


TRAILWOODS NEIGHBORHOOD BEST MANAGEMENT PRACTICES

FY 2011 §319(h) CA # C9-996100-16 Project 5 (Task 5.2.6c)

For
United States Environmental Protection Agency (Regional 6) and
Oklahoma Conservation Commission

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Contents

1. Background

Since this project began, many advances have been made in the area of urban stormwater management. At the commencement of the project in 2009, the application of "green infrastructure" at the site scale was not yet a part of the parlance for a design approach for managing stormwater (Tzoulas et al. 2007). Instead, the field relied on the term "best management practices" to convey something other than the traditional curb and gutter approach. At that time, bioretention was being investigated in urban settings as a way to improve runoff quality (Hunt et al. 2006). In Oklahoma, few examples of low impact development, green infrastructure, and bioretention existed.

The *Lake Thunderbird Watershed Workplan* calls attention to declining water quality of the reservoir and summarizes that urban expansion in the form of suburban land use conversion was negatively impacting lake water quality. A series of reports by Oklahoma Water Resources Boards illustrating declining water quality led to a study by Vieux and Associates (2007) that identified land use conversion to be a significant impact to the lake's declining water quality, in part due to its release of phosphorus into receiving streams. In long range municipal land use plans, such as Norman's, much of the watershed allowed for new suburban development.

In the western headwaters, Carrington Lakes, a newly developing residential community, had built the early stages of a green space community using bioretention in the form of public rain gardens (Coffman and Strosnider 2009). In 2007, four rain gardens were installed in a public green space to accept first flush storm events from 5 acre suburban basins. With a functioning prototype for the watershed, this project was initiated to examine the application at the site based on other best management practices in the public right-of-way of newly developing entry-level market homes. The goal was to deploy curbside rain gardens and as many other practices as possible into a market-driven subdivision.

The project team included the Oklahoma Conservation Commission, University of Oklahoma, City of Norman, Ideal Homes Development, and two consulting firms, CH Guernsey and SMC Engineering. Oklahoma Conservation Commission has been increasingly involved in the watershed with monitoring activity for the development of a TMDL and with a Wetland Treatment Study as a viable BMP. The University of Oklahoma is continually participating in various watershed studies. Dr. Reid Coffman of the College of Architecture and Planning led the project team with the assistance of Dr. Robert Nairn, College of Engineering and Environmental Science, due to previous work in the watershed. Ideal Homes, a locally-based national home builder, has numerous neighborhoods planned and under development in the watershed. Richard McKown, Land Development Director for Ideal Homes, acted as the lead private partner. The City of Norman Planning Director and the Public Works Director were cooperating partners.

2. Introduction

In June 2009, the site selection and planning began. By December, the team had selected the forthcoming Section 5 of the Trailwoods neighborhood as the project site. Located in North Norman in the Little River Tributary (35º15'02.29" N, 97º27'03.47" W, Elev. 1186 ft.), the site offered the opportunity to plan and design the best management practices into the initial stages of a 5 acre project.

In the winter of 2010, the master plan was created. Through various iterations, four best management practices were selected: rain gardens, rain barrels, diversions of downspouts, and a small area of porous paving. In early spring, the plan was given internal approval by Norman Public Works, and construction drawings were developed. Preliminary site grading and utilities commenced in April 2010, and the roadway was paved in October. The best management practices were formally presented and approved by the City Council in December.

Construction of homes began in early 2011. In March, the first rain garden was installed on the first lot. As each lot opened, site-based best management practices were installed as a part of the lot development. Unfortunately, home sales and development slowed in the latter half of 2011 and into 2012, dramatically extending the installation phase. It was not until July of 2013 that the last home was completed and best management practices installed. This was 1.5 years after the planned completion.

Monitoring equipment was installed the Spring of 2013 and became fully operational after the completion of the last lot in October 2013.

The project includes 17.5 lots using three types of best management practices: curbside rain gardens, rain barrels, and downspout diversions, while the adjacent 17.5 lots were conventionally developed with curb and gutter and downspout to driveway conveyance. One area in the demonstration basin has 120 sq.ft. of porous concrete.

The neighborhood is built of homes averaging 1,100 sq.ft. and selling for $110,000.

By the Numbers

- 5 acres
- 35 lots
- 2 basins
- 18 rain gardens
- 17 rain barrels
- 3,940 s.f. of rain garden
- $29 s.f. rain garden
- $6 s.f. porous paving
- $35 per barrel
- $6,125 per lot

Figure 1: Site location in the basin (Upper left), the site's developing residential context (Upper right), and the site upon completion in 2013 with the left-side street being the demonstration (Bottom).

Figure 2: Site predevelopment condition (Top), the site under development September 2010 (Middle), and the site upon completion in 2013 (Bottom).

3. Objectives and Methods

The project has five major objectives:

- Profile universal, but locally untested, street-side best management practices (BMPs) in a residential community
- Participate with local government officials and departments to allow for BMPs
- Situate BMPs in an entry-level home community
- Educate local developers, agency officials, designers, contractors, and residents
- Evaluate the life cycle costs of the BMPs

The project profiles several universal but locally untested best management practices in an entry-level home community. The selection of the rain gardens is intended to enhance a sense of community character and improved quality of life.

The project was designed to measure runoff water quantity and quality from comparative suburban basins. This paired basin analysis equally divided a horseshoe shaped neighborhood. The east side was conventionally developed (control) and the west employed best management practices (demonstration). Monitoring locations for each basin were located at the downflow outlet.

The project was supported, situated, and stewarded by the local developer Ideal Homes. Their design team, including external engineering consultants (SMC), was involved in providing base information and fitting the designs into a proposal for the City. They used their ongoing relationship with the City to initiate the dialogue and advocate for the functionality. External consultants (CH Guernsey) provided calculative design support, direction, and feedback on BMP hydrology and landscape architecture. OU Engineering and Environmental Science staff led the monitoring design and provided feedback on installation/setting of the monitoring flumes. OU Landscape Architecture staff led the BMP design, supervision, and project coordination. The Oklahoma Conservation Commission, with funding provided by EPA, facilitated all parties and coordinated the experimental monitoring equipment and protocols, while providing feedback through the design and construction process.

