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## Hydrologic Effectiveness and Plant Survivability in the Holmes Lake Rain Garden Pilot Program: Year Three

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**Hydrologic Effectiveness and Plant Survivability  
in the Holmes Lake Rain Garden Pilot Program:  
Year Three  
Lincoln, Nebraska**

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Masters Horticulture Project  
University of Nebraska–Lincoln  
August 2011



## **Abstract**

Rain gardens are increasingly being used as small scale stormwater best management practices (BMPs) to reduce stormwater runoff through infiltration and to remove pollutants through filtration. In 2007, as part of a comprehensive water quality restoration process of Holmes Lake in Lincoln, Nebraska, 20 pilot rain gardens were installed in residential and school properties in the watershed. Currently, assessment and monitoring has been limited to participant surveys and cannot be used to determine if hydraulic or vegetative problems exist within the garden area. In this study, visual inspections were conducted to establish a database standard for successful rain gardens, hydraulic and/or vegetative problems were noted, followed by interviews with rain garden owners. Of the 18 surveyed rain gardens, several issues appeared that were attributable to garden revisions by property owners. In all but three gardens, there was an overall problem with plant survivability. Issues more closely studied included use of sprinkler systems, hydraulic function, and plant placement within the garden. Plant placement appears to be a major concern relative to plant survivability. Plant lists need to be updated to include where a plant will do best within the rain garden depression and the installer needs to be further educated on these findings. This study also shows that visual inspections can be an efficient and low cost, effective way to detect problems within a residential rain garden.

Additional index words: stormwater runoff, BMPs, hydraulic function, groundwater recharge, impervious surface, watershed.

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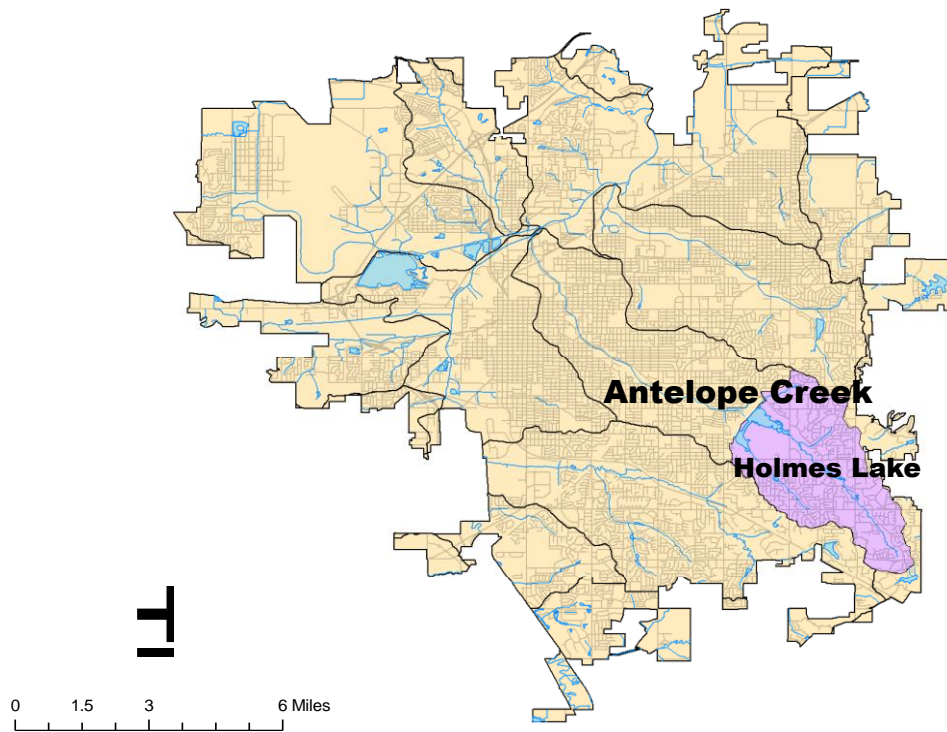
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# Introduction

## Project Location and Context

The City of Lincoln, Nebraska through its Department of Public Works and Utilities, Division of Stormwater Management manages urban runoff to reduce flood hazards and improve water quality. The Lincoln City – Lancaster County 2030 Comprehensive Plan states a watershed master plan would be ideally completed and adopted prior to urban development occurring within a new basin. However, plans do not always deter problems. As development expanded in the City of Lincoln, urban and construction site effluent carried excess sediments and nutrients into Holmes Lake (Fig. 1). In 1998, the Nebraska Department of Environmental Quality (NDEQ) responded to the water quality degradation by adding Holmes Lake to the Impaired Water Bodies listing (as required by the state’s Clean Water Act section 303 (d)) citing aquatic life use impairments. Total Maximum Daily Loads (TMDL) measured for Holmes Lake by the NDEQ in 2003, determined phosphorus loading must be decreased by 97% and sediment loading by 53%.



(Fig. 1) Holmes Lake watershed as part of Antelope Creek basin in Lincoln, Nebraska



Rain gardens are increasingly being used as part of stormwater best management practices (BMPs) in residential areas to reduce stormwater runoff through infiltration and to remove pollutants through filtration (Asleson et.al 2007). Limited research has looked at the aesthetic and functional characteristics of rainwater gardens over time or the perceptions of garden owners related to those characteristics. This report summarizes a follow-up survey on rainwater gardens installed on private and school property through a City grant program in 2007 seeking to understand: (1) the existing condition of the gardens and their plantings and (2) the perceptions and feedback from garden owners. It will briefly describe the stormwater quality regulatory contexts, rainwater garden hydrologic function, and the target sub-watershed. The Materials and Methods section will describe the selected rainwater gardens and the information gathered about the gardens. The Results section will compare the gardens and point out common similarities and differences between the current garden conditions and owner's concerns. Finally, recommendations will be made for future information-gathering and rainwater garden design and maintenance adjustments to improve garden aesthetics and functionality in Lincoln.

### **Stormwater Pollution and Rain Garden Definition**

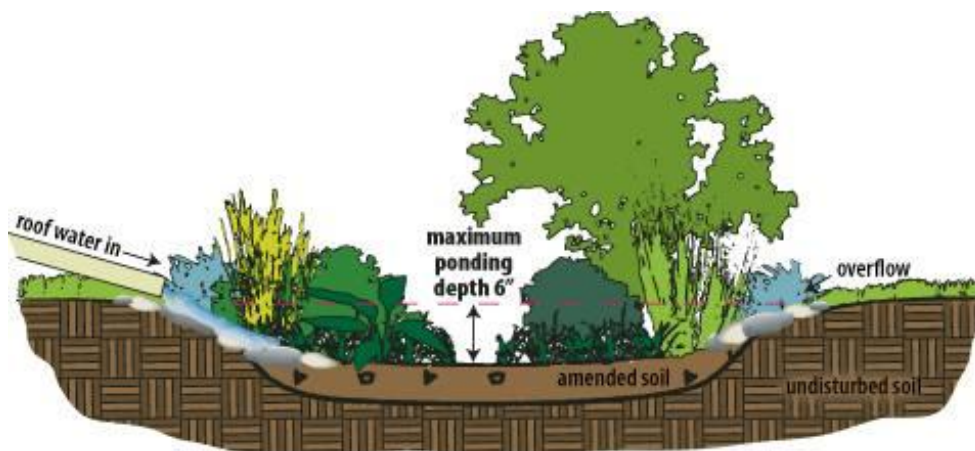
Polluted stormwater runoff generally occurs wherever there is human use or alteration to land cover. Our daily activities produce the primary source of stormwater pollutants and most people remain unaware of how their actions impact water quality. Examples include overlooked activities such as excessive pesticide use, overuse of lawn fertilizers, not picking up pet waste, using salt to de-ice driveways, letting oil drip out of their vehicles, and littering which lead to common non-point sources of pollution. Excessive water quantity also impacts urban settings where untreated stormwater runoff flows quickly over impervious surfaces, such as driveways, roofs, sidewalks and patios, overwhelming storm drainage system capacities which leads to flooding and additional pollution of water bodies.

By treating stormwater as a resource rather than a waste product, rain gardens become functionally and aesthetically appealing components in a site drainage system. Practices that store and infiltrate stormwater have been around for decades; however, the introduction of plants to the system was a new idea for stormwater engineers. In 1990, stormwater specialists in the state of Maryland first conceived of rain water gardens driven by the need for low cost stormwater infiltration methods to improve water quality, and the concept of rain gardens has spread across the country.



(Fig. 2) Residential rain garden with roof downspouts and rain barrel overflow hose directed into the garden area for infiltration.

On the surface, a rain garden looks like a regular garden (Fig. 2). The major difference between them comes from the bed of the rain garden being formed and planted into in a depression rather than in a mound or being left at ground level (Fig. 3) (Meder 2009). This design temporarily holds runoff from impervious surfaces and allows it to infiltrate into the soil, thus more closely mimicking the natural hydrological system. A properly designed rain garden can achieve four main protection goals; flood control, channel protection, ground water recharge, and pollutant removal (EPA 2006).



(Fig. 3) Cross-section of a rain garden with a roof downspout inflow. (Oregon Environmental Council)

## Methods/Materials

### Background

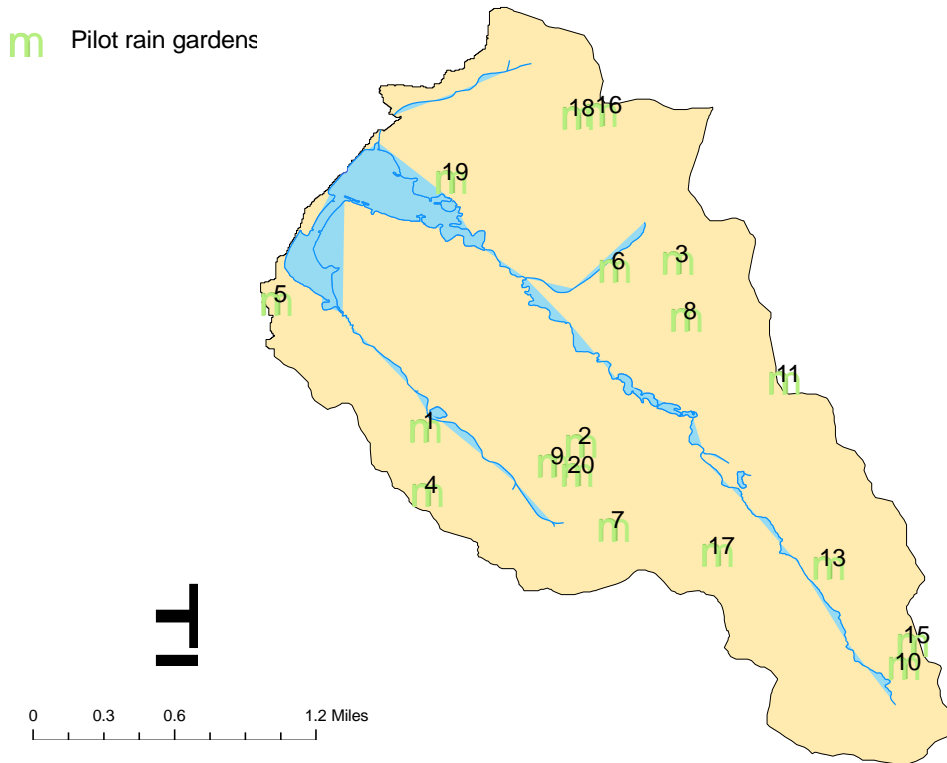
Holmes Lake watershed occupies the upper half of Antelope Creek basin (refer back to Fig. 1, pg. 1) and is fed by two drainage systems that enter from the south/southeast. The drainage area is approximately 5.4 square miles. The lake was formed by a dam that controls flooding; it also adds aesthetic and recreational value to the surrounding area, much of which has been developed as residential subdivisions. The \$5.5 million Holmes Lake Restoration Project was completed in 2006 through funding by the City of Lincoln, NDEQ, Nebraska Game & Parks Commission and the U.S. Environmental Protection Agency. The goal of the project was to increase awareness about simple personal lawn care management changes that can be made by homeowners to improve stormwater quality by reducing the amount of stormwater runoff and phosphorus fertilizer draining into Lincoln/Lancaster County streams and lakes, especially Holmes Lake (City of Lincoln). Lake restoration required the dredging of 321,000 cubic yards of sediment, stabilizing 2.4 miles of shoreline, and restoring fish habitats. On ground controls included a 10 acre wetland development, 20 rain gardens and drainage network stabilization.

To successfully obtain the goals of the project, community involvement and increasing awareness about stormwater quality issues was a vital element. On June 20, 2007, the City of Lincoln Watershed Management Division held a public meeting for residents in the Holmes Lake Watershed to learn about a new water quality program. The program included offering 20 rain garden installations at 90% cost reduction to homeowners residing within the Holmes Lake Watershed. Applications were reviewed and awarded on a first come, first serve basis and rain garden installations began in early fall 2007. Funding for the program was financed and supported by the NDEQ and the Lower Platte South Natural Resources District.

To initiate follow up on the conditions of the 20 three-year-old rain water gardens, participants were sent a letter by the City of Lincoln Watershed Management Office in April 2010, informing them the University of Nebraska Extension had received a USDA grant to examine hydrologic effectiveness and plant survivability and suitability in rain gardens (Appendix A). The research focus addressed evaluation of soil properties, sizing procedures, plant selection, and installation standards for rain gardens in high clay soils that are typical of the Great Plains regions and included on-site visual inspections during the summer of 2010. A visual inspection involves a comprehensive evaluation of the vegetation and soil in the rain garden (Gulliver *et. al* 2008) and will serve as a low cost, effective way to determine if the pilot rain gardens are functioning properly, suitable plants selections survived, and need individual maintenance.

The letter stated they had the option of participating and that personal contact information would not be shared. The Watershed Management Office provided copies of the original

diagrams and a list of participant names and addresses. The list of participants involved primarily single family dwellings (17) with traditional turf lawn settings. It also includes one apartment complex and two schools. Participants are under contract with the City of Lincoln to maintain the rain garden (Fig. 4) for five years, fill out annual surveys, allow the city to photograph the rain garden, and to contact the city and garden installer, if problems occur.



(Fig. 4) Locations of participating pilot rain gardens with in the Holmes Lake Watershed Basin

### Assessment Method and Criteria – Initial Visit

During the summer of 2010, the primary investigator sent each participant a letter stating they would be contacted about participation in this research project (Appendix B). After contacting each participant by phone, 18 agreed to allow the visual inspection, one declined and one had moved. Driving past the property of the participant that moved confirmed the garden was no longer on the property. Currently, the City of Lincoln does not have regulations in place for transfer of rain garden ownership should a residential property with an existing rain garden be sold. A study by the City of Maplewood and the Wisconsin Department of Natural Resources, noted that the impacts of homeowner

turnover on residential rain gardens needs further study. Inherited rain gardens maybe more prone to misunderstandings about proper operation and maintenance and how an established rain garden is integrated into the community system of water management (City of Maplewood 2002).

A visual inspection was conducted on the first visit to each property. This did not require the participant to be present during the time of inspection. The following criteria and questions were used to inspect each garden (the list is summarized in Appendix C):

- Street view impression – Upon arriving at the property, noted the first impressions in relation to placement, aesthetics, maintenance, and surroundings.
- Hydraulic assessment - Noted any obvious hydraulic problems through the following questions.
  1. Has it rained within the last 48 hrs?
  2. Are any inlet structures clogged? Look for debris, sediment, vegetation, or other obstruction. Inspect downspouts for blockages or disconnections from roof gutters.
  3. Are any inlet structures misaligned? Look for erosion, channelization, or flooding in surrounding areas.
  4. Is there any standing water? Look for green or murky color.
  5. Bottom assessment – does it contain sediment deposits, erosion or channelization, excessive vegetation, or litter/debris?
  6. Bank assessment – does it contain erosion or channelization, soil slides or bulges, animal burrows, seeps or wet spots, poorly vegetated areas, or are unplanned trees present?
  7. Is the overflow structure clogged? Look for debris, sediment, vegetation, or other obstruction.
  8. Is the overflow structure misaligned? Look for erosion, channelization, or flooding in surrounding areas.
- Site conditions – These included time of growing season, sun/shade patterns, garden placement with respect to residential home, wind exposure, air circulation among the plantings, whether a sprinkler systems is present, and plants currently in bloom.
- Vegetation assessment - The plant selections were native plant material as is often recommended for rain gardens and their performance was evaluated through the following questions.
  1. Approximate % of vegetation coverage. Be sure to note bottom vegetation abundance.
  2. Compare current vegetation to original design. Look for species not surviving or that have disappeared, introduction of weeds, or invasive vegetation.
  3. Does vegetation appear healthy? Look for wilted leaves/stems, discoloration of leaves, lack of flowering buds developing, stunted growth, or decrease in plant numbers.
  4. Is vegetation appropriate density/size?

5. Where is vegetation located relative to top/sides/bottom of garden? Note relative position so comparisons can be made to health and growth characteristics in relation to probable soil moisture.
- Side notes – Included general comments not specific to listed questions and criteria and observations/patterns that were relevant to more than one rain garden.
  - Individual suggestions added to handout – After conducting all inspections, each participant received a tip sheet with suggestions for keeping their garden looking and working well for years to come (Appendix D). Included were overall visual inspection research observations and individual rain garden suggestions for maintenance or problems tailored specifically for their garden.

Few assessment studies on rain gardens exist. In two studies on rain garden assessment, Erickson *et.al* (2010) and Hutchinson (2010) used visual inspections and questions. However, those studies did not reference private residential rain gardens, so the questions used for the hydraulic and vegetation assessments have been modified for this investigation.

### **Assessment Method and Criteria – Second Visit**

Fourteen of the eighteen participants agreed to a second visit to conduct a homeowner assessment discussion. Permission protocol and questions were approved by the UNL Institutional Review Board (IRB#20100911078 EX) for this phase of the study. The direct questioning of participants required this approval to ensure that participants are not placed at undue risk, gave informed consent to their participation, and have their rights and welfare protected throughout the project. Prior to the homeowner assessment discussion, each participant signed and kept a copy of a Participant Informed Consent form (Appendix E). The second visit included the following questions and activities:

- Homeowner assessment discussion – Face to face interviews were conducted with each homeowner responding to the following discussion points:
  1. Describe current functional garden rating. The garden is draining in \_\_\_\_ hours after rain event; OK or not ‘fast enough’?
  2. Describe current aesthetic rating. On a scale of 1-10; 1 being hate it, 10 being love it. What would be done differently in hindsight; specific to plant heights, plant selection, edging, mulching, location, etc.?
  3. If existed prior to rain garden installation, what drainage problems were solved?
  4. Check for plant information available through homeowner. Such as replaced plants that aren’t obvious or on original plan; known diseases, bug or animal damage witnessed by homeowner, changes in watering patterns, etc.
  5. Has your rain garden experience enhanced your knowledge and awareness of stormwater management and runoff water quality as important issues in Lincoln?

6. Have you educated others and/or made them aware of stormwater management issues? If so, have any of your contacts led to additional rain gardens being installed?
- GPS reading - Since the privacy and confidentiality of participants are protected, each rain garden will be referred to by a number for identification purpose in the discussion of results. A GPS reading was taken at each site using a hand held unit that will correspond to the identification number assigned to each rain garden (Appendix F). These readings will be applied to GIS ArcMap for displaying spatial mapping of each garden and to analyze several of the visual inspection questions. Meenar et al. (2006) note that watersheds are complex ecosystems and ArcGIS with its number of widely available extensions, serve as a powerful platform for integration and analysis of a wide range of data sources. In addition to geo-spatial mapping, participant perceptions and aesthetic preferences can be used in GIS layering as a spatial-to-social comparison or social-to-social comparison. For example, participant aesthetic rating might be directly correlated to the plant survivability with in the rain garden. Another example would be the extent of educating others on stormwater management as compared to the aesthetic rating of the garden.
  - Photos – Photos were taken to further document the gardens and for possible future research use; individual rain garden, specific plants and maintenance problems were documented as well. The individual rain garden photos were also provided to the City of Lincoln Watershed Management Office for placement on their website *Water Quality Improvement Program: Holmes Lake Watershed* as participants are under contact to allow garden photography for five years.

## Results

Results for all rain garden visual inspections are summarizing by street view impressions, hydraulic assessment, vegetative assessment and homeowner assessment discussion sections, including tables, figures and GIS maps. For each question, the hydraulic and vegetative assessments include eighteen rain garden visual inspection summary findings; the homeowner assessments include fourteen participant discussion summary responses. Complete reports with original diagrams, notations to original diagrams, photos, GPS coordinates and responses to the visual inspection questions for each rain garden site are included in the appendix section of this report (Appendix G).

### Initial Visit - Hydraulic and Vegetative Assessments

**Street view impressions:** The intent of the City of Lincoln Watershed Management Office was to ‘sell’ the pilot program rain gardens and make them visible to educate neighbors in the targeted watershed. Thirteen of the eighteen rain gardens could be viewed from the street. Of the remaining five rain gardens; #1 could be viewed from a neighborhood lake, #5 from the Holmes Lake walking trails, and #11 from a golf course. Only gardens #7 & 13 were fully enclosed within backyards.

**Hydraulic assessment:** These questions address the hydraulic function of the rain garden as determined through a thorough visual examination of garden characteristics (Appendix C). During 2010 when the hydraulic assessment was completed, June precipitation was 5.99 inches above normal and for the month of July, 2.29 inches above normal (Table 1). Excess precipitation had caused problems within all 18 rain gardens that might not occur in years with normal rainfall amounts, such as bank overflow and erosion and overflow structure clogging and obstruction. For an overall assessment of questions #1-4, 7 & 8, refer to Table 2.

