FORT WORTH

City of Fort Worth Storm Water Management
Feasible Options Study

Central Arlington Heights Stakeholder Committee Meeting

February 24, 2011, 6:30 pm
Stripling Middle School

AGENDA

1. **Welcome/Introductions** (10 minutes)
    - Previous Meetings
    - Upcoming Public Meeting

2. **Field Trip Presentation** (10 minutes)

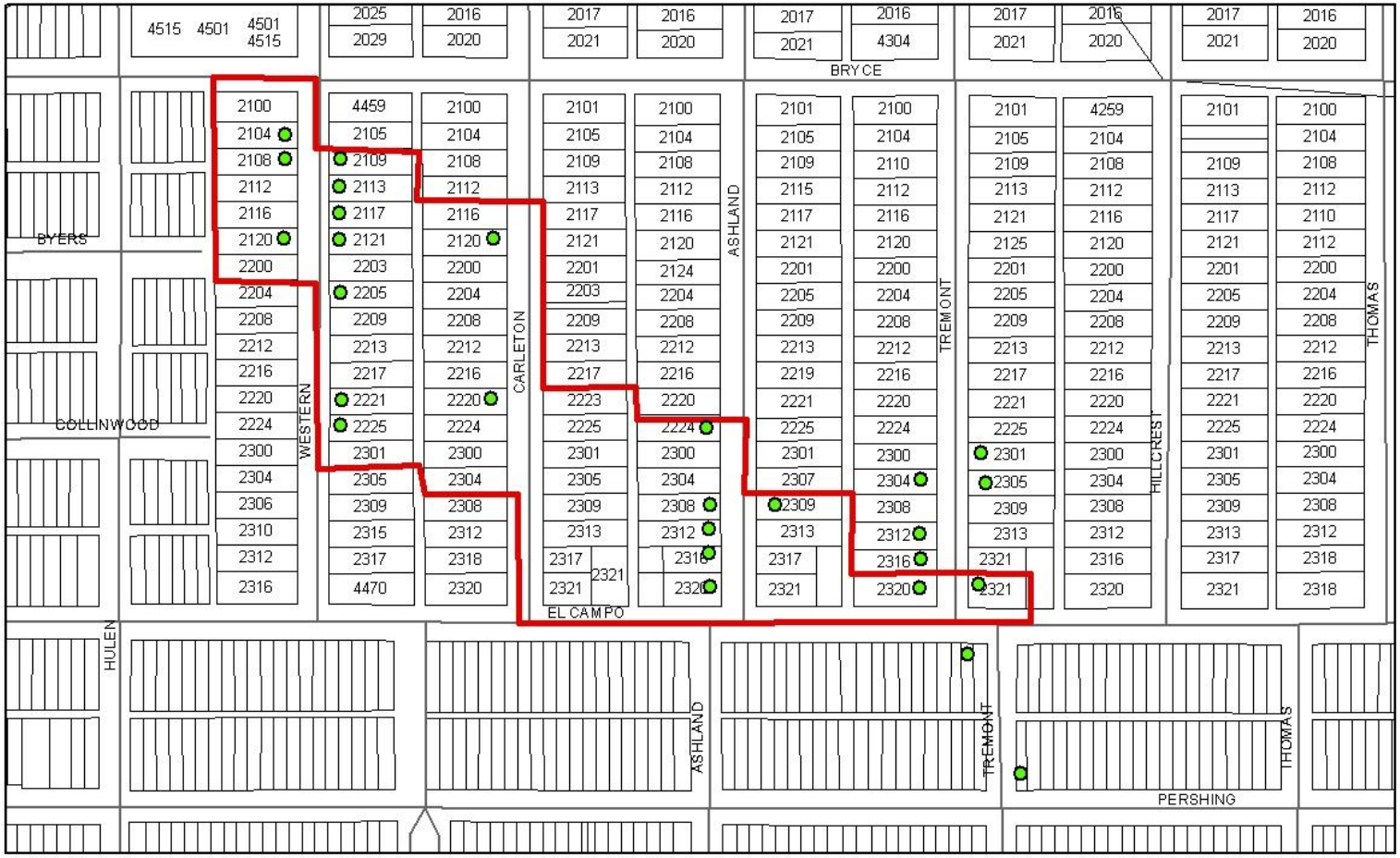
3. **Benchmarking Exercise (Other Cities)** (10 minutes)

4. **Cost and Frequency of Flooding Summary** (10 minutes)

5. **Workshop – Presentation of Alternative Measures** (60 minutes)

6. **General Discussion** (20 minutes)

Central Arlington Heights Watershed
Households Surveyed by AHNA, Feb 2011



0 0.125 0.25 Miles

N

Characteristics of Respondents

All but one were property owners

No basements

Length of time in the home ranged from 6 months to 75 years.

