Managing Water Pollution With Urban Wetlands

How Cities Reduce Contamination from Farms and Urban Development

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EXECUTIVE SUMMARY

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How Cities Reduce Contamination from Farms and Urban Development

By J. Elizabeth Maas and E. Arthur Bettis III

Surface waters are among society's most valuable natural resources. They provide recreational and economic opportunities and support many critical ecological functions. They also present a serious challenge to Iowa policy makers. More than one-third of the surface waters assessed in Iowa are unable to support their designated uses, with a significant portion of water-quality degradation tied to agricultural runoff. While urban stormwater contributes a comparatively minor share of the pollution in the state's rivers and streams, local governments are mandated to deal with it.

The challenges today are the result of dramatic land-use change in Iowa over more than a century, beginning in the 19th century with the transformation of native prairies into agricultural fields, and the harvesting of woodlands for fuel and building materials. More recent change has brought the draining of wetlands for greater agricultural production, and changes to creeks, streams and rivers that moves water more quickly through the landscape. Today about 98.9 percent of the native prairie and woodland ecosystem has become an agricultural landscape dotted with a few moderate-size cities and many small towns. The impacts of this transformation are especially evident in surface water, and extend well beyond Iowa's borders, to the ecosystem effects related to hypoxia in the Gulf of Mexico and to migratory bird populations that rely on wetland habitat in the Central North American flyway.

This report deals with the result of these great changes in Iowa. In towns and cities, stormwater is rainfall and/or snowmelt that runs off roads, parking lots, roofs and other impermeable surfaces. It is usually directed via culverts and storm drains to the nearest ditch, stream, river or lake. Flood and erosion control, water quality, community health, and management of greater ecosystem services require a local action.

Stormwater Management

Stormwater is a challenge for cities no matter the source. Towns and cities do have options when faced with managing their stormwater and agricultural runoff from outside their jurisdiction. In Iowa, communities are seeing that constructed wetlands are a very effective practice for managing stormwater and improving water quality in urban and rural environments. Constructed wetlands modify peak flow rates and floods in streams and rivers by temporarily storing water and releasing it more slowly than it enters the wetland and/or allowing a portion of the water to infiltrate into the local groundwater.

Constructed wetlands take a variety of forms including stormwater basins, the most widely used method; bioswales, which are designed with vegetation and permeable soil mixtures to maximize

the time water spends before moving out; and bioretrention cells (or bio-cells) that capture and temporarily pond water from surfaces such as parking lots and roofs.

Constructed wetlands also offer a wide range of cost-free benefits to people and the environment. Properly constructed and maintained wetlands are attractive water features that enhance the local scenery and provide opportunities for a variety of outdoor recreational activities such as hiking, bird watching, nature photography, picnicking, and a variety of other outdoor recreational pursuits. Larger wetlands may provide opportunities for boating, canoeing, kayaking, swimming and fishing, and waterfowl hunting.

Wetlands also contribute to the diversity of habitats. They support wetland plants, amphibians, insects, birds and other wetland species with local habitat and are important components of regional landscapes that support migratory waterfowl. Habitat diversity is critical for protecting biodiversity and for ensuring that organisms have suitable habitat and habitat corridors to better adapt to changing climate.

A final cost-free benefit of constructed wetlands is that some of the stormwater they capture infiltrates and contributes to aquifer recharge. This is an important benefit since much of what runs off today's altered landscape formerly infiltrated and recharged local and regional aquifers. A large percentage of Iowa's water-supply needs are met by groundwater, and recharge is critical to maintaining the abundance and quality of groundwater. Groundwater also contributes to the state's streams, springs, lakes, and wetlands year-round, sustaining them and the habitats and industries they support during droughts and dry summer months.

Many Iowa municipalities must manage not only stormwater generated within their limits, but also runoff from agricultural sources outside their jurisdiction. Increasingly, they choose to manage all types of runoff with constructed wetlands. These wetlands bring stability to the watersheds they serve by reducing storm event energy and decreasing flood events. They improve overall water quality, increase biodiversity, and build economic stability through the reduction of pollution and the creation of beautiful attractive community spaces for citizens to enjoy.

This report provides a general guideline for local governmental and private organizations to construct and properly maintain constructed wetlands. This guide also identifies potential collaborators and funding sources, and outlines regulations and permitting requirements for some constructed wetlands.

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POLICY BRIEF

Managing Water Pollution with Urban Wetlands

How Cities Reduce Contamination from Farms and Urban Development

By J. Elizabeth Maas and E. Arthur Bettis III

Cities and towns often use constructed wetlands to manage water. Many Iowa municipalities are faced with managing not only stormwater generated within their limits, but also water from agricultural sources originating outside their jurisdiction. Managing urban and agricultural runoff, and the pollutants associated with it, provides unique challenges that are often best met with constructed wetlands. In addition to their benefits as stormwater infrastructure, wetlands also offer value-added opportunities for community and ecosystem improvement. They can be attractive community assets for citizens to enjoy. This report provides an overview of how constructed wetlands function, their ecological benefits, regulations related to wetlands, how to build and manage wetlands, and where to look for funding for a constructed wetland.

Introduction

Historically, Iowa has seen dramatic land use change. Settlement and agricultural development proceeded rapidly during the second half of the 19th century as native prairies were turned into agricultural fields, and woodlands were harvested for fuel and building materials. Alteration of the landscape continued into the 1900s as extensive draining of wetlands to facilitate agricultural production dried up most of the state's natural wetlands (Jaynes and James, 2007). Without the deep-rooted prairie vegetation and well-vegetated creeks and streams, erosion and flooding increased. Creeks were straightened to make rivers and creeks more efficient in carrying floodwater, more wetlands were drained and extensive systems of drainage tiles installed to improve drainage and create more arable land. The manner in which water moves through the landscape has drastically changed. Today approximately 98.9 percent of the native prairie and woodland ecosystem has been transformed into an agricultural landscape dotted with a few moderate-size cities and many small towns. The impacts of this transformation are especially evident in surface water, and extend well beyond Iowa's borders, to the ecosystem effects related to hypoxia in the Gulf of Mexico and to migratory bird populations that rely on wetland habitat in the Central North American flyway.

Surface waters are among society's most valuable natural resources. They provide recreational and economic opportunities and support many critical ecological functions. When vegetation cover is adequate much of the precipitation infiltrates into the soil where it provides for plants and other organisms and recharges groundwater. If vegetation cover is inadequate, or when the rate of precipitation exceeds the soil's ability to absorb it, runoff occurs. Many land use activities have decreased the ability of the land surface to absorb precipitation and as a result, runoff amounts and rates are much higher than they were before the advent of towns and modern farming. Flooding in Iowa in 1993, 2008, 2010 and 2011 has demonstrated how dramatically the absorptive native

landscape has been altered and replaced by one that efficiently sheds water. Too much runoff leads to flooding, but excess water is not the only problem. Sediment, excess plant nutrients, pesticides, and other pollutants washed and leached from agricultural fields, lawns and urban landscapes degrade surface waters and impair their function. Today more than one-third of the surface waters assessed in Iowa are not able to support their designated uses (U.S. EPA, 2006 http://water.epa.gov/lawsregs/guidance/cwa/305b/96report_index.cfm). A significant portion of this water quality degradation can be tied to agricultural runoff with urban stormwater contributing a minor part. (Heffernan, Galluzzo & Hoyer 2010 http://www.iowapolicyproject.org/2010docs/100927-nutrients.pdf)

In towns and cities stormwater is rainfall and/or snowmelt that runs off roads, parking lots, roofs and other impermeable surfaces. It is usually directed via culverts and storm drains to the nearest ditch, stream, river or lake. In agricultural areas stormwater runoff enters streams and other water bodies via overland flow, rills and gullies and road ditches when the soil's ability to infiltrate rainfall or snowmelt is exceeded. While agricultural land is the source of most of the contaminated runoff in Iowa, managing stormwater that enters rivers and streams is a mandated responsibility of local government. Flood and erosion control, water quality, community health, and management of greater ecosystem services require a local action.

Flowing Surface Waters

Water and Watershed

Surface water is closely linked to the surrounding landscape in a variety of ways (Frissell et al. 1986). Flow, or discharge, can respond quickly to precipitation because the watershed serves to collect rainfall or snowmelt from uplands and slopes and route it to surface water through a variety of mechanisms including artificial drainage systems, shallow and deep groundwater pathways, and overland flow. Each of these mechanisms can transport sediment and other pollutants. It generally is overland flow, however, that erodes soil and transports most sediment and compounds, such as phosphorus (P) that are attached to soil particles and transported to surface waters. Whether a given precipitation event will generate overland flow is dependent on soil conditions, the type and extent of vegetation, and the intensity and duration of the precipitation.

During dry periods, water seeping through saturated sediment and rock is the source water for surface water. When the discharge in a stream consists only of inputs from shallow and deep subsurface flow, the stream is said to be at baseflow. During baseflow, erosion and sediment transport are minimal and streams tend to have high water clarity. Compounds that have infiltrated the soil and entered the shallow groundwater, such as nitrates (N), will be transported to the stream with the movement of groundwater. When the level of the shallow groundwater drops below the streambed, streams may go dry. Such streams are referred to as ephemeral, as opposed to perennial streams, which flow continuously. The shallow channels and swales occupied by ephemeral streams often have well-developed vegetation, and such vegetation slows the movement of water and decreases erosion during runoff periods.

The soils and geologic material of a watershed have a strong influence on surface and groundwater. The geology of a watershed influences water chemistry as well as the types and sizes of materials found on bed and banks of streams draining the watershed. Bed and bank material of low-gradient streams often will consist mainly of small particles, such as silt, clay and sand. Larger or higher-gradient streams often contain sandy bed and bank materials as well as gravel bars. The interface between the streambed and the water column is the benthic zone, and it is here that many of the important chemical and biological processes that occur within streams take place.

The riparian zone, the area immediately adjacent to stream channels, also plays a critical role in the health of surface waters. Riparian zones influence the movement of water and sediment via slowing, trapping and redistributing before reaching the stream channel. In the riparian zone subsurface water often passes through organic-rich soils where, given the right conditions, nitrate dissolved in the water is removed. This process, denitrification, also occurs within the bed and benthic zone of healthy streams. Sediment and sediment-attached pollutants can also be removed from runoff in the riparian zone, especially if a good vegetation cover is present.

Surface Water Degradation

In agricultural and urban landscapes degradation of surface waters results from changes in the watershed, riparian vegetation, and chemistry of runoff and groundwater. Activities that cause degradation are called stressors because they place a stress on the health of the system. The type, intensity, and location of the stressors determine the impact on surface waters. Often, multiple stressors occur simultaneously. Likewise, activities to improve the situation can address more than one stressor. For example, a constructed wetland might trap sediment, increase the rate of denitrification, and provide habitat — addressing three common stressors to Iowa's surface waters.