(Table 1) Rainfall averages and 2010 actual amounts for June and July in Lincoln, Nebraska

Month	Average	2010 Actual	Difference
June	3.91 in.	9.90 in.	+5.99
July	3.54 in.	5.83 in.	+2.29



1) **Has it rained within the last 48 hrs?** Rain gardens # 9 & 20 had rain within the last 48 hours; however, neither had standing water. Inspections during an actual rain event would be ideal to see how the rain garden is functioning and is an area that could use further research.

2) **Are any inlet structures clogged?** Inlet structures should be free of debris and other obstructions to allow stormwater runoff to freely enter the rain garden. All the rain gardens had good inlet flow, except garden #8 that had two buried and clogged downspouts. Two other rain gardens had buried downspouts which were free of obstruction; garden #2 showed channelization at the entry, garden #7 was functioning properly (Fig. 5). Most of the rain gardens have roof downspouts that intercept a turf lawn and need to be monitored for grass and leaf litter that cause clogging. Gardens #1, 3, 5, 13, 16, & 17 all had unmown grass causing downspout obstruction. Garden #9 had a slightly crushed downspout. Gardens #4 & 16 need the use of a turf edger on the inflow edge of the rain garden.



(Fig. 5) Buried downspout entering rain garden #2 showing channelization.

3) **Are any inlet structures misaligned?** A misaligned inlet structure will not allow stormwater runoff to freely enter the rain garden for proper infiltration/filtration. Gardens #15 & 16 have downspouts that need to be redirected to capture more water from the roof areas. Garden #10 could direct another downspout into the rain garden basin. The north downspout of garden #17 diverts some runoff. In addition to the inlet structures, gardens #1 & 8 had lawn runoff that could be directed into the garden.

4) **Is there any standing water?** Standing water beyond the 48 hour time period indicates infiltration problems. Despite the above average precipitation, none of the rain gardens had standing water. Bottom moisture was present in gardens #1, 6 & 8 most likely due to an adjacent sprinkler system and in garden #13 due to a recent standing water issue. The bottom of garden #19 was mucky. Garden #7's buried drainpipe below the rain garden allows water to stand in the pipe outlet and the bottom was covered with algae growth.

5) **Do sediment deposits, erosion, channelization, excessive vegetation, litter or debris cover the bottom and negatively affect the rain garden infiltration performance?** Gardens #1, 16 & 19 had substantial loss of bottom vegetation. Gardens #3, 6, 8, 10, 17, 18 & 19 have litter, weeds, and/or invasive plant material. Gardens #4, 6, 7, 8 & 10 needed mulch added or redistributed. Gardens #5, 7, 8 & 15 showed rills and channeling from inflow. Garden #9 had lawn turf and excess salt covering the surface. Garden #10 had a different basin formed than was indicated on the design.

6) **Do erosion, channelization, soil slides, bulges, animal burrows, seeps, wet spots, poorly vegetative areas or trees present on the basin banks reduce or damage rain garden effectiveness?** Note that berm plants for stabilization were not added to the rain garden program until year two by the City of Lincoln Watershed Management Office as a result of bank damage received during year one (Fig. 6). Rain garden banks showed the effects of higher than normal precipitation. For example, gardens #5, 10, 16 & 20 showed signs of erosion. Gardens #1 & 20 showed signs of overflow channelization. Garden #4 had mulch overflow and garden #15 had sediment overflow. In gardens #3, 17 & 18 weeds appeared, while in gardens #5, 7, 9, 13, 16, 18 & 19 lawn turf encroached.



(Fig. 6) *Sedum floriferum* 'Bailey's Gold' used for bank stabilization.

7) **Is the overflow structure clogged?** Overflow structures must be free of debris and other obstructions to allow stormwater runoff to freely exit the rain garden in the event of

a large storm event. Note that overflow structures were not added to the rain garden program until the second year of the program by the City of Lincoln Watershed Management Office as a result of mulch and sediment overflowing into lawns during year one. It did not appear that every rain garden received overflow structures and the reason is not known. Overflow structures had been used more often due to higher than normal precipitation and showed significant problems, such as mulch washed and extended into turf areas and wider overflow than the structure allowed. Since this year produced higher than average precipitation, next year the overflow structures might be sufficient. Eleven of the eighteen rain gardens had issues with clogging. For example, garden #1 had sediment and plant litter while gardens # 2, 3, 4, 5, 6, 7, 9, 10, 15, 16, 17, 18 & 19 had excess mulch, weeds, or grass that needed to be pushed back or removed (Fig. 7). Gardens #7 & 11 possess buried overflow drains. Gardens #13 & 20 lacked overflow structures.



(Fig. 7) Clogged rock overflow showing encroaching mulch needing redistribution.

8) **Is the overflow structure misaligned or does the water leave the rain garden at what appear to be unintended locations?** A misaligned overflow structure allows stormwater to exit the rain garden other than where intended. One of the eighteen rain gardens possessed a misaligned overflow structure. Two more had possible misalignment issues. Garden #8 was misaligned. Gardens #1, 5, 10 & 15 had additional overflow at locations where overflow structures were not constructed. Gardens #2, 4, 6, 16, 17 & 19 had overflow outside of the overflow structure boundary. Garden #7, 11, 13 & 20 did not have overflow structures installed after year one.

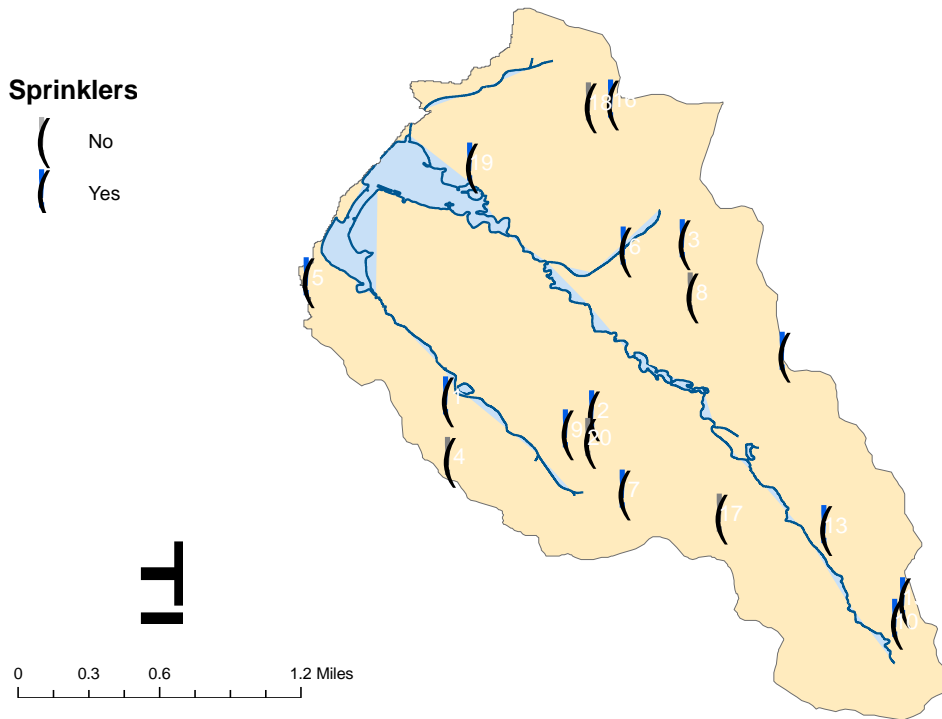
(Table 2) Overall hydraulic assessment of questions #1-4, 7 & 8.

Rain Garden #	1	2	3	4	5	6	7	8	9
1) Has it rained within the last 48 hrs?	No	No	No	No	No	No	No	No	Yes
2) Are any inlet structures clogged?	No	No	No	No	No	No	No	Yes	No
3) Are any inlet structures misaligned?	No	No	No	No	No	No	No	No	No
4) Is there any standing water?	No	No	No	No	No	No	No	No	No
7) Is the overflow structure clogged?	Yes	Yes	Yes	Yes	Yes	No	Maybe	No	Yes
8) Is the overflow structure misaligned?	No	Maybe	No	Maybe	No	No	N/A	Yes	No

Rain Garden #	10	11	13	15	16	17	18	19	20
1) Has it rained within the last 48 hrs?	No	No	No	No	No	No	No	No	Yes
2) Are any inlet structures clogged?	No	No	No	No	No	No	No	No	No
3) Are any inlet structures misaligned?	Yes	No	No	Yes	Yes	No	No	No	No
4) Is there any standing water?	No	No	No	No	No	No	No	No	No
7) Is the overflow structure clogged?	Yes	No	N/A	No	No	Yes	Yes	Yes	N/A
8) Is the overflow structure misaligned?	No	N/A	N/A	No	No	No	No	No	N/A

N/A – information not available

**Site conditions:** The context of the rain garden heavily influences its functional and aesthetic characteristics. Adding rain garden bioretention into private residential properties presents a new issue – conflicts with sprinkler systems. Routine watering of native plant material can cause it to grow inordinately large, fall over, or die (Lamb 2009). Typically, native plant material is rain fed. In the study area, thirteen of the eighteen rain gardens were irrigated by sprinkler systems designed to accommodate supplemental water applications for turf. The five remaining rain gardens relied on natural rainfall; three were residences and two were schools (Fig. 8).



(Fig. 8) Sprinkler systems shown in blue within the pilot rain gardens.

Shading by trees also effects the growth and performance of rain water garden plants. Many of the rain garden locations were in recently developed residential areas where trees were young and small when the rain gardens were installed in 2007. Gardens #5, 7, 9, 11, 13, 15 & 16 had young trees that are now starting to add significant shade to the rain garden basin and garden #3 and 10 had added trees since installation.

**Vegetation assessment:** These questions deal with the visual inspection of the rain garden vegetation that serves a vital role for stormwater infiltration/filtration (Appendix C). All rain gardens had been installed for three years and were selected from a standard list of forty-five perennial native and adapted species and cultivars (Appendix H). Complete plant descriptions can be found in *Sustainable Landscapes: Rain Gardens, Bioswales and Xeric Gardens* (Rodie *et al.* 2010). The type of vegetation selected was based on location within the rain garden, sun and participant preference. All rain gardens have mulch covering the soil surface. Recommended mulch depths for rain gardens were two to three inches, however, participants of gardens #1, 4 & 16 over mulched to depths of five to six inches.

1) **Approximate % of vegetation coverage.** Adequate vegetation aids in infiltration/filtration of stormwater runoff. This is especially true for the bottom of the rain garden basin where stormwater runoff may stand for longer periods of time. Eighty to ninety percent coverage is optimal for good plant health, allowing air circulation around the vegetation. In the study area, overall coverage percentages, as determined visually, range from 30-90% (Table 3). Thirteen of the eighteen rain gardens had an overall coverage of 70% and higher. The remaining five rain gardens appeared to lack

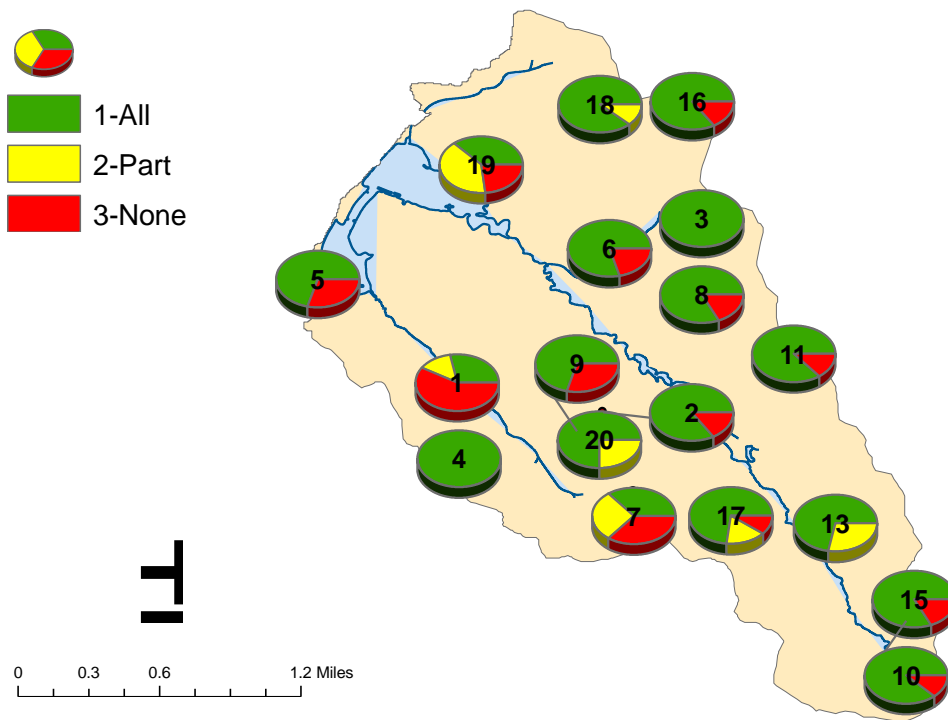
sufficient vegetation for effective infiltration/filtration of stormwater runoff. Specifically, bottom coverage percentages ranged from 10 – 90%. Seven of the eighteen rain gardens had a bottom coverage of 70% and higher which was consistent with their overall coverage percentages. The remaining 11 rain gardens lacked sufficient coverage. Garden #8 had excess vegetation in the entire basin and #13 had excess bottom area vegetation.

(Table 3) Percent of total overall and bottom area vegetation coverage within the rain gardens

Garden #	Total %	Bottom %	Garden #	Total %	Bottom %
1	50	10	10	70	50
2	70	50	11	80	70
3	70	50	13	90	80
4	70	50	15	70	50
5	75	75	16	30	10
6	70	50	17	50	50
7	50	40	18	90	70
8	90	90	19	50	30
9	70	70	20	70	70

2) **Compare current vegetation to original design.** Rain garden performance may be affected if plants species are not surviving or weeds are competing for garden space. According to original planting numbers taken from the design plans, 441 plants were used. In 2010, the surviving number was 367. This is a 17% loss from the original planting. Loss of plantings means less vegetation to aid with infiltration/filtration. Of that loss, only 32% of the plants (24 plants) were replanted or replaced.

Note that these numbers are approximate as substitutions and/or deletions may have occurred at the time of planting. In addition, they do not contain any transplanted plant material because actual quantities used were not included on the original diagrams. Since a visual inspection relies on a qualitative overview, a map has been included with the number of varieties per each rain garden that shows all, partial or none survival ratings for each variety (Fig. 9). The maps are intended to aid in seeing the actual loss by variety rather than individual planting quantities.



(Fig. 9) Survival rating of varieties per each rain garden.

Only rain gardens #3 & 4 had all original plantings survive. Gardens #1, 3, 6, 13, 15, 17, 18, 19 & 20 had invasive/volunteer plant material (Fig. 10). Garden #8, 9 & 13 had original plantings growing out of bounds. Gardens #17, 18, 19, 20 were weedy. #1, 7, 9, 10, 15, 16, 17, 19, 20 have open areas within the rain garden. Gaps in plantings create open space in which weeds and invasive vegetation can establish. Note that higher than normal amount of rainfall may have added to weed and invasive problems.



(Fig. 10) Invasive vegetation in rain garden #1 due to open spaces from plant loss.

3) **Does vegetation appear healthy?** Plant health indications can include wilted leaves/stems, discoloration of leaves, lack of flowering bud development, stunted growth or a decrease in plant numbers. Overall the vegetation health was very good in most rain gardens with the exception of gardens #2, 3, 4, 7 & 20 with indicated slight problems. Problems with vegetation vigor are often tied to site conditions. Garden #8 had mildew on the shasta daisy plants (Fig. 11). In rain garden #19, the amount of stormwater runoff may have been underestimated by the contractor and the plants are showing signs of being water logged. In addition, the area had invasive wetland vegetation, including cattails, rushes and willow trees. Specific plant issues include rudbeckia showing leaf mottling. Monarda, sweetshire and siberian iris had leaf yellowing.



(Fig. 11) Signs of mildew on shasta daisy plants.

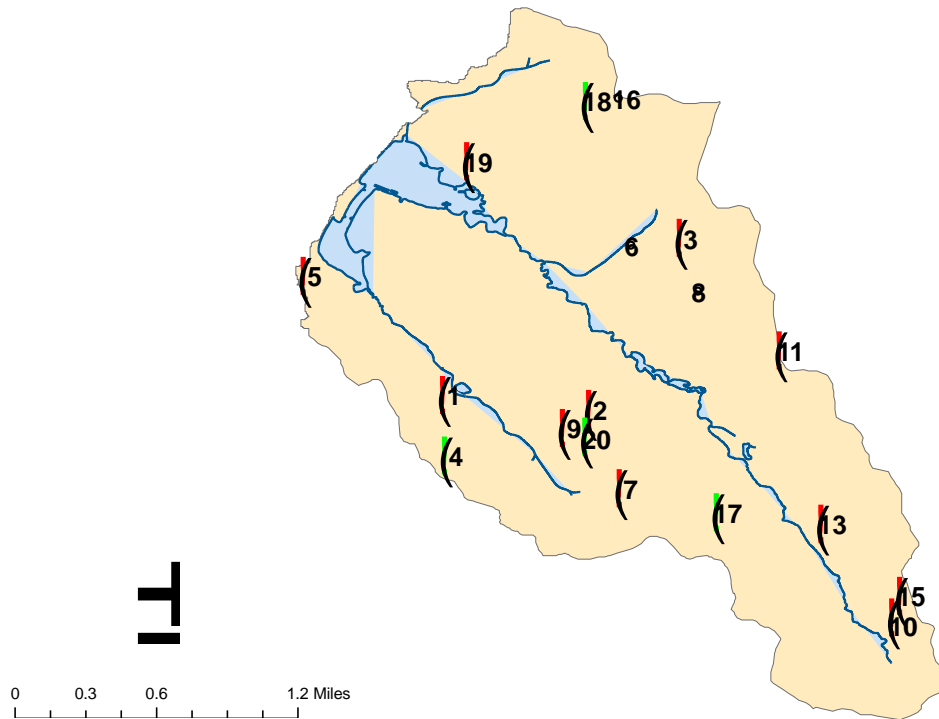
4) **Is vegetation appropriate density/size?** This study was conducted in the third year of plant growth by which time the plants should be at the appropriate density/size for each particular variety. Under development indicates poor health or problems with hydraulic function. Over development can be an indication of extra watering or use of fertilizers. Gardens #1 & 15 reflected appropriate density/size, while the majority of the gardens (#2, 3, 4, 5, 6, 7, 9, 10, 11, 17, 18, 19 & 20) had slight issues. As already described in question 4 above, gardens #8 & 13 had plantings growing out of bounds (Fig. 12). In some gardens plants need dividing. In rain garden #16, the sunlight conditions may not have been estimated properly by the contractor. The plants were grossly undersized as varieties for a sunny site had been selected and this is a dry, shade site. Specific plants with growth issues include rudbeckia, variegated sedge, summersweet, siberian iris, red baron grass and obedient plant in which all were shorter than expected for healthy plants. Siberian iris showed bare centers. Red baron grass and siberian iris were sparse. Penstemons, monarda and spiderworts became leggy and liatris bolted.





(Fig. 12) Obedient plant growing out of bounds and becoming invasive.

5) **Where is vegetation located relative to top/sides/bottom of garden?** In addition to aesthetic placement of planting within a rain garden, location of the planting is vital to survivability. With reference to Fig. 9, of the varieties used within the 18 rain gardens, 41 varieties had a survival rating of ‘partial and none’ where 33 were in the side-bottom or bottom areas. These areas show significant plant loss. A complete list of placement for all variety plantings is included in this report (Appendix I). For example, Woods aster (blue, pink and purple) was used in 15 rain gardens (Fig. 13). Nine gardens had a partial or none survival rating in the side-bottom and bottom areas. Of the four gardens where all survived, one was planted in the top area, two in the top-side area and one in the bottom area. Note that the one that survived in the bottom area grew in a rain garden where all plants survived. Typically, asters needs well-drained soil and placement in the area of the rain garden where water may be standing for long periods of time, exemplifies the need to consider plant ecology over aesthetic placement. Other varieties that appear to require top/top-side locations versus side-bottom/bottom locations for survival are columbine, miscanthus, phlox and sea oats.



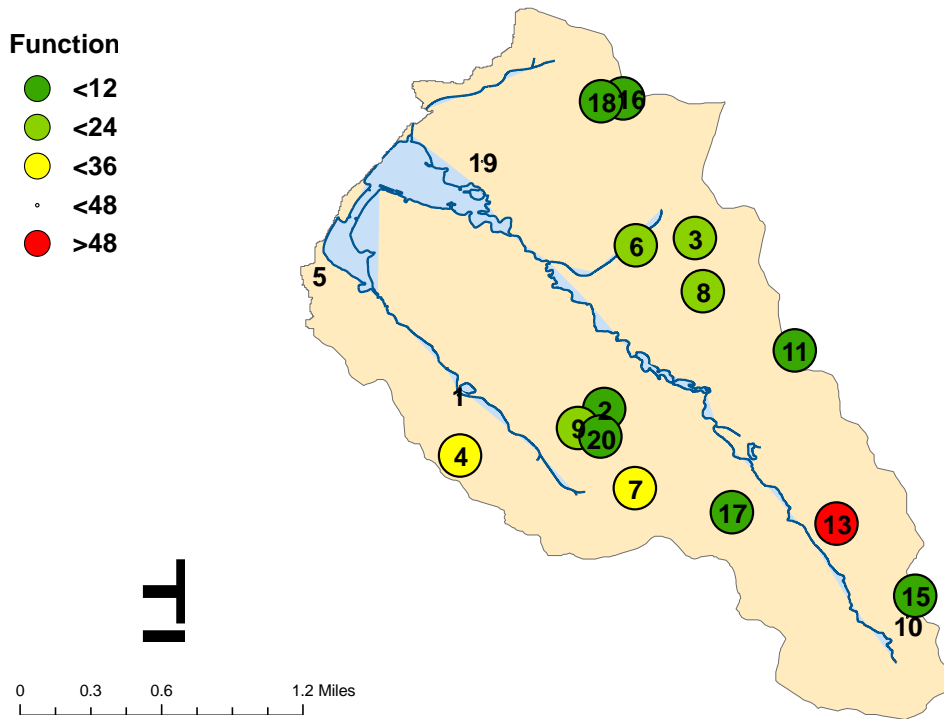
(Fig. 13) Woods Aster with green as top/top-side survival and red as side-bottom/bottom non-survival rating.

