A designer's guide to bio-retention area planning, design, and implementation

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Report prepared … for the Kansas Department of Health & Environment and U.S. Environmental Protection Agency, August 2013 revision

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July 11, 2012 photo by Lee R. Skabelund

The Kansas Department of Health and Environment (KDHE) provided financial assistance to the Sunset Zoo Bio-Retention Area Gardens (K-State Demonstration Project) through USEPA Section 319 Nonpoint Source Pollution Control Grant #C9007405 14 (KDHE Funding Codes 3889 2649598) as part of the KDHE Clean Water Neighbor Program.

A Designer's Guide to Bio-Retention Area Planning, Design, and Implementation

Kansas State University, Dept. of Landscape Architecture / Regional & Community Planning—prepared for the Kansas Department of Health & Environment and U.S. Environmental Protection Agency.

Introduction & Literature Review

In the book *Water Matters: Why We Need to Act Now to Save Our Most Critical Resource* we are reminded of the urgent need to act to protect our freshwater systems (Lohan 2010). In many articles, documents, reports, and books the value of rain-gardens and bio-retention areas are described as significant tools for reducing stormwater runoff and increasing infiltration rates in urban areas. The USEPA, Center for Watershed Protection, Low Impact Development Center, along with Ferguson (1994), France (2002), Davis & McCuen (2005), Hunt & Lord (2006), Clar (2007), Davis et al. (2009), Li et al. (2009), Calkins (2012), Venhaus (2012), and many others, discuss what we can learn from bio-retention facilities implemented in various parts of the U.S. Additionally, well designed gardens connect people to place/region.

The **recharge potential <u>and</u> functioning of watersheds as integrated systems that temper flooding and cleanse water** are impaired by the removal of native vegetation and permeable plant-soil systems as well as widespread use of impervious surfaces. Water flows swiftly off of most paved surfaces in our urban areas, and many landscapes have poor infiltration due to surface compaction by vehicles and people. Likewise native songbirds are undermined by the loss of native plants, which can offer high aesthetic value (Oudolf & Gerritsen 2003) while supporting essential hydrological and ecological functions (Burrell 2006; Tallamy 2007).

In "Water Matters" Brock Dolman (2010, 130) indicates that we have a great opportunity to change these undesirable conditions by implementing urban infrastructure and stormwater practices that **slow, spread, and sink precipitation into the earth**.

Patchett & Wilhelm (2008), Condon (2010), Dinep & Schwab (2010), and Douglas (2011) all note how **filtering water through soil-and-vegetation systems is vital to the health of watersheds**—providing cleaner and more stable water supplies for downstream ecological systems as well as for people with property, homes, and businesses downstream.

Water conservation—supported by creating rain-gardens and bio-retention areas that need no or very minimal supplemental irrigation once established—**has many positive effects, including energy and economic savings** (Schmidt et al. 2007; Woelfle-Erkskine & Uncapher 2012).

Nassauer (1997), Dreiseitl, et al. (2001), Echols (2007), and the University of Arkansas (2010) highlight the importance of **creating artful stormwater management facilities for enjoyment, engaged education, and perceived value** by residents and stakeholders.

This guidebook shows how designers in the Kansas Flint Hills Eco-region were able to replace approximately 2,000 square-feet of impervious surfaces with a permeable and visually pleasing bio-retention garden that needs very minimal supplemental irrigation once established.

Purpose of this Guidebook

This guidebook aims to benefit both property owners and planners/designers by describing important considerations related to bio-retention planning, design and management.

Two succinct chapters are provided: the first, addressing the planning/design phase of a small-scale urban stormwater management project; the second, offering guidance for the implementation of bio-retention areas in locations similar to the new garden at Sunset Zoo.

Project Accomplishments

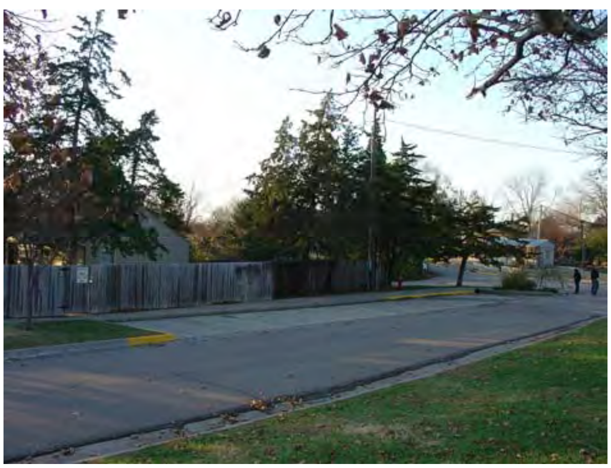
One bio-retention area garden was installed in the fall of 2011 to reduce impervious surfaces and increase infiltration of stormwater runoff at Sunset Zoo in Manhattan, Kansas.
The garden lies north of the central amphitheater and "Kansas Plains" displays and west of the Prairie Dog display. An underutilized concrete sidewalk and asphalt parking area were removed and replaced with a series of bio-retention pools that collect a portion of the water running off of upslope pavement and turfgrass. Photos below were taken October & November 2012.

An on-site education session was held on June 21, 2012 and involved interested citizens.
This session (pictured below-right) was co-sponsored by the Wildcat Creek Watershed Council. Additional on-site education and hands-on maintenance events were held September 28, 2012 and involved landscape architecture and planning students from Kansas State University.

Chapter One: Bio-retention Area Planning/Design

The most important idea we can share at the outset is that planners, designers and property owners should **seek to integrate proposed bio-retention areas and rain-gardens into both the larger eco-region** (with thoughtful consideration of the regional climate and plants native or well-adapted to the region) **and to the specific site** (including soils, topography, hydrology, on-site and nearby vegetation, and the bio-physical and socio-cultural context). Budgetary limits (time and financial resources) are almost always an important factor and frequently determine how one proceeds during the planning/design process as well as implementation.