Why are Nitrogen and Phosphorus a problem in surface waters? Nitrogen and Phosphorus have the same fertilizing effect on algae and aquatic plants that these nutrients have on crops and lawns. The result of nutrient loading to surface waters is eutrophication; excessive growth of algae and aquatic plants. Severe eutrophication, which lowers the amount of oxygen dissolved in the water, kills fish, facilitates harmful algal blooms, causes odor problems, and decreases the recreational and aesthetic value of surface waters. Eutrophication also decreases the diversity of pollution-sensitive animals but may increase the abundance of undesirable species. Surface and shallow groundwater have a natural capacity to process and retain nutrients because of the biological activity of microorganisms in the soil and the benthic zone. However, excessive input of nutrients from the watershed or decreasing the amount of time water spends in contact with the soil through artificial drainage can overwhelm this natural cleansing capacity. When this occurs, surface waters become a conduit for transporting excess nutrients and other pollutants to downstream water bodies, such as lakes, ponds, rivers, and the ocean.

Many of the characteristics of streams, such as temperature, turbidity and sediment size distribution, depend on the flow of water. As a result, changes to the natural hydrology, or patterns in discharge, act as a stressor to stream organisms. The life histories of many aquatic invertebrates and fish are closely tied to particular water temperature, flow and streambed conditions. Modifications to the hydrology of a watershed, such as channelization and tiling, change the flow conditions in the stream. Physically, a stream responds to hydrologic change by channel — adjustments such as by down-cutting, filling, widening, narrowing, or pattern shift. Down-cutting can lead to bank erosion, whereas filling will lead to the loss of channel capacity and flooding. Biologically, changes in hydrology result in loss of aquatic species for which the stream no longer supports suitable flow, temperature, substrate and chemical conditions.

Surface waters that are degraded or impaired typically suffer from multiple stressors, and it can be very difficult to isolate the impact of any one stressor. In the case of some stressors the origin may be in the upland areas of a watershed, whereas other stressors may originate locally. Designing, implementing and assessing programs to improve the health of surface waters should, therefore, consider all the interacting components of water bodies and their watershed as an integrated, temporally dynamic system.

Table 1. Approaches to Restoring the Natural Functions of These Systems

Principal stressors to flowing surface waters and their effects.	
Stressor	**Effects on Surface Waters**
Runoff Sediment Runoff	Increases turbidity; impairs interaction zone with groundwater; decreases primary production and food quality; in-filling of interstitial crevices harms crevice-occupying organisms and decreases availability of suitable substrate for gravel-spawning fishes; coats gills and respiratory surfaces; decreases water body depth and bed variability
Nutrient Enrichment	Increases autotrophic biomass and production resulting in proliferation of filamentous algae, especially if light also increases; favors some undesirable species such as cattail and reed canary grass, accelerates litter breakdown rates; fosters a decrease in dissolved oxygen and a shift to more tolerant, usually less desirable species
Contaminant pollution	Increases heavy metals, synthetics, and toxic organics in suspension and in bed materials and increases concentrations of dissolved pharmaceuticals and pesticides; increases deformities; increases mortality rates and negatively impacts invertebrates; depresses growth, reproduction condition, and survival among fishes; endocrine system disruption negatively impacts reproduction of some water-dwelling organisms
Hydrologic Alteration	Alters rainfall runoff relationship promoting increases in flood magnitude and frequency; changes shallow groundwater (baseflow) contribution to stream flow; alters channel behavior; increases nutrient, sediment, and contaminant transport efficiency thereby negatively impacting downstream areas, decreases residence time of water in marshes; increases number and intensity of wetting and drying cycles in marshes
Riparian Zone Clearing/Canopy Thinning	Decreases shading which increases water temperatures and the magnitude of daily temperature variation during low flow; increases light penetration and in-water plant growth; may promote the growth of some invasive species such as reed canary grass, decreases stream bank stability and inputs of litter and wood; decreases trapping of sediment from adjacent landscape; alters quality and character of dissolved organic carbon reaching streams; lowers retention of benthic organic matter by decreasing direct input and loss of retention structures; alters food webs
Loss of woody debris (in streams)	Decreases habitat; decreases stream energy dissipation; decreases bank stability; decreases fine-grained sediment and organic material storage; disrupts habitats by altering flow hydraulics; has deleterious effects on invertebrate and fish diversity

Stormwater Management

What options do towns and cities have when faced with managing their stormwater and agricultural runoff from outside their jurisdiction? Constructed wetlands are a very effective practice for managing stormwater and improving water quality in urban and rural environments. Constructed wetlands modify peak flow rates and floods in streams and rivers by temporarily storing water and releasing it more slowly than it enters the wetland and/or allowing a portion of the water to infiltrate into the local groundwater.

Constructed wetlands also offer a wide range of cost-free benefits to people and the environment. Properly constructed and maintained wetlands are attractive water features that enhance the local scenery and provide opportunities for a variety of outdoor recreational activities such as hiking, bird watching, nature photography, picnicking, and a variety of other outdoor recreational pursuits. Larger wetlands may provide opportunities for boating, canoeing, kayaking, swimming and fishing, and waterfowl hunting.

Wetlands also contribute to the diversity of habitats. They support wetland plants, amphibians, insects, birds and other wetland species with local habitat and are important components of regional landscapes that support migratory waterfowl (Gallant et al., 2011). Habitat diversity is critical for protecting biodiversity and for ensuring that organisms have suitable habitat and habitat corridors to better adapt to changing climate.

A final cost-free benefit of constructed wetlands is that some of the stormwater they capture infiltrates and contributes to aquifer recharge. This is an important benefit since much of what runs off today's altered landscape formerly infiltrated and recharged local and regional aquifers. A large percentage of Iowa's water-supply needs are met by groundwater, and recharge is critical to maintaining the abundance and quality of groundwater. Groundwater also contributes to the state's streams, springs, lakes, and wetlands year-round, sustaining them and the habitats and industries they support during droughts and dry summer months.

Types of Constructed Wetlands

Stormwater basins

Stormwater basins are the most widely used method for managing stormwater in Iowa. Basins are designed to collect stormwater and slowly release it at a controlled rate to prevent flooding and erosion in downstream areas. While effective for flood and erosion control, these practices are not very effective for improving the quality of stormwater runoff and thereby preventing impacts to stream biological systems. There are two kinds of stormwater basins: detention basins and retention basins.

The main difference between the two types is whether the basin is designed to have a permanent pool of water — like a traditional "pond." A low flow orifice controls the water level in these basins. Most of the time the orifice is part of a metal or concrete structure called a riser. A detention, or dry, basin has an orifice level with the bottom of the basin so that all of the water eventually drains out at a controlled rate and it remains dry between storms – hence, a dry basin. Retention basins have a riser with an orifice at a higher point so that it retains a permanent pool of water. Detention basins can provide water quality benefits by reducing the amount of sediment and sediment-attached pollutants entering streams. Some retention basins, known as stormwater wetlands, are designed with significant wetland vegetation that promotes biological activity to reduce the concentration of other pollutants such as Nitrogen and Phosphorous.

Bioswales

Bioswales are swaled drainage courses with gently sloped sides that contain vegetation growing in a permeable material (usually a soil/compost/sand mixture) and/or riprap. The water's flow path, along with the wide and shallow ditch, is designed to maximize the time that water spends in the swale, which aids the trapping of sediment and attached pollutants and infiltration and biological treatment of soluble pollutants. Swales can be designed with an underdrain (dry swale) or without an underdrain. In the latter case, the bioswale acts much like a long, narrow intermittent wetland.

Bioretention Cells (Bio-cells)

Bio-cells are vegetated depressions that are sized and located to capture and temporarily pond runoff from impervious surfaces such as parking lots and roofs. They are filled with permeable bio-soil to a depth of 42 inches to 48 inches underlain by a perforated drainpipe in a rock bed, covered by sand. They are typically designed to pond from 6 inches to 9 inches following a runoff event and drain down in 12 to 24 hours. Bio-cells are planted to appear garden like, and plantings of deep-rooted native plant species are especially successful. Bioretention cells are very effective at filtering sediment and removing pollutants and excess nutrients from stormwater if properly designed and installed.

Other Biological Treatment Infrastructure

Other measures are available to manage local stormwater, although they will not treat agricultural flows. Green roofs are vegetated roofs that absorb most of the rainfall and thus decrease stormwater runoff at the source. Raingardens are small-scale bio-cells, usually without a subdrain, that collect runoff and allow it to infiltrate. These low-cost measures typically treat runoff from single downspouts or relatively small parking lots or other impermeable surfaces. Curb cuts are bioswales along streets where curbing along the gutter directs runoff into the bioswale. They function to remove sediment and other debris in the runoff and allow some of the runoff to infiltrate into the bioswale's engineered soil.

For detailed information about these and other stormwater infrastructure, see the Iowa Stormwater Manual: http://www.iowadnr.gov/Environment/WaterQuality/WatershedImprovement/WatershedBasics/Stormwater/StormwaterManual.aspx

Information regarding small-scale homeowner or business owner stormwater management is available at Rainscaping Iowa: http://www.rainscapingiowa.org/

Contaminant Removal

Stormwater wetlands vary widely in their ability to remove contaminants. All types of stormwater wetlands are effective at removing sediment. Excess nutrients in stormwater are also effectively removed in wetlands. Nitrogen concentration of stormwater can be reduced by 20 percent to 40 percent in wetlands (Dinnes, 2004). Several processes including denitrification, dilution, temporary nutrient sequestration in soil organic matter, trapping and retention of transported Nitrogen in nutrient-enriched sediments and particulates, and vegetative assimilation operate in wetlands to reduce nutrient concentrations. Heavy metals generally accumulate either in sediments or are associated with organic detritus and may or may not be taken up by plants and animals living in the wetlands. Many pesticides, organic compounds, oils and greases are broken down by microbes in these wetlands. Removal rates for bacteria are fair to good, and many viruses are immobilized or destroyed in wetlands.

Small wetlands have a large edge to surface area ratio and serve to slow water flow through them more than do larger wetlands. Wetland vegetation also slows water flow and attenuates peak runoff flows. In addition, a significant amount of water may be removed from a wetland by evapotranspiration. Because of all these factors, a series of small constructed wetland areas are generally more effective at reducing peak stormwater flows and reducing pollutant levels than a single large wetland.