### Second Visit - Homeowner Assessment

Few assessment studies on rain gardens that incorporate direct homeowner feedback exist. The Holmes Lake rain garden program has previously documented homeowner feedback on rain garden design, function and maintenance through annual mail-in surveys. In contrast, going out to visit and inspect rain gardens with owners offers a unique opportunity for face-to-face feedback. For example, understanding how owners maintain and appreciate their garden is a critical program component and can be greatly enhanced through direct feedback from owners. Since education in water quality improvement was the main goal of the Holmes Lake program, finding out if the participant had gained knowledge and shared that knowledge would indicate achievement of that goal.

**Homeowner assessment discussion:** The following questions deal with interview responses for 14 of the 18 rain garden participants (Appendix C). All 18 rain gardens are located on property where responsibility for the rain garden is that of the individual participant. Since they live with the rain gardens on a day-to-day basis, their input is a valuable resource. Other than annual mail-in surveys, the participants have not discussed performance nor had any inspections done on their rain garden. For an overall assessment of questions #1-3, 5 & 6, refer to Table 4.

1) **Describe current functional garden rating.** The garden is draining in \_\_\_\_ hours after rain event; OK or not ‘fast enough’? Infiltration within 48 hours is considered functional for rain garden bioretention. Gardens #2, 11, 15, 16, 17, 18 & 20 are draining in <12 hours, within that time frame gardens #11, 15 & 17 drain within a couple of hours. Gardens #3, 6, 8 & 9 are draining within 24 hours; gardens #4 & 7 take a full 24 hours to drain. Only garden #13 takes longer then the desired 48 hrs, but note that this rain garden site had standing water issues prior to installation (Fig. 14).



(Fig. 14) Functional rating within 14 rain gardens.

2) **Describe current aesthetic rating using a scale from 1 (hate it) to 10 (love it). What should be done differently in hindsight; specific to plant heights, plant selection, edging, mulching, location, etc.?** Introducing rain gardens into residential neighborhoods adds the necessity of a nice aesthetic appearance, as homeowners are often highly concerned about how their yards are perceived within a neighborhood. Aesthetic ratings ranged from 6-10. Anecdotally, for rating 6 – the owner of garden #2 would have liked more color. The owners of gardens #8 & 16 gave them a rating of 7. It is interesting to note that garden #16 was struggling due to incorrect plant selections, yet they were still happy with the concept of a rain garden. For rating 8 – the owner of garden #4 was not happy with the daylily and would have liked more summer blooming, the owner of garden #7 hopes the garden will fill in more and the owner of garden #9 was not happy with the large size of the hibiscus. For rating 10 – the owners of gardens #6,

11, 15, 17, 18 & 20 were very satisfied and would do nothing different, the owner of garden #3 was happy with the variety of flowering and the owner of garden #13 would like a larger selection of native plants.

3) **If problems existed prior to rain garden installation, were they solved?** The City of Lincoln Watershed Management Office was very interested in any participants with current standing water issues since success in this area would demonstrate the infiltration ability of rain garden bioretention to solve water issues. Gardens #2, 3, 4, 6, 7, 8, 9, 15, 16 & 20 had no prior issues. The owner of garden #20 did note that the rain garden helped control runoff to sidewalk areas. Gardens #11, 13, 17 & 18 had water issues prior to installation of a rain garden. Water issues were corrected after installation for all four participants and it is interesting to note that all four gave an aesthetic rating of 10 for their garden.

4) **Check for plant information available through homeowner; examples included replaced plants that aren't obvious or on original plan, known diseases, insect or animal damage witnessed by homeowner, changes in watering patterns, etc.** Any replaced plants are noted on the diagrams in the appendix. Owners of gardens #3, 4, 6, 7, 8, 9, 11, 15, 18 & 20 did not make note of any issues. Owners of gardens #2, 13 & 16 noted rabbit damage. Specifically, obedient plant is an early spring plant and is susceptible to rabbit feeding until other foliage becomes available. The owner of garden #2 noted that the installer rolled sod under the berm and the turf grass was growing through which hampered maintenance.

5) **Has your rain garden experience enhanced your knowledge and awareness of stormwater management and runoff water quality as important issues in Lincoln?** The main goal of the 20 rain gardens installed in the Holmes Lake Pilot Program was to increase homeowner and public awareness of water quality improvement, especially as it relates to use of lawn fertilizers and pet waste clean-up. Eleven of the fourteen participants indicated their knowledge and awareness had been enhanced and several indicated they had little to no prior knowledge of stormwater management before participating in the rain garden program. Owners of gardens #2 and 9 were not aware of the water quality issue at Holmes Lake. Owners of gardens #6 & 18 knew about the Holmes Lake problem, but are now more informed. The owner of garden #11 had done some research and was convinced that a rain garden was the way to go. The owner of garden #4 has attended additional workshops in stormwater management since adding the rain garden. The owner of garden #15 has added rain barrels. The owners of gardens #17 & 20 have incorporated their rain gardens into student lesson plans. Three participants indicated they were well aware of stormwater management practices. The owner of garden #7 works for the City of Lincoln Department Public Works Division. The owner of garden #8 is interested in adding a rain barrel or cistern. The owner of garden #13 works for the City of Lincoln Parks and Recreation Department.

6) **Have you educated others and/or made them aware of stormwater management issues? If so, have any of your contacts led to additional rain gardens being installed?** The city was interested in street view rain gardens to aid in 'selling' the

program. All fourteen rain garden owners had neighbors who ask about their rain gardens. Many had people in their neighborhood stop and talk about the rain garden while out walking. Friends, family members, church members, organization members, and visitors were also educated by the participants. As stated above, owners of gardens #17 & 20 are incorporating the rain gardens into interactive student lesson plans. All participants were very enthusiastic about their efforts to spread the word on the water quality and stormwater management practices a rain garden can offer.

(Table 4) Overall homeowner assessment for questions # 1-3, 5 & 6.

Rain Garden #	1	2	3	4	5	6	7	8	9
1) Current functional rating		<12 hrs.	<24 hrs.	24 hrs.		<24hrs.	24 hrs.	<24hrs.	<24hrs.
2) Current aesthetic rating		6	10	8		10	8	7	8
3) Prior drainage problem/solved?		No	No	No		No	No	No	No
5) Enhanced knowledge?		Yes	Yes	Yes		Yes	No	No	Yes
6) Educated others?		Yes	Yes	Yes		Yes	Yes	Yes	Yes

Rain Garden #	10	11	13	15	16	17	18	19	20
1) Current functional rating		<12 hrs.	>48 hrs.	<12hrs.	<12hrs.	<12 hrs.	<12 hrs.		<12hrs.
2) Current aesthetic rating		10	10	10	7	10	10		10
3) Prior drainage problem/solved?		Yes/Yes	Yes/Yes	No	No	Yes/Yes	Yes/Yes		No
5) Enhanced knowledge?		Yes	No	Yes	Yes	Yes	Yes		Yes
6) Educated others?		Yes	Yes	Yes	Yes	Yes	Yes		Yes

## Summary

The results from the visual inspections and homeowner discussion are summarized below and focus on key points made through the observations and interviews. This includes the following areas; maintenance within the rain garden, site conditions for sprinkler systems and shading, homeowner expectations, rain event problems, issues related to design and installation and stated opinions about the city rain garden program.

Based on the inspections of the rain gardens, weeding, edging and mulching were key maintenance issues within the rain garden basins. Also, turf encroachment appeared to be an important problem due to rain garden locations within turf lawns. Two inflow devices need monitoring and potential correction: (1) crushed roof downspouts and (2) clogged buried downspouts. In rain gardens where plants are aggressively spreading or becoming too tall or wide for their location, plants need dividing or pruning to maintain overall plant and garden competition and health. Obedient plant, an early spring plant, was prone to significant rabbit damage.

Site conditions indicated sprinkler systems and shading negatively impacted several rain gardens. Thirteen of eighteen rain gardens had sprinkler systems and the best bottom plants grew in those without sprinkler systems, relying only on rain event watering. In the newer residential developments, small existing trees near rain gardens that were not an issue at the time of rain garden installation are now beginning to cast shade on previously sunny rain garden locations. In addition, some participants have recently planted trees without regard to their location and potential shading impact on the rain garden.

Overall, designers and installers have done a good job of landscaping to making the rain gardens look ornamental while incorporating native plant material. The majority of the rain gardens had the traditional kidney bean design. Rain garden placement for over half the rain gardens was as close as possible to the stormwater inflow source. One participant was happy that their garden was installed within two hours. Some homeowners had concerns about lack of color within the rain garden. Garden #10 has a developed a different bottom area than was indicated on the original design diagram. One homeowner noted that the installer left sod under the berm and this allowed grass to grow through which created additional maintenance concern. Not all rain gardens had overflow structures installed and reasons are unknown. Two gardens demonstrated possible design errors, garden #16 had underestimated shade for sunny plant selections resulting in underdeveloped growth of the plantings and garden #19 had underestimated stormwater runoff resulting in the establishment of invasive wetland plant vegetation in the rain garden basin area.

On the whole, the participants have unrealistic expectations of native plant vegetation. Several participants were unsure of the required maintenance and did not realize that a rain garden needs to be managed like any other garden. Some participants had trouble

waiting for perennials to establish and added extra ornamental plants in the rain garden. One homeowner called the installer asking how to get rid of the Monarch butterfly caterpillars which demonstrates a lack of knowledge regarding rain garden habitat value.

Plants placed in the bottom of the rain garden basin struggled; 11 rain gardens lacked sufficient bottom vegetation coverage. Bank stabilization and overflow problems, such as bank erosion and mulch flowing out on to the lawn, were more prevalent in the smaller rain gardens.

One homeowner had moved and the rain garden had not been maintained and was no longer functioning for the current homeowner. One participant had three specific concerns with the pilot program, including (1) the city had limited rain garden installation to front yards, (2) there was limited native plant selection available through the designer/installer and (3) the turf encroachment problem that surfaced in their rain garden was not addressed.

## Conclusions

To ensure continued success of the city rain garden program, the following are some findings and recommendations based on information gathered from the visual inspections and homeowner discussion for improvements in rain garden design and practices. The visual inspections for hydraulic and vegetative assessment provided valuable information about rain garden function, plant selection survivability and individual maintenance. The homeowner assessment discussion gave a unique opportunity for face-to-face feedback on how the participant felt about their rain garden. The inspection and interview did serve as a low cost, effective way to help identify problems within the rain gardens and the information gathered created a data base standard for future inspections.

Overall, the participants in the Holmes Lake pilot program were extremely satisfied with their rain gardens and were eager to share their experience and garden with others. For homeowners with pre-existing water issues, all gave their rain garden an aesthetic rating of 10 which indicates that the installation of a rain garden was able to turn a water problem area into one that became aesthetically pleasing.

Individual participant maintenance needs to be considered because weeding, edging and mulching problems may be related to lack of rain garden knowledge or gardening in general. Installation did not include edging around the berm portion of the rain garden basin and needs to be required on future basins to deter turf encroachment, ensure rain garden peak performance and ease of maintenance for the participants. Turf encroachment will become a significant problem unless controlled, because it can spread to the rain garden basin choking out desired plantings. Another strategy to limit turf encroachment includes locating rain gardens within larger existing or future landscape beds to eliminate the proximity of invasive turf growing immediately adjacent to the rain garden. Cleaning out debris and redistributing mulch in the rain garden basin, should be high priority. Further observation needs to be done on obedient plant in late summer or early fall to determine whether rabbit damage was permanent and if early spring fencing is necessary.

Site conditions revealed that sprinkler systems may be adding excess water to the native plant vegetation used in the rain gardens. With such increased moisture, different plant selections will need to be considered, such as incorporating rushes, sedges or other plants with higher moisture tolerance. In some cases, individual changes in watering habits may be all that is needed to correct the problem of over watering native plant vegetation. Simple things such as changing sprinkler patterns or disconnecting sprinkler heads within the basin area could enhance rain garden plant success for gardens that overlap irrigated landscape areas. Using a system less frequently and applying less water per cycle, might also enhance rain garden success, but the water adjustments will need to be balanced with the surrounding landscape areas. Further research needs to be done to see if use of sprinkler systems affects plant survivability, especially in the rain garden bottoms. Another site consideration, tree placement with respect to rain garden location, needs to be considered as this will change the sun/shade dynamic of garden plants and conditions,



such as shade effecting the growth and performance of rain water garden plants. Designers and homeowners need to be cautioned about planting trees in proximity to an existing rain garden as current plant performance could be affected. If trees currently shade the garden location then shade-tolerant plants should be selected; if shade is expected in the future, then plants should be selected that tolerate a range of conditions and adapt to changes over time.

The installer placed over half of the rain gardens as close as possible to the stormwater inflow source. Gardens where the stormwater runoff flowed over significant lawn area before entering the basin, however, had better plant growth. For example garden #10 was located furthest away from the inflow source and yet was one of the best looking gardens. Suggestions for this occurrence could be related to lower velocity and less water from runoff inflow entering the rain garden basin.

Filling the rain garden prior to planting would help verify the bottom of the basin and aid in proper plant selection for specific basin areas. Based on feedback from the homeowners, designing the rain gardens to look ornamental did seem to help 'sell' rain gardens for residential settings, however the gardens looked a bit similar with many of the same plants and design shapes repeated. From an investigation stand point, this made it is easy to conduct visual comparisons, but the designer should try to avoid repeating the same plants and layouts to establish visual variance among the rain gardens. Greater plant variety would also help identify which plants have more success for rain garden use, establish more habitat value and diversity, and potentially generate a more unified aesthetic fit with adjacent landscape plants. Rain gardens are often populated with natives or native cultivars because those are most well adapted to a locality (EPA 2008). Efforts should be strengthened to educate homeowners on the benefits of using native and non-invasive well-adapted plant material and selecting plants that will brighten the garden with flower and foliage color. If homeowners appreciate and ask for more native and adapted plants, then they typically become more available in the trade.

In addition, while the homeowner whose garden was installed within two hours was happy with that time frame, quick installation of the rain gardens could lead to problems. For example, was the soil properly amended within that time frame? The installer needs to be contacted to determine what percentages of sand, topsoil and compost were used. Current research is being conducted on leaf based compost leaking phosphorus; therefore this type of compost may need to be avoided (Morgan et al. 2010). During installation, sod needs to be completely removed or killed, especially if a berm is to be added as the grass will grow through the soil and become a maintenance issue for the homeowner. Overflow structures need to be a part of careful rain garden design. While some years lack significant precipitation, garden overflow can occur in any year so a reinforced location for water to leave the garden is always required. The year 2010 had above average rainfall, so the concern with overflow problems in the rain gardens was more apparent. For the two gardens that demonstrated possible design errors, the designer/installer and homeowner need to work together to make the changes necessary for proper rain garden function. This might include new plant selections or replacement of plants that did not survive.

It is apparent that homeowner education relative to rain garden maintenance and the benefits of native/adapted plant use is vital for long-term success. Participants need to understand that the plants used in the garden serve an aesthetic purpose, but more importantly they are essential in the infiltration process (Laberee 2004). Education should help homeowners adapt their notion of the perfect garden from pristine and picture-perfect to a functioning ecosystem where patience for plant development is required. Similarly, native plants supply food and chewed leaves from insects should be expected. They need to understand rain garden maintenance is no different than any other garden maintenance and is a continuous process where proper maintenance is vital for functionality and longevity. Extra ornamental plants were added to the rain garden basin by impatient homeowners waiting for plants to establish. This has caused overcrowding of plant material which can hinder the development of the plants selected to aid with infiltration and decrease air circulation necessary for good plant health.

Midwest precipitation can come from large volume rain events and several gardens, based on significant and numerous overflow events, could have been sized larger to better distribute the amount of water and aid to decrease runoff overflow. Most rules-of-thumb for garden design require sizing to hold 90% of all rainfall events. For future reference, some calculations could be applied to existing gardens to determine whether their storage volume is appropriate for their location, water inflow, and soil infiltration rate.

Bank stabilization was more of an issue in small gardens where the high velocity of runoff was too intense for the close proximity of the inflow source; this was an issue in over half of the rain gardens. The larger garden basins did not show bank stabilization problems, which may have occurred because the runoff can be distributed shallower across the basin allowing for quicker infiltration. Bottom plants in small gardens might have water standing for longer periods due to increased depth of runoff. Further research needs to be done to determine if bank erosion correlates to the size of a rain garden basin and its ability to handle the volume of stormwater runoff that can occur during a Midwest rain event. In addition, plants on the bottom part of the rain garden basin were struggling or missing which might be attributed to higher precipitation for 2010. Eleven rain gardens lacked sufficient coverage where bottom vegetation is vital; however, none of the rain gardens inspected had standing water and all reported hydraulic functional ratings were within the desired 48 hours. Reasons for loss of plant material needs to be examined further, especially in the bottom part of the rain garden basin, as this is vital to the success of rain garden infiltration function. Areas to consider include prolonged exposure to standing water, excess use of sprinkler systems, soil properties, individual maintenance and most importantly, plant placement within the garden.

Driving past one of the rain garden locations, confirmed that the original homeowner had moved and the new owner had removed the garden. Currently, the City of Lincoln does not have regulations in place for transfer of rain garden ownership. Since the city has financial investment in the rain gardens, homeowner turnover needs to be addressed.

One homeowner had three disagreements with the City Watershed Management Office rain garden program. First, they believed the city should not limit garden installation to

front yards. The rain garden pilot program was offered as part of a way to increase awareness about the small changes in lawn care and landscaping practices that can make positive impacts on water quality (City of Lincoln Watershed Management, 2010). Since the pilot was limited to 20 rain gardens, front yard placement would make the gardens more publicly visible. Contrary to the complaint, five gardens were located in backyards including the rain garden installed for the homeowner voicing the disagreement. Second, there was concern about the limited native plant list offered by the rain garden installer. This shows the homeowner has an understanding on the benefits of using native and adapted plant vegetation in a rain garden and wanted to further expand garden plant variety. Future rain garden and education programs should strive to maximize native and adapted plant availability since the benefits of using native and adapted plants have been documented and broader plant diversity enhances garden habitat and aesthetic benefits. Providing homeowners with rain garden reading material specifically designed for their growing area, such as *Sustainable Landscapes: Rain Gardens, Bioswales and Xeric Gardens* (Rodie *et al.* 2010) can aid in education. Third, there was concern that turf encroachment was not being addressed. This was a serious issue for most of the participants and as introduction of rain garden construction into traditional turf lawns is a widely-accepted concept, turf encroachment may not receive enough recognition as a potential maintenance problem. Natural or structural edging of the rain garden basin area needs to be implemented as part of the design to help ease maintenance for the homeowner. Additionally, locating a rain garden within larger landscape beds eliminates the potential for turf to encroach into the garden.

Since it would be desirable for the rain gardens to be maintained beyond the city's five-year contract period, testing for hydraulic function and/or soil compaction at contract completion would help assure participants that their rain gardens will be working for years to come. To aid in determination of hydraulic function longevity, the ratios of sand, topsoil and compost added to the rain gardens at installation should be assessed and revisited. At that time should corrections to enhance infiltration be necessary, it is in the best interest for all parties that the city considers providing that service. Also, for any plantings that did not survive from the original rain garden design, the city may want to consider replacement or substitute plants to ensure peak rain garden performance and participant satisfaction.

Based on this investigation, key points for keeping a rain garden aesthetically pleasing and functioning properly for many years are summarized as follows:

- ❖ **Weed, Edge and Mulch** – Keep the basin free of weeds. Edging will help deter turf encroachment, as will incorporating the garden into an existing or more extensive landscape bed. Add or redistribute mulch to a desired depth of 2-3 inches; do not overmulch.
- ❖ **Clean the basin** - Remove debris and redistribute mulch in the rain garden basin to ensure proper infiltration.
- ❖ **Check inflow and overflow structures** – Structures need to be clean of debris, mulch and turf. Watch for crushed, clogged or misaligned downspouts, and ensure that water enters and leaves the garden where intended.