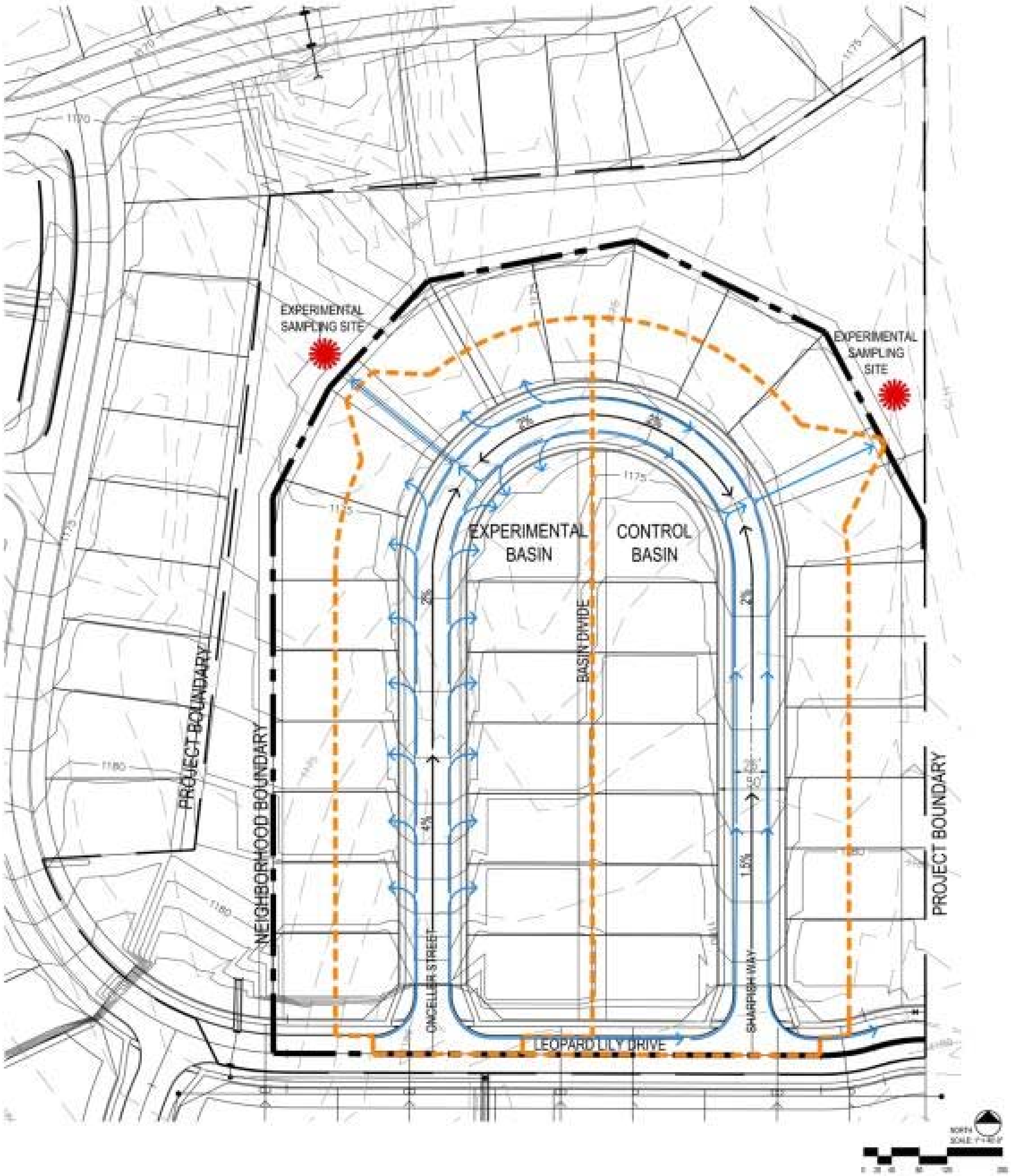


Figure 3: Plan diagram of the paired basin analysis.

Figure 4: The demonstration basin (Top) and the conventional basin (Bottom) September 2014.

Figure 5: Photos of the demonstration basin (Top) and the conventional basin (Bottom) September 2014.

4. Planning and Design

The planning and design process included phases of site planning, master planning, design development, and construction drawings. The site was within a Planned Urban Development (PUD) land use designation, obtained by Ideal Homes from the City of Norman. This designation allowed for a rapid approval process in which our proposal was classified as a change within the PUD, and brought to City council approval by the Public Works Department. Representatives of the Planning and Development Department were team members advising on the larger role of the project, while Public Works personnel approved the sequence of design and engineering proposals. The City Council approved the PUD alterations that included our proposal. This also assisted with the required special dispensation made by the City for two of the four selected BMPs: the rain gardens and the porous paving.

In October of 2009, conceptual designs were developed for planning and engineering feedback (Figure 6). The streetside rain gardens were linked to nearby parks with sidewalk connections, future trails, and educational signs. Concerns about road base and curb sub-grade water saturation required a sub-drain in the gardens creating a filtration, rather than infiltration, style of best management practice. The material in the rain garden was selected to be a coarse engineered substrate made of expanded clay over a layer of gravel. This substrate was proven to support local vegetation in previous installations and reduce nutrients with improved water holding capacity in lab column studies. The vegetative aesthetics was selected to be large groupings (ribbons) of nursery available plants (Figure 7). High visibility was created by using trees and waist-down vegetation. Utilities lines of electric, gas, water and sewer were moved away from the garden under a variance approved by the City. Seven feet was added to west side R.O.W. to accommodate utilities. In the master plan, sub-basin analysis showed >90% runoff coming from the individual lots, and the rain garden curb inlets were omitted. This eliminated the concern for flash flooding erosion and allowed the garden to gather runoff from downspout diversions and parcel sheet flow (Figure 8). At that time, utility placement was coordinated and phased to be completed to prevent trenching through the gardens. The rain gardens were advanced in their design, with clay and sand layers averaging 16” media, 16” sand, and 2” of clay, and calculated to hold the 1” (12 hour) event. The flow (Q) was calculated for the 2-100 year design storms for both in both basins to prevent flooding or pooling in the streets (Figure 9).

The planting concept for the gardens was created by graduate landscape architecture students to recall the Oklahoma landscape. Dryland species were placed at the top of the basin and transitioned to more mesic species near the outlets. At the top, pale green, silver, and tan color foliage are more common hill tops. Near the bottom, dark green foliage plants are more common. The vegetation was grouped in larger ribbons that extend across property lines, driveways, and the street to create a civic scale planting scheme. This would assist with maintenance and was anticipated to be most acceptable by homebuyers and future homeowners. Native and exotic species would be used. Lot plans were given to new homebuyers (Figure 10) that illustrated the plan and described the concept of a rain garden.

A set of construction drawings was created and submitted to the City describing the implementation of the best management practices (BMPs). The drawings included grading and drainage and planting plans for the BMPs (Figure 10). These drawings were used to guide independent contractor work of the BMPs (Marcum's Nursery). Stormwater and flume design work was contracted separately (Larry Kirkland).

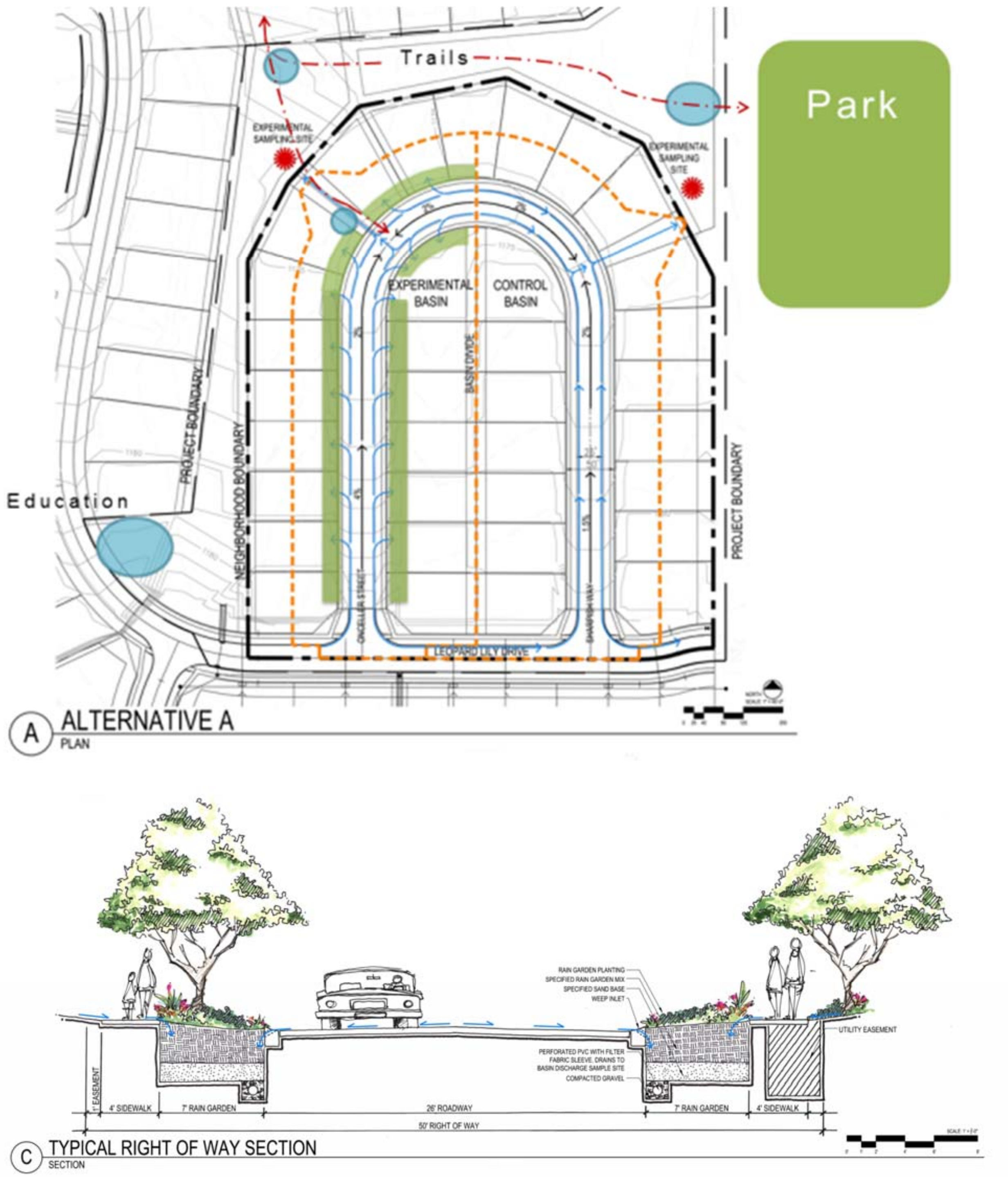


Figure 6: A Planning scheme for the neighborhoods and its context (Top) and a cross section of the street side rain gardens were approved in Fall/winter of 2009-10.