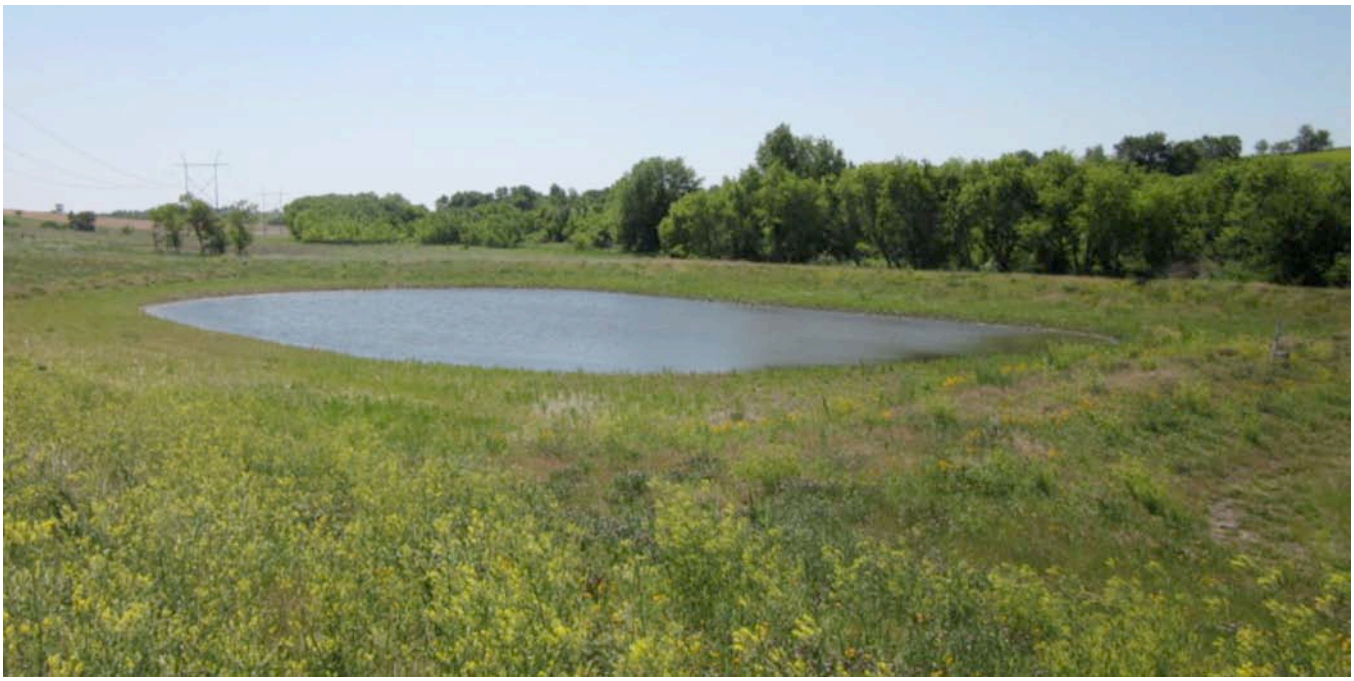
Before constructing a wetland for stormwater management, the local hydrology must be understood in terms of catchment area and runoff volumes, local recharge or discharge areas, soil

types and the seasonal pattern of water flow. In a groundwater recharge area, water in wetlands contributes to the recharge, and care must be taken to ensure that polluted or nutrient-rich waters do not enter and contaminate the ground water. In a groundwater discharge area, polluted stormwater may be diluted with ground water and if the groundwater quality is good, water quality improvement of stormwater entering the wetland will occur.

Conclusion

Many Iowa municipalities are faced with managing not only stormwater generated within their limits, but also runoff from agricultural sources outside their jurisdiction. Constructed wetlands are increasingly being used to manage all types of runoff. In general, constructed wetlands bring stability to the watersheds they serve by reducing storm event energy and decreasing flood events. They improve overall water quality, increase biodiversity, and build economic stability through the reduction of pollution and creation of beautiful community spaces.

The following information provides a general guideline for local governmental and private organizations to construct and properly maintain constructed wetlands. This guide also identifies potential collaborators and funding sources, and outlines the regulations and permitting requirements for some constructed wetlands.



The Iowa City Landfill wetland mitigation site now meets state and federal requirements, has created habitat for wildlife and captures and treats runoff before it reaches Phoebe Creek (photo May 2012 — see summary, page 26).

A Wetland How-To Guide

Managing Stormwater With Constructed Wetlands in Urban Areas

The Iowa Policy Project report, Managing Water Pollution with Urban Wetlands, presents the reasons local governments should and must deal with water runoff issues caused not only within their communities, but from the surrounding agricultural areas, which are a source of significant water-quality degradation in Iowa. This guide is designed to help cities and developers deal with this important responsibility.

Site Design

Proper site selection and design is a major factor in determining the success of the wetland creation project. IDALS Urban Conservationists are ready to meet and advise city leaders and have a list of Rainscaping contractors certified to design and install these types of structures.

What to consider

The surrounding hydrology should be considered when designing the stormwater management system. How will the adjacent properties change over time, might they add additional water, sediment, or other pollutants to the site? The best design should include a watershed perspective instead of just managing for the water that is entering the site at this time. Quality of water should also be considered. Agricultural water entering an urban site near a city border may contain different types and perhaps great amounts of nutrients. Other important site characteristics include soils, invasive species and sensitive areas.

Soils

The soils present at a site strongly influence how water infiltrates and the degree to which pollutants and excess nutrients can be removed. These are some of the most important considerations for identifying a site that will perform well. A trained professional should evaluate soils during the planning stages of the project. We recommend contacting an IDALS Urban Conservationist to find a qualified person.

The Iowa City Eastside Recycling Center demonstrates careful engineering of a constructed wetland, especially with regard to soil and the choice of plantings.

The desirable soil characteristics vary with the type of stormwater control method under consideration. Detention basins and constructed wetlands should have soils that have a shallow water table and allow some infiltration, but not so much that they are prone to either drying out or to frequent very low water levels. Soils that meet these requirements are generally classified as "hydric soils" by the Corps. Retention basins, on the other hand, can be successful where the water table is deeper or where soil infiltration rate is higher since these structures are designed to only temporarily pond excess stormwater.

Soils in rain gardens, biocells and bioswales are generally engineered to provide a combination of relatively rapid infiltration and water and nutrient holding capacity that provides effective control of both stormwater volume and pollutants. (See Eastside Recycling project, photo above and next page.) One very important key to the proper performance of any of these stormwater control systems is to avoid excessive compaction of the soils, because compaction significantly decreases infiltration rates. Compaction can cause failure in retention basins, bioswales, biocells and rain

Eastside Recycling Center Biocell Site

Iowa City, Iowa

The city of Iowa City constructed six biocells covering one-third of an acre at the East Side Recycling Center to educate citizens on best stormwater management practices using Iowa's native prairie species. The site provides a variety of other water management features such as rain gardens, a green roof, permeable pavers and porous concrete, which control runoff for the site and also provide examples for home use. The center officially opened April 2012. While not technically a wetland, the site serves the important function of managing stormwater runoff in an urban setting. Planning and creation of the biocells spanned several years to assure a successful project. A consultant was hired a few years prior to construction to determine a good soil medium that would drain at a preferred rate and also have the proper nutrients and water-holding characteristics for plant growth and minimal watering. The city then created a test plot with this soil mix to experiment with over 60 plant species to see which grew successfully. Another consultant was hired to determine a landscaping scheme for these the chosen species. The design plan includes a variety of colors, with each biocell containing various species that bloom from May to October.

The biocells were built from fall 2010 through spring 2011. Contractors had difficulty building to specification without compacting the biocell soil, so continued inspection by city staff was needed to ensure compliance with the design. The biosoil was mixed offsite and once the cells were constructed, the soil was delivered and placed in the cells. The cells were rototilled by the city because of compaction from contractors' activities and then covered with 3-4 inches of wood mulch. City staff planted over 2,000 1-inch plugs. To deal with drought conditions and grazing by rabbits and deer, staff used paper cups to shade small plants, and caged plants preferred by rabbits and deer. The plantings succeeded, most reaching full size within two to three years of planting. Annual weeds, an issue the first two years, have declined significantly.

This property had been an asphalt plant and degraded parking lot that contributed significant runoff directly to the bordering stream. The biocells now keep stormwater from the site's roofs and parking areas from reaching the creek rapidly and also remove oil and other potential pollutants washing from the parking areas before the stormwater that infiltrates the biocells enters the stream. The site has changed from an eyesore that was negatively impacting the adjacent stream to a visually pleasing and welcoming public area with habitat for many insects, amphibians, birds and other species.

Site	City of Iowa City East Side Recycling Center
Age	3 years old
Size	0.3 acres
Problematic Design Features	Stormwater does not sheet flow from parking lot as designed but enters at biocell at high energy in specific points causing severe erosion issues
Current Status	Site is becoming more stable yearly, due to regular maintenance by city staff
Cost	$78,000 not including research, planning, maintenance
Ownership	City of Iowa City
Location	Southeast side of Iowa City
Hydrologic setting	Adjacent to two joining tributaries which join into Snyder Creek
Management Issues	Weed management, mulch movement, hydrologic control
Solutions	Routine weeding, berms built, mulch reapplication
Benefits	Widely enjoyed by citizens, high visibility, a variety of educational opportunities

gardens. Close monitoring during the construction phase is strongly suggested since compaction of the soil is a common and desirable practice when constructing, the berms, dams and embankments often associated with stormwater wetlands. There are a variety of recommended soil infiltration rates and suggested mixtures of sand, silt, clay, topsoil, compost or other materials suitable for engineered soils in stormwater treatment systems. The details of the engineered soil will depend on site characteristics, the amount of stormwater that needs to be controlled and treated, and the moisture and nutrient needs of the plantings in the system. Find more information and recommendations from an IDALS Urban Conservationist or from Iowa Rainscaping (http://www.rainscapingiowa.org/index.php/home).

Existing invasive species management

Prior to construction, an evaluation of the site should include an invasive species investigation. Rural sites with adjacent natural vegetation have been known to fail due to the influx of invasive species. Success of these sites would have been better if it was known that invasive species needed to be managed in properties adjacent. The county weed commissioner will have a list of noxious weeds that should be looked for but many other species, not listed also cause problems. Some of the common wetland invaders include reed canary grass (*Phalaris arundinacea*), Purple loosestrife (*Lythrum salicaria),* Common reed (*Phragmities australis)* and Japanese hops (*Humulus japonicus*). For information on treatment and removal, your county Iowa State Extension[1] office should have recommendations on how best to eradicate or remove these types of species. An additional resource is the Midwest Invasive Plant Network.[2]

Sensitive areas

If not part of a required sensitive areas review, the designer should consider other sensitive features. Sometimes these can be integrated in a unique way to the site. Things to consider include adjacent streams or watercourses, existing wetlands, steep slopes, delicate soils, woodland or native prairie habitats.

Scope of projects

Timing and order of operations is important to consider when constructing wetlands to manage stormwater. Construction during the drier, fall months will reduce the risk of erosion from rainfall and allow for a dormant (winter-time) seeding of the site. However, if other mature vegetation will be used, those materials will need to be installed in the spring following fall construction. Different seeding and planting times might require several visits by contractors; this can increase costs.