- ❖ **Control plant size** – Over-crowding of plants can hinder the development of surrounding plants and decrease air circulation necessary for good plant health. Divide and prune as necessary.
- ❖ **Bottom plant coverage** – Maintain adequate plant coverage in the basin bottom for effective infiltration and to enhance rain garden visual character. Replace plants if necessary.
- ❖ **Sprinkler systems** – Incorporation of native plant vegetation means less watering is necessary to maintain plant health. Considering alternative watering habits such as changing sprinkler patterns, disconnecting sprinkler heads within the basin area, using a system less frequently and applying less water per cycle while not compromising other landscape plants that depend on existing irrigation applications.
- ❖ **Shading** – Tree growth may effect the growth and performance of existing plants. Changes to more shade tolerant plants may become necessary. Consult the city or installer prior to addition of new trees within the rain garden proximity. If transitions from sun to shade conditions are expected over the life of the garden, plants that are tolerant of variable light conditions should be selected.
- ❖ **Consider a larger rain garden** – The basin needs to be large enough to accommodate the runoff from all impervious surfaces directed to the garden at a depth that is matched to the infiltration rate of the soil. A larger basin will decrease overflow and better distribute stormwater runoff for quicker infiltration and will allow for higher diversity of potential plant choices.
- ❖ **Native and adapted plant benefits** – Native plants do not require fertilizers, require fewer pesticides, use less water, reduce air pollution, provide food and shelter for wildlife, and promote biodiversity.
- ❖ **Education** – Rain gardens require maintenance similar to any other garden. They potentially require increased patience in plant establishment and a broader acceptance of naturalistic character and use of plants for a food source and habitat. Workshops can demonstrate how successful rain gardens are highly aesthetic while providing a wide variety of important landscape functions. Garden tours with owners of successful rain gardens can be a valuable educational resource for potential owners and provide insights that will maximize success for future gardens.

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US Environmental Protection Agency. 2008. Green Landscaping: Greenacres. Internet Resource: <http://www.epa.gov/greenacres/nativeplants/factsht.html>

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## Appendix A: City of Lincoln Watershed Management Office letter

April 16, 2010

Dear NET Rain Garden Project Participant:

University of Nebraska-Lincoln Extension has received a USDA grant to study the hydrologic effectiveness and plant survivability/suitability in residential rain gardens – specifically, the gardens installed in Lincoln over the past 1-2 years, which includes the rain garden on your property. This grant also includes statewide outreach and developing curriculum for low impact design – which this study will aid. The faculty members heading up this project are Dr. Steve Rodie and Dr. Tom Franti. Incidentally, Steve and Tom are the authors of the Rain Gardens NebGuides used to design your rain garden.

Faculty and researchers have requested design plans, pictures, soil data, and contact information for each rain garden property owner. Since your rain garden was installed with 80% of public funds, I will provide UNL faculty with this data. They will **NOT** share your personal contact information.

The research will begin with a pilot project in 2010, with only a few rain gardens needing evaluation. In 2011, researchers hope to evaluate more rain gardens throughout Lincoln. If you are contracted by one of these researchers, please be aware that you have the **OPTION** of participation, it is not required. However, it would be very helpful towards the research. Nebraska currently has no data to support local rain garden effectiveness, though research has been done in other states, with different soil and growing conditions.

If you have any questions about this research program or any concerns about your garden, or any other questions, please contact

Again, thank you for your help in improving the environment and water quality in our community.

Sincerely,

Water Quality Educator



## **Appendix B:** Primary investigator letter

July 14, 2010

Name  
Street  
City, State, Zip

Greetings Rain Garden Participant,

You should have been informed by the City of Lincoln Watershed Management Office to the possibility of volunteering to participate in a research grant obtained by the University of Nebraska – Lincoln. The research will study the hydraulic effectiveness and plant survivability/suitability in rain gardens designed for Eastern Nebraska. At this time, I am ready to conduct visual inspections and ask a few interview questions on your rain garden experience thus far.

I will be contacting you next week by phone to see if you are willing to participate. The visual inspection only needs your permission to access your property. The interview portion will need about 30 min. to 1 hr. of your time and requires you to sign an informed consent form explaining your participation. It would be wonderful if you would be willing to participate with both parts of the research and I am able to meet with you at your convenience.

While I will be able to gather a lot of information from just looking at your gardens, having your valuable insight would be most helpful. It is my hope that you will volunteer to participate in the research opportunity. If the phone number provided on your application has changed, please contact me via phone or email. I look forward to seeing your rain garden and visiting with you about the experience.

Best regards,

Marilyn Liebsch  
Graduate Horticulture Student  
University of Nebraska – Lincoln

## Appendix C: Visual inspection and homeowner discussion questions

Hydraulic assessment: Note any obvious hydraulic problems.

- 3) Has it rained within the last 48 hrs?
- 4) Are any inlet structures clogged? Look for debris, sediment, vegetation, or other obstruction. Look at downspouts.
- 5) Are any inlet structures misaligned? Look for erosion, channelization, or flooding in surrounding areas.
- 6) Is there any standing water? Look for green or murky color.
- 7) Bottom assessment – does it contain sediment deposits, erosion or channelization, excessive vegetation, or litter/debris.
- 8) Bank assessment – does it contain erosion or channelization, soil slides or bulges, animal burrows, seeps or wet spots, poorly vegetated areas, or trees present.
- 9) Is the overflow structure clogged? Look for debris, sediment, vegetation, or other obstruction.
- 10) Is the overflow structure misaligned? Look for erosion, channelization, or flooding in surrounding areas.

Vegetation assessment: Note time of growing season, species present and growth requirements, site conditions, and if in-ground sprinklers present. Also, note wind exposure, air circulation within plantings, sun/shade patterns, aesthetic character.

- 1) Approximate % of vegetation coverage. Be sure to note bottom vegetation abundance.
- 2) Compare current vegetation to original design. Look for species not surviving or that have disappeared, introduction of weeds, or invasive vegetation.
- 3) Does vegetation appear healthy? Look for wilted leaves/stems, discoloration of leaves, lack of flowering buds developing, stunted growth, or decrease in plants numbers.
- 4) Is vegetation appropriate density/size?
- 5) Where is vegetation located relative to top/sides/bottom of garden? So comparisons can be made to health and growth characteristics.

Homeowner assessment discussion:

- 7) Describe current functional garden rating. The garden is draining in \_\_\_\_ hours after rain event; OK or not 'fast enough'?
- 8) Describe current aesthetic rating. On a scale of 1-10; 1 being hate it, 10 being love it. What would be done differently in hindsight; specific to plant heights, plant selection, edging, mulching, location, etc.?
- 9) If existed prior to rain garden installation, what drainage problems were solved?
- 10) Check for plant information available through homeowner. Such as replaced plants that aren't obvious or on original plan; known diseases, bug or animal damage witnessed by homeowner, changes in watering patterns, etc.
- 11) Has your rain garden experience enhanced your knowledge and awareness of stormwater management and runoff water quality as important issues in Lincoln?
- 12) Have you educated others and/or made them aware of stormwater management issues? If so, have any of your contacts led to additional rain gardens being installed?

## Appendix D: Participant rain garden tip sheet



Overall the gardens are looking very nice, make wonderful street presentations, and more than that are working to help reduce stormwater runoff. To keep your gardens looking and working great for years to come, I am providing some of my research observations.

Three things are key to rain garden success:  
**WEEDING, EDGING, MULCHING**

Use the half-moon edger to keep encroaching turf grass out of the rain garden. Adding wood mulch not only helps keep weeds down, but the lignin in wood helps filter out pollutants.

Keep inflow and outflow areas clean of debris, mulch, and turf. Watch out for crushed downspouts! Occasionally check to see if downspouts are aligned to flow into the rain garden.

In spite of all the rain this year, the plants are looking disease and pest-free. Two reasons for this; one, the plants are just now getting to full size and two, there is good air circulation among the plantings.

To keep plants healthy, controlling size of individual plant and maintaining space between plants is vital. Coverage should be in the 80 – 90% range. Pruning and dividing will start to become necessary. For those plants developing open centers, use the long bladed spade to remove the dead centers and add fresh soil to encourage the plant to re-grow towards the middle.



Many trees were new or smaller when your rain garden was planted three years ago. If your garden was designed for full sun, you may have to switch to more shade tolerant plants in the future.

Bottom plants seemed to suffer the most. It is hard to say whether this was due to high precipitation or if the plant did not survive with the garden conditions. However, keeping plants in the bottom of the rain garden is important for infiltration of stormwater.

Some bottom plant suggestions: (many come in additional cultivars for variety in flower and foliage color)

**FULL SUN/PART SHADE**

*Chelone glabra* – turtlehead

*Liatris spicata* – dense blazing star

*Monarda didyma* – bee balm

*Pycnanthemum virginianum* – Virginia mountainmint

*Calamagrostis acutiflora* – feather reedgrass.

SHADE

Geranium 'Rozanne'

Anemone [hupehensis](#) 'September Charm'

Itea virginica - Little Henry Sweetspire

Calamagrostis x 'Avalanche' - Feather Reed Grass

Hostas, Ferns, Astilbes, and heucheras all do well.

Your rain garden photos will be updated on the City of Lincoln Watershed Management website at:

[www.lincoln.ne.gov/city/pworks/watrshed/educate/garden/registry/holmes/index.htm](http://www.lincoln.ne.gov/city/pworks/watrshed/educate/garden/registry/holmes/index.htm)

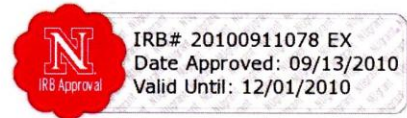
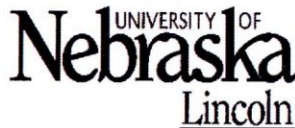
It was a pleasure working in your rain gardens. It is the hope that information gathered will help to improve and maintain rain gardens for now and years to come.

Thanks for sharing your personal time and rain gardens with me!

Marilyn Liebsch

UNL Horticulture Graduate Student

## Appendix E: Participant informed consent form



INSTITUTE OF AGRICULTURE AND NATURAL RESOURCES  
DEPARTMENT OF AGRONOMY AND HORTICULTURE

### PARTICIPANT INFORMED CONSENT

#### Assessment of Holmes Lake Rain Garden Participant Experience

You are invited to participate in this research study. The following information will assist you in making an informed decision on whether to participate or not. If you have questions at any time, do not hesitate to ask.

The purpose of this study is to study the hydraulic effectiveness and plant survivability and suitability for Eastern Nebraska Rain Gardens. Participants in the City of Lincoln Holmes Lake Rain Garden pilot program are the focus of this research project.

The interview will take approximately 30 min. – 1 hr. Questions will consist of describing your rain garden function, aesthetics, prior drainage problems, and plant changes or observations.

There are no known risks or discomforts associated with this research.

No information obtained in the research that might identify you will be released. Results may be published in scientific journals or presented in meetings, but individual identities will not be disclosed.

Participation in this research survey is totally voluntary and you are free to withdraw at any point without affecting your relationship with the investigator, the City of Lincoln, or the University of Nebraska-Lincoln. You are free to ask questions about the research procedures at any time. If you choose to participate, you may decline to answer any question you are not comfortable answering.

If you have any questions about your rights as a research subject or you wish to report any concerns, please contact the University of Nebraska – Lincoln, Institutional Research Board at (402) 472-6965. If you have any questions about the research, you may contact

By signing below, you are freely providing consent to participate in this research and that you have read and understood the information presented. You will be given a copy of this consent form to keep.



IRB# 20100911078 EX  
Date Approved: 09/13/2010  
Valid Until: 12/01/2010

\_\_\_\_\_  
Signature of Participant

\_\_\_\_\_  
Date

\_\_\_\_\_  
Signature of Principle Investigator

\_\_\_\_\_  
Date

\_\_\_\_\_  
Signature of Secondary Investigator

\_\_\_\_\_  
Date

**Appendix F:** Rain garden GPS readings and decimal conversions for GIS application

RG = rain garden 1-20 = rain garden number dec =decimals

RG	latitude	longitude	lat in dec	long in dec
1	N 40° 45.813'	W 096° 37.783'	40.76355	-96.6297
2	N 40° 45.743'	W 096° 37.061'	40.76238	-96.6177
3	N 40° 46.588'	W 096° 36.611'	40.77647	-96.6102
4	N 40° 50.147'	W 096° 43.738'	40.83578	-96.729
5	N 40° 46.401'	W 096° 38.474'	40.77335	-96.6412
6	N 40° 46.553'	W 096° 36.905'	40.77588	-96.6151
7	N 40° 50.848'	W 096° 43.811'	40.84747	-96.7302
8	N 40° 46.325'	W 096° 36.572'	40.77208	-96.6095
9	N 40° 45.654'	W 096° 37.264'	40.7659	-96.6211
10	N 40° 44.714'	W 096° 35.561'	40.74523	-96.5927
11	N 40° 46.019'	W 096° 36.096'	40.76698	-96.6161
13	N 40° 45.177'	W 096° 35.911'	40.75295	-96.5985
15	N 40° 47.285'	W 096° 36.969'	40.78808	-96.6162
16	N 40° 47.279'	W 096° 36.966'	40.78798	-96.6161
17	N 40° 45.234'	W 096° 36.428'	40.7539	-96.6071
18	N 40° 47.265'	W 096° 37.076'	40.78775	-96.6179
19	N 40° 46.967'	W 096° 37.664'	40.78278	-96.6277
20	N 40° 45.608'	W 096° 37.079'	40.76013	-96.618

## **Appendix G:** Complete rain garden reports

Complete reports for rain gardens #1-11, 13 & 15-20 with original diagrams, notations to diagrams, 2010 sketch of rain garden, photos, GPS coordinates and responses to the visual inspection questions for each rain garden is included in this appendix section.

### **Noted on the original diagram:**

The actual number of plants from 2007 installation, present at time of inspection.

(X means the entire planting is missing)

Inflow direction.

Overflow direction.

Additional trees.

### **Noted on 2010 sketch of diagram:**

Current plantings, including added plants since 2007 installation.

Location of planting within the rain garden basin:

**T** top

**T-S** top-side

**S-B** side-bottom

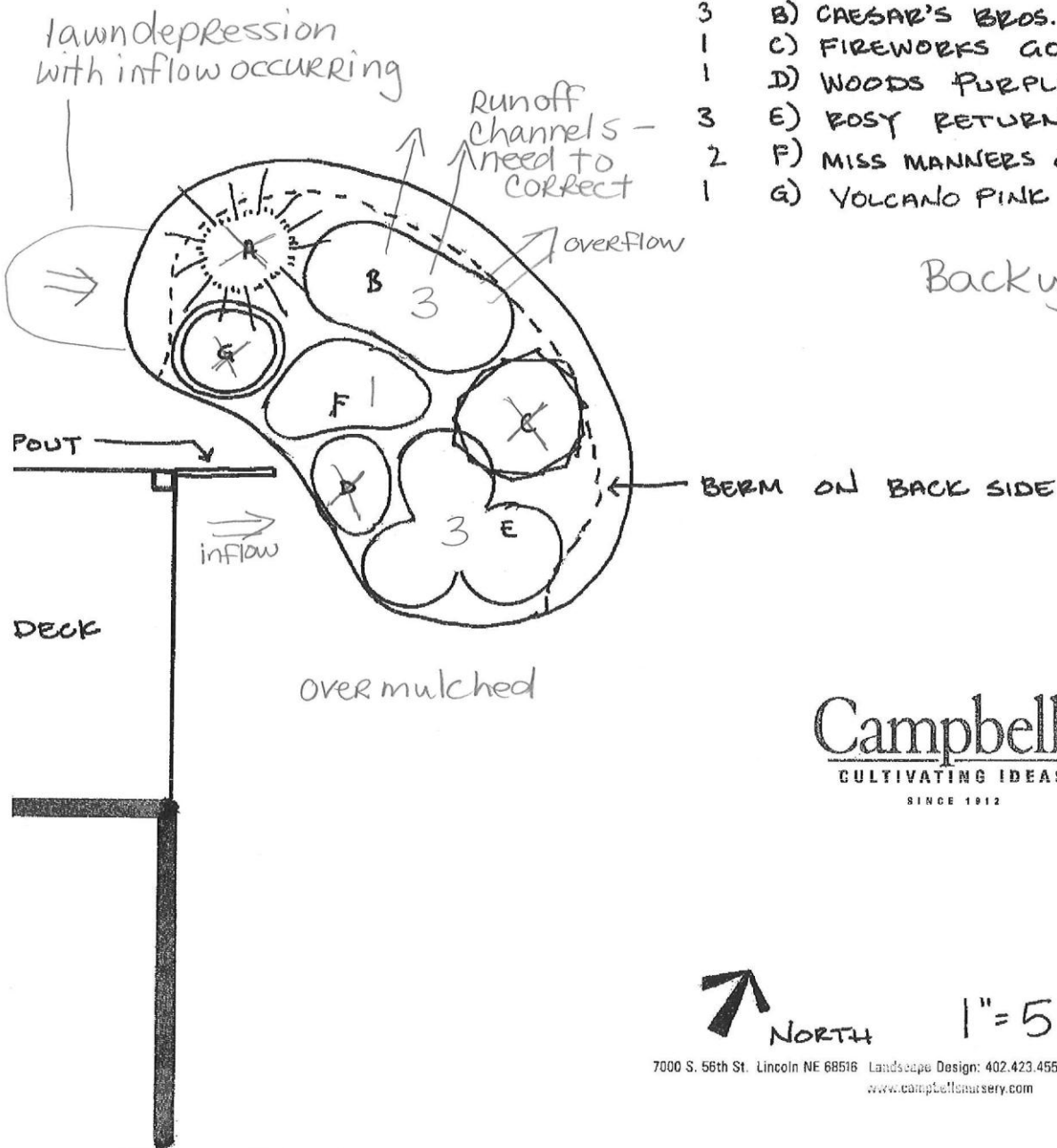
**B** bottom



Rain Garden #1  
 N 40° 45.813' W 096° 37.783'

PLANT KEY

QTY.	
1	A) MORNING LIGHT MISCANTHUS-gone
3	B) CAESAR'S BROS. IRIS
1	C) FIREWORKS GOLDENROD-gone
1	D) WOODS PURPLE ASTER-gone
3	E) ROSEY RETURNS DAYLILY
2	F) MISS MANNERS OBEDIENT PLANT
1	G) VOLCANO PINK PHLOX-gone <sup>partial</sup>



Backyard

**Campbell's**  
 CULTIVATING IDEAS  
 SINCE 1912

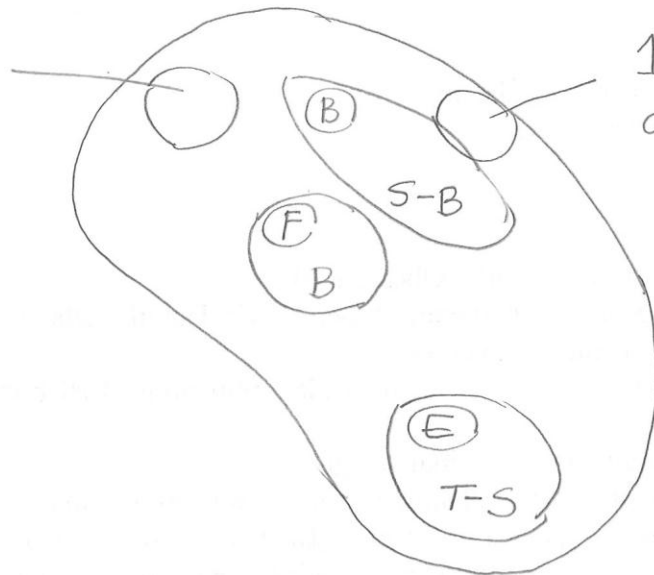


1" = 5'

7000 S. 56th St. Lincoln NE 68516 Landscape Design: 402.423.4566 Garden Center: 402.423.1133  
 www.campbellnursery.com



Added 1  
Echinacea



1 beem plant  
added  
thyme

## Rain Garden #1

7/26/10

### First impression:

Nice location, side-backyard with nice view from neighborhood lake, strong sloping yard, very sparse plantings, good mulch, no weeds.

### Hydraulic assessment:

- 1) Has it rained within the last 48 hrs?  
No
- 2) Are any inlet structures clogged?  
No, but needs to keep downspout clear of turf grass.
- 3) Are any inlet structures misaligned?  
Not from downspout, but lawn runoff occurring is not directed into rain garden, front edge nicely edged!
- 4) Is there any standing water?  
No, but bottom area has moisture, soil and lawn wet, but not soggy, may have run sprinkler system.
- 5) Bottom assessment  
Vegetation is missing.
- 6) Bank assessment  
Good shape, clean of turf, shows overflow channelization in two spots.
- 7) Is the overflow structure clogged?  
Yes, with sediment and plant litter.
- 8) Is the overflow structure misaligned?  
Original overflow is fine, but needs additional added. Overflow issue could be due to lack of bottom plant material, thus no aid in infiltration.

### Vegetation assessment:

Mid-summer

Full sun with no shade during the day

North-east side of the building

Full wind exposure

Air circulation good

Sprinkler system – Yes

Plants currently in bloom: Daylily, Obedient Plant

Plants that were especially nice overall: Siberian Iris, Daylily, Obedient Plant

- 1) Approximate % of vegetation coverage.  
50%, bottom vegetation gone, one Obedient Plant remaining, 10% bottom coverage.
- 2) Compare current vegetation to original design.  
Does not look like anything was planted in area C, not sure if homeowner did not want suggested Goldenrod, but it or Swamp Milkweed would have been a good choice. Miscanthus, Aster, and Phlox are missing. Only one Obedient Plant surviving. Only one creeping Thyme for berm is barely surviving. Invasive reed grass developing in the bottom area. Homeowner added transplanted Echinacea, but barely hanging on, it could be moved to area C and do well.

