

# Stormwater Management

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A report on stormwater management for the city of Manhattan, Kansas

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## Introduction

Stormwater runoff is coming under increasing scrutiny as both a source of pollutants to water bodies, and as a cause of depleted groundwater resources. Increased public awareness of the issue will help improve quality and reduce quantity during a precipitation event. We have developed information (see appendix) to be posted on the City of Manhattan's website, a brochure, a news release for the K-State Collegian and Twitter updates for stormwater management education purposes. We have researched methods for property owners, developers, agricultural producers and tenants to increase infiltration and improve the quality of water.

The focus of our education outreach project focuses on improving the water quality within the Wildcat Creek Watershed (Figure 1), where there are documented water quality problems. Wildcat Creek Watershed covers 99.5 square miles in Riley County, Kansas, eight square miles of which are located within Manhattan, Kansas city limits. The watershed is listed as impaired phosphorus, fecal coliform bacteria, and low levels of dissolved oxygen<sup>(1)</sup>. In addition, Wildcat Creek and its tributaries are habitat for the Topeka Shiner, which is an endangered fish species that requires very specific water quality conditions<sup>(2)</sup>.

## Why You Should Care About Stormwater

Stormwater is water from rain or melting snow. It flows from rooftops, over paved streets, sidewalks and parking lots, across bare soil, and through lawns and storm drains. As it flows, runoff collects eroded soil, pet waste, salt, pesticides, fertilizer, oil and grease, litter and other pollutants<sup>(3)</sup>. The fast-moving water does not have the chance or ability to soak into the ground, to recharge groundwater reserves, and rushes into storm drains. The drains discharge directly into nearby creeks, streams and rivers, without receiving treatment at sewage plants.

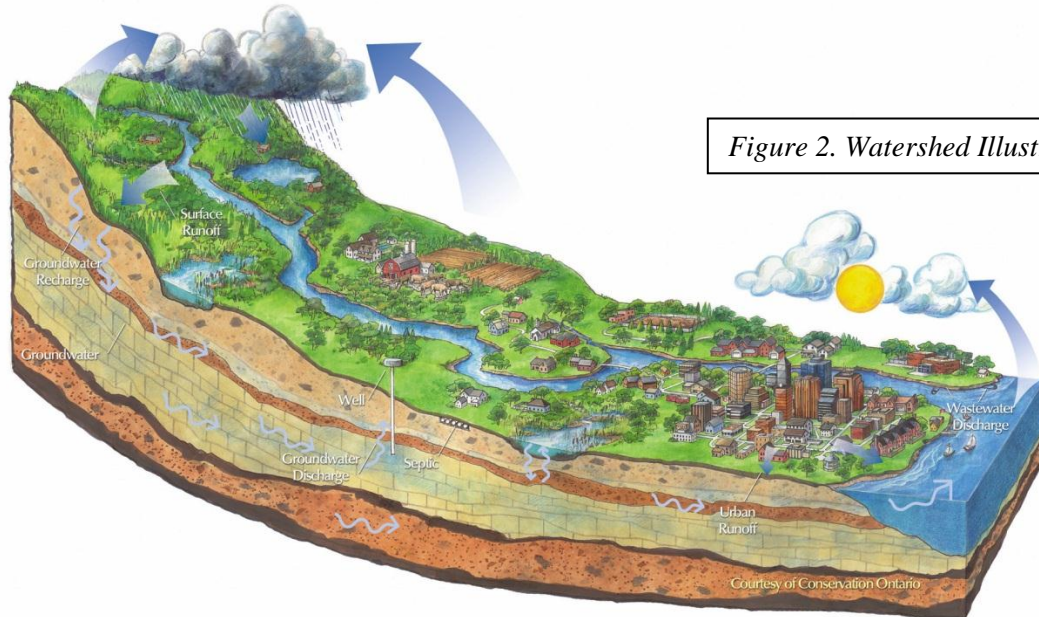
Stormwater is one of the main causes of pollution in lakes and rivers. Sediment, the most common water pollutant<sup>(4)</sup>, fills up storm drains (causing localized flooding), makes the water cloudy which makes it difficult for aquatic animals to hunt for food, requires additional treatment for human consumption, clogs fish gills and can alter the flow of water when deposited.

Aquatic life is extremely susceptible to changes in water temperature and pH. Even a small contribution of chemicals can have deadly results. High levels of nutrients, like nitrogen and phosphorus, can encourage the growth of algae blooms. Some types of algae release toxins harmful to humans, pets and wildlife. In the right conditions, just one pound of phosphorus introduced into the waterway can produce 500 pounds of algae<sup>(5)</sup>. Pet waste, lawn cuttings and leaves, among others, consume oxygen in the water as they decay. If oxygen levels become too low, aquatic plants and animals could die. Pet wastes, in particular, may carry bacteria and viruses that threaten the health of humans and wildlife.

While most municipal water sources are treated with chlorine and filtration, the effectiveness of these treatments are reduced by high levels of contaminants. Bacteria can gain resistance to chlorine through repeated exposures. Even if treatments are working perfectly, nitrogen and phosphorus fertilizers aren't removed by conventional treatments. Nitrates are

especially dangerous to pregnant women because they can disrupt the ability of blood to carry oxygen which can be fatal to infants, as well as increasing the chance of miscarriage.

## What Is A Watershed?



*Figure 2. Watershed Illustration*

Every small watershed drains to a larger watershed that eventually flows to the ocean, as seen in Figure 2. So, everyone lives in a watershed, which contains all the land surfaces from which water drains into stream and river channels. Taken individually, impacts from any one home on any one lot may seem marginal, barely even detectable, but taken together as part of a total watershed system, impacts accumulate and become much more serious. Severe channel erosion and undercutting, increased flooding, declining stream base flows and a lowered water table, dried up wetlands, impacted aquatic communities and other problems are now all too common.

Throughout broad watershed areas and headwater tributaries, large-lot single-family rural and residential developments occupy the land area. The impervious surfaces created on these lots, as well as the compacted lawns, which have followed, have translated into significant reductions in natural infiltration. Thus, runoff volume and velocity have increased, resulting in more water running off faster. The increased volume of water results in increased flooding, while the increased velocity greatly increases erosion. Most of the initial erosion will cut the stream deeper, this can uncover/damage pipes and cables that were buried under the stream. Once the streambed cuts down to bedrock, it can cut into the bottom of the banks and cause them to collapse. If the stream is in a residential area, then this can severely damage any houses that are built close to the stream.

## Stormwater In The Wildcat Creek Watershed

Manhattan is located on the floodplain at the junction of the Kansas and Big Blue rivers. The city's average annual precipitation is 34.8 inches. Heaviest rainfall is expected during the spring and summer months with 70% of the total precipitation falling from April to September<sup>(6)</sup>. Rainfall events that place the most frequent demands on the drainage system occur as convective thunderstorms having intense, short duration rainfall. On average, measurable precipitation occurs on 97 days each year<sup>(7)</sup>. Stormwater has caused flooding in Manhattan, which is a separate issue that requires much attention. Our focus is improving the quality of water from precipitation events.

Wildcat Creek cuts through Manhattan to the southwest and empties into the Kansas River. Rapid development along the creek has resulted in substantial erosion, impaired water quality, endangered aquatic species and caused property damage and habitat loss. Many urban residents live in apartments or mobile home parks and are directly impacted by adverse water quality, flooding and lowered property values. Flooding in Manhattan has increased from a 1 in 20 year occurrence to almost an annual event. The June 2011 flood caused just short of \$1 million in damages to city property.

The Wildcat Creek Watershed covers 99.5 square miles in Riley County, Kansas. As seen in Figure 1, the majority of the watershed is located outside of Manhattan, so it is important that we take necessary precautions to avoid water contamination.

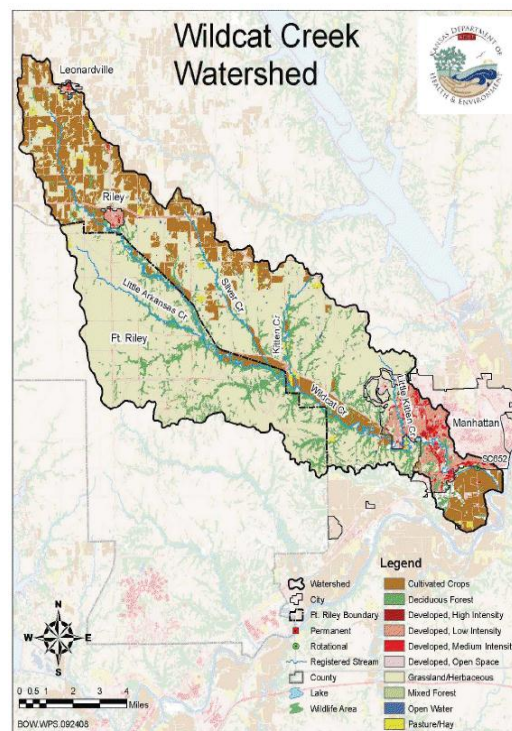


Figure 1. Wildcat Creek Watershed

One inch of rain that falls over one acre of land creates approximately 27,000 gallons of runoff. Over the entire city of Manhattan, that translates to 325 million gallons of water and 1.7 billion gallons in the Wildcat Creek Watershed.

## Addressing Stormwater

Most stormwater management systems are outdated leaving states, cities, and individuals using a mixture of systems. There are currently two approaches to stormwater management:

1. The traditional approach is draining runoff into a pipe as quickly as possible to prevent ponding. It does not attempt to prevent or control stormwater pollution. As a result, the traditional approach often results in downstream flooding and water quality problems.
2. The new system is an integrated system of preventive and control practices. The first goal is to minimize the generation of runoff and pollutants through a variety of

techniques. The second goal is to manage runoff and its pollutants to minimize its impacts on humans and the environment in a cost effective manner. This approach stresses optimum site planning and the use of more natural drainage systems, rather than traditional curb, gutter and piped systems. This “soft approach” can often reduce the cost of stormwater management on development sites.

The City of Manhattan is currently addressing stormwater in a number of ways:

1. They have a website (<http://ci.manhattan.ks.us/index.aspx?NID=307>) or see Appendix A
2. Are in the process of establishing stormwater abatement services
3. Have established the Wildcat Creek Watershed Area Working Group to review and recommend solutions to flash flooding along Wildcat Creek

## Our Recommendations

We believe that the average person will have difficulty locating stormwater information on the city’s website. We postulate that the following updates will greatly improve the city’s ability to disseminate information regarding stormwater:

1. The Stormwater site is not immediately accessed from the homepage. Stormwater is under Public Works and the Working Group is under Public Works>Engineering. If you do a search for “stormwater”, information regarding the Working Group is not one of the results, see Appendix B. If you do a search for “flooding,” links to the Working Group, the June 2011 flooding and inundation maps appear. Since stormwater is a cause of flooding, all three topics should be related: Stormwater, Working Group, Inundation Mapping. Post links to others on each site.
2. Add a link to the Stormwater page under the “New Resident” tab on the homepage, see Appendix C.
3. Update the stormwater management master plan.
4. We have created a brochure, see Appendix D, educating the public on stormwater management in the Wildcat Creek Watershed as well as measures individuals can make to improve the situation. Post the brochure on the main Stormwater page.
5. Distribute the brochure in residents’ water bills. If this is not possible due to budget constraints, add a QR code to the actual bill with a small paragraph telling residents to scan the code with their smart phones to link to the brochure posted on the main Stormwater page. The QR code shown in Figure 3 links directly to the Stormwater site but once the brochure is live on the city’s website, creating a QR code with the brochure’s address is very simple.
6. Create more memorable web addresses, i.e. [www.cityofmnhk.com/stormwater](http://www.cityofmnhk.com/stormwater); [www.cityofmnhk.com/wildcatcreek](http://www.cityofmnhk.com/wildcatcreek)
7. On the first of every month or every Friday, whatever is convenient, post stormwater tips on the city’s Twitter, see Appendix E.
8. Send news release, see Appendix F, to K-State Collegian since most college students rent and do not receive water bills.

Figure 3. QR code



9. Redistribute the information on the Stormwater page, see Appendix G, based on information below.

City officials have the opportunity to regulate subdivision development and encourage low impact developments and preservation of open space. Suburban development in Manhattan is rapidly growing and people have migrated to more suburban or rural areas on the outskirts of towns and cities. City officials are able to influence these developments through zoning. The zoning ordinances in most communities have encouraged such traditional designs by requiring minimum lot sizes, uniform road frontage and lot setbacks, specific road standards, and other standard requirements. In general, the only open space within such developments has been the yards between adjoining privately owned housing lots. This type of development does not preserve or improving the quality of the open-space areas, which would benefit stormwater management. Cluster developments usually site homes on smaller lots and there is less emphasis on minimum lot size. However, the total number of homes, or density, on a given acreage does not necessarily increase over that allowed in the traditional subdivision designs. The remaining land, which would have been allocated to individual home sites, is then converted into protected open space and shared by the residents of the subdivision and possibly the entire community. The City of Manhattan needs to update ordinances and regulations in order to facilitate building conservation development subdivisions. We suggest a revision of the 1995 Stormwater Management Master Plan as there have been advances in ways to improve quality and reduce runoff since this was released.

We divided residents into four groups: property owners, developers, tenants and agricultural producers. We researched what each could do to improve water quality and reduce quantity. We did not post all the information below on the mock websites, but more can be easily added.

### **Property owners**

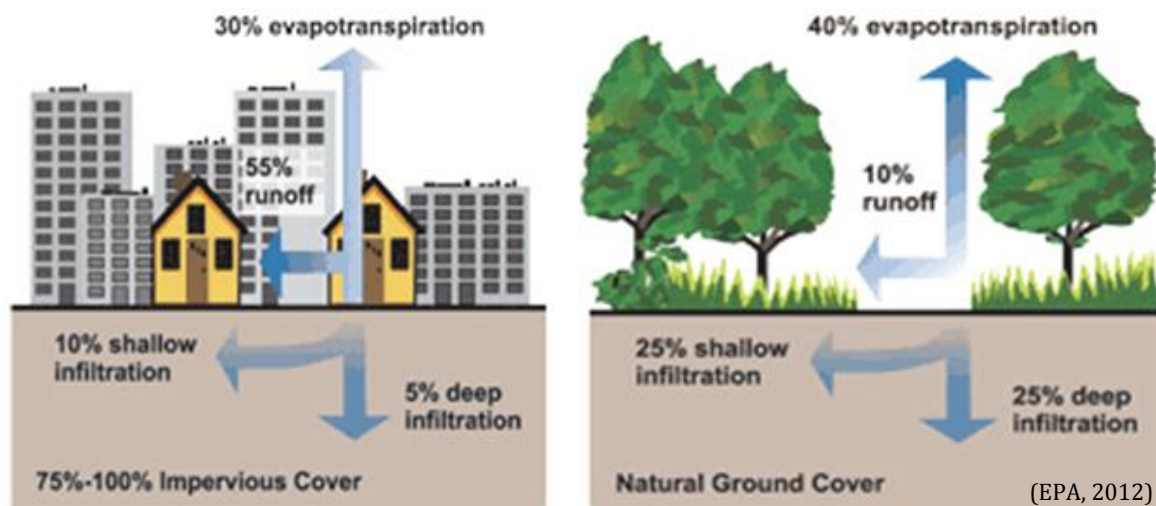
As a property owner your lawn does impact stormwater. Research has shown that nutrient runoff generated from lawns can cause eutrophication in streams, lakes, and estuaries. Property owners should understand that lawn fertilizer can cause water quality problems, and before adding any nutrients to your lawn you should take a soil test to determine if fertilization for your lawn is even needed. Furthermore, planting grass on bare soil or areas of your yard that has patches is the best way to stop erosion. For proper lawn care practices consider the following:

- Planning and design. Consider sunlight, soil and drainage conditions; desired maintenance level; which existing plants will remain; plant and color preferences; and budget.
- Soil improvement. Mix peat moss or compost into soil before planting to help the soil retain water. Use terraces and retaining walls to reduce water run-off from sloped yards.
- Appropriate plant selection. Choose low-water-using flowers, trees, shrubs, and groundcovers. Many of these plants need watering only in the first year. Also planting warm season grasses require less water than cool season grass and reach their maximum growth height throughout the summer months when storms are present and have a larger root system to slow stormwater runoff more effectively.

- Practical lawns. Limit the amount of grass area, plant ground-covers, indigenous plants, or slow-growing, drought tolerant vegetation. If replanting lawns, use drought-tolerant grass seed mixes.
- Efficient irrigation. Install water-efficient drip or trickle irrigation systems.
- Effective use of mulches. Use a 3-inch deep layer of mulch, such as pine needles, shredded leaves, or bark. Mulch keeps soil moist, prevents erosion, and smothers weeds.
- Appropriate maintenance. Properly timed fertilizing, weeding, pest control, and pruning preserve a landscape's beauty and water efficiency.

Green roofs are an effective tool in fighting stormwater runoff. As a property owner the loss of infiltration due to roof tops impacts stormwater management greatly. A productive way to counter the effects of rooftop runoff is to implement green roofs on your property. A green rooftop, also called a “living roof top”, is a thin layer of vegetation installed on top of a flat or sloped roof ([www.greenroofs.com](http://www.greenroofs.com)). The vegetation can range from turf grass, native grasses and flowers to shrubs.

Green roofs reduce stormwater runoff by absorbing and slowing down stormwater as it falls on your roof, this result in less water directed into storm drains. Depending on rain intensity and green roof soil depths, runoff can be absorbed between 15 to 90 %, thereby considerably reducing runoff and potential pollutants from traditional impervious roofing surfaces<sup>(8)</sup>. Among decreasing the rate of stormwater runoff there are many other benefits of having greenroofs.



Figures 4 & 5. As urbanization increases impervious surfaces increase which lowers water infiltration. This causes severe water pollution and flooding.

Installing green roofs on your property isn't unrealistic. The initial cost of a green roof can be 30% greater than a conventional roof; however the long term maintenance of traditional roofs and energy cost savings of green roofs can offset the cost increase considerably. One source states that green rooftops prolong the life of a conventional roof by 20 years<sup>(9)</sup>. The cost of a green will also determine which type of a green roof you install. For intensive green roofs should estimate the cost to be between \$16 and \$35 per square foot. For an extensive green roof you should estimate the cost to be between \$7 and \$35 per square foot. Installations of green

roofs are sometimes eligible for tax relief, energy conservation credits or lower stormwater charges from municipalities.

A great way to help alleviate stormwater runoff is to capture the water runoff from rooftops and utilize that water for personal gain around your property. One way to achieve that is utilizing a new technique, through rain barrels. Collecting rainwater from your roof during storms will not only lower your water bills, but also help to decrease stormwater runoff. Rainwater collection and reuse is beneficial to the environment because the stored water would otherwise run off into the storm sewers, bringing pollutants such as oil and grease, bacteria, and nutrients with it. Once water gets into a storm sewer, it eventually ends up in our streams and rivers. Obtaining rain barrels (Figures 6 & 7) can be relatively easy, you can purchase a rain barrel at most major lawn and garden centers, and you can find them on craigslist, Reser's food distribution center or other sources.



*Figures 6 & 7. In urbanized areas where infiltration has decreased, rain barrels are an inexpensive yet efficient way to collect storm water runoff from your roof.*

Rain gardens are another cheap and productive way to fight against water pollution and decreasing stormwater runoff. Since rain gardens incorporate native vegetation they are easy to maintain and therefore, no fertilizer is needed. Rain gardens are generally constructed in depressions on the downside of a slope on your property and collect rainwater runoff from impervious surfaces such as roofs and parking lots. They are designed to temporarily hold and soak in rainwater runoff. This also allows water to be filtered and sediment to settle helping with erosion as it passes through the vegetation. Rain gardens are effective in removing up to 90% of nutrients and chemicals and up to 80% of sediments from the rainwater runoff. Compared to a conventional lawn, rain gardens allow for 30% more water to soak into the ground. A rain garden is not a water garden. Nor is it a pond or a wetland. Conversely, a rain garden it is dry most of the time. It typically holds water only during and following a rainfall event.

Along with rain gardens, vegetative filter strips (Figure 9) can be incorporated on your property as well, and they are just as effective.



Figure 8. Rain garden utilized to slow the velocity of the storm water runoff from the roof.



Figure 9. Vegetative strip is utilized in this parking lot to filter pollutants and capture storm water runoff.

In order for rain gardens to reach maximum efficiency there are a few important elements:

- Stormwater enters the garden through roof downspouts or rain barrels as discussed earlier.
- The water needs a ponding area which provides temporary surface area for water to store and evaporate.
- The garden should be planted with native species that are adapted to periods of seasonal weather patterns.
  - In sloped areas: Big bluestem grass, shoreline sedge, pest sedge, switch grass
  - In shoreline/ wet areas: swamp milkweed shoreline sedge, burhead, cardinal flower, minkey flower, prairie cordgrass, winged loosestrife.
- The plant soil provides nutrients to the vegetation and can be supplemented with organic rich compost material
- The mulch or organic layer protects the underlying soil from erosion.
- The optional sand bed/gravel base (also called an Infiltration Bed) should be wrapped in filter fabric (If you decide to go this route, you should contact the township for assistance).
- A positive overflow is a design feature that allows stormwater to overflow during large storm event. The structure is design dependent (the more technical your design, the more technical your outlet) and can range in sophistication from a “domed riser” to something as simple as a graded river rock channel or even a small soil berm.

Impervious surfaces are associated with urbanization or otherwise known as the urban sprawl. Impervious surfaces such as sidewalks, parking lots, driveways and heavily compacted soil from human interaction cause a decrease in water infiltration which in turn leads to an increase in water runoff during heavy rainstorms. However, there are several ways to counteract impervious surfaces. Some proven methods include several types of pervious paving materials, including permeable interlocking concrete pavers, concrete pavers, porous pavements, and plastic reinforcing grids<sup>(10)</sup>.



*Figures 10 & 11. Installing pervious concrete so the water is able to be absorbed, rather than runoff.*

The cost of pervious surfaces depends largely on the amount and type of materials as well as site preparation. The typical construction costs vary from \$5 to \$10 per square foot (Florida Concrete Products Association). Though permeable pavement (Figures 10 & 11) is more expensive than conventional pavement, it can be cost competitive when it reduces the size or even eliminates, the need for curb and gutter conveyance systems and large stormwater retention ponds<sup>(11)</sup>.

## **Developers**

Developers have a rather significant impact on stormwater runoff during construction. During most of the construction period the soil of the construction site is bare and susceptible to erosion from rain and construction equipment. The Clean Water Act and the Safe Drinking Water Act both impose restrictions on how much erosion is allowed during construction. Construction sites are therefore the most heavily regulated areas in terms of stormwater management; because of this developers must take steps to ensure that erosion is all but eliminated before they can start working. This is usually accomplished with techniques that are known as Best Management Practices (BMPs).

Common BMPs include:

- Silt Fences
- Fiber Rolls
- Compost Blankets
- Infiltration Trench
- Vegetated Buffers
- Filter strip
- Washing Areas
- Geotextiles
- Riprap
- Check Dams
- Restore/Preserve Existing Native Vegetation



*Figures 12 & 13. Silt Fence & Fiber Rolls*

Silt fences and fiber rolls (Figures 12 & 13) are commonly used around the perimeter of the construction site to prevent sediment from leaving the construction site; and around drains to prevent sediment from entering the waterways. While all 3 are used for the same purpose, there are differences between them that contractors need to take into consideration. Silt fences made of a plastic liner partially buried and supported by wooden stakes. This makes them more time consuming to install, but are much more effective at trapping sediment. Straw bales are just that, bales of straw used to impede sediment. Installation is easy, just set them where they're needed, but they are the least effective at trapping sediment. Fiber rolls are made of straw or some type of organic fiber that's been rolled into a tube. They can be simply laid on the ground if needed quickly, or they can be partially buried and staked into the ground similar to silt fences for more effective protection. Even if staked into the ground, they aren't as effective as silt fences because fiber rolls are about 8" tall, while silt fences can be up to 12" to 15" tall.

A compost blanket is a layer of organic material that helps stabilize an exposed area of soil by:

- by providing a barrier that cushions the soil from precipitation
- filling in rills in the soil before they can grow into channels or gullies
- promoting vegetation growth by retaining water and providing a habitat for microorganisms to break down organic materials for nutrients
- Filters pollutants from water flowing through it

These blankets are best suited for areas on a slope that need to establish vegetated cover quickly.

Vegetated buffers are areas where natural vegetation is used to intercept stormwater runoff and allow it to infiltrate into the soil. These are usually used in agriculture to protect waterways from agricultural runoff. They can also be used for construction sites that have adequate land and vegetation between the site and a waterway.

Washing areas are simply areas where construction equipment is cleaned before leaving the construction site. They are usually used in conjunction with gravel entrance/exits. Used properly, washing areas ensure that sediments and pollutants don't leave the construction site with the equipment.



*Figure 14. Workers stalling geotextiles to improve stormwater runoff.*

Geotextiles (Figure 14) are fabrics made from various materials that can be used to enhance a soil layer. They have a wide variety of applications: reinforcing soil banks, separating soil layers, draining excess water from underneath a soil layer, erosion control as a silt fence, or water filtration. Each application requires a different type of geotextile, so care must be taken when selecting a fabric to ensure that it will perform as desired. The liner used for silt fences are geotextiles.



*Figure 15. Example of riprap along shoreline.*

Riprap is rock or similar a material that is used to protect shorelines (Figure 15), streambanks, or other waterway boundary from erosion. The rocks absorb or deflect the impact of waves away from the soil or structure underneath.

Check dams are small structures placed across a channel or swale to prevent downstream erosion. The dam slows the water flowing in the channel, this allows sediments and pollutants to settle out as well as reducing erosion downstream by lowering the kinetic energy of the water.

Since stormwater runoff and soil erosion issues during construction are well understood and already heavily regulated there isn't much more developers can do to improve stormwater

quality. Contractors and developers can however, further help by suggesting that their clients add other control methods to the design. These control methods continue to function after construction is complete, but are difficult to implement after construction is finished. Examples include:

- Porous concrete
  - Discussed in detail above
- Bioretention cells/Rain Garden
  - Discussed in detail above
- Slope Diversions
- Grass-lined channels

Slope diversions are used to let water flow downhill without causing erosion. This is done by either using a series of channels perpendicular to the flow direction, or by diverting the water to an area that won't be eroded as heavily. The perpendicular channels intercept water flowing downhill and force it to come to a stop before either continuing downhill or flowing out the sides of the channel.



*Figure 16. Grass lined channel.*

Grass lined channels (Figure 16) can be used instead of concrete ditches and there are a number of advantages and disadvantages with both. Grass lined channels provide more resistance to flowing water and allow water to infiltrate into the soil, both of these effects reduce the potential for erosion downstream. However, since they don't let water flow as quickly, they are more likely to flood during heavy rains than a concrete channel.

## Tenants

Although renters cannot help reduce stormwater runoff as much as property owners, they still can help significantly by reducing pollution. If tenants are living in houses, they can talk with their landlord and mention common ways for homeowners to reduce stormwater runoff. If living in an apartment, there are fewer options, but still opportunities to improve the situation. Some simple improvements tenants can do include:

- Never dump anything down a storm drain.
- Dispose of household hazardous wastes only at Riley County Hazardous Waste Facility.
- Plant a tree.
- Maintain your vehicle to reduce leaks and recycle motor oil.
- Wash your car at a designated car wash where they have proper drainage.
- Choose to live in a neighborhood that provides you with all conveniences- shopping nearby, close to work and green space.
- Set out container planters outside of your home.
- If possible, talk to your landlord about installing water recycling or green roofs.

## Agricultural Producers

The focus within our project is educating the citizens on Manhattan on stormwater management. The agricultural community lies out of our focus, but we find it important to include resources for further information and funding as agriculture is the largest contributor of non-point pollution. The USDA offers financial assistance programs if you are voluntarily addressing water quality, erosion control, or other innovative conservation practices in your farming operations: <http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/>

- Never apply fertilizers or pesticides when rain is forecasted
- Properly store, apply and dispose of fertilizers and pesticides
- Properly treat and dispose of animal waste
- Reduce livestock interaction with streams

Consider installing:

- detention basins – basins that hold stormwater to be released at a designated time
- retention basins – like detention basins but contain a permanent pool of water
- tile drains – pipe system which removes excess water from soil subsurface
- riparian buffers/buffer strip – vegetated area near stream, includes woody vegetation and native grasses
- weirs – barrier across a stream that allows water to pool behind the structure and flow over the top
- stream exclusion fencing – fencing placed around stream

**Conclusion**

We believe the City of Manhattan has made great strides in developing stormwater management practices. Our suggestions are meant to be incorporated into already existing procedures. Our goal was to assist the city in creating communication materials. Stormwater and watershed management are greatly influenced by individual actions. The city alone cannot solve the problem. Manhattan and Riley County residents need to understand the problem and how they can contribute to the solution.

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## Appendix A.

### Stormwater Webpage

Manhattan, KS: Home | Departments | Public Works | [Stormwater](#)

## Stormwater

### About Manhattan's Stormwater Program

Water running along curbs and into storm drains flows untreated into our local streams, rivers, and lakes. Keeping them clear of debris and chemicals improves Manhattan's water quality.

### What You Can Do To Help

Stormwater is runoff from rain and snow. The City has a system of storm drains and ditches to collect this runoff and discharge it to our area rivers. Stormwater that flows from driveways, rooftops, and across our lawns eventually picks up debris, dirt, chemicals from yards, even dog waste, and flows into the City stormdrains. This water eventually works its way into our water supply. Protecting our water before it drains into our water supply system is the first step to success!

- Take hazardous household chemicals, such as cleaning supplies, used motor oil, paint, and spray cans to the [Riley County Hazardous Waste Facility](#).
- Use lawn chemicals such as fertilizers and pesticides properly.
- Plant native plants and gardens that need less yard maintenance.
- Pick up after your pets and dispose of their waste.
- Do not wash your car at your residence, use a commercial car wash, which recycles their water, and uses less water than you would at your home.

If you know of any illegal dumping in the area, there are several ways to contact our Stormwater Department. You can report any violation on a confidential basis by using this [form](#). You may also contact our Department by [email](#), the Stormwater Officer at 785.587.2427 or call our Stormwater hotline at 785.587.2441.



### Contact

Shane Swope  
Stormwater Engineer  
[Email](#)  
Ph: (785) 587-4533

Theresa Crubel  
Stormwater Officer  
[Email](#)  
Ph: (785) 587-2427

### Stormwater Quality Improvement Plan

The City of Manhattan recently developed a plan to improve stormwater quality in our community. After submitting a plan to the [National Pollutant Discharge Elimination System](#) (NPDES), a division of the Environmental Protection Agency, the City received a [permit outlining deadlines and goals](#), which includes public education. View [Clean Water for the Future: Manhattan's Plan](#), an excellent summary of Manhattan's Stormwater Program written by one of our citizens.

### Post Construction Best Management Practices (BMP) Manual

View the [BMP Manual](#).

### Find Out More

- [Frequently Asked Questions](#)
- [Kansas Stormwater Consortium](#)
- [Stormwater Management Master Plan](#)
- [Stormwater Pollution and What You Can Do](#) - Keep the water you drink, bathe in, cook with, and swim in clean
- [Where Do I Take This Waste?](#) - A guide to Manhattan's recycling facilities

## Appendix B.

### Stormwater Search Results

### Search Results

[Advanced Search](#)

Your search: **stormwater**

#### Page Matches

1 - 3 of 15 | [Next 10 >](#)

- 
[Stormwater](#)  
 Last Modified: 10/23/2012 3:03 PM  
*Stormwater*
- 
[1995 Stormwater Management Master Plan](#)  
 Last Modified: 1/4/2012 11:30 AM  
*1995 Stormwater Management Master Plan*
- 
[Current Projects](#)  
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*Current Projects*

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#### Archive Center Matches

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- 
[2006 Autumn Neighborhood Newsletter](#)  
 Last Modified: 10/31/2006 5:15 PM  
*Walkable Neighborhoods, Stormwater Management, and Neighborhood Coalition Information*
- 
[2006 Spring Neighborhood Newsletter](#)  
 Last Modified: 7/27/2006 2:07 PM  
*City's Road Construction & Maintenance Update, Linear Park Trail Updates & Map; Depot Dedication, Arbor Day, Season Swim Passes, Manhattan Day, Stormwater Protection, and Neighborhood Leaders' Forum*
- 
[2012 Aug 14 Special City Commission Meeting Minutes](#)  
 Last Modified: 8/22/2012 9:38 AM  
[Show All Archive Center Matches](#)

#### Calendar Matches

1 - 1 of 1

- 
[Wildcat Creek Watershed Meeting](#)  
 Last Modified: 6/19/2012 3:07 PM  
*Visit Sunset Zoo this evening to learn more about two stormwater management projects implemented within the last year along the Wildcat Creek watershed - a new bio-retention garden at Sunset Zoo & a Green Roof at K-State's Seaton Hall. This event is hosted by a City of Manhattan and Riley County working group focused on Wildcat Creek stormwater management. For more information please contact: Prof. Lee Skabelund, ASLA, The College of Architecture, Planning & Design at Kansas State University // lskab@k-state.edu // Rod Harms, Wildcat Creek Watershed Council // 785-341-3773 // rharms@purpleprairie.net*  
[Show All Calendar Matches](#)

#### Staff Directory Matches

1 - 1 of 1

- 
[Theresa Crubel - Stormwater Officer I](#)  
 Last Modified: 5/29/2012 2:45 PM  
 785-587-2427 [crubel@cityofmhk.com](mailto:crubel@cityofmhk.com)  
[Show All Staff Directory Matches](#)

#### Document Center Matches

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- 
[Take Our Stormwater Survey](#)  
 61 KB, Last Modified: 6/7/2006 3:37 PM  
*Survey*
- 
[07077\(CC\)Stormwater Regulatory Ordinance](#)  
 28 KB, Last Modified: 6/8/2007 8:28 AM
- 
[Stormwater: Pollution and What You Can Do](#)  
 249 KB, Last Modified: 2/27/2007 3:48 PM  
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#### FAQ Matches

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- 
[I have concerns about Storm Water Drainage. Who do I contact?](#)  
 Last Modified: 1/30/2006 5:38 PM

## Appendix C.

### New Resident Tab



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Discover the Flint Hills

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#### Riley County Half-Cent Sales Tax Renewal


The City Commission approved Policy Resolution No. 082112-E on August 21, 2012, to establish the guidelines that will govern expending the City's share of proceeds from the 2012 Riley County Sales Tax Renewal. Learn more about the sales tax renewal and intended use of the funds [here](#).



Fly MHK



Sunset Zoo




Discovery Center


News & Announcements


Calendar of Events


#### **Social Services Voluntary Donation Program**


In March 2012, the City Commission authorized the creation of a donation program for social services. As a result, City staff developed a program to allow citizens to make a voluntary donation, on monthly utility bills, to help social service agencies. [Read on...](#)

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■ Translate this Page

■ Water Utility Service

## Appendix D. Brochure

### The Wildcat Creek Watershed

in Riley County, Kansas covers 99.5 square miles with eight square miles within Manhattan city limits. Wildcat Creek cuts through Manhattan to the southwest and empties into the Kansas River. Rapid development along the creek has resulted in substantial erosion, impaired water quality, endangered aquatic species and caused property damage and habitat loss. Many urban residents live in apartments or mobile home parks and are directly impacted by adverse water quality, flooding and lowered property values.

Wildcat Creek has documented water quality problems. The watershed is listed as impaired for nutrients, bacteria and low levels of dissolved oxygen. In addition, Wildcat Creek and its tributaries are habitat for the Topeka Shiner, which is an endangered fish species that requires very specific water quality conditions.

Flooding in the urban portions of the watershed has increased from a 1 in 20 year occurrence to almost an annual event. The June 2011 flood caused just short of \$1 million in damages to city property.

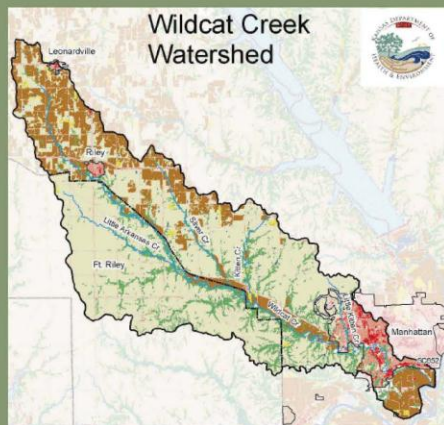
For more information on the watershed or to see how you can help, visit:

Wildcat Creek Watershed Council

(<http://www.wildcat-creek.org>)

Wildcat Creek Watershed Area Working Group

(<http://www.ci.manhattan.ks.us/index.aspx?NID=1763>)



### Manhattan

is located on the floodplain at the junction of the Kansas and Big Blue rivers. The city's average annual precipitation is 32.9 inches. Heaviest rainfall is expected during the spring and summer months with 75% of the total yearly precipitation falling from April to September. Rainfall events that place the most frequent demands on the drainage system occur as convective thunderstorms having intense, short duration rainfall. On average, thunderstorms occur on about 55 days each year in Riley County. In Manhattan, stormwater management is typically associated with extreme flooding events. It is necessary to be aware of such flooding and take necessary precautions on how you can improve water quality and reduce runoff.



Created by 2012 NRES Capstone Course

### To Report Illegal Dumping

Visit <http://www.cityofmnhk.com/forms.aspx?FID=164> to complete the confidential form or email [stormwater@cityofmnhk.com](mailto:stormwater@cityofmnhk.com)

### To View Local Inundation Maps



## Stormwater Management



IT ALL DRAINS TO THE RIVER  
How You Can Improve Water  
Quality and Reduce Runoff

CITY OF  
**MANHATTAN**  
KANSAS

## What is stormwater?

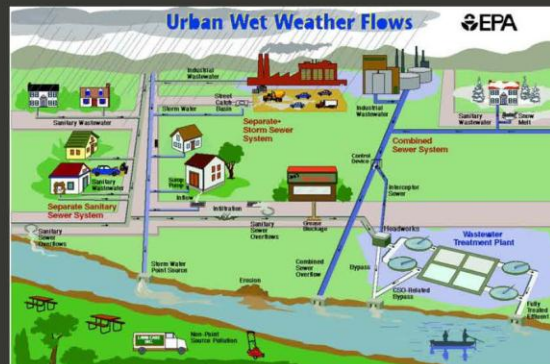
Stormwater is rain and snow melt that falls onto developed surfaces, such as rooftops, roads and parking lots, where it does not have the ability to soak into the ground, creating large quantities of runoff. The runoff picks up pollutants and debris before entering storm drains and is discharged directly into local waterways, untreated. Stormwater runoff is a source of pollutants to water bodies and a cause of depleted groundwater resources.

**Property owners** can improve stormwater water quality and reduce runoff by:

- Planting rain gardens and buffer areas.
- Using rain barrels to catch roof runoff.
- Properly storing, applying and disposing of lawn, garden and industrial chemicals.
- Installing dripline infiltration trenches, dry wells, infiltration steps, pervious walkways, water bars, green roofs, etc.
- Installing terraces or retaining walls on sloped yards.
- Mixing peat moss or compost into the soil before planting.

**Developers** have a significant impact on stormwater runoff during construction. During most of the construction period, the soil at the construction site is bare and susceptible to erosion from precipitation and construction equipment. Because of this, developers must take steps to ensure that erosion is avoided by following Best Management Practices (BMPs). After construction, they can recommend ongoing erosion control methods to their clients, including porous concrete, slope diversions, bioretention cells, preserving natural vegetation, grass-lined channels, etc.

One inch of rain over one acre produces approximately  
**27,000 gallons**  
 of runoff. That translates into  
**325 million gallons**  
 of water in the city of Manhattan and  
**1.7 billion gallons**  
 in the Wildcat Creek Watershed.



## What Everybody Can Do:

- Disposing of household hazardous wastes at the Riley County Hazardous Waste Facility.
- Having vehicles regularly maintained to reduce leaks and recycling motor oil.
- Never dumping waste down storm drains (cigarettes, oil, paint, antifreeze, fertilizers, lawn cuttings, etc.).
- Properly disposing of pet waste.
- Washing vehicles at commercial car washes or on lawn/gravel using biodegradable soaps.

## Stormwater causes:

- Downstream flooding
- Contaminated water bodies
- Stream bank erosion
- Increased turbidity from erosion
- Habitat destruction
- Sewer overflows
- Infrastructure damage



**Tenants** can improve stormwater water quality and reduce runoff by:

- Choosing to live in a neighborhood that provides all the conveniences – close to work, shopping and green space.
- Talking to landlord about installing water recycling or a green roof.
- Using container planters.
- Volunteering for the City installing drain signs.
- Sweeping dirt onto lawn.
- Picking up litter.

**Agricultural producers** can improve stormwater water quality and reduce runoff by:

- Looking at rain forecasts before applying fertilizers and pesticides.
- Properly storing, applying and disposing of fertilizers and pesticides.
- Properly treating and disposing of animal waste.
- Reducing livestock interaction with water sources.
- Installing detention basins, retention basins, tile drains, riparian buffers, weirs, stream exclusion fencing, etc.
- Maintaining septic systems.



**City of Manhattan** @cityofmhhk

Check out the brochure on our website created by K-State students on how you can reduce and improve stormwater runoff!

**City of Manhattan** @cityofmhhk

Visit our website to see how students renting can improve stormwater quality [www.ci.manhatta.ks.us/index.aspx?nid=307](http://www.ci.manhatta.ks.us/index.aspx?nid=307)

**City of Manhattan** @cityofmhhk

Find out how homeowners can get funding for rain barrels & rain gardens at [www.ci.manhatta.ks.us/index.aspx?nid=307](http://www.ci.manhatta.ks.us/index.aspx?nid=307)

**City of Manhattan** @cityofmhhk

One inch of rain over one acre of land produces ~ 27,000 gallons of runoff. For MHK, translates into 325 million gallons of water.

**City of Manhattan** @cityofmhhk

See how you can reduce stormwater runoff and improve water quality at [www.ci.manhatta.ks.us/index.aspx?nid=307](http://www.ci.manhatta.ks.us/index.aspx?nid=307)

**City of Manhattan** @cityofmhhk

Learn what developers are doing to improve stormwater runoff at [www.ci.manhatta.ks.us/index.aspx?nid=307](http://www.ci.manhatta.ks.us/index.aspx?nid=307)

**Source:** Shane Swope, 785-587-4533, [swope@cityofmnhk.com](mailto:swope@cityofmnhk.com)

**Website:** <http://www.ci.manhattan.ks.us/index.aspx?NID=307>

**Dec. 13, 2012**

### **COMMUNITY PARTICIPATION KEY TO REDUCING STORMWATER**

MANHATTAN, Kan. — The City of Manhattan's Stormwater Management Department needs residents' assistance in reducing stormwater quantity and improving quality. Stormwater is precipitation that falls onto developed surfaces, for instance rooftops, roads and parking lots, where it does not have the ability to soak into the ground, creating large quantities of runoff. The runoff picks up pollutants and debris, such as lawn chemicals, litter, lawn cuttings, leaves, oil, toxic chemicals from car leaks and pet waste, before entering storm drains and discharged into the Kansas River, untreated.

While many consider pet waste, lawn cuttings and leaves natural, sweeping them into storm drains or allowing them to be caught up in stormwater is detrimental to the river. All three consume oxygen in the water as they decay. If oxygen levels become too low, aquatic plants and animals could die. Wastes also carry bacteria and viruses that could be deadly to humans and wildlife. All chemicals discharged into the river will effect animal and plant life downstream.

Just one of inch of rain over Manhattan creates 325 million gallons of runoff. All residents can make commitments to help the Kansas River and all those downstream, by: flushing pet waste, picking up litter, never disposing of anything down storm drains, sweeping dirt on lawn, washing vehicles at commercial car washes, disposing of household wastes to the Riley County Hazardous Waste Facility, reporting illegal dumping to the City and discussing water recycling to landlord. Residents can also volunteer for the City cleaning up or installing storm drain signs. Follow @cityofmnhk on Twitter to see more tips every Friday.

To visit the City of Manhattan's Stormwater Management Department webpage, scan:

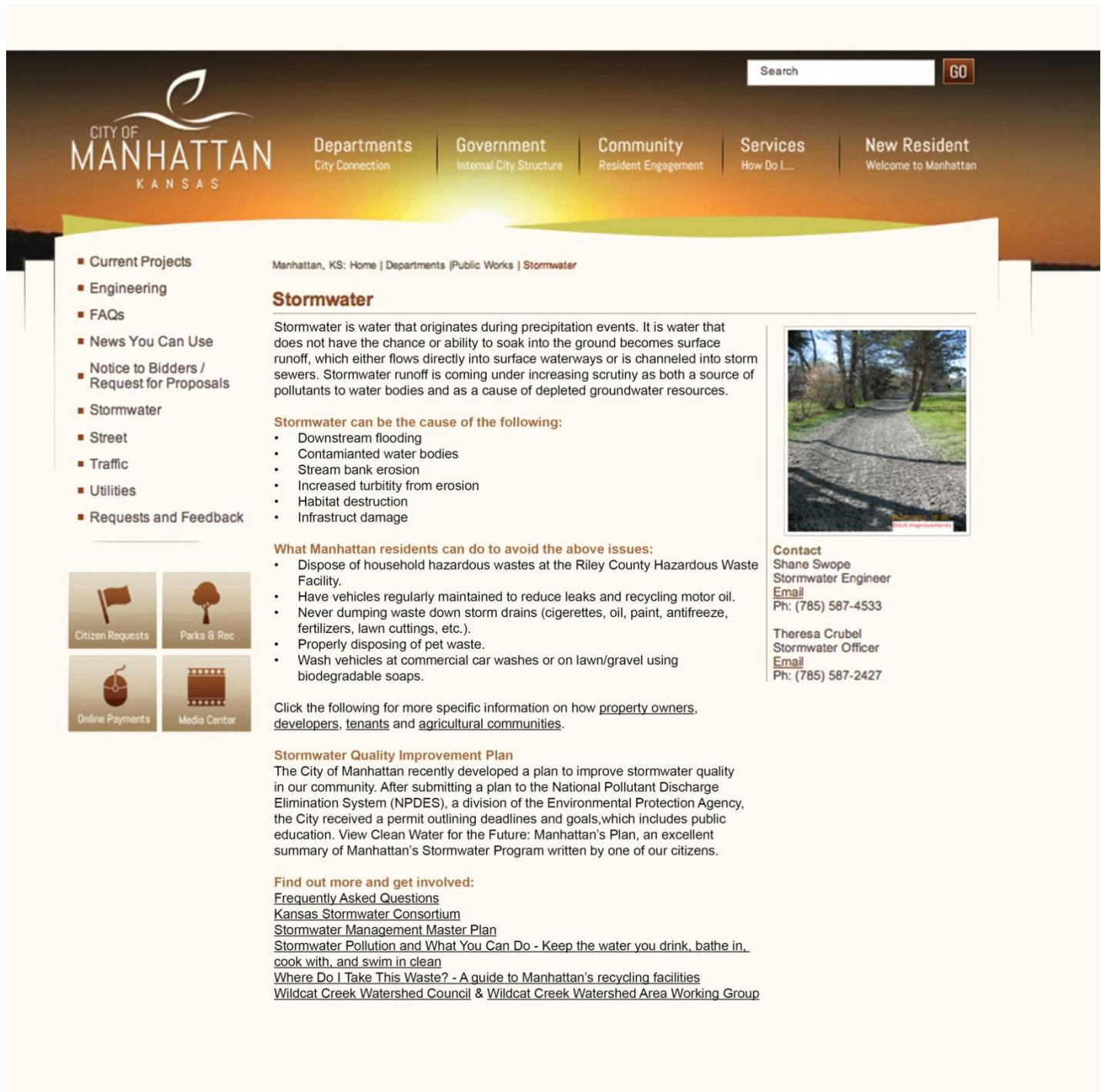



To visit the National Weather Service's flood inundation maps for Manhattan, scan:



## Appendix G.

### Suggested website improvements





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Citizen Requests



Parks & Rec



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## What You Can Do – Property Owners

Property owners can improve stormwater quality and reduce runoff by:


- Disposing of household hazardous wastes at the Riley County Hazardous Waste Facility.
- Having vehicles regularly maintained to reduce leaks and recycling motor oil.
- Never dumping waste down storm drains (cigarettes, oil, paint, antifreeze, fertilizers, lawn cuttings, etc.).
- Properly disposing of pet waste.
- Washing vehicles at commercial car washes or on lawn/gravel using biodegradable soaps.
- Planting rain gardens and buffer areas.
- Using rain barrels to catch roof runoff.
- Planting native plants that require less water.
- Properly storing, applying and disposing of lawn, garden and industrial chemicals.
- Installing dripline infiltration trenches, dry wells, infiltration steps, pervious walkways, water bars, green roofs, etc.
- Installing terraces or retaining walls on sloped yards.
- Mixing peat moss or compost into the soil before planting.



Stormwater Infiltration Trench

**Contact**  
 Shane Swope  
 Stormwater Engineer  
[Email](#)  
 Ph: (785) 587-4533

Theresa Crubel  
 Stormwater Officer  
[Email](#)  
 Ph: (785) 587-2427



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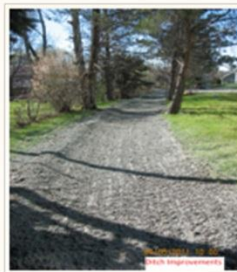
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### What You Can Do – Developers

Developers have a significant impact on stormwater runoff during construction.


During most of the construction period, the soil at the construction site is bare and susceptible to erosion from precipitation and construction equipment. Because of this, developers must take steps to ensure that erosion is avoided by following Best Management Practices (BMPs). After construction, they can recommend ongoing erosion control methods to their clients, including porous concrete, slope diversions, bioretention cells, preserving natural vegetation, grass-lined channels, etc.


[View Post Construction Best Management Practices Manual](#)





**Contact**  
Shane Swope  
Stormwater Engineer  
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Ph: (785) 587-4533


Theresa Crubel  
Stormwater Officer  
[Email](#)  
Ph: (785) 587-2427


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### What You Can Do – Tenants


Tenants can improve stormwater quality and reduce runoff by:

- Disposing of household hazardous wastes at the Riley County Hazardous Waste Facility.
- Having vehicles regularly maintained to reduce leaks and recycling motor oil.
- Never dumping waste down storm drains (cigarettes, oil, paint, antifreeze, fertilizers, lawn cuttings, etc.).
- Properly disposing of pet waste.
- Washing vehicles at commercial car washes or on lawn/gravel using biodegradable soaps.
- Choosing to live in a neighborhood that provides all the conveniences – close to work, shopping and green space.
- Talking to landlord about installing water recycling or a green roof.
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## What You Can Do – Agricultural Producers

Agricultural Producers can improve stormwater quality and reduce runoff by:

- Disposing of household hazardous wastes at the Riley County Hazardous Waste Facility.
- Having vehicles regularly maintained to reduce leaks and recycling motor oil.
- Never dumping waste down storm drains (cigarettes, oil, paint, antifreeze, fertilizers, lawn cuttings, etc.).
- Properly disposing of pet waste.
- Washing vehicles at commercial car washes or on lawn/gravel using biodegradable soaps.
- Looking at rain forecasts before applying fertilizers and pesticides.
- Properly storing, applying and disposing of fertilizers and pesticides.
- Properly treating and disposing of animal waste.
- Reducing livestock interaction with water sources.
- Installing detention basins, retention basins, tile drains, riparian buffers, weirs, stream exclusion fencing, etc.
- Maintaining septic systems.




**Contact**  
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Ph: (785) 587-4533

Theresa Crubel  
Stormwater Officer  
[Email](#)  
Ph: (785) 587-2427

**Financial Assistance:**

- USDA Financial Assistance Programs if you are voluntarily addressing water quality, erosion control, or other innovative conservation practices in your farming agricultural operations:  
<http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/>
- The Conservation Reserve Program: <http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp>



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### For More Information

**Downloads:**

- [Frequently Asked Questions](#)
- [What is Stormwater Pollution and What You Can Do](#)
- [Flint Hills Recycling Directory](#)
- [Stormwater Brochure](#)


**Additional Websites:**


- [Kansas Stormwater Consortium](#)
- [Stormwater Management Master Plan](#)
- [Wildcat Creek Watershed Area Working Group](#)
- [Wildcat Creek Watershed Council](#)





**Contact**  
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## Useful Links:

### Property Owners & Renters:

<http://www.kcare.ksu.edu/p.aspx?tabid=939>

<http://www.ks.nrcs.usda.gov/programs/eqip/nwqi.html>

Human Health Effects - <http://www.riverlink.org/stormwaterseriesfinal2.pdf>

EPA Health Lawn Care: <http://www.epa.gov/oppfead1/Publications/lawncare.pdf>

New Hampshire Homeowner's Guide to Do-It-Yourself Stormwater Solutions:

<http://des.nh.gov/organization/divisions/water/stormwater/stormwater-mgmt-homeowners.htm>

EPA site of BMP Categories <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/>

K-State Pollution Prevention Institute: <http://www.sbeap.org/water/green-infrastructure/tools-guidelines>

Compost Blankets - <http://www.epa.gov/npdes/pubs/compostblankets.pdf>

### Developers:

Construction BMPs :

[http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=min\\_measure&min\\_measure\\_id=4](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=min_measure&min_measure_id=4)

[www.ieca.org](http://www.ieca.org)

### Other:

1995 Stormwater Management Master Plan: <http://ci.manhattan.ks.us/index.aspx?NID=618>

KDHE Industrial Stormwater Programs: <http://www.kdheks.gov/stormwater/index.html>

KDHE Municipal Stormwater Program: <http://www.kdheks.gov/muni/ms4.htm>

Wildcat Creek Watershed Council: <http://www.wildcat-creek.org/>

EPA Flood Preparation & Recovery: <http://www.epa.gov/naturalevents/flooding.html>

FEMA Flood Preparation & Recovery: <http://www.ready.gov/floods>

FEMA National Flood Insurance Program: <http://www.fema.gov/national-flood-insurance-program>

USDA Conservation Programs:

<http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp>

EPA NPS Outreach Materials: <http://cfpub.epa.gov/npstbx/WhereYouLive.cfm?StateID=17>

Friends of the Kaw (Kansas River): <https://sites.google.com/site/friendsofthekaw/home>

WaterLINK: <http://www.k-state.edu/waterlink/>

KCARE Watershed Restoration & Protection Strategy:

Stormwater Pollution Contents -

<http://www.kingcounty.gov/environment/waterandland/stormwater/introduction/stormwater-runoff.aspx>