In regards to the **Sunset Zoo Bio-Retention Area Gardens** two broad options were considered by KSU faculty, students, and staff between Fall 2008 and Fall 2011: 1) address the entire area between the residential fence and the roadway, including the removal of the existing large clay pipe and concrete pad leading to this pipe (see photos below); or 2) focus the bio-retention garden more narrowly by removing the underutilized concrete sidewalk and asphalt parking area and retaining the clay pipe and associated concrete pad. Due to both financial and time constraints it became clear that the large pipe should not be removed. Additionally, there was a desire to make sure that the new gardens were able to handle high volume stormwater flows running towards the garden and to also provide a location for plowed snow near the pipe.



<u>Important Planning/Design Considerations:</u>

1) Create a bio-retention garden sized for the specific limitations and opportunities of the selected property, with careful consideration of the impermeable and permeable surfaces associated with the site, present and anticipated (future) watershed conditions, projected stormwater flows into the garden through different seasons, on-site soil and microclimate attributes, and the likely timing of bio-retention area implementation and establishment.

a.) Determine the size of property, structures, and impermeable surfaces. Consider the specific context for the site. Determine if the proposed bio-retention area should be in-line or off-line. In other words, should stormwater runoff be moved directly through the garden *or* should only a portion of upslope stormwater flows be re-directed towards and moved through the garden?

Given the large size of the drainage area above the Sunset Zoo Bio-Retention Area Gardens (approximately 1.5 acres of mostly impermeable paving and semi-permeable turfgrass surfaces) early on it was determined that a majority of the garden would <u>not</u> have all upslope runoff directed into the bio-retention area. Eventually, in large measure due to budgetary constraints and the lack of a legal mandate to immediately remove the pipe or increase stormwater detention, the decision was made to also keep the large pipe and associated concrete pad (immediately above the pipe) in order to handle high-volume flows. At some future time it is certainly possible for the pipe to be removed and thus the bio-retention capacity expanded.

b.) Determine size of watershed and size of bio-retention cells based on surface area. parameters. As needed, seek advice from local landscape architects, USDA-National Resource Conservation Service staff, and city/county engineering departments to obtain needed maps and data and to assist in making accurate calculations. Calculate the total watershed area (specifically the area draining to the proposed bio-retention area). Include a calculation of both permeable and impermeable surface areas within the contributing drainage area.

c.) Obtain the water quality storm value for your site from the local city/county engineer's office. The "water quality storm" is typically one that produces less than or equal to 90 percent volume of all 24-hour storms on an annual basis, per the *Mid-America Regional Council, Best Management Practices Manual* (MARC 2009).
d.) Identify soil types and assess their porosity or permeability.
e.) Identify plant material cover types and determine the coefficient factor(s).

f.) Calculate the water storage needed to capture and treat 90 percent runoff quantities for at least 90 percent of the "one-year storm event." (Reference *Mid-America Regional Council Best Management Practices Manual* for formulas or consult a qualified planner/designer and/or engineer/natural resources specialist. Utilize MARC's "short-cut method" for sites of less than 10 acres. Utilize MARC's "small storm hydrology method" for areas larger than 10 acres.)

Although initial watershed calculations were completed for the Sunset Zoo Bio-Retention Area Gardens it was determined that this demonstration project would retain the concrete gutter pan running alongside the proposed garden, and as a result would not require detailed calculations to determine how much water would flow into and through the garden. In short, the designers planned to skim a small portion of large stormwater runoff flows as it moves along the gutter.

The designers decided that this adaptive and cautious approach would be helpful to safeguard soils and vegetation, with no cuts being made to the gutter until after bio-retention area vegetation had a chance to establish itself for at least one growing season. Thus, in November 2012, more than one year after 2011 planting days, multiple cuts to the concrete curb were made to encourage some (but not most stormwater runoff) to move into this five-pool garden.

g.) Consider and appropriately address any potential impacts on neighboring properties. Locate and design the bio-retention cells and size the garden pools so that water collection and movement does not adversely impact nearby structures and upland vegetation to remain (either or on or off of a selected property). As needed (and as much as time and budget allow), property owners and planners/designers should consult a civil engineer, soil scientist, natural resources specialist, landscape architect, botanist, horticulturalist, and/or other qualified professional(s) to evaluate existing and proposed soil and topographic conditions, existing and proposed vegetation, and relationships to existing structures and infrastructure (including above and below ground utilities). Recognize that unforeseen issues will always arise when one begins to dig into the earth in urban areas—and be prepared to collaboratively figure out how to best respond to both probabilities and surprises.

At the Sunset Zoo Bio-Retention Area Gardens designers consulted with soil specialists, had the soil tested to determine (estimate) the pH level, discussed removal of some of the nearby Eastern Red Cedar and honeysuckle with zoo staff (which included a staff member with horticultural expertise), and consulted with local fire department staff in regards to providing adequate access to an existing fire hydrant on the site. Underground utilities were also discussed with zoo staff and then marked by City and utility company personnel prior to excavating the bio-retention pools. Buried conduit (encased in concrete and more prominent than expected) had to be considered once the asphalt parking area was removed. It was determined that the access walk to the fire hydrant could help serve to mark the conduit, function as a walkway, and also serve as a terrace between two of the bio-retention pools. Although lots of planning and design takes place on paper, there are always many design decisions to be made in the field, and this was true for the Sunset Zoo project.

h.) Consider sun/shade conditions and other microclimate attributes associated with the proposed site as well as potential invasive species concerns.