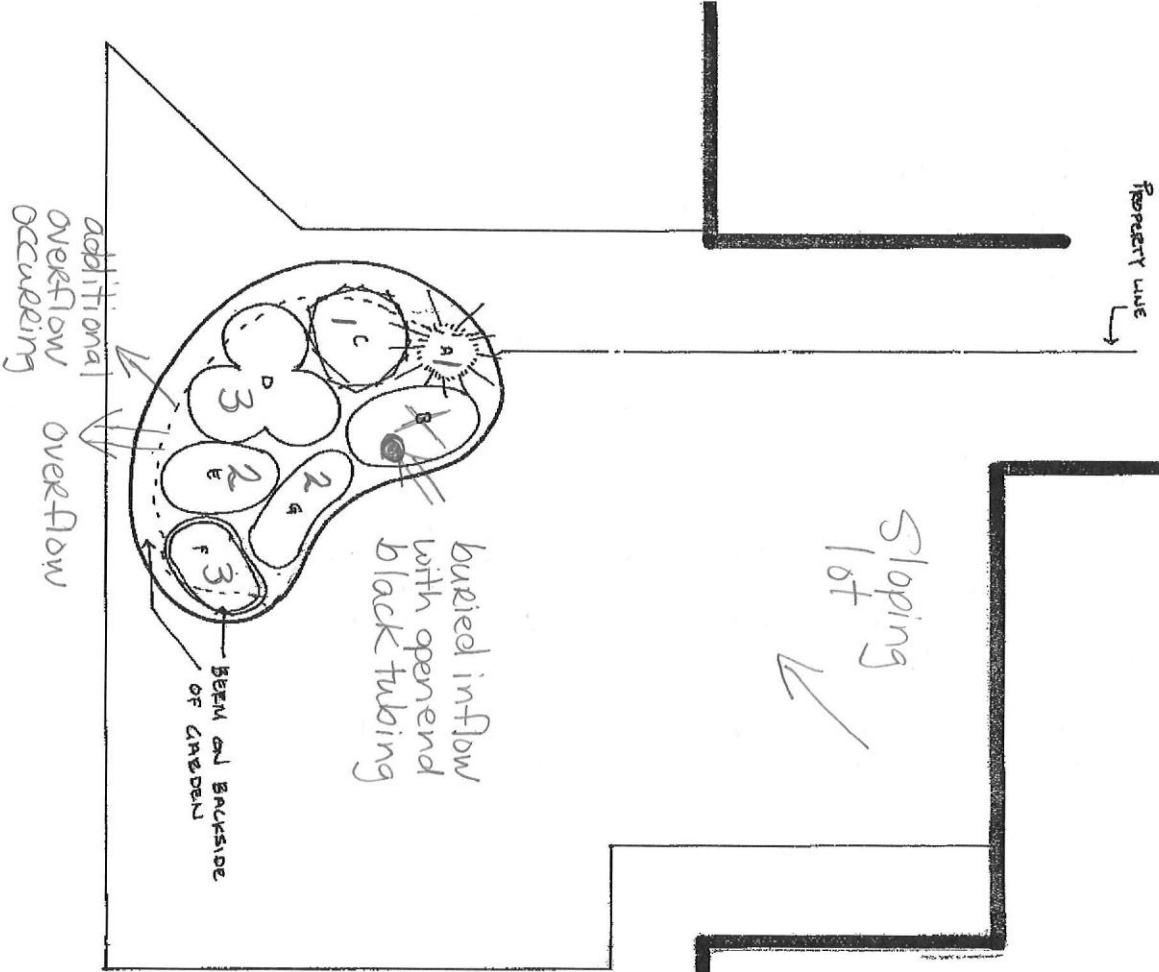
- 3) Does vegetation appear healthy?  
This garden only has 7 plant surviving (8 with berm plant added). Those that survived look healthy and size appropriate. Nice 'Rosy Returns' Daylily.
- 4) Is vegetation appropriate density/size?  
Yes, very appropriate for year 3.
- 5) Where is vegetation located relative to top/sides/bottom of garden?  
Noted on diagram

Homeowner assessment discussion:

Did not participate

Side notes: Only homeowner who edged the inflow side of the rain garden with a spade. This garden does not have enough plants to assist with infiltration. Homeowner has expansive Echinacea and Rudbeckia in other garden areas that could be added at no extra plant cost.

Individual suggestions added to handout: Keep downspout clear, need more plant material to aid with infiltration, could transplant some Rudbeckia and/or Echinacea from other garden beds.



Rain Garden #2  
 N 40° 45.743' W 096° 37.061'

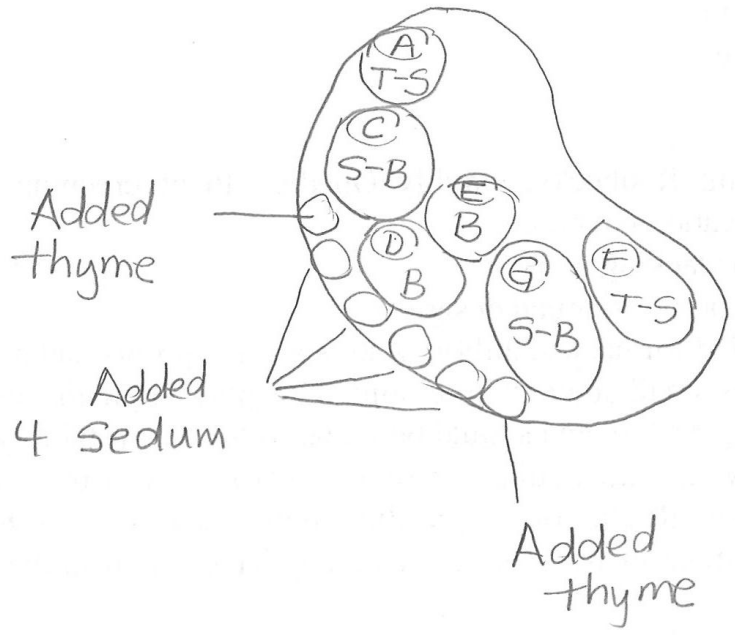


7000 S. 56th St. Lincoln, NE 68506 Landscaping Design: 402.423.4558 Garden Design: 402.423.1193  
 www.campbellscorp.com

Plant Key

- |      |                                   |
|------|-----------------------------------|
| QTY. |                                   |
| 1    | A) RED SPREAD JAPANESE BLOODCRASS |
| 3    | B) WOODS PURPLE ASTER - gone      |
| 1    | C) FIREWORKS GONDELLPOD           |
| 3    | D) CRESPER'S BRDS. SIBERIAN IRIS  |
| 2    | E) MISS MANUELS OBEIDYLT PLANT    |
| 2    | F) GOLDSTURM RUBACICIA            |
| 3    | G) ROSY RETURVEDS DAYLILY         |

\* NOTE: QUANTITIES ARE APPROXIMATE NUMBER OF PLANTS TO FILL THE GARDEN, YET ALLOW ROOM FOR PLANTS TO GROW.



6  
berm plants  
added

## Rain Garden #2

7/26/10

### First impression:

Excellent street presentation on main drive of newly developed neighborhood, kept up very nicely, fits in with other landscaping, no weeds, mulched, edged.

### Hydraulic assessment:

- 1) Has it rained within the last 48 hrs?  
No
- 2) Are any inlet structures clogged?  
No, but has buried downspout and angle of entry shows channelizing/erosion occurring.
- 3) Are any inlet structures misaligned?  
No, drain feeds into rain garden.
- 4) Is there any standing water?  
No, looks good and dry.
- 5) Bottom assessment  
Good
- 6) Bank assessment  
Very nice, added berm plants doing a good job.
- 7) Is the overflow structure clogged?  
Yes, needs to have mulch removed.
- 8) Is the overflow structure misaligned?  
Possibly, good original placement, but with excess rainfall, water is flowing adjacent to east side of overflow. It might need to be widened.

### Vegetation assessment:

Mid-summer

Full sun with no shade during the day

North side of the building

Adequate wind exposure

Air circulation good

Sprinkler system – Yes

Plants currently in bloom: Rudbeckia, Daylily, Obedient Plant, creeping Sedum.

- 1) Approximate % of vegetation coverage.  
70%, bottom coverage is lacking at 50%.
- 2) Compare current vegetation to original design.  
Sedums and Thyme added for bank stability. Asters are 1" sprouts and need to be replaced. Siberian Iris is small and did not bloom. Creeping Thyme is much smaller than the creeping Sedum and should be replaced for berm stability and continuity. Discrepancy on original diagram if Obedient Plant was used, but it does appear in the garden. Rudbeckia is spreading, but stunted. Homeowner transplanted some into other areas of the yard and may have damaged the root stock.
- 3) Does vegetation appear healthy?  
Rudbeckia shows leaf mottling.

- Siberian Iris is sparse and did not flower.  
Asters need to be removed.
- 4) Is vegetation appropriate density/size?  
Siberian Iris too short and sparse.  
Rudbeckia too short.  
Overall appearance, the plants seemed shorter, but in proportion. Density is good.
  - 5) Where is vegetation located relative to top/sides/bottom of garden?  
Noted on diagram.

Homeowner assessment discussion:

- 1) Describe current functional garden rating.  
Less than 12 hrs. Would fill up, but only spilled over one time.
- 2) Describe current aesthetic rating.  
6. Would like more color.
- 3) If existed prior to rain garden installation, what drainage problems were solved?  
No prior issues.
- 4) Check for plant information available through homeowner.  
Rabbits. Installer rolled sod under berm and grass grew through.
- 5) Has your rain garden experience enhanced your knowledge and awareness of stormwater management and runoff water quality as important issues in Lincoln?  
Yes. Participant is new to Lincoln and did not know about the Holmes Lake watershed issue.
- 6) Have you educated others and/or made them aware of stormwater management issues? If so, have any of your contacts led to additional rain gardens being installed?  
Yes. People stop and ask about garden. Three new gardens have been installed due to participant.

Side notes: Need to fill in or change inflow/bottom plants, as this is a busy street and a good setting to display a rain garden. This garden is placed well to accommodate roof and sloping lawn runoff.

Participant noted that sump pumps in neighborhood are directed into the street. Suggested they be directed into a rain garden.

Individual suggestions added to handout: Place rock under buried inflow drain pipe to help control erosion, replace asters. We discussed substitutes.



Added Tree

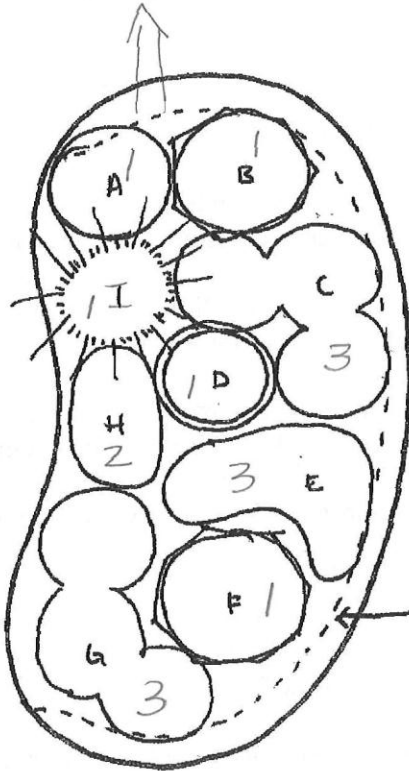


PLANT LIST

QTY.	PLANT NAME
1	A) GOLDSTURN R.
1	B) AQUARIAN LII
3	C) CAESAR'S BROS
1	D) MARSHALL DE
3	E) MISS MANNERS
1	F) FIREWORKS G
3	G) ROSE RETURNS
2	H) WOODS PURPL
1	I) RED BARON .

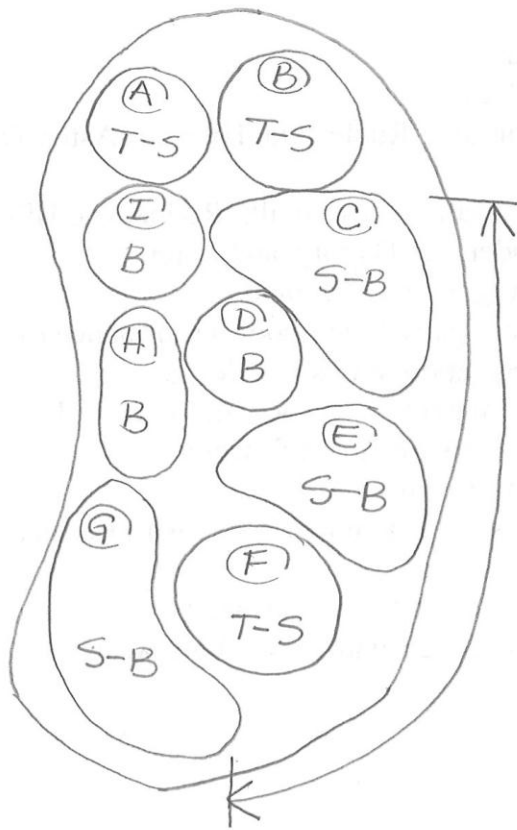
↓ NORTH 1" = 5'

overflow



All plantings survived

Rain Garden #3  
N 40° 46.588' W 096° 36.611'



Berm plants  
added -  
sedge

### Rain Garden #3

7/23/10

#### First impression:

Good presentation, excellent street view, has been weeded, nicely mulched, owner has a waterfall that will overflow into the garden during rain events.

#### Hydraulic assessment:

- 1) Has it rained within the last 48 hrs?  
No
- 2) Are any inlet structures clogged?  
No, but plant litter needs to be removed.
- 3) Are any inlet structures misaligned?  
No
- 4) Is there any standing water?  
No
- 5) Bottom assessment  
Good mulch, litter and weeds have been removed.
- 6) Bank assessment  
Plants have been added for bank stabilization, sparse weeds present.
- 7) Is the overflow structure clogged?  
Yes, needs to clear weeds and mulch; overflow should be widened.
- 8) Is the overflow structure misaligned?  
No, does not look like much overflow has occurred.

#### Vegetation assessment:

Mid-summer

Full sun for now, but maple tree planted south of the garden will become a problem within a few years.

West side of the building

Full wind exposure

Air circulation good

Sprinkler system – Yes

Plants currently in bloom: Rudbeckia, Hibiscus Aster, Obedient Plant, and creeping Sedum.

Plants that were especially nice overall: Rudbeckia, Hibiscus, Bee Balm, Obedient Plant, Goldenrod, Daylily, and Aster.

- 1) Approximate % of vegetation coverage.  
70%, bottom 50%, has gaps due to poor performance of Siberian Iris.
- 2) Compare current vegetation to original design.  
Same design, but berm plants were added. Siberian Iris is very sparse, but is surviving, looks like only one plant flowered.
- 3) Does vegetation appear healthy?  
Overall appearance is healthy, noted plants with issues below.  
Monarda leaves yellowing.  
Hibiscus is falling over and has been staked.  
Some volunteer ferns are growing in the bottom area.

- 4) Is vegetation appropriate density/size?  
Monarda was too tall and leggy.  
Red Baron Grass is too sparse and short.  
Obedient Plant was short, but flowering nicely.  
Solidago needs to be trimmed, so as to not overshadow the Obedient Plant.
- 5) Where is vegetation located relative to top/sides/bottom of garden?  
Noted on diagram.

Homeowner assessment discussion:

- 1) Describe current functional garden rating.  
Within 24 hours.
- 2) Describe current aesthetic rating.  
10. Good flowering variety.
- 3) If existed prior to rain garden installation, what drainage problems were solved?  
No prior issues.
- 4) Check for plant information available through homeowner.  
No problems noted.
- 5) Has your rain garden experience enhanced your knowledge and awareness of stormwater management and runoff water quality as important issues in Lincoln?  
Yes. Greatly.
- 6) Have you educated others and/or made them aware of stormwater management issues? If so, have any of your contacts led to additional rain gardens being installed?  
Neighbors stop to talk.

Side notes: Hibiscus may have fallen over after initial planting, it needs to be dug up and repositioned upright. Homeowner does a nice job of promoting rain gardens.

Individual suggestions added to handout: Lift and replant leaning Hibiscus plant, watch Maple tree to the south for shading plants in the future.

overmulched

SIDEWALK

BEEN ON BACKSIDE OF RAIN GARDEN

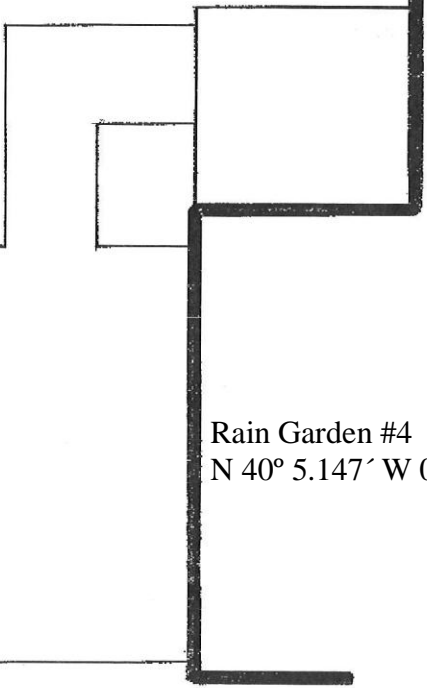
No tree in this location

CREATE SWALE

Sloping lawn

- Plant Key**
- | QTY | Plant Name                  |
|-----|-----------------------------|
| 1   | A) SEPTEMBER CHARM ALEMORLE |
| 3   | B) VARIATED SEDGE           |
| 1   | C) ROZANNE GERANIUM         |
| 3   | D) HAPPY BETULAS DRY LILY   |
| 1   | E) WOODS BLUE ASTER         |
| 2   | F) LITTLE HEALY SWEETSPICE  |
- \* Plant quantities are approximate & are subject to change pending space restrictions.
- All plantings survived

Downspout  
inflow



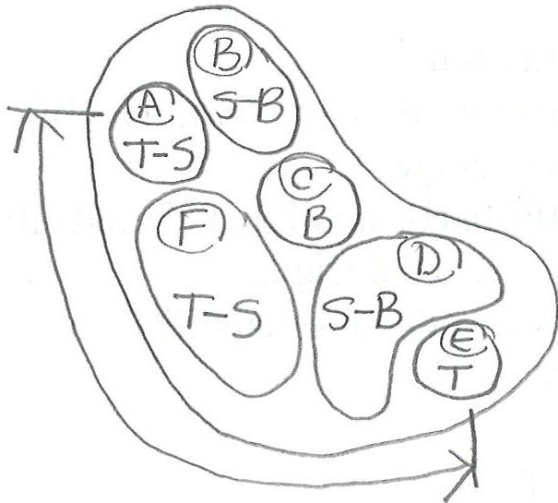
Rain Garden #4  
N 40° 5.147' W 096° 43.738'

⊕ = EXISTING TREES

North  
1" = 5'



7000 S 860 St. Omaha, NE 68130 Landscape Design: 402.424.4500 Garden Consult: 402.423.1133  
www.345landscaping.com



5

beem plants  
added -  
sedum

## Rain Garden #4

7/28/10

### First impression:

Dry, partial sun, mostly shade rain garden, nice street view, good shape, but needs edging .

### Hydraulic assessment:

- 1) Has it rained within the last 48 hrs?  
No
- 2) Are any inlet structures clogged?  
No, but needs edging, mulch needs to be redistributed.
- 3) Are any inlet structures misaligned?  
No
- 4) Is there any standing water?  
No, very dry.
- 5) Bottom assessment  
Mulch has been washed away, bottom area is bare.
- 6) Bank assessment  
Mulch overflow, but soil is stable. Berm plants added.
- 7) Is the overflow structure clogged?  
Yes, mulch needs to be cleared from opening.
- 8) Is the overflow structure misaligned?  
Possibly, could be due to excess rain, but overflow is occurring adjacent to current overflow structure on the north side. Current needs to be widen or relocated.

### Vegetation assessment:

Mid-summer

Mostly shaded, may receive some partial late afternoon sun.

East side of the building

Full wind exposure

Air circulation good

Sprinkler system – No

Plants currently in bloom: Geranium

Plants that were especially nice overall: Geranium, Daylily

- 1) Approximate % of vegetation coverage.  
70%, 50% bottom, plantings still fairly small, but should fill in.
- 2) Compare current vegetation to original design.  
Original design. Berm plants were added for stability. No weeds, no invasives.
- 3) Does vegetation appear healthy?  
Variegated Sedge is short.  
Sweetspire leaves look yellowish.  
No disease.
- 4) Is vegetation appropriate density/size?  
Geranium has 4' spread, but does not look invasive.  
1 Sedge is very short.

Only 1 Sedum flowered, but others are growing.

- 5) Where is vegetation located relative to top/sides/bottom of garden?  
Noted on diagram

Homeowner assessment discussion:

- 1) Describe current functional garden rating.  
Within 24 hours. Could be closer to 24.
- 2) Describe current aesthetic rating.  
8. Not happy with daylilies and would like more summer blooming.
- 3) If existed prior to rain garden installation, what drainage problems were solved?  
No prior issues.
- 4) Check for plant information available through homeowner.  
No problems noted.
- 5) Has your rain garden experience enhanced your knowledge and awareness of stormwater management and runoff water quality as important issues in Lincoln?  
Yes. Has attended workshops.
- 6) Have you educated others and/or made them aware of stormwater management issues? If so, have any of your contacts led to additional rain gardens being installed?  
Talk to everyone about it.