- Less than 1 year = 4 respondents
- 1-5 years = 7 respondents
- 6-10 years= 4 respondents
- 11-20 years = 3 respondents
- More than 20 years = 10 respondents

Ten reported flooding

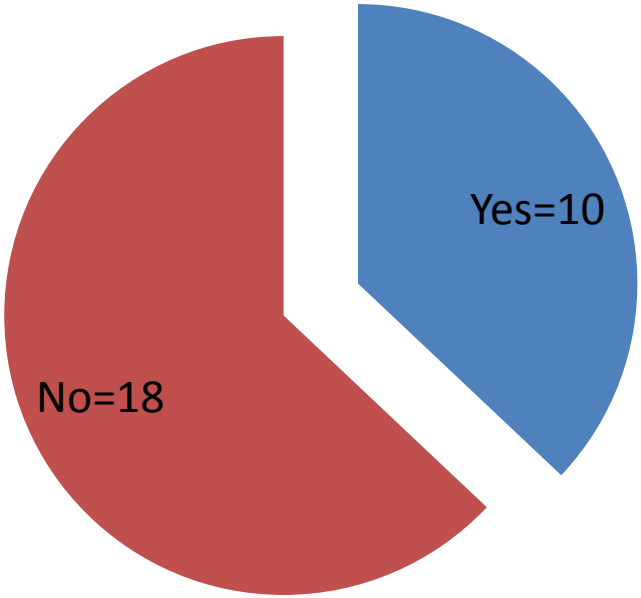
Eighteen reported no flooding

Of those who flooded:

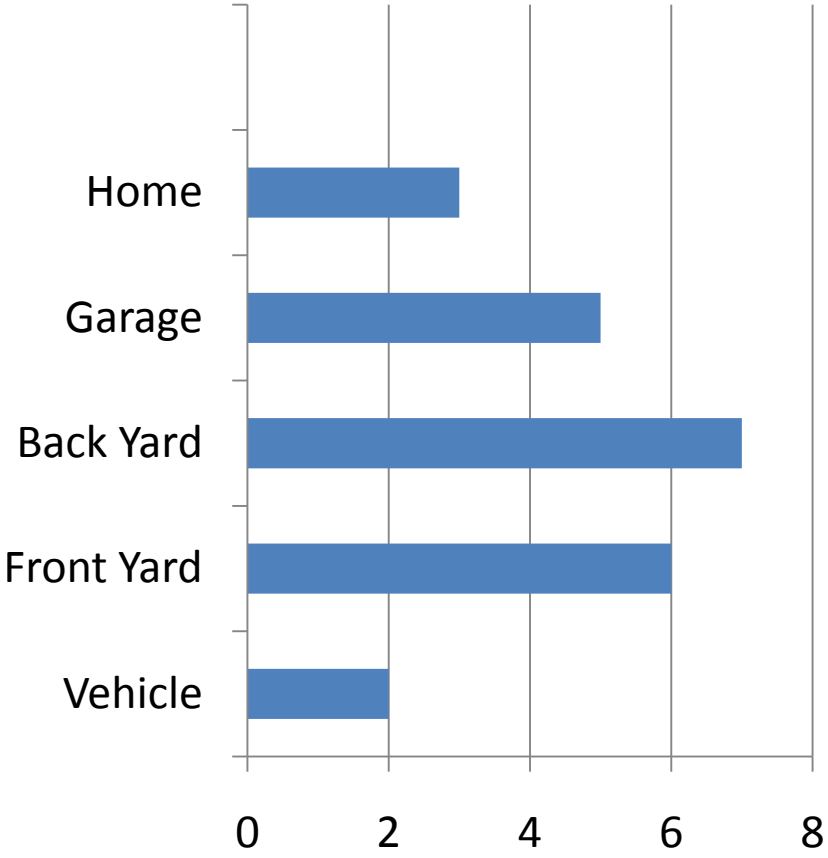
- Frequency ranged from one to six times per year
- Height of water from 1-3 inches to 4-5 feet

Survey Responses

Has the property flooded while you lived there?