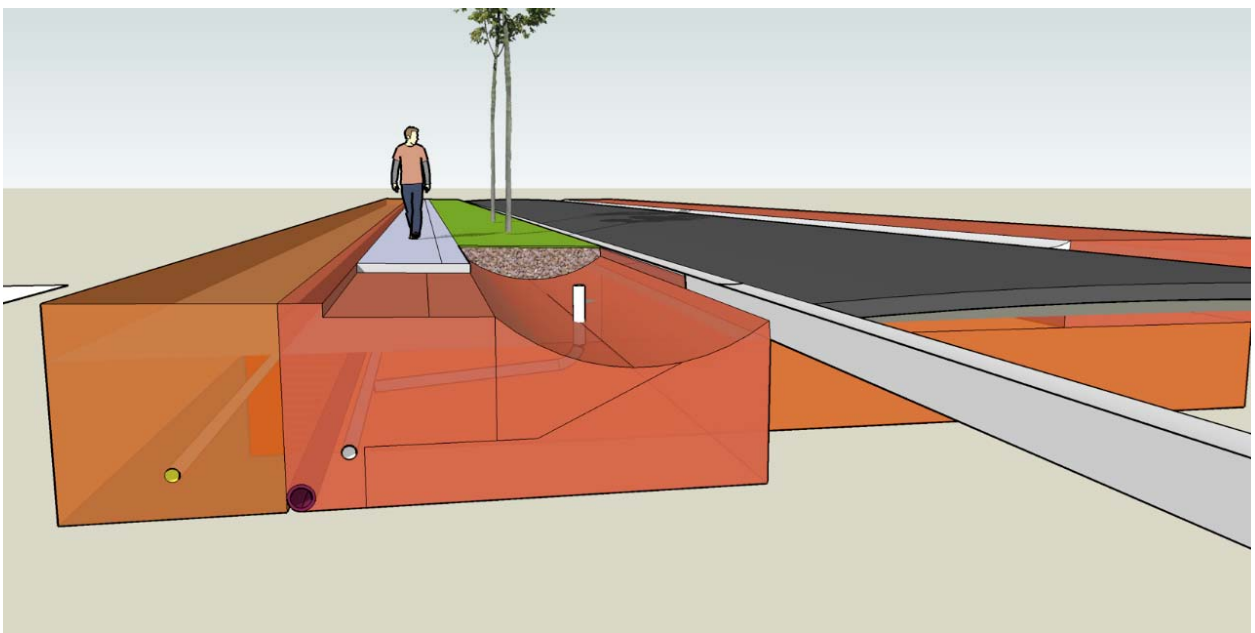


Figure 7: Imagery of the rain garden aesthetics depicting the conceptual vegetation community (Top) and a mid-iteration of a cross section of the street side rain garden studying the drain pipe and gas and water utility locations (Bottom).

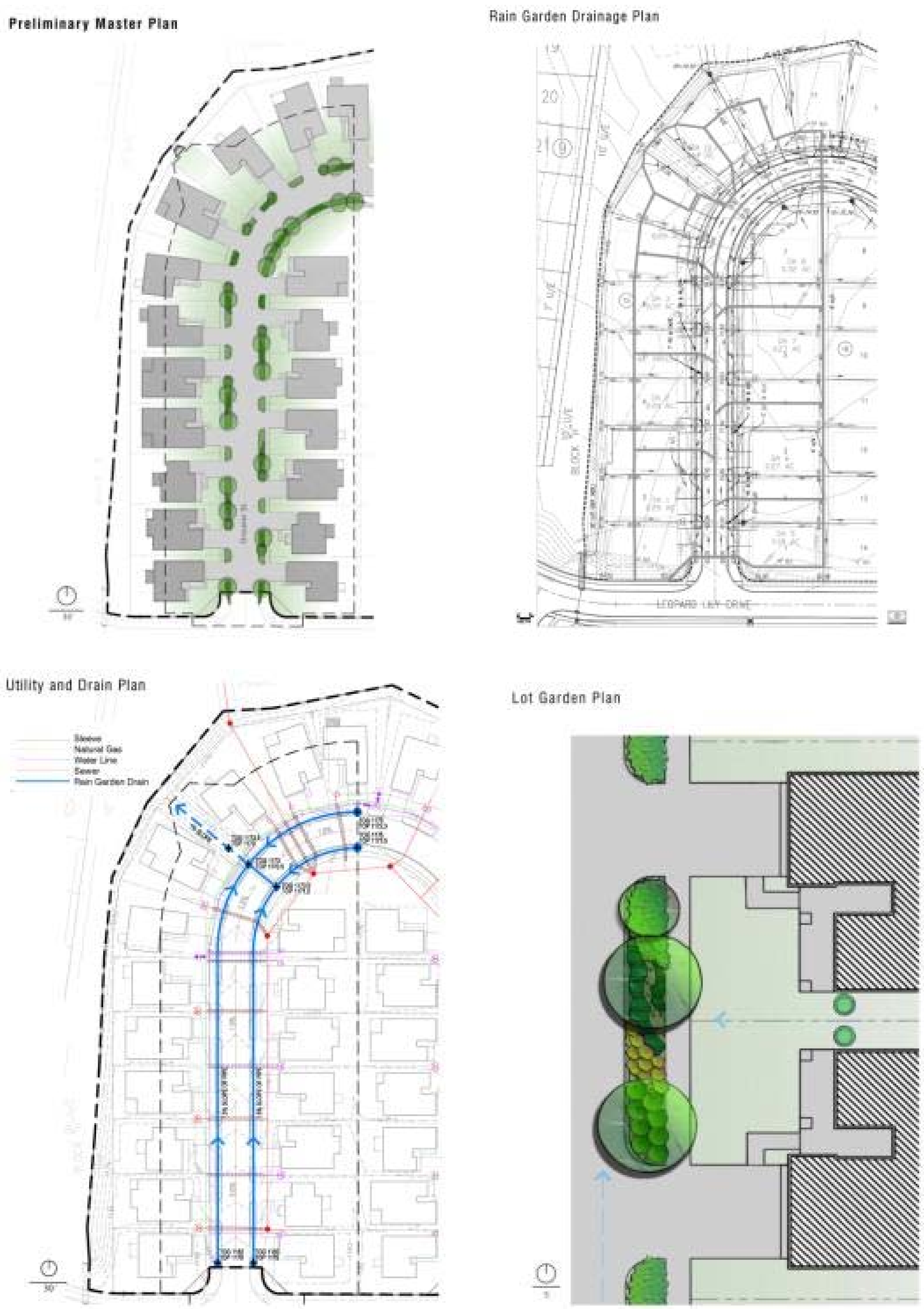
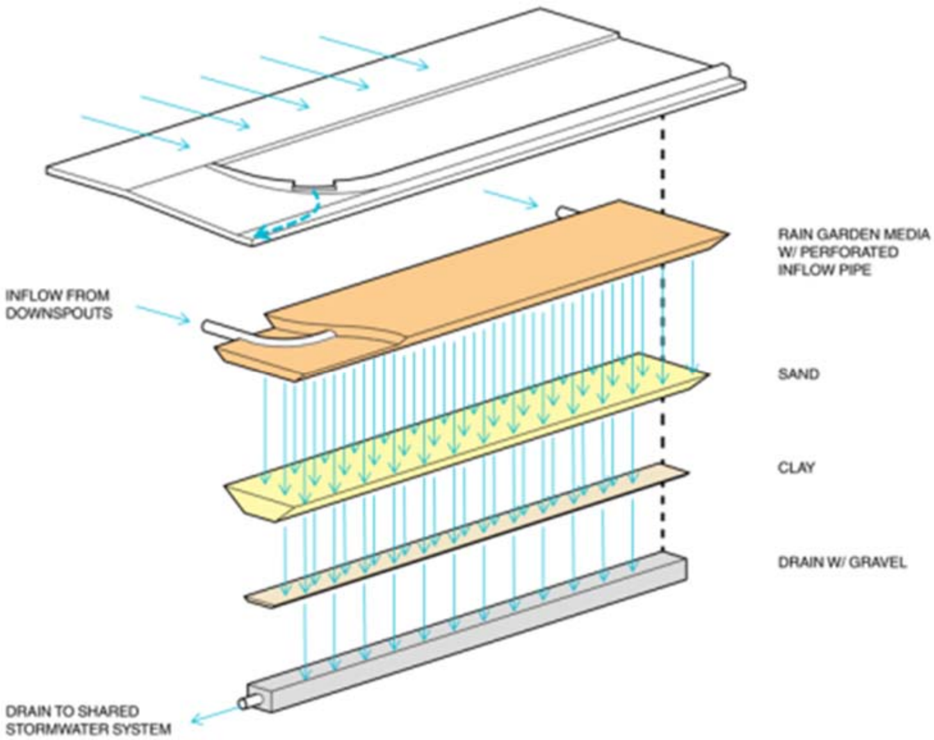


Figure 8: Series of schematic drawings street side rain garden illustration (Top left); micro-basin analysis which removed curb cuts and focused on parcel capture (Top right); utilities coordination plan (Bottom left); and lot illustration of rain gardens, rain barrels and surface flow (Bottom right).