Selecting the right plants for the existing and envisioned microclimate is essential. As with most designs, there will generally be no perfect solution, but the fit between a plant species' soil moisture tolerances and on-site conditions is essential. At the Sunset Zoo Bio-Retention Gardens (and most other urban sites) there will inevitably be many invasive or unwanted plants that can influence ultimate plant composition in the garden. Where there are large numbers of invasive or unwanted species (true for Sunset Zoo) then regular, ongoing monitoring and management (weeding) will be required. Eastern red cedar, shrub-form honeysuckle, a range of native and non-native woody plants, and a number of exotic grasses could overwhelm the Sunset Zoo Bio-Retention Gardens if not kept in check. These concerns should be planned and designed for by creating competitive new plant communities, using 2-3 inches of mulch, and allowing for access by volunteers and/or maintenance personnel without causing undue compaction of soils.

i.) Identify local and state regulations regarding implementation strategies, and siting criteria.

At the Sunset Zoo Bio-Retention Gardens designers were not required to meet specific legal or regulatory stormwater management mandates, thus allowing for a great amount of flexibility in regards to the design and ultimate size and depth of bio-retention pools and cells. From a creative design standpoint, such flexibility is helpful, but is not always possible.

m.) Consider budget parameters. Relocate the proposed bio-retention garden if it is determined that the target site is not the best place for such a facility. Or, re-size the bio-retention pools and garden as needed to effectively address the amount of water that will flow into the garden.

At the Sunset Zoo Bio-Retention Gardens designers found the selected site to be an ideal location for a bio-retention facility even though nearby Eastern Red Cedar would drop fruit into the garden, potentially increasing the need for more regular monitoring and weeding.

2) Know your maintenance needs & capabilities

a.) Contact the property owner to determine maintenance expectations.

b.) Design garden with maintenance capabilities in mind.

At the Sunset Zoo Bio-Retention Gardens dialogue with the zoo director and staff (including maintenance personnel) gave everyone involved a clear picture of expectations and needs. Regular monitoring and weeding was performed by the lead designer, who had intimate understanding of the vision for the garden and all of the species planted. Where this kind of hands-on monitoring and management (including regular watering and weeding) cannot be done by the bio-retention designer, training of staff or volunteers is needed.

3) Determine a proposed soil mix that incorporates existing soils into the mix unless they are hazardous or contaminated in a manner that necessitates their removal.

a.) Does the site require specially designed soil mixes? As needed, consult a soil scientist or soil testing facility to determine the composition and characteristics of the soil. As needed, consult a landscape architect and/or civil engineer to help you determine the appropriate bio-retention soil mix related to your site and bio-retention goals and objectives.

The Mid-America Regional Council's *BMP Manual* (2008, 117) indicates that a bio-retention soil mix (the amended planting soil or "BSM") should be a minimum of 2.5 feet deep and a maximum of four (4) feet deep. The BSM needs to "enhance nutrient uptake" and "have a combination of chemical and physical properties to support a diverse microbial community."

Gregg Eyestone, Riley County, Kansas Horticulture Extension Agent, recommends the use of organic matter that is plant tissue based, with no or very sparing use of manure and the incorporation of a well-balanced organic topsoil and/or organic vegetable compost of two to four feet deep if this is possible (personal conversation, Jan. 2013).

At the Sunset Zoo Bio-Retention Gardens designers dug several test holes and found that the depth to bedrock was quite shallow in a number of locations (expected based on knowledge of the underlying geology shared by zoo staff). Additionally, the intent was to use and amend existing soils as needed rather than to meet some specific engineered soil specification.

When the concrete sidewalk was removed there was 1-3 inches of sand in the area where the sidewalk had been and this sand was incorporated into the beds via rototilling. Based on a soil test by the K-State Research and Extension Soil Testing Lab (which indicated a soil pH of around 8.6—with phosphorus levels of 7ppm and potassium at 153ppm—for the soils uncovered once the asphalt was removed from the old parking area) it seemed wise to bring in topsoil to the garden. Additionally, several selected woody plant species (namely one Betula nigra 'Heritage' [River Birch], one Ostrya virginiana [American Hophornbeam], and nine Hydrangea quercifolia [Oak-Leaf Hydrangea]) received inputs of cottonburr compost as a way to lower pH levels, per the recommendation of Kyle Koehler, a landscape architecture graduate student with a bachelor's degree in horticulture.

b.) Consider budget parameters as well as availability of local materials.

At the Sunset Zoo Bio-Retention Gardens designers were able to use salvaged materials already available at the zoo (namely limestone rock for the walkways/terraces and a large limestone seat rock). This helped reduce project costs and also minimized expenditures of fuel/energy.

c.) Consider new uses and/or re-use of existing soils. Is it practical to utilize existing site soils to save money when creating new soil mixes? Is it practical to dispose of existing site soils and bring in new? Consider the effect on the "borrow" site when considering off-site soils. The NRCS-SCS Web Soil Survey is a good place to get an overall sense of soil types, but testing by a qualified extension agent or other university or private soil testing lab is a good idea. Recognize that amending existing soils may not be needed to create a rain-garden, and that only modest inputs may be needed depending on the specific site and project goals and legal requirements.

At Sunset Zoo we had no need to dispose of excavated soil from the site, but there was a diligent effort to pick out all of the broken pieces of concrete and asphalt we could find. Approximately eight cubic yards of topsoil came from Pottawatomie County. No pH test or other soil testing was required by the designers for the topsoil as we were simply looking to improve the texture of the highly compacted and high pH soil on the site. In hindsight, however, soil tests from several different locations within the topsoil and cottonburr compost amended bio-retention area would have been wise, as would have more in-depth conversations with County Extension staff about the results and implications of the initial and post-amendment soil tests.