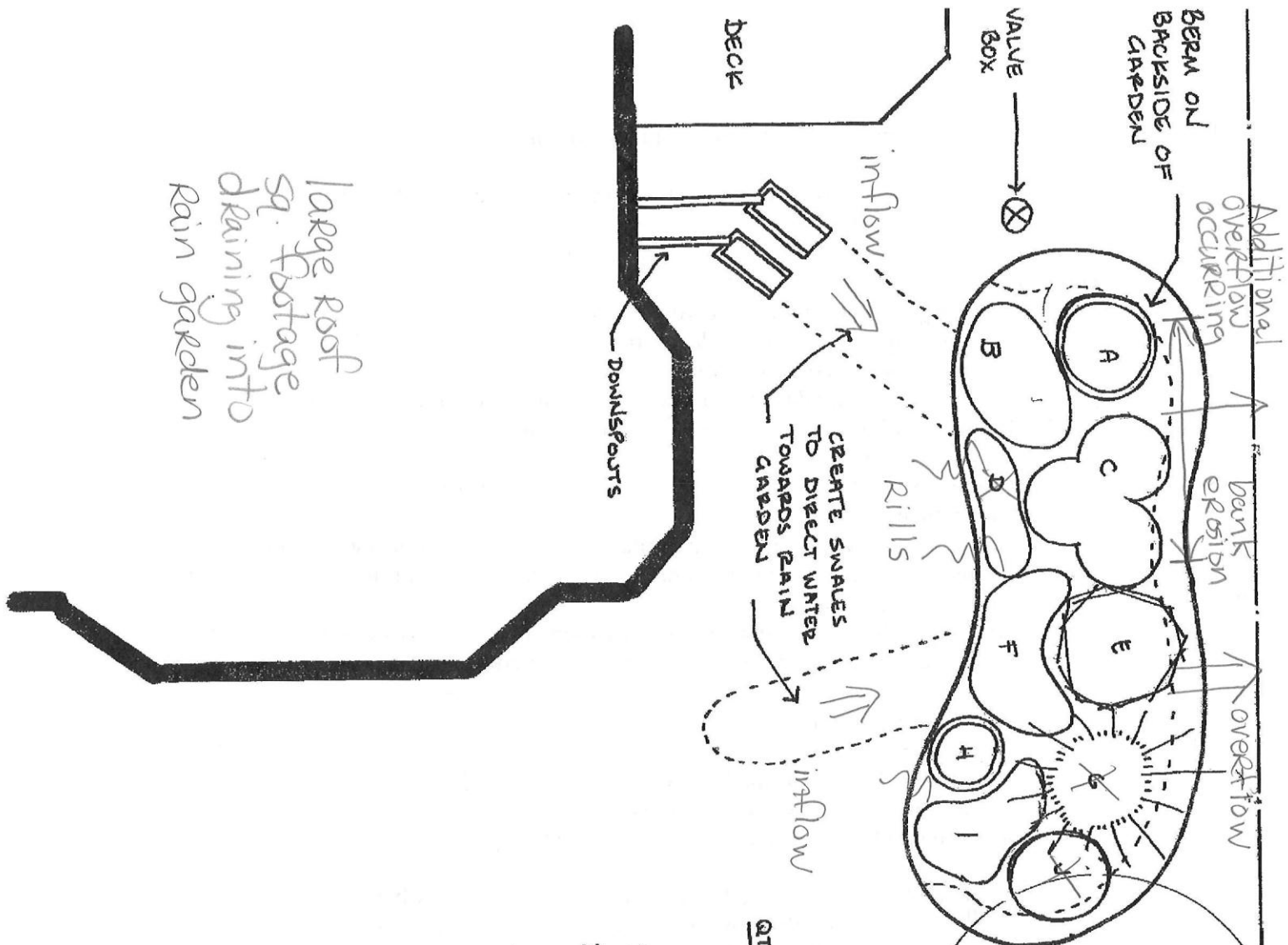
Side notes: Nice little shade garden, good location for catching runoff.  
Homeowner was on vacation, so plants showed signs of wilt, especially the Anemone. Overall, a nicely managed garden.

\*Note that this garden had to be replanted by the nursery because work was done in the backyard and those workers accidentally drove over the garden. This garden is technically only 2 years old.

Participant noted that garden was originally installed within 2 hrs.

Individual suggestions added to handout: No additional suggestions needed.





Large roof  
sq. footage  
draining into  
rain garden



PLANT KEY:

- 1 A) SWAMP MILKWEED
- 3 B) MISS MAJORS Obedient plant
- 3 C) CAESAR'S BROS. SIBERIAN IRIS
- 2 D) WOODS PURPLE ASTER - gone
- 1 E) FIREBALL ALIBISCUS
- 3 F) HAPPY RETURNS DAYLILY
- 1 G) MORNING LIGHT MISCAULTIUS - gone
- 1 H) FIREBALL BEE BALM - different location
- 2 I) VOLCANO WHITE PILEOX
- 1 J) GOLDSTUEM RUDBECKIA - gone

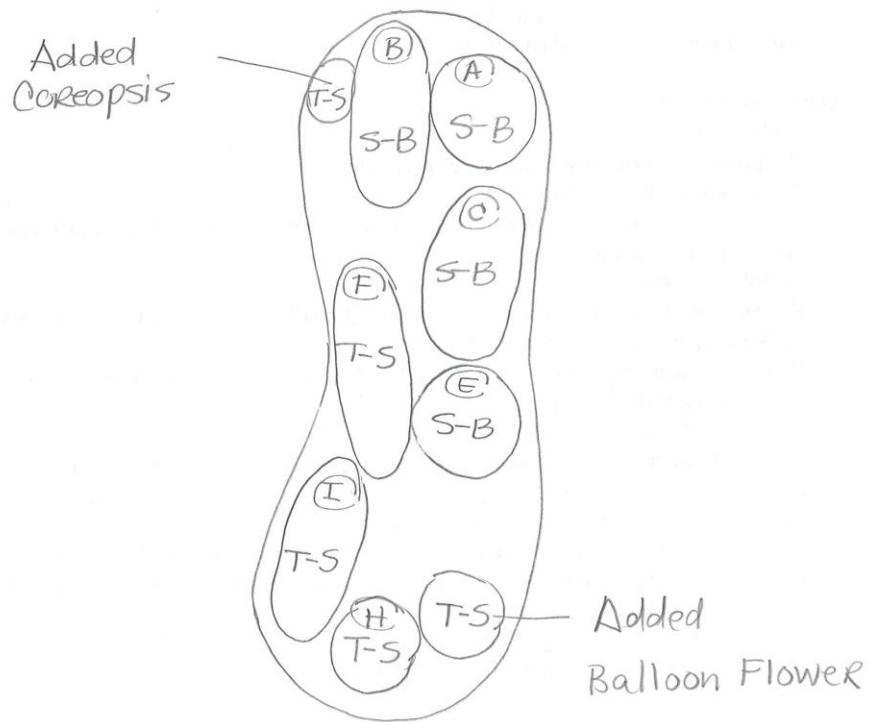
Plant Key

pine tree -  
receives  
morning  
shade

Rain Garden #5  
N 40° 46.401' W 096° 38.474'

**Campbell's**  
CULTIVATING IDEAS  
SINCE 1972  
Backyard

1" = 5' NORTH



## Rain Garden #5

7/26/10

### First impression:

Nice garden, in backyard, but has view from Holmes Lake walking paths, good presentation, large roof area draining into rain garden, nicely weeded, but turf encroachment.

### Hydraulic assessment:

- 1) Has it rained within the last 48 hrs?  
No
- 2) Are any inlet structures clogged?  
No, some sediment build up at grass swale entry, needs mulching and redistribution.
- 3) Are any inlet structures misaligned?  
No, has cement pads under downspouts for directing runoff.
- 4) Is there any standing water?  
No, looks good.
- 5) Bottom assessment  
Slight start of rills from inflow area.
- 6) Bank assessment  
No plants on berm, turf encroachment, some bank erosion.
- 7) Is the overflow structure clogged?  
Used 6" stones that has turf growing in between and mulch overflow.
- 8) Is the overflow structure misaligned?  
No, but needs additional overflow added.

### Vegetation assessment:

Mid-summer

Receives no morning sun, full afternoon sun

North side of the building

Full wind exposure, garden extends east of the house so it receives south wind.

Air circulation good

Sprinkler system – Yes

Plants currently in bloom: Hibiscus, Obedient Plant, Coreopsis, Swamp Milkweed, Balloon Flower, Phlox.

Plants that were especially nice overall: Milkweed, Obedient Plant, Siberian Iris, Hibiscus, Daylily, Phlox.

- 1) Approximate % of vegetation coverage.  
75%, bottom area has gap on east end where bird bath is placed and Miscanthus is missing.
- 2) Compare current vegetation to original design.  
Miscanthus and Rudbeckia are missing. Homeowner added Balloon Flower. Coreopsis added by nursery. Original Monarda did not survive, but new plant was added in location J to replace Rudbeckia.
- 3) Does vegetation appear healthy?  
Plants present look very nice, no sign of disease or pests.

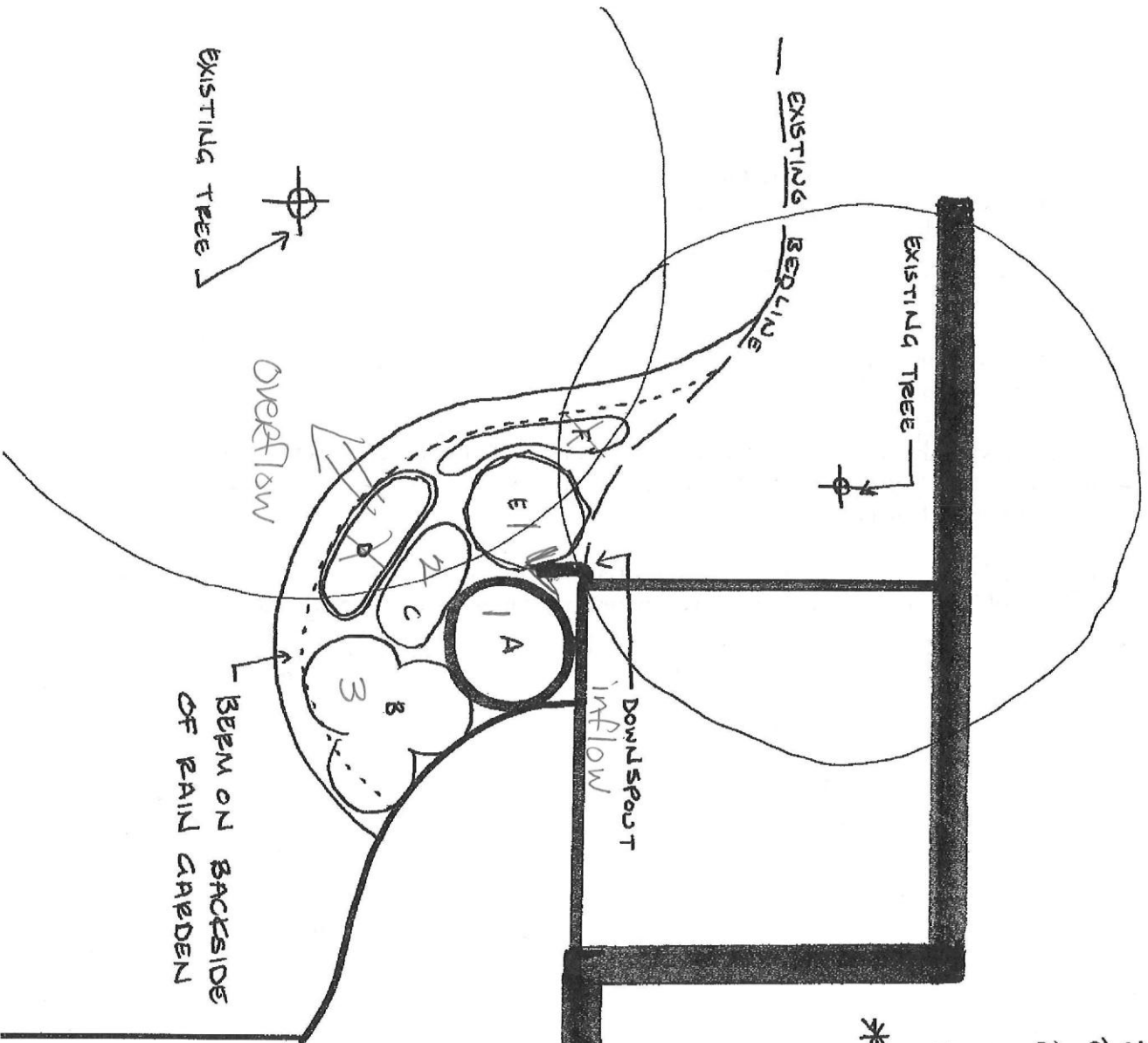
- 4) Is vegetation appropriate density/size?  
Overall vegetation appropriate for year 3,  
Obedient Plant was short, but looked nice.  
Monarda was too leggy and flopping due to receiving too much shade.
- 5) Where is vegetation located relative to top/sides/bottom of garden?  
Noted on diagram

Homeowner assessment discussion:

Did not participate.

Side notes: 'Fireball' Hibiscus is the best looking of Hibiscus varieties viewed; less eaten, less leggy, stays shorter and more shrub like, better size appropriate for smaller resident rain gardens.

Individual suggestions added to handout: East side morning shade is causing some problems for Monarda and gave suggestions for Miscanthus substitution.



PLANT KEY

- QTY
- 1 A) HUMMULCIBED SUMMERSWEET
  - 3 B) HAPPY BUTIRUS DAYLILY
  - 2 C) VISIONS IN PEO ASTIRGE
  - 2 D) BLUE SHADES COLUMBINE - gone
  - 1 E) SEPTENBER CATHAM ANEMONIE
  - 3 F) JAPANESE PAINTED FEEN - did not use
- \* NOTE: PLANT QUANTITIES ARE APPROXIMATE & SUBJECT TO CHANGE

Shade garden

**Campbell's**  
CULTIVATING IDEAS  
SINCE 1912

Rain Garden #6  
N 40° 46.553' W 096° 36.905'

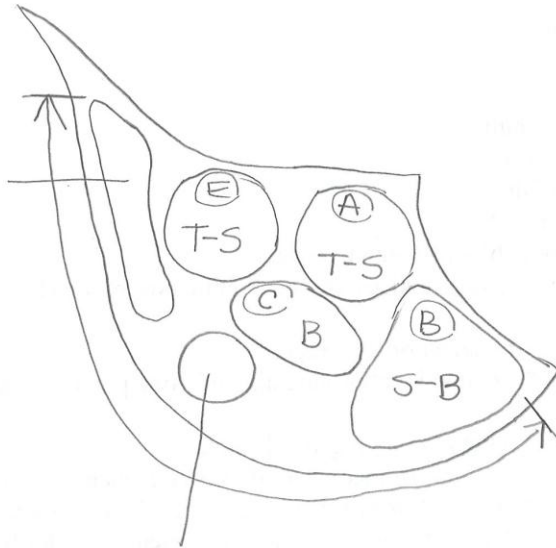


North

1" = 5'



Transplanted  
plant material



Added 1  
Heuchera

7 berm plants  
added -  
'Fatsia japonica'

## Rain Garden #6

7/27/10

### First impression:

Street view shade garden, nice growth, nice shade example, but needs color variation/blooms to brighten up the area, rain garden is close to the house as an extension of an existing garden, needs added mulch.

### Hydraulic assessment:

- 1) Has it rained within the last 48 hrs?  
No
- 2) Are any inlet structures clogged?  
No, has hanging downspout, but placed large rocks below to control erosion.
- 3) Are any inlet structures misaligned?  
No
- 4) Is there any standing water?  
No, but soil is moist, needs mulch added and/or redistributed.
- 5) Bottom assessment  
Needs plant litter cleaned up, mulch redistributed, some volunteer violets need to be removed.
- 6) Bank assessment  
Has brick edging, berm plants were added for stability.
- 7) Is the overflow structure clogged?  
No, but mulch needs to be pushed back from entrance.
- 8) Is the overflow structure misaligned?  
No, but needs to be widened to the east of overflow due to excess runoff.

### Vegetation assessment:

Mid-summer

Full shade

West side of the building

Fair wind exposure

Air circulation fair

Sprinkler system – Yes

Plants currently in bloom: Summersweet

Plants that were especially nice overall: Summersweet, Daylily, Astilbe, Anemone.

- 1) Approximate % of vegetation coverage.  
70%, bottom 50%, Columbine missing and only one plant was added as replacement.
- 2) Compare current vegetation to original design.  
D, Columbine is missing. Homeowner added one Heuchera. Area F is transplanted plant material from adjacent garden. Violets, Sweetclover, and Virginia Creeper starting to invade. Fatsia japonica added for bank stability.
- 3) Does vegetation appear healthy?  
Summersweet is very short, but nicely blooming and healthy.  
Added Heuchera is small, but recently planted.

- Three of the berm plants (look like *Fatsia japonica*) on east side have burned leaves, due to hot afternoon sun.
- 4) Is vegetation appropriate density/size?  
Plantings are within bounds.  
Except for Summersweet height, all original plants have filled in extremely well.
  - 5) Where is vegetation located relative to top/sides/bottom of garden?  
Noted on diagram

Homeowner assessment discussion:

- 1) Describe current functional garden rating.  
Within 24 hours. No standing water.
- 2) Describe current aesthetic rating.  
10. Very happy with it.
- 3) If existed prior to rain garden installation, what drainage problems were solved?  
No prior issues.
- 4) Check for plant information available through homeowner.  
No problems noted.
- 5) Has your rain garden experience enhanced your knowledge and awareness of stormwater management and runoff water quality as important issues in Lincoln?  
Yes. Knew about Holmes Lake issues prior.
- 6) Have you educated others and/or made them aware of stormwater management issues? If so, have any of your contacts led to additional rain gardens being installed?  
Talk to others at work and family members.

Side notes: Nice shade plant choices, but could add variegated plant selection to lighten the area. Homeowner needs to add at least two other *Heuchera* to fill out area D.

Individual suggestions added to handout: Add *Heuchera* to fill in space, watch berm plants for too much sunlight.



Rain Garden #7  
 N 40° 50.848' W 096° 43.811'

QUANTITIES ARE  
 VOLUME + SUBJECT  
 RANGE BASED UPON  
 SIZE OF RAIN GARDEN

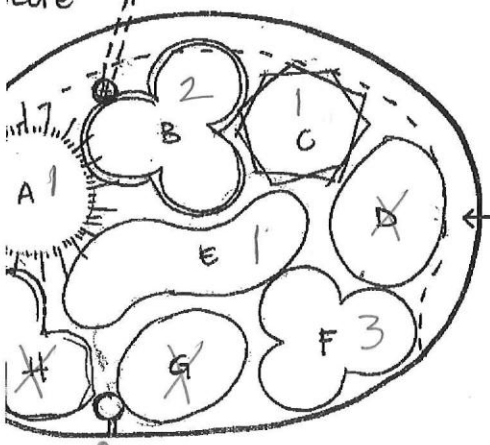
PLANT KEY

QTY:

- 1 A) MORNING LIGHT MISCANTHUS
- 3 B) CAESAR'S BROS. SIBERIAN IRIS - partial
- 1 C) FIREWORKS GOLDENROD
- 3 D) MAGNUS PURPLE CONEFLOWER - gone
- 3 E) MISS MANNERS OBEDIENT PLANT - partial
- 3 F) PARDON ME DAYLILY
- 2 G) WOODS PURPLE ASTER - gone
- 2 H) GOLDSTURM RUDBECKIA - gone

buried overflow -  
 was not able to  
 locate outlet

EXISTING  
 LAWN SLOPE



BERM ON BACKSIDE OF RAIN GARDEN

Enclosed backyard

DECK

EXISTING  
 LANDSCAPE

**Campbell's**  
 CULTIVATING IDEAS  
 SINCE 1912

severe lawn slope  
 8-10 ft. drop HOUSE

UP  
 SEN

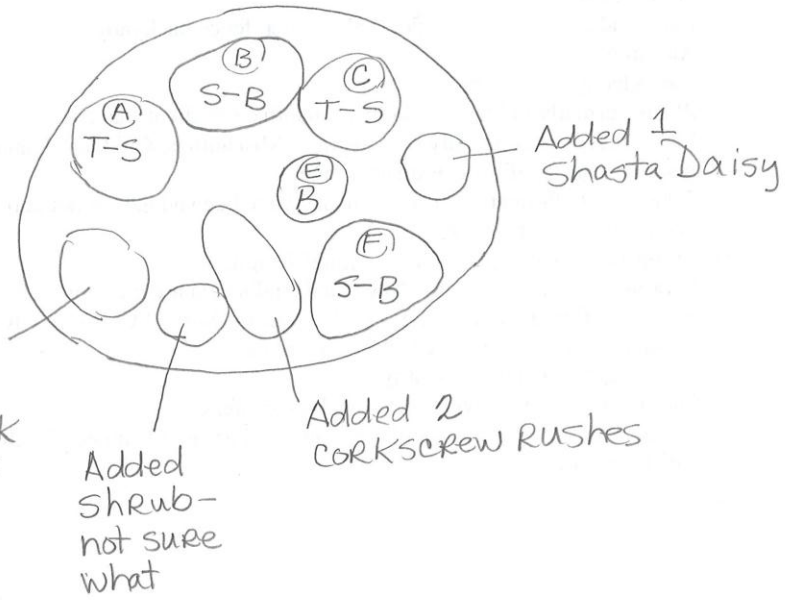
➔ NORTH 1" = 5'



← wooden fence



Pine tree



Added 1 Cottage Pink Dianthus

Added Shrub - not sure what

Added 2 Corkscrew Rushes



Pine tree

Rain Garden #7

7/30/10

First impression:

Nice, small backyard setting, bottom plants issues due to roof and lawn slope volume of runoff, rather sparse and overall shorter stature.