Design Flows (cfs)

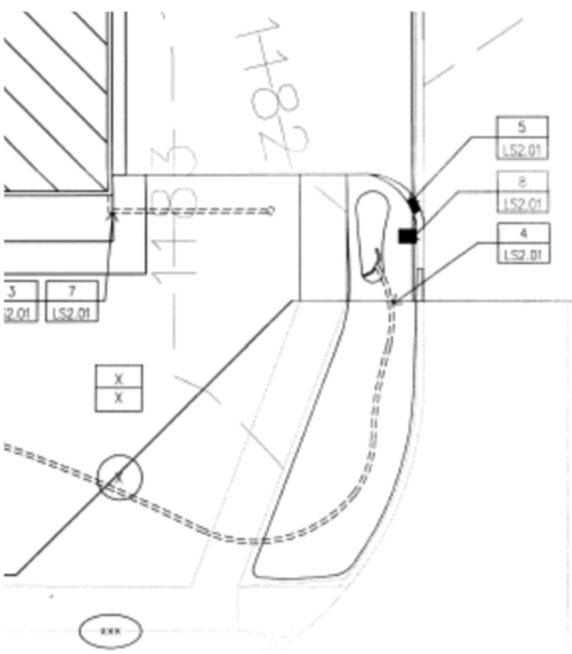
Design Storms	West Side	East Side
Q2	6.40	7.38
Q5	7.49	8.84
Q10	8.53	10.07
Q25	9.89	11.67
Q50	11.24	13.27
Q100	12.49	14.74

Figure 9: The final designs for the rain gardens (Top) and the calculations of flow (Q) to size the stormwater and test flumes (Bottom).

What is a Rain Garden?

The Trailwoods Rain Garden Project is a neighborhood project designed to help clean Norman's drinking water while creating beautiful and livable streets. A rain garden is a specially designed garden along the street that cleans storm water and provides natural beauty without fertilizers and herbicides. It gathers water from you and your neighbor's properties and uses the nutrients to grow low maintenance plants.

Seventeen lots on your street have been installed with rain gardens. You play an important part in the project if you have been given a rain garden. Because this is a new idea, researchers are recording how well the gardens perform. Over the next three years, researchers will maintain your rain garden as part of our ongoing monitoring program allowing you to relax and enjoy the flowers. We ask that you don't plant, weed, fertilize, or water any of the plants between the sidewalk and the street. If you have concerns please contact Dr. Reid Coffman at rcoffman@ou.edu.



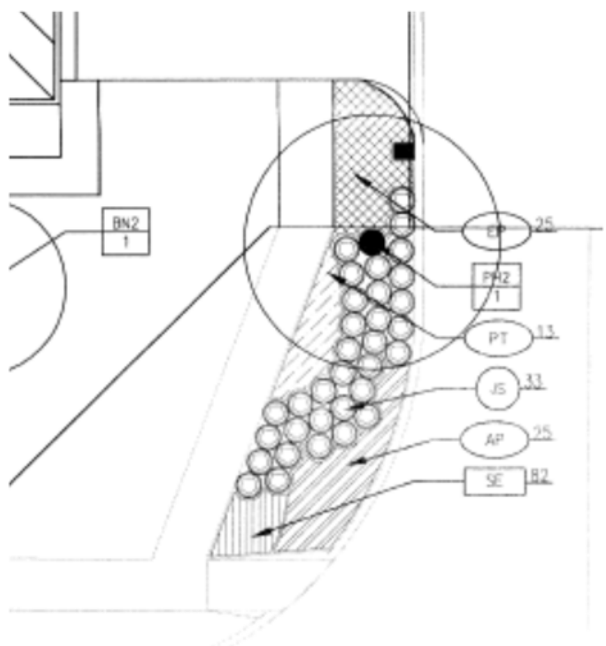


Figure 10: New homebuyer's lot plan and informational write up regarding the rain garden (Top) and selections of the construction drawings showing the lots #1 drainage and grading (Bottom left) and planting (Bottom right).

5. Installation

The project installed four best management practices in the neighborhood by deploying four strategies: 1) biological (rain gardens), 2) containment (rain barrels), 3) diversion (downspouts), and 4) capture (porous concrete) (Figure 11).

Site grading, road construction, and utilities began June 2010. The sub-drain pipes for the rain gardens were installed as a part of basic utilities contract prior to road construction in July. The conventional and demonstration basins commenced and concluded at the same time.

Installation of the BMPs occurred from January 2011 to October 2013, with a final replanting of garden vegetation in August 2014. Installation was negatively impacted by delayed home purchases as result of the slow local economy in 2011-12. In December of 2011, when construction should have been near completion, only ten control lots and nine experimental lots had been constructed (Figure 12). As each lot was completed, BMPs were installed prior to individual homeownership. Home sites at the top of the basin were completed first to protect any downstream erosion effects. This proved less important to top loading sediment in the gardens as the BMPs gathered the majority of stormwater from the home sites. However, the sub-drains did require flushing prior to monitoring.

Rain Gardens
Each experimental lot was installed with 265 sq.ft. (mean) of rain garden. A 6" perforated flexible pipe, required by the City of Norman to dewater the road, was surrounded by 5/8" limestone aggregate, enclosed with landscape fabric, and topped with a 4" layer of sand (Figure 12). The pipes ran parallel to the curb line at 3' offset and were joined with a T intersect at the low point so they could daylight into the test flume. The outlet elevation had to rise in the field to accommodate downstream invert elevations. This resulted in 18-24" deep gardens in the lots surrounding the test flume (see below). The last house constructed was in the experimental basin in July 2013.

The garden installation went through a construction sequence aimed to protect water quality. After sub-drain installation, the gardens were used as mini-catch basins to trap sediment during lot development (Figure 13). When each house was sold, the sediment was excavated, the area was filled with substrate, and plants were installed within one day to prevent soil exposure. The installation of vegetation was required for issuance of the City Occupancy permit.

The substrate was a mix of 70% expanded clay, 20% sand, and 10% compost by volume. The expanded clay was sourced from Tulsa, OK and Wichita, KS. It was procured and mixed by Marcum's Nursery.

The plants were procured and installed by Marcum's Nursery of Goldsby, OK. Rain gardens were installed with 1 shade tree (2.5 cal) to meet code and at least 1 additional tree, an additional shade tree or ornamental. In some cases, additional trees were added if space allowed. The garden was completed with grasses, low shrubs, flowers and ground covers in (1 gal. or #1 containers). The materials size provided a proper appearance at installation and helped reduce weeds. Vegetation was both native and exotic and grown locally when available. One benefit of the delayed installation process was the ability to see if certain species thrived better than others (see next section for description). They were watered upon installation.

Downspouts
The downspouts were diverted to grass swales that ran into the rain gardens or sub-grade piping directly to the gardens (Figure 14). The control neighborhood was installed to meet local code with Bermudagrass sod and downspouts that were turned onto hard surfaces for conveyance.

Rain Barrels
Each house received one 50 gallon decorative rain barrel. The barrels were placed in the front corner of the house, visible to the street, near gardens when possible and equipped with insect screen on the top and 6' poly hose on the bottom with a hose bib for conventional garden hose attachment. Downspouts were modified to direct roof runoff into the barrel.

Porous paving
The use of porous paving in the area is in an early experimental stage and, due to the technical challenges of qualified mixers and installers, there were concerns about durability of the material and the homeowner/homebuyer acceptance, so large public and private paving areas were treated conventionally. However, a small section of porous concrete was installed in the stormwater flume, just before the test flume, of the demonstration basin. During the project, the contractor received classroom and field training in Tulsa, OK to order and install porous concrete. A 120 sq.ft. pad of 8" thick concrete was installed over 36" of aggregate. The pad was set level and elevation was set to accommodate high stormwater flows preventing flooding. The pad was aimed to capture first flush events. The rain garden sub-drain daylights just after the pad.