4) Specify non-invasive plant material that is well-adapted to the eco-region and specific soils, microclimate, etc. Specify plant material according to the American Standard for Nursery Stock. Plant pots and balls shall be, at minimum, at least as deep as their circumference.

a.) Specify seed as "pure live seed" and obtain seed and live perennial plants from well-respected nurseries or suppliers within the eco-region.

b.) Use "grade one" woody plant material from a nursery licensed and inspected by local and state authorities.

In the Flint Hills Eco-region we have few specialized native plant nurseries, so we often need to draw upon nurseries in nearby eco-regions when desired native grasses and wildflowers are not available from local sources. As noted below there are a number of good options to consider when specifying plants in central and eastern Kansas.

5) Choose plants that can handle water and drought and locate specific species in settings that are appropriate to their cultural needs (particularly soil type, texture and moisture).

It is wise to provide some diversity in plant material so that the plant community that is formed can be more adaptive than would likely be possible with use of just two or three species. At the Sunset Zoo Bio-Retention Gardens designers selected 17 species of native wildflowers and nine (9) species of native sedges and grasses. These perennials (planted as small live plants) were supplied by two nurseries within 225 miles of Manhattan, Kansas. Ideally, plants and seed would come from local sources or from nurseries that grow plants within about 100-150 miles of a site, but this is not always feasible.

In Kansas our native prairie species are well-adapted to drought and many perennial plants (as seed or live plants) can be obtained from native plant nurseries such as Kaw River Restoration Nurseries in Lawrence, Kansas (http://www.restorationnurseries.com/index.cfm) *and the Prairie & Wetland Center in Belton, Missouri* (http://www.critsite.com/).

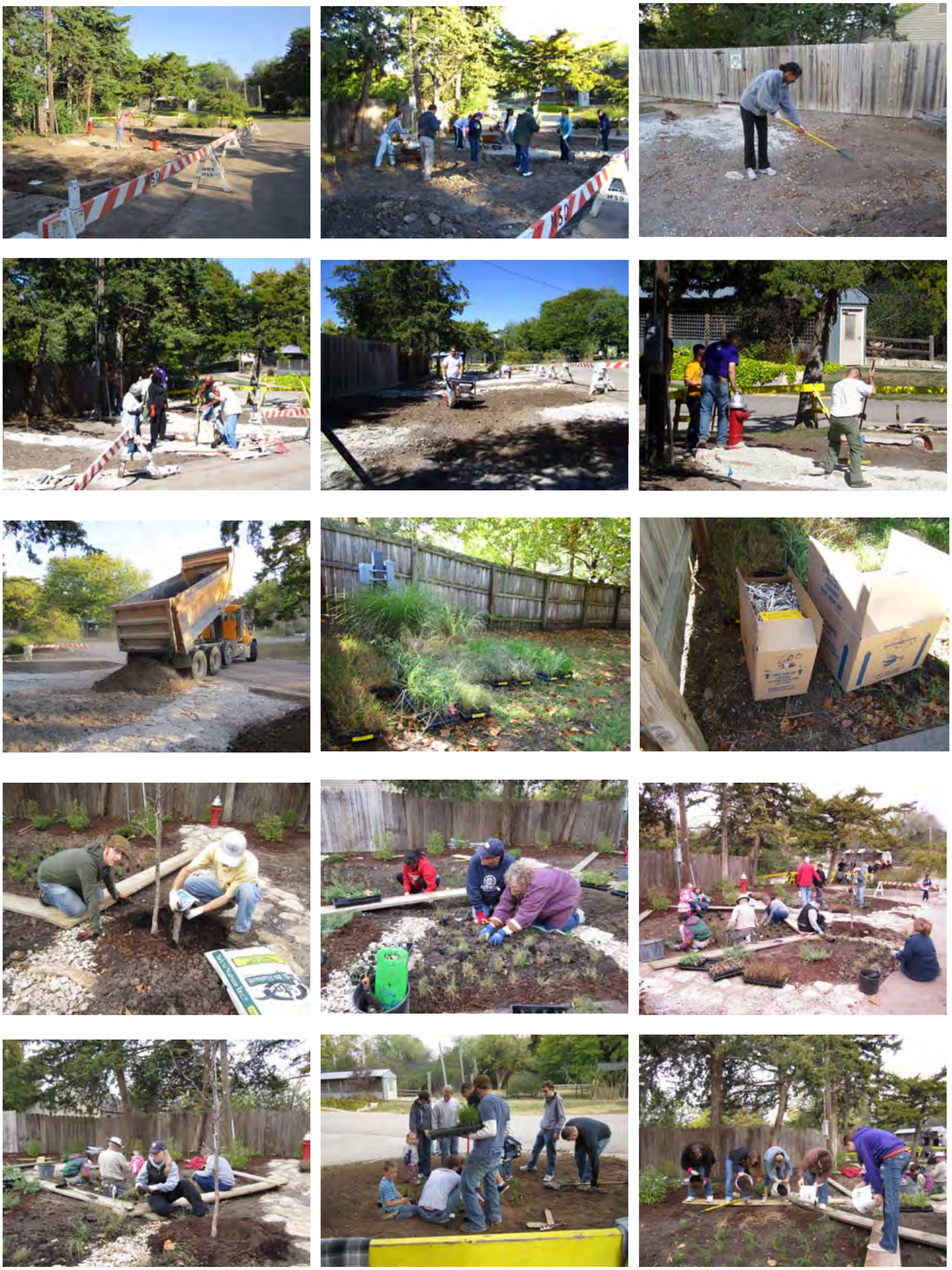
For more native plant information and nursery/supplier options refer to:
http://www.kansasnativeplantsociety.org/plant_seed_sources.php
http://www.wildflower.org/collections/collection.php?collection=KS
http://www.bluebirdnursery.com/Products.asp
http://www.feyhfarmseed.com/index.html
http://dyckarboretum.org/
http://www.kswildflower.org/
http://plants.usda.gov/java/

6) Learn from others, and from your own experiences.

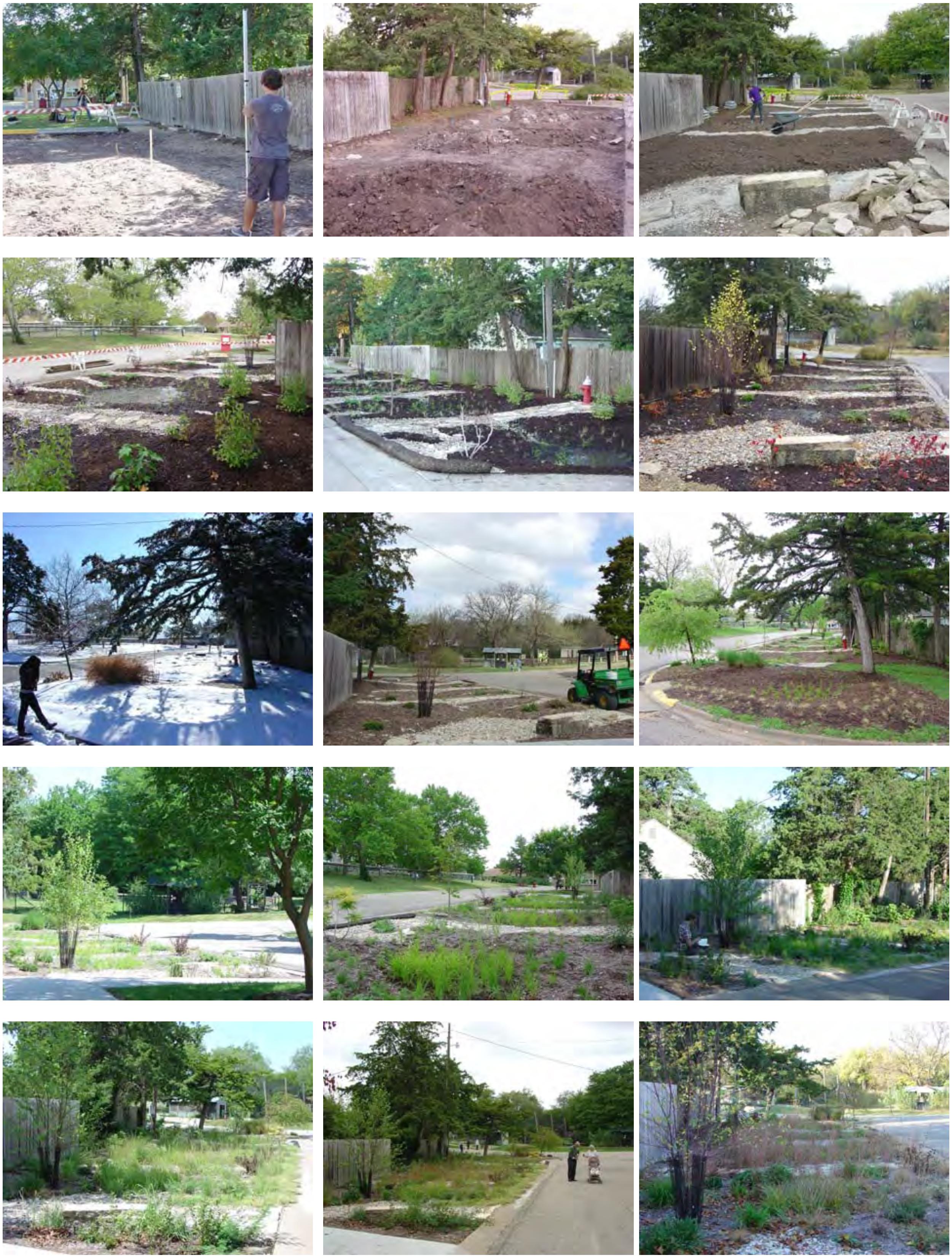
Design a way for water flowing into the garden to safely flow through and out of the garden during a large storm event. Use a range of plants to provide biological diversity and varying rooting densities and depths, specifying those species that will handle expected periods of drought and very wet conditions. Recognize that well-designed and managed bio-retention areas typically infiltrate water within 2-48 hours, depending how dry or wet the soils remain. Once constructed, if bio-retention areas hold water for more than two days perhaps the surface has been compacted and/or sealed by deposited silts and needs to be roughened using a rake. Specifying several inches of clean hardwood mulch (not wood chips as they can float or blow away) on the garden will help to reduce the number of weed seeds that germinate.

Consider the following suggestions as you work through the planning/design process: think long-term and be bold (aim for zero waste and reduced life-cycle costs); consider the details (such as how micro-topographic changes will influence plant survival and health—select plants that match the bio-physical conditions of the place where they are to be planted); know your budget and the institutional capacity of the property owner/client; seek to understand soil, water and plant interrelationships; be practical, ambitious and creative (accounting for aesthetics and human needs and interests as well as ecological concerns); design to conserve water and energy; remember that it planning/design is a process—learn all along the way (especially after you have implemented the project and you document successes and mistakes).

Selected Sunset Zoo Bio-Retention Area Implementation Images (photos by Dea Brokesh, Fall 2011)



Selected Sunset Zoo Bio-Retention Area Images (photos by Lee Skabelund, Aug 2011-Oct 2012)



Chapter Two: Bio-retention Area Implementation & Management

Steps in the Implementation Process

1. Preserve native vegetation
    a. Install temporary construction fencing at least five feet beyond (or outside of) drip-lines of all trees to be preserved.
    b. Do not park or store materials within fenced areas or underneath the drip-line of trees to be preserved. Note that in some locations you may need or choose to work beneath tree canopies and this work should account for the durability or sensitivity of the particular species involved (some species are much more sensitive than others).
2. Preserve native soils to remain by minimizing compaction and disturbance.
    a. Prepare an area for stockpiling and re-use of existing topsoil. Remove undesirable vegetation by hand-pulling or clipping (or when necessary by spot spraying undesirable "weeds" or painting cut stumps with glyphosate 10 days prior to soil stripping or working with the soils; if chemical herbicides are used make sure all directions are followed and employ a trained or certified applicator). Utilize a sod cutter to remove vegetated sod. Reuse sod strips as possible on other parts of project site.
    b. For soils to be re-used strip topsoil and save separately from lower sub-soils.
        i. Place topsoil in area that will not cause disturbance of other natural systems.
        ii. Protect topsoil from contaminants and pollutants:
            1. install water diversion devices to deter erosion;
            2. cover soil, if practical, to protect from air-borne contaminants or place soil in locations away from air-borne contaminants;
            3. keep stockpiled soils shallow (less than four feet depth maximum).
3. Stabilize contributing drainage areas against erosion and sediments prior to construction. As much as possible, route stormflows around the bio-retention area worksite while soils are bare (exposed) and cover with a mulch or non-invasive cover crop if soils are to be exposed for more than a month or two during the growing season.
4. Excavate bio-retention cells to accept bio-retention soil mix
5. Install underdrainage system, if specified by landscape architect and/or engineer
6. Rip, scarify or till at least six (6) inches deep at the bottom of the bio-retention cells to alleviate compaction and help integrate the planting soil into the subsoil and do not run heavy equipment over the planting soils once they are laid down.
7. Place bio-retention soil mix with low ground contact pressure equipment.
8. Plant material (vegetation) handling techniques:
    a. Protect plants during shipment by placing in covered vehicle to avoid wind burn;
    b. Protect live plants on the job site by placing them in the shade (especially during the heat of the summer, covering them as needed to protect from cold or windy weather, and watering them as needed to keep plant roots moist.
9. Install live plant material according to State Extension services guidelines. Excavate plant pits to level of soil found in pot or slightly higher. Make planting holes/pits deep enough to accommodate roots. Backfill plant pits by hand with loose excavated soil. Gently compact soil around each plant by hand during backfill operations so that plants are

snuggly nested into the soils and will not float away if they are within a bio-retention pool. Water the plant roots and soil around each plant soon after planting in order to keep the plant roots moist. Generally projects specifying less than several thousand plants can be readily implemented using small live plants from flats as well as bare-root, container grown, or balled-and-burlap woody plants. Seeding is generally most cost-effective for very large bio-retention areas (several thousand square feet or greater of sedges, grasses and wildflowers) but seeds can be used for smaller projects as well. A biodegradable matrix/slurry, geo-textile fabric, or other suitable erosion control covering should be used wherever there is a good chance for erosion.

10. Seed to the depth recommended by landscape architect, designer, or ecological restoration practitioner based on the selected plant type or mix of species. Annual oats or another non-toxic annual can be used as a temporary cover crop for erosion control.
11. Hand rake soil in the planting bed so that it provides positive drainage away from structures or other areas that water should not be sent to. Variations in micro-topography can be beneficial for native plants and help retain and infiltrate water. Compaction of soils needs to be avoided in order for infiltration to occur. 2x10 or 2x12 boards can be used as bridges over bio-retention pools during both the planting operations and final raking (fine grading) work.
12. If live plants are used the bio-retention garden should be covered with shredded hardwood mulch, landscape rock, or another suitable erosion control material as specified by landscape architect/designer. Wood chips need to be avoided within bio-retention pools as they will likely float and be displaced when pools fill with water.
13. Monitor erosion and sediment control at least once per month or after significant storm events during construction operations and during plant establishment.
    a. Remove silt build up and dispose of silts at an appropriate stockpile location or reuse at low spots of site. Make certain that bio-retention soils are not compacted. Roughen the surface area of bio-retention garden soils to help precipitation and surface water move into the soil profile.
    b. During the establishment period, add mulch to the garden as is necessary to prevent erosion, keep plant roots moist, and discourage the growth of weeds.
    a. Reset and/or replace plants as necessary, making sure that these plants are watered in and roots kept from drying out.
14. Hand water or irrigate as needed during the first year of plant establishment. Monitor the precipitation on-site, or use data from a nearby weather station to know when supplemental watering is needed. Check soil moisture using a trowel and fingers or, if the budget allows and appropriate monitoring equipment can be secured use a soil moisture sensor to help determine when to water the garden. Alternatively, attentive observation of vegetation, weather, and site conditions should provide enough information to guide watering.
    a. During the first two weeks of seed establishment, provide (or see that the garden receives) 1.0 to 1.5 inches of water per week. Afterward decrease irrigation to 1.0 inch of water per week during warmer months and decrease irrigation to 0.5 inches of water per week during cooler months.

b. During the first two weeks after live plants (plug, bare-root, container, or balled-and-burlap material) are installed provide at least 1.0 inch of water per week. Afterward decrease water to 0.5 inches of water per week.

15. Weed undesirable grasses, broadleaf weeds, and woody plants from the garden, being careful to minimize soil disturbance and not compact soils. Refer to the discussion of maintenance practices below for additional guidance.

Maintenance Practices

Any garden requires ongoing and dedicated monitoring and maintenance. Weeding is essential. Fertilizing is not needed if native plants adapted to the location are used and soils have a reasonable amount of nutrients (especially phosphorus and potassium) to begin with. Pruning is rarely needed, though clipping back perennials before spring is important. Watering during the first growing season is vital, and may also be needed during periods of drought for species that do not have a long-term genetic memory of the eco-region where they are planted. Building institutional interest and capacity for ongoing maintenance is essential. Colleges universities, high schools, and other educational institutions can play an important role in assisting local communities monitor sites, and help stakeholders increase their knowledge of sustainable planning, design, and construction practices.

<u>Key ideas to remember regarding maintenance:</u>

1) **Bio-retention gardens need to be maintained. For this type of native plants garden it is wise to plan on 1-2 hours of maintenance** (primarily weeding out unwanted trees and other plants) **every two or three weeks during the first growing season. Visiting the site at least monthly is wise after establishment.** This type of maintenance can be done by grounds staff, a gardener, or a volunteer with a good sense of the native plants used and the design intentions.

2) **Weeding is essential in urban settings**—even though a good hardwood mulch can reduce the number of weeds and make weeding easier. **Pruning is needed time-to-time**—for example to remove dead or damaged materials and to clip back perennials before spring. Maintenance staff, gardeners, and other volunteers may desire to transplant and water in seedlings, and they will definitely want to remove more aggressive perennials if they begin to dominate the garden.

3) **Learn what the "weeds" and invasive species are in the local area and eco-region and prepare to remove them from a bio-retention garden as soon as possible.** Budget at least a few hours a week during the first growing season for monitoring and weeding; it saves lots of time down the road!

4) **Watering during the first growing season is vital** (try to strike a balance between providing too much and too little water). If you **choose plants well-adapted to your eco-region and specific site**, no or very minimal watering should be needed once the plants are established. Check for exposed soil and erosion, and add organic weed-free mulch. **If too much sediment is flowing into the garden find the source and stabilize the area** (if needed, you may need to reduce the volume or intensity of stormwater flowing into the garden).

5) **Draw upon the experience of others**. **Recognize that all good ideas must be adapted to the local site and its context—including client and stakeholder needs and concerns.**

Cuts into the concrete gutter help move more water into the bio-retention garden while a soil moisture and temperature sensors assist Kansas State University faculty and staff to better understand the interrelationships between soils, vegetative growth, and climatic variables.

These three images were taken by Lee R. Skabelund Jan. 9, 2013 during installation of monitoring devices.

Outreach and Education

The text below was prepared for reference when discussing the rain-garden at formal and informal public education events *and* as the project team developed an interpretive sign for the zoo's new bio-retention area garden. The aim was to connect with 3rd to 6th Grade audiences.

The Sunset Zoo Bio-Retention Area Demonstration Project is a cross between a bio-retention area and a rain-garden. It collects and slows down rainwater with plants, soil, and rock.

What is a Bio-Retention Area?
A bio-retention area collects and slows down stormwater.

Living plants, soils, and organic matter soak up much of the water instead of allowing excess water to flow downhill. Sometimes a bio-retention area has specially engineered soil and an underground pipe and/or inlet.

Bio-retention areas are usually located in upland areas. It is easier to manage stormwater when rain collection starts near the top of a hill.

What is a Rain-Garden?
A rain-garden has a shallow basin that temporarily holds rainwater.
Like a bio-retention area, it uses plants to soak up rainwater.
A rain-garden can be created using existing soil.

Bio-retention areas and rain-gardens allow rainfall and snowmelt to refresh vegetation and soils and can recharge underground water supplies.

This **multi-pool stormwater management garden at Sunset Zoo** includes **native Flint Hills prairie plants** that are well-adapted to the soils, topography, micro-climate, and expected moisture levels within each part of the garden.

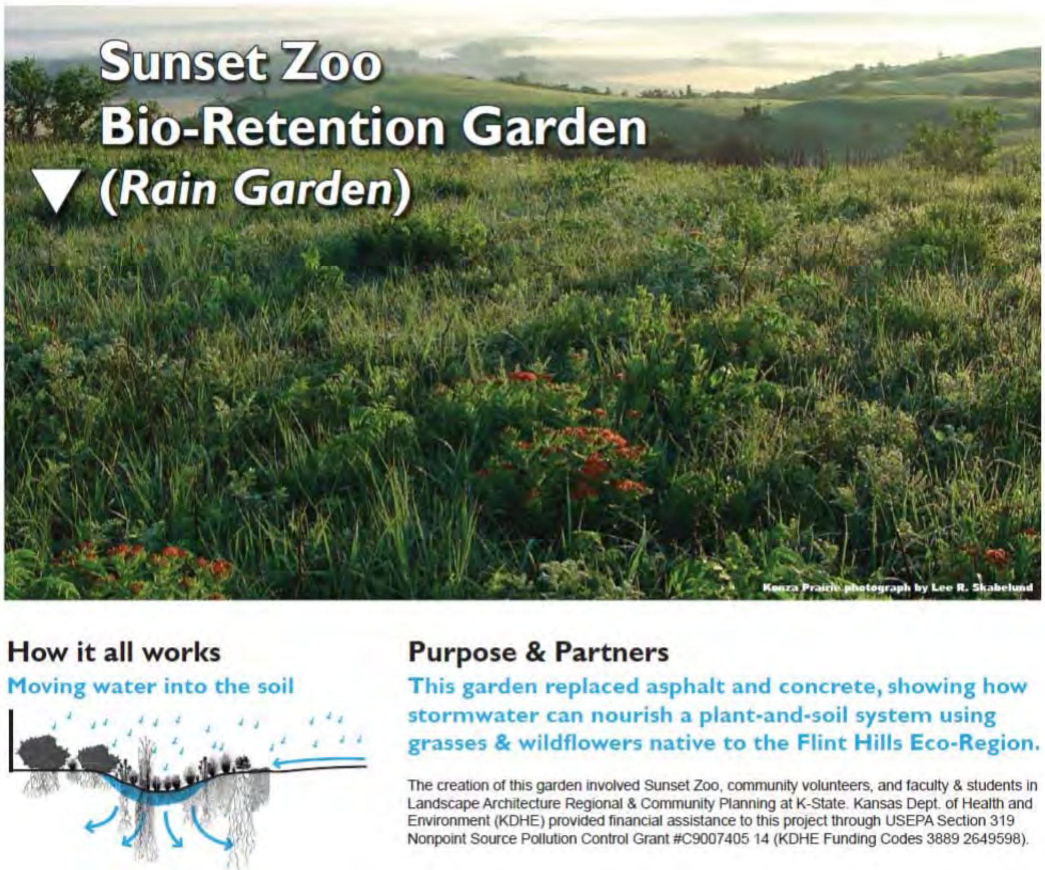
The garden, limestone pathways, and terraces were implemented in Fall 2011 with assistance from Kansas State University faculty and students and community volunteers. Many thanks!!!

Sunset Zoo staff **removed underutilized asphalt parking and a concrete walk**. Zoo staff next rough-graded **several pools** to **serve as stormwater collection areas**. Volunteers placed rock terraces and walkways, and planted **vegetation** to **fit soils and landform**. Natural processes will ensure that the garden changes over time—while staff and volunteers seek to keep the garden a pleasant place to visit and learn from season to season.

If you wish to volunteer your time to maintain this garden, please contact Sunset Zoo's main office at 587-2737. City and Sunset Zoo staff and K-State's faculty, staff and project managers greatly appreciate all who contributed to this project effort!

The Kansas Department of Health and Environment has provided financial assistance to this project through EPA Section 319 Nonpoint Source Pollution Control Grant #595. This Clean Water Neighbor grant was received by Kansas State University's Department of Landscape Architecture / Regional & Community Planning in Fall 2010. Conceptual design ideas were prepared by KSU Planting Design students and refined by KSU faculty and staff.

Ultimately, Sunset Zoo staff wanted a minimum amount of text displayed on the interpretive sign and so the following signboard was created by K-State faculty and staff for the garden.



Concluding Thoughts

Creativity and persistence is required to create well-designed and effectively implemented stormwater management demonstration projects on a private or public site.

Interest in energy and water savings in a community can open the door for creative, multi-benefit projects that have the opportunity to create more sustainable landscape structure and functions and set a standard for other future projects.

Deep-rooted prairie plants and small-scale bio-retention areas and rain-gardens can make an immediate, noticeable impact on stormwater runoff from a property.

When carried out in an integrated and holistic manner—especially as usable garden spaces—even very small-scale projects can make a very important and positive impact.

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Photos by Lee R. Skabelund (October and December 2012)

Photos by Lee R. Skabelund (August and December 2012)

Photos by Lee R. Skabelund (May and August 2013)

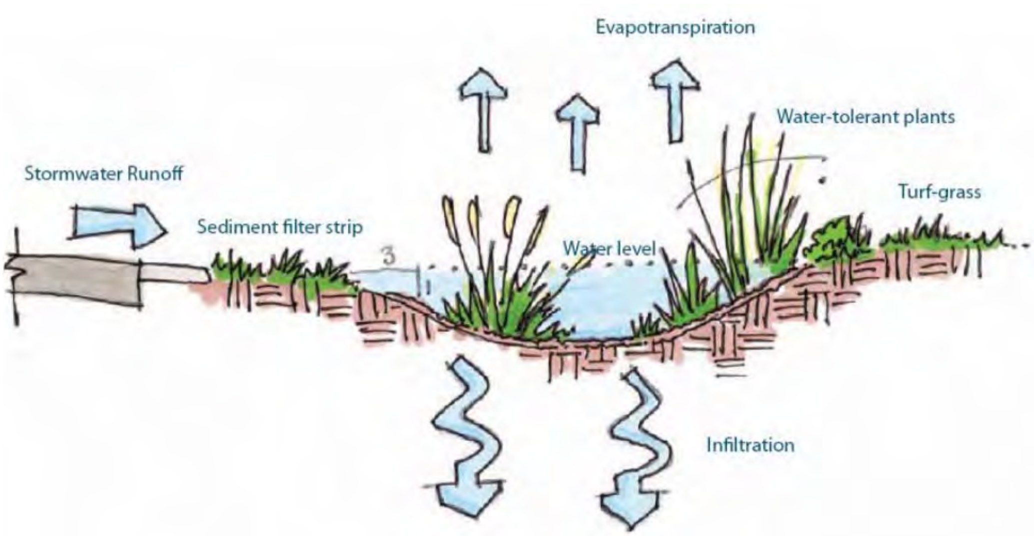
A Parting Thought and Nod to an Earlier K-State Guidebook

“Rain-gardens are a solution that can be readily adapted to capture and infiltrate stormwater on nearly every property, no matter the type of soils or slopes.”

(Skabelund 2008, 3)

The quote above comes from the following guidebook, also supported by USEPA & KDHE:

Rain-Garden Design and Implementation for Kansas Property Owners: With a Discussion of Lessons Learned from Kansas State University’s International Student Center Rain-Garden Design-Build Demonstration Project in Manhattan, Kansas



Rain-Garden sketch by Tim Merklein (KSU-LARCP 2008)

http://faculty.capd.ksu.edu/lskab/KSU-LARCP_Rain-Garden-Guidebook-lrs.pdf

For a discussion of other Kansas State University LARCP projects refer to:
http://faculty.capd.ksu.edu/lskab/