Hydraulic assessment:

- 1) Has it rained within the last 48 hrs?  
No
- 2) Are any inlet structures clogged?  
No, has buried inflow drain with protector cap.
- 3) Are any inlet structures misaligned?  
No
- 4) Is there any standing water?  
No, but there is standing water in the drain pipe and green areas in the bottom area. Soil is wet, but not mucky.
- 5) Bottom assessment  
Contains some channeling, needs mulch redistributed and more added.
- 6) Bank assessment  
Completely turf covered. While this does add stability, turf is encroaching into the bed area.
- 7) Is the overflow structure clogged?  
Design indicates a buried line, but could not find outlet in the yard.
- 8) Is the overflow structure misaligned?  
N/A

Vegetation assessment:

Mid-summer

Full sun to partial shade, east Pine tree is starting to shade garden.

West side of the building

Fair wind exposure, fully enclosed wooden fence backyard.

Air circulation fair

Sprinkler system – Yes

Plants currently in bloom: Daylily, Diantha, Obedient Plant.

Plants that were especially nice overall: Miscanthus, Goldenrod, and Daylily.

- 1) Approximate % of vegetation coverage.  
50%, 40% bottom area, different plants have been added, so not sure of age of plants, but they are small .
- 2) Compare current vegetation to original design.  
Serious turf encroachment. Asters and Rudbeckia are missing. 1 Siberian Iris and 1 Obedient Plant missing. Added Shasta Daisy, 2 Corkscrew Rushes, 1 Dianthus, and 1 unidentified shrub-like plant.
- 3) Does vegetation appear healthy?  
Siberian Iris are yellowing and have bare centers.  
Added Corkscrew Rushes look very nice and are good choices for the amount of moisture in the garden.

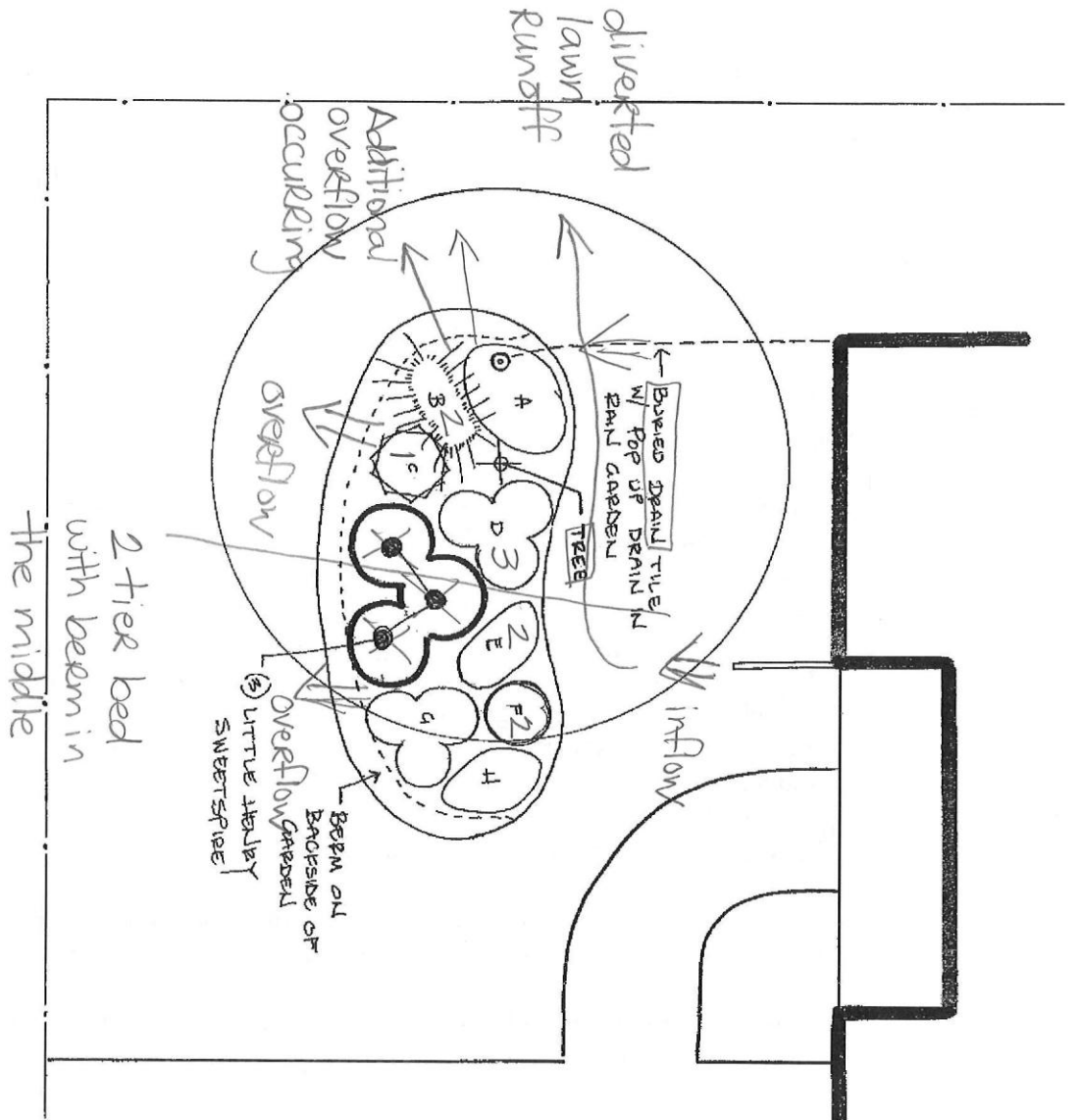
- 4) Is vegetation appropriate density/size?  
Obedient Plant very short.  
Added plants are very small. Since, dianthus growth from last year was not removed this would be season two.
- 5) Where is vegetation located relative to top/sides/bottom of garden?  
Noted on diagram

Homeowner assessment discussion:

- 1) Describe current functional garden rating.  
Within 24 hrs., sometimes taking a full 24 hrs.
- 2) Describe current aesthetic rating.  
8. Hopes it will fill in more.
- 3) If existed prior to rain garden installation, what drainage problems were solved?  
No prior problems.
- 4) Check for plant information available through homeowner.  
No additional that already noted in vegetative section.
- 5) Has your rain garden experience enhanced your knowledge and awareness of stormwater management and runoff water quality as important issues in Lincoln?  
Already well aware, as they previously used to work for the Department of Roads.
- 6) Have you educated others and/or made them aware of stormwater management issues? If so, have any of your contacts led to additional rain gardens being installed?  
Passes on information to interested parties.

Side notes: Bed has formed a basin low spot at the drain inflow. This allows water to sit within the drain outlet and may dry out completely.

Individual suggestions added to handout: Needs plants added, we discussed more water tolerant plant selections.



Rain Garden #8  
 N 40° 46.325' W 096° 36.572'

Plant Key

- ATTN
- 1 A) Transplanted Purpletop
  - 2 B) Nephrolepis fern
  - 3 C) SERTENBERG CHARM ALMONDS
  - 2 D) BEED GREAT SPIDERWEED
  - 2 E) VISIONS IN BED ASTER
  - 2 F) COLUMBINE
  - 1 G) Transplanted DAYLILY
  - 3 H) Transplanted Purple Coneflower
  - 3 Sweetshrike - gone

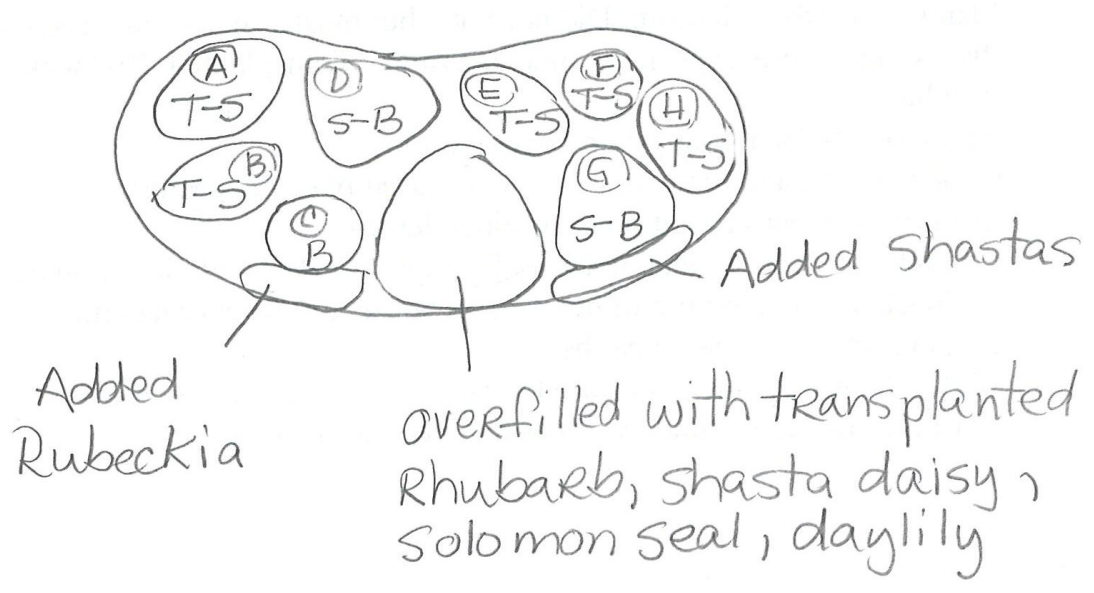
Full shade garden

**Campbell's**  
 CULTIVATING IDEAS  
 SINCE 1911



North 1" = 5'

2000 S. 88th St. Lincoln, NE 68508 Telephone: 402.424.4555 Fax: 402.424.1123  
 www.campbellscolorado.com



Rain Garden #8

7/23/10

First impression:

Full shade garden, rather jumbled street appearance, too much transplant material from other garden beds, needs edging.

Hydraulic assessment:

- 1) Has it rained within the last 48 hrs?  
No
- 2) Are any inlet structures clogged?  
Yes, has two buried downspouts that enter into the rain garden, one was clogged but homeowner cleaned it out.
- 3) Are any inlet structures misaligned?  
No, but yard runoff shows mulch movement to the south from beds west of rain garden, some is not going into the rain garden area.
- 4) Is there any standing water?  
No, but moisture present, needs mulch added/redistributed.
- 5) Bottom assessment  
Divided into two tiers with berm through middle. Shows signs of channelization, mulch washing, plant litter.
- 6) Bank assessment  
Homeowner has planted material for stabilization.
- 7) Is the overflow structure clogged?  
No
- 8) Is the overflow structure misaligned?  
Yes, mulch run off to the south of the rain garden area.

Vegetation assessment:

- Mid-summer  
Full shade  
South side of the building  
Some wind exposure from south, but protected by house to the west and cars to the north.  
Air circulation good, but plants need to be thinned.  
Sprinkler system – No  
Plants currently in bloom: Did not note, but mostly an overall green appearance.  
Plants that were especially nice overall: Transplanted Rudbeckia, Sea Oats, Astilbe
- 1) Approximate % of vegetation coverage.  
90%, thinning and removal of some diseased plants necessary.
  - 2) Compare current vegetation to original design.  
Columbines dead, foliage needs to be removed. Daylily, Solomon Seal, and Rudbeckia spreading out of bounds, no weeds or turf encroachment.
  - 3) Does vegetation appear healthy?  
With full shade some plants are leggy; Spiderwort, Shasta Daisy.  
Most Shasta's have mildew issues and need to be removed.

- Columbines need to be replaced.
- 4) Is vegetation appropriate density/size?  
Most of the transplanted material has spread to the point of becoming invasive.  
Nursery material is appropriate size/density for year 3.
  - 5) Where is vegetation located relative to top/sides/bottom of garden?  
Note on diagram.

Homeowner assessment discussion:

- 1) Describe current functional garden rating.  
Within 24 hours.
- 2) Describe current aesthetic rating.  
7.
- 3) If existed prior to rain garden installation, what drainage problems were solved?  
No prior issues.
- 4) Check for plant information available through homeowner.  
No problems noted.
- 5) Has your rain garden experience enhanced your knowledge and awareness of stormwater management and runoff water quality as important issues in Lincoln?  
Already was aware. Had received information on the low/no phosphorus fertilizer program from the city. Is looking into adding a rain barrel or cistern.
- 6) Have you educated others and/or made them aware of stormwater management issues? If so, have any of your contacts led to additional rain gardens being installed?  
Neighbors ask.

Side notes: Sea Oats are very nice, but need to be grouped en mass for better effect. Astilbe and Anemone need clearing around for growing space. Overall, doing well for a full shade garden, mostly disease free. Needs plant spacing for better air circulation.

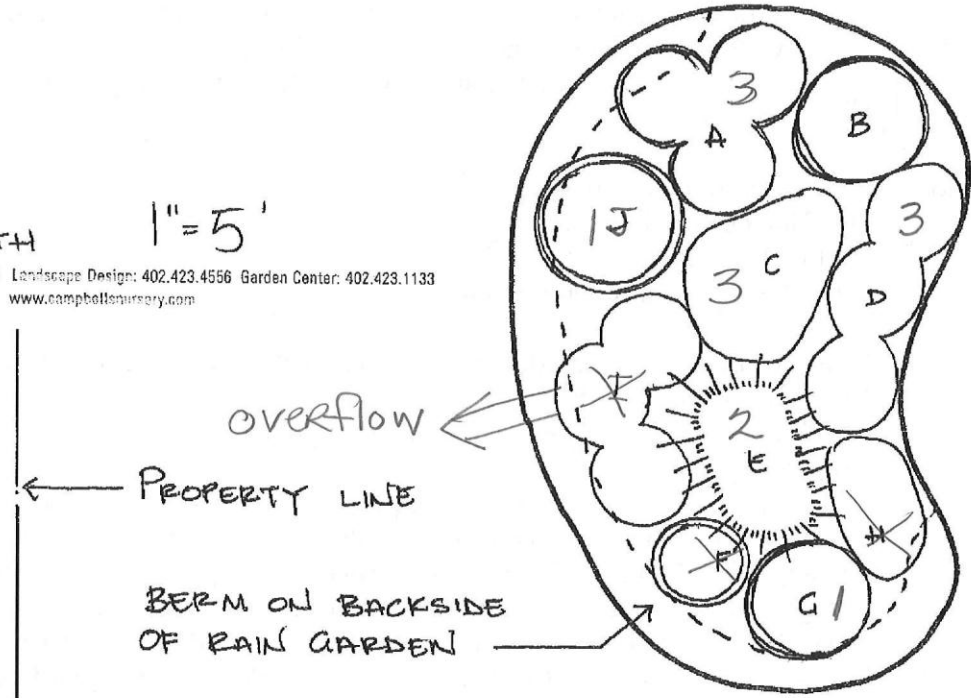
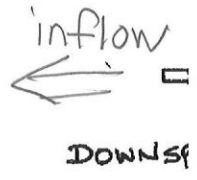
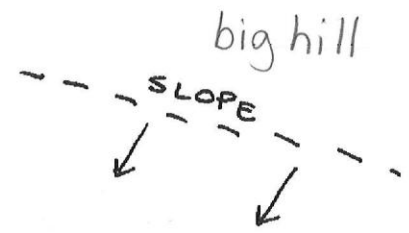
Individual suggestions added to handout: Check buried inflow for clogging, thin for better air circulation, remove transplanted Shasta's because of mildew problems.



7000 S. 56th St. Lincoln NE 68516 Landscape Design: 402.423.4556 Garden Center: 402.423.1133  
www.campbellnursery.com



1" = 5'

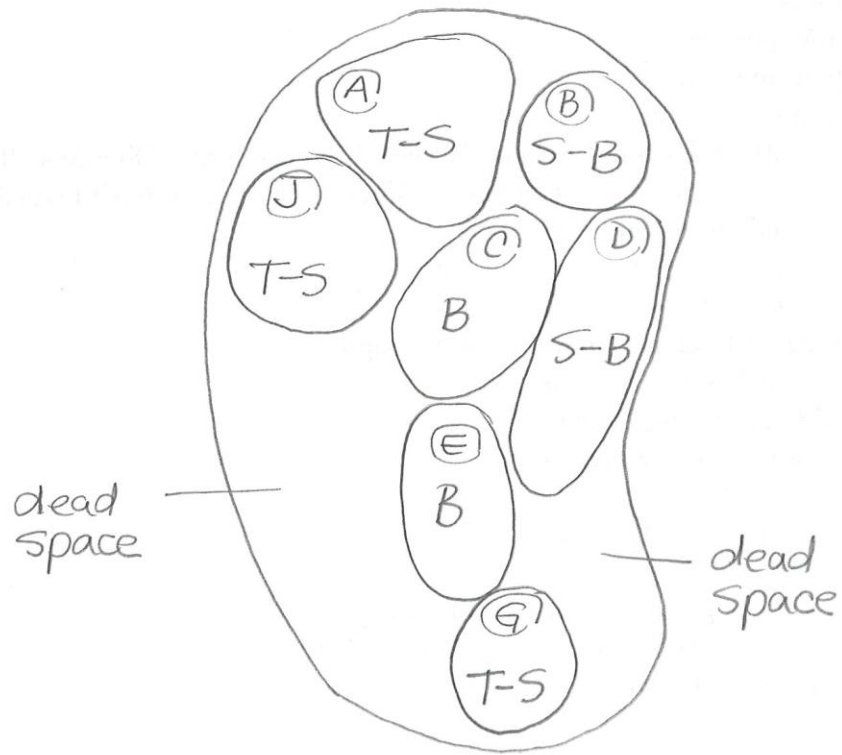


PLANT KEY

<u>QTY.</u>		<u>QTY</u>
3	A) CAESAR'S BROS. IRIS	1
1	B) SWAMP MILKWEED	1
3	C) MISS MANNER OBEDIENT PLANT	3
3	D) HAPPY RETURNS DAYLILY	1
2	E) KARL FOERSTER REED GRASS	
2	F) WOODS PURPLE ASTER - gone	
1	G) Goldenrod	
2	H) Rudbeckia - gone	
3	I) Purple Coneflower - gone	
1	J) Hibiscus	

Rain Garden #9  
N 40° 45.654' W 096° 37.264'





Rain Garden #9

7/22/10

First impression:

Very nice aesthetically, very good location, receives lots of run off due to size of house downspout and hill in backyard, needs edging.

Hydraulic assessment:

- 1) Has it rained within the last 48 hrs?  
Yes
- 2) Are any inlet structures clogged?  
No, but downspout opening slightly crushed.
- 3) Are any inlet structures misaligned?  
No
- 4) Is there any standing water?  
No, but takes full 24 hrs to drain.
- 5) Bottom assessment  
Grass is encroaching into garden, excess salt on soil surface.
- 6) Bank assessment  
Good shape, grass encroaching.
- 7) Is the overflow structure clogged?  
Yes, grass and mulch clogging.
- 8) Is the overflow structure misaligned?  
No, but back part of overflow may need to be lowered to assist with better flow.

Vegetation assessment:

Mid-summer

Full sun, but Ash tree SW of garden might start to partially shade in late afternoon as it matures.

Full wind exposure

Air circulation good

Sprinkler system – Yes

Plants currently in bloom: Swamp Milkweed, Hibiscus and Obedient Plant.

Plants that were especially nice overall: Siberian Iris, Swamp Milkweed, Daylily, Hibiscus, Goldenrod and Reed Grass.

- 1) Approximate % of vegetation coverage.  
70%, good bottom coverage.
- 2) Compare current vegetation to original design.  
Coneflower and Asters are missing.  
Milkweed is becoming invasive.  
Turf grass invading is a big issue.  
Minimum of weeds.
- 3) Does vegetation appear healthy?  
Overall, very nice.  
Reed grass starting to brown at the bottom.
- 4) Is vegetation appropriate density/size?  
Obedient plant small, <1 ft.

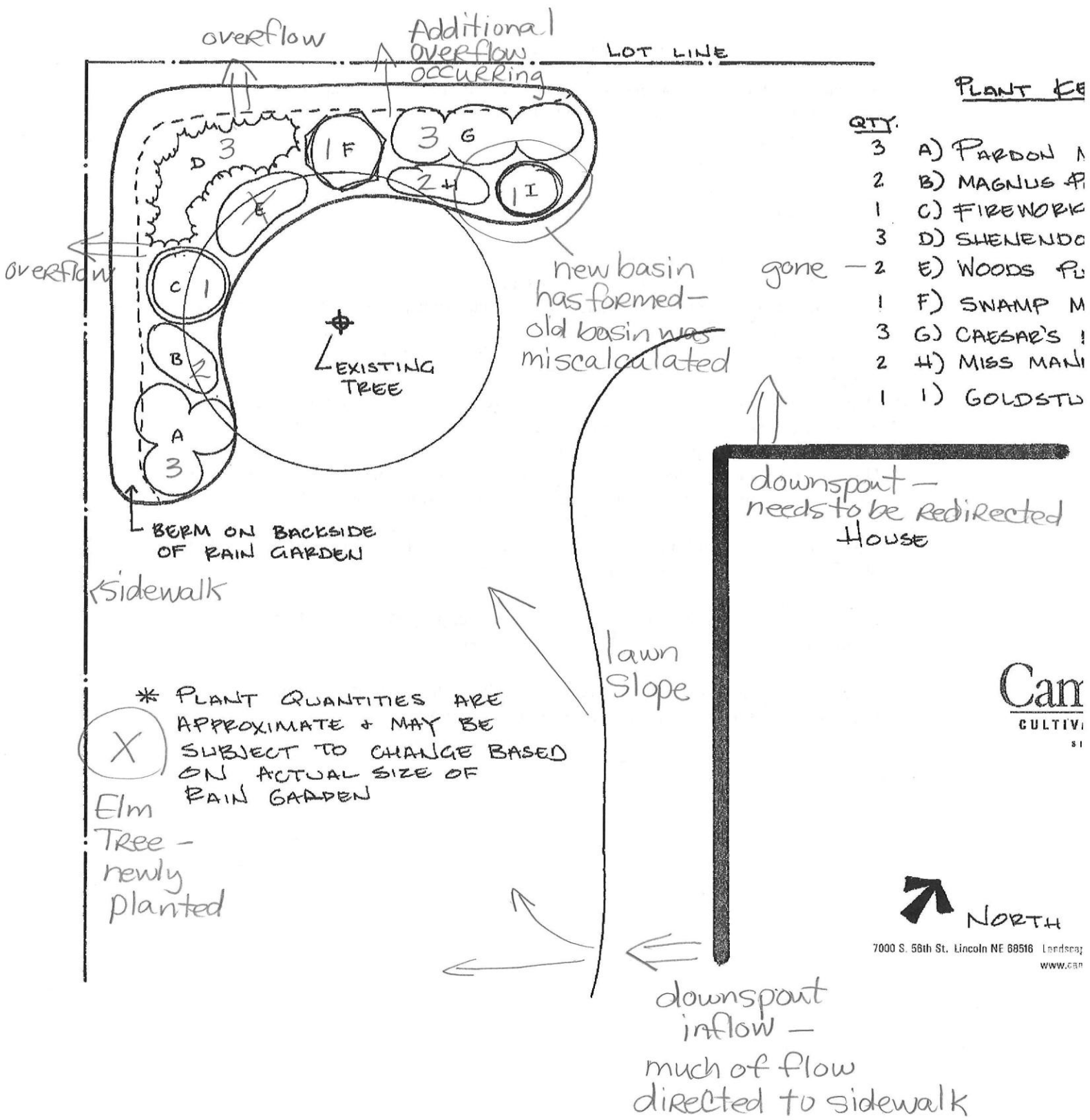
- Siberian Iris has dead centers and will need to be redone to keep in place.
- 5) Where is vegetation located relative to top/sides/bottom of garden?  
Noted on diagram.