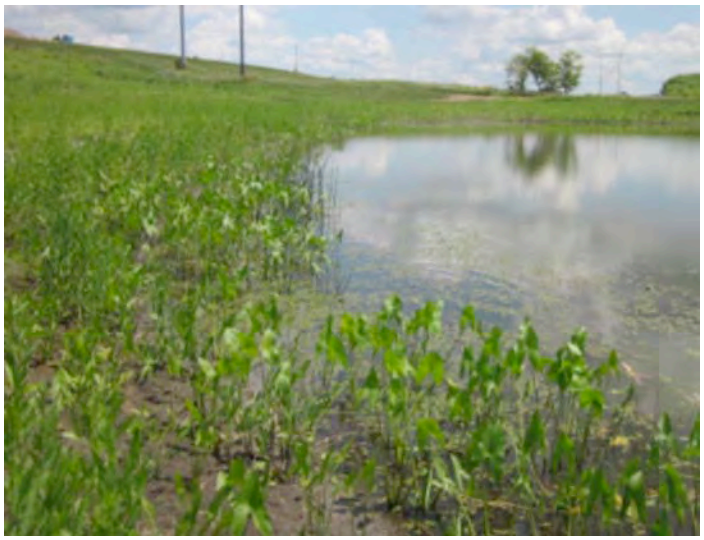
Additionally, odd weather patterns or unusual and extreme weather events can make it more challenging to correctly establish vegetation in wet areas. In the recent past, Iowa has experienced both localized flood events and periods of drought; success of young wetland vegetation can be limited by these extremes. While there is no way to plan for the extremes, contracts and specifications for seeding and planting work may need to include provisions for re-seeding of an area or other warranties for materials. This also may increase costs.

Costs

Naturally there are the upfront costs of engineering, building, planting, erosion control, and permitting fees; stormwater management projects take time. But the costs don't stop there. After construction, the plantings must be established, and the site maintained and managed throughout its functional life. This may require a funding source to be set aside to pay for all upkeep.

[1] http://www.extension.iastate.edu
[2] http://www.mipn.org

Average costs of constructed wetland are $15,000-40,000/acre depending on what type of wetland must be constructed. Constructing shallow water, emergent habitats is less expensive than the construction of wooded wetland, which includes planting trees and shrubs. Additional costs for establishing and maintaining the wetland site are variable and should be included in cost estimates. These costs depend on scale, condition of existing site, availability of staff or volunteers, local market for contractor services and other factors. Case studies presented in this report outline costs of different projects, including the Iowa City Landfill wetlands mitigation project, where emergent vegetation is shown in the photo at right.



Public Awareness

One of the greatest challenges of trying something new is public opinion. "Attracting wildlife" may mean improving wildlife to one person or attracting undesirable species like Canada geese. Long-term success of a project involves early public support and awareness. These projects take time to construct and establish, but the final outcome produces aesthetically pleasing and environmentally beneficial sites that can become public treasures for outdoor enjoyment.

When citizens request information about the benefits of constructed wetland sites a good resource is the Iowa Association of Naturalists publication entitled Iowa's Wetlands.[3] Another resource is provided by the NRCS at www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p_006832.pdf and provides great information.

Construction and Seeding

Grading

As with construction of any new landscape feature, protecting the site from erosion is strongly encouraged. These types of areas must function to drain water away from the site, but more importantly to allow water to infiltrate down into the soil, to re-charge the groundwater. Good infiltration is dependent upon the site having little compaction. This can be challenging considering the heavy equipment used to construct these sites. Irregularities within the mitigation site are encouraged, as minor divots and topography of the basin bottoms will increase biodiversity. However, linear tracks that direct flow and increase erosion should not be allowed to remain. Linear, heavy equipment track marks should be perpendicular to the direction of flow.

Compaction will likely cause the site to fail. If the site has a history of previous use it may be necessary to amend the soils with additional materials or "rip-till" the existing soils to reduce historic compaction and improve functionality of the site. Again, understanding soil type and proper construction techniques is crucial to success of the site.

Seeding

First the seedbed must be prepared. Recently graded sites should be disked by smaller equipment and then harrowed to create a level, friable soil surface. Once the seedbed has been prepared, the

[3] www.extension.iastate.edu/publications/ian204.pdf

best time to seed native wetland species is in the late fall or early winter. Seed may be broadcast directly onto snow as native seeds need the scarification (freeze/thaw action) produced by winter weather. This greatly improves germination. Once the seeding has been completed, the site should be culti-packed or rolled to "press" the seeds into the friable soil; this can also reduce erosion.

Prepared seedbeds of newly graded sites usually provide ample opportunities for good seed-to-soil contact, which is also very important for improving germination. While the use of a seed drill has become popular, the best technique for seeding native wetland is broadcasting by hand or broadcast seeder onto a properly prepared seedbed. The use of sand or cat litter when broadcasting native seeds will help to evenly disperse and anchor lightweight seeds. It is common to use a nurse crop of oats or annual rye both as erosion control, as an indicator for success, and to reduce predation of native seeds from mice and other common seed eaters.

Recommended Seed Suppliers

Ion Exchange
1878 Old Mission Drive
Harpers Ferry, IA 52146
1-800-291-2143
http://www.ionxchange.com/

Prairie Nursery, Inc.
P.O. Box 306
Westfield, WI 53964
1-800-476-9453
http://www.prairienursery.com/store/

Prairie Moon Nursery
32115 Prairie Lane
Winona, MN 55987
1-866-417-8156
https://www.prairiemoon.com/

Iowa Prairie Seed Company
911 Elm Avenue
Story City, Iowa 50248
1-515-733-4634
http://www.iowaprairieseed.com

Use of Plugs vs. Seed

Over the last few years it has become evident that the use of seed alone can create greater challenges when attempting to establish a site. In addition to seed, it is common to also recommend small plant plugs. While more expensive than seed and require more work to plant, these plugs provide instant competition for weeds and invasive species that may infiltrate; in the long run saving money later spent on weed control. Plugs of species similar to those listed in the seed mix can be purchased and planted on site to provide more immediate success. Additionally, many communities see plugs as an opportunity for community volunteers and groups to participate in the installation and ownership of the site.

Another alternative is the use of seed balls.[4] Seed balls are small balls of clay, compost and seed that can be made by groups of volunteers, dried, and then spread by volunteers. These small balls grow up into diverse plugs and can more quickly improve the success of a site.

It should be noted that sites with large numbers of waterfowl might need to protect their plug and seed ball plantings. Geese and other wildlife love to eat freshly seeded or young natives. The use of netting, loud sounds to deter their presence and even guard dogs have helped reduce the pressure these wild animals can exert on young sites.[5]

Trees and Shrubs

Native trees and shrubs can also be used. If possible it is always best to plan for biodiversity and this includes planning plantings that will attract and feed insects (pollinators), birds and other

[4] http://www.wildflower.org/step/show.php?id=28&frontpage=true
[5] http://www.berrymaninstitute.org/pdf/urbangeese.pdf

wildlife. Trees and shrubs that produce spring flowers, summer berries and fall nuts are most attractive. Many acceptable native trees and shrubs can be purchased from the Iowa State Nursery: http://www.iowadnr.gov/Environment/Forestry/StateForestNursery/SeedlingCatalog.aspx

Alternatives to Natives

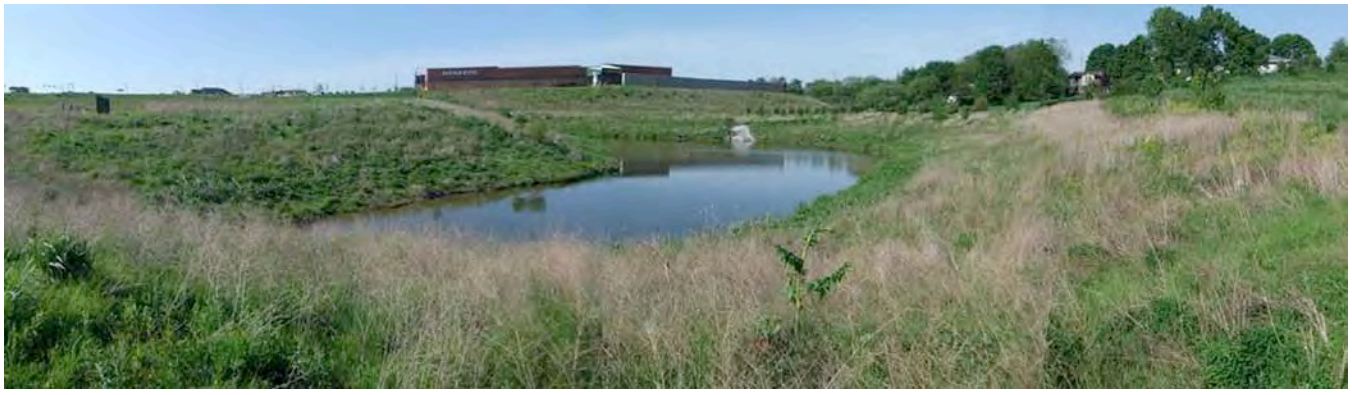
Because natives are adapted to local conditions they are often more successful and can reduce long-term costs. It is possible that native plantings will be less desirable than more conventional plantings. While some of these species do well in improving infiltration, attracting wildlife, and adding to biodiversity there are some that are considered a nuisance. Many species we consider invasive today started out as species we chose to include in our urban plantings (for example, multi-flora rose (*Rosa multiflora),* honeysuckles (*Lonicera spp.)* and Oriental bittersweet (*Celastrus orbiculatus*). Before using conventional plantings in a constructed wetland or stormwater management site consider checking with your county weed commissioner and review the most current Iowa State Noxious Weed List.[6] Not all weeds will be listed; it is also a good idea to contact your district forester to find out what unlisted species may already be a problem in the wild.[7]

Erosion Control

When constructing sites that are planned to hold or infiltrate water, site construction is best during the fall or early winter, to limit site erosion. During construction, common erosion control measures, such as silt fence, fiber rolls, straw bales and erosion control matting, can be employed where necessary to comply with stormwater regulations and improve the success of the site.

Additional, alternative erosion control can include the use of a hydro-seeder to spray not only the seed onto a slope but a layer of compost as well. Studies from North Carolina State University have shown that compost provides nutrients to a recently seeded slope or berm face and can hold and infiltrate rain water and further prevent erosion.[8]

The IDALS Rainscaping Iowa program has a specific unit on Soils Restoration[9] and where possible, in the buffer areas around the constructed site, it is sensible to consider soil restoration to further improve moisture retention and vegetational success of the site.



Menards Wetland Mitigation Site, Iowa City. See summary of project, page 25.