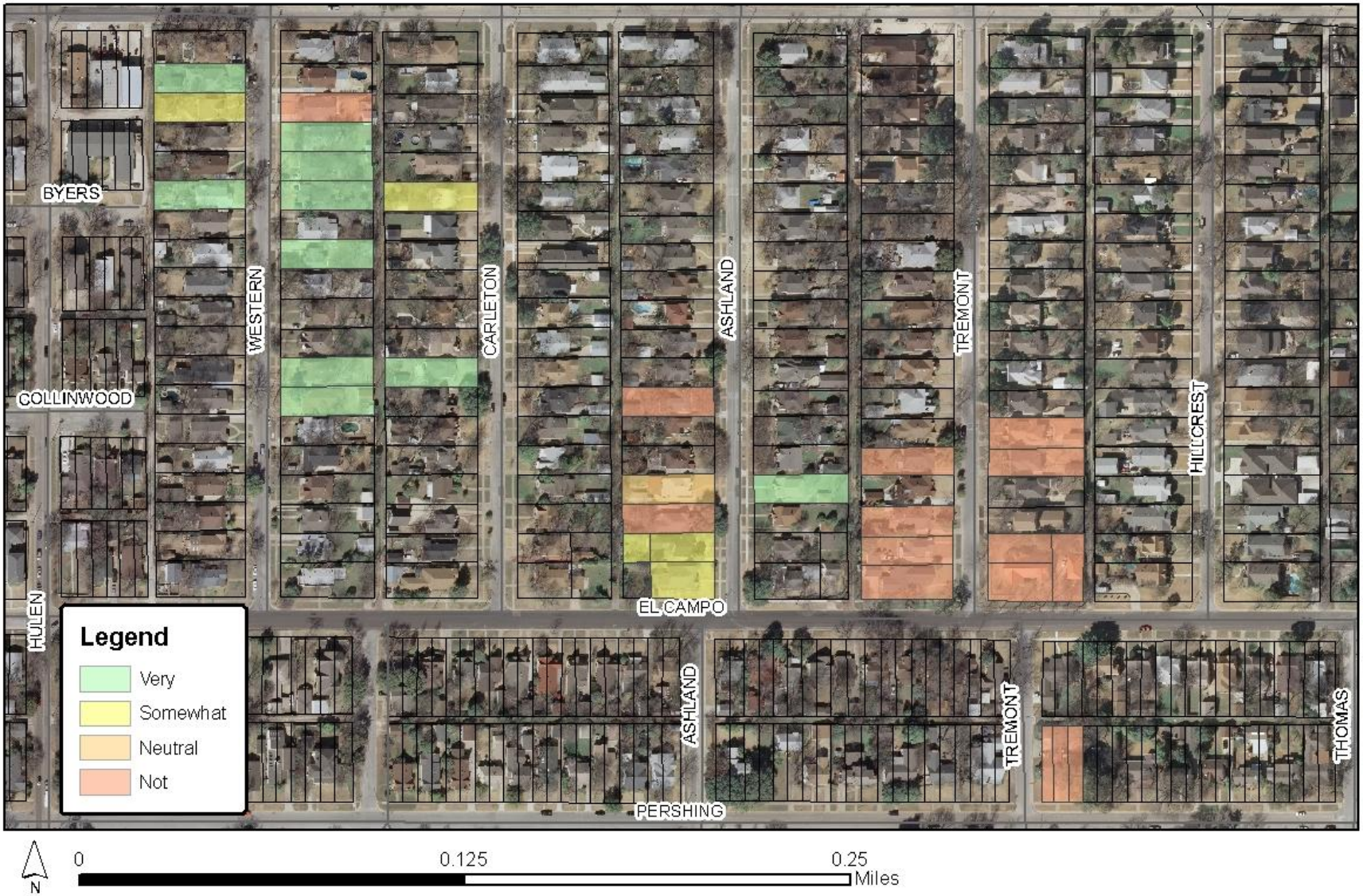


If yes, where?



Central Arlington Heights Watershed
Households Surveyed by AHNA, Feb 2011

How concerned are you about flooding in our neighborhood?



Next Steps

- Finish collecting surveys in target area
- Phone calls or visits with respondents who want to share more with City staff
- Get the word out about Public meeting on March 3
- Launch online survey for the entire neighborhood

Central Arlington Heights
Tally of Homes Directly Impacted

	Storm Event			
Existing Conditions	**2-year**	**5-year**	**10-year**	**100-year**
Estimated number of lots inundated	134	145	155	187
Estimated number of homes inundated	12	18	24	53

A lot is considered inundated if more than 1,000 sq. ft. of the lot is inundated with at least 3" of water
A home is considered inundated if the maximum water surface elevation in its parcel is at least 1" above the first floor elevation

Economic Damage Calculations

Return Period	Annual Prob	Estimated Total Damage	Number of Properties Damaged	Total Appraised Value of	Average damage per property	Area under curve
100	1%	$ 1,914,598	58	$ 8,693,000	$ 33,010	
50	2%	$ 1,792,146	55	$ 8,540,000	$ 32,584	$ 18,500
25	4%	$ 1,606,559	51	$ 8,097,200	$ 31,501	$ 34,000
10	10%	$ 1,349,896	45	$ 7,085,500	$ 29,998	$ 88,700
5	20%	$ 1,158,848	40	$ 6,132,000	$ 28,971	$ 125,400
2	50%	$ 886,780	35	$ 5,412,000	$ 25,337	$ 306,800
1	100%	$ 612,244	29	$ 4,391,700	$ 21,112	$ 374,800
					Total Average Annual Damage	**$ 844,200**

Net Present Value (Cost) of Flood Damages = ($15,090,000)

Green and Sustainable Services, LLC

(Designing Programs For A Better Future – Developing Concepts For Tomorrow – Building Projects For Today)

Go Green and Sustain Life!

Memo

To: Burton Johnson, PE

From: Thomas Smith, PE, MBA, BCEE, DWRE, LEED AP, CPESC, CPSWQ

CC: Charlotte Smith, M.S.Ed.

Date: January 13, 2011

Re: City of Fort Worth, Texas Storm Water Feasible Option Study Preliminary Cost Estimations for Underground Storm Water Detention Storage

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Per your request, please find below Green and Sustainable Services' (GSS) preliminary cost estimations for underground storm water detention storage. This is additional information to further build on the concepts outlined in GSS' September 8, 2010 Report on Low Impact Development Considerations for City of Fort Worth's Feasible Option Study.

Underground Storm Water Detention Storage Material of Construction	Estimated Material and Installation Cost ($/cubic foot) of Water Storage
Plastic and Metal Pipe	3.00 to 10.00
Modular Systems	10.00 to 14.00
Pre-Cast or Poured In Place Concrete (Pipes, Boxes & Vaults)	16.00 to 23.00

Note: site conditions and other construction variables may increase or decrease the estimated cost

Cost can vary as follows:

- Storage Vessels can be made from a variety of materials, including corrugated metal pipe, aluminum, steel, plastic, fiberglass, pre-cast or poured-in-place concrete, etc.
- Storage volume required
- Amount of excavation
- Amounts of fill required
- Construction and labor costs
- Site location

- Physical condition of site

Steven Eubanks, Senior P.E. with the city of Fort Worth asked GSS to gather information on the various modular systems that are available in the marketplace and see if the modular units can be utilized under streets and roads for underground storm water detention storage.