Homeowner assessment discussion:

- 1) Describe current functional garden rating.  
Within 24 hrs.
- 2) Describe current aesthetic rating.  
8. Not happy about the size of the Hibiscus.
- 3) If existed prior to rain garden installation, what drainage problems were solved?  
No prior issues.
- 4) Check for plant information available through homeowner.  
No problems noted.
- 5) Has your rain garden experience enhanced your knowledge and awareness of stormwater management and runoff water quality as important issues in Lincoln?  
Yes. Wasn't aware prior to City meeting.
- 6) Have you educated others and/or made them aware of stormwater management issues? If so, have any of your contacts led to additional rain gardens being installed?  
Yes. Convinced a neighbor to install a garden through the City program and talk about it at church and organizations.

Side notes: Turf encroachment is an issue and edging could be difficult as homeowners are older.

Individual suggestions added to handout: Check downspout opening, shading is becoming an issue, we discussed possible plant substitutions.



PLANT KEY

QTY.	PLANT KEY
3	A) PARDON M
2	B) MAGNUS F
1	C) FIREWORK
3	D) SHENENDO
gone - 2	E) WOODS F
1	F) SWAMP M
3	G) CAESAR'S !
2	H) MISS MANI
1	I) GOLDSTU

BERM ON BACKSIDE OF RAIN GARDEN

new basin has formed - old basin was miscalculated

downspout - needs to be Redirected HOUSE

\* PLANT QUANTITIES ARE APPROXIMATE & MAY BE SUBJECT TO CHANGE BASED ON ACTUAL SIZE OF RAIN GARDEN

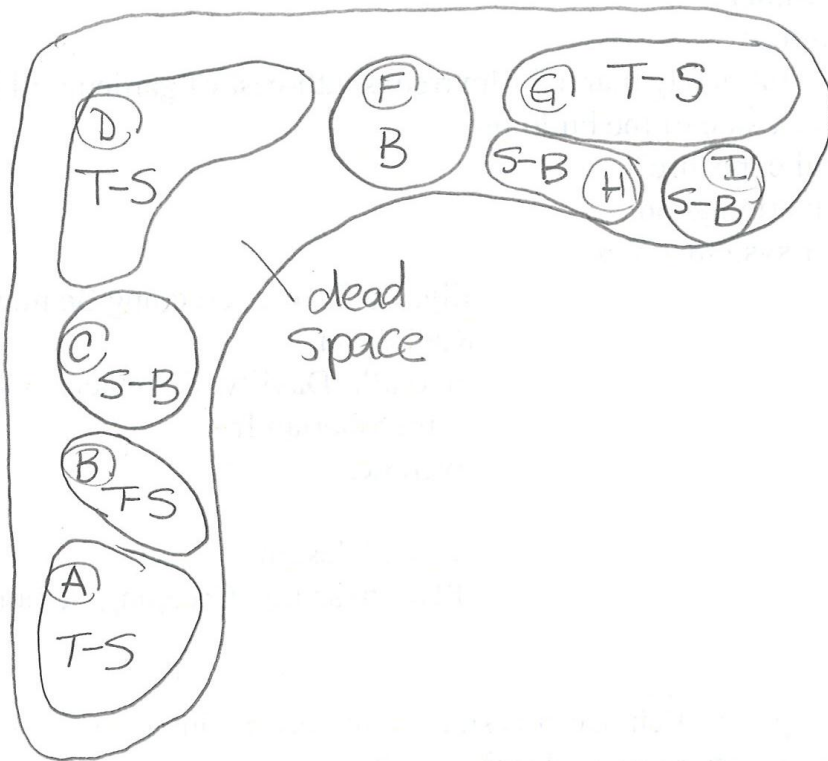
(X) Elm Tree - newly planted



7000 S. 56th St. Lincoln NE 68516 Landscap www.can

downspout inflow - much of flow directed to sidewalk

Rain Garden #10  
N 40° 44.714' W 096° 35.561'



## Rain Garden #10

8/2/10

### First impression:

Large corner, streetview presentation, dry and sunny location, original design, very nice and good location for rain garden example, needs mulching.

### Hydraulic assessment:

- 1) Has it rained within the last 48 hrs?  
No
- 2) Are any inlet structures clogged?  
No, inflow is nicely edged.
- 3) Are any inlet structures misaligned?  
Yes, 1 back of house downspout should come off the side.
- 4) Is there any standing water?  
No
- 5) Bottom assessment  
A basin has formed on the north-west end. Mulch piling, needs more added and redistributed, turf clippings.
- 6) Bank assessment  
Berm plants added, some erosion of east end on sidewalk side.
- 7) Is the overflow structure clogged?  
Yes, needs mulch removed, some slight turf and weeds.
- 8) Is the overflow structure misaligned?  
No, but one needs to be added as indicated on diagram.

### Vegetation assessment:

Mid-summer

Full sun, but newly planted Elm tree, south-east of garden will become an issue.

North-west side of the building

Full wind exposure

Air circulation good

Sprinkler system – Yes

Plants currently in bloom: Daylily, Echinacea, creeping Sedum, Swamp Milkweed, Obedient Plant and Rudbeckia.

Plants that were especially nice overall: Daylily, Echinacea, Goldenrod, Switchgrass, Swamp Milkweed, and Siberian Iris.

- 1) Approximate % of vegetation coverage.  
70%, 50% bottom
- 2) Compare current vegetation to original design.  
Asters are missing. 1 Obedient Plant missing. Creeping Sedum was added for bank stability.
- 3) Does vegetation appear healthy?  
Yes, very good. Echinacea is starting to become invasive. No weeds present.
- 4) Is vegetation appropriate density/size?  
Siberian Iris starting to form bare centers.  
Switchgrass is short, but healthy.

Obedient Plant is short and less dense.

Rudbeckia very short.

Overall, the plantings are short, but the garden looks proportional and not overgrown.

- 5) Where is vegetation located relative to top/sides/bottom of garden?  
Noted on diagram

Homeowner assessment discussion:

Did not participate.

Side notes: Rudbeckia and Obedient Plant in the newly formed basin are effected by water standing in this area longer. This garden has great flower color and nice plant specimens. It should stay a nice size and shape for the next few years with little maintenance needed, except Iris centers and keeping Solidago and Echinacea within bounds.

Individual suggestions added to handout: Re-align downspout, need another overflow added, and watch for increasing shade.



Rain Garden #11

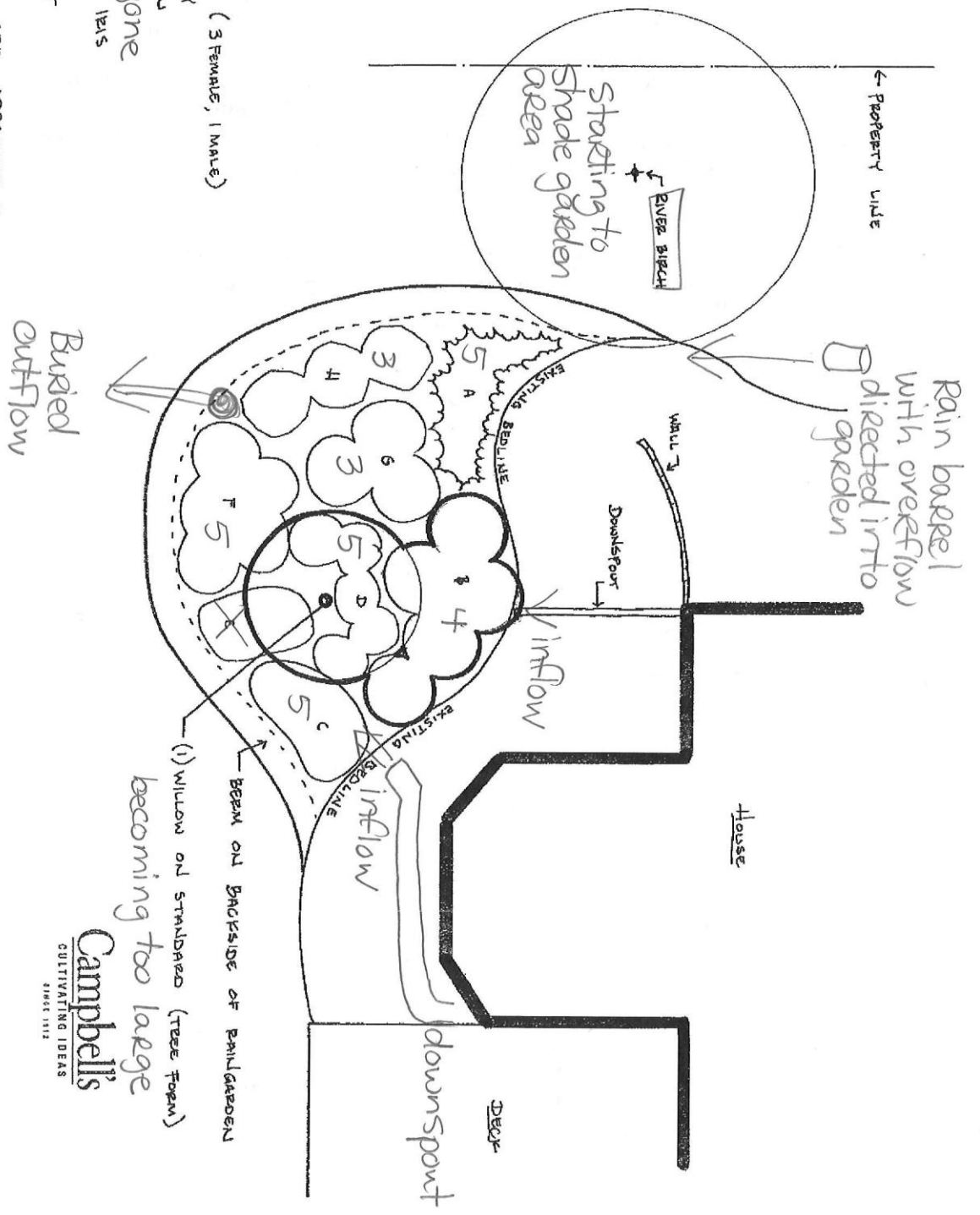
N 40° 46.019' W 096° 36.096'

Qty

- 5 A) SHELDONIA SWITCOWGRASS
- 4 B) RED SPIRITS MILTERRAPERY (3 FEMALE, 1 MALE)
- 5 C) HAPPY RYRUPUS DRYVIVY
- 5 D) HUSKER RED PULSTRUM
- 3 E) WOODS PINK ASTER - gone
- 5 F) OREARS BEOS. SIBERIAN LEIS
- 3 G) FIRE WIPKS GOUNDERED
- 3 H) WILKER'S LOW CATWILT

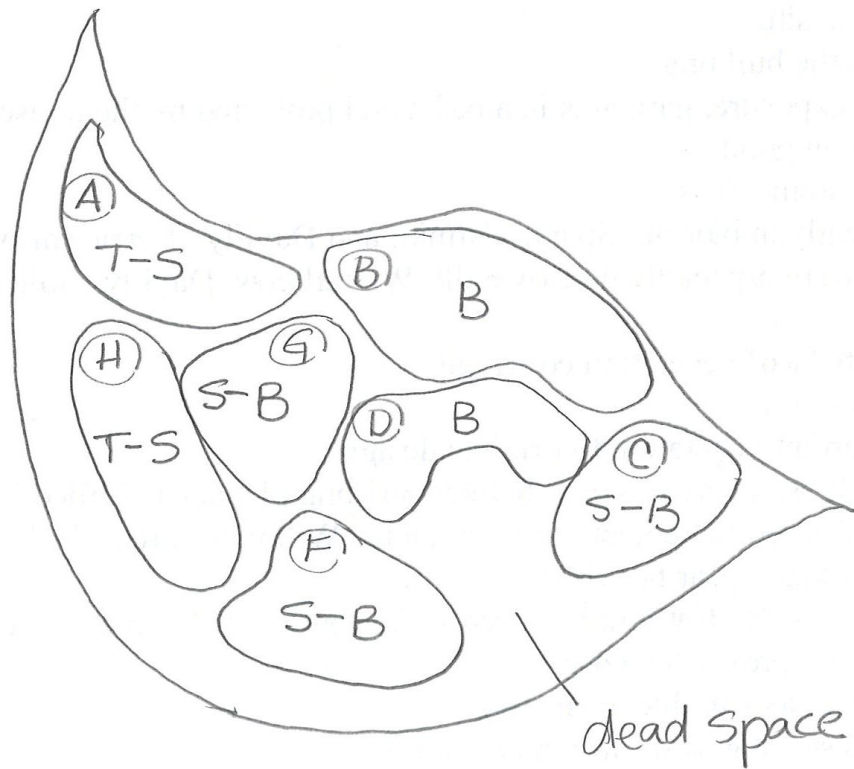
\* NOTE: PLANT QUANTITIES ARE APPROXIMATE  
 † SUBJECT TO CHANGE DEPENDING UPON  
 ACTUAL SIZE OF RAIN GARDEN.

Backyard



Campbell's  
 CULTIVATING IDEAS  
 SINCE 1912

North 1" = 5'  
 7000 S. 36th St. Lincoln NE 68516 | Landscape Design: 402.423.4550 Garden Center: 402.423.1188  
 www.campbellsc.com



## Rain Garden #11

7/30/10

### First impression:

Very nice, highly functional garden, excellent condition and maintenance, has a tree within the garden area, backyard location with view from golf course.

### Hydraulic assessment:

- 1) Has it rained within the last 48 hrs?  
No
- 2) Are any inlet structures clogged?  
No
- 3) Are any inlet structures misaligned?  
No, downspouts have large rock splash guard to receive inflow. Also, runs rain barrel overflow into garden.
- 4) Is there any standing water?  
No, but garden has an overflow drain. This is a basin area where there was standing water previous to garden installation, the area now drains.
- 5) Bottom assessment  
Good
- 6) Bank assessment  
Excellent shape
- 7) Is the overflow structure clogged?  
No, the drain pipe drains back of property garden.
- 8) Is the overflow structure misaligned?  
N/A

### Vegetation assessment:

Mid-summer

Partly shaded site

East side of the building

Good wind exposure, garden is in a basin and protected by the house.

Air circulation good

Sprinkler system – Yes

Plants currently in bloom: Sparse Catmint and Daylily. Berries on Winterberry.

Plants that were especially nice overall: Winterberry, Daylily, Goldenrod, and Catmint.

- 1) Approximate % of vegetation coverage.  
80%, 70% bottom
- 2) Compare current vegetation to original design.  
Same except, asters are missing, but surrounding plants have filled in the area. Solidago will need to be kept within bounds. Willow is a real shade issue.
- 3) Does vegetation appear healthy?  
Overall, very good. Catmint has dead stalks, but could be due to excess moisture.
- 4) Is vegetation appropriate density/size?  
Switchgrass is shorter due to shading.  
Siberian Iris starting to show empty centers.

Penstemons are tall and leggy, not dense.

Solidago and Siberian Iris are at peak density and will need to be managed.

Winterberry is ok for year 3.

- 5) Where is vegetation located relative to top/sides/bottom of garden?

Noted on diagram

Homeowner assessment discussion:

- 1) Describe current functional garden rating.  
A couple of hours.
- 2) Describe current aesthetic rating.  
10. Would do nothing different, very satisfied.
- 3) If existed prior to rain garden installation, what drainage problems were solved?  
Had standing water which rain garden corrected.
- 4) Check for plant information available through homeowner.  
No problems, this is the original design.
- 5) Has your rain garden experience enhanced your knowledge and awareness of stormwater management and runoff water quality as important issues in Lincoln?  
Yes, did some research and decided this was the way to go. Daughter participates in the KC 10,000 rain garden project and suggested this to participants.
- 6) Have you educated others and/or made them aware of stormwater management issues? If so, have any of your contacts led to additional rain gardens being installed?  
Neighbors.

Side notes: This is one of the nicer pilot gardens, if not the best in the pilot program, and an excellent example of a garden can correct water drainage issues. Concerns about shade and planted willow, gave homeowner pruning tips. Heavy use of sprinkler system with one placed within the garden bed. River Birch is getting large and is starting to block sun from the south-west. This garden might need redesigning due to increasing shade.

\*This garden may drain into Stephens Creek.

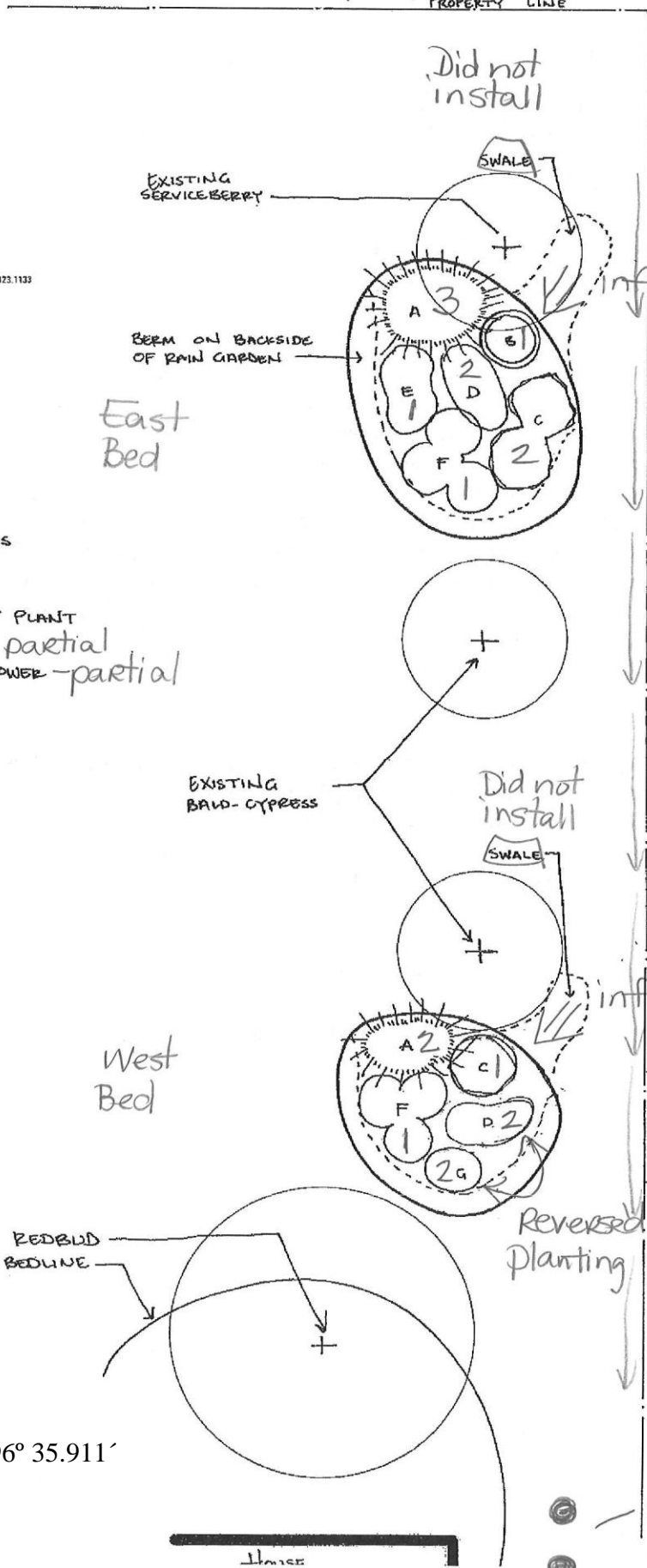
Individual suggestions added to handout: Prune willow tree when dormant, can remove 1/3 of old growth.

4 backyards draining onto this property



← NORTH 1" = 5'

7000 S. 96th St. Lincoln NE 68516 Landscape Design: 402.423.4555 Garden Center: 402.423.1133 www.campbellscountry.com



East Bed

West Bed

Backyard

PLANT KEY

- 5 A) SHENANDOAH SWITCