regions. Following suit, other

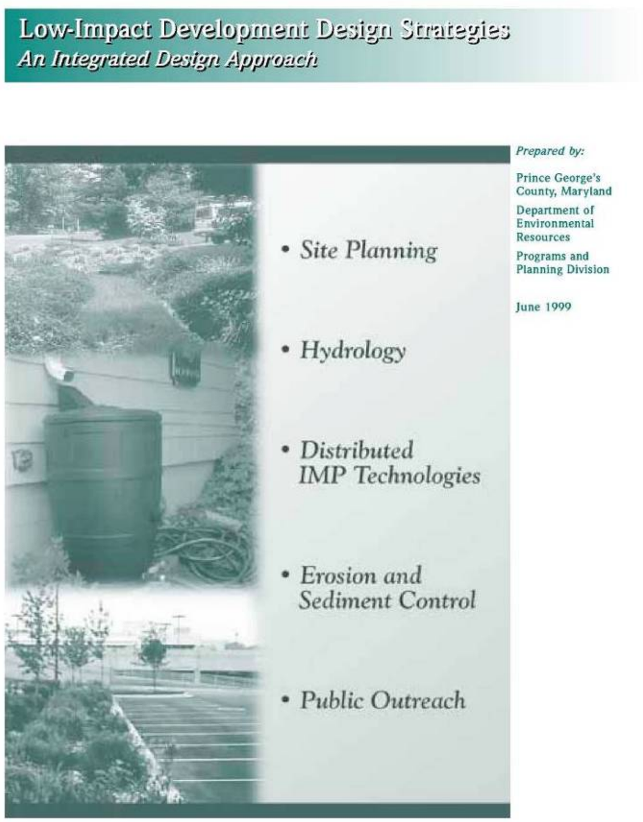


Figure 2-1: LID National Manual (DER PGC, 1999)

cities have adapted and developed LID principles to meet their own environmental circumstances.

Table 2-1: LID Goals (DER PGC, 1999, 1 2-3)

- Provide an improved technology for environmental protection of receiving waters.
- Provide economic incentives that encourage environmentally sensitive development.
- Develop the full potential of environmental sensitive site planning and design.
- Encourage public education and participation in environmental protection.
- Help build communities based on environmental protection.
- Help build communities base on environmental stewardship.
- Reduce construction and maintenance costs of the stormwater infrastructure.
- Introduce new concepts, technologies, and objectives for stormwater management such as micromanagement and multi-functional landscape features (bioretention areas, swales, and conservation areas); mimic or replicate hydrologic functions; and maintain the ecological / biological integrity of receiving streams.
- Encourage flexibility in regulations that allows innovative engineering and site planning to promote "smart growth" principles.
- Encourage debate on the economic, environmental, and technical viability and applicability of current stormwater practices and alternative approaches.

Many of the ideas, concepts, and techniques of LID are not new and have been used by professionals in the fields of hydrology and watershed planning for many years. As noted earlier, Ian McHarg and WMRT team made hydrology and stormwater infiltration a major part of the planning and design of The Woodlands during the early 1970's. Early phases of The Woodlands had vegetated swales adjacent to the roads for stormwater infiltration and cleansing. Likewise, specific areas of the development were preserved for groundwater recharge. Village Homes in California also employed distributed stormwater management tools and techniques throughout the development.

Roots of LID ideas and concepts "arose in the early 1980s from other nations, including Germany, France, and Japan, where cities were interested in applying distributed, integrated management techniques to reducing stormwater quantity to alleviate problems with combined sewer overflow" (Hager, 2003, 3).

What is unique and new to LID is the movement towards stormwater treatment on-site versus end-of-pipe methods in the various parts of United States. LID strategies began with local government in Maryland. LID has now been adapted to areas within Washington State, Oregon, California, Connecticut, Illinois, and a number of other states and localities.

The LID principles and strategies for stormwater are holistic, with the highest priority being the hydrology of the site and the watersheds downstream. The conventional method of curb, gutter, and pipe cannot sustain the natural functions of the hydrologic cycle and LID seeks to rectify this serious water quality problem.

LID Cost Incentives-

LID stormwater management is cost effective. According to Anne Guillette, LID principles saved developers of the Somerset Community in Prince Georges County, Maryland $916,382. In 1995 a 60-acre development integrated LID technologies, to fit 199 homes on 10,000 square foot lots. Alternative development patterns were used to distribute stormwater management systems. This LID design yielded 6 additional lots and resulted in increased revenues at $40,000 each (Whole Building Design Guide, 2006).

The breakdown of costs according to Guillette was:

1. $300,000 savings on LID vs. stormwater ponds

   LID Cost: $100,000

   Conventional Cost: $400,000;
2. $240,000 additional revenue on 6 additional lots (space previously allocated to ponds) 6 x $40,000 Net;
3. $916,382 overall cost savings or $4,600 savings per lot.

The Somerset Community has no curb and gutter, but uses shallow swales to store, infiltrate, and convey stormwater. Every lot has a bio-retention cell, also known as "rain garden", which cleanses the stormwater pollutants from the drives and roads. The roof downspouts drain into the bio-retention cells or rain barrels. Community members recognize the positive impact their development has in helping to preserve the water quality within the Chesapeake Bay (Whole Building Design Guide 2006).

Figure 2-2: Somerset Rain Gardens and Swales (Whole Building Design Guide, 2006)

Developers are constantly looking to save money and while some may not be too keen on the positive ecological impacts, financial savings is a strong component of LID. The LID manual suggests the various savings methods:

- Reducing impervious surfaces (roadways), curb, and gutters;
- Decreasing the use of storm drain piping and inlet structures; and
- Eliminating or decreasing the size of large stormwater ponds (DER PGC, 1999, 1-3).

Another significant savings relates to the high cost of maintaining conventional stormwater pipe systems as they age. LID tools and techniques require smaller scale maintenance, typically related to each lot.

LID Manual and Components-

The LID manual includes guidance that "allows the site planner/ engineer to use a wide array of simple, cost-effective techniques that focus on site-level hydrologic control". The manual teaches the basic science, planning principles, hydrology and design, and then it is left to the designer to implement the technology according to the specifics of the site. The LID manual is specifically written for stormwater management on the site level and does not address the larger watersheds. However; the consequences of the implemented LID principles have a tremendously positive outcome in the larger watershed and regional context. The basic components of the LID manual (PGC-DER, 1999) are:

- Site Planning
- Hydrology
- Distributed Integrated Management Practices (IMP) Technologies
- Erosion and Sediment Control
- Public Outreach

This thesis will provide a brief overview of the components with a more in depth discussion of the IMP Technologies or LID stormwater techniques (such as bioretention cells).

Site Planning-

The LID stormwater approach begins with planning, no matter the scale or size of the projects. The main idea is to marry the stormwater management with the project's objectives, such as: "site plans that are adapted to natural topographic constraints, maintain lot yield, maintain site hydrologic functions," and aesthetically pleasing (PGC-DER, 1999, 2-1). This holistic approach to planning with stormwater being a major factor will facilitate a creative and sound design, in which sustainability is achieved.

The LID manual provides five basic concepts to incorporate into design, which include:

Table 2-2: LID basic design concepts

1.	Using hydrology as the integrating framework
2.	Thinking micromanagement
3.	Controlling stormwater at the source
4.	Using simplistic, nonstructural methods
5.	Creating a multifunctional landscape

Concept 1- Hydrology as the Framework-

Conventional stormwater methods focused on "rapidly and efficiently draining the site", in contrast the LID methodology is to "preserve the natural hydrologic functions of the site" (PGC-DER, 1999, 2-2). Planners and designers study out and plan for the site to keep its same basic hydrologic function, yet still allow for the site to keep its desired functions. The main hydrologic features which need to be identified and preserved include: stream corridors with appropriate buffers, floodplains, wetlands, steep slopes, highly permeable soils, and woodlands, grassland, or other vegetative communities (PGC-DER, 1999, 2-2). A development envelope is the result of protecting all the sites hydrologic features.

In the fields of landscape architecture and architecture one methodology of site design is to use a Parti, a basic backbone of the site layout. The Parti is simply a diagram representing the layout of the main spaces and the structures. By making the major drainage channels of site the Parti, the designer will be able to better buffer the channels, create a nice natural linear walk, and have a more organic design. Too many designs are laid out without adequately protecting all drainage ways and riparian corridors. However, by respecting the natural topography and protecting hydrologic features a design will then be unique to the site, original, and of higher quality.

Precedence of Site Design and Stormwater Management-

Figure 2-3 is a master site plan of Coffee Creek Center in Chesterton, Indiana done by Conservation Design Forum (CDF). Coffee Creek Center is 640 acres, 160 of which is prairie, woodland, wetland and stream restoration. The site hydrology

Figure 2-3: Coffee Creek Site Plan

(http://www.cdfinc.com/CDF_Portfolio/Community_Scale/Community_Scale_Portfolio.htm 4-6-06)

was designated as high priority and as noted on the plan the Coffee Creek riparian corridors serves as the backbone or Parti of the development. "State of the art stormwater and wastewater treatment systems integrate water resource management without creating waste. The goal of these systems is to restore a groundwater based hydrology and minimize surface runoff" (http://www.cdfinc.com/CDF_Portfolio/Community_Scale/Community_Scale_Portfolio.htm 5-5-06).

Figure 2-4: Coffee Creek Level Spreader (http://www.coffeecreekcenter.com/media/mediaattn/CCC-Codebook_web.pdf 5.2 5-4-06**)**

Hydrology regarding Coffee Creek Center is different than most developments in that "there is a complete absence of infrastructure to hold stormwater or to remove it from the site – no retention ponds, no big drainage pipes or other conduits to move water off" (http://www.cdfinc.com/CDF_Portfolio/Community_Scale/Community_Scale_Portfolio.htm 5-6-06). The design achieves stormwater infiltration by using swales and level

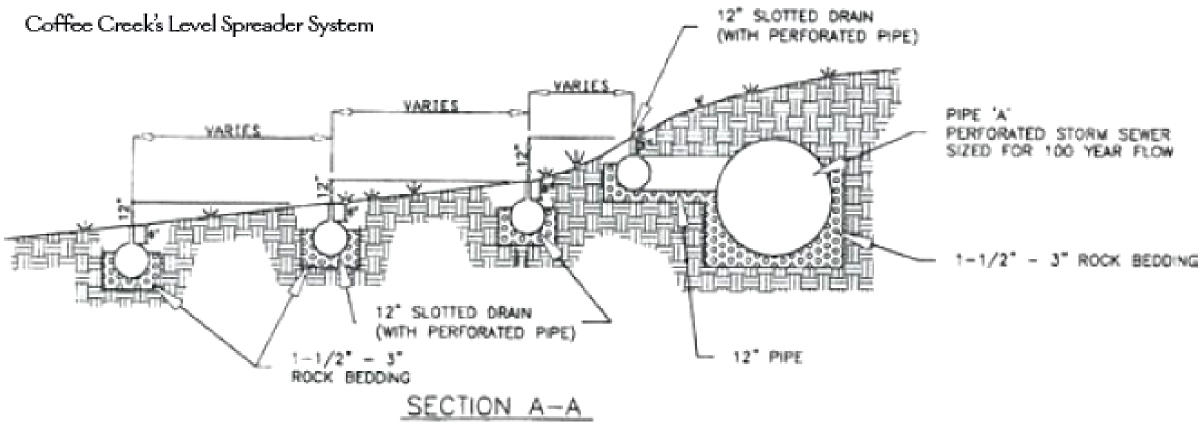


Figure 2-5: Level Spreader Detail (http://www.coffeecreekcenter.com/media/mediaattn/CCC-Codebook_web.pdf 5.5 5-5-06)

spreaders which evenly drain the stormwater into the prairie. Level spreaders are "12-inch-diameter perforated pipes that allow water seepage, running for hundreds of yards from the developed areas into the restored prairies, just below the surface of ground. A pipe is placed along each 1 foot contour in land elevation, spaced closely in steep areas and further apart in more level sections of the terrain. In heavy rainfall, the pipes will fill with water and release it through perforations; water will flow evenly over the land until is absorbed or falls into the next spreader".

The effective planning, design, and execution of Coffee Creek Center is the result of collaboration between the design firms, planners, engineers, biologist, and developers each having ecological integrity in mind.

Concept 2-Thinking Micromanagement-

Another drastic change from conventional methods is thinking small, rather than large lengthy systems with ponds at the end of the pipe. The designer needs to change to a perspective of microwatersheds, siting surface runoff controls at the smaller scale. Doing this size and frequency of storms that can be more effectively controlled. Site controls should focus on infiltration, depression storage, interception, and reduction in the time of concentration. Such micro-management techniques are called "integrated management practices" (IMP) (PGC- DER, 1999, 2-3).

The typical Wal-Mart and other big box stores have large expansive parking lot with sheet drainage. Stormwater flows across impervious surfaces to either a storm drain, which goes directly into concrete pipe, channel or a detention pond. Minimal amounts of the stormwater in the detention pond infiltrate into the grass or soils and the rest flows at separate rate into the stormwater drain pipe or channel. In this example the stormwater works as a carrier of all of toxins left by cars on the asphalt (the grass does little if anything to cleanse the water before sending it into receiving streams).

Figure 2-6 offers an aerial view of a typical Wal-Mart. There is no effort to correctly control stormwater at the source. The proper method would be to provide bio-retention swales in between the lots, allowing for infiltration and contaminant removal. Trees would be planted in the swales, which would reduce the urban heat island effect, which results from higher temperatures of asphalt and other hard surfaces. Rooftop storage or the use cisterns would further refine runoff and allow for the re-use of stormwater for irrigation.

Figure 2-6: Aerial of typical Wal-Mart (Google Earth, 2006)

Concept 3 – Controlling Stormwater at the Source-

The key to have a positive stormwater in the Wal-mart case and every project "is first minimize and then mitigate the hydrologic impacts of land use activities closer to the source of generation" (PGC-DER, 1999, 2-4).

An undisturbed landscape, such as an ephemeral stream in the prairie has hydrologic functions throughout the landscape. These functions include: plants and trees offering interception and transpiration, plants filtering the surface runoff, water flowing into depressed land, and infiltration of stormwater into the soil. All of these functions cannot perform efficiently using the conventional end-of-pipe method. By treating the stormwater close to the point of impact the cost of stormwater infrastructure can be eliminated or reduced dramatically.

Concept 4- Utilization of Simplistic, Nonstructural Methods-

The LID manual recommends first looking at simple methods of dealing with stormwater in contrast with the conventional structures of concrete and steel. By using plants, soil, gravel, and rock, the landscape will have a more aesthetic and natural feel.

The LID manual indicates that "small, disturbed, micro-control systems also offer a major technical advantage: one or more of the systems can fail without undermining the overall integrity of the site control strategy" (PGC-DER, 1999, 2-5). LID facilities are smaller basins, swales, filters, subsurface pipes, and natural drainage channels. When one facility overflows it goes to the next, functioning somewhat like a floodplain. The slopes are gentle and the depths are shallow thus increasing safety over steeply sloped retention ponds.

Concept 5- Creating a Multifunctional Landscape and Infrastructure-

Another way in which LID differs from conventional approaches is that LID blends stormwater treatment with everyday urban landscape or infrastructure. Features such as roofs, streets, parking, sidewalks and green space can incorporate stormwater treatment. Trees can be planted in swales to serve as check dams, thus slowing water and offering interception and transpiration. The trees also would provide shade next to parking or a nature walk. Green roofs and porous paving are additional examples of LID tools that may be used to catch, slows, and temporarily holds rainwater.

The LID Site Planning Process-

The concepts provided by LID give the purpose, intent, and ideology of planning for development improvements and stormwater. The second part to the LID Site Panning is the process. Table 2-1 provides the steps of the planning steps in the LID manual.

Table 2-3: LID Site Planning Steps (PGC-DER, 1999)

Step 1	Identify Applicable Zoning, Land Use, Subdivision and Other Local Regulations
Step 2	Define Development Envelope
Step 3	Use Drainage and Hydrology as a Design Element
Step 4	Reduce and Minimize Total Site Impervious Areas
Step 5	Integrate Preliminary Site Layout Plan
Step 6	Minimize Directly Connected Impervious Areas
Step 7	Modify and Increase Drainage Flows Paths
Step 8	Compare Pre and Post Development Hydrology
Step 9	Complete LID Site Plan

This section of the background will briefly highlight the each of the steps of the planning process, for complete information see the (PGC-DER, 1999).

Step 1- Government planning-

Every local government entity has zoning ordinances and regulations which control the type of development allowed and the density. These regulations are designed to coordinate development in conjunction the urban master plan or the land use plan of the area. Zoning ordinances can also define roadway widths, parking requirements, and natural resources which need to be protected. The establishment of zoning and ordinances for municipalities take years and are very politically charged. Currently many local government regulations do not require or allow for sound environmental practices, such as LID. Cities which have embraced LID principles include: Seattle, WA, Portland Oregon, San Francisco, CA, Prince George's County, MD, Chicago, IL, and others. Part of the LID philosophy is public outreach and regarding zoning, LID offers the alternatives (Table 2-3) for which government officials should consider in for planning purposes.

Table 2-4: Zoning Options (PGC-DER, 1999, 2-8)

Zoning Option	Functions Provided
Overlay District	Uses existing zoning and provides additional regulatory standard
Performance Zoning	Flexible zoning based on general goals of the site based on preservation of site functions
Incentive Zoning	Provides for give and take compromise on zoning restrictions allowing for more flexibility to provide environmental protection

Imperviousness Overlay Zoning	Subdivision layout options are based on total site imperviousness limits
Watershed-based Zoning	Uses a combination of the above principles to meet a predetermined watershed capacity or goal

Step 2 Define Development Envelope and Protected Areas-

The building envelope is outlined by regulations and protected important site features. The regulations will include setbacks, easements, and others. The protected site features includes: wetlands, ephemeral or perennial streams/ rives, riparian zones, floodplains, woodlands, important trees, steep slopes, and high permeable and erosive soils (PGC-DER, 1999, 2-8). GIS software applications provide an effective method of overlaying site sensitive areas and defining build-able areas.

Step 3- Reduce Limits of Clearing and Grading-

This section is similar to defining a building envelope with emphasis on located the development in areas that have lower hydrologic function. Buildings, structures, walks, drives, and parking can be careful planning to preserve existing trees, drainage channels, and prairies or meadows (PGC-DER, 1999, 2-8).

Step 4- Use Site Fingerprinting-

Site Fingerprinting is the smaller scale focus of "restricting disturbances by identifying the smallest possible area and clearly delineating it on the site". By actually flagging or using other types of markers on the site, construction workers will be more aware of the areas and trees which need to be preserved. Paved or compacted surfaces should be kept to a minimum to reduce runoff and increase infiltration. Impervious surface areas should be disconnected as much "as possible to increase opportunities for infiltration and reduce water runoff flow" (PGC-DER, 1999, 2-9). It essential to preserve existing topography associated with the major drainage channels.

Step 5- Use Drainage/ Hydrology as a Design Element-

Studies have shown that increase in imperviousness of urban or suburban landscapes have impacts on the receiving streams (Both & Reinelt, 1993, cited; from (PGC-DER, 1999, 2-10). Some local governments are responding to the impacts on receiving streams by creating stronger laws and other local governments will or are being strongly encourage the EPA and Federal laws. Developers, engineers, and designers need to embrace the philosophy of "Design With Nature" and incorporate hydrology as a design element. A significant difference between the conventional method and LID, is that LID systems are open, free flowing, and work with natural material (plants, soil, and etc.). The free flowing drainage network can be a significant aesthetic component of the site and design.

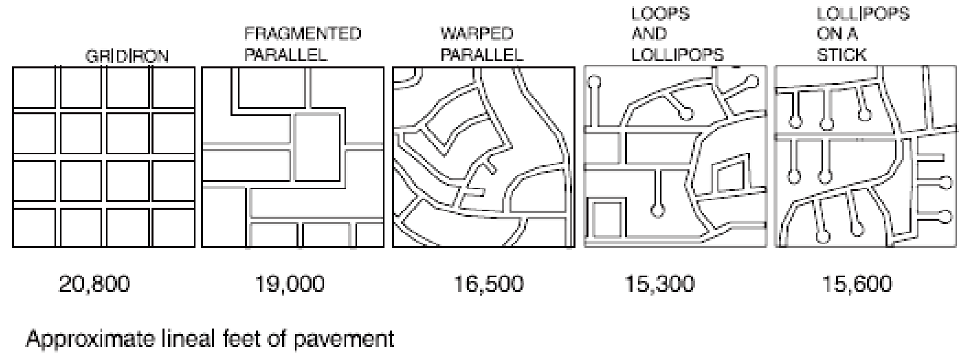


Figure 2-7: Road/ Development layout options (PGC-DER, 1999, 2-11)

Step 6- Reduce/ Minimize Total Impervious Areas-

Roads, streets, drives, and parking areas are typically the greatest source of site imperviousness. Impervious surfaces alter runoff, recharge values and overall site hydrology (PGC-DER, 1999, 2-11).

Road layout of housing areas can have a dramatic effect on the total amount of impervious surface. As shown in Figure 2-7 Loops and Lollipops has 5,500 ft. less linear of roadway than the typical Gridiron. That area can be used for higher yield, open space, and features. The LID manual doesn't state if the yields from the various layouts are the same, nor does it indicate that grid layouts are generally highly efficient where topography is compatible.

Another way in which paved area can be reduced is by limiting the road width. Roads that do not need street parking can be 24 feet wide, with a grass or porous concrete shoulder. Reducing the width of street from 36' wide to 24', is a 33 percent reduction. Trees alongside the road will add a pleasant atmosphere and calming effect, which increases safety. Street parking can also be changed to one side rather than both, to reduce parking, although this must be addressed to see if it meets the site's programming requirements.

Step 7- Develop Integrated Preliminary Site Plan-

The next step is to take the design phase from concept and schematic to preliminary site plan with all of the site improvements and stormwater features included. The site plan provides the base for conducting a more detailed hydrologic analysis.

Step 8- Minimize Directly Connected Impervious Area-

Reducing connected impervious areas decreases site runoff and other environmental benefits. The LID manual provides strategies for disconnecting impervious areas:

Table 2-5: Disconnecting Imperviousness (PGC-DER, 1999, 2-14)

- Disconnecting roof drains and directing flow to vegetated areas.
- Directing flows from paved areas such as driveways to stabilized vegetated area.
- Breaking up flow directions from large paved areas surfaces.
- Encourage sheet flow through vegetated areas.
- Carefully locating impervious areas so that they drain to natural systems, vegetated buffers, natural resources areas, or infiltratable zones/ soils.

Step 9- Modify/Increase Drainage Flow Paths-

Tc or time of concentration is defined as "the time required in runoff for water to flow in the watershed from the most remote area to the point of pickup or discharge, including overland flow time and ditch flow time" (Day, personal comm., 2005). Time of concentration is affected by: "travel distance, slope of the ground surface and/ or water surface, surface roughness, channel shape, pattern, and material components" (PGC-DER, 1999, 2-14). It is important for the time of concentration to be as long as possible. In simple terms straight flows on concrete or asphalt should be avoided. Short time of concentration is directly related to flushing pollutants to receiving streams, degrading receiving streams, decreasing infiltration, and increased flood potential.

The LID manual mentions several techniques to control Tc namely: "maximize overland sheet flow, increase and lengthen flow paths, lengthen and flatten site and lot slopes, maximize use of open swale systems, and increase and augment site and lot vegetation" (PGC, DER, 1999, 2-14-15). Velocities of stormwater flow are recommended "in the range of 2 to 5 feet per second" (PGC-DER, 1999, 2-15). By slowing the velocity erosion potential is decreased and infiltration is increased. It is recommended that roads be located on the tops of ridges rather alongside slopes or adjacent to drainage channels. These activities will help preserve the drainage patterns and the sensitive steep slopes.

Step 10- Compare Pre- and Post Development Hydrology-

The designer compares the predevelopment and post development hydrology and runoff (for more info. see PGC-DER, 1999, 3-1). The hydrologic analysis calculates the runoff of the LID site planning and the IMPs.

Step 11- Complete LID Site Plan-

The major part of completing the LID Site Plan is to adjust or change the plan and IMPs to meet the hydrology and runoff goals. If hydrology requirements cannot be met "with IMPs alone additional stormwater controls can be provided using conventional stormwater techniques" (PGC-DER, 1999, 2-19). Many municipalities will still require conventional techniques such as detention ponds for flood control.

Low Impact Development Hydrologic Analysis

In the LID manual this chapter reviews and covers the basics for calculating the hydrology of predevelopment and post development. For more in-depth information see LID manual or Introduction to Stormwater (Ferguson, 1998). Definitions of the major components of stormwater such as **Hydrograph**, **Design Storm**, **Rainfall Abstraction**, **Runoff**, **Time of Concentration**, and **Groundwater Recharge** are defined in the following pages.

Before beginning the hydrologic analysis of site development it is important to understand the regional climate characteristics of a site. It is important to look at average yearly rainfall, precipitation amounts from storms, frequency, and characteristics of the eco-region. The LID manual discusses some of the regional problems of Florida, such as "heavily reliant on groundwater supplies" and "experiencing a serious lowering of the regional water table" (PGC-DER, 1999, 2-3). Florida's problems are largely because of increasing groundwater withdrawals and loss of groundwater recharge due impervious surface, which has increase runoff. Many other regions are experiencing similar effects or unique regional water problems. The solution to Florida's problem and "most urban runoff control problems, is to try to mimic or maintain the predevelopment site hydrology. This is precisely the objective of low-impact development" (PGC-DER, 1999, 3-2).

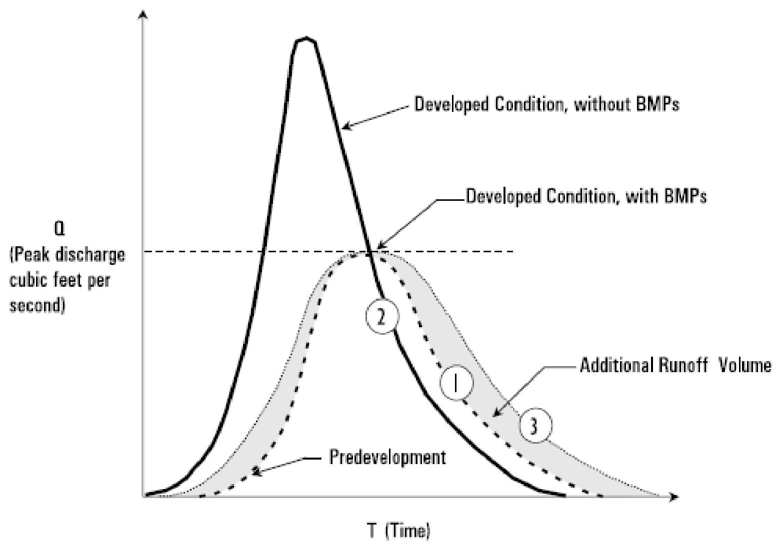


Figure 2-8: Hydrograph (PGC-DER, 1999, 3-3)

One of the most common ways in which the hydrology of a fluvial system is studied is through a runoff **hydrograph** (see Figure 2-8).

Table 2-6: Hydrograph lines (PGC-DER, 1999, 3-3)

- Hydrograph 1 represents the response to a given storm of a site in a predevelopment condition (i.e., woods, meadow). A gradual rise and fall of the peak discharge and volume define the hydrograph.
- Hydrograph 2 represents the response of a postdevelopment condition with no stormwater management BMPs. This hydrograph definition reflects a shorter time of concentration (Tc), and an increase in total site imperviousness from the predevelopment condition. The resultant hydrograph shows a decrease in the time to reach the peak runoff rate, a significant increase in the peak runoff and discharge rate and volume, and increased duration of the discharge volume.
- Hydrograph 3 represents a postdevelopment condition with conventional stormwater BMPs, such as a detention pond. Although the peak runoff rate is maintained at the predevelopment level, the hydrograph exhibits significant increases in the runoff volume and duration of runoff from the predevelopment condition, which is depicted by the shaded hydrograph area in Figure 2-8.

Figure 1-3 shows that the discharge rate of developed urban landscapes without LID improvements can dramatically increase the peak discharge in both time and volume, thus increasing flooding potential.

In planning for stormwater management the **Design Storm** "is a specific size storm event to plan for and design stormwater controls" (PGC-DER, 1999, 3-4). The characteristics used to categorize storms are rainfall precipitation, intensity, duration, and return period. The commonly used design storms are 2, 5, 10, 25, 50, 100 year. The previous three are more for everyday stormwater management and precipitation, while the latter three are more for flood control. The possibility of a 2-year storm event to occur in any given year is 50% and 1% for a 100-year storm. Rain storm data may be obtained from National Resource Conservation Service or National Weather Service. When designing for infiltration it is best to use the 2 and 5 year design storm, because in larger storms the soil will reach field capacity and runoff (even if it is a natural landscape). Larger design storms are considering when designing flood control escape routes for runoff.

A **rainfall abstraction** "includes the physical processes of interception of rainfall by vegetation, evaporation from land surfaces, and the upper soil layers, transpiration, by plants, infiltration of water into soils surfaces, and storage of water in surface depressions" (PGC-DER, 1999, 3-6). The abstraction is the combined processes (mentioned above) minus the runoff. A rainfall abstraction is key to understanding the hydrology of a vegetated site and will contribute to the stormwater plan and design.

Runoff is "the portion of rainfall that is not abstracted by interception, infiltration, or depression storage, becomes surface runoff" (PGC-DER, 1999, 3-6). Development unless carefully planned and built with LID design principle, can greatly increase the runoff.

Groundwater recharge is "the amount of precipitation that infiltrates into the soil and contributes to groundwater" (PGC-DER, 1999, 3-8). Groundwater feeds streams which keeps them flowing even when it is not raining and without infiltration streams will dry up. Renewable groundwater supplies are very important in supporting agriculture and human populations.

LID Hydrologic Evaluation Steps-

The LID manual offers a procedure for hydrology analysis, which can be adapted for the site, eco-region climate and soils, preferred modeling technique (such as TR55 or Rational Method) and the chosen IMPs. The procedure is (PGC-DER, 1999, 3-12-13):

Step 1. Delineate the watershed and microwatershed areas. Hydrologic evaluation requires delineation of the drainage area for the overall study area or site and the subwatersheds contributing to key portions of the site. Delineation may need to consider previously modified drainage patterns, roads, or stormwater conveyance systems.

Step 2. Determine design storm(s). The design storms considered in the analysis should be determined based on the basic LID philosophy identified. Regulatory requirements for design storms may also be stipulated in local ordinances, and these may limit or constrain the use of LID techniques or necessitate that structural controls be employed in conjunction with LID techniques.

Step 3. Define modeling technique(s) to be employed. Data gathering and analysis will depend on the specific type of model selected. The model selected will depend on the type of watershed, complexity of the site planning considerations, familiarity of the agency with the model, and level of detail desired. Certain models use simplified estimation methods whereas others provide detailed process-based representation of hydrologic interactions.

Step 4. Compile information for predevelopment conditions. Typical information needed includes area, soils, slopes, land use, and imperviousness (connected and disconnected).

Step 5. Evaluate predevelopment conditions and develop baseline measures. The selected modeling techniques are applied to the predevelopment conditions. The results of the modeling analysis are used to develop the baseline conditions using the four evaluation measures.

Step 6. Evaluate site planning benefits and compare with baseline. The site planning tools provide the first level of mitigation of the hydrologic impacts. The modeling analysis is used to evaluate the cumulative hydrologic benefit of the site planning process in terms of the four evaluation measures. The comparison is used to identify the remaining hydrologic control needs.

Step 7. Evaluate Integrated Management Practices (IMPs). The hydrologic control needs may be addressed through the use of IMPs. This represents the second level of mitigation of the hydrologic impacts. After IMPs are identified for the site, a second-level hydrologic evaluation that combines the controls provided by the planning techniques with the IMPs can be conducted. Results of this hydrologic evaluation are compared with the predevelopment conditions to verify that the discharge volume and peak discharge objectives have been achieved. If not, additional IMPs are located on the site to achieve the optimal condition.

Step 8. Evaluate supplemental needs. If after use of IMPs supplemental control for either volume or peak flow is still needed, selection and listing of additional management techniques should be considered. For example, where flood control or flooding problems are a key design objective, or where site conditions, such as poor soils, or high water table limits the use of IMPs, additional conventional end-of-pipe methods, such as large detention ponds or constructed wetlands, should be considered. In some cases these controls can be sized much smaller than normal due to use of LID as part of the management system. The hydrologic evaluation is used to compare the supplemental management techniques and identify the preferred solutions.

The Low Impact Development hydraulic evaluation is similar to standard hydrology procedures from other sources. Except the focus of using LID IMPs is on-site infiltration and not draining as quickly as possible like conventional end-of-pipe methods. In LID post and predevelopment runoff should be close. Two of the most common modeling techniques used to calculate runoff are TR55 and the Rational method. The inputs are land area, type of land cover (impervious, prairie, woods and etc) slope, concentrated (in a swale or ditch) or open, and design storm. The outputs are total runoff, velocity in swale or ditch, and time of runoff (Tc).

LID Management Practices

In the stormwater hydrology evaluation need water storage (ponding) amount is calculated by subtracting the pre-development runoff from the post-development runoff. This water storage requirement is used to select, design, and size the proper Integrated Management Practice (IMP) according to the site. IMPs are similar to newer, ecologically and infiltration oriented Best Management Practices (BMPs). Most likely LID uses a term, because some of the BMPs are still using conventional end of pipe planning and design. The steps for choosing, designing and sizing an IMP (PGC-DER, 1999, 3-12-14) are:

Step 1- The information gained from the hydraulic analysis such as "runoff volume, peak discharge, frequency and duration of discharge, groundwater water recharge, and water quality parameters" defines the required hydraulic controls for the site.

Step 2- LID encourages creativity and uniqueness for every stormwater design approach. Careful evaluation of each sites opportunities and constraints will offer a unique design.

Step 3- The next step is an evaluation of IMPs according the hydraulic requirements and IMPs. The LID manual provides tables which define the site constraints of IMPs, as ways to eliminate inappropriate IMPs from the pool.

Step 4- Once IMPs are chosen they are placed in the site plan according to their role and function. As outlined in the Hydraulic Analysis the stormwater runoff and other factors are calculated based on the IMP. Most likely adjustments will need to be made for the IMPs or the stormwater management plan to meet the goal of balancing pre and post development hydrology on-site.

Step 5- The site design and IMPs are adjusted for aesthetic and functional needs. The cost of implementation and budget should be taken into account.

Step 6- If stormwater management objectives cannot be reached using IMPs it is necessary to add conventional structures such as detention ponds. "Sometimes site constraints like low-permeability soils, the pressure of a high water table or hard rock, or very intensive land uses such as commercial or industrial sites can preclude the use of sufficient IMPs to meet the hydrologic design objectives" (PGC-DER, 1999, 3-13).

It is important to note that IMPs are not a "cookie cutter" model straight out of the box. The designed IMP is **site specific** and may include a combination of different IMPs.

In the past conventional stormwater management methods included Best Management Practices (BMPs). Not all BMPs focus on maintain the hydrology of the site as defined by the LID manual. The Low Impact Development manual has introduced Integrated Management Practices (IMPs) to be distinguished from BMPs. IMPs are micro-management techniques used to deal with stormwater near the source of impact and at a smaller scale. The IMPs described include:

- Bioretention facilities;
- Filter/ buffer strips;
- Grassed swales, bioretention swales, and wet swales; and
- Infiltration trenches.

Bioretention facilities-

A bioretention cell or facility treats stormwater "by using a conditioned planting soil bed and planting materials to filter runoff stored within a shallow depression" (PGC-DER, 1999, 4-8). The "bio" part of bioretention implies that there is an active biological process occurring between stormwater, plants, organic matter, and living soil. This process is intended to infiltrate, clean, and convey the stormwater through the soil profile. A bioretention cell also has inlet(s) to direct runoff into the cell and outlet(s) or overflow in the event that the cell overflows.

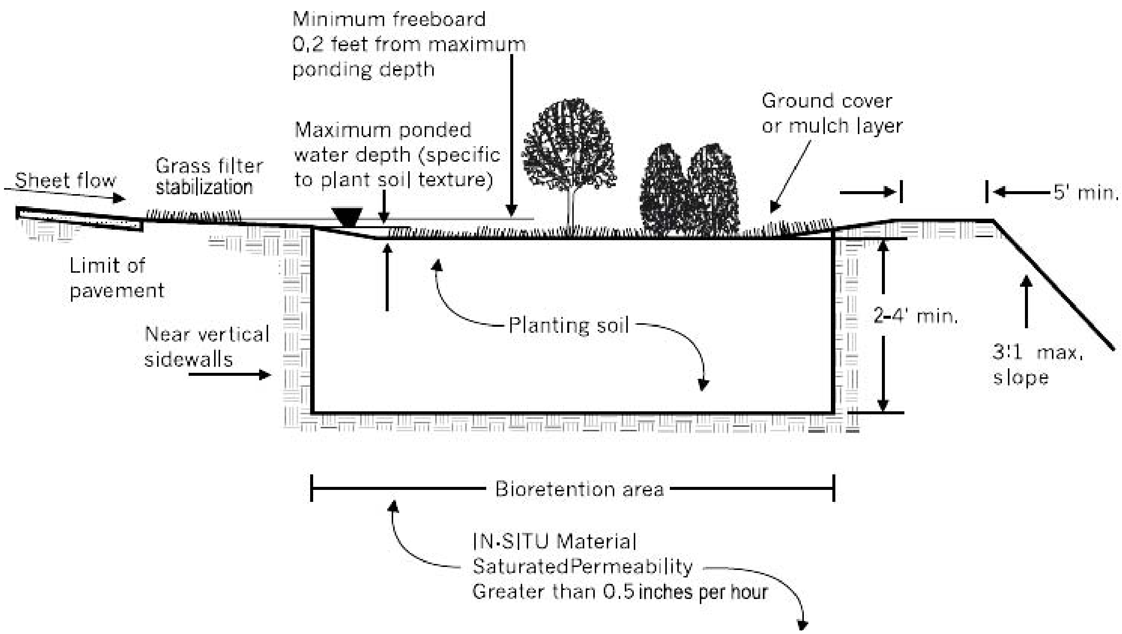


Figure 2-9: Bio-retention cell (PGC-DER, 1999, 4-10)

Figure 2-10: Rain Garden
(http://www.uvm.edu/~ran/ran/toolbox/images/raingarden04.jpg 5-6-06)

A rain garden is an example of a bioretention facility. Although rain gardens typically include minimal or no soil amendments, other than the incorporation of organic matter into a shallow depression. It has specific plants which slow water, increase infiltration, detain water, and add beauty. Bioretention cells and rain gardens can be used for commercial, government building, and even residential contexts.

Currently Kansas City, MO has a 10,000 Rain Garden program, which is encouraging businesses, home owners, and local government agencies to retrofit their landscape to install rain gardens. The project is in the beginning and is offering out reach educational programs to professional and citizens alike (http://www.rainkc.com/HOME/INDEX.ASP 4-6-06).

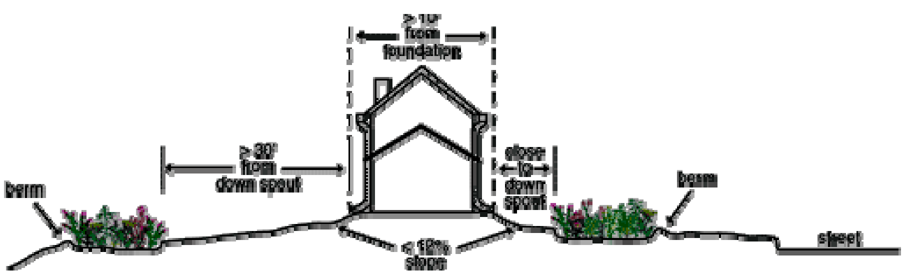


Figure 2-11: Rain Garden Section

(http://www.rainkc.com/GARDENS/INDEX.ASP 5-6-06)

Filter Strip-

A filter strip is a strip or band of vegetation (usually grass) which acts a filter as stormwater passes from a road, parking lot, garden plot, or agricultural field into a swale or some type of water conveying system. The main purpose of the filter is to help clean the water of pollutants and sediments (PGC-DER, 1999, 4-12).

Grass or Vegetated Swales-

A swale is a water drainage system that is open and conveys water through a dense matrix of vegetation. Ideally an ephemeral stream acts the model of a swale. Swales are typically turf grass or can be designed to contain specific plant material to increase stabilization, infiltration, and aesthetics. Swales may also have an under drain (as shown in figure 2-12). The slope, side slopes, and dimensions of a swale are calculated according to engineering standards. The desirable slope is calculated according to erodibility of the soil. Erosion resistant soils can have swales between 5-10% depending on chosen grass species, but typically 3-5% is recommended. Typically a velocity of no more than of 3-5 cubic feet per second is recommended for vegetated swales. Swales with native grasses (such as Midwest prairie grasses) do best when left unmowed (Strom, 2004, 229).

Besides conveying stormwater swales also infiltrate a certain amount of water depending on the permeability of the soil and geology. The climate will influence the type of vegetation that can grow in the swale and through time swales which are not fully vegetated are more susceptible to erosion, especially in high precipitation areas.

Infiltration Trench-

"An infiltration trench is an excavated trench that has been back-filled with stone to form a subsurface basin. Stormwater runoff is diverted into the trench and is stored until it can be infiltrated into the soil, usually over a period of several days. Infiltration trenches are very adaptable IMPs, and the availability of many practical configurations make them ideal for small urban drainage areas. They are most effective and have a longer life cycle when some form of pretreatment is included in their design" (PGC-DER, 1999, 4-20).

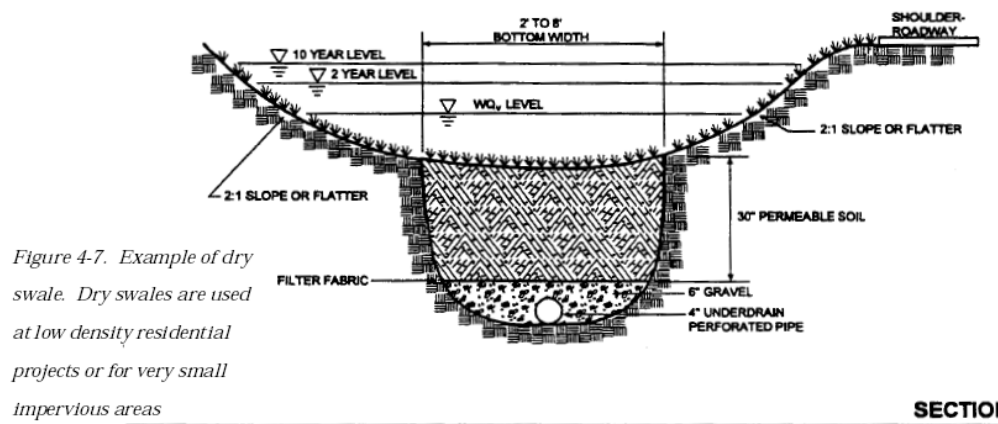


Figure 2-12: Dry Swale (PGC-DER, 1999, 4-16)

Chapter 3: Methodology

Introduction-

The overall goal of Low Impact Development is to "mimic the predevelopment site hydrology by using site design techniques that store, infiltrated, evaporated and detain runoff" (PGC-DER1999. P.1-2). The LID Design Strategies manual was developed and written within the regional context of Maryland. The LID manual provides general principles, techniques, and instructions, all of which need to be adapted to specific sites, municipalities, and regions in order to effectively manage stormwater. LID technologies have been implemented and more extensively researched within the context of the mid-Atlantic region of the United States. The purpose of this thesis is to contribute to the adaptation of LID principles, techniques, and knowledge to the region associated with Topeka, KS. It is hoped that this thesis will also be of value for those working with stormwater throughout the Central Plains.

It is important to note that while a "Low Impact Development" manual has not been done for the Topeka, KS, progress has been made with regard to treating stormwater on-site and using ecological principles. Professionals from both the private and public sectors have been making important advances in treating stormwater runoff according to ecological principles.

Thesis Research-

The thesis research was carried out using two main steps. First, a study of **ecoregional factors which influence the planning and design of stormwater management in the Topeka, KS** area was undertaken. Second, two **case studies of LID-type** techniques or stormwater structures used in Topeka were prepared to learn from projects previous implemented in the area.

Ecoregional Factors-

The purpose of studying primary ecoregional factors are to provide knowledge of the components that govern how stormwater reacts naturally within the regional environment and to help establish reference points or a framework to stormwater planners.

According to the EPA, "**Ecoregions** denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources. They are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components" (http://www.epa.gov/wed/pages/ecoregions/ecoregions.htm 4-06-06). An ecoregion serves as the framework of an area which has common physical attributes and characteristics. Common characteristic factors include physiography, geology, climate, plant associations, landform, soils, and hydrology.

The ecoregional factors to be studied for this thesis include: ecosystem classification, geology, soil types, climatic factors (temperature, rainfall frequency, rainfall intensity, and amounts), and plant associations. An understanding of these factors will contribute to the effectiveness of planning and designing stormwater facilities to sustain natural and human-altered ecosystems in eastern Kansas and western Missouri.

Case Studies-

Since 1999 a number of Low Impact Development type projects have been constructed in Topeka and the Kansas City area. The term "LID-type" is used because each project is unique and is not implemented in exact accord with the LID manual (nor should they be). LID projects include: bioretention cells, vegetated swales, infiltration trenches, and vegetated filters. Implemented LID-type stormwater projects in Topeka have involved city watershed planners and engineers, university professors, and planning and design professionals.

The general mindset regarding stormwater management for the eastern Kansas/ western Missouri region has been that **conventional end of pipe** methods (which are common in most of the United States) are appropriate ways to deal with stormwater runoff. In order to carry out alternative and ecologically sensitive stormwater techniques professionals have to blaze new territory and take on significant challenges. Research of local LID-type stormwater management projects reveal what was successful and what could be improved. Many of the LID projects have been "pilot projects" and have undergone scrutiny from political officials and citizens. Most of these projects were done as demonstration projects for communities and residents living Topeka-Kansas City area.

The topics to be discussed in the two case studies are listed in Table 3-1. The methods of gathering information for the case studies include: personal communication with key individuals involved in the projects, site visits, review drawings, specifications, and other readily available projects documents.

Table 3-1: Case Study Research Topics

- Background
- Political approval process
- Condition of site before implementation
- Project planning and design
- Stormwater design
- Soil medium
- Record of vegetation success or failure
- LID techniques used
- Lessons learned
- Critique of project

The findings from the case studies will be used to suggest ways for improving stormwater LID implementation in Topeka and the surrounding region. Recommendations for planning, design, maintenance, and management are offered in Chapters 5 and 6 of this thesis.

Topeka was chosen as the case study city due to having LID type stormwater techniques implemented for at least two growing seasons, proximity to Kansas State University and (KSU), availability of professionals involved in the projects, and research relationships between the City of Topeka Water Pollution Control Division and Department of Bio-Agricultural Engineering at KSU. The Water Pollution Control (WPC) Division is responsible for the stormwater management and sewer system for the City of Topeka, KS.

The case study projects address the bio-retention cells implemented at the Hillcrest Community Center and along Jackson Street near the Capital. Hillcrest was the first LID type project done by Topeka and a number of significant lessons were learned. Hillcrest was a straight-forward parking lot retrofit and provided a way to immediately improve water quality by managing stormwater using ecological processes, (namely infiltration of stormwater into a plant soils system). Jackson Street entailed more complex issues, including political and public approvals, as well as the following factors: Its location is a prominent site near the Capitol. The site spans three city blocks within the urban core of the city. Maintenance and management of prairie grasses and other native plants, and design and implementation of LID techniques are new to design firms and contractors. Both projects are being monitored by KSU (for water quality parameters) on an ongoing basis.

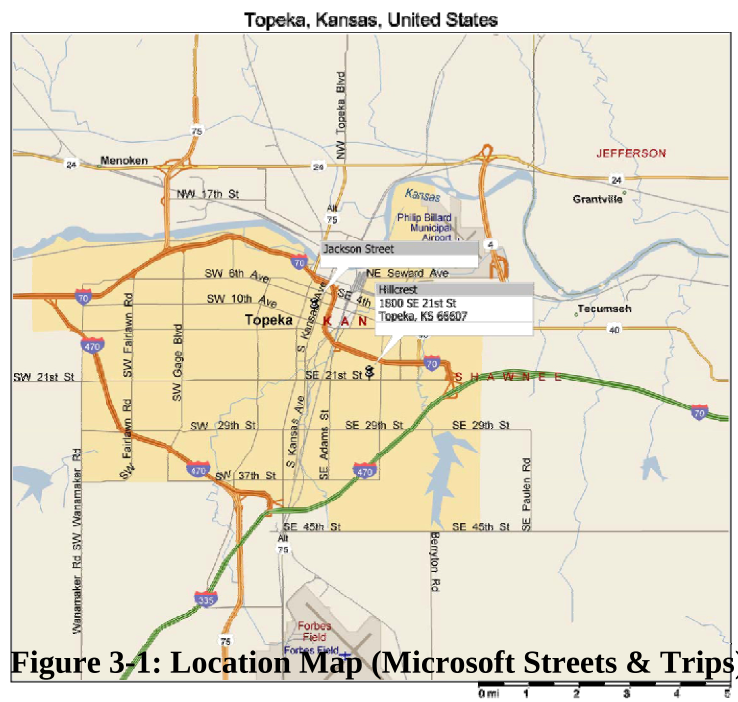


Figure 3-1: Location Map (Microsoft Streets & Trips)

Chapter 4: Ecoregion Context

Introduction-

The demands of today's fast track society has led to development of communities and commercial sites which lack sensitive planning and design according to the site and regional context. Have you ever visited a retail center and thought that place looks the same as another retail center across the state or country?

Planning, architecture, landscape architecture, and engineering must interweave planning and design proposals with the unique attributes of the site, area, and region in order to

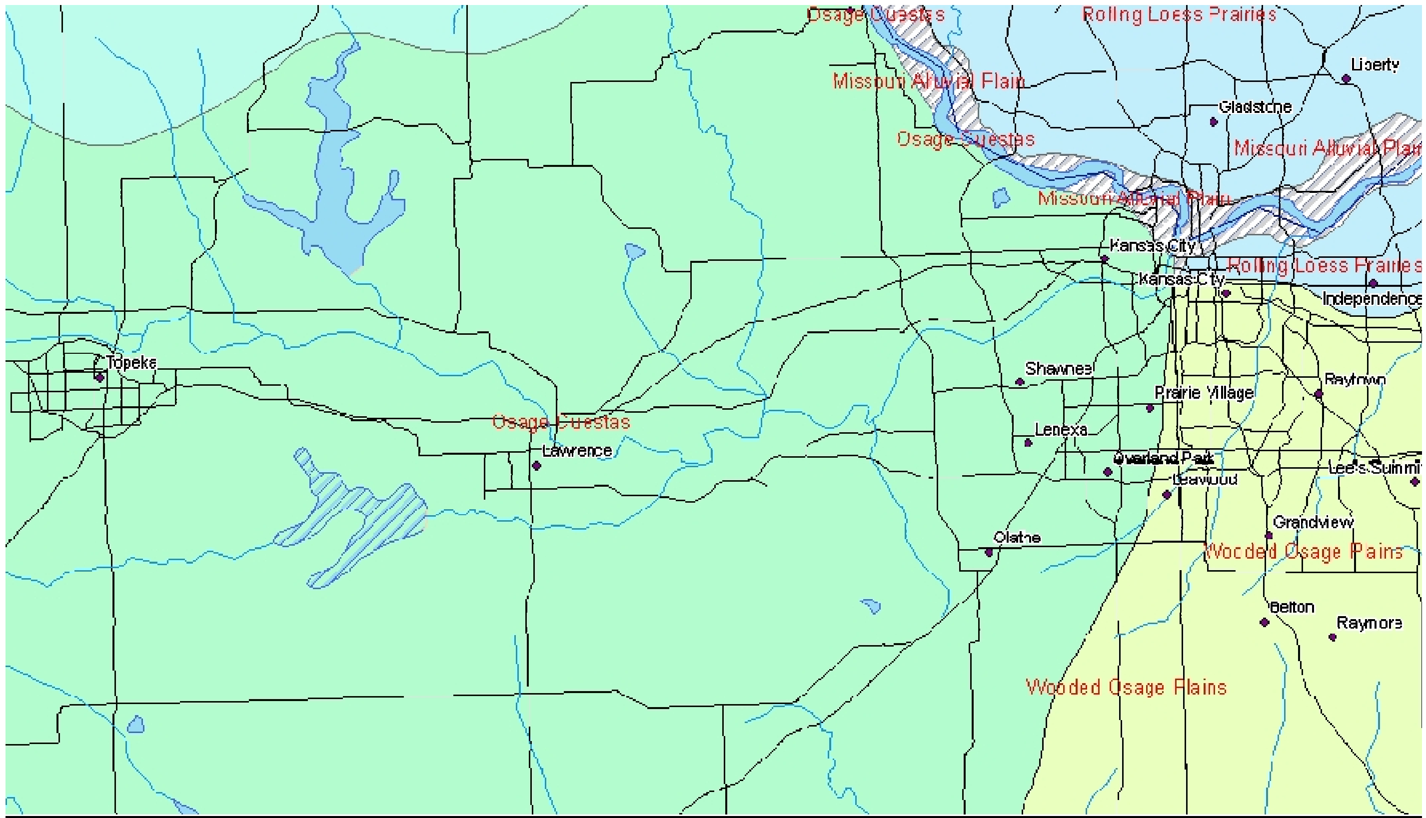
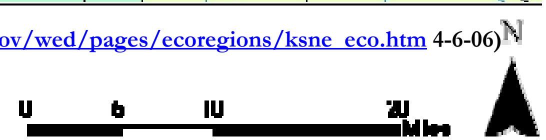


Figure 4-1: Eastern Kansas Ecoregions **(Data Source: http://www.epa.gov/wed/pages/ecoregions/ksne_eco.htm 4-6-06)**



successfully incorporate ecological processes.

As stated by Robert Bailey: because "ecology based design responds to the ecoregion, we must consider the relationships among soils, vegetation, materials, culture, climate and topography in a particular region. In other words, the ecoregional setting needs to be taken into account in our designs (Bailey, 2002, 59). The Environmental Protection Agency (EPA) has classified ecoregions at various scales throughout the US. Figure 4-1 represents a GIS map of the Level IV ecoregions. The four main ecoregions of eastern Kansas are Osage Cuestas, Wooded Osage Plains, Missouri Alluvial Plain, and Rolling Loess Prairies. These four ecoregions are based on common climatic and biotic factors throughout the landscape as wells as subsurface conditions. This thesis will provide more detail about the Osage Cuestas because the case studies are located within this ecoregion.

Ecoregion-

The ecoregion surrounding Topeka and partially encompassing Kansas City is called Osage Cuestas. This area is a transitional landscape between tallgrass prairie and woodlands.

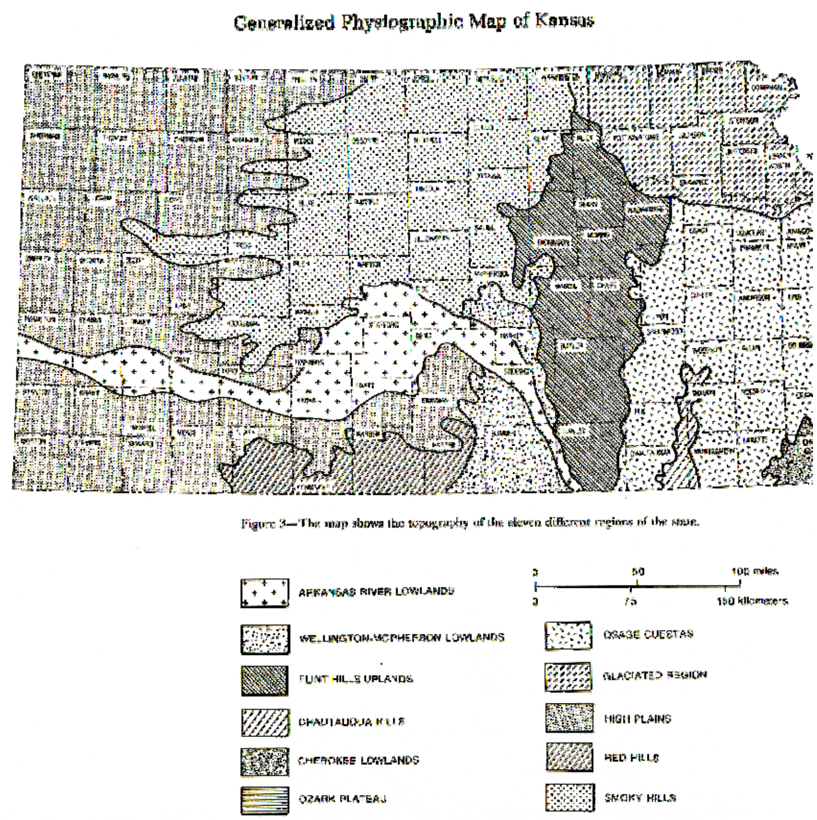


Figure 4-2: Physiographic Map of KS (Buchanan, 1984, 7)

The western portion of the ecoregion dominated by tallgrass prairie and the eastern portion marks the beginning of eastern deciduous forest. "The Osage Cuestas region is a gently undulating cuesta plain composed of several alternating layers of sandstone, limestone, and shale. Topography is distinct from the more dramatic rolling hills of the Flint Hills to the west. Potential natural vegetation ranges from a mosaic of mostly tallgrass prairie in the west to a mixture of tallgrass prairie and oak-hickory forest in the east, with floodplain forests along streams. The moist, silty clay loams are formed in material weathered from limestone and shale, and support a land use composite of cropland, woodland, and grassland/rangeland"

(**http://www.epa.gov/wed/pages/ecoregions/ksne_eco.htm** 4-06-06).