[6] http://plants.usda.gov/java/noxious?rptType=State&statefips=19
[7] http://www.iowadnr.gov/Environment/Forestry/ForestryLandownerAssistance/DistrictForesterContacts.aspx
[8] http://www.ncsu.edu/ncsu/wrri/pdfs/pastevents/escS2013/Pearson.pdf
[9] http://www.rainscapingiowa.org/index.php/practiceslink/soilquality

City of Tipton Wetland Mitigation Site, July 2013, after planting and the start of vegetation establishment. *See summary, page 17.*

Site Establishment

Perhaps the greatest reason many constructed stormwater management sites do not succeed is that they are not properly established. Once seed and/or plugs have been planted, management of the site during the first year of growth is crucial to the success of the site. Even in sites once covered with vegetation, or used for agriculture, the soil contains a rich weed seedbed. In recently graded sites these seeds finally have an opportunity to germinate and develop. Plus, weed seeds blown or carried in by animals and foot traffic can begin to dominate. In order to manage these undesirable species it will be necessary to manage the site with some site appropriate methods.

Establishing Vegetation

During the establishment period hydrology will need to be carefully monitored. Monitoring will be rain event-dependent and may include daily to weekly site visits to determine soil saturation. If design of the site includes control of the hydrology then erosion and vegetation success can be more easily managed. If hydrology is not controlled, then more monitoring and further establishment will be required. The establishment period is usually two to three years, but erratic weather patterns or other unanticipated circumstances may extend the establishment phase.

Perhaps the No. 1 reason stormwater wetland sites fail is a lack of monitoring and maintenance during the first and second year of establishment. Native seed mixes will only be established and annual and biennial weeds will be reduced by mowing. A site should be mowed three to five times throughout the first two growing seasons. Vegetation should not be mowed to a height less than 5 inches and should not be allowed to grow beyond a height of 14 inches. This regime will mimic grazing pressure and encourage native perennial seedlings to establish deep, permanent roots. An additional purpose of mowing is to discourage annual and biennial weed seed production. These establishment treatments will help to encourage native species, reduce the impact of invasive species, and ensure the overall long-term success of the wetland seeding.

During the first and second year of vegetation development, invasive species should be identified, spot sprayed or hand pulled. Within the first two years, if vegetation does not appear to be developing as prescribed, plugs can be used to improve vegetation diversity in those areas that have not been established. As mentioned before, re-establishment seeding should occur in late fall/early winter and, where possible, the seedbed should be properly prepared. Those areas that have stabilized with 50 percent or more native vegetation should not be disturbed; sloped areas should not be disturbed to a point where erosion would increase. In areas most invaded by invasive species, once the invasive species have been spot sprayed and managed, where sensible, planting of wetland plugs or sod chunks near the invaded area can create immediate competition for the invasive species. Plug species may be selected from any of the recommended species outlined in the seeding plan and purchased from any of the recommended nurseries. Alternatively,

Tipton Wetland Mitigation Site

Tipton, Iowa

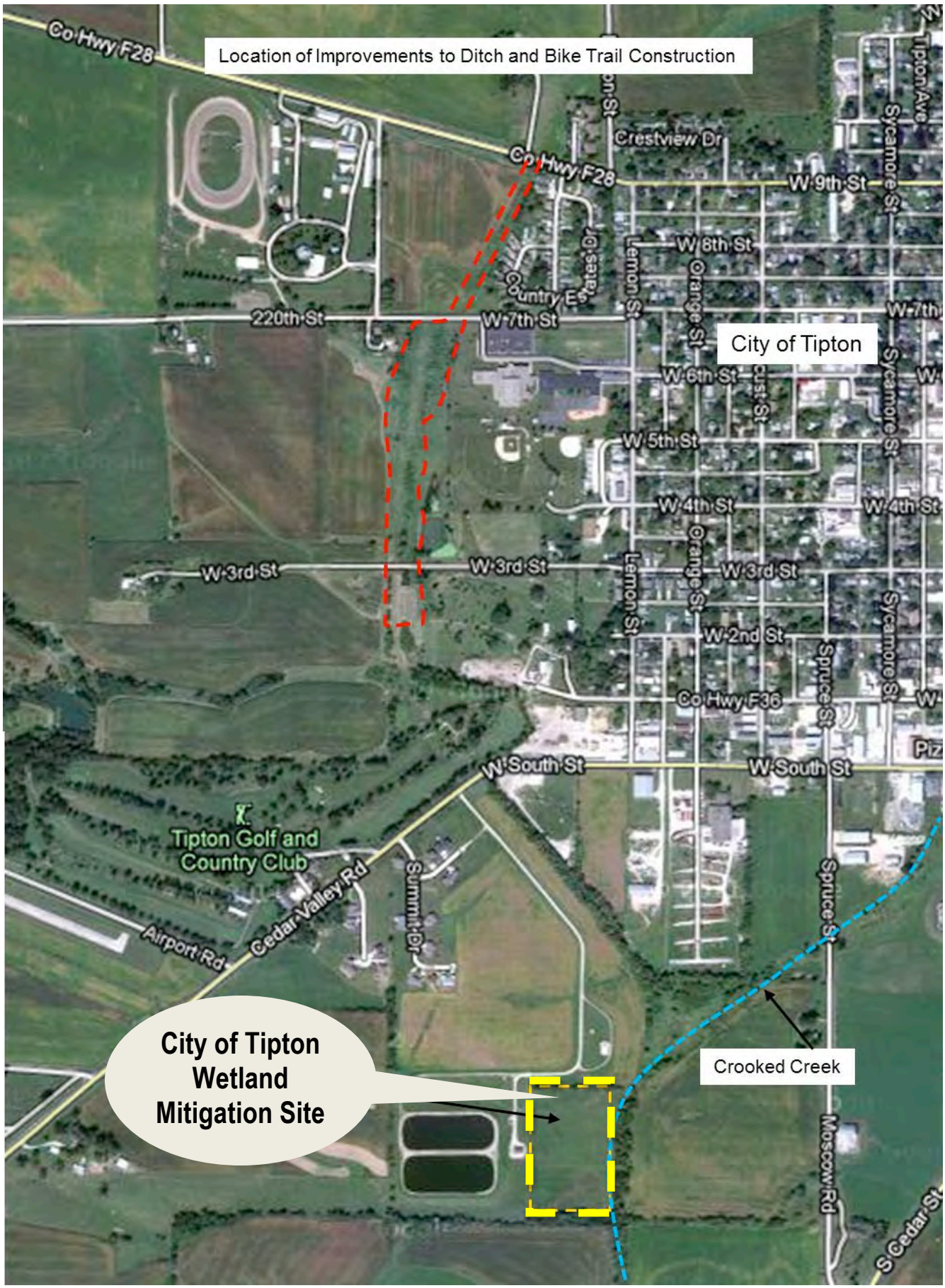
Like many small towns, the city of Tipton relies on open ditches and natural pre-existing swales to direct runoff water from the city and surrounding farmland around the boundaries of the town. In areas not yet fully developed, there is little or no need or funding to construct expensive water management features.

In 2011, the city planned to straighten and deepen a pre-existing swale to better conduct storm runoff water through the growing outskirts of town. The swale had historically carried water from surrounding farm fields and as the western edge of town began to develop, volumes increased, causing erosion and flooding farther down in the watershed of Crooked Creek. After further urban development along the western outskirts of town and several flood events over two main roads (Seventh and Third streets), Tipton realized it would need to improve drainage. In addition to the water improvements, city managers realized that excess earth from the swale construction could be used to construct a bike trail and add a much-needed amenity to their town; providing a safe, healthy alternative for students to get to school and citizens to get around town. After talking with the U.S. Army Corps of Engineers and the Iowa Department of Natural Resources, Tipton discovered that its project would impact wetlands and the city would be required to mitigate for the wetlands disturbed by the project. The proposed improvements and bike trail would impact 1.60 acres of existing wetlands.

The city was required by the Clean Water Act to construct 3.63 acres of reconstructed wetland mitigation. The city chose a property south of the proposed impact site (see aerial photo, next page), which was also owned by the city and adjacent to a new wastewater treatment plant. The wetland site, constructed in the winter of 2012 and planted in the spring of 2013, will collect and treat stormwater passing through town. It also will protect the adjacent creek from increasingly volatile flows, provide habitat and improve biodiversity. As the site is city-owned, it is hoped that once established, the site could become an outdoor classroom or park.

Grading for a shallow pool with three deeper spots was completed in the winter of 2012. The site was seeded and planted with small wetland plugs in the spring of 2013 by a group of Tipton school children. One challenge was the heavy spring rains in 2013 made planting and risked survivorship of the seedlings. Steve Nash, city public works director, used a pump to remove water from the wetland and pump it back into the creek. This allowed the young vegetation to have an appropriate amount of water to become successfully established.

Site	City of Tipton Wetland Mitigation Site
Age	1 year old
Size	3.63 acres
Problematic Design Features	Infiltration of invasive species, possible erosion along the weir
Current Status	2013 Site was constructed
Cost	$3,000-$5,000 per acre
Ownership	City of Tipton
Location	South of Tipton, east of the City Wastewater Treatment Site
Hydrologic setting	Adjacent to a small creek
Management Issues	Weed management and hydrologic control
Solutions	Install a pump to remove excess water and pump it back into the creek
Benefits	Met state and federal requirements, may be used as a City Park area


Location of Improvements to Ditch and Bike Trail Construction
Co Hwy F28
Crestview Dr
W 9th St
W 8th St
W 7th St
220th St
City of Tipton
W 6th St
W 5th St
W 4th St
W 3rd St
W 2nd St
Co Hwy F36
W South St
Tipton Golf and Country Club
Cedar Valley Rd
Airport Rd
Summit Dr
Lemon St
Orange St
Sycamore St
Spruce St
Moscow Rd
S Cedar St
City of Tipton Wetland Mitigation Site
Crooked Creek

a community may already have a functional wetland site where wetland plant materials or sod chunks could be harvested and installed.

Specific Establishment Methods

Mowing

The purpose of mowing is to discourage annual and biennial weed seed production and improve root establishment of planted species. When a site is too wet to mow with a tractor mower, then it can be mowed with a small brush mower or manual powered brush cutter. Mowing is one of the best and easiest ways to manage and refurbish a site. Mowing reduces the infiltration of woody species and encourages the development of native species by mimicking historical grazing pressures. If hydrology is controllable, the flow of water can be reduced and the site can be temporarily dried out to allow for an aggressive mowing campaign during an entire growing season. However, long-term plant survival should also be considered.

Use of Chemicals

During the first year of establishment only spot chemical treatments are used for the management of invasive species. If chemicals are used in herbal applications, a glyphosate herbicide like Rodeo™, recommended for use within the margin of water bodies, should be used as provided by the manufacturer. Chemical applications should only be used on the most aggressive and persistent invasive species. Broad spectrum chemical use is commonly used in conjunction with other management techniques and is rarely successful on its own or recommended during site establishment.