Some modular systems have been tested to highway/bridge standards for loading which takes into account static and dynamic loads. However, we did not find any manufacturer of modular systems that were aware of their products being installed under heavily traveled roadways. It seems that most modular systems that are installed under pavements are used for parking lots or driveways into offices, gas stations, shopping malls etc. Based on our research to date, we think it is incumbent on the manufacturers to prove that their modular systems can be used safely under roadways when installed in accordance with the manufacturer's recommendations.

The city of Fort Worth may still be able to utilize the modular units for underground storm water detention and still get the storage volume Mr. Eubanks desires by installing the modular systems under the sidewalks adjacent to the city streets and roads.

Assuming the side-walk easement would accommodate a system on both sides of the street 6ft wide, by 6ft deep; the city of Fort Worth could obtain 7200 cubic feet of storm water storage (0.165 acre ft.) per 100 linear feet of street. Multiple inlet and outlet applications would not be a problem in this scenario. The cost to obtain 7200 cubic ft. of underground storm water detention storage would be $86,400.00 (assuming a cost of $12.00 per cubic ft. of water storage).

Underground Storm Water Storage Systems

Underground storm water storage systems can be used for retention or detention to capture and store storm water collected from impervious areas. Underground storm water storage can be used as infiltration basins or detention basins. A low impact development option for consideration regarding the Fort Worth Feasible Option Study is underground storm water detention storage with controlled outflow that allows for the controlled release of collected storm water over a given time interval. Surface inlets and other collection methods, i.e.: riser pipes and curb cuts allow surface storm water to be collected via underground containment which is designed to allow for controlled outflow so detention storage is available to capture subsequent rain events.

Underground storm water storage can be a viable part of the overall storm water management plan when integrated with other best management practices (BMPs). Subsurface storage relies on water storage structures made of pipes, arches, vaults or other modular systems. These

various systems that accommodate underground storage are made from various materials, i.e.: corrugated metal pipe, aluminum, steel, plastic, fiberglass, pre-cast or poured-in-place concrete, etc. Underground storage is often used where land availability is limited, site conditions or not favorable and land cost is expensive for surface storm water retention basins or detention basins.

Underground storm water storage can be ideal for use under recreation parks and complexes, athletic fields and sport complexes, parking lots, sidewalks and areas adjacent to roadways, and other commercial, industrial and residential paved areas. Advantages include:

- Reduction of storm water runoff flow
- Extended storage and slow, measured release of collected storm water runoff
- Good option for high density or urban areas with limited available space, unfavorable site conditions or cost of land that is expensive
- Installation can be accomplished rapidly using modular systems and components
- Durability and long life (20 to 50 years plus depending on materials and components used)
- Increased level of safety by not having open ponds and other surface BMPs
- Insulated from freezing
- Aesthetically pleasing because systems are out of sight and out of mind.

Site selection and planning must adhere to any applicable regulations regarding design requirements and necessary permits for construction of undercount storage. It is essential to use experienced engineers, suppliers and contractors, especially if using proprietary system. Placement of underground storm water storage is sit specific. Underground storm water storage must be planned as part of a comprehensive storm water management approach.

Site specific conditions can influence the materials and components used for underground storage systems. Conditions like depth and area of excavation, shape of space, shape of structure related to storage capacity, excavation/fill requirements, depth of water table, construction cost and maintenance requirements must be considered prior to design and construction of an underground storm water storage system.

Design considerations (as applicable) include capacity and discharge rate, facilitate drainage of water, accommodate emergency overflow to divert water if inoperable, account for adequate personnel access points to allow for proper maintenance, and measures to reduce erosion at outfall.

Maintenance to underground storage systems should include periodic inspection of the inlet and outlet areas to insure proper operation and help maintain system. Things that must be taken into consideration if applicable are keeping surface impervious areas clean, removing floatables and sediment from underground storage system, and ensuring inlets and outlets are not obstructed. Proper confined space safety procedures must be followed at all times when inspecting or performing maintenance to the underground storm water storage system.

In general underground storm water storage systems are more expensive than surface water storage alternatives. However, in areas where land is expensive, in short supply or there is not adequate surface space available underground storage systems can be cost effective. Cost is highly variable and is dependent on materials used, storage volume required, construction and labor costs, site location and physical condition of site location.

References:

1. Lakesuperiorstreams. 2009. LakeSuperiorStreams: Community Partnerships For Understanding Water Quality and Storm water Impacts at the Head of the Great Lakes (http://lakesuperiorstreams.org). University of Minnesota-Duluth, Duluth, MN 55812 (**Authors:** Axler, R., C. Kleist, G. Host, C. Hagley, M. Lonsdale, J. Reed, J. Schomberg, N. Will, J. Henneck, G. Sjerven, E. Ruzycki, T. Carlson, B. Munson, and C. Richards): http://www.lakesuperiorstreams.org/stormwater/toolkit/underground.html

2. Storm water Technology Fact Sheet On Site Underground Retention/Detention(Sept. 2001) by USEPA: http://www.epa.gov/owm/mtb/runoff.pdf

3. Brentwood Industries Storm Water Management: http://brentwoodprocess.com/stormwater.html

4. Cultec Storm Water Solutions: http://www.cultec.com/stormwater_systems.html

5. BRAE Rain Tank: http://www.braewater.com/index.php?/products/matrix_d_raintank/ & http://www.braewater.com/pdf/atlantis_brochure_braewater_5_05.pdf

6. Invisible Structures Rainstore[3]: http://www.invisiblestructures.com/rainstore3.html

7. Conservation Technology Raincavern:
http://www.conservationtechnology.com/rainwater_storage_raincavern.html

8. Contec Construction Products Designing a New Project:
http://www.contech-cpi.com/DesignToolbox/StartaProject.aspx

9. Storm Water Buyers Guide 2010 Structural Storm Water BMPs:
http://www.stormh2o.com/buyers-guide-2010/structural -stormwater-bmps.aspx

Notice and Disclaimer: *This document presents preliminary* cost estimations for underground storm water detention storage *for consideration and discussion purposes only by the Michael Baker Peer Review Team regarding the Fort Worth Feasible Option Study. This document has not been edited for detail (providing proper quotations, citations and technical references) and is not intended as pre-publication work or publication material. All parties viewing, downloading and/or printing this document for review acknowledge the disclaimer and note that it is not solely the original work of Thomas Smith and/or Green and Sustainable Services, LLC located at 2421 Amyx Ranch Drive, Ponder, Texas 76259-8032.*

Memo

To: Burton Johnson, PE

From: Thomas Smith, PE, MBA, BCEE, DWRE, LEED AP, CPESC, CPSWQ

CC: Charlotte Smith, M.S.Ed.

Date: January 24, 2011

Re: Rain Garden/Bioretention Consideration for City of Fort Worth, Texas Feasible Option Study

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Per your request, please find below Green and Sustainable Services' (GSS) Rain Garden/Biioretention Memo for the Peer Review Team's consideration regarding City of Fort Worth, Texas Feasible Option Study. This is additional information to further build on the concepts outlined in GSS' September 8, 2010 Report on Low Impact Development (LID) Considerations for City of Fort Worth's Feasible Option Study.

Bioretention (also known as rain garden) is a very important LID stormwater technique that has become more prominent over the years. Bioretention is a practice to manage and treat stormwater runoff (before it is infiltrated or discharged) by using a conditioned planting soil bed and planting materials to filter runoff stored within a shallow depression. The method combines physical filtering and adsorption with biological processes. The ideal bioretention unit includes several components, including a pretreatment filter strip (grassed channel) inlet area, a ponding area, a rain garden planting area, a soil zone, an underdrain system, and an overflow system.

- The Bioretention Unit ***(also known as "Rain Garden")*** is one of the best integrated management practices for commercial and residential developments. Rain Gardens enhance landscaping, are well-suited to a wide variety of locations, and can have a significantly beneficial effect on both stormwater quantity (help control flooding) and stormwater quality.
- Rain gardens are designed to hold rain water temporarily onsite by channeling the flow to depressions onsite.

Management Objectives

- Provide water quality treatment; remove suspended solids, metals, nutrients.
- Increase groundwater recharge through infiltration.
- Reduce peak discharge rates.
- Reduce total runoff volume.
- Improve site landscaping

Bioretention areas can provide excellent pollutant removal and recharge for the "first flush" of stormwater runoff. Properly designed cells remove suspended solids, metals, and nutrients, and can infiltrate an inch or more of rainfall. Distributed around a property, vegetated bioretention areas can enhance site aesthetics. In residential developments they are often described as "rain gardens" and marketed as property amenities. Routine maintenance is simple and can be handled by homeowners or conventional landscaping companies, with proper direction.

Bioretention Applications:

Median Strips ***Residential & Commercial Rooftop Runoff*** ***Parking Lot Islands***

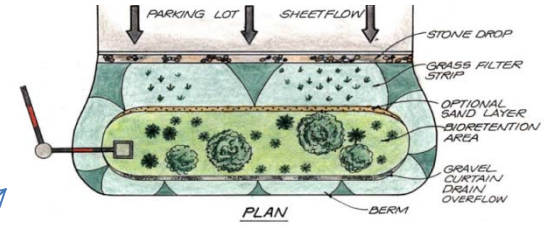
On the lower left are some commercial applications and on the lower right is a parking lot bioretention cell

Note: Trees will provide shade in the parking lot once they mature.

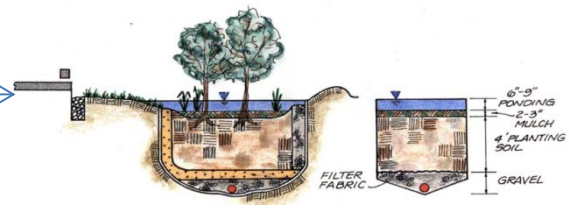
Bioretention Design Considerations

The major components of the bioretention system all require careful design considerations. These major components include:

- Pretreatment area (optional)
- In situ soil
- Ponding area
- Plant material
- Ground cover layer
- Inlet and outlet controls
- Planting soil
- Maintenance



Example Bioretention Unit Diagram on Right



Applications and Design Principles

Bioretention systems can be applied to a wide range of development in many climatic and geologic situations; they work well on small sites and on large sites divided into multiple small drainages. Common applications for bioretention areas include drainage for residential/commercial rooftops, parking lot islands, median strips, and traffic islands. Bioretention is a feasible "retrofit" that can be accomplished by replacing existing parking lot islands or by re-configuring a parking lot during resurfacing. On residential sites they are commonly used for rooftop and driveway runoff. Generally, bioretention areas are designed to store water for no more than 72 hours after a storm.

Bioretention cells are usually excavated to a depth of 4 feet, depending on local conditions. Generally, cells should be sized (based on void space and ponding area) to capture water quantity and/or treat the water quality volume. Some manuals suggest a minimum width of 15', though much narrower bioretention cells have been installed in parking lot islands and are functioning well. Regardless of size, some type of filter should cover the bottom of the excavation. Filter fabric is commonly used but can be prone to clogging; consequently some engineers recommend a filter of coarse gravel, over pea gravel, over sand.

The cell should be filled with a desirable engineered soil mix. The area should be graded to allow a ponding depth of 6-8 inches; depending on site conditions, more or less ponding may be appropriate. The area should be planted with a mix of herbaceous perennials, shrubs, and (if conditions permit) understory trees that can tolerate intermittent ponding and occasionally saline conditions (due to road salt, mostly in colder climates.) The soil should be covered with 2-3" of fine-shredded hardwood mulch.

In very permeable soils, some bioretention areas can be designed as "off-line" treatment structures (no overflow necessary), but in most situations they will be an "on-line" component of the stormwater management system, connected to downstream treatment structures through an overflow outlet or an overflow drop inlet installed at the ponding depth and routed to the site's stormwater management system. Ideally, overflow outlets should be located as far as possible from runoff inlets to maximize residence time and treatment. In general, bioretention area should be designed to drain within 72 hours. In slowly permeable soils (less than 0.3 inches/hour) a perforated underdrain can be installed at the bottom of the excavation to prevent ponding.

Bioretention areas usually work best if designed with some pretreatment, either in the form of swales or a narrow filter strip. A stone or pea gravel diaphragm (or, better yet, a concrete level spreader) upstream of a filter strip will enhance sheet flow and better pre-treatment.

Benefits and Effectiveness:

- Bioretention areas remove pollutants through filtration, microbes, and uptake by plants; contact with soil and roots provides water quality treatment better than conventional infiltration structures. Studies indicate that bioretention areas can remove 75% of phosphorus and nitrogen; 95% of metals; and 90% of organics, bacteria, and total suspended solids.
- In most applications, bioretention areas increase groundwater recharge as compared to a conventional "pipe and pond" approach. They can help to reduce stress in watersheds that experience severe low flows due to impervious coverage.
- Low-tech, decentralized bioretention areas are also less costly to design, install, and maintain than conventional stormwater technologies that treat runoff at the end of the pipe. The use of decentralized bioretention cells can also reduce the size of storm drain pipes, a major driver of stormwater treatment costs.
- Bioretention areas enhance the landscape in a variety of ways: they improve the appearance of developed sites, provide wind breaks, absorb noise, provide wildlife habitat, and reduce the urban heat island effect.

Limitations:

- Because bioretention areas infiltrate runoff to groundwater, they may be inappropriate for use at stormwater "hotspots" (such as gas stations) with higher potential pollutant loads. On these sites, the design should include adequate pretreatment so that runoff can be infiltrated, or else the filter bed

should be built with an impermeable liner, so that all water is carried away by the underdrain to another location for additional treatment prior to discharge.

- Premature failure of bioretention areas is a significant issue that results from lack of regular maintenance. Ensuring long-term maintenance involves sustained public education and deed restrictions or covenants for privately-owned cells.
- Bioretention areas must be used carefully on slopes; terraces may be required for slopes >20%.
- The design should generally ensure vertical separation of at least 2' from the seasonal high water table.

Maintenance:

Bioretention requires careful attention while plants are being established and seasonal landscaping maintenance thereafter. In many cases, maintenance tasks can be completed by a landscaping contractor working elsewhere on the site.

- Inspect pretreatment devices and bioretention cells regularly for sediment build-up, structural damage, and standing water.
- Inspect soil and repair eroded areas monthly. Re-mulch void areas as needed. Remove litter and debris monthly.
- Treat diseased vegetation as needed. Remove and replace dead vegetation twice per year (spring and fall.)
- Proper selection of plant species and support during establishment of vegetation should minimize—if not eliminate—the need for fertilizers and pesticides.
- Remove invasive species as needed to prevent these species from spreading into the bioretention area.
- Replace mulch every two years, in the early spring.
- Upon failure, excavate bioretention area, scarify bottom and sides, replace filter fabric and soil, replant, and mulch.

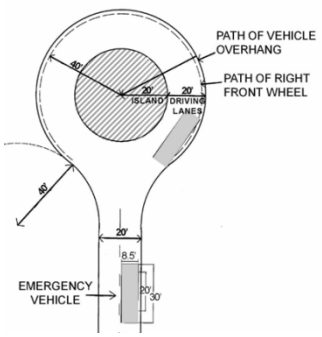
Cost:

Bioretention areas require careful design and construction, the price of which will depend on site conditions and design objective. Generally, the cost of bioretention areas is less than or equal to that of a catch basin and underground chambers intended to treat the same area. Additionally, bioretention areas treat and recharge stormwater thereby reducing the amount/size of piping needed and the size of downstream basins and treatment structures.

Techniques such as bioretention provide multiple stormwater functions, including water quality treatment, retention, and infiltration. By combining functions in a single structure, the amount of land devoted to stormwater management is reduced. If they are planted with shade trees, bioretention cells distributed throughout a parking lot can help to reduce the urban heat island effect.

Large cul-de-sacs create correspondingly large amounts of stormwater runoff, and alternative designs can minimize impervious surface while also allowing adequate access and room for school buses, garbage trucks and fire trucks and other large vehicles. Many communities require cul-de-sacs with a radius of 45 feet, which results in an expanse of asphalt nearly 100 feet across. A smaller radius is an effective way to reduce impervious surface. The radius should be large enough to accommodate school buses, garbage trucks and fire trucks and other large vehicles, with the recognition that if there are no curbs the fire trucks will be able to use some of the grassed area adjacent to the road. Many communities now allow landscaped islands in the middle of cul-de-sacs, and these can

be designed as bioretention areas, so that the runoff from the cul-de-sac drains into the bioretention area and is retained and infiltrated.



The upper image shows a design that is a hybrid cul-de-sac island / one-way loop road

Rain Garden Initiatives

Maryland and Minnesota are noted for helping advance the use and further development of rain gardens, but Kansas City, Missouri and Seattle, Washington have created public awareness regarding the use of rain gardens/bioretention units as an effective part of the cities storm water management plans.

Kansas City's - 10,000 Rain Gardens Public-Private Initiative

Kansas City, Missouri wants to build 10,000 rain gardens to reduce the amount of runoff that pollutes their waterways. 10,000 Rain Gardens is not a government program. It is a public-private initiative, involving citizens, corporations, educators, and nonprofit organizations and government agencies such as the Kansas City Metropolitan Area (KCMO) Water Services Department. City and county officials and executive staff joined in a call for regional participation in the environmental initiative.

Photo courtesy 10,000 Rain Gardens: Volunteers planted a rain garden in front of a Kansas City drain pipe to capture runoff and rain.

Former Kansas City Missouri Mayor Barnes: "Protecting our streams and rivers from pollution and our homes and businesses from flooding requires a regional approach to be truly effective upstream and downstream."

The 10,000 Rain Gardens concept appears to be working and that can be attributed to the public education initiative. In 2003 the Mid-America Regional Council (MARC) conducted a first, benchmark water quality survey of residents in the metropolitan Kansas City area. The survey was part of an ongoing effort to measure the impact that water quality education efforts in the region was having on the public's overall awareness and behavior.

In that first survey, less than half those questioned thought they could do something to help improve water quality. Only one-fourth of those surveyed had seen or heard ads related to water quality.

In 2004 and 2005, consultants for the KCMO Water Services Department conducted interviews throughout the region to determine how stakeholders viewed the issues of stormwater runoff and sewage overflowing into rivers and streams. Stakeholders included neighborhood activists, elected officials, government employees, developers, economic development officials, educators, corporate citizens, and civic leaders. There was consensus on the importance of these issues to the community's quality of life, and stakeholders wanted a regional approach. They suggested more green solutions to the problems of flooding and runoff polluting streams and rivers, and stressed the importance of a comprehensive public education plan to help citizens become part of the solution. During 2005, MARC conducted its second water quality survey of residents in the metropolitan Kansas City area. This poll showed a majority of citizens have seen or heard information about the 10,000 Rain Gardens initiative.

Former Mayor Barnes was behind the initiative because Kansas City's water and wastewater infrastructure was aging. Some water pipes and sewer lines have been in the ground more than 100 years. In 2003, Barnes formed the Wet Weather Solutions Program, a city-wide sewer overflow, stormwater and waterways initiative. The panel helped shape a plan to address sewer overflows, stormwater management and waterway uses.

On August 2, 2005, voters in Kansas City approved the issuance and sale of negotiable, interest bearing waterworks and wastewater revenue bonds of the City in the amount of $500 million. Over the next seven to 10 years, the bonds will fund new interceptor sewers and pump stations, pump station improvements, sewer rehabilitation, the over-flow control program for combined and separated sewers, wet weather projects, water-in-basement program, treatment plant improvements and sewer facility improvements, among other water needs.

Kansas City's Water Services Department developed KC-ONE, a Comprehensive Stormwater Management Plan to manage stormwater throughout Kansas City. The Water Services Department identified watersheds within Kansas City for which master plans had been developed or would be developed in the future. KC-ONE incorporates the master plans together into one comprehensive plan and describes the city's strategy, policy and administrative plans for the future of the stormwater management program.

The 10,000 Rain Gardens project's Web site (www.rainkc.com) is listed as a resource in the handouts of rain garden programs all around the country. And this public-private initiative is deemed a success by many as an effective storm water management strategy.

Other areas of the United States are starting to look at the benefits associated with bioretention projects because of the success and public awareness associated with Kansas City and Seattle's rain garden programs. Mt. Airy, Ohio is a good example, Mt. Airy Rain Catchers is a US Environmental Protection Agency project that enlisted the help of Mt. Airy neighborhood partners to install rain gardens and rain barrels in their yards. The goal is to evaluate how individual households can improve local water quality. Project measurements include monitoring the health of Shepherd Creek before and after the installation of rain barrels and rain gardens.

This project helps emphasize that rain gardens and rain barrels work at the household level to reduce pollution and conserve water. These measures make economic sense for the homes through water savings and added value on

the property and for the community. This EPA pilot program encourages the public to participate in reducing storm water runoff and pollution at the household level.

The project began with one rain barrel at the Mt. Airy Arboretum building and two demonstration rain gardens along the road to the Arboretum.

Information about the project was mailed out to property owners in the Spring of 2007. EPA chose this neighborhood because it is a good example of a suburban area with storm water problems and it can serve as a pilot example for restoration of other watersheds. Selected homes were able to receive up to 4 rain barrels and a rain garden.

The home owners decided if they wanted rain barrels and/or rain gardens. For this project EPA covered the cost of installation, planting and hardware minus the selected household bids. Home owners bid the amount they wished to pay for installation and maintenance of rain gardens and rain barrels. The EPA usually selected homes where the agency incurred a reduced cost.

The EPA's contactors installed 50 rain gardens and 100 rain barrels at the selected homes in the summer of 2007. Maintenance on the rain gardens that were installed in 2007 was performed for 3 years. EPA decided to expand on the concept in the spring of 2008. Another 31 rain gardens and 60 rain barrels were installed. The rain gardens installed in 2008 will be maintained till 2011. EPA will continue to monitor the project to note the effectiveness of the rain gardens and rain barrels.

Seattle Public Utilities sponsored a citywide effort to install rain gardens in residential yards. The effort is part of a larger program to help meet federal requirements of the Clean Water Act. The city will pay for design and installation of the gardens, which help minimize storm and wastewater runoff that compromises the quality of local waters such as Puget Sound.

Ballard is the first of 15 neighborhoods to receive rebates from the city of Seattle for rain gardens. In the picture to the left a local homeowner has rain gardens in the front and back of residence that were paid for as part of the city program to reduce stormwater runoff.

Residents living in the Ballard Combined Sewer Overflow basin were eligible for rebates (2010 Storm Water Incentive) covering most of the cost of installing a rain garden or cistern to control their roof runoff. The city will also be installing roadside rain gardens and green alleys in this area.

The city of Seattle will finance thousands of new rain gardens over the next decade. The program website is located at the following website address: https://rainwise.seattle.gov/city/seattle/overview.

Over a period of 15 years, it has been reported that the city is expected to spend $500 million to reduce storm and wastewater pollution and clean local waterways. The intent is to reduce storm water runoff that enters into existing sewer pipes, causing them to overflow. The

program is necessary to meet water quality standards of the federal Clean Water Act. Seattle Public Utilities has divided the city into 15 combined sewer overflow areas. Ballard was the first, followed by North Union Bay and Montlake slated to come online in 2011.

Within each area Seattle is staging a 3 phase effort as follows:

- The city is installing roadside rain gardens with swales and curb cuts.
- Alleyways will be converted to permeable pavement so water will slowly percolate through rather than increase run off.
- The city is offering rebates to homeowners who install rain gardens and cisterns (the Rainwise Program aims for 600 households, approximately 15% of residents in the Ballard Combined Sewer Overflow basin to increase rain gardens' water quantity.

The city will provide rebates based on a square foot of roof runoff that will be diverted to a rain garden. Even with rebates Seattle Public Utilities rates are expected to increase. "Seattle home owners and residents can expect increases in their drainage bills as well as their waste water bills," said Andrew Lee, manager of System and Planning operations for Seattle Public Utilities. "In addition, we're gonna be seeking as much federal funding as possible through federal loans and grants."

Rain gardens are a very effective low impact development measure that has a positive impact on storm water quantity and quality.

Photo below by Seattle Public Utilities

The Pictures above are Rain Gardens in the City of Maplewood, MN

The above picture shows a Rain Garden application that can be effective at reducing storm water runoff

Information contained in this report was obtained from the following sources:

- University of North Carolina Charlotte - The William States Lee College of Engineering (Low Impact Development Principles, Techniques, and Implementation) website: http://www.coe.uncc.edu/~hhilger/aaaSustainable%20Design_08_&_on/LID/LID_Toolkit_Slide_Show.ppt

- Metropolitan Area Planning Council located in Boston, MA (Low Impact Development Toolkit and Attachments) website: http://mapc.org/resources/low-impact-dev-toolkit

- Prince George's County, Maryland Department of Environmental Resources Programs and Planning Division (Low-Impact Development Design Strategies An Integrated Design Approach) website: http://www.princegeorgescountymd.gov/der/esg/manuals.asp

- Department of Environmental Resources, Prince George's County, MD; 1993: Design Manual for Use of Bioretention in Stormwater Management

- Bioretention as a Water Quality Best Management Practice, Article 110 from Watershed Protection Techniques; Center for Watershed Protection; 2000

- The EPA has published a Storm Water Technology Fact Sheet about Bioretention as well as a study of Bioretention Applications, Inglewood Demonstration Project, Largo, MD and Florida Aquarium, Tampa, FL

- The Low Impact Development Center has prepared specifications and details for construction of bioretention areas.

- The Federal Highway Administration has also prepared a Bioretention Fact Sheet.

- Kansas City's Dream- 10,000 Rain Gardens: ***http://www.ens-newswire.com/ens/jun2006/2006-06-27-01.asp***

- 10,000 Rain Gardens project's Web site: http://www.rainkc.com

- Kansas City, Missouri Overflow Control Plan Overview, January 30, 2009, prepared by the City of Kansas City, Missouri

- Rain Gardens Reign: http://www.stormh2o.com/may-2008/rain-gardens-management.aspx

- Mt. Airy Rain Catchers project website: http://www.mtairyraincatchers.org/

- **Local waters will benefit from Seattle's program to install rain gardens: http://seattletimes.nwsource.com/html/pacificnw/2012783039_pacificplife12.html**

- The Seattle RainWise program website is located at the following website address: https://rainwise.seattle.gov/city/seattle/overview.

- RainWise Rebates for Cisterns and Rain Gardens: http://www.seattle.gov/util/About_SPU/Drainage_&_Sewer_System/GreenStormwaterInfrastructure/ResidentialRainwiseProgram/Incentives/index.htm

- Ballard at forefront of city's rain garden program: http://ballard.komonews.com/content/ballard-forefront-citys-rain-garden-program

- Rain Garden Handbook for Western Washington Homeowners

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