Another aspect of this watershed project is to collect run-off samples on both the experimentation and control street sites to determine the effectiveness of the BMPs. The stormwater and test flumes were constructed over a 12 month period and instrumentation was calibrated for 6 additional months due to drought conditions from Spring 2013-14.

Concrete flumes were built to carry runoff away from the streets and prevent backflow into traffic (Figure 16). Plasti-fab test flumes were manufactured off site and shipped for installation. Sampling equipment specified to meet EPA regulated quality assurance was set in place by OU's Dr. Nairn and Dr. Strevett. Volumetric discharge data is being generated using a trapezoidal flume, bubbler/automated water sampler system, and datalogger (Figure 17). Stormwater quality samples will be collected using a flow-triggered automatic composite sampler. Upon completion of sample collection, physical parameters (pH, temperature, specific conductance, and related parameters) will be measured using properly calibrated multi-parameter data sondes. Collected samples will be analyzed for total suspended solids, biochemical oxygen demand, total and dissolved reactive phosphorus, nitrate-nitrogen, and ammonia-nitrogen at OU CREW laboratories.

Figure 11: Shows the four BMPs per lot: Biological (rain garden), Containment (rain barrel), Diversion (downspouts), and Capture (a small section of porous pavement). Below (left) is a lot with rain garden in mid construction, a downspout diversion (middle), and plant installation (right).

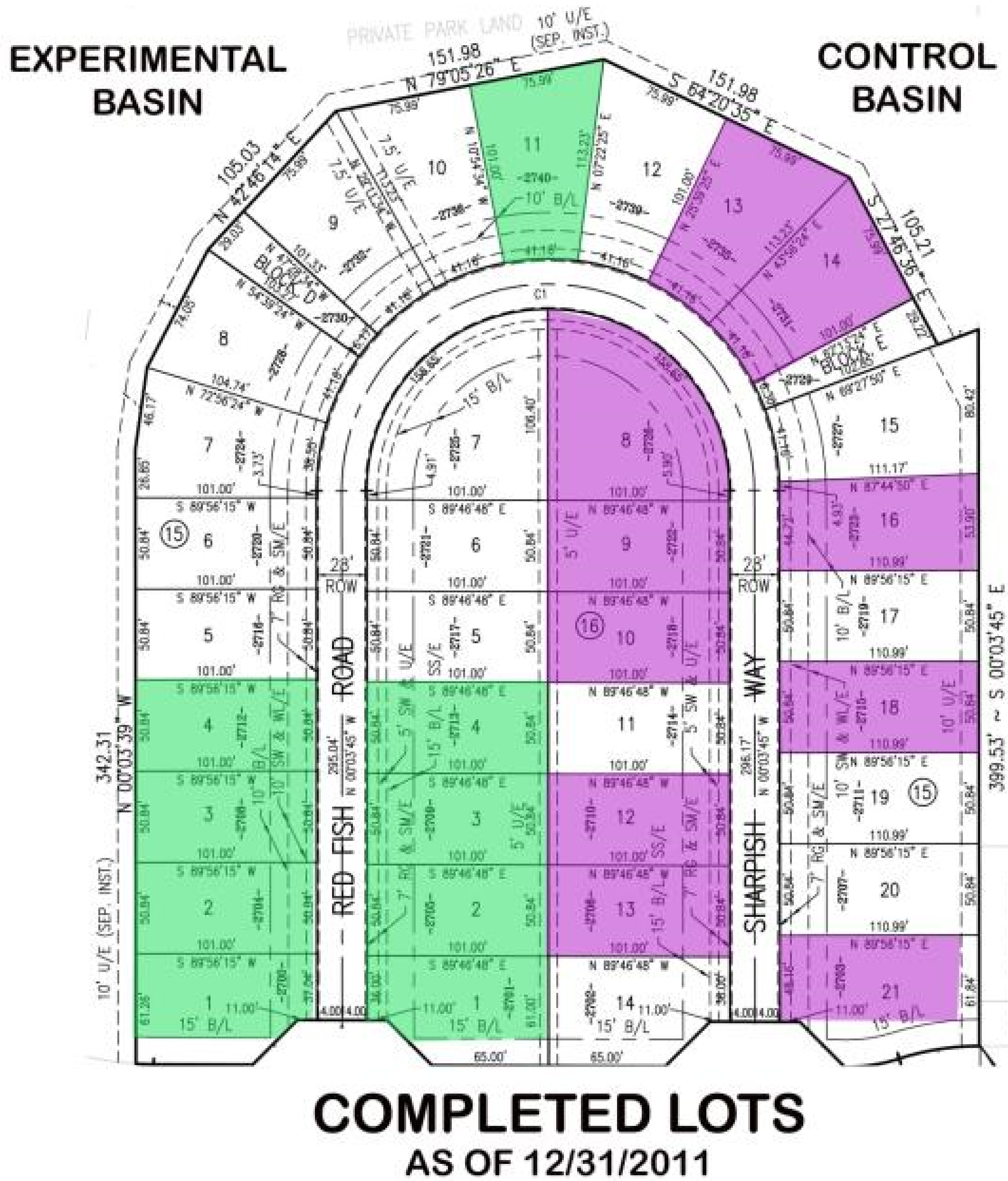


Figure 12: Map of completed lots December 31, 2011

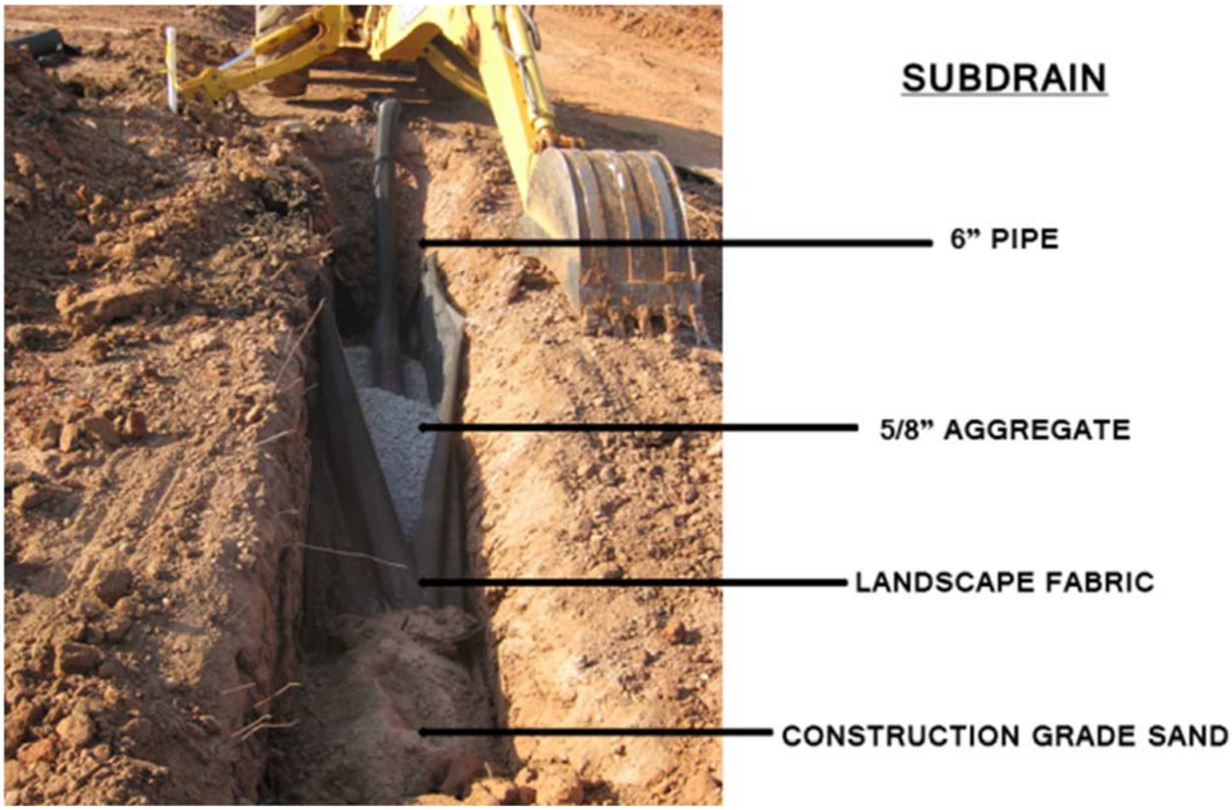


Figure 13: Shows the rain garden sub drain pipe installation with aggregate, fabric and sand (Top) and during parcel development as a mini catch basin (Bottom left), once completed the garden was excavated, filled with substrate (Bottom middle) and planted in the same day (Bottom right).

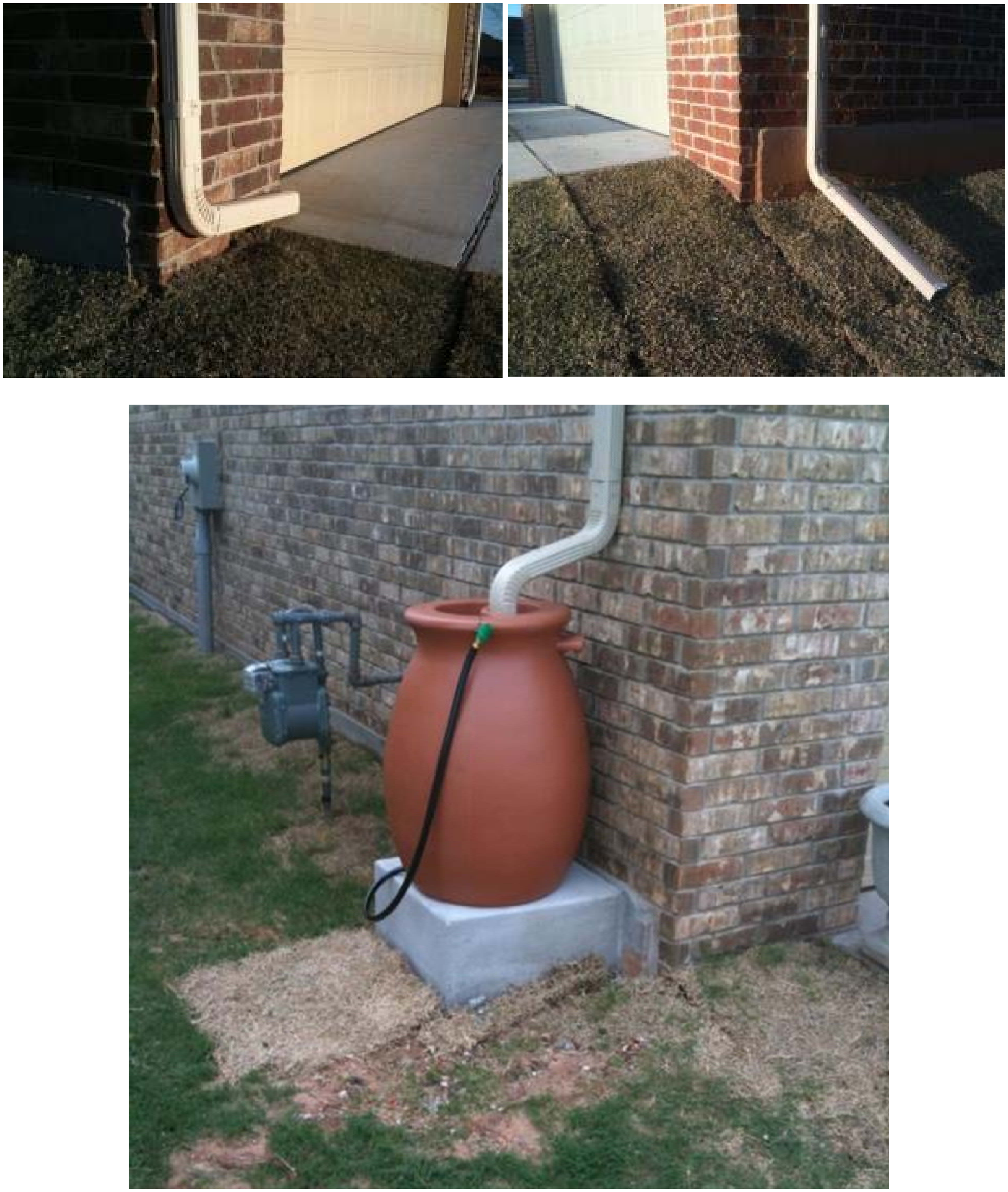


Figure 12: Photos of downspout conveying roof runoff directly to the driveways in the conventional neighborhood (Top left) and the diversions conveying runoff to a grass swale in demonstration neighborhood (Top right). Photo of the 50 gallon rain barrels placed on concrete footer (Bottom).

Figure 15: A small pad of porous concrete (120 s.f.) was placed over 36" of aggregate in the stormwater flume of the demonstration basin (Top). The pad accommodates both high flows to prevent flooding and the rain garden sub-drain pipe which daylights prior to the downstream test flume (Bottom). Wells were installed monitor sub-grade infiltration.

Figure 16: Photo of the team of scientists, engineers, landscape architects, client representatives, city officials and contractor locating the west stormwater and test flumes (Top). Photo of the east stormwater flume under construction (Bottom).

Figure 17: Photo of Plasti-fab test flumes were installed at the end of the concrete stormwater flumes and equipment closets were set adjacently on the top of bank west flume (Top) and east (Bottom).

6. Establishment

The establishment period for the vegetation in the rain gardens ranged from over three years to fourteen months based on when the garden was installed. The first garden was installed April 8, 2011 and the last was installed July 1, 2013. Due to the seasonal climatic conditions in the area, an establishment period of two years was expected. The severe climatic condition and the required summer planting of some gardens negatively impacted some plants. Although most plants fared well, some species failed to establish.

The weather conditions influenced establishment throughout the project. The site experienced severe drought in three of the five years and record setting summer temperatures in 2011 and 2012. This demanded extensive supplemental irrigation for the full years of 2011 and 2012 including weekly irrigation through the growing period (Figure 18). In 2013 an ice storm and severe cold temperatures damaged many trees.

The plant palette was selected to be a narrower palette made of well-known, established, and nursery available plants. The lower species diversity would create a more formal civic aesthetic that is desired in this buying group. The massing of those plants assisted with maintenance and establishment.

The plants were grouped into three sections: *prairie, park,* and *forest* (Figure 19). At the top of the basin in the *prairie* section silver, pale green, and tan foliage predominate. Species of Wormwood *Artemisia* 'Powis Castle', Autumn Sage *Salvia greggi,* and Desert Willow *Chilopsis linearis* predominate. These plants are complemented by Dwarf Fountain Grass *Penesetum aloperoides* 'Hamlin'. *Sedum* spp. struggled in these areas. Orange coneflower *Echinacea fulgida* showed lots of basal leaf dormancy, but responded with a full late summer display of color. Powis Castle and Autumn Sage established so well they required mid-season pruning to clear the sidewalks in addition to cutting back during winter dormancy. These two plants were some of the strongest establishing plants.

In the *park* section, a blue-green transition occurs and species texture becomes more refined and conventional. Silver dryland foliage of Russian Sage *Perovskia atriplicifolia* and the blue-orange prairie color of Little Bluestem *Schizachyrium scoparium* are mixed with the verdant greens and yellows of Daylilly *Hemerocalis* spp. and fine textures of Broadmore Juniper *Juniperus sabina* 'Broadmore'. All of these species established well. A few plants failed due to summer planting but were successfully replaced. Evening Primrose *Oenothera speciosa* and Mexcan Primrose *O. berlandieri* established moderately. Russian Sage established the most easily and spread through the beds into areas of other plants.

Figure 18: Photo of supplemental irrigation in April 2011. Irrigation was required in 2011 and 2012 due to severe drought and summer heat.

At the lower portion of the basin, in the forest section, darker and deeper greens predominate. This section reflects a cooling area with refined forest textures and less flowering color. Big Blue Liriope *Liriope muscari* and Lilyturf *L. spicata* established well to provide a uniform and dense matting ground cover mixed with Dwarf garden Juniper *Juniperus procumbens* 'Nana' and Blue Pacific Juniper *J. conferta* 'Blue Pacific'.

Figure 19: Image of the planted plant palette by section. Prairie had more dry land plants. Parkland had conventional plants, and Forest had more mesic species.

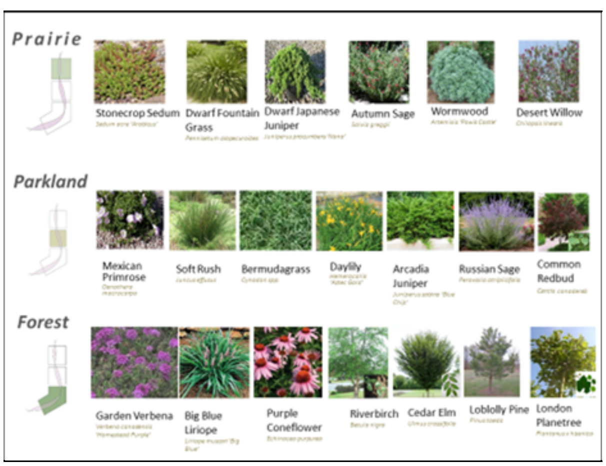
7. Stewardship and Stakeholders

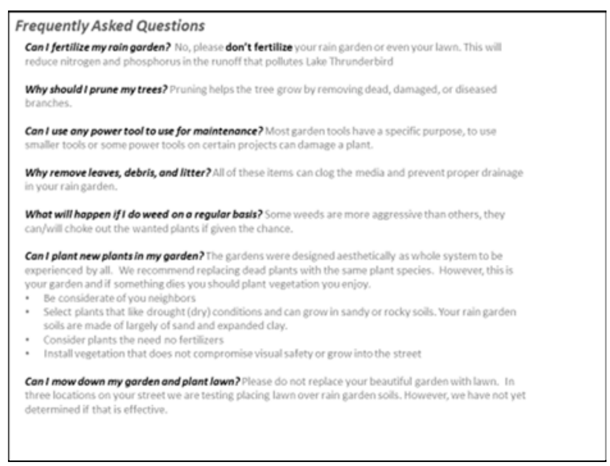
There were stewardship workshops held in the Spring 2014 for the homeowners to discuss proper maintenance techniques to be performed in the gardens. These techniques explained proper tools, methods, and times of maintaining the garden plants throughout the season. These practices were presented to the homeowners to encourage them to take part in not only their rain gardens but also their own plant material on their property. The homeowners showed interest and asked questions about how to improve the quality of their rain gardens for the future.

A stewardship guidebook was completed for the use of the homeowners with rain gardens in Trailwoods. The guidebook is approximately fourteen pages of information ranging from the purpose of the project that explains the connection of the neighborhood to the water quality of the Lake Thunderbird watershed, using the Dr. Seuss book "The Lorax" as conveyance, the design scheme of the plant material, a brief description of how the beds are constructed, and the practices that are involved in the project. There is information pertaining to all four seasons of the year that help explain what kind of tools can be used for maintenance. There are helpful hints and tasks that should be repeated when in their gardens, which plants to focus on and also what species of weeds to remove. There is also information that discusses frequently asked questions on dos and don'ts in the rain garden as well as additional resources to answer questions and the parties that are involved in the project.

Homeowners run the range of interest in the BMPs. From informal discussions, six homeowners showed a very high interest in the rain gardens. A couple remarked, "That's why I bought this house,"or, "I love my rain garden." However, two homeowners have avoided all participation and have asked when they can "take out their garden" or "replace it with grass." The majority supports the use of the site BMPs and recognizes their value to keeping the watershed healthy. Compounding the homeowner knowledge has been the resale and subsequent leasing of the homes. These new tenants or owners have been less informed about the project and tend to be slower to adopt a supportive position.

At the management level, planners, designers, contractors, and decision makers are recognizing the benefit of stewardship of BMPs as a critical component of the project. With proper planning and education these practices are acceptable to most homeowners.





Frequently Asked Questions

Can I fertilize my rain garden? No, please **don't fertilize** your rain garden or even your lawn. This will reduce nitrogen and phosphorus in the runoff that pollutes Lake Thrunderbird

Why should I prune my trees? Pruning helps the tree grow by removing dead, damaged, or diseased branches.

Can I use any power tool to use for maintenance? Most garden tools have a specific purpose, to use smaller tools or some power tools on certain projects can damage a plant.

Why remove leaves, debris, and litter? All of these items can clog the media and prevent proper drainage in your rain garden.

What will happen if I do weed on a regular basis? Some weeds are more aggressive than others, they can/will choke out the wanted plants if given the chance.

Can I plant new plants in my garden? The gardens were designed aesthetically as whole system to be experienced by all. We recommend replacing dead plants with the same plant species. However, this is your garden and if something dies you should plant vegetation you enjoy.

- Be considerate of you neighbors
- Select plants that like drought (dry) conditions and can grow in sandy or rocky soils. Your rain garden soils are made of largely of sand and expanded clay.
- Consider plants the need no fertilizers
- Install vegetation that does not compromise visual safety or grow into the street

Can I mow down my garden and plant lawn? Please do not replace your beautiful garden with lawn. In three locations on your street we are testing placing lawn over rain garden soils. However, we have not yet determined if that is effective.

Figure 20: Images of the Homeowner Stewardship workshop (top) and selected images of the Stewardship Manual provided to each homeowner.

8. Education and Community Impact

The project has positively impacted the local development community, City officials, schools, and area regional governments. In addition, it is used nationally as an educational example in universities and professional design and stormwater disciplines.

Most importantly, it has impacted the citizens of Trailwoods. Children living on the street recognize their street is unique, and they take pride in the gardens (Figure 21). They pick flowers and talk about the birds and butterflies that visit their gardens. Most interestingly, a few homeowners are using the gardens as a place for wildlife photography. Butterflies, birds, and bees are commonly observed during flowering season.

The project has created external impacts by aiding the development of additional bio-retention projects in the watershed basin. City of Oklahoma City Parks and Recreation Department installed rain gardens and best management practices at Kitchen Lake in the Thunderbird basin in 2014. Ideal Homes, led by Land Development specialist Zack Roach has implemented bio-retention and GI strategies in additional sub-division communities in the Thunderbird basin and the metropolitan area; Little River Trails and Green Leaf Trails in Norman, OK and Featherstone in Moore, OK. The construction BMP of mini-sediment catch basins has been employed in nearly all new Ideal Homes developments throughout the state.

Many of these educational impacts have been created by the nearly 20 presentations, the tours, and the use of the project in university curriculum. As the project completes the data recording phase we anticipate additional impacts in the areas of paper publications and scholarly presentations. All in all, the benefits to water quality resulting from this project stretch far beyond the subject watershed.

Papers of the Project to date

Coffman, R., Graves, D. Vogel, J. and G. Brown, "Vegetation in dryland bioretention", *Conference Proceedings Council of Educators of Landscape Architecture* (CELA) March 2015 (accepted)

Presentations of the Project to date

1. Mitchell, K., Ladoceur, A., Lui, R., and Coffman, R., "Triple Bottom Line Cost-benefit Analysis of Green Infrastructure in Norman, Oklahoma" Constructed Environment Conference, Pennsylvania Oct 16th 2014
2. McKown, R "Trailwoods and Carrington GI" Flood Managers Tulsa, Ok Sept 2014
3. McKown, R "Recent works" Guest lecture Architecture for Non-Majors, University of Okla homa Sept 2014
4. McKown, R "Green Infrastructure' Norman Business Association". Norman July 24, 2014
5. McKown, R "Local Projects" Norman Tips Club, Aug 2014
6. McKown, R "Rain Gardens and GI" Carrington Home owners Association June 2014
7. Coffman, R. and Shadid-Anvar, M. "Establishing Dryland Plants in Semi-arid Rain Gardens" Great Plains Low Impact Development Symposium, Apr. 02, 2014.
8. Coffman, R. "Coupling | Stacking | Bundling Green Infrastructure", University of Toronto, College of Architecture, Landscape and Design, Arc 341 Building Systems, Mar. 02, 2014
9. Coffman, R. "Investigating Ultra-Urban Ecological Infrastructure" University of Akron, Inte grated Bioscience Speakers Series Feb. 14, 2014
10. McKown, R "Local success" Great Plains LID Design Kick-Off Keynote. Tulsa, OK Dec 2 1 2013
11. Coffman R. and McKown, R. "Planning and Building Better Communities", Oklahoma Con servation Commission, Norman OK Dec 9, 2013
12. Frost, B., Coffman, R., Nairn, B., and Rice, M. "Proactive Landscape Design Addressing Water Quality in Lake Thunderbird Watershed" Oklahoma Clean Lakes and Watershed Annual Meeting. Tulsa, OK April 15, 2013
13. Reindell, N., Nester T. and Coffman R. "Communicating Non-point Source Practices through Distilled Graphic Representation" 21st Annual National Non-point source pollution conference, Cleveland OH Oct 28, 2013
14. Roach, Z. "Trailwoods BMPs" Low Impact Design Seminar, Oklahoma City, OK Oct 2012

15. Novonty, L. and Coffman, R. “Constructing Rain Gardens”, Oklahoma Governors Water Conference, Norman OK 2011
16. Phelan, M and Coffman, R. “Trailwoods Greenstreet” Oklahoma Governors Water Conference, Norman OK 2010
17. Coffman, R. “Green Infrastructure in the Little River Watershed”, Oklahoma Clean Rivers, Lake and Watershed Conference, Oklahoma City, OK Apr 2010
18. Coffman, R. “Urban Green Infrastructure”, Cleveland Co. Extension Apr 2010
19. Coffman, R. and McKown R. “LID Green Development” Norman Business Association, Aug 2009

Tours of the Project

1. Oklahoma Planning Association (OKAPA) Annual Mtg. Oct 2010
2. Oklahoma Flood Plain Managers Annual Conference Aug 2011
3. Cleveland County Master Gardeners, June 2012
4. Norman Developers Council, Sept 2013
5. City of Norman Greenbelt Commission/ECAB May 2014

Workshops

1. Low Impact Development Workshop, Norman, OK December 2013
2. Home Owners Spring Stewardship Workshop March 2014
3. Home Owners Summer Stewardship Workshop May 2014
4. Home Owners Fall Stewardship Workshop Sept 2014

Student Involvement

The project supported six masters students and involved 100+ students in coursework in four fields over the five years: Architecture (Fall 2009), Landscape Architecture (Fall 2009-Spring 2014), Regional and City Planning (Spring. 2012-14) and Environmental Science (Spring 2011-14). The project is frequently cited as an example throughout the Colleges of Architecture and Engineering coursework and continues to be a routine part of courses. The site recurrently hosts University of Oklahoma students from LA 5924 Planting Design, LA 5535 Studio III, and RCPL 5813 Environmental Planning Methods. It continues to be a study site for CEES masters students.

The project directly supported six graduate students: five Landscape Architecture and one in Regional and City Planning. Unique to this support was five of the students were under-represented minorities: Alisha Grayson, Megan Phelan, Leslie Novotny, Bryce Frost, Mehdi Shadid-Anvar, and Darren Graves. All past students are employed in the various professions locally and nationally (Grayson, OK DEQ, Oklahoma City, OK) (Phelan, K &K Landscape, Norman, OK), (Novonty, CH Guernsey Engineering, Oklahoma City) (Frost, ima Design, Los Angeles, CA) and (Shadid-Anvar, Marcums Nursery, Goldsby OK).

Phelan, Novonty, Frost, Shadid-Anvar, and Graves each presented work in professional conferences at the state or national level.

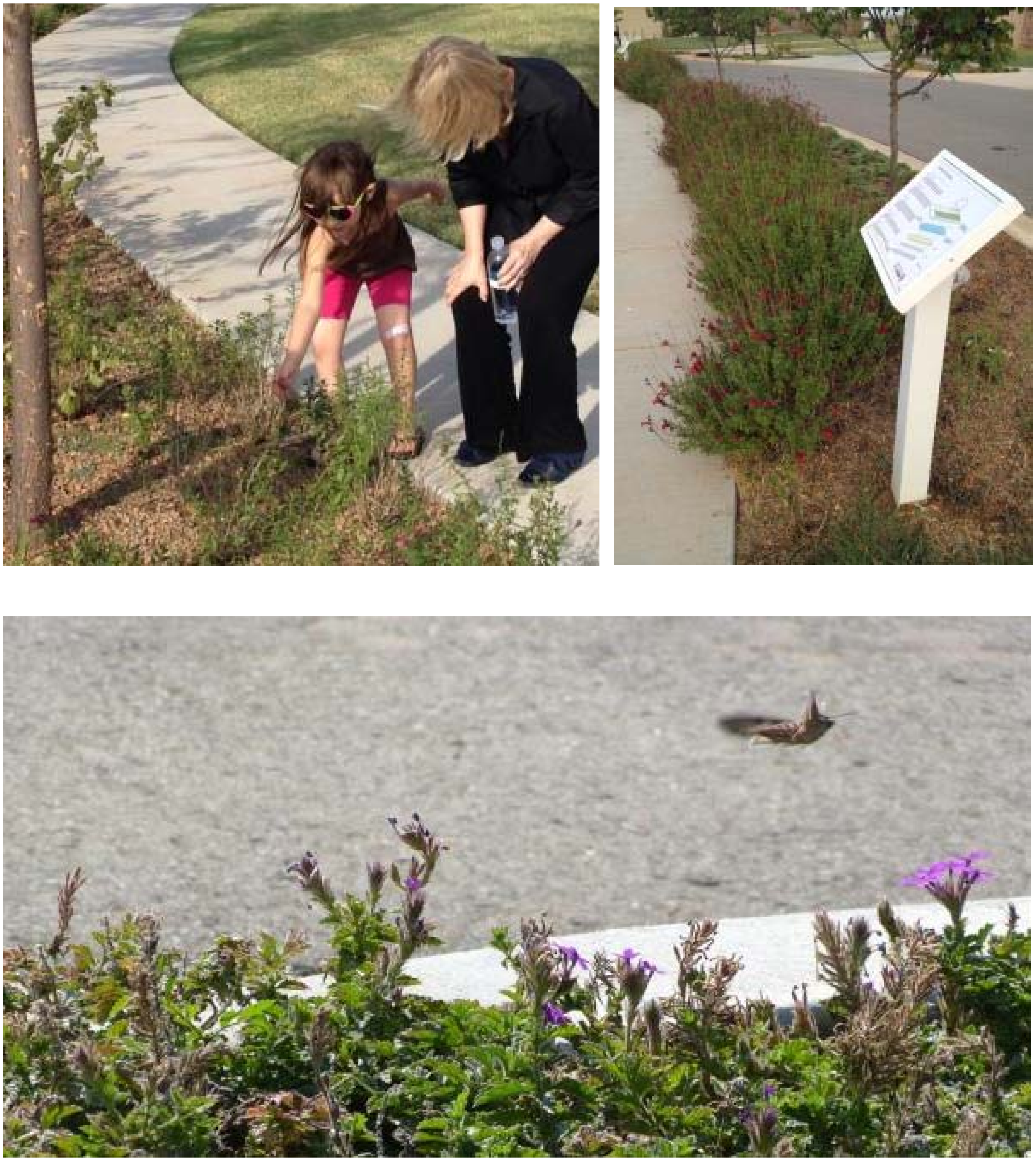


Figure 21: Neighborhood children show visitors the flowers in the rain garden (Top left) and citizens can learn from educational signage. Homeowners document wildlife visiting the rain gardens such as this hummingbird moth (Bottom).

Figure 22: Oklahoma Flood Managers tour in 2011

9. Lessons learned

1. Even though the students and not the homeowners were maintaining the gardens in the first two years, early information sessions would have been beneficial to the residents. It is recommended that half-way through, a project meeting with the homeowners on completed parcels would have assisted with developing key stakeholders earlier.

2. The 17 lot installation sequencing drove the installation costs up and significantly hampered project installation oversight. It would be an advantage to consider alternatives with fewer installation sequences. A shorter duration of installation would assist with quality control as well.

3. Future sidewalks of porous pavement adjacent to bioretention might be good.

4. The developer's prioritizing of the BMPs was critical to the communication with the various sub-contractors working in the neighborhood.

5. The City's requirement to have plants installed prior to occupancy required planting vegetation in very inappropriate weather periods. A variance should be requested in future projects.

6. The use of engineered soil assisted with plant establishment during the severe summer drought and heat. It was observed in surrounding landscapes in projects in other Ideal Homes communities, plants failed to establish like those in the rain garden.

7. The use of a pre-excavated rain gardens constructed as sediment catch basins functioned very well as a construction BMP. Although the data is anecdotal, this project cost the developer significantly less in clean-up costs after rain events compared to other projects.

Figure 22: Photo of the rain gardens functioning as a mini sediment catch basin during construction.

10. Citations

Coffman R. and Strosnider, K. 2009 "Public rain gardens for water quality in extreme environments." *Land and Water Magazine,* Nov-December pgs 37-40

Hunt, W. F., A. R. Jarrett, J. T. Smith, and L. J. Sharkey. "Evaluating bioretention hydrology and nutrient removal at three field sites in North Carolina." *Journal of Irrigation and Drainage Engineering* 132, no. 6 (2006): 600-608.

Tzoulas, Konstantinos, Kalevi Korpela, Stephen Venn, Vesa Yli-Pelkonen, Aleksandra Kaźmierczak, Jari Niemela, and Philip James. "Promoting ecosystem and human health in urban areas using Green Infrastructure: A literature review." *Landscape and urban planning* 81, no. 3 (2007): 167-178.

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