Geology of Topeka area-

Topeka lies within Shawnee County, KS, and according to the Generalized Physiographic Map of Kansas (Figure 4-2), the geology of Shawnee county is split between the Osage Cuestas and Glaciated Region.

In general the Kansas River is the divide between the glaciated area and non glaciated area (Keane, personal comm., 2006). The area to the south is typically non-glaciated and both case studies lie in this area. The glaciated land is similar to the Osage Cuestas to the south in both geological and topographical form, however, glaciated areas generally have more till (unsorted clay, sand, and gravel borders) and deeper soils (Buchanan, 1984, 16-18).

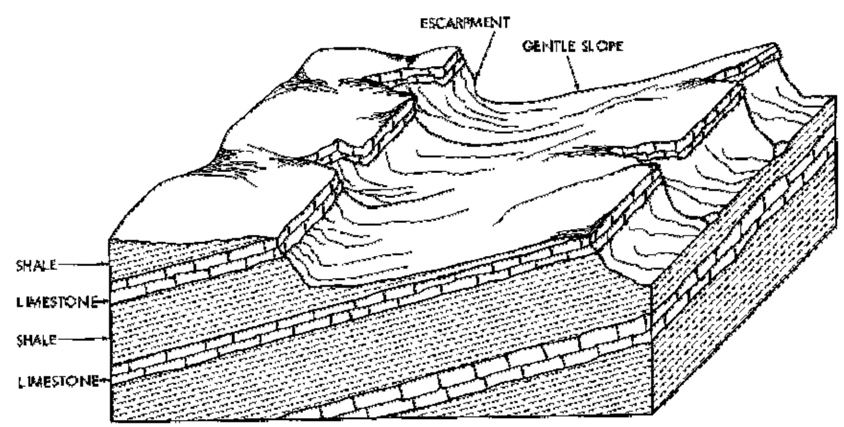


Figure 4-3: Osage Cuesta (Buchanan, 1984, 17)

The Osage Cuestas are tilted layers of shale and limestone, with the escarpments or exposed limestone facing west. "The limestone formations are more resistant to weathering than are the shales occurring between them and, because of that, the limestones crop out as the tops of steps while the thick shales form risers between steps. All beds slope gently toward the west-northwest, so the rise in the ground surface from one step to the next is not great" (Buchanan, 1984, 16). A diagram of a Cuesta is shown in Figure 4-3.

Shale is hardened, compacted clay or silty clay that commonly fractures along bedding planes (Buchanan, 1984, 50-51). "The particles that make up shale are too small to be seen without a microscope. Many shales have a leaflike bedding and weather into thin slabs or plates, some of which are no thicker than paper. When shales weather they form clays or muds" (Buchanan, 1984, 50). Consequently shale (which can form clay soils) is dense and offer resistance to water infiltration or percolation. As water is percolating into the soil it will run along top of dense shale layers and penetrate downward until it hits limestone.

Limestone absorbs a minimal amount of water; therefore most water percolating will not go through or into the limestone layer, but will find the cracks and openings of limestone to penetrate. For any stormwater planning and design it is important to understand the geology of the site and how water will percolate and recharge aquifers. The major questions which need to be answered concerning the geology of each site are:

- Depth to shale.
- Depth to limestone and its thickness.
- Depth and thickness of groundwater aquifers.

Soils-

Soils provide an incredible role in the water process of infiltration, percolation, evapotranspiration, and transporting water to groundwater aquifers. Primary soil types in the Topeka area include the Martin-Pawnee-Labette association and Pawnee-Shelby-Morrill associations.

Hillcrest is located within the "Martin-Pawnee-Labette association: Deep and moderately deep, well-drained and moderately well drained, sloping strongly, sloping soils that have a silty clay or clay subsoil; on uplands" (Abmeyer, 1970, 4).

Jackson Street is located within the "Pawnee-Shelby-Morrill association: Deep, well-drained and moderately well drained, gently sloping to strongly sloping soils that have a clay or clay loam subsoil; on uplands" (Abmeyer, 1970, 3). Both associations indicate the potential for good soil drainage as well poor drainage if high content of clay or steep slopes are found on the sight.

In soil the A horizon is the top layer or topsoil and is the most fertile, B horizon is generally good soil, but not as nutrient rich as the A, and C horizon is the transition layer between soil and bedrock. Table 4-1 lists the general depths of the horizons for the soils series in the case study area.

Table 4:1 Soil series depths (Abmeyer, 1970, 7-28)

	Depth in inches to bottom of horizon		
Soil series	A horizon	B horizon	C horizon
Martin	0-17"	21-30"	36-96"
Pawnee	0-19"	19-48"	48-79"
Labette	0-13"	13-42"	42-46"
Shelby	0-17"	17-44"	44-80"
Morrill	0-17"	17-48"	48-70"

It is important to do on-site soil testing and investigations to obtain more detail soil information. Soil surveys contain more general information and specific on-site testing can reveal the soil hydraulic capacity, which is essential in achieving success in bioretention (Bartlett, 2006, 96-98).

Climate-

The climate of Topeka, along with most of Kansas encounters dramatic changes throughout the course of the year.

Temperature-

As shown in Figure 4-4 the average winter cold low is 17.2 °F in January and the summer average maximum heat is 89.1 °F in July. (RSS Weather). The extreme temperatures are below 0°F in winter and above 100° F in the summer time.

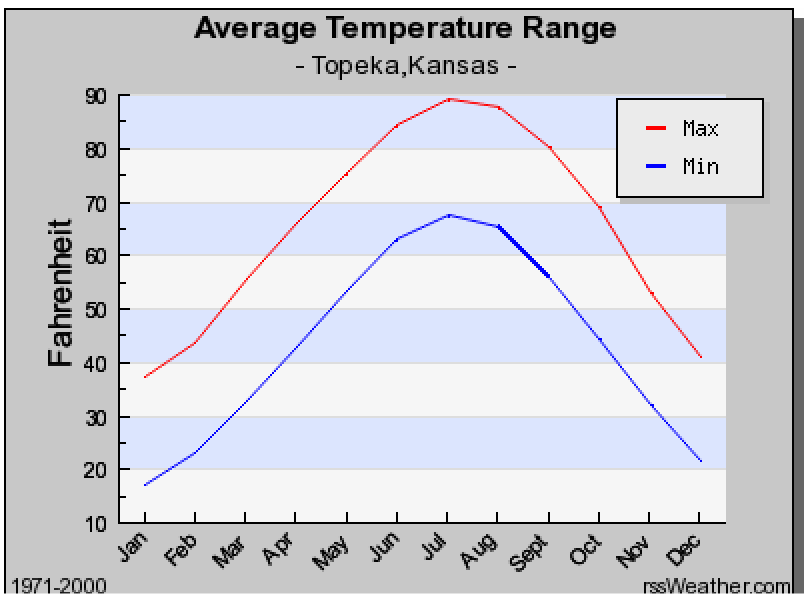


Figure 4-4: Average temperature, Topeka

(http://www.rssweather.com/climate/Kansas/Topeka/ 4-06-06)

Precipitation-

The average annual precipitation for Topeka is 35.2 inches, most of which is rainfall from April through October (Climate Zone). The number of days with precipitation averages 97, which means about 26% of total days, receives rainfall or snow. Rainstorms in Topeka along with much of the Midwest can be violent or at the least have a high intensity of rain per hour. As shown in Table 2-2 the design storm for a two- year storm is 3.5 inches of rain in a 24 hour period. A design storm or storm frequency is the "number of years in which a rain storm of a given magnitude (inches per 24 hr. period) will occur on average, but it doesn't mean the storm will not occur more often" (Day, personal comm.., 2005).

Table 4-2: Topeka Design Storms (Ward, 2004, 114)

Design Storm or Frequency in Years	Rainfall Inches per 24hr period
2 year storm	3.5
5 year storm	4.5
10 year storm	5.25
100 year storm	7.8

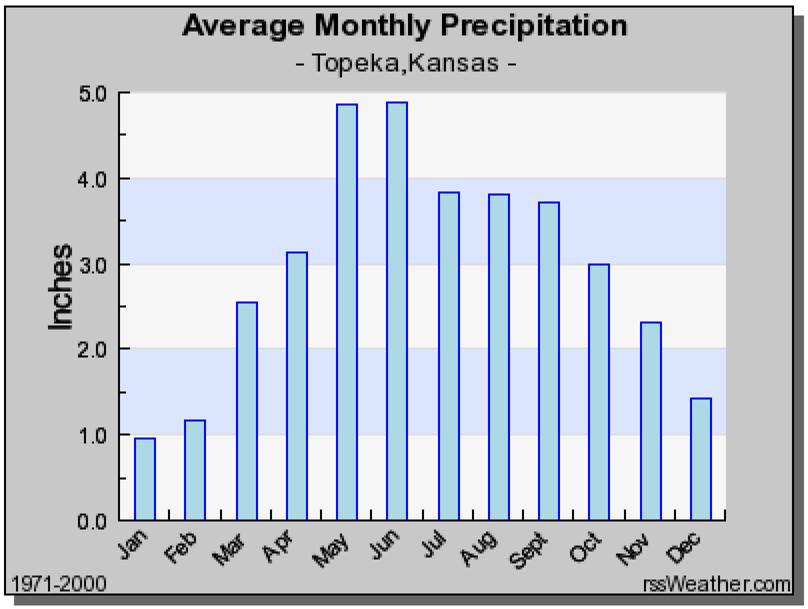


Figure 4-5: Precipitation for Topeka, KS

(http://www.rssweather.com/climate/Kansas/Topeka/ 4-06-06)

The high rainfall intensity and amounts per storm requires that stormwater management systems be designed for larger storms and larger volumes of water.

Evapotranspiration-

Evapotranspiration (ET) is when water returns to the atmosphere through various methods and continues the hydrologic cycle. "Evapotranspiration can be divided into two sub-processes: evaporation and transpiration. Evaporation essentially occurs on the surfaces of open water, such as lakes, reservoirs, or puddles or from vegetation and ground surfaces. Transpiration involves the removal of water from the soil by plant roots, transport of the water through the leaf plant into the leaf, and evaporation of the water from the leaf's stomata into the atmosphere" (Ward and Trimble, 2004, 83).

Figure 4-6 shows the mean annual lake evaporation rates for the United States, which is the amount of water typically evaporated from a lake or reservoir (according to location and climate). A reservoir in Topeka would approximately evaporate 46" of water annually. Evaporation rates of lakes and evapotranspiration rates (water through plants) are different, yet comparable. Topeka receives about 35' of rain a year; hence Topeka generally will evaporate more water than receiving rainfall. Plant ecosystems in the east, northeast, and northwest

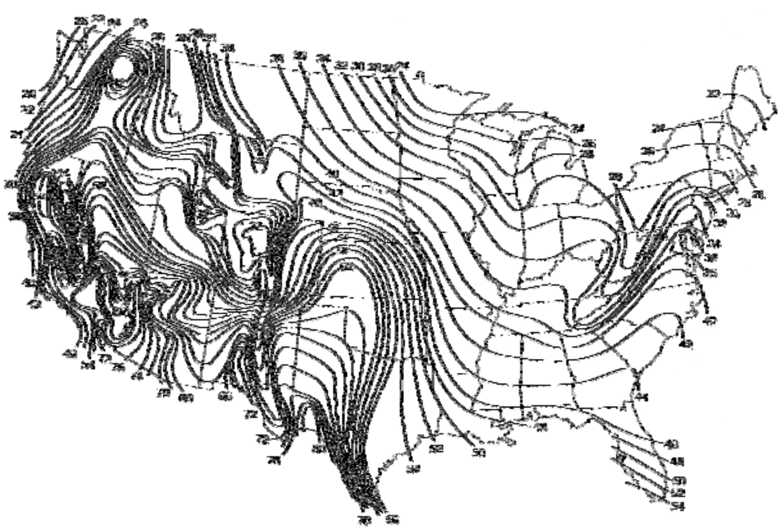


Figure 4-6: US Evapotranspiration Rates (Ward and Trimble, 2004, 114)

are different because their evaporation rates are generally less than their precipitation rates. Plants from these different ecoregions will not be as hardy as Central Plain native plants, due to loss of available water when combined with runoff created by intense storms.

Vegetation-

Osage Cuestas vegetation includes: "mostly tallgrass prairie in the west (with) a combination of tallgrass prairie and oak-hickory woodland in the east. Upland forests (are) dominated by shagbark hickory (*Carya ovata*), bitternut hickory (*Carya cordiformis*), red oak (*Quercus rubra*), white oak (*Quercus alba*), and black oak (*Quercus velutina*), with Ohio buckeye (*Aesculus glabra*), American bladderpod (*Lesquerella gordonii*), and pawpaw common understory trees."

(http://www.epa.gov/wed/pages/ecoregions/ksne_eco.htm 4-06-06).

Primarily tallgrass prairie species indigenous to the area include: Switchgrass (*Panicum virgatum*), Big Blue Stem (*Andropogon gerardii*), Little Blue Stem (*Andropogon scoparius*), Side Oats Grama (*Bouteloua curtipendula*), and Indian Grass (*Sorghastrum nutans*). Prior to European settlement Topeka would have been predominately tallgrass prairie (Keane, personal comm. 2006). Woodland species in the Topeka area are (and historically were) predominately located in the floodplains of the Kansas River. The increase of water from flooding offers a more consistent wet soil for riparian species.

The prairie species of the Midwest offer an incredible resource for managing stormwater focused on infiltration. In *The Ecology and Culture of Water* by James M. Patchett and Gerould S. Wilhelm they discuss the amazing infiltration potential of prairie grasses. Quoting Weaver and Noll "The porosity of … most grassland soil into which the water sinks is impressive. It accounts for the fact that on fully vegetated land practically no erosion occurs except, possibly during storms of unusual violence, and even then erosion is seldom serious" (Patchett, 1999, 3).

In quoting another study, Patchett and Wilhelm note "In a study involving interceptometers in Nebraska … eleven rainfall events over a year resulted in the loss of about 1% of the total rain from a prairie dominated by *Andropogon scoparius* (Little

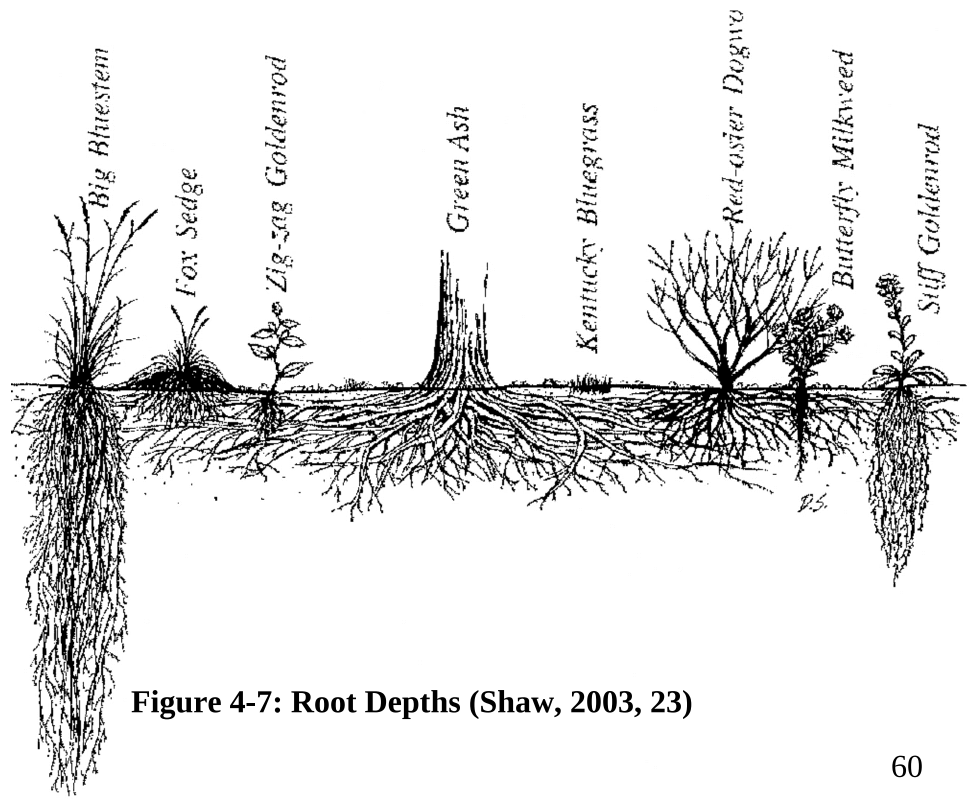


Figure 4-7: Root Depths (Shaw, 2003, 23)

bluestem grass) and with a slope of five degrees. A wheat field under the same condition lost more than seven times that percentage of water volume, and a fallow field lost more than nine times that of the prairie, or 10.2% of the rain that fell" (Patchett, 1999, 3).

Native grasses in the Midwest "have extensive roots systems which improve the ability of the soil to infiltrate water and withstand wet or erosive conditions" (http://www.il.nrcs.usda.gov/technical/plants/npg/NPG-rootsystems.html 4-06-06). Figure 4-7 is a drawing representing the root depths of various grasses, forbs and trees. Grasses such as switchgrass or big bluestem can have roots that penetrate 6-10' into the soil. Notice the root depths of Kentucky bluegrass (typically 2-4") in comparison to big bluestem (6-10'). Comparing root depths points to the problems of using common foreign species of grasses (such as Kentucky bluegrass) for stormwater detention, retention, or infiltration areas.

The extensive root systems associated with deep-rooting native grasses open up dense, clay soils allowing water to percolate down into the openings (pore spaces) created by the roots. There area also important root, soil, and water interactions including absorption of nutrients and chemicals and the creation of habitat for soil fauna (micro organisms) (Skabelund, personal comm., 2006). LID suggests using native plants for stormwater management, but most of the LID literature lists eastern plants (due to its context). By using native grasses infiltration rates and water holding capacities can be high, even in small cells.

Chapter 5: Case Studies

Introduction-

The original intent of this thesis was to do a cross examination of multiple LID-type stormwater techniques (called LID structures) used in the eastern Kansas region with a specific focus on design. However, early investigation suggested that only a handful of implemented LID structures exist in eastern Kansas. Types of LID structures under consideration included bioretention facilities, rain gardens, filters and buffer strips, bioretention swales and infiltration trenches. Preliminary investigation also revealed that knowledge of and **support for ecological stormwater management was lacking** by the general public and local municipalities. It was concluded that LID-type stormwater structures in eastern Kansas would be most beneficial in order to understand the major problems and solutions related to using LID structures. A holistic assessment is offered including a review of planning, design, political approval process, management, and maintenance.

The City of Topeka Water Pollution Control (WPC) Division was among the first government agencies in Kansas to plan, design and implement LID structures. WPC has

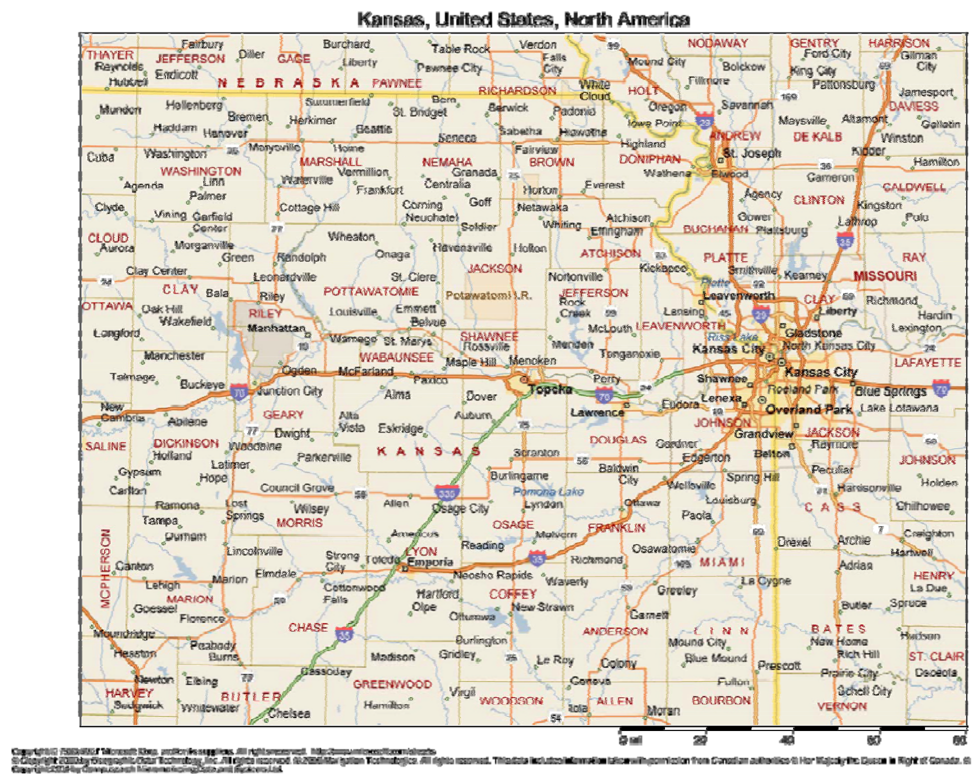


Figure 5-1: Regional Map of eastern Kansas (Microsoft Streets & Trips)

implemented at least six innovative stormwater management projects with two of these stormwater bioretention areas created to treat stormwater runoff from paved surfaces. The advantages for choosing WPC and Topeka projects were:

- Employees from WPC were early pioneers in the eastern Kansas region in treating stormwater with ecological practices and they offered to pass along lessons learned from early experiences;
- WPC has coordinated water quality research with from members of the KSU Department of Biological and Agricultural Engineering, at several locations where LID structures have been implemented.
- Topeka's proximity to the researcher at KSU;
- WPC has implemented a number of diverse stormwater projects including: bio-retention cells, wetlands, detention ponds, stream buffer ordinances, and stream and riparian restoration;
- Lessons can be learned from WPC's history in this emerging area of stormwater planning, design, and management.

The two chosen projects for the case study include the bio-retention facilities at Hillcrest and Jackson Street.

Watershed Background-

Both Hillcrest and Jackson Street share common watershed boundaries. The largest watershed is the Missouri Region or HUC 10 (see figure 5-2). The upper reaches of this watershed are in Montana and Alberta, Canada. The sub region is the Kansas or HUC 1027 (see figure 5-3).

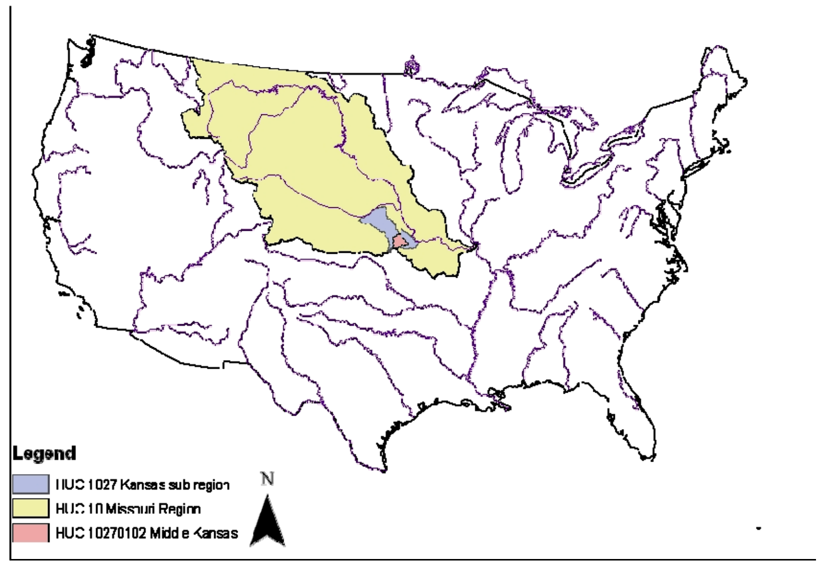


Figure 5-2: HUC 10 Missouri Region (Data Source: DASC, 2006)

The greater Topeka area is part of the Middle Kansas or HUC 10270102 watershed. The Kansas River is the largest river in the watershed and the other streams are Mill Creek, Spring Creek, and Vermillion Creek. The Middle Kansas River is considered to be an impaired stream; meaning that it is below the acceptable level of contamination (Kansas Department of Health and Environment (KDHE), 2000, 4).

The Middle Kansas watershed has a high level of contamination (see Figure 5:5). Due to the majority of the overall watershed being rural and agricultural lands the major pollutant sources include: feedlots, wastewater treatment facilities, septic systems, and wildlife. According to the Watershed Conditions Report for HUC 10270102 "the primary pollutant concern within HUC 8 10270102 streams and rivers is fecal coliform bacteria (FCB). FCB is a bacteria present in human and animal waste. It serves as an indicator of potential disease causing organisms" (KDHE, 2000, 2).

Pollutants in a watershed affect streams, rivers, ponds, lakes, and the aquifers below. The groundwater for HUC 10270102 is in the Alluvial aquifer and "water from these aquifers is very hard with naturally occurring minerals and nitrates as the primary pollutant concerns" (KDHE, 2000, 8).

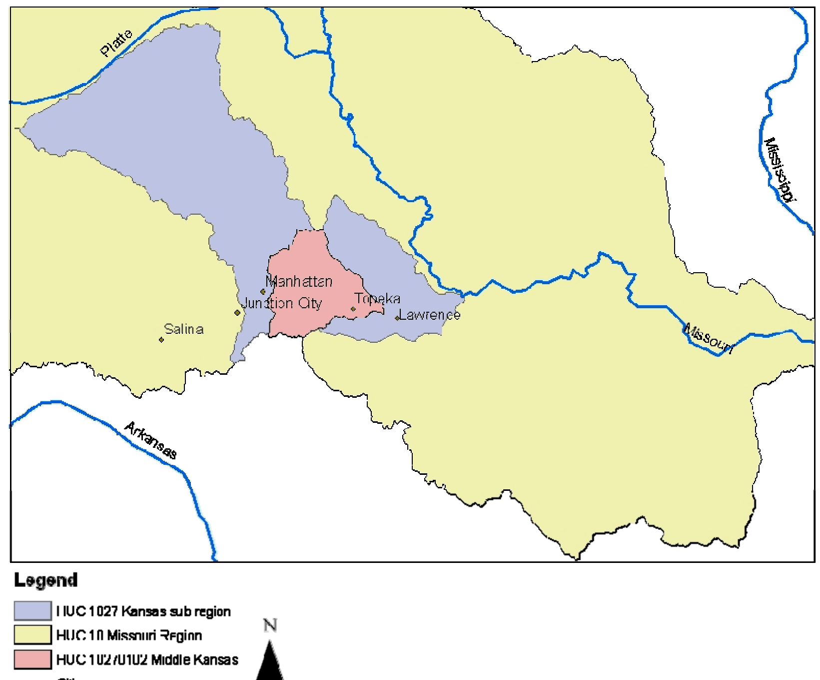


Figure 5-3: HUC 1027 Kansas Sub Region (Data source: DASC, 2006)

Sediments are another form of pollutants. They can raise the water temperature (which changes fish habitat), carry chemicals, and change the structure of a stream banks by eroding.

Sediments sources include: construction sites, stream bank erosion, urban and suburban development, and row crop agriculture. The sources of nutrients include: row crop agriculture, urban/ suburban runoff, registered feedlots, unregistered feedlots, wastewater treatment facilities, septic systems, and wildlife (KDHE, 2000, 4-5). The use of LID principles and techniques can improve the water quality within the watershed.

The KDHE report recognizes that urban and suburban impervious areas highly contribute to erosion, flooding, and nonpoint source pollution. "The watershed has an increasing population living in suburban areas. Residential landscapes are often designed with large turf areas which require high amounts of water and chemicals to maintain. The use of excessive

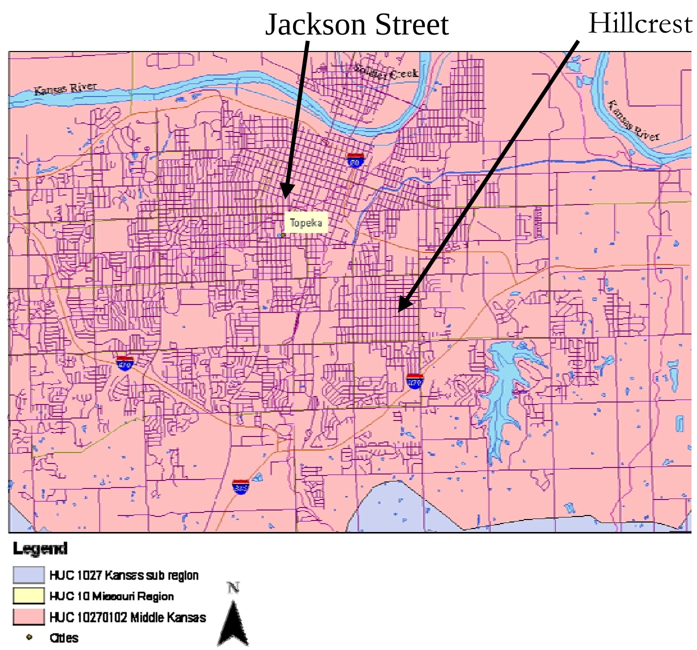


Figure 5-4: Sites and Local Watershed **(DATA source: DASC, 2006)**

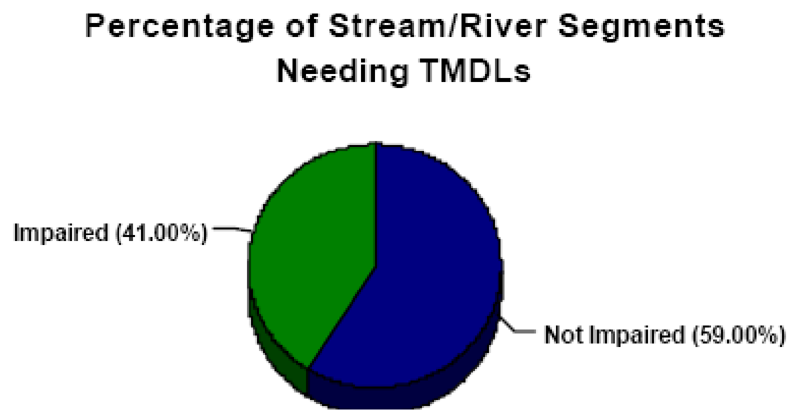


Figure 5-5: Impaired Streams in Watershed (KDHE, 2006, 7)

amounts of fertilizers and lawn care chemicals in residential areas can contribute a significant amount of pollution to nearby water resources" (KDHE, 2000, 6). Designers have a major responsibility and opportunity to improve the water quality and the hydrology of watershed through ecologically oriented landplaning and landscapes. Both Hillcrest and Jackson Street are pilot projects done by WPC with the hope of improving the water quality of HUC 10270102 watershed and changing to ecological methods of stormwater management for the City of Topeka.

The main topics investigated and to be discussed for each case study include:

- Background
- Political approval process
- Condition of site before implementation
- General project design
- Stormwater Design
- Soil
- Plants
- LID principles or techniques used
- Lessons learned
- Critique

Hillcrest

Background –

AS a park, community center Hillcrest is an important gathering place for the surrounding neighborhoods. The Hillcrest park and community center was built in 1977. The address is 1800 SE 21st Street, Topeka, Kansas. Activities offered at Hillcrest include: sports events, athletic and fitness activities, crafts, preschool programs, computer classes, youth activities, and seasonal activities (http://www.topeka.org/parksrec/hillcrest.shtml 4-23-06). The community center acts as a community hall for meetings and parties. "Hillcrest Community Center has a beautiful park that surrounds the building. The park includes three outdoor basketball courts, a tennis court, playground equipment, two sand volleyball courts, an outdoor pool, and a soccer field" (http://www.topeka.org/parksrec/hillcrest.shtml 4-23-06).

Hillcrest is an active public-use facility located along a main thoroughfare, and as such, is an important place project to site is not as prominent as Jackson Street, yet is still valuable to demonstrate ecological stormwater management. "The Hillcrest Bioretention Cell was the first bioretention cell installed in Topeka" (www.greentopeka.org 4-06-06) and was constructed in July 2001 (Green, personal comm., 2006). Being the first bioretention structure located in the area, some mistakes were made and lessons were learned.

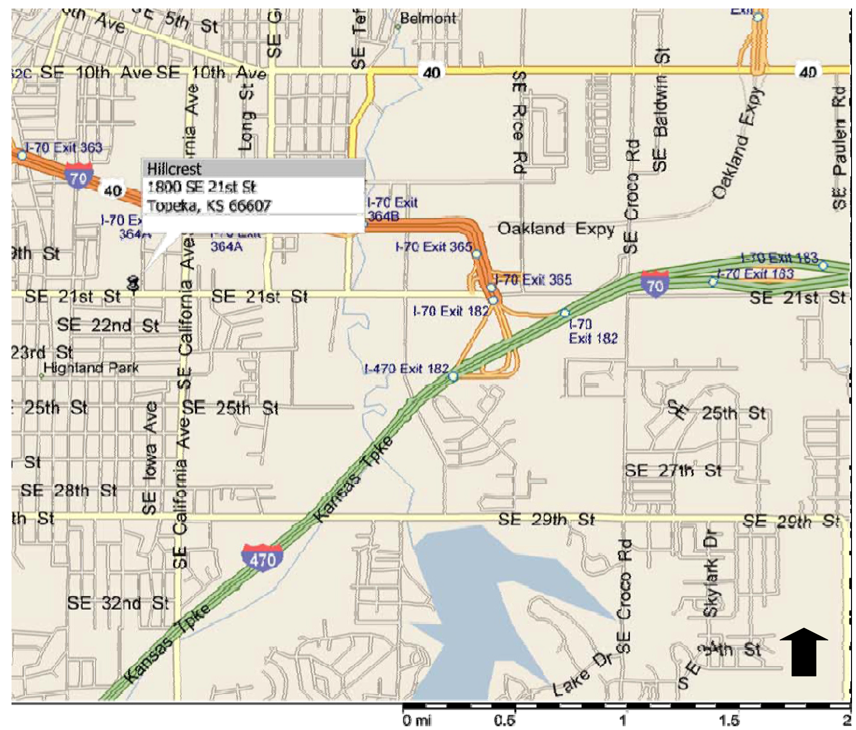


Figure 5-6: Hillcrest Location Map (Microsoft Streets & Trips)

Project Management Background-

Mark Green's educational background is an undergraduate degree from United States Naval Academy with a Bachelorate of Science in Math and graduate degree from the University of South Carolina in Civil Engineering (with a focus on water, wastewater, and hydrology). The educational background in engineering and hydrology, along with learning in the regional context of the Atlantic coast gave Green an understanding of the ecological impacts of stormwater management. Green also had an understanding of LID stormwater management techniques and literature (Green, personal comm., 2006).

Political approval process-

Mark Green P.E. the former Superintendent of City of Topeka Water Pollution Control (WPC) was "looking for a place to do a public demonstration of a bioretention" (Green, personal comm., 2006). He learned from a public works meeting that the City of Topeka Parks and Recreation department was preparing to redo repave Hillcrest parking lot. Green's impression was that Hillcrest was a good location for a bioretention cell and that the parking lot was sufficiently large to remove some of the parking area and replace the impervious material with a bioretention cell. Green talked with the Director of Parks and Recreation who had a desire to make the "park look nicer" and Green suggested that a bioretention would improve the aesthetics and help with stormwater (Green, personal comm., 2006).

As will be discussed later in this thesis, the Hillcrest approval process was more simple than Jackson Street. The suburb location of Hillcrest and the scope of the project are the most probable reasons for a simple approval process. The Hillcrest retrofit did not involve any major roads improvements, thus it would not have required the scrutiny of the civil engineers from the Public Works department.

Site conditions before implementation-

Hillcrest was a typical asphalt parking lot, which was in need of being repaved. The approximate area of the lot is 22050 square feet, with the bioretention cell approximately in the middle. The slope of the parking lot is estimated at 2%, with the higher elevation rising along the east side.

General project design-

Green had a desire to do a LID type stormwater structure for the Hillcrest and his major design and technical reference was the Design of Stormwater Filtering Systems by Claytor and Schueler (Claytor, 1996). This manual offers technical and specific recommendations for treating stormwater and the information comes from the same context as the LID manual (Prince George's County, Maryland).

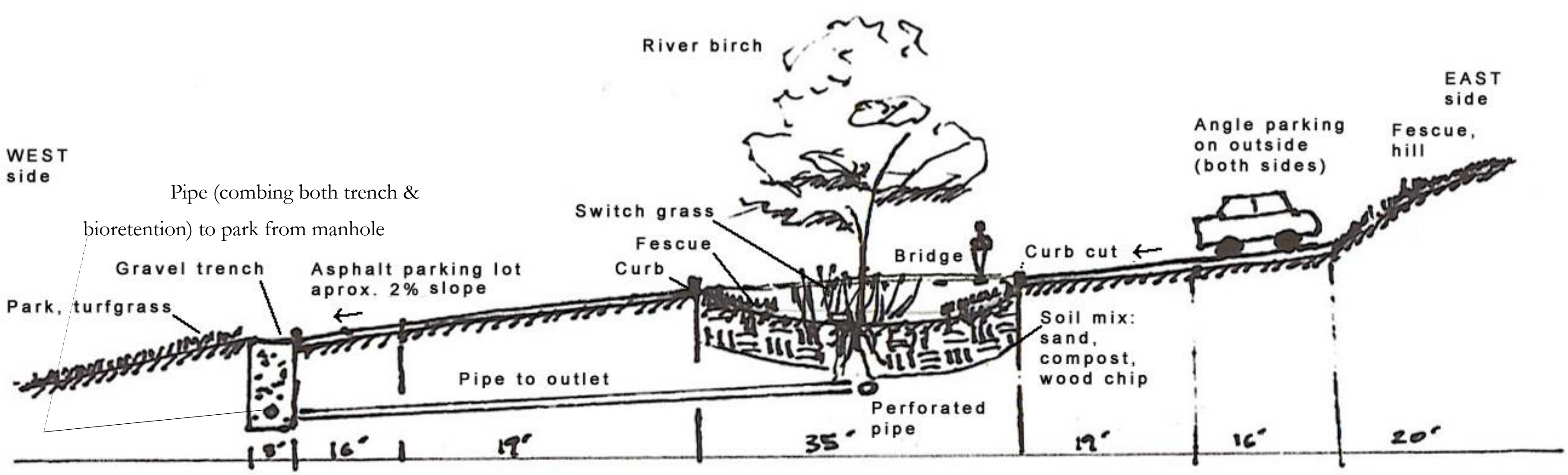


Figure 5-7: Hillcrest diagram sketch (not to scale), (Author)

The Design of Stormwater Filtering Systems was developed within the context of the mid-Atlantic region, which has different ecoregion factors than Topeka; such as more precipitation, increased frequency of storms, lower evapotranspiration rates, and in general more sandy soils (less clay). Design of Stormwater Filtering Systems is among early literature regarding ecological practices for stormwater and when Green used the manual it had not been tested sufficiently in the mid Central Plains region (Claytor, 1996). The Hillcrest design was done in house and construction documents were not generated for bid.

Figure 5:7 (on the previous page) is a section sketch diagram of Hillcrest (according to the site in spring 2006) and illustrates the basic features of the site. The Parks and Recreation Department did not want to re-grade the site; therefore the stormwater design was retrofitted to meet the existing grading. The outer sides of the parking lots have diagonal parking and the paved areas adjacent to the bioretention cell (on each side) are for vehicular circulation. Surface water runoff flows from east to west. The east parking drains into the bioretention, with inlets being curb cuts and the west parking lot side drains towards (west) the park into a French drain (gravel trench).

Green did not want to use the suggested curb cuts in the manual (which are rectangles, with a 6" drop at the edge of curb). The curbs were considered by Green to be potentially dangerous for someone walking through the bioretention cell. Instead

Figure 5-8: Hillcrest Curb Cut (Author)

Green used a more free flowing curb, which is more aesthetically pleasing and provides drainage into bioretention cell (see Figure 5:8). The curb cuts are on the east side of the bioretention cell and the east side of the French drain (Green, personal comm., 2006).

In the center of the bioretention is a storm drain inlet (approximately 4" above ground level), which was sized for a 10-year storm (for the whole parking lot). The bioretention cell itself is designed to receive and infiltrate around 1 – 1 ½" of rain in a single storm (Green, personal comm., 2006). A wooden bridge was built by Boy Scouts for a service project and offers a convenient method to cross the cell. The storm inlet is under the bridge (see Figure 5-9) .

Figure 5-9: Overflow Inlet In The Middle of the Bioretention, at Hillcrest (Author)

Stormwater design-

Claytor and Schueler define bioretention as a practice that manages and treats "stormwater runoff using a conditioned planting soil bed and planting materials to filter runoff stored within a shallow depression. The method combines physical filtering and adsorption with biological processes. The system consists of a flow regulation structure, a pretreatment filter strip or grass channel, a sand bed, pea gravel overflow curtain drain, a shallow ponding area , a surface organic layer of mulch, a planting soil bed, plant material, a gravel underdrain system, and an overflow system" (Claytor, 1996, 6.-1).

Green closely followed the standard out of the manual in using sandy soil, shallow basin, perforated underdrain pipe, overflow storm drain inlet, and conventional (for Topeka) nursery plants. The manual calls for a perforated pipe for the underdrain, but Green used solid pipe PVC Schedule 40) with holes on the bottom half. The entire pipe wrapped was wrapped in filter fabric and buried in gravel. Green said: "It's a very good draining system, not very good for plants" (Green, personal comm., 2006).

After 4 to 5 years of experience with Hillcrest and other LID-type stormwater projects Green commented "I am not real big proponent of what they designed as a bioretention system. I would rather see no under drain, I don't know why you would want an under drain system. I would rather look at a bioretention with a beehive inlet (see Figure 5-32, pg. 91), which directly flows to a major system or an open channel (Green, personal com., 2006).

The bioretention system which was originally developed by Prince George's County, MD is designed for regions that receive more precipitation than Topeka and the rainfall is on a more continual basis throughout the year. In discussing how the bioretention design from the Design of Stormwater Filtering Systems manual is problematic Green said "The reason these [designs] are flawed is

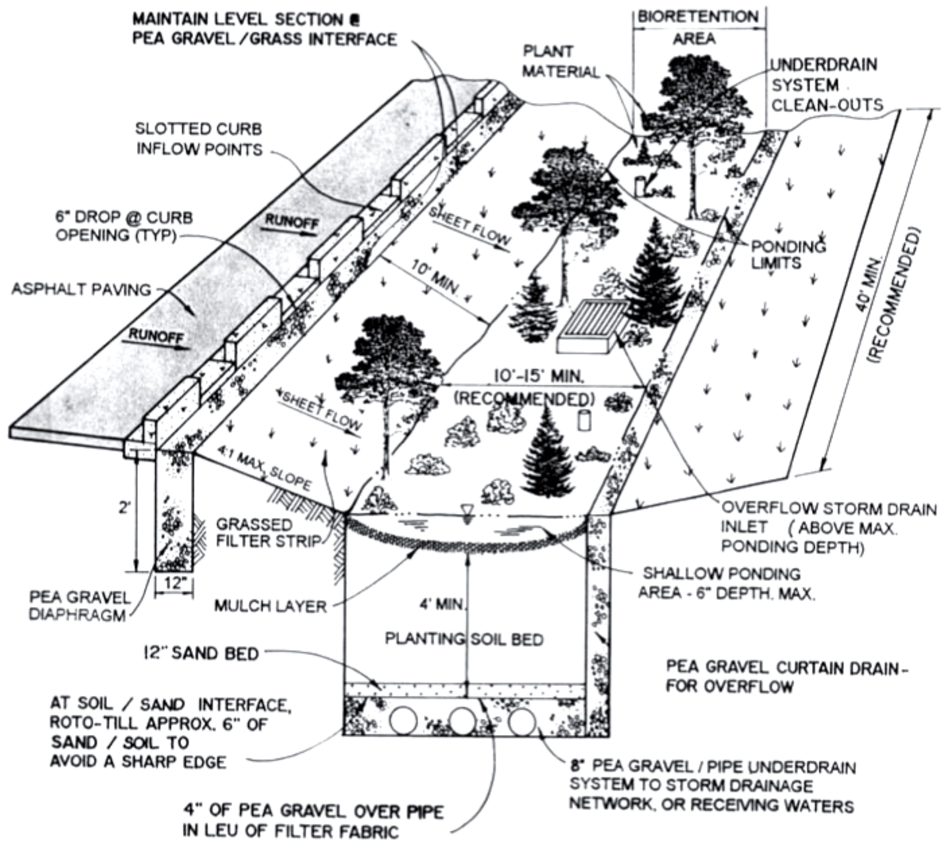


Figure 5-10: Referenced Bioretention Cell (Claytor, 1996, 6-1)

they talk about plant material or plants that like to get their feet wet, but they have engineered a system that doesn't allow the water to stay in there. We followed this system. We planted the plants, trees, and sodded it. Basically all the trees and shrubs died. They didn't survive because there was no constant water. We didn't do a lot of supplemental watering, which probably impacted it to a degree" (Green, personal comm., 2006).

As mentioned on the West side of the parking lot drains into a gravel trench. The gravel trench not part of the first instillation, but was later added due to erosion. The drain "starts off at three feet (deep) and goes down to five (near the outlet) (Green, personal comm., 2006). Both the gravel trench and bioretention cell discharge into a common manhole, which day lights onto an area of lawn and tress within the park.

During the author's site visits in March and April of 2006, the gravel trench was experiencing no erosion and appeared to be functioning properly. The curb cuts at both the bioretention cell and gravel trench had received a fair amount of sediment building up, which shows that the water slows down when it hits the

Figure 5-11: Under Drain (Author)

Figure 5-12: French Drain (Author)

gravel and deposits the silt. However the silt deposit is providing a medium for weed growth. A concrete apron, with rocks to slow down flow is recommended (see Figure 5-50, pg 102).

Soil medium-

Below the parking lot at Hillcrest was a compacted urban soil, which was removed to the depth of five feet and replaced with bio solids, mixed with coarse sand, "which made for a well drained soil. Almost a golf course green" (Green, personal comm., 2006). Sand provides a fast medium for percolation and does not stay wet long enough for "wet feet" plants to survive. Green also learned that soil high in bio solids is "too hot" or has too much nitrogen, which can burn up plants. From the Hillcrest project Green and WPC developed their current soil medium mix which is one part bio solid, one part wood chips, one part sand, and one part top soil.

Vegetation-

Plants provide a key role in the process of infiltration and percolation and the LID manuals (including Design of Stormwater Filtering Systems) stress the importance of using the right plant palette for the site and ecoregion. The original plants used at Hillcrest bioretention include: fescue sod, swamp white oak, river birch, and a few ornamental shrubs (species unknown).

Figure 5-13: Hillcrest Original Planting

(http://www.topeka.org/parksrec/hillcrest.shtml 4-23-06)

As previously mentioned the plants died shortly after instillation, due to being nursery plants, not drought tolerant, and the bioretention cell drains water quickly (Green, personal comm., 2006).

The shrubs, trees (except river birch), and central area of fescue were later replaced with switch grass (*Panicum virgatum)*. Figure 5-14 shows how the bioretention cell looked on April 20th 2006.

Commenting on switch grass Green said "We have gone back and put switch grass down the middle (of the bioretention cell). It will find water and survive. It lives in dry places and has done fine" (Green, personal comm., 2006). Green also mentioned that if he were doing the project over again he would have used buffalo grass (*Buchloe dactyloides*) instead of fescue because it is drough tolerant.

Buffalo grass is a native prairie grass that has been bred to develop a sod variety. Green has learned that buffalo grass burns right along with the prairie even after it has been mowed (Green, personal comm., 2006).

Hillcrest has been established long enough to be tested against major storms. Green noted "I believe, based on what we have seen at Hillcrest and other places, that bioretention cells are supposed to accommodate 1/2" to 1" stormwater event, but over time they will be able to handle a 5 year rain storm (about 2" in first hour). The effects of these ecological practices down stream

Figure 5-14: Hillcrest Bioretention (Author)

are significant. A couple years ago we had a huge rain storm in Oakland (Topeka suburb), when you stepped out of the car the water was over the curb and the water would come up to your knees in water. We ran out to Hillcrest and we had received about 5" inches of rain in thirty minutes. It was about a 10 year (storm) event in thirty minutes… I have a 6" pipe that leaves Hillcrest, (at the time) it was flowing half full and there was hardly any standing water in the system. Two weeks later water was still percolating out of that system through the under drain" (Green, Mark 2006).

LID-type techniques used-

- Bioretention components including, sandy soils, perforated pipe as an underdrain, depressed cell to hold water, grass filter for entering runoff, and overflow inlet to storm drain pipe;
- Gravel trench with perforated pipe;
- Modified curb cuts

Lessons learned-

WPC considers Hillcrest to be sufficiently infiltrating stormwater. It served as a pilot project and a testing ground for LID techniques in Topeka and Central Plains region. According to Green and WPC the major lessons learned include:

- A bioretention structure designed for high percolation (using **high amounts of sand**) does not work in the Topeka area;
- Switch grass (and other grasses deep rooted grasses) provide the best plant material for stormwater bioretention cells (not conventional ornamental plants);
- An underdrain is not needed and changes the ability of site to hold water and support plant communities;
- The curved curb cuts (as used in Hillcrest) work, but potentially could be more aesthetically pleasing. Also the total number could have been reduced and still achieve the same result (Michaelis, personal comm., 2006);

- Soil should be level with curb to reduce the safety hazard (added by Sylvia Michaelis of WPC (Michaelis, personal comm., 2006)

Critique-

While switch grass is working well, the plant palette lacks visual interest. It is recommended that the turf grass (which should be replaced with buffalo) only needs to be planted on the outer edges of the bioretention cell (5' wide). In the center should be more native grasses to add variety and aesthetic appeal. Little blue stem offers wonderful winter auburn color. Other potential grasses that would make a good prairie mix are Indian Grass, Big Bluestem, Eastern gramagrass, and Sideoats grama. Green mentioned that using too many grasses causes people to think it's a "weed patch"; therefore it would be good to limit the number of grasses to 3-5 species (Green, personal comm., 2006).

Adding perennial wildflowers would add color and attract butterflies. In general the public often prefers flowers over grasses; by planting grasses and wildflowers together the aesthetics and function will be met. Perennial flower species bloom at different time periods during the seasons and by choosing the right palette color could be in bloom from spring to fall.

Hillcrest was a pilot and demonstration project, yet is lacking the design and aesthetic emphasis which could convince the public and local politicians that bioretention cells can be functional and beautiful. It should be mentioned that the budget of WPC and the Parks and Recreation department was limited in design and implementation.

Other suggested design elements include sculpture, signs, pervious paving, and water feature. Potentially the storm water could follow a series of steps or waterfalls where runoff enters the bioretention.

Currently there are no signs indicating the importance of the project and explaining how it is differs from conventional stormwater management. It is recommended that a sculpture, which could include some type of project explanation be built at Hillcrest. The sculpture would draw the attention of people passing by, and would celebrate rain water and prairie ecosystems. The integrated signage would explain the negative effects of conventional end-of-pipe stormwater management, the positive effects of LID type stormwater management, and offer simple illustrations of water percolating into prairie systems. The sculpture integrated with signage would highlight the importance of the bioretention project and educate visitors to the Hillcrest park and community center.

While the budget was limited it would have been good to look at pervious paving, since Hillcrest is a demonstration project. Impervious parking lots are not the only solution, but one of many that can be used with LID techniques to solve the negative runoff problems. For example pervious paving could be implemented for bike parking near the community center.

At Hillcrest both of the underdrain pipes (from the gravel trench and bioretention cell) meet at a manhole. The water is then piped into the park (see Figure 5-15). The current structure has scattered rocks around the outlet, with one tree growing in the middle. The structure is displeasing and appears randomly built. It is recommended that a rain garden be built at the outlet. The rain garden would offer an added measure to infiltrate stormwater and a good design and implementation could offer valuable aesthetic appeal to the park and the LID site.

Figure 5-15: Pipe Outlet at Park (Author)

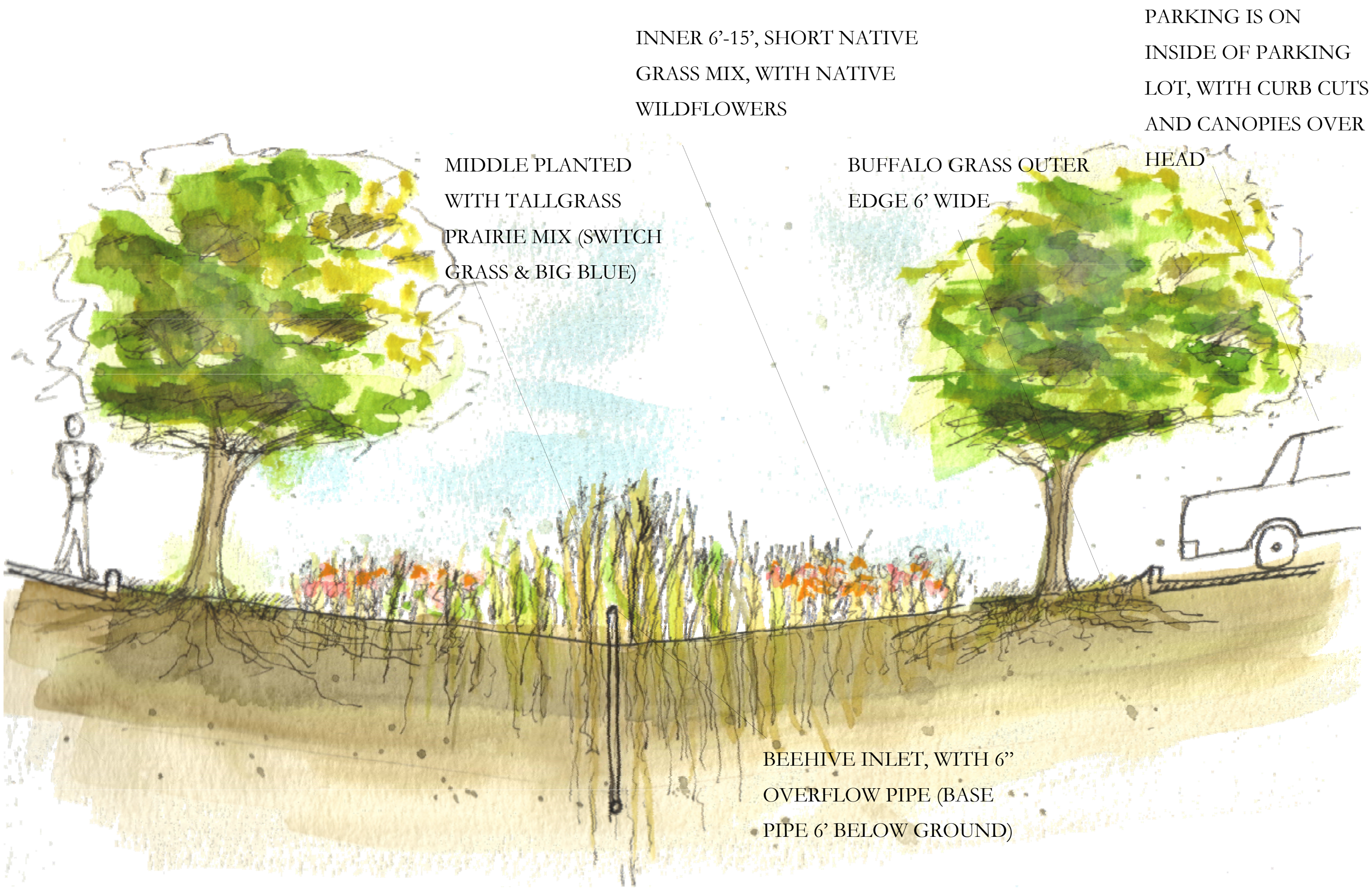


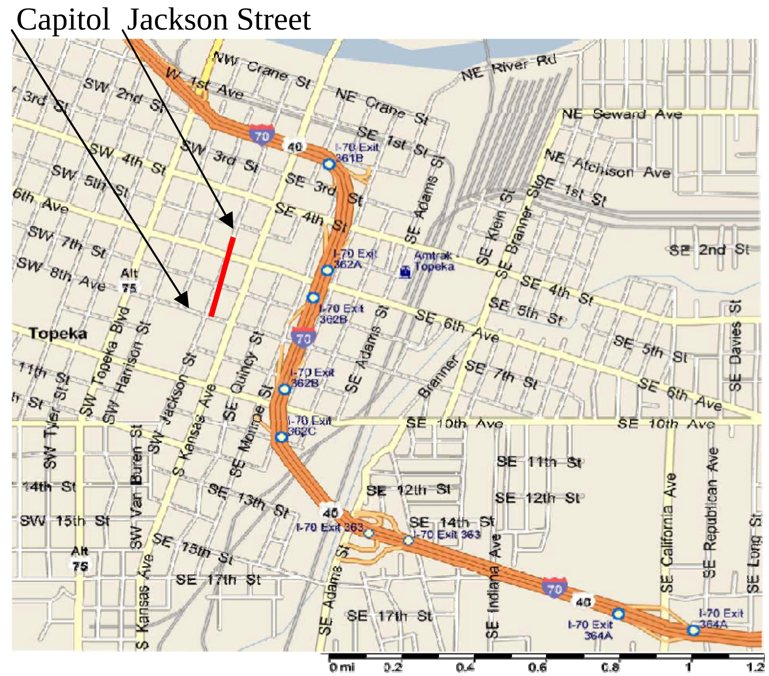
Figure 5-16: Hillcrest Redesign Sketch (Author)

Jackson Street

Background –

In reflecting upon the Jackson Street project Mark Green said "Jackson was a bold statement right in the middle of downtown" (Green, personal comm., 2006). During the genesis of the project it was likely that Green did not realize the range of positive and negative responses the project would develop.

Jackson Street is in the heart of downtown Topeka and is a highly used urban space. One block to the east is Kansas Avenue, which is the primary and most active street in Topeka. Kansas Avenue has 4 traffic lanes with a medium at intersections. The sidewalks are paved with bricks and offer a pleasant pedestrian corridor. Walkways are busy during weekday lunch times. Major buildings on Kansas Ave. include banks, government buildings, institutions, boutiques, and restaurants. In the spring of 2006 during a business day lunch the street was



busy with pedestrians and vehicles. Topeka Trolley and Topeka

Figure 5-17: Location map (Microsoft Streets and Trips)

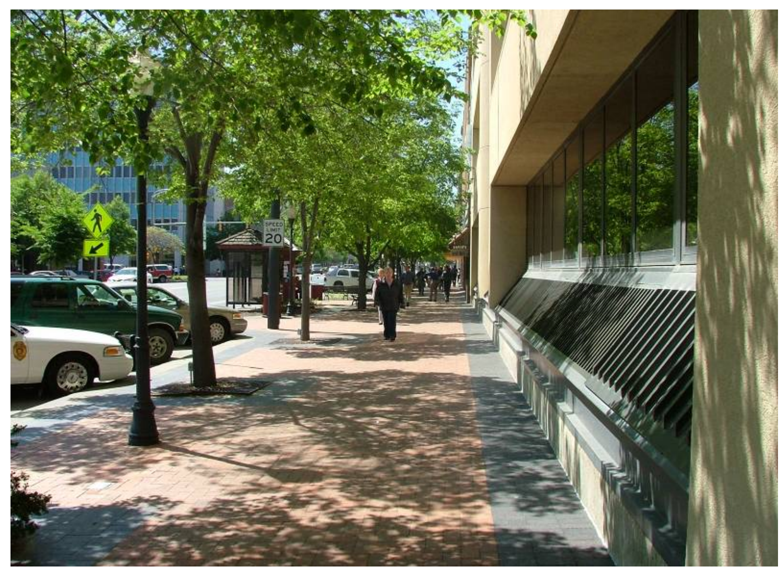


Figure 5-18: Kansas Avenue (Author)

Transit have routes on Kansas Ave. Parking on Kansas Avenue is limited to diagonal street parking and a few parking garages along the street.

The Jackson Street project starts at the intersection of 8th street and ends on 5th street, with stormwater flowing northeast towards the Kansas River. At the intersection of 8th and Jackson can be see the Capitol building and block (see Figure 5-19). Jackson Street itself has a strong supporting role to Kansas Avenue.; it offers lots of parking space via on street parking, surface lots and garages, the Jay-hawk Theater (currently closed and planned for renovation), a combined church and school, and a few businesses. Also present are a few vacant buildings, which are currently being remodeled.

During the late 1990's Jackson Street had been experiencing frequent flooding. Stormwater pipes were not large enough and the street and sidewalk was in very poor condition. In 1999 a design had been done to redo the street paving and to install a larger storm-drain system (designed by public works civil engineers, it was ready to be bid for construction). At this point Green became involved and the project changed significantly (Green, personal comm., 2006).

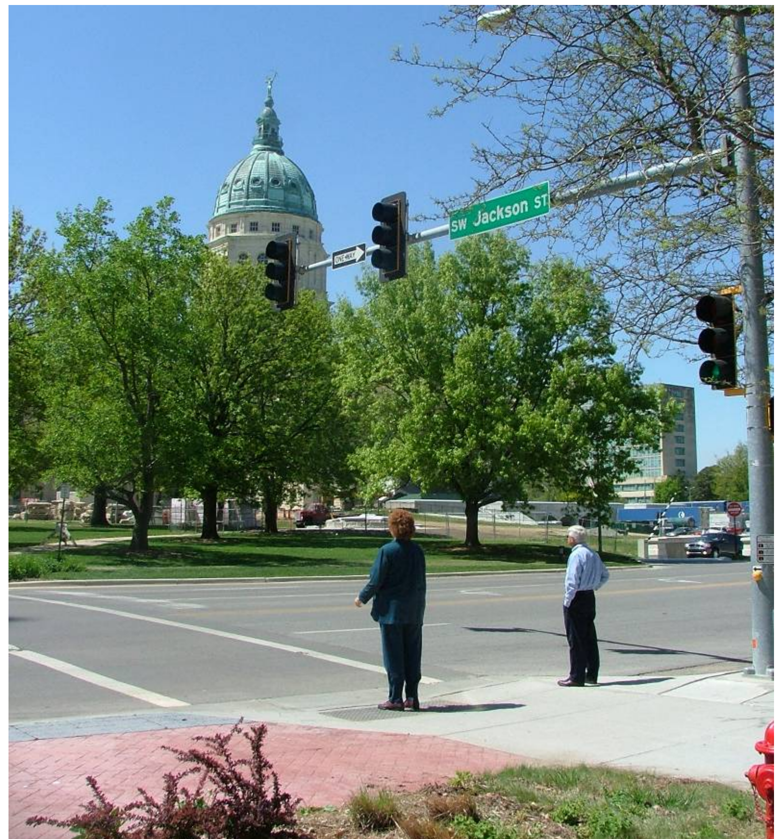


Figure 5-19: Capitol from Jackson and 8th (Author)

Political Approval Process-

The original storm sewer design was about 95 percent complete when Green went to the city engineer who managed projects for WPC. Green indicated that the city engineer did not wish and to make any changes. In fact, the engineer did not want to talk about changes. We were peers, so I went to see our boss. In a meeting with Mayor Wagnon, Green explained "you have a three lane street that runs downtown. Its ugly and the sidewalks are dilapidated. I think we can do this in a different way" (Green, personal comm., 2006). In 2000 Green received approval from Mayor Wagnon and began designing Jackson Street using LID techniques.

Green's original vision was to do an open channel swale system, by removing one of the lanes and have no storm sewer (Green, personal comm., 2006). WPC had a design charrette and modeled (for runoff capacity) the open channel system. The model showed it would have worked. Green noted the following "I had an engineering firm in town telling me that a cross section of a 72" pipe can hold more water than a cross section of a 10' wide, 3' deep open channel. No way. The amount of water I could convey [in the open channel] was much greater" (Green, Mark 2006).

Following the charrette there was a change of administration and Green lost the backing of the new Mayor. The compromise was to do bioretention cells, which would treat some of the overflow. Green said "unfortunately it cost the project more than it should have. The natural solution, had it been looked at first, would have cost less than the storm sewer, but the storm sewer still had to happen so the cells were to treat the smaller rain events" (Green, personal comm., 2006). Throughout the project Green and WPC received opposition from some City Council members and public works engineers.

The Green Topeka website states that in 2003 all the stakeholders were consulted and the main issues were "green infrastructure, water quality, pedestrian benches and lighting, and adding green space to the downtown sector" (http://www.greentopeka.org/Projects/?project=14 4-23-06)).

The compromise came from an "Alternative Development Workshop", which lasted "three days with groups of individuals looking at different options for the project. The result was a design that would control flooding and enhance water quality" (http://www.greentopeka.org/Projects/?project=14 4-23-06)). "Construction [on Jackson Street] was started in June 2003 and was complete in spring 2004" (Green, personal comm., 2006). The landscape planting began in spring of 2004.

WPC made pamphlets and shared information with Jackson Street business owners, held meetings to share design ideas and received feedback, and offered press releases. Downtown Topeka Inc. is given credit for rallying support from downtown businesses (Michaelis, personal comm.., 2006).

It is amazing the project was actually built despite the opposition that Green faced from city engineers and city council members. In reflection Green noted "I saw it [Jackson Street] as an opportunity, but the other person [the city civil engineer] saw it as a design that was about to bid for construction. In their mind they are thinking, we spent a year designing this and you're going to stop it… [Thus] the right time to get plugged into the planning process is not projects that are about to get done this year or even 2007. You really want to look at those ideas down the road… That is the time to go in and say what do you have planned for the future park. That's when to start plugging in these kinds of features into the projects. It is a more proactive way, than reactive way to deal with the situation" (Green, personal comm., 2006).

Green is suggesting that to be successful in collaborating with other professionals and politicians you need to be thinking far in advance and begin educating participating stakeholders early on. In the author's opinion the most significant lesson learned from Jackson Street is the **value of advanced planning and building a team of professionals who understand ecological design and establishing relationships and support from politicians and the public**. As shown from the Jackson Street experience, an LID-type (ecological) project can be approved and built, but the process is made more difficult, and may not be sustaining for future projects, if supporting relationships are not developed and harnessed.

WPC worked with Bartlett and West Engineering (of Topeka) and their role was lead designer and construction administrator of the project. Keith Warta of Bartlett and West said, "We were intimately involved in every aspect of the project from beginning to end" (Warta, Keith 2006). This was the first project of this type (alternative stormwater management) for Bartlett and West, who partnered with Tetra Tech to offer support (Warta, personal comm., 2006). Commenting on

Figure 5-20: Jackson Looking North (before construction) (http://www.greentopeka.org/Projects/?project=14 4-23-06)

working with WPC, Warta said, "Our collaboration with WPC worked great. They were very helpful during the project design and now, after construction, are providing manpower to maintain the cells" (Warta, personal comm., 2006).

Bartlett and West had limited experience in ecological stormwater management. Similarly many engineering firms currently lack understanding of LID and ecological stormwater planning and design, while some firms lack the desire to learn and do ecological projects with an emphasis on infiltration rather than end-of-pipe technologies. Green's prospective is that Topeka does "not have any firms who have bought into this process, zero. They have done (ecological work) based on what I asked them to do, but that was it. We are still in the demonstration and education phase" (Green, Mark 2006). Green did mention that in Kansas City there were a few firms who were capable of doing this type of work, but only because they worked in other national

Figure 5-21: Jackson Near School/ Church
(http://www.greentopeka.org/Projects/?project=14 5-06-06)

markets, which required stormwater sustainability (Green, personal comm., 2006).

Site conditions before construction-

As previously mentioned the storm sewer below Jackson Street needed to be enlarged, and the sidewalks were dilapidated. The street had three lanes of one way traffic and parallel parking on both sides. It was decided that there was sufficient parking

Figure 5-22: Jackson streetscape
(http://www.greentopeka.org/Projects/?project=14 5-06-06)

and traffic lanes, to replace one traffic lane and one side of parking to build the bioretention and greenway. It should also be noted that downtown Topeka was highly urbanized and contained very limited green space (as shown in Figures 5-22).

Figure 5-23: Jackson Looking South (http://www.greentopeka.org/Projects/?project=14 5-06-06)

Figure 5-24: Aerial Photograph of Topeka (Data source: DASC 2006)

General Project Design-

The aerial photograph on the previous page (Figure 5-24) offers a clear view of the minimal amount of green space in downtown Topeka and the high percentage of impervious surfaces namely in roofs, streets, and parking. This suggests the why downtown Topeka is experiencing flooding. High amounts of imperviousness change the hydrology by increasing runoff volumes and velocity. The improvements in the Jackson Street project included: asphalt re-paving of the two auto lanes, curb and gutter with open flumes to convey stormwater into bioretention cells, storm sewer inlets going to the stormwater infrastructure, bioretention cells (with soil and plants) with beehive inlets going to the storm pipe, stamped concrete sidewalks, seating areas with borders, a series of small interpretive signs, on street diagonal parking, and lighting.

The traffic lane on the west side and associated parallel parking were removed to provide ample space for the bioretention cells and walks. The street design is conventional asphalt with a crown running down the center line dividing the drainage areas. Jackson Street used a series of open flumes (see Figure 5-27) to convey stormwater from the street into the bioretention areas. The bioretention cells cover three city blocks, as shown in the aerial photograph taken in 2005 (Figure 5-24).

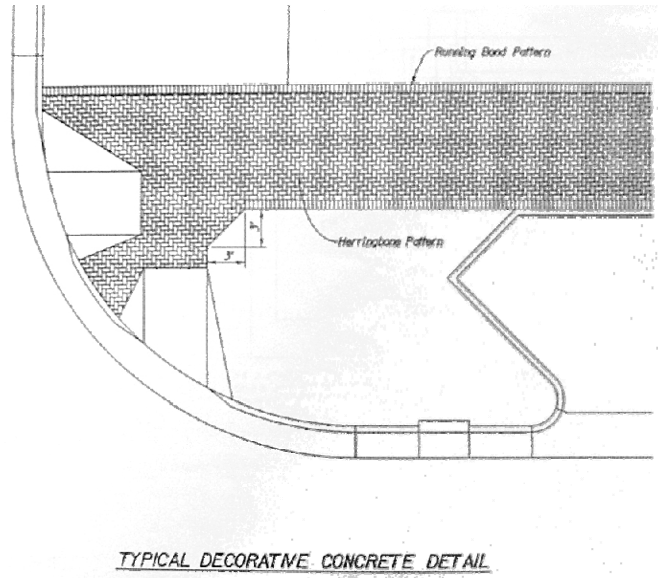


Figure 5-25: Concrete Detail (Bartlett and West Engineers, 2003)

The walkways and bioretention cells combine to serve as a greenway for those working, living and visiting downtown and the Capitol. The sidewalk varies in width (typically 13 feet) and is sufficiently wide for large crowds. Jackson Street is used for a parades and festivals several times a year and the new greenway offers a much improved venue for these events. Regarding pedestrian use Green said "One of the selling points was, that by doing an open channel type system it really divides the pedestrian corridor from the vehicle corridor. We have seen an increase of people using Jackson Street, from a pedestrian stand point. So people must find it a pleasant place to walk" (Green, personal comm., 2006).

Jackson Street has red stamped concrete in Herringbone and Running Bond patterns in key areas: such as intersections and seating areas. Colored stamped concrete is less expensive than brick pavers, however it tends to fades overtime (as noted in April 2006). The colored paving patterns dresses up the pedestrian walk and adds an important aesthetic component to the greenway.

Figure 5-26: Birds Eye View of Jackson

(http://www.greentopeka.org/Projects/?project=14 5-4-06).

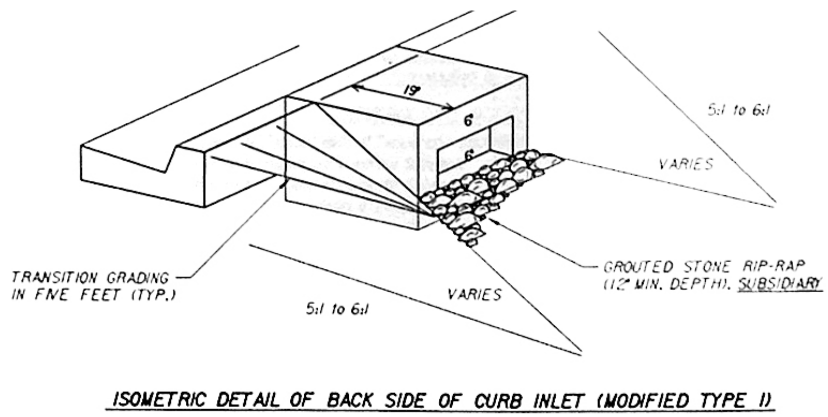


Figure 5-27: Open Flume Drawing (Bartlett and West Engineers 2003)

Along the walkway are (early 1900's style) light fixtures installed at a pedestrian scale, which complement the design. The light fixtures have a historic feel to them and are pedestrian friendly than tall conventional street lights night.

The bioretention cells are divided according to the need for vehicle entrances into parking lots (see Figure 5-27) and street crossing. Some of the cells have an open flume (or open back inlet), which directs flow from the curb into the bioretention cell. Regarding the inlet Green said "To break up the flow coming off (the street), we designed an open flume inlet… We worked with a local concrete company to design it. The public works director didn't want a curb cut. It is a nice model because it works well for [plows removing snow]. The Maryland manuals recommend curb cuts, but they do not look as clean. They don't give you that [sense] of a nice street" (Green, personal comm., 2006). These features are mentioned to highlight the fact that the bioretention areas were envisioned as an integrated landscape design.

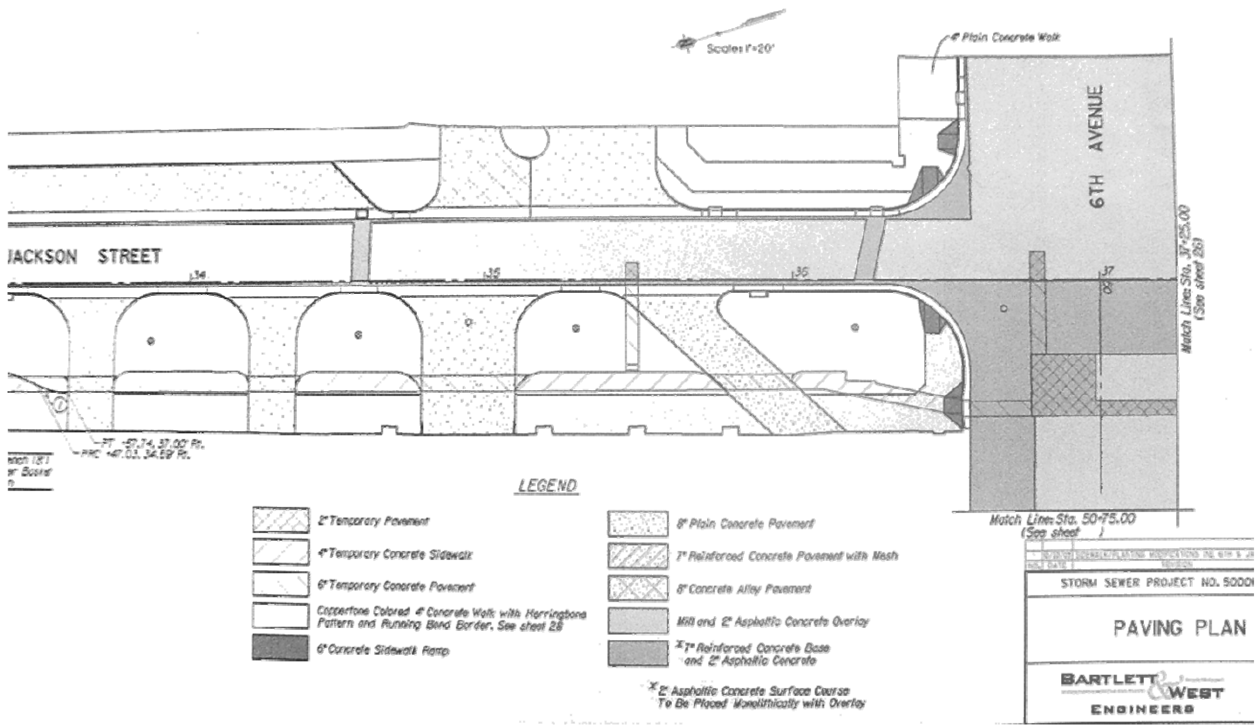


Figure 5-28: Paving Plan (Bartlett and West Engineers, 2003)

Stormwater design-

The Stormwater runoff along Jackson Street project either drains straight into the bioretention cells or moves directly into storm inlets. The project has two pipe networks: regular storm drains (at the end of each block) and beehive inlets in the bioretention cells (which then connect to the regular storm drain network) (Green, personal comm.., 2006).

Figure 5-30: Open Flume (Author)

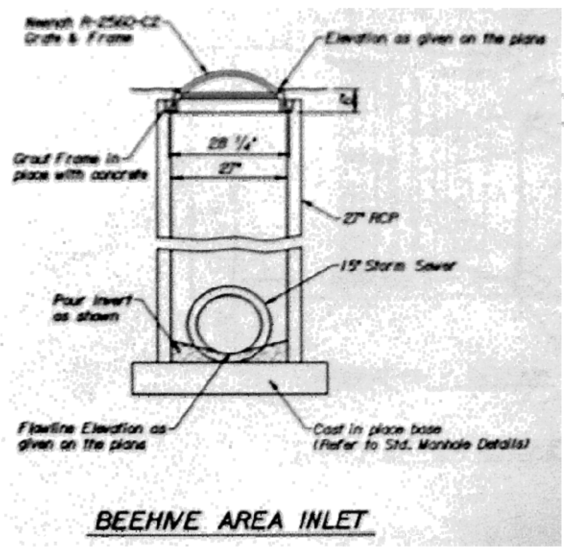


Figure 5-29: Beehive Inlet connected to storm sewer pipe (Bartlett and West Engineers 2003)

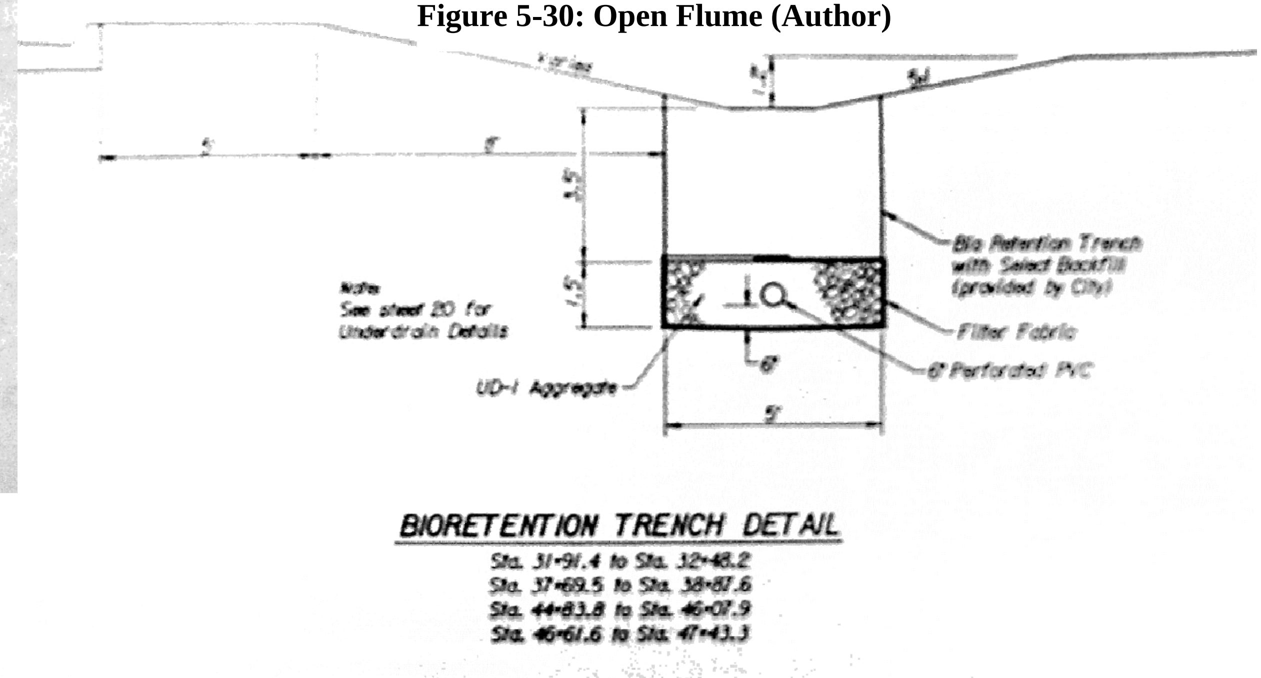


Figure 5-31: Bioretention Detail the underdrain was not used as indicated in the detail drawing (Bartlett and West Engineers 2003)

Green learned from Hillcrest that "underdrain systems do just that, drain the water and stress the plant life. I think the use of bee hives with adjustable cones to raise the depth as plants mature provide a better, and more sustainable solution. Hillcrest has an underdrain system. One of the main purposes for doing the Jackson Street Project was to install a larger storm sewers to prevent flooding and increase the sewers flow capacity" (Green, personal comm., 2006). Because each block is required to have an inlet at the end, storm inlets are placed at the end each block. The major disadvantage to having regular storm inlets at the end of each block is that a significant portion (approximately 1/5) of the block's runoff goes straight to the pipe and not to the adjacent bioretention cells.

The runoff at Jackson Street is designed to pond in the bioretention cells for a short period of time (maximum 24-48 hours), while some of the water infiltrates into the soil. Deep rooted native grasses increase the porosity of the soil and offer downward root channels for percolation. When the ponding water reaches a certain level it enters the beehive inlet. The inlet height can be adjusted to increase ponding amounts and those structures are located on the down slope end of each cell. Smaller cells do not have inlets and the overflow would into the next cell or street. The beehive inlets were installed to be level with the ground surface so that the cells would not be inundated for too long during the establishment of vegetation.

Figure 5-32: Beehive Inlet (Author)

Runoff calculations were done to size the storm sewer system and not the bioretention cells (Warta, personal comm., 2006). Hence the precise drainage area per cell is not known, but each cell drainage area is approximately the length of the cell times the width (crown to edge of walk, approximately 50 feet depending on location).

Soil Medium-

Hillcrest provided a testing ground for the suggested LID soil medium and a number of plants species. Prior to construction soils were highly compacted and almost entirely covered by asphalt or concrete. The soil mixture used was one part bio-solids, two parts wood chips, one part sand, and one part topsoil. The most important lesson learned regarding soils from the Jackson Street project relates to compaction. "The unfortunate

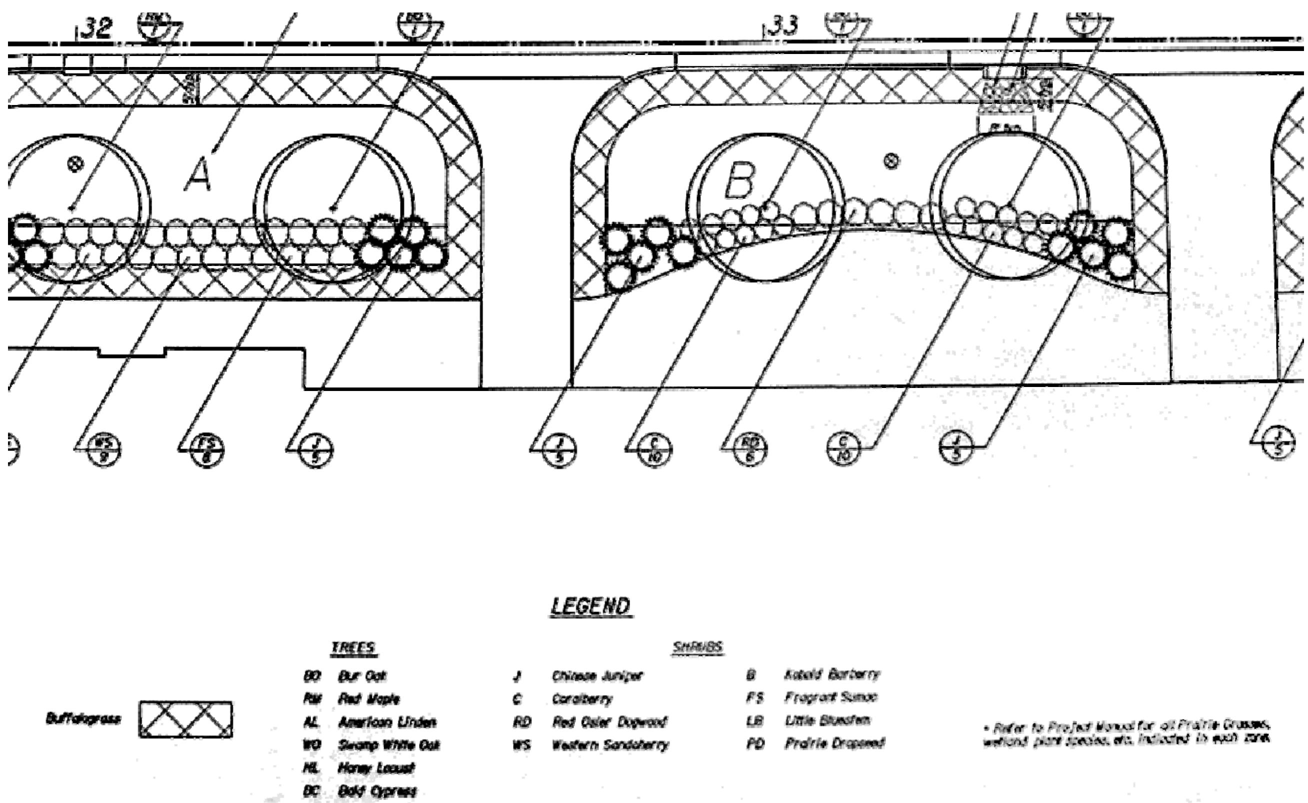


Figure 5-33: Plant palette prepared by engineer, but not implemented due to insufficient understanding of the intent to use native species and infiltrate runoff (Bartlett and West Engineers 2003)

thing with Jackson is they put the soils in the fall and then they compacted them all winter long while they were finishing the project. [During spring planting] one of the guys put in a bareroot [plant] with the auger [used to dig holes]. The soils were so compact that it broke the shear pin on the auger and chipped a tooth" (Green, personal comm.., 2006).

Based on this and many similar experiences Green's it is recommended that restrictions be placed on using construction equipment on top of bioretention areas to prevent soil compaction.

Vegetation-

The vegetation is the most prominent feature on the greenway (and should be, due to the intent of the project). The original plant palette was developed by Bartlett and West. Some of the plant palette consisted of nursery stock plants and was not

Figure 5-0-14: Jackson Planting July 04

(http://www.greentopeka.org/Projects/?project=14 5-5-06)

Figure 5-35: Recently planted switch grass

(http://www.greentopeka.org/Projects/?project=14 5-6-06_

native. As of April 2006 most of the nursery plants have been replaced by native grasses.

From Hillcrest and Jackson Street it was learned that nursery plants do poorly in bioretention areas, due to lack of irrigation, nursery plants are developed in a high a maintenance environment, and not all can handle the stresses of ponding and infiltrating water (Green and Michaelis, personal communication, 2006).

Jackson Street was first planted during June and July of 2004 (see Figure 5-31). WPC decided to that Buffalo grass (*Buchloe dactyloides*) sod would be planted around the perimeter of each cell, which provides a more manicured look. During spring of 2006 the Buffalo grass was in healthy condition throughout the site.

Green said that maybe using drill buffalo grass and (or) seeding would have worked equally well (or better) and would have cost less. Regarding the native grass planting Green indicated that he thought it would have been better if WPC would have planted the center of the channel with switch grass plugs where the water flows and then seed the rest (with a tall prairie grass mix. Then WPC could have used a once a month mowing schedule for three months, for the first two years. By the third year, when the prairie grasses were really firm, WPC could come back and burn it. In this way, the public would think

Figure 5-36: Big bluestem, March 2006 (Author)

WPC had created a natural system in the middle and were mowing the cells like good public stewards (Green, personal comm.., 2006).

Most of the cells are planted with native grasses. The most used or dominate species as of spring 2006 include big blue stem (*Andropogon gerardii*), little blue stem (*Andropogon scoparius*), switch grass (*Panicum virgatum*), side-oats grama (*Bouteloua curtipendula*), and prairie cordgrass (*Spartina pectinata*). Little blue stem offers a nice winter auburn color and is doing well at Jackson Street (see Figure 5-36). Some of the cells have a strong prairie grass mix and others have more conventional nursery plants (such as, red-osier dogwood, sandcherry and other shrubs).

Seeing a tallgrass prairie in downtown Topeka is a new paradigm for urban design and not everyone has embraced it. A local nursery owner who also serves as a city councilmen said the following "[The] plant selection was poor and design was poor. Not a bad concept for a river bank or out of the way area, but terrible for a highly visible area" (Blackburn, personal comm., 2006). The same nursery man noted that the belief that prairie grasses should only be in the rural or native landscape is shared by others as well. Along those same lines the nursery man said "I believe even if they had used a proper turf grass, unlike buffalo grass which is not suitable for Topeka, I still would probably not be worth the expense and maintenance" (Blackburn, personal comm., 2006). The same nurseryman commented that the "plant selection could have been more mainstream [ornamental turffgrass and shrubs] suitable for low maintenance and still look nice" (Blackburn, personal comm., 2006).

While some people view the tallgrass prairie out of place it is important to note that during spring 2006 the cells which were planted with tallgrass prairie were more filled in (as a mature landscape) and contained less weeds, than the conventional ornamental cells. As noted in Chapter 2 (pgs 59-60) native prairie grasses out perform ornamentals in stormwater infiltration and percolation. It is the author's opinion that the bioretention cells planted with tallgrass prairie at Jackson Street are more aesthetically pleasing than the ornamental cells.

The Jackson Street project's typical maintenance schedule was reported as follows "[we] mow the buffalo grass around the edges every two weeks in the spring/early summer and then less frequently in the hottest part of the summer. Weeding takes more time, but as the plants in the center of the cell grow and have begun to fill in, the weed population has decreased (we are now focusing our weeding efforts on the formal areas which are weeded once every two weeks) and the center of the cells are left to grow with (weeding of large invasive species once a month, possibly more frequently if needed). New mulch is applied to formal areas once a year. Pruning is done once a year as needed. We also check the open-back curb inlets once a month to see if they need cleaning due to sediment build-up" (Michaelis, personal comm., 2006).

Jackson Street maintenance is different than a conventional landscape in that it doesn't need fertilizer, irrigation, and weekly mowing. However it does need bi-monthly mowing and bi-monthly weeding. It is expected that when the native plants fill in, less weeding will be required.

Sylvia Michealis of WPC said: "It should be noted that weeding is more difficult in the natural, less formal areas of the cells in the beginning of the growing season due the inability to distinguish weeds from young grasses and forbs. In time, many of these weeds will be squelched by the network of native species. At this point in time, I would have to say maintenance costs are higher on the west side of Jackson Street as compared to the East side where the areas are more formal. Since the project's inception, the total maintenance has steadily decreased" (Michaelis, personal comm., 2006).

LID Techniques and Practices

A number of LID-type techniques were used in the Jackson Street project. The techniques used include:

- Runoff drains to **bioretention cells**, which do not have underdrains like Hillcrest. Bioretention cells use native grasses to infiltrate water, hold water (in soil profile) for plant uptake and evapotranspiration, and percolation.
- **Public outreach** using press releases, public meetings, brochures and online webpage, and sharing with professional and educational communities.
- Open flumes (**modified curb cuts**) are used to direct stormwater runoff into the cells.
- Attempt to **mimic native prairie hydrology**, with focus on infiltration enhanced by deep-rooting herbaceous species.
- Testing is being done on Hillcrest and Jackson Street to measure the **water quality** achieved at the projects (www.greentopeka.org, 5-5-2006).

Lessons learned-

The first and most obvious lesson learned from Jackson Street is that **projects of this size, prestige, and precedence can be accomplished**. Planning, design, and engineering professionals have the ability to make a difference and try something new. Green has learned one way "to make the natural (plant) communities more accepting of the public" is by "**putting in edging. By making sure there is a clear and defined edge. So it looks like its meant to b**e" (Green, Mark 2006). At Jackson Street the edging is Buffalo grass. Green indicated that by "minimizing the variety of plants" or keeping the number species to three to five (rather than a true prairie which has much higher number of species), then a more pleasing aesthetic appeal is achieved (Green, Mark 2006

Jackson Street project did cost more than if it wad done without the bioretention cells; however, more runoff would have been sent downstream, likely exacerbating flooding and decreasing water quality. Green remarked "Anytime a natural solution becomes an add… [there is] additional cost. **In the decision matrix, as bare minimum you should look at the natural solution and if it works go that route, because you're going to save money**. If it doesn't fit and you try to make it fit you're going to add cost to the project." (Green, Mark 2006). If there had been a common vision of the project from the beginning between WPC, city engineers and Bartlett and West, the costs would have been decreased.

Another lesson learned concerns communication. WPC could have **improved communication with the public and politicians if they emphasized the fact that creating (building and growing) ecological systems take time**. Green indicated that we as Americans can be impatient and that prairie systems take time (difficult for impatient people) (Green, personal comm., 2006).

It is important to educate politicians and the public about the processes and time involved in building a prairie based bioretention and stormwater management system. By so doing people will have a better understanding of the Topeka ecoregion. An engaging sculpture (with educational signs) is one additional method of education for those who are walking down Jackson Street. Another suggestion is to publish a series of articles in a local newspaper over time documenting and educating the readership about what is happening to the development of a natural prairie stormwater management system.

Summary critique-

At Jackson Street there are 14 bioretention cells varying in size. The bioretention cells differ in coverage vegetation by plant growth and planting palette (native grasses or ornamental) (see Figures 5-37 and 5-38). It would have better if there were a continuous flow of prairie grasses. The height of prairie grasses would lessen the visual impact of the drives from the pedestrian viewpoint and the overall appearance when looking down the street would be a linear prairie. More grasses need to be planted or seeded, **using a consistent palette for each cell**. The project has the potential to be a mini sea of grasses blowing and swaying in the wind, providing a strong visual statement.

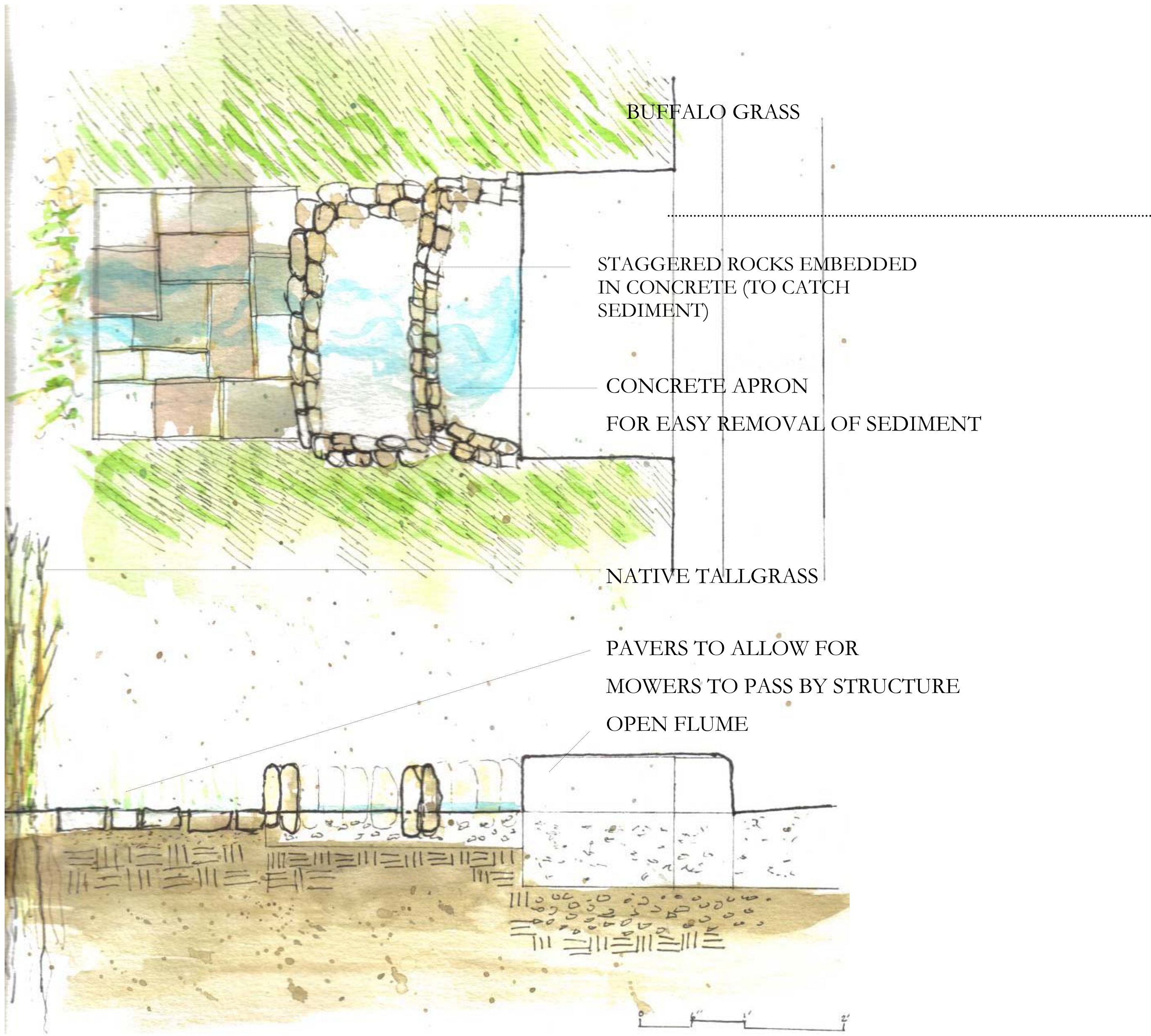
Sediment build up is common for every stormwater inlet, which is better than the sending sediment into receiving streams. Like most projects Jackson Street has a problem with sediment build up (see Figure 5-39). To slow incoming runoff flow Jackson Street open flume inlets have river rock and some have

Figures 5-37 / 5-38: Varying Plant Palettes (Author)

Switch grass planted behind the inlet. The difficulty posed by using rock is shown in Figure 5-39. It is challenging to easily remove sediments without also removing rocks, vegetation, and soils. Figure 5-40 is a sketch offering a potential solution. Runoff enters the open flume and passes over a concrete apron. The runoff then passes through a staggered rocks embed in concrete (six inches in height), which have the purpose to catch the sediment. The sediment will be easily removed (by shovel or mechanism) from the concrete apron or pavers. The pavers width matches the need of the mower width.

Figure 5-39: Sediment Buildup (Author)

Sediment Trap (Figure 5-40, Author)



As mentioned previously the use of signs at Jackson Street is minimal and easy to pass over. The signs are small. There are a few signs on each block offering educational material about stormwater, prairies, plants, and identifying plant species (see Figure 5-41). Missing is one or two prominent large signs, explaining the project, the stormwater management techniques being explored, and prairie ecosystems in retaining and infiltrating stormwater. It is recommended that the proposed signs be integrated with a sculpture. A sculpture has the ability to call attention to the place, represent the significance of the project, and educate through signs and symbolism.

Figure 5-41: Jackson Street Signage (Author)

Chapter 6: Conclusions and

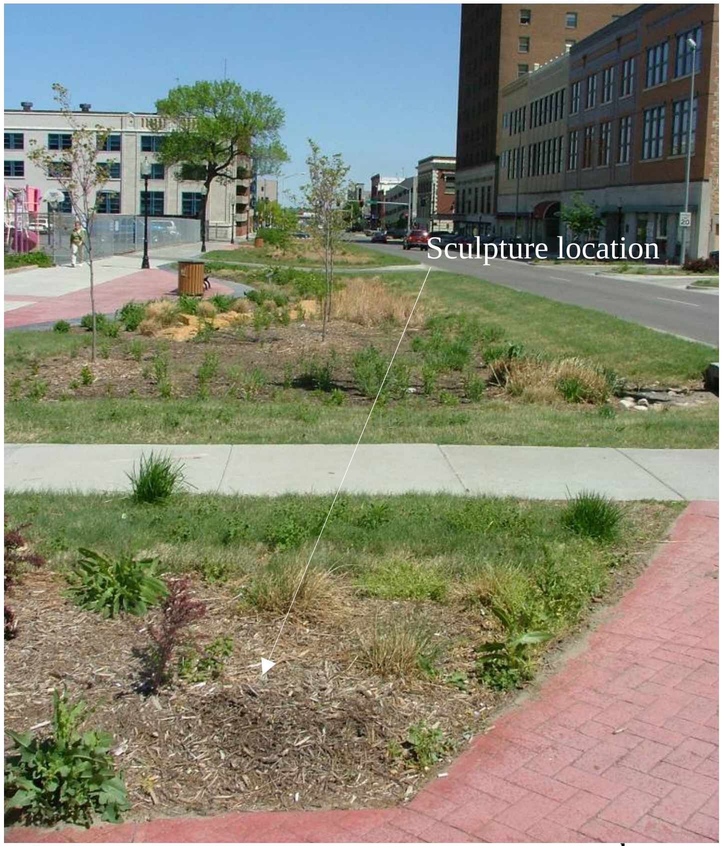


Figure 5-42: Proposed Sculpture Location (8th street and Jackson Street (Author)

Recommendations for Further Research

Conclusions-

The City of Topeka Water Pollution Control agency and staff should be applauded for their contributions in making a difference in stormwater management. Doing work in an alternative ecological way is more difficult than following the conventional end-of-pipe method. The conclusions to be discussed include:

- Community Vision
- Increase the Understanding of LID Economics
- Techniques used by WPC need further exploration and implementation by WPC and other stormwater agencies from.

Vision-

The City of Topeka needs to develop a city wide sustainability vision and plan. Plan should be supported by policies, ordinances, and training for employees. In order for the city vision and plan to be successful planners, designers, and engineers need to increase collaboration and communication amongst each other and politicians.

The city wide vision and plan would need to include public input, followed by public outreach to educate the public. Part of the LID program is to develop a Public Outreach Program. The steps outlined by the LID Design Strategies manual are:

1. Define public outreach objectives.
2. Identify the target audience.
3. Develop materials for those audiences.
4. Distribute outreach materials.

   (PGC-DER, 1999).

WPC has developed an outreach program. The program has included a website, brochures on the stream buffer ordinance and demonstration projects, and a press release for the Jackson Street project. The website called "Green Topeka, Moving toward a Greener Community" (http://www.greentopeka.org/ 4-23-06). The website offers information and images on WPC projects, research done in collaboration with KSU Department of Biological and Agricultural Engineering, outreach of public activities involving stormwater education, and resources to learn more. The pamphlets offer simple and essential information regarding the main WPC projects such as Stream Buffer Ordinance and Jackson Street (http://www.greentopeka.org/ 4-23-06).

At this point it is uncertain how much impact the WPC outreach program has made on key stakeholders, the general public, and common users of their projects or programs. It is recommended that further study be done to gauge the success of the WPC outreach efforts. An outreach program and institutionalizing ecological stormwater practices may be done simultaneously as part of a community-wide vision.

A search of articles from the Topeka Capital Journal (http://cjonline.com/) revealed only 2 articles discussing the WPC's Jackson Street project. Both articles discussed the city's construction plans, but both failed to mention the many benefits public regarding the new methods of treating stormwater on Jackson Street.

It is recommended that an article be written from WPC (or someone else) and published in the Topeka Capital Journal to better inform the public regard the LID or ecological stormwater practices used on Jackson Street. If the general public had a better understanding the Jackson Street project and how it is intended to increase the health and water quality of their streams, it is more likely they would appreciate it.

Increase the Understanding of LID Economics-

Professionals using LID techniques and ecological practices need to improve their understanding of the costs of LID and how to use this as a selling point.

Keith Warta from Bartlett and West noted that the biggest issue with Jackson Street was the cost. "The main lesson learned on this project relates to cost. I believe it is cost prohibitive to construct bioretention on these types of projects (of) highly urbanized, older parts of town with many underground utilities. Constructing bioretention in this type of environment is much different than a suburban subdivision" (Warta, personal comm., 2006).

As mentioned in Chapter 2, LID stormwater strategies can save money when conventional stormwater pipe infrastructure is replaced with LID techniques. In the case of Jackson Street it had both conventional infrastructure and LID techniques (such as beehive inlets and under drains). In order for LID to have broad use and success two major objectives much be achieved. The **first objective is that LID structures or ecological stormwater techniques must be proven in an urban setting without added conventional stormwater infrastructure**.

Once ecological stormwater techniques in an urban setting using prairie grasses (without storm pipes) have been tested and proven successful, it will have greater weight in convincing politicians to modify policies. Economics are a major factor in decision making for government agencies and developers. More research on LID cost savings needs to be done in terms of actual projects built and future projects.

The **second objective is to share the ecological and financial benefits with all concerned parties**. The sharing of knowledge could be done through professional publications, workshops, conferences, and the public outreach program mentioned previously. By combing economics and ecology the ability to persuade law makers will be increased.

Further Exploration and Advancement of LID Techniques Used by WPC-

The new LID adaptation or techniques used by WPC for Hillcrest mainly included using deep rooted prairie grasses down the center of the bioretention (switch grass) and the modified curb cut. Techniques adapted and developed for Jackson Street project include further expansion of deep rooted prairie grasses, no underdrain and use of beehive inlet, non sandy soils, and open flumes sending runoff into bioretention areas. These techniques are significantly different approaches to LID and as of spring 2006 it appears that the techniques are working well. Major differences include use of prairie grasses, which often prefer a period dryness rather constantly standing in water or top soil being constantly saturated. Along these same lines Green and WPC are stating that for the central plains region it is better for the deep rooted prairie grasses to hold and slowly release the infiltrated stormwater, rather than a fast infiltration and percolation through sandy soils to an underdrain. This significant difference requires further use and studies.

Recommendations for Further Research

From this thesis comes numerous ways to advance LID and the use of ecological stormwater techniques. Listed below are considered by the author to be the most prevailing.

- **Research in changing acceptable or preferred landscapes**
- **Scientific research in testing the full capacity of the LID techniques used on Jackson Street**
- **An LID manual for Topeka**

Changing acceptable or preferred landscapes-

The public has developed a certain paradigm of what the urban landscape should look like. Are there any communities or cities that changed what was perceivable aesthetically pleasing and if so how? Today's built landscape is often monotonous and boring; it usually entails manicured turf grass and pruned ornamental shrubs and trees.

Green's experience regarding public opinion is "in the urban settings you expect to see sidewalk three feet from back of curb, grass in between the two, and all of it maintained and clean. We have this real pristine [image] of the urban corridor in our minds. In Kansas and Missouri we have taken that paradigm and applied to our own backyards. At one point in time backyards used to be shade trees and picnic spots and still had drainage patterns. We're unhappy with that and we have concrete channels in our backyards. We've given people a way to keep their front yard manicured and now we're letting them do it in their backyard. So every place around their house is sterile. That's the paradigm they like and I don't understand why they like it. We have had conversations with homeowners about trickle channels and concrete flumes in their backyards and trying to explain about doing something different" and they are often upset (Green, personal comm., 2006).

It is debatable whether the current public view of the built landscape is a learned preference over generations or it is human nature to desire a manicured landscape (by a larger population). It is the author's opinion that by bringing the native landscape into the urban setting will enrich the aesthetics and further the relationship between the built landscape and the ecoregional context.

Many cities such as Portland, Seattle, and cities in Minnesota have programmed stormwater management into the mainstream landscaping. It is recommended that further investigation be done to see how residents of these communities have responded the shift in landscape.

Scientific research in testing the full capacity of the LID techniques used on Jackson Street-

As mentioned in this chapter the LID techniques used on Jackson Street differ from techniques used in the mid-Atlantic region. Currently Jackson Street and other LID stormwater structures send a significant portion of runoff to a stormwater drain system. The drainage areas per cell on Jackson Street are minimal being from the road crown to the edge of sidewalk (approximately 40-50 feet depending on cell), with have of that being inside the cell. Prairie grass stormwater infiltration systems take time to develop and mature. It is expected that upon maturation of these systems that the infiltration and percolation capacities will be very high. It would be ideal to build similar projects to Jackson Street with great drainage areas and upon maturation of the prairie system test the bioretention cells to understand the full capacity infiltration and percolation for mature deep rooted prairie grasses.

An LID manual for Topeka-

Cities such as Seattle have developed a detailed LID manual specific to their ecoregion, which is a great resource to planners and designers. The LID manual for Seattle is comprehensive and detail. It helps professionals understand techniques for achieving water quality and building LID structures. It also helps people understand local ordinances (http://www.psat.wa.gov/Publications/LID_tech_manual05/LID_manual2005.pdf, viewed 5-29-06). It is recommended that WPC or a partner organization develop an LID manual specific for Topeka. It could help professionals understand the best LID techniques for the reason, how to achieve water quality, and offer technical help in designing and building LID structures.

Following more LID experience, such a manual for Topeka or the Central Plains regions would be invaluable.

Summary-

Achieving water quality according to the Clean Water Act is essential for the health of the nation's streams, rivers, lakes, and groundwater. Stormwater runoff is a major contributor in polluting streams, especially in urban areas. LID techniques such as bioretention cells, bioretention swales, filters, gravel infiltration trenches, green roofs, and others can greatly reduce the negative impacts of stormwater runoff.

It is important for professional involved in planning and designing stormwater systems (no matter the scale) understand the basic factors of their ecoregion. These factors include geology, soils, plant associations, and climate. Deep rooted tallgrass prairies are native to the central plains region and Topeka. These deep rooted prairie grasses have an amazing ability to infiltrate, percolate, store, and covey stormwater. These practices have been employed by WPC in projects such as Hillcrest and Jackson Street.

It is important to note that the Jackson Street project is effective overall in function and pleasing aesthetics. The bioretention cells are functioning properly by infiltrating and conveying stormwater. Many of the cells have a strong aesthetic appeal and had a real sense of place to downtown Topeka and the Capital area. By using native prairie grasses the Jackson Street project has strong functional and symbolic relationship with its ecoregion and historical landscape.

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Appendix A - Literature Matrix

LITERATURE MATRIX: STORM WATER MANAGEMENT	INFORMATION ANALYSIS: FIND BEST RESOURCES FOR TREATING AND INFILTRATING STORM WATER ONSITE	JAKE YOUNG, MLA FALL 2005 LAR 700 PROFESSOR R. FORYSTH	Academics						Practicing Professionals		Journals & Articles		
			Rick Forsyth, Professor	Lee Skabelund, Professor	Eric Bernard, Professor	Tim Keane, Professor	Dennis Day, Professor/ Contractor	Stacy Hutchinson, Professor Bio/ Ag Engineering	Laura Turnbull, Lenexa City Watershed Manager	Mark Green, Topeka Superintendent of Water Pollution Control	Landscape Architecture Magazine	Kansas City Mid-America Regional Council (MARC)	Storm Water Journal
Book Title	Author	Publication Date											
Environmental Land Use Planning & Management	John Randolph	2004			X								
Sustainable Landscape Construction	J. William Thompson/ Kim Sorvig	2000		X									
Site Planning and Design Handbook	Thomas H. Russ	2002			X								
Site Engineering for Landscape Architects	Steven Strom/ Kurt Nathan/ Jake Woland	Fourth Edition, 2004			X		X						
Introduction To Stormwater Management/ Stormwater Infiltration/ Porous Pavements/ On-Site Stormwater Management: Applications for Landscape and Engineering	Bruce Ferguson		X				X						
Design for Human Ecosystems: Landscape, Landuse, and Natural Resources, Regnerative Design for Sustainable Development	John Tillman Lyle	Island Press, October 1999, John Wiley & Sons Inc., Oct 1996				X							
Ecologcial Engineering and Ecosystem Restoration, Wetlands 3rd edtion	William J. Mitsch & Sven Erik Jorgenson/ William J. Mitsch & James G. Gosselink	John Wiley & Sons September 2003/ John Wiley & Sons Inc July 2000						X					

Environmental Hydrology 2nd Edition	Andy D. Ward, Stanely Trimble	2004						X					
Nature of Design: Ecology, Culture, and Human Intention	David Orr	Oxford Univ. Press Sept 2004											
Low Impact Development Design Strategies	Prince George County, Maryland	Jun-99		X		X			X	X			
Best Management Practices (BMP) Manual	Mid-America Regional Council & American Public Works Associates	Mid-America Regional Council & American Public Works Associates, September 2003, http://www.kcapwa.net/docs/specs/APWA5600BMP.pdf							X			X	
2000 Maryland Stormwater Design Manual, Volume I	Maryland Department of Environment											X	
Division V Section 5600 Storm Drainage Systems & Facilities (Construction & Material Specifications)	Kansas City Metropolitan Chapter/ Amercian Public Works Association	November 19th, 2003							X			X	
Oklahoma's Nonpoint Source Management Program	OSU	http://www.okcc.state.ok.us/Publications/WQ_NPS_Management_Plan.pdf						X					
Stormwater Management Manual, Revision # 2	Environmental Services, City of Portland, Clean River Works	Sep-02									X		
The Stormwater Manager's Resource		www.stormwatercenter.net										X	X
Storm Water Journal		http://www.stormh2o.com/sw.html		X			X						X
Water Environment Federation		http://www.wef.org/Home						X					
Landscape Architecture Magazine			X										X

Appendix B - Personal Communications with Professionals

Personal communications

1. **Mark Green, P.E. former superintendent of City of Topeka Water Pollution Control**
2. **Keith Warta, P.E. Civil Engineer for Bartlett and West, Topeka, KS**
3. **Brett Blackburn, nurseryman and City of Topeka city council member**
4. **Sylvia Michaelis, ASLA, watershed planner and landscape designer, City of Topeka Water Pollution Control**
5. **Patricia Ogle, Stormwater Quality Technician, City of Lawrence, Public Works**

1. Mark Green, P.E.

Quotes from Mark Green during personal communication Tuesday April 4th, 2006.

Mark Green: There is what has been determined to be an accepted a paradigm or standard of what people accept. Depending on where you're at that could be different. If you live in a rural area you expect open channels, seeing native grass, and brome rolled up at the end of the summer.

In the urban settings you expect to see side walk three feet from back of curb, grass in between the two, and all of the maintained and clean We have this real pristine thought of the urban corridor in our mind. In Kansas and Missouri we have taken that paradigm and applied to our backyards. At one point in time backyards used to be shade trees and picnic spots and still had drainage patterns. We're unhappy with that and we have concrete channels in our backyards. We've given people a way to keep their front yard manicured and now we're letting them do it in their backyard. So every place around their house is sterile. That's the paradigm they like and I don't understand why they like it. We have had conversations with home owners about trickle channels and concrete flumes in their backyards and trying to explain about doing something different and they're up in arms. So that's where the politically effort comes in because they're responding to their constituents.

When you look at from an engineering standpoint, who really decides on what to do. Most of the time it's the civil engineering community. Then you have to look at the civil engineering background and where are the decisions coming from. I would say Kansas and Missouri are perfect examples of folks that deal with drainage and watersheds and those types of designs are civil engineers with a transportation background that have learned how to calculate flow for culvert sizing and bridging sizing. The have had no exposure to natural processes, plant communities, and nothing else. The movement (of ecological approaches to stormwater) are folks like myself that have a background in wastewater and water in environment and really have focused more on the watershed and hydrology. There are very few programs out there doing that. I think that universities are still struggling with what type of professional person to stand and say this is the right thing to do. Folks listen to me because I'm an engineer, but they call me grassing hugging engineer, green engineer, and soft engineer. I'm a naval academy graduate and I'm probably as hard conservative as you can be, but somehow because I understand how these things work and its better for us. So that's what you're battling, not only the paradigms of the public and politicians, but their professional advisors are against it too. The professional engineering community is not willing to learn enough about it to make a switch. One of the things that frustrated me this last year or so was not the effort that I was allowed to do, but the fact that what we were doing was not becoming institutionalized. As soon as I leave grass gets mowed down to the nub and in an area we said we would burn this year. Because of somebody's paradigm that we have tall weeds standing on a main street. Without a recognition that little bluestem in an auburn color is pretty attractive, but I love it. Now we've taken something and made it un attractive in my mind. That's where aesthetics come into play and how you attack that I don't know. We have learned a lot of lessons in how to make the natural (plant) communities more accepting of the public, by putting in edging. By making sure there is a clear and defined edge. So it looks like its meant to be and not a hodge podge. By minimizing the variety of plants. Less diverse of species depending on the size (of space). Obviously if you're looking at restoring a prairie system next to a stream on ten acres and parkland, a typical tallgrass or short grass prairie will be perfect. But if you're looking at a project like Jackson Street, City of Lenexa has talked to me about is when you put a 1000 plants or varieties, it looks terrible. You have to focus on those 5-7 or 9 varieties. Makes it look like its meant to be. Then you get the purist idea and they're on other extreme thinking seeds that come off tires ought to be in there and this ought to be a complete diverse prairie (6:00). From my perspective I am pretty simple about, I believe as a good civil engineer that looks at watershed design and stormwater infrastructure that we have to look at the natural solution as part of our decision matrix. That its not an add on, that its not a beautification, its part of your flow chart. You need to apply it where it works. Where it works you should apply it because its more sustainable and it looks better. It should look better. That's where landscape architects come in.

The problem is we have engineering design manuals. For instance a good one is. Most engineering manuals will say you cannot use vegetation and open channels that have a flow higher than 5 cubic feet per second. That's a hard standard to meet. The reason they say that is. If you take a channel that has a greater flow than that and you seed it, its not going to make it Its not going to make it, its going to undercut and rush out. What we have found is, if you take that centerline of channel and plug switch grass and actual plugs of grass every foot on center. Those do fine. Its not a matter of should it be an open channel or not. It's a matter of when its above this, here is how you implement the natural stand point. The here's how you do it part, isn't in a text book. That's not the guideline. What it says is that above 5 cfs you armor the channel and armoring is rip rap or concrete. If you go to Iowa or Minnesota they're doing it up there and they have just as bad of run off as we do, if not worse. Some that is through seeding and scale.

The change in rural character is so fast that what is accepted in a rural standpoint and suburban standpoint is so vastly different . The way we have allowed growth to go on. When people move into the country they convert everything to mowed lawn. People move out to the country because they enjoy the country, but then they want to make it look like the city.

Jake: Have your neighbors complained to you at all?

No, there has been no discussion. We've bordered all our roads.

Jake: I looked over all the stormwater project and decided there is only a handful in the area. I decided on Hillcrest and Jackson Street as case studies. I have two main case studies to dive more into the details and understand better the projects. The design, the construction, the maintenance, and also approval process and how the project came to be, mainly Jackson Street. I think Jackson Street is a really good project and seems to be functioning and aesthetically well. From the landscape architecture point of view I think its looking really good. I would like to learn more about that project. If you could explain a little about the background of Jackson Street. What point was the project at when you came aboard and how did you determine the decisions you made? How did you move forward on the politically process?

Mark: All those very tough questions. That's the project that almost cost my job. Because of a change in administration. But to back up a little bit. When I got involved I was managing both the waste water and stormwater utilities. Jackson Street had an undersized storm sewer that was flooding downtown. There was a project to upsize that sewer. I had just got my masters in hydrology and studied watersheds, but had not had the chance to bring it all together. I had looked at work done by Applied Ecological Services, Grays Crossing (Illinois). Native landscaping and developments. I had seen some things out of Seattle. I realized that we had this project on Jackson Street. Unfortunately it was at about 95% design for the storm sewer. It was a three lane highway. I went to the city engineer who manages the projects for us and he was very un-receptive at that point to make any changes. Did not want to talk about it. At that point we were peers, so I went to see our boss. I had a meeting with Mayor Wagner and explained you have a three lane street that runs downtown. Its ugly and the sidewalks are dilapidated. I think we can do this a different way. My vision at that time was to put an open channel system down Jackson Street and no storm sewer. It would have worked and it was being bought into at that time. Then we had a change in administration. After we had already done a charrette on the project to see if we could do it another way and I knew we could. I have an engineering firm in town telling me looking a cross section of 72" pipe and telling me that's bigger than a cross section of a 10' wide with a 3' bottom open channel. No way. The amount of water that I could hold was much greater than was their discussion about. When the change happened in (administration) it supported more the city engineer than my philosophy on Jackson Street. The middle or medium approach was why don't we allow some cell development in that abandoned lane to occur. And that can treat some of that overflow and that's why we ended up with a series of bioretention cells on Jackson Street.

Unfortunately it cost the project more than it should have. The natural solution had it been looked at first would have been much less than the storm sewer. But the storm sewer still had to happen so the cells were to treat the smaller rain events.

Jake: If you had used an open channel system would you have had to used an sewer system for stormwater.

Mark: No, it would have be fine. It would have taken all the water from higher in the watershed and moved it through there. We had modeled that in a charrette process and come up with a cross section.

So that added cost (adding the retention cells and storm sewer). It became an add on. Anytime a natural solution becomes an add on. That's where the rubber meets the road because that's an additional cost. In the decision matrix as bare minimum you should look at the natural solution and if it works go that route because you're going to save money. If it doesn't fit and you try to make it fit you're going to add cost to the project. The regulations right now do not require us to do those kinds of things. They require us to do more education and standards. Its not a hard line or fact as to what municipalities or EPA is requiring people to do. Without that Hitch, being able to go in front of politicians and say I am required to do this by law. They think you're just adding cost to the project. And they may not care for the editions anyways. Mayor Wagner said if you can make Jackson Street look better go ahead, I'm all for it. Which at that time overturned the city engineers and it got reversed a year later.

The other thing I learned on that projects was: My experience has been Americans and we as people are very impatient and prairie systems are not a very good system to use for impatient people. So we end up doing plugs and plants and try to make an impact right away. And that's unfortunate it. If I had to do it over again, I may do it differently. We used buffalo grass sod for the edge and sites that we used drill buffalo grass that turned out just as nice and just as good as coverage with the right maintenance by the end of the year. If you always go with the lowest cost solution that's always going to be your best solution. Nurseries don't like it because they don't make as much money on seed. Because they don't make, because they don't sell it. From a maintenance and longevity stand point I think its going to work out better. I think if we would have plugged the centerline channels where the flow came through and seeded the rest and put it on an every month mowing session for the three months those first couple years and then by the third year when the prairie was really firm come back and burn it. Then the public would think you guys just have a natural system in the middle and are mowing your cells like good public stewards.

The problem with the plugs is while you wait for the plants to spread out the weed infiltration is a maintenance nightmare. At some point you have to say this going to be long and this is going to be short. Right now we have a couple politicians who aren't willing to live with it, which is why we saw it weed whacked last week.

I've had buffalo grass at my house for four years. On Jackson it did a lot better last year with the sod. The problem is that there is a not a lot of experience in getting this stuff established. The farmers are pretty good using NRCS because they CRP planting and CRP requires native grass. So you have native grass grow. They're tall grass, but not prairies. They use 40/60 percent split to get cover. Future CRP practices will have demonstration outside the city. You don't want to be in the regulations or the public side, telling the private home owners what to do. You would rather lead by example. So that's why we try to do so much on our projects to show them what its going to look like.

Jake: How would you explain the approval process for Jackson Street? With everything that was against you and how did you get approved.

Mark: Ours is a bad example to follow. Because it really became personality driven. I had an administration that was backing. The administration changed, turned to an administration that wasn't backing it and we ended up with what was a compromise situation. I saw it as an opportunity, but the other person (city civil engineer) saw it as a design that was about to bid for construction. In their mind they are thinking, we spent a year design this and you're going to stop it. When I do presentations now I explain that some of the right people to talk with and where the budgets are att. The right time to get plugged into the planning process is not projects that are about to get done this year or even 2007. You really want to look at those ideas, three years from now we're doing this street or 2010 we have Riverside park planned. That's the time to go in and say what do you have planned for the park. That's when to start plugging into that design these kinds of features into the design. A much more pro-active than reactive way to deal with the situation. My personality is that I'm a bulldozer. I saw an opportunity and got backing from the mayor. I never thought a year from now the Mayor is going to loose her job and we're stuck with somebody else and a lot of ramifications. That was my first public service job out of Florida from the Navy. I didn't realize that part of my job here was to please consultants, I thought they were supposed to please me. A lot of politics in the background.

The other thing is to recognize in your area what is the acceptance. Its fun here because there is so much opportunity, because nothing is getting done. You may go to Oregon and I may be considered a real conservative, land person. Here I am a radical. Its just different context. If you go to

Boulder, Colorado it may be entirely different there where everyone wants something like that. They're wondering why aren't you coming up to speed. Kansas and Missouri give you an opportunity to try, but they also give you some challenges.

The other thing is the level of understanding by the firms. I would still say here locally we do not have any firms who have bought into this process, zero. They have done (ecological work) based on what I asked them to do, but that was it. We are still in the demonstration and education phase.

Jake: Would you say those firms are architecture, design, and engineering or just engineering?

Mark: Pretty much in Topeka it's primarily the Engineering firms. Even some of the big firms out of Kansas City. A little more accepting over there because there are some national firms serving clients in other locations. These localized firms are having a hard time. Its not profitable for them, its much more profitable to pull off canned sheet off a shelf, stamp it, and call it a subdivision. Then it is to come up with new thought.

Communities without vision including: Manhattan, Topeka, and Lawrence to some degree are moving along without a lot of vision and thought process for the future. That would help. When we got the stream buffers ordinance passed. We actually took a public survey that asked folks if they are concerned about water quality, do they want us to preserve wildlife habitat, do they think it's a public responsibility. We got an overwhelming 80-90% percent very important, very important results. When we presented this to the city council, we didn't say this is because its a water quality issue. It was in response to a public survey that we had taken and here are all things it will do for us. So I received a 9 to 0 vote that night. They're not going to vote against 90% of the public. We don't do enough of that.

Note to self: This is a good example of how to approach a city wide stormwater management plan. Educate the public, do a survey, and take the results to the city.

One outstanding example when it comes to the capital planning and approval process is Austin, TX. They have a checklist that they go by on capital projects that talks about sustainability, use of material, and open space. They have a grading criteria and they grade their projects. They have to achieve a minimum score. On public and private projects they have to have a minimum score. That's a real model.

Chattanooga, Tennessee is another one which has gone through a visioning process. With out those goals and visions written down it will not happen. Lenexa is the closest one, with the water to recreation where they got the community involved. Sylvia and I went to a meeting in Overland Park where they are looking at design standards on stormwater issues. Part of their review committee includes a city council person and county commissioner. It was a lunch meeting and I said you guys are way ahead of us. You're sitting a table with two politicians. They think Topeka has done so many things, but I said its not an institution. Its basically one person driven and without that one person there its probably going to falter and not be important any more.

Jake: Are there any major challenges or lessons learned from Jackson Street that we haven't discussed?

Mark: The intensive maintenance and implementation. It would be better to up front with people right away and say this is what it is going to look like. We're not going to mow the center, we're going to grow buffalo grass and this is what it is going to look like. The problem is that when streets get torn up for a year. People want to see a tree and see it right away. Its hard to explain that some of that may take some time.

To break up the flow coming off, we designed an open flume inlet. That was good. We worked with a local concrete company to design that. The public works director didn't want curb cut. That's a nice model because it works well for plow trucks and snow addresses that. The Maryland manuals recommend curb cuts, but they do not look as clean. They don't give you that paradigm of a nice street.

Maybe we should have a used a different type of vegetation in front of the inlets. I'm a big switch grass lover. The choices we used didn't do well from an aesthetic view point, but they did great functionally. We put switch grass right at the back of the flumes to break up flow. Pretty big plants that we took out of a native plants nursery of ours and that worked great. From a design stand point you got to consider the velocity coming off the street and handle that. It doesn't bother me, but I know people don't like the aesthetics of that. It does a great job though.

We incorporated obviously with the pedestrian feel. One of the selling points was, that by doing an open channel type system it really divides the pedestrian corridor from the vehicle corridor. We have seen an increase of people using Jackson Street, from a pedestrian stand point. So people must find it a pleasant place to walk.

If I had to do it over again rather doing 14 cells into native vegetation, more we should have done more (traditional). We had a focus that if a visitor came to the capital to meet with the Senator or congressmen came for a session he or she could go down Jackson Street and see what native grass looks like. Maybe it didn't have to be important for all the cells. Maybe there good have been some traditional landscape in some of the cells and the others would have been true demonstration projects. That could have stood out. We did end up putting in some traditional landscape plants.

The problem with natives is that when the rest of the city is waking up in the spring and the red buds are starting to show. Jackson Street looked dead, a month later it still looked dead because native grass is dormant for a while. Some of the wildflowers and forbs show, but most are still dormant. It would have been nice to be a little more strategic about that (using early bloomers to schedule show). For our plants we used a couple students and Barlett and West had a landscape architect that probably wasn't very good. We didn't get a lot of up front design discussion about that. If you're going to do something in that dense of area (urban setting) think about spring wake up.

Jake: I did notice driving here that Konza is just barely starting to turn green.

Mark: If it's a prairie system and the wind is blowing that's fine. We put in two or three red bud trees at Eighth and Jackson Street. We're hoping as you turn the corner that should open your eyes a little bit.

Jake: If its okay I would like to talk a little bit about Hillcrest. Originally it was one parking and then you decided we don't need that much parking?

Mark: Actually it was just another opportunity. I was looking for a place to do a public demonstration of a bioretention and I heard at a public works meeting that they were getting ready to redo the paving at Hillcrest. When I went out at looked at it, it looked a like big parking lot. So I talked to the Parks and Recreation Director. They had a desire to make it look nicer and I had a desire to do this, so that was the partnership. We learned a lot from that project.

Jake: What did you learn?

Mark: I learned that the limited amount of design information out there can be flawed. Tom Schuler out of the Center for Watershed Protection he has Design of Stormwater Filtering Systems. In there is a couple of flaws. I have had a talk with the guys in Wisconsin because unfortunately they have adopted this as their standard. Their curb cuts are not very attractive, we did put that in at Hillcrest. The reason these are flawed is when they talk about plant material or plants that like to get their feet wet, but they have engineered a system that doesn't allow the water to stay in there. We followed this system. We planted the plants, trees, and soded it. Basically all the trees and shrubs died. They didn't survive because their wasn't any water. We didn't do a lot of supplemental water, which probably impacted it to a degree. That was probably the biggest lesson learned.

We have gone back and put Switch grass down the middle. That is going to survive, it will find water. It lives in dry places. That's done fine. The fescue sod has done okay. That's another situation where you have a curb line. Buffalo probably would have been better than fescue as a choice, but I wasn't familiar with Buffalo grass at that time. It probably would have been a better choice for the edge. One thing you have to remember about Buffalo is that you can't use Buffalo grass for an edge unless you have a an edge around the Buffalo grass. The Buffalo grass burns right along with the prairie, even though its mowed. Jackson and Hillcrest are not a concern because they have a curb. Use Buffalo as an edge to your prairie, its nice and will be great, but have a curb. Its not a firewall.

Jake: When I was there a month ago we opened up the cap and looked down to see some flow, which was before the recent rains. That was good that it had that continual flow. When we looked down the manhole by the park there were leaves inside and I don't understand how they got there.

Mark: The probably get blown up there.

Jake: At Hillcrest how come one side of the parking lot drains to the swale/ bioretention and the other side drains to the infiltration trench. How it all doesn't drain to the bioretention?

Mark: Because of the slope and they didn't want to redo that side of the parking lot (grading). When I designed it I looked at the overall rain that came in and did it for the ten year storm. That also assumed the entire parking lot, so that's a conservative design. Really only half the parking lot can reach it, plus the hillside. The rest of the parking lot goes down (continual slope towards the park). Next to the parking lot it was causing some pretty good erosion into the park. We went ahead and did a French drain system here, pretty deep. It starts off three feet and goes down to five feet. Both of them discharge into a common man hole. That's just a French drain to collect the water and stop the erosion.

Jake: You have the perforated pipe at the base at hillcrest?

Mark: Yes. We filter fabric wrapped it. Its not the typical black drain tile, I used the perforated pipe, that just has the bottom perforations. It's a solid pipe with holes, like pvc schedule 40. It's a hard pipe, so its not the flexible plastic drain tile.

Jake: How does the water get into it?

Mark: Its open on the bottom and the water rises up into the pipe and goes out. You cap that with filter fabric and then you have the gravel, so that the gravel always stays clean. It's a very good draining system, not very good for plants. My philosophy on this stuff now is to do it more like Jackson Street. I am not a real big proponent of what they designed as a bioretention system. I would rather see no under drain, I don't know why you would want an under drain system. I would rather look at a bioretention or what you would call have a beehive inlet, that directly goes to some major system or some open channel.

Jake: That's the overflow?

Mark: Yes. Then maybe you also have an emergency overflow. More than likely that would be enough, depending on the size of the rain event. What I like about that is, that overtime as your plants mature your percolation rates increase in your soil. It allows to put the inlet at base elevation when you first build the site. So every rain event gets a little bit that goes in there. After a year or two when the plants start to mature and get good percolation rates go ahead and raise that up six inches. It gives you that opportunity to allow more ponding (and infiltration). Then you gage it based on how long you have standing water and the height of your inlet. I believe based on what we have seen at Hillcrest and other places is these things are supposed to accommodate 1/2" to 1" stormwater event, but over time they will be able to handle a 5 year rain storm. The effects of these things down stream are huge. We had a huge rain storm in Oakland, when you stepped out of the car the water was over the curb and the water would come up to your knees in water. We ran out to Hillcrest. We had about 5" inches in thirty minutes. A 10 year event in thirty minutes. Easily a 100 year storm. I have a 6" pipe that leaves Hillcrest, it was flowing half full and there was hardly any standing water in the system. Two weeks later water was still percolating out of that system. Incredible what it can do.

There is only so much water that can stay in a soil. Whether you have a drain system or an overflow system, once those voids get saturated, they are saturated. So its either draining off or its not. The difference in the draining system, is now you are still draining overtime. But if you didn't drain it you would have evapotranspiration working for you. You would probably have some fairly healthy plant communities after a while. If you think of the right plant palette.

Jake: Any idea when that storm event was?

Mark: Probably July three for four years ago.

Jake: At Hillcrest were the rocks at the curb cuts part of the original design?

Mark: I just put some large limestone tailings in there to break up the flow. The design showed peat gravel, but if that was there it would just be dumping that into your basin.

Jake: What kind of amendments did you do to the soil (Hillcrest):

Mark: We dug down about 5 feet and we used the bio solids at the plant. We mixed in coarse sand, which made for a well drained soil. Almost a golf coarse green. We backed off of that. The bio solids itself is kind of hot for a while. We started doing a little more wood chips. 1 part bio solids, 2 parts would chips, 1 part sand and 1 part top soil. I have been working with Stacy. They were doing tests at our house to see the percolation differences between insitu soils over time versus these amended soils. When you get the kind growth out of these major systems that you get. I just have to think are you really getting that much out of amending the soil? If you just went with an insitu you wouldn't have these issues, with different plant communities

Jake: On Jackson Street what did you do with the soils?

Mark: It was the same thing. The unfortunate thing with Jackson is they put the soils in the fall and then they compacted them all winter long when they were finishing the project. One of the guys put in a bare root with the auger. The soils were so compact that it broke the shear pin on the auger and chipped a tooth. So one recommendation would be to have requirements for protecting soil compaction.

The thing about stormwater design that folks don't understand is when you size a development you are looking at a ten year storm to size your pipes. They're making an assumption of mature vegetation for the lot plots. You're not getting ten year coverage from day one, it may take you twenty. By the time the soil is un-compacted from the routine mowing and construction compaction. That's why I think that these kind of systems are little more forgiving. These systems go the other way. You design them for a ½ - 1" rainstorm and twenty years later they are handling a five year or ten year rain storm.

Jake: Design for less and get more. Was Jackson Street designed for a ten year storm?

Mark: Yes. The storm sewer was designed for a ten year storm and fifty year in the curb line. There really isn't a lot to put into the cells, because only part (half) of the crown of the street gets it. It's a retrofit.

Jake: I was a disappointed in not seeing the downspouts of the buildings directed toward the bio-retention cells, because there is a lot of impervious surface.

Mark: When I asked that's when the change started happening. When the administration change happened, the Civil Engineering department was directed "this is your project". I was only to provide certain in put on certain things. I started to get out of the loop of how things would turn out. Politics at its finest.

Jake: Is there anything that you have learned, that we haven't covered. Which you could pass on?

Mark: Trying to find willing clients and places where you can do demonstrations. Some of the stuff gets over sold (the demonstration or native plants projects). The few folks who are doing it, may have a tendency to over sell it. That can be a problem about it. We have to be more realistic about it. Not every body likes native grass and we have to understand that. You have to pick where you want to do some of this stuff.

Jake: I have seen the signs at Jackson Street. Besides that, has there been any public outreach in terms of public education?

Mark: Yes. We did a press a press release when as commissioning the project, we have written letters to the business owners along there, we have offered them brochures of Jackson Street that they could use in their place of business so people could understand. There is still a need to have a sign at one of the corners, probably closest to the capital. Which would explain the project and that would be nice. Yes there has been some outreach. We have presented that project at three or four community functions. Like a sierra club meeting and neighborhood meeting. I think we have been proactive. Prior to the project I visited with all of the business owners before we started so I could get their buy in. There was some parking space issues that they would have to come to grips with.

Since it hasn't been adapted (the Jackson Street method of stormwater). There have been three brand new street projects which have happened in the last three years. And none of them have any of those attributes. That's the institution that I am talking about. It was okay on my project, but its not going to be enough to adopt that this is going to be a city standard to look at this on every project. That's the issue that Topeka will have. Lenexa will have it to if they have over sold their project. They have had people ask them to mow it.

But Jackson was a bold statement right in the middle of downtown down town. I don't know what it is going to look like in ten years. I am concerned that soon someone will say spray the whole thing and plant fescue. It could happen.

Eric: You hope that ten years down the road, everybody looks back and says this was the first.

Email
Date: Wed, 19 Apr 2006 11:18:51 -0500
From: Green Mark A Maj 190CES/CEE <Mark.Green@kstope.ang.af.mil>
To: "'jyoung1@ksu.edu'" <jyoung1@ksu.edu>
Subject: RE: Stormwater Thesis: infiltration and Jackson Street, Topeka

Hi Mark,
I have a couple more questions:
What year and month did you join the Jackson Street project?
When was the start and end of construction?
Also when was Hillcrest project started and built?
You mentioned you're a Naval Academy graduate was that in hydrology or engineering? Where was your other degree from?
Last question. Could I get a copy of the CDs or should I ask Sylvia?

Thanks again. I appreciate your help and my thesis is coming along well, Jake

Mark Green's response:

Jackson Street - original design was in 1999 (not sure month) in 2000 I spoke with Mayor Wagnon about a different approach.
Construction was in June 2003 and completed spring 2004. Planting occurred starting early summer 2004. Hillcrest was constructed July 2001.
Undergraduate Degree from USNA - BS Math
Graduate Degree University of South Carolina - ME Civil Engineering, water, wastewater, hydrology focus.

Mark

----Original Message-----
From: jyoung1@ksu.edu [mailto:jyoung1@ksu.edu]
Sent: Monday, April 24, 2006 4:56 PM
To: Green Mark A Maj 190CES/CEE
Subject: Hillcrest plants and bioretention

Hi Mark,

My thesis is coming along well. I have learned a lot from the various people involved with the Topeka stormwater projects and I've been to the sites a few more times.

I have two more questions.
1. I downloaded the Design of Stormwater Filtering Systems from CWP, by Schuler. What page is the standard on, that you used to help design the first bio-retention for Hillcrest (from Maryland LID)?

2. During my visit you mentioned that all of the plants used in the first bio-retention at Hillcrest died/ failed. What were the main species which failed (either common name or botanical)?

Thank you again, I really appreciate your help. I will be done in a few weeks and will send you a copy.

adios, Jake

Response:

Date: Tue, 25 Apr 2006 07:59:48 -0500
From: Green Mark A Maj 190CES/CEE
<Mark.Green@kstope.ang.af.mil>
To: "'jyoung1@ksu.edu'" <jyoung1@ksu.edu>
Subject: RE: Hillcrest plants and bioretention

Jake - not sure if my manual is current but the section was Chapter 6, Key Design Elements of Bioretention Systems , Figure 6-1.
I also looked through my hillcrest notes - I kept my design calculations and have the construction photos but Parks and Recreation planted. I know we included river birch, swamp oak, but can't remember the shrubs.

Mark

-----Original Message-----
From: jyoung1@ksu.edu [mailto:jyoung1@ksu.edu]
Sent: Wednesday, April 26, 2006 11:50 AM
To: Green Mark A Maj 190CES/CEE
Subject: RE: Hillcrest plants and bioretention

Hi Mark,

I forgot to mention that I think the Green Topeka website is great and offers good simple explanations of past projects. I hope more people know about it and have looked at it.

The page for Hillcrest shows a picture of instillation, dated July 2001. Did the regular nursery plants die the first year? What year was switch grass planted and did you use plugs?

thank you, Jake

Response:

From: Green Mark A Maj 190CES/CEE
<Mark.Green@kstope.ang.af.mil>
To: "'jyoung1@ksu.edu'" <jyoung1@ksu.edu>
Subject: RE: Hillcrest plants and bioretention

Jake - for the most part the plant material did not make it through the first season. We had drilled native grass seed at North Topeka and dug up the switch grass plants from that field (about 1 gallon size) and transplanted the following spring/summer.

Mark

-----Original Message-----
From: jyoung1@ksu.edu [mailto:jyoung1@ksu.edu]
Sent: Thursday, April 27, 2006 3:56 PM
To: Green Mark A Maj 190CES/CEE
Subject: RE: Jackson Street

Hi Mark,

I have a few more questions.

Questions:
1. At Jackson Street how come the storm inlet at the end of each block goes to the storm sewer drain and not the bioretention cells?

2. Why is the signage "non intrusive" rather than bold and calling attention so more people passing by would stop and read?

3. Besides the Beehive Inlets and Storm Sewer Inlets, does Jackson Street also have an under drain (peforated pipe)? Is it the same as

Hillcrest?

thank you again, Jake
-----Original Message-----
Response:
Date: Mon, 1 May 2006 14:02:43 -0500
From: Green Mark A Maj 190CES/CEE
<Mark.Green@kstope.ang.af.mil>
To: "'jyoung1@ksu.edu'" <jyoung1@ksu.edu>
Subject: RE: Jackson Street

Jake - I try and respond accordingly:

1) we diverted street runoff into the inlets into the bioretention cells. The elevation at the end of the block would have tried to have water flow upstream and so did not get treated. Keep in mind this is a retrofit project. The other consideration is that the storm sewer is lower than the bottom of the basins in order to make the drainage elevations work.

2) We wanted this to be passive education rather than bold. There were plans to have an overall layout sign at the corner of Jackson and 8th which would call more attention.

3) Jackson street does not have an under drain system. This is something I learned from Hillcrest and would prefer an overflow system with adjustable ponding instead of construction of an underdrain. I have found the underdrain systems do just that - drain the water and stress the plant life. I think the use of bee hives with adjustable cones to raise the depth as plant matures will provide a better sustainable solution. Hillcrest has an underdrain system.

Hope this helps,

Mark

From: jyoung1@ksu.edu [mailto:jyoung1@ksu.edu]
Sent: Wednesday, April 12, 2006 8:55 AM
To: Keith Warta
Subject: Re: Jackson Street/ one more question

2. Personal communication with Keith Wart, P.E. Bartlett and West Engineers, Topeka, KS

Ketih,
I just thought of one simple question, which I'll need for a basic understanding. What was Bartlett and West's role in the Jackson Street project?

thanks again, Jake

Quoting Keith Warta <keith.warta@bartwest.com>:

RESPONSE:
Date: Sat, 15 Apr 2006 22:20:26 -0500
From: Keith Warta <keith.warta@bartwest.com>
To: jyoung1@ksu.edu
Subject: RE: Jackson Street/ one more question

Jake, our role was lead designer and construction administrator of the project. In other words, we were intimately involved in every aspect of the project from beginning to end. Keith

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----Original Message-----
From: jyoung1@ksu.edu [mailto:jyoung1@ksu.edu]
Sent: Wednesday, April 12, 2006 8:54 AM
To: Keith Warta
Subject: Re: Jackson Street

Hi Keith,

Email works great for me and I really do appreciate your help. My thesis has to do with adapting Low Impact Development (LID) principles and techniques to the Midwest. The main goal of LID is that the hydrology of a site for post development should equal predevelopment or the natural landpatterns. In short, water needs to infiltrate back into the ground and not conventional end of pipe.

My two case studies in Topeka are Jackson Street and Hillcrest. Mark Green mentioned that Bartlett and West Engineers offered the engineering for the structural components of Jackson Street.

My understanding is that Jackson Street, being a stormwater bioretention cell, was a new experience for Bartlett and West. Is this correct?

What were the main challenges for you and/ or Bartlett and West in working with a bioretention cell? What were the main lessons learned? How did the collaboration work with the Water Pollution Department of Topeka?

Keith thank you again and if you need a couple days to answer these questions I understand. Also please add anything essential that I should know from your point of view regarding Jackson Street and working with engineers on ecological stormwater projects that focus on infiltration.

Jake

RESPONSE:
Date: Sat, 15 Apr 2006 22:18:05 -0500
From: Keith Warta <keith.warta@bartwest.com>
To: jyoung1@ksu.edu
Subject: RE: Jackson Street

Jake, refer to responses below. Let me know if you need additional information.

1. This was our first project of this type. We partnered with Tetra Tech, a very large environmental firm, to provide expertise on certain aspects of the project.

2. The main lesson learned on this project relates to cost. I believe it is cost prohibitive to construct bioretention on these types of projects - highly urbanized, older parts of town with many underground utilities. Constructing bioretention in this type of environment is much different than a suburban subdivision, for example. Our collaboration with WPC worked great. They we very helpful during the project design and now, after construction, are providing manpower to maintain the cells.

Keith

3. Personal communication with Brett Blackburn, nurseryman and Topeka City Council member (Young in blue)

Dear Mr. Brett Blackburn,
It is my understanding that you served or do serve on the City Council of Topeka and of course operate a plant nursery. I wanted to ask you your opinion regarding the new Jackson Street project as city councilman and nurseryman.
Jackson Street was a pilot project to look at alternative methods oftreating stormwater in Topeka.
As a city council member:
-What was your overall opinion of the project and do you foresee more similar projects in Topeka?
>> Plant selection was poor and design was poor. Not a bad concept for a river bank or out of the way area, but terrible for a highly visible area.<<
-Does the project add to the aesthetics of the capital and neighborhood?
>>I believe even if they had used a proper turf grass (unlike buffalo grass which is not suitable for Topeka), I still would probably not be worth the expense and maintenance.<<
-What were the major challenges and lessons learned from Jackson Street?
>> It should have been designed by a professional in the business and not a wet behind the ears city hort specialist<<
As a professional nursery owner/ operator?
Jackson Street used some conventional nursery plants and also native grasses.
>>>With a proper design and proper plant election, it could have been more viable from the aesthetic point of view.<<<<
-What is your opinion of the plants used on Jackson Street?
>>Park grade trees were used. Plant selection could have been more mainstream and suitable for low maintenance and still look nice.<<

-Because of the plant selection Jackson Street has a different look than a traditional landscape. What is your opinion on the aesthetics of the plants on Jackson Street?
>>I think it was an Ok idea that could have worked if an experienced professional (in the nursery business, in Topeka) was given some input. I don't mean to belittle the effort of the designer, they just were not too familiar with Topeka, and the over effectiveness of the design.<<
-Anything else that I should know about Jackson Street?
>>The city does get a lot of complaints about the way it looks. Had they used more edging, fescue instead of buffalo, and a more tailored design, the concept

still could have worked and looked much better.<<
Thank you again. I really appreciate your time and know that you're busy, in fact I have called the nursery at least 5 times and you were either in the yard or out. I myself have worked in a nursery and understand how busy it is in the spring.
I'm doing a case study on Jackson Street and want to get input of various people involved in the project.
thanks again, Jake

4. Personal communication with Sylvia Michaelis, landscape designer and watershed planner WPC

Questions
Responses in orange: Kate Grover, former Environmental/ Fields Services Manager at Topeka Water Pollution Control
Responses in red: Sylvia Michaelis, ASLA, City of Topeka Water Pollution Control

Hillcrest:
Were any design/ engineering services sub-contracted out (to a firm)?

The design for Hillcrest came partially from design information available from the Center for Watershed Protection (CWP). The major difference was that the site used soil amendment due to the high clay soils. At that time, the CWP suggested that clay soils could be mixed on site to allow for better drainage. After Hillcrest the City began replacing clay soils instead of mixing them with an amendment and leaving them in place.

The Hillcrest project came about when the City decided to redo the parking lot at Hillcrest Community Center. The project was designed in-house by an engineer and had no construction documents generated for the build.

The original plant palate included river birch and other trees and shrubs. Due to the nature of the project and the extreme changes in weather, many of the plants did not survive. Species that replaced the original plant material include switch grass through the center of the channel and a river birch and purple ash tree.

Lessons learned from the project include:

- Reduce number of curb cuts
- Use open-back curb inlet design instead of curb cuts
- Use one or two species of grasses in center of channel and more tolerant tree and/or shrub species on the outer edge
- Bring ground level up to be equal with curb
- Use buffalo grass native turf instead of fescue

Jackson Street:
You mentioned that your office distributed the Green Topeka brochure to downtown businesses. What other efforts were made in an outreach to educate the public and government officials?

Other "outreach/educational" efforts include tours and the inclusion of the Jackson Street information on the Green Topeka web page as well as inclusion in many presentations. Specific educational efforts have been geared toward academia and professional organizations.

Downtown Topeka, Inc. played a huge role in rallying the downtown businesses in support of the project. Several meetings were held to discuss changes in the original design which upsized the traditional storm sewer system. Several press releases were distributed throughout the construction of the project and during the final phases.

Mark Green mentioned that in order to have continual success (with ecological and sustainable practices) it must be institutionalized?

I would suggest that institutionalization is important. But it depends on what your idea of institutionalization means. I would assume that Mr. Green is referring to the politicos buying in and supporting these types of projects. I believe that is true, but it is only a piece of what institutionalization should be. Municipal staff should do such an amazing job of working with neighborhoods and civic organizations that they never even think of doing anything else but the green solution. Even with that buy-in of the public however there will always be challenges that will make green infrastructure a constant battle. First is the fact that you have to have very good planning and timing regarding projects. Working with plants is a timing issue regarding the seasons. Second, it is of utmost importance that maintenance activities are appropriate, timely and funded. It should be said upfront that for the first couple of years these projects are going to be very time intensive regarding maintenance.

I feel it would be a huge help for us to continue these practices if we had a written statement from the City Council stating that they were committed to using sustainable practices throughout the city, specifically in the handling and treatment of stormwater and wastewater. It would be a huge step for the city and each of the various departments within it if that position was taken, but for now, we can institutionalize it internally by incorporating those thoughts into our division goals and objectives and Mission Statement.

Is this happening with Topeka City and or Water Pollution Control?

As far as happening in Topeka and at WPC I think it depends on who you ask. The main thing that WPC is trying to do now is prioritize so as to not stop providing basic storm water services to the community.

This prioritization stems from the fact that we are in the process of paying off the debt that was incurred with some of these larger stormwater projects, as well as the money that we have spent improving our infrastructure including a new Wastewater Treatment Facility and several new/improved pumpstations within the City.

What is being done now to do more sustainable practices?

WPC is focusing on finishing up the large scale projects that we have had in the works for the last couple years. This includes final planting (native prairie seeding on Belle Avenue Pond, seed and plugs in the Quinton Heights bioretention cells, and overseeding/planting on a couple other projects) and finishing up some areas that have been damaged since project completion. It is our goal to make these projects a success so that we can use them as a model for future design.

While we are performing these finishing touches, we are also focusing on studying the natural treatment processes and determining how much success we are having in that arena. It is not enough to say we think or we believe that this works, instead we must have factual data to support those claims.

We are also taking a sustainable look at every drainage correction project (dcp) that we get called out on. These are typically smaller projects that affect three or more properties in an area that we can fund a solution for. Typical answers to these flooding problems include hard solutions like piping and concrete trickle channels. We are striving to keep as much drainage on the surface using green infrastructure as we possibly can. These small efforts go a long way in the whole scheme of things.

What was the biggest challenge associated with Jackson Street and what did you learn?

The biggest challenge with Jackson Street will always be perception. When you have someone like Bret Blackburn – who owns a nursery – on the City Council who disagrees with the idea of sustainable landscapes, similar projects will be a challenge. I believe however that once the person on the street understands that the vegetation services a purpose, that it has a different season that early spring and that the plants are different but still beautiful then things will be great!

I agree with Kate in her statements about perception. The way we have been combating that is through education. The more people know about why that depressed landscaping is in place and what it's purpose is, then the more accepting they are about it. Another huge issue was maintenance. If we were to do it again, we would not only put larger plugs of plant material in place, but we would also use native seed throughout the project to help fill in the spaces between plugs and get a more even coverage. We would also use less of a variety of plant species and really group them together to get a more uniform appearance. Another plus is that the smaller variety of species, the easier it is to pick out weedy species.

It would also have been interesting if porous pavement were used in the project to see how that affected drainage. And of course, if we were to do this all over again, it would be a huge plus if we could have gone without upsizing the traditional system underneath and been able to prove that we could reduce/eliminate flooding simply by using the natural, in-line treatment process.

Jackson Street/ Design & Maintenance:

What is the basic maintenance schedule for Jackson Street?

The typical schedule is to mow the buffalo grass around the edges every two weeks in the spring/early summer and then less frequently in the hottest part of the summer. Weeding takes more time, but as the plants in the center of the cell grow and have begun to fill in, the weed population has decreased. We are now focusing our weeding efforts on the formal areas which are weeded once every two weeks and the center of the cells are left to grow with weeding of large invasive species once a month, possibly more frequently if needed.

New mulch is applied to formal areas once a year. Pruning is done once a year as needed. We also check the open-back curb inlets once a month to see if they need cleaning due to sediment build-up.

Do you think it costs more or less than if it were a traditional landscape?

I think that over time the maintenance will decrease. That is off course if WPC is allowed to manage the project appropriately without interference from the City Council.

With traditional landscaping you would still have weekly or bi-weekly mowing and weeding. The area of the bioretention system is so large that regardless of the landscaping approach, it would take a good deal of upkeep. It should be noted that weeding is more difficult in the natural, less formal areas of the cells in the beginning of the growing season due the inability to distinguish weeds from young grasses and forbs. In time, many of these weeds will be squelched by the network of native species. At this point in time, I would have to say maintenance costs are higher on the west side of Jackson Street as compared to the East side where the areas are more formal. Since the project's inception, the total maintenance has steadily decreased.

Reid C. mentioned that Jackson Street soil is all organic compost. Do you think it has been a good soil?

The soil over all has been good. It has been rather obvious however that the soil combined with the extreme environment on Jackson Street has played an important part in how well plants survive and thrive there.

Was it organic compost and mulch or all one?
I believe it was all amended soil, which simply means that we used a combination of topsoil, biosolids, and mulch to form a soil that had a much better infiltration rate than the typical clay soils that were there originally. Reid or Stacy would have more information on the soils used in the area.

I notice this week that some weeds were coming out. Do you think it was the mulch that brought in the weeds?

Weeds are a constant enigma on Jackson Street. It is tough early in the season to determine some weeds from the forbs that are beginning to sprout.

I believe that many seeds were in the mulch that was brought in, and possibly some in the sod that was originally installed, but more so, I think that the weeds come from the wind that is very heavy down the street corridor along with the stormwater that runs in from every direction. Also, the fact that most native plant material that was planted is warm-season species, cool season weeds really stick out. It is something that we have yet to get a real handle on, but we are still working on it.

My understanding is that Jackson Street was meant to burned, but policy makers decided to weed whack instead, due to upcoming St. Patrick's Day parade. Could it have been burned after or were there other political issues?

The plants were not whacked down to the nub. That said, the grasses were left long enough that they still could have been burned.

The grasses were left long, but because of the wet winter and spring that we have had, many of the plants greened up extremely quickly and burning would not have been as successful as we had hoped. We didn't have a great experience with the burns we performed on some other projects. We will still plan on burning the cells next spring or even late fall this year.

5. Patricia Ogle, Stormwater Quality Technician, City of Lawrence, Public Works

-----Original Message-----
From: jyoung1@ksu.edu [mailto:jyoung1@ksu.edu]
Sent: Wednesday, March 15, 2006 4:54 PM
To: Patricia Ogle
Subject: Low Impact Development Thesis: Question regarding Lawrence

Hi Patty,

My thesis research in the Landscape Architecture program at Kansas State deals with stormwater infiltration techniques.

As you probably know Low Impact Development goals are to mimic the hydrology of the site from pre-construction to post-construction. LID is oriented around infiltrating stormwater, maintaining existing time of concentration, and using plants to clean, store, and infiltrate water.

The LID techniques I am studying are: bio-retention cells (including rain gardens), infiltration trenches, and bio-swales. Are there any developments or built projects in Lawrence which have included the goals and techniques of LID (or close too)?

Jake

Jake Young
Master in Landscape Architecture candidate
Department of Landscape Architecture
Kansas State University
Email: jyoung1@ksu.edu
Please check out my online portfolio
http://www-personal.ksu.edu/~jyoung1/index.html

Response:

Date: Thu, 16 Mar 2006 08:18:50 -0600
From: Patricia Ogle <pogle@ci.lawrence.ks.us>
To: jyoung1@ksu.edu
Subject: RE: Low Impact Development Thesis: Question regarding Lawrence

Not that I am aware of. Builders in Lawrence have been fairly slow to accept new regulations such as required detention, let alone show some initiative for other more creative systems.

We have been promoting Rain Gardens for the past two years, but mainly on an individual homeowner basis, nothing large scale such as entire subdivision.

I believe some larger developments using alternative systems have been done in the KC area, but I don't have details. Sorry I couldn't be of more help.

Patty Ogle
Stormwater Quality Technician
City of Lawrence / Public Works
785-832-3136
785-832-3398 FAX
pogle@ci.la

Appendix C – Plant History for Jackson Street project

Native/Naturalized Kansas Plants	Developed by Sylvia Michaelis of City of Topeka Water Pollution Control (spring 2006)	
	Highlighted plants were used on Jackson Street	
Trees		
Redbud	Cercis canadensis	Highly recommended for hardiness and color. Really attractive to pedestrians. Installed in mid to upper areas.
Pawpaw	Asimina triloba	
Ohio Buckeye	Aesculus glabra	
Downy Serviceberry	Amelanchier arborea	
Persimmon	Diospyros virginiana	
Hackberry	Celtis occidentalis	
Blackhaw Viburnum	Viburnum rufidulum	
Pecan	Carya illinoensis	
Honey Locust	Gleditsia triacanthos	Highly recommended. Likes moist areas. Planted as nursery stock.
Swamp White Oak	Quercus	Highly recommended. Does well in wetter areas.
Bur Oak	Quercus macrocarpa	Highly recommended. Installed as nursery stock and as large specimen transplant. Good survivability
Sugar Maple		
Chokeberry		
Bald Cypress	Taxodium distichum	Highly recommended. Extremely hardy and tolerant. Does enjoy the wetter areas.
Sycamore		
Red Maple	Acer rubrum	Installed as nursery stock. Plant death result of poor planting technique. Otherwise, would have done well. Moderate hardiness.
American Hophornbeam		
Soapberry		
Rusty Blackhaw Viburnum		
American Linden		Moderate hardiness. Nice tree, will do fine in mid to upper areas. Planted as nursery stock.
Smoketree		Installed as nursery stock on East side. Did well, but was not planted in a stormwater cell.
Chinkapin Oak		Highly recommended.
Kentucky Coffeetree		
White Ash		
Black Locust		
Boxelder		
Green Ash		

Black Walnut		
Shagbark Hickory		
Catalpa		
Black Cherry		
Cottonwood		
Eastern Redcedar		
Shrubs		
Chinese Juniper		Planted as nursery stock in formal areas. Did very poorly. What survived the first year began to fade the next year-all were removed.
Kobold Barberry		Planted in formal areas. Did well. Planted as nursery stock.
Coralberry	symphoricarpos orbiculatus	Highly recommended. Installed as bare-root shrubs.
Filbert (Hazelnut)		
Red Osier Dogwood	Cornus sericea	This plant was installed as nursery stock. Did extremely well during first year, but every plant died during the next two years. Not recommended.
American Plum/Sandhill Plum		Did extremely well. Planted as bare-root stock. Highly recommended.
Elderberry		
Buttonbush		
Serviceberry		
Fragrant Sumac	Rhus aromatica	The nursery stock 'Grow Low' variety that was planted did extremely poor. The bareroot stock performed better, but only moderate.
Wahoo		
Gooseberry		
Rusty Blackhaw Viburnum		
Amorpha canescens	Lead Plant	
Amorpha fruiticosa	False Indigo	
Vines		

Virginia Creeper		
Bittersweet		
Trumpetvine		
Grasses		
Andropogon gerardii	Big Bluestem	Not originally installed due to height of mature plants. Some specimens were planted when other species were being transplanted. Kept in center due to height, but not as tolerant of soggy bottoms. Wouldn't recommend for urban environment due to size. If used, recommend large areas for biggest impact, uniformity.
Bouteloua gracilis	Blue grama	Small amount of blue grama was planted in container form. Very tolerant, mixes well with buffalo grass. Was used in more formal areas as it stays in small bunches and doesn't spread as readily as other grasses.
Chasmanthium latifolium	Broad-leaf Wood-oats	
Buchloe dactyloides	Buffalo Grass	Sodded around edges of Jackson Street. Has been excellent turf grass, only complaint is the fact that the cool season weeds green up faster than the buffalo, creating an unkempt appearance until it starts to green up in late April. Doesn't tolerate being inundated with water, so keep on upper areas. Extremely drought tolerant, frequent mowing reduces weed population.
Elymus canadensis	Canada Wildrye	
Tripsacum dactyloides	Eastern Gamagrass	
Bouteloua hirsuta	Hairy grama	
Sorghastrum nutans	Indiangrass	A few species were introduced when transplants were installed. See big bluestem for recommendations on use in urban setting. Tolerates wet feet, though it hasn't been present on Jackson long enough to determine its hardiness.
Schizachyrium scoparium	Little Bluestem	Little bluestem has taken over in the Jackson cells. It is extremely hardy and grows quickly in all areas. This species was installed using plugs but it is recommended to overseed to fill in any gaps. Highly recommended.
Spartina pectinata	Prairie Cordgrass	

Sporobolus herterolepis	Prairie Dropseed	
Eragrostis spectabilis	Purple Lovegrass	
Aristida purpurea	Purple Threeawn	
Sporobolus cryptandrus	Sand Dropseed	
Eragrostis trichodes	Sand Lovegrass	
Bouteloua curtipendula	Side-oats grama	Side-oats has done well on Jackson. It grows in most areas, but not as tolerant in consistantly wet areas. Highly recommended and pairs well with little bluestem. Again, installed with plugs, but recommend overseeding for additional coverage.
Bothriochloa spp.	Silver bluestem	
Panicum virgatum	Switchgrass	Installed by plugs and larger transplanted species in center of cells. Extremely hardy, loves the wetter areas and can spread aggressively. Does not have great specimen value, so it is most effective when planted in masses. Highly recommended for stormwater.
Sporobolus asper	Tall Dropseed	
Agropyron smithii	Western wheatgrass	
Perennials		
Achillea millefolium	Yarrow	Yarrow was planted as a specimen plant in two of the Jackson cells. Planted as nursery stock in upper section of cells. All plants that were installed last year survived.
Allium canandense	Canada Wild Onion	
Allium cernuum	Nodding Onion	Planted as plugs in lower-middle and bottom sections. Seems to tolerate moist areas. Great for wet areas.
Allium stellatum	Prairie Onion	
Artemisia ludoviciana	White Sage, Prairie Sage	Planted as plugs last summer-unsure as to its survival rate.
Asclepias syriaca	Common Milkweed	

Asclepias tuberosa	Butterfly Milkweed	Plugs were just installed last summer. Survival rate yet to be determined. In other areas where installed, this plant did great. Extremely drought tolerant-prefers drier areas.
Asclepias verticillata	Milkweed	
Aster ericoides	Heath Aster	
Aster laevis	Smooth Aster	Originally installed after completed construction. Just now really showing. I believe this species did well throughout, but has little to no presence in the wet,central areas.
Aster nova-angliae	New England Aster	Just installed last summer-so far, these plants look like they are doing very well. Planted in the mid to upper section of cells in plug form.
Aster oolentangiense	Sky Blue Aster	
Aster oblongifolius	Aromatic Aster	
Aster sericeus	Silky Aster	
Baptisia australis	Blue Indigo	
Baptisia leucantha	White Wild Indigo	
Callirhoe involucrata	Purple Poppy Mallow	Does extremely well-early spring bloomer. Installed as plugs when construction was completed on mid to upper areas.
Campanula americana	Tall Bellflower	
Carex blanda	Woodland Sedge	
Carex hystricina	Bottlebrush Sedge	
Carex meadii	Mead's Sedge	
Carex vulpinoidea	Fox Sedge	
Castilleja coccinea	Indian Paintbrush	
Cassia chamaecrista	Showy Partridgepea	
Coreopsis grandiflora	Big Flower Coreopsis	
Coreopsis tinctoria	Plains Coreopsis	Installed in plug form last summer in higher/drier areas. Came up beautifully this spring with great survivability rate.
Dalea candida	White Prairie Clover	Both purple and white prairie clover were originally ordered for Jackson. I believe the survivability rate was very low and I would not recommend it for stormwater purposes.
Dalea purpurea	Purple Prairie Clover	Both purple and white prairie clover were originally ordered for Jackson. I believe the survivability rate was very low and I would not recommend it for stormwater purposes.
Delphinium virescens	Prairie Larkspur	

Desmanthus illinoensis	Bundleflower	
Desmodium illinoensis	Illinois Tick Trefoil	
Desmodium canadense	Showy Tick Trefoil	
Echinacea purpurea	Purple Coneflower	Installed as plugs originally and additional plugs were installed last summer. Plant enjoys mid to upper areas and is very hardy.
Echinacea pallida	Pale Purple Coneflower	
Eleocharis palustris	Creeping Spikerush	
Eupatorium maculatum	Joe Pye Weed	
Gaillardia pulchella	Indian Blanket	Installed as plugs last summer. Is extremely hardy and drought tolerant. Highly recommended.
Gentiana andrewsii	Bottle Gentian	
Gentiana puberulenta	Downy Gentian	
Geranium maculatum	Wild Geranium	
Glanularia canadensis	Rose Verbena	
Helenium autumnale	Sneezeweed	
Helianthus annuus	Common Sunflower, Annual Sunflower	
Helianthus grosseserratus	Sawtooth Sunflower	
Helianthus maximilianii	Maximilian Sunflower	
Helianthus salicifolius	Willow-leaved Sunflower	
Heliopsis helianthoides	Ox-eye Sunflower	
Hibiscus lasiocarpos	Rose Mallow	
Hypericum pyramidatum	St. Johns Wort	
Juncus torreyi	Torreys Sedge	
Lespedeza capitata	Roundheaded Bushclover	
Liatris aspera	Rough Blazingstar	
Liatris pycnostachya	Thickspike, Bottlebrush Blazing Star	Installed originally after construction completion. Does okay-not extremely fantastic, but would recommend.
Liatris squarrosa var. glabrata	Scaly Blazingstar	
Lobelia cardinalis	Cardinal Flower	Installed last summer in plug form. Does well in these areas and is a stand-out specimen for aesthetic purposes.
Lobelia siphilitica	Blue Lobelia	
Mimosa nuttallii	Catclaw Sensitive Briar	
Monarda citriodora	Lemon Mint	
Monarda fistulosa	Wild Bergamot, Bee Balm	This plant is by far the most hardy forb on Jackson. Loves the mid to upper sections and is highly recommended. Very tough and has extremly quick establishment. May be a bit invasive if you are trying to restrict it to a specific area.
Oenothera macrocarpa	Missouri Primrose	
Oenothera speciosa	White Primrose	
Penstemon cobaea	Purple Beardtongue	
Penstemon digitalis	Foxglove Beardtongue	

Penstemon grandiflorus	Large-flowered Beardtongue	
Phlox divaricata	Wild Sweet William, Blue Wood Phlox	
Phlox paniculata	Tall Phlox	
Physotegia angustifolia	Obedient Plant	
Ratibida columnifera	Mexican Hat	
Ratibida pinnata	Gray-headed Coneflower	
Rudbeckia hirta	Black-eyed Susan	Another extremly hardy plant that was installed by plugs in the orginal planting and also as supplementary plantings last summer. Easily established-highly recommended.
Ruellia humilis	Wild Petunia	
Salvia azurea	Pitcher Sage	
Senna marilandica	Wild Senna	
Silene regia	Royal Catchfly	
Silphium integrifolium	Rosinweed	
Silphium laciniatum	Compass plant	
Solidago petiolaris	Woodland Goldenrod	
Solidago rigida	Rigid Goldenrod	Good plant that is hardy and well-suited for the area. Installed as plugs originally. Recommended.
Tephrosia virginiana	Goat's Rue	
Teucrium canadense	Germander	
Tradescantia bracteata	Prairie Spiderwort	
Tradescantia ohiensis	Ohio Spiderwort	Loves the moist areas on Jackson. Planted in orginal planting and has done extremely well. Highly recommended for stormwater projects.
Verbena hastata	Blue Vervain	
Verbena stricta	Hoary Vervain	
Verbesina helianthoides	Crownbeard	
Vernonia baldwinii	Western Ironweed	
Vernonia fasciculata	Common Ironweed	
Viola pedatifida	Bird's Foot Violet	
Vernonicastrum virginicum	Culver's Root	
Zizia aptera	Heartleaf Alexanders	
Zizia aurea	Golden Alexanders	