Hand Pulling

Depending on accessibility and the size of the site, hand pulling weeds and other undesirable species can be successful. Additionally, this technique can utilize volunteers, provides for education of the community, and ownership of the site.

Prescribed Grazing

While still considered a new technique to improve biodiversity and remove undesirable species, grazing of small herbivores such as goats or sheep may be a necessary management technique for some sites. Ames, Iowa, supports a small goat grazing business,[10] and California has used small herbivores to manage vegetation along steep highway Right-of-Ways for many years.

Site Maintenance

Once the site has been established it is equally important to maintain the site for long-term function. Many techniques are available for long-term maintenance of these sites. But the most important aspect is being attentive to the site as it continues to develop and age. Lack of funding and knowledge of their function leaves many sites without a maintenance budget or plan. Municipalities assume that once seeded these types of sites can be left to their own devices. However, these sites provide so many different services they also require maintenance and care. It is important to remember that while perennial native plantings are used in many of these sites and are expected to return year after year, they can only do that if they are not threatened by conventional species. These sites are islands and should be managed as such.

[10] http://www.goatsonthego.com/

Many of the techniques described above for establishment can also be used for long-term maintenance and up-keep of these sites. In addition to mowing, grazing, chemical use and hand pulling, the use of prescribed fire can be a useful technique.

Prescribed Fire

Prescribed fire has become a popular way to establish and manage wetland sites. Native plants evolved with fire as part of their life cycle. Many native species are actually fire dependent and thrive when fire is used. Fire reduces the presence of woody species and should strengthen natives providing competition against undesirable species. However, many things must be considered before this technique can be safely employed. A prescribed fire plan should be composed and if necessary the appropriate permits received before the fire. Many different components should be considered like physical features of the landscape, wind direction, wind speed, humidity, position of burn breaks, proximity to structures, roads, smoke management, availability of trained personnel, and water sources.

A professional consultant practicing prescribed fire or the municipal fire department should be involved in the planning and execution of this management technique. It is commonly recommended that within five to seven years after construction of a site, that it be burned with a prescribed fire. Site managers should use their best judgment to determine the goals for site management and any necessary safety issues and/or site preparation. Prescribed fire should then be used as a consistent means of site management every three to 10 years, depending on infiltration of unwanted species. While popular to burn the entire site, it is beneficial to allow some of the site to remain unburned as a refuge for insects and other animals. Since prescribed fire may be used as a management tool, siting of buildings and development features should be taken into account during future development. The county USDA NRCS office has a list of contractors qualified to carry out a prescribed fire.

Preparing for Invasive Species

Invasive species are any species that disrupt natural habitats by their dominant colonization, resulting in the loss of native species and biodiversity. Usually invasive species are those that have no natural predator and alter the ecological balance of the habitat. To combat these risks, some counties have collaborated and organized cooperative weed management groups that host annual meetings, print handouts describing the latest invaders, and work together to collectively eradicate and manage weed penetration. For example, the Hawkeye Cooperative Weed Management Area includes Benton, Linn, Jones, Iowa and Johnson counties.[11]

Trash, erosion and wildlife

Naturally as a site ages is can collect trash and erosion can still occur. Maintenance of these sites is recommended if not for the health and function of the site but because of public opinion.

Just because the site has been successfully established and well maintained does not mean that unforeseen events may cause erosion. Older sites should be annually inspected and repaired where needed.

Animals such as beavers, muskrats and turtles can damage dams, berms, liners and constructed soil structure and can impact water movement. They also may harm vegetation, trees, shrubs and other plantings, which should be protected. It may become necessary to remove problem animals.

[11] http://www.hawkeyecwma.org/

One of the most important elements of maintaining basins is making sure the low flow orifice is not blocked or clogged. Other maintenance activities include repairing erosion, removing sediment, and managing the vegetation. Repairing erosion early can save significant costs, both in the erosion and the resulting sedimentation that can end up needing to be removed from the basin. Vegetation should be kept to heights that allow inspection for animal burrows, sinkholes, wet areas, etc. along the fill embankments. Common mistakes are not mowing important areas because they are too steep or ignoring mowing completely.

Options for Collaboration and Assistance

The following are examples of some of the organizations that may be viable collaborators or able to provide assistance for educational programming, training, or other resources.

Iowa Department of Agriculture and Land Stewardship (IDALS)

The Iowa Department of Agriculture and Land Stewardship (IDALS) has an Urban Conservationist program. Their mission is to "help communities install new systems and retrofit existing infrastructure in a way that will move the water off our streets while keeping soil and pollutants out of our waterways. Our goal is to have urban and rural areas working together to protect our soil and improve water quality in the state."[12] In addition to collaborating with Kirkwood Community College with Rainscaping Iowa Programming, the group of four to five Urban Conservationists work diligently to develop green infrastructure stormwater projects as models throughout the state.

Private Land Protection Organizations

Iowa hosts three Land Trusts accredited by the Land Trust Alliance, a national conservation organization.[13] Land Trusts protect land through outright ownership, conservation easements, or purchase and sale to other conservation organizations. While not always recognized as a collaborative partner, these organizations mission is to advocate for programs and funding for conservation and land management practices, including stormwater management. Sometimes their non-profit status can leverage funding for different types of collaborative projects.

County Conservation Boards

In 2008, Johnson County voted for a conservation bond issue to raise $20 million for the purchase and protection of conservation land. This type of advocacy by a county conservation board can be used to raise money for grant programs sponsoring alternative stormwater management practices both in the county and in municipalities.

Resource Conservation and Development Groups

In 1962 the USDA was tasked with implementing the Resource Conservation and Development Program (RC&D), which would assist multi-county areas in enhancing conservation, water quality, wildlife habitat, recreation and rural development. The state of Iowa has 12 Resource Conservation and Development groups encompassing the entire state.[14] These nonprofit groups are funded by the USDA and administered by the Natural Resource Conservation Service (NRCS). They do much to grow the economy through projects unique to the area in which they operate.

The Iowa League of Resource Conservation and Development provides "leadership, services and a unified voice to member Councils."[15] As an advocacy group, the league lobbied the Iowa Legislature

[12] http://www.iowaagriculture.gov/FieldServices/urbanConservation.asp
[13] http://www.landtrustalliance.org
[14] http://iowaleaguercd.org/
[15] http://iowaleaguercd.org/

to create a Natural Resource Based Opportunity Grant Program (NRBOG) and invest $1,093,354 in projects led by the RC&Ds between 2006 and 2011.

While each RC&D has its own set of projects, some RC&Ds collaborate in statewide projects, such as the Wetland Mitigation Banking Project. When development of an area will cause wetland impacts but there is no suitable local site for wetland mitigation, a mitigation bank can be utilized. Instead of designing and constructing a wetland mitigation site, a site developer can purchase credits in an established wetland mitigation bank. This type of bank is permitted by the Corps and the IDNR to sell and build wetland mitigation at a recognized site that services a greater watershed area.

Properly sited, wetland mitigation banks can do much to protect water quality. Some communities purposely select a wetland mitigation banking site where watershed management is needed. Then when a development project in their community requires mitigation they can use the mitigation bank. Some cities collaborate with county conservation boards for city and county projects and other communities collaborate with private wetland mitigation banks that sell credits directly to private developers. The city of Charlotte and Mecklenburg County in North Carolina have collaborated in this manner.[16]

While it takes time and funding to properly permit a wetland mitigation bank, many developers prefer to work directly with a bank instead of following their own independent permitting process. It is easier to pay for the mitigation up-front rather than pursue design, permitting, installation, establishment, monitoring and long-term maintenance of their own project. Since it is organized, the mitigation banking entity is responsible for the long-term establishment, management and maintenance of the wetlands. Once the developer has paid, responsibility for mitigation is transferred to the bank. For more about wetland mitigation banking in Iowa, a good Rock Island District Corps resource outlines the steps for a permit: http://www.mvr.usace.army.mil/Portals/48/docs/regulatory/mitigation/Iowa%20Mitigation%20Banking%20Information%20Package.pdf.

Funding Sources

U.S. Department of Agriculture (USDA) and Natural Resource Conservation Service (NRCS)

Projects on agriculturally zoned land may apply for funding through the USDA. The NRCS has a variety of agriculturally specific programs available for wetland construction, educational field days, and other conservation practices.

Wetland Reserve Program (WRP)
The NRCS through the Wetland Reserve Program (WRP)[17] provides financial and technical support to landowners to protect, restore, and enhance wetlands.

Conservation Reserve Program (CRP)
Another possible source, the Conservation Reserve Program (CRP), "provides technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner."

Iowa Department of Natural Resources (IDNR)

Resource Enhancement and Protection (REAP)

The REAP program is funded by the state's Environment First Fund (Iowa gaming receipts) and from the sale of natural resources license plates and provides money through state funded projects

[16] http://charmeck.org/stormwater/stormwateragencies/pages/streamandwetlandmitigationbank(city).aspx
[17] http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/

or as grants. Before applying for a REAP grant it is a good idea to visit the website and discover current funding status and application deadlines.

Iowa Department of Agriculture and Land Stewardship (IDALS)

The Watershed Improvement Review Board (WIRB) was established in 2005 by the Iowa Legislature. Annually this Board offers grant funding to local watershed improvement committees, soil and water conservation districts, public water supply utilities, county conservation boards, cities and counties. Typically the projects supported include those addressing agricultural runoff and drainage, flood prevention, stream bank erosion, municipal discharge, stormwater runoff, unsewered communities, industrial discharge and livestock runoff. A board of 15 members representing environmental, agricultural, commodity, water-related organizations, and other state representatives evaluate the grant applications and typically a match is required.[18]

State Revolving Loan Fund (General Non-Point Source)

State of Iowa has the State Revolving Fund (SRF) which can provide low interest loans to communities for stormwater projects. Depending on the project, there are at least two different loan programs that may provide assistance.

Storm Water Program

The Storm Water Program provides low-cost loans for stormwater projects, for example detention basins, grassed waterways, infiltration practices, pervious paving systems, ponds or wetland systems, soil quality restoration, and other practices that are shown to improve or protect water quality. Both public and private groups can apply but projects must be designed to keep pollutants out of waterways.[19]

General Non-point Source Program

The General Non-point Source Program provides low-cost loans for a variety of water quality improvement activities like, remediation of storage tanks, restoration of wildlife habitats, stream bank stabilization, and wetland flood prevention areas.[20]

Local Water Protection Program

The Local Water Protection Program is a low-interest loan program for landowners who want to control runoff of sediment, nutrients, pesticides or other nonpoint source pollutants. The program is administered by the IDALS through local Soil and Water Conservation Districts (SWCD). The SWCD must grant approval to the landowner prior to receiving a loan. Loans have been granted for contour buffer strips, field borders or windbreaks, filter strips, grade stabilization structures, grassed waterways, terraces and other practices that are shown to improve or protect water quality.[21]

Vision Iowa

Vision Iowa is one of the programs sponsored by the Iowa Economic Development Authority. There are three Vision Iowa funding options, but the one most likely to pertain to stormwater projects is the River Enhancement Community Attraction and Tourism (RECAT) Program. This program supports projects that promote and enhance recreational opportunities on and near rivers or lakes within cities. Usually these types of applications need to contain a strong connection to economic development of an area, so may be best for larger scale projects.

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[18] http://www.agriculture.state.ia.us/IWIRB.asp
[19] http://www.iowasrf.com/program/other_water_quality_programs/storm_water_program_overview.cfm
[20] http://www.iowasrf.com/program/other_water_quality_programs/general_nonpoint_source.cfm
[21] http://www.iowasrf.com/program/other_water_quality_programs/local_water_protection.cfm

County Foundations

Nearly every county in Iowa hosts a county foundation, or 501(c)3 nonprofit organization whose mission is to meet the current and future needs of the county. Many of these have funding programs available for environmental projects. This can include improvements to outdated stormwater infrastructure and educational programming. To find your county's foundation visit http://www.iowacommunityfoundations.org/

Long-term site protection

Once a privately developed stormwater site or constructed wetland has been crafted there are three common means of long-term protection.

City Ownership

In many cases stormwater areas developed for new residential or retail developments are set aside as "outlot" and donated to the city for their long-term protection. Usually, these agreements are not overly detailed and the city is burdened with more property that a Parks Department or Public Works Department does not have the staff or budgeting to properly maintain. Over time the designed functions are degraded, biodiversity is lost, and the area becomes unsightly. Some cities have solved this with the development of more specific ordinances outlining long-term requirements for these sites. Sometimes these requirements demand the developer to put up a bond or money in an escrow account for long-term maintenance of the area.

Continued Developer Ownership

Developers who hold title to areas dedicated to stormwater management can choose to encumber the property with a deed restriction. With a deed restriction, a description of the area to be protected and its purpose and use are attached to the deed documents and recorded with the local Recorders Office. Every 20 years a deed restriction is renewed with the recorder. This reminds managers of the project/site that the area is protected for natural purposes and cannot be developed. When the property is transferred the deed restriction would be discovered and transmitted to alert the new owner of the need to keep the site in a natural functional state.[22]

Protection with a Conservation Easement

The next level of protection is a conservation easement. For this form of protection to work, the titleholder sells or donates a conservation easement to a second party. The second party is typically a nonprofit organization that annually inspects the site to confirm its natural state and function and continues to meet the specifications of the easement. Depending on the purpose and need of the site, this type of protection can occasionally reap a tax benefit from the IRS for the titleholder.[23]

Homeowners Associations

As required, developers construct wetland stormwater treatment sites for their developments. These sites are usually designated as outlots within the development. Outlots are either deeded to the city or become the responsibility of the Home Owners Association (HOA). It is very challenging for a HOA to properly maintain these sites. Cities should consider accepting these sites so they are responsible for their long-term care and maintenance or providing educational services to HOA so they will be better organized to properly care for these sites.

[22] http://www.realtor.com/home-finance/homebuyer-information/what-are-real-estate-deed-restrictions.aspx
[23] https://www.landtrustalliance.org/conservation/landowners/conservation-easements

Menards Wetland Stormwater Mitigation Site

Iowa City, Iowa

Large stores often locate near the edge of expanding towns. Such sites increase impermeable surfaces and can generate large volumes of stormwater. They also may collect water from adjacent properties that have not yet been developed; in Iowa this is generally agricultural water from fields and pastures.

In 2006, a runoff collection and wetland mitigation site was built to capture and treat water generated by the relocated Iowa City Menards. This constructed wetland site was designed to both capture stormwater from the new parking lot and rooftop and mitigate the wetland impacts from the development of the Menards building. After consultation with the city of Iowa City, developers were required to complete a wetland delineation. The delineation revealed the development would impact 3.55 acres of wetland and approximately 600 feet of an unnamed tributary stream.

Since the development of the site consumed much of the buildable area and there was not enough space to construct required mitigation acreage, mitigation proceeded in two parts. Part I included the creation of 3.76 acres of new wetland area at an offsite location and Part II included the on-site construction of a 5.14-acre reconstructed wetland area below the construction site. In addition to the wetland creation, 680 linear feet of stream was re-meandered and four riffle structures were installed.

The Menards site contains a small ditch that flows along the west side of the property, down and through the northern end of the property from the southwest to the northeast. The small reconstructed creek empties into a pond that was enlarged and deepened to provide soil for the development. Water from this area continues on under Highway 218 and ultimately joins Willow Creek, a tributary of the Iowa River. Reducing volumes and capturing pollution upstream of the Iowa River will improve water quality.

The site was graded and seeded in 2006 and monitoring began in 2007 and was completed in 2011. The vegetation of the site has been very successful and provides a great array of biodiversity and color throughout the growing season. However, unusual rain events have caused erosion of the streambed and damage to the weir above the pond. The weir has been repaired and will be monitored to ensure it provides a slow outlet of water to the pond below.

Site	Menards Wetland Mitigation and Storm water Management Site
Age	8 years old
Size	7.3 acres
Problematic Design Features	Infiltration of invasive species, additional erosion along the weir
Current Status	Stable, diverse, and providing treatment for the stormwater from the parking lot and rooftop of the Menards building.
Cost	$60,000-$80,000
Ownership	Developer owned
Location	Southwest side of Iowa City, Iowa
Hydrologic setting	Tributary of Willow Creek
Management Issues	Weed, Trash and erosion management
Solutions	Continue to monitor, clean stormwater outlets as necessary
Benefits	Menards Wetland Mitigation and Stormwater Management Site

City of Iowa City Landfill Wetland Mitigation Site

Iowa City, Iowa

As part of expansion of the landfill a wetland mitigation site was constructed in fall 2010 to meet federal and state requirements. The site includes 4.35 acres of wetland and 7.5 acres of upland buffer. Its two constructed wetlands have outlets that control water levels and that connect the two wetlands. During construction topsoil was removed from the wetland areas, two shallow basins were excavated and berms were constructed to form the wetland basins. Heavy machinery traffic during construction compacted soil in the basins. A contractor later seeded the area with wetland seed mix (in the constructed wetlands) and prairie seed mix and annual rye mix (on the surrounding upland buffer). The ensuing spring both wetlands filled with water and remained so for several months. Shallow monitoring wells installed in the wetlands by city staff indicated water was perching on the compacted wetland soil. These conditions prevented germination of the wetland seed mix and as the water levels declined during the summer, wetland plants did not emerge and invasive and other undesirable plant species began to occupy the wetlands. The wetland soil was amended to increase drainage and to create microtopography in the wetlands, which were reseeded. After regrading and reseeding part of the area, water again filled the wetlands and volunteers and city staff planted plugs of wetland plants around the water's edge. Over the summer plug growth was minimal, but a few emergent wetland plants began to sprout and grow. Continued maintenance of the wetlands, including weeding and removal of willow seedlings, has allowed vegetation to begin to establish in both wetlands. The upland buffer surrounding the wetlands was mowed twice each of the first two years to promote root growth of the native prairie plants and to prevent maturation and seed formation of undesirable annual and biennial plant species. Prairie plantings are now well established.

A unique management issue for this site is trash management. On windy days light materials such as paper, cardboard and plastic bags can escape from nearby landfill areas to the upland prairie buffer and wetlands. A fence around the upland buffer catches most material, and trash is routinely removed in the wetland mitigation area. This site demonstrates the need for proper construction and rather intensive management during the establishment phase for a constructed wetland.

Site	City of Iowa City Landfill Wetland Mitigation Site
Age	3 years old
Size	11.85 acres (including upland)
Problematic Design Features	Poor grading, compaction and lack of microtopography in the constructed wetlands, seeding submerged and failed first year due to inadequate drainage, invasive species
Current Status	Site is stabilizing, diversity is increasing, adjacent upland area is established with prairie
Cost	$150,000, not including delineation, permitting, design, monitoring
Ownership	City of Iowa City
Location	West of Iowa City, Iowa
Hydrologic setting	Adjacent to Phoebe Creek
Management Issues	Invasive species, lack of successful seeding in one area, % of bare ground, trash
Solutions	One area was re-graded, wetland soil was amended, re-seeded, invasive species control, continued monitoring and maintenance
Benefits	Met state and federal requirements for wetland mitigation, created habitat for native birds, migratory waterfowl, amphibians and other animals. Captures and treats runoff before reaching Phoebe Creek

Regulations and Permitting

The following section is meant to provide an introduction to regulatory requirements surrounding water quality and pollutants in surface waters. In few cases will these laws affect construction of a new wetland but they must be considered.

Regulations, Collaboration and Funding Options

Federal Regulations

In 1948, the Federal Water Pollution Control Act (FWPCA) (P.L. 80-845, 62 Stat. 1155) was enacted by Congress as the first law addressing water pollution in the United States. It was an ineffectual law and did little to regulate pollution and protect American waters. In 1972, the FPCA was reorganized as the Federal Clean Water Act (CWA). This Act is much more detailed and gave power to the federal government and states to regulate surface water quality and the discharge of pollutants into the waters of the United States. Several different federal agencies have jurisdiction to carry out the regulations laid out in the CWA. For example, the U.S. Environmental Protection Agency (EPA) has implemented pollution control programs such as setting wastewater standards for industry and water quality standards for all contaminants in surface waters. In comparison, the US Army Corps of Engineers (Corps) oversees the removal and discharge of fill material into wetlands and other waters of the United States. At the state level the CWA also bestows responsibility to an agency such as the Iowa Department of Natural Resources to regulate human and animal waste management, wetland impacts, and floodplain alterations.

One of the most well-known permit programs is the EPA's National Pollutant Discharge Elimination System (NPDES), Section 402 of the CWA. This permit program controls the discharge of point sources; pipes or ditches that convey water from industrial, municipal and other facilities to surface waters. A permit is required if these types of discharges go directly to surface waters.[24]

Local Regulations

Many cities transport runoff from rooftops and streets through ditches, storm drains and pipes. These structures, owned by states, cities, towns or other public entities are known as Municipal Separate Storm Sewer Systems or MS4s. MS4s often empty untreated stormwater into local creeks, streams and other surface waters. It is then the city's responsibility to prevent harmful pollutants from being washed or dumped into an MS4, and so communities must develop a municipal stormwater management program (SWMP). The Iowa Department of Natural Resources has a web-page dedicated to the Iowa Storm Water Program at (http://www.iowadnr.gov/InsideDNR/RegulatoryWater/StormWater.aspx).

Phase 1 of the NPDES program, issued in 1990, requires medium-size and large cities with populations greater than 100,000 to obtain NPDES permit coverage for their stormwater discharges. NPDES Phase II, issued in 1999, requires communities smaller than 100,000 to obtain NPDES permit coverage for municipal stormwater discharges.[25]

Since these regulations went into effect years ago, most communities have developed a formal SWMP and have obtained a NPDES permit to manage stormwater within their boundaries. In most cases the SWMP outlines a permitting process for many different types of urban activities; these include permitting construction sites where dirt, debris, and other waste materials can enter storm drains if not properly managed. Most communities now mandate that contractors, builders and developers have, prior to construction, an approved Stormwater Pollution Prevention Plan that

[24] http://www2.epa.gov/laws-regulations/summary-clean-water-act
[25] http://cfpub.epa.gov/npdes/stormwater/munic.cfm

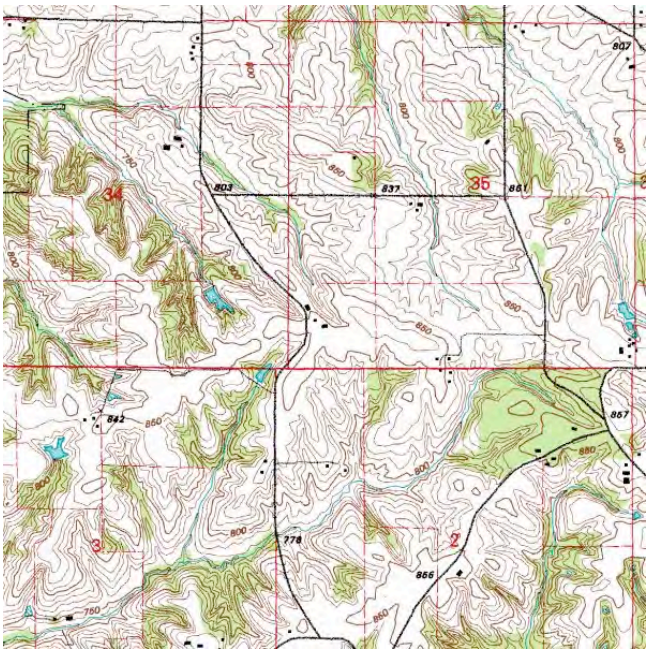
outlines the recommended Best Management Practices to be used on site, during construction activities to limit stormwater pollution.

In 2004 members of the Iowa Association of Municipal Utilities organized a second organization called the Iowa Stormwater Partnership.[26] This group established the Iowa Storm Water Education Program for MS-4 Municipalities, Professional Services, Business, and Education Members. It includes quarterly programming, certification programs, technical services, and workshop programs for partnership members. Perhaps one of the best collaborations has been the Rainscaping Iowa program.[27] This program is a *"statewide educational campaign that promotes urban stormwater management practices to protect water quality and reduce runoff with the help of its partners. The ultimate goal of the program is to build awareness and behavioral change that will result in the improvement and protection of water resources in Iowa."* This program provides training for engineers, contractors, designers, city public works and administrative staff. Their programs include instruction on how to install, design, and construct Bioretention Cells, Bioswales, Ecological Restoration, Green Roofs, Native Landscaping, Native Turf, Permeable Pavement Systems, Rain Gardens, Rainwater Harvesting, Roadside Native Plantings, Soil Quality Restoration, Stream Corridor / Shoreline Stabilization and Vegetated Box Filters. In addition to this training, they provide a certification program for practitioners and a website directory of those who have experience in these practices.

Waters of the United States

Other sections of the CWA relevant to municipalities are sections 401 and 404. These sections regulate the discharge or removal of fill material from "*Waters of the United States.*" Waters of the United States includes federally protected "blue line streams" and wetlands. The definition of both of these features can be confusing. A blue line stream is anything that appears on a USGS 7.5 minute topographic quadrangle map as a blue line stream (right). These types of maps are commonly available through Google Maps or other online mapping programs, so that identification of blue line streams has become easier. Additionally, the Iowa Geographic Map Server hosted by Iowa State University is a very useful warehouse for these and other GIS related resources.[28]

Blue Line Streams



Blue lines indicating creeks and streams that would be considered regulated by the federal and state governments.

In 1987, as directed by the CWA, the Corps finalized a wetland delineation manual, outlining the steps to follow to identify federally recognized wetlands. This manual was updated for the Midwest Region in 2010.[29] Wetlands are identified as any feature that has saturated soils for 14 consecutive days out of the growing season, hydric soils and hydrophytic vegetation. In addition to these three components, the

[26] http://www.iowastormwater.org
[27] http://www.rainscapingiowa.org/index.php/home
[28] http://ortho.gis.iastate.edu/
[29] http://www.usace.army.mil/Portals/2/docs/civilworks/regulatory/reg_supp/erdc-el-tr-10-16.pdf

wetland area must also be connected to a blue line stream. Usually this connection is by means of a ditch, unnamed tributary or drainage way, but can be by an underground pipe. Whatever the means of connection, for a wetland to be regulated by the government it must provide or share water through a hydrologic connection with other Waters of the United States. This means that wetlands fed only by groundwater may be considered isolated and not under CWA jurisdiction. Before determining that a wetland is isolated it is best to have it evaluated by a professional wetland scientist and/or the IDNR or the Corps. Typically, a wetland delineation is completed by a professional wetland scientist, trained and recognized by the Corps to determine the presence or absence of required wetland features. The Rock Island Corps District, which has jurisdiction in Iowa of Waters of the United States, can provide a list of acceptable consultants servicing your area.

Construction of detention basins often results in the discharge or removal of fill material from Waters of the United States, including wetlands. These types of alterations would put sections 401 and 404 of the CWA into effect. Section 401 of the CWA is the section that describes a state's responsibility for permitting alterations to federally protected and recognized Waters of the U.S. In most states an agency such as the IDNR evaluates Section 401 permit applications, communicates with the interested Federal government agencies and allows or denies the impact. In Iowa, a Section 401 Water Quality Certificate is the state's certification that a project will not violate state water quality standards and is required before the Section 404 permit can be issued.[30]

Section 404 of the CWA describes the federal government's responsibility to permit and evaluate these types of applications. While many different government agencies review and evaluate blue line stream and wetland impact applications, the lead agency at the federal level is the Corps. Iowa is managed by the Rock Island Corps District and we are fortunate to have a joint permit application process. This means that any permit application forms sent to the IDNR for receipt of a Section 401 permit can also be sent to the Corps for application for a Section 404 permit.

In general, two types of permits allow for impact or alteration to wetlands and blue line streams. If proposed impacts are greater than one-tenth of an acre but less than half an acre, the applicant will apply for a Nationwide Permit. This permitting process is usually easier, proceeds quickly and does not always require public notice. The wetland proposed for impact will require a wetland delineation, an impact analysis, and a mitigation plan will need to be devised before the applicant can submit a permit request to the IDNR or the Corps. Usually it is wise to have a pre-meeting or consultation with representatives from both the Corps and the IDNR to discuss the site, proposed impacts, rationale for the impacts and proposed mitigation prior to application. This allows the regulators the opportunity to suggest improvements to the plan and makes the application process proceed more quickly and without the need for a second or third application.

The second type of application is called an Individual Permit and is for impacts greater than half an acre. This process is similar to a Nationwide application; the same permitting materials; delineation, impact analysis, and mitigation plan need to be provided but this process usually takes longer and requires the application be put on public notice for 60-90 days.

For those impacts less than one-tenth of an acre the Corps and the IDNR should still be notified and they will still issue a permit for these impacts. This process usually only requires a letter of intent and explanation of the proposed impact so that should the work be noticed by someone who reports it , the Corps or IDNR will be aware of the situation and understand the manner and intent of the work.

[30] http://www.iowadnr.gov/InsideDNR/RegulatoryWater/WetlandsPermitting.aspx

The Corps has a preferred process for dealing with proposed impacts to wetlands and blue line streams. Applicants should first try to avoid impacts. If impacts are unavoidable then they should be minimized, and the design should show thought and planning as to how impacts were minimized to wetlands and streams. If it is impossible to minimize impacts then the Corps will require mitigation; or the reconstruction of wetlands or stream banks. It is common to expect the Corps to require 1.5-2 acres of wetland reconstructed for every 1 acre of wetland impacted. Typically they require that the wetland constructed is of similar type to the wetland impacted or "like for like". For example, if you impact wooded wetland then wooded wetland must be constructed. However, each application is evaluated on a case-by-case basis and the Corps can require greater replacement ratios if the quality of the wetland or stream to be disturbed is considered high or the habitat unique.

After all of this paperwork has been submitted, the Corps and the IDNR will require at least five years of monitoring of the mitigation site. Monitoring includes professional site visits several times throughout the growing season. Vegetation, soils, and hydrology must be described. A specific form must be used. The Corps and the IDNR will annually inspect the site and respond with recommendations for improvements. If the site does not perform as designed, the permittee may be required to re-construct, re-seed or rebuild the entire site. Attention during vegetation establishment and frequent monitoring of these sites will improve their success.

In Iowa, when a wetland area is being evaluated by the 401/404 process it triggers an archeological review of the site. An archeological survey of the site is often required and reports should be sent to the Iowa State Historic Preservation Office (SHPO) for clearance before construction begins. The Association of Iowa Archeologists has a list of professional consultants who can provide this service (http://www.uiowa.edu/~osa/aia/consultants.html).

Depending on site specific circumstances, alterations to blue line streams and wetlands may also require the review of other agencies such as the state DNR Floodplains section, the US Fish and Wildlife Service, the US Bureau of Indian Affairs, US and State Sovereign Lands agencies, EPA, and other agencies regulating archaeological and historic artifacts or properties.

Other factors to consider before pursuit of a 401/404 permit include evaluating for Federal and State Listed Threatened and Endangered Species. While it is less likely that these types of species may be present it is good to consider them. The federal lists can be found at http://www.fws.gov/endangered/and state and county lists can be found at http://www.iowadnr.gov/Environment/ThreatenedEndangered.aspx. For example, the following species are investigated in Johnson County, Iowa: the Indiana Bat (*Myotis sodalis*), the Eastern Massasauga (*Sistrurus catenatus*), Western prairie fringed orchid (*Platanthera praeclara*), Prairie bush clover (*Lespedeza leptostachya*), Sheepnose (*Plethobasus cyphyus*). Each of these species has unique habitat requirements and not all are found throughout Iowa.

Additionally, some cities and counties have instituted Sensitive Areas Ordinances (SAO) that may be more restrictive or require a greater mitigation ratio than that required by the state and federal governments. Being attentive to these entities and meeting their requirements is also important to consider.[31] Oftentimes these ordinances consider not only wetlands and streams but sensitive slopes, woodlands, prairies, savannas and other historic or natural features of note that may require conservation or protection.

[31] The City of Iowa City SAO can be found at http://www.sterlingcodifiers.com/codebook/index.php?book_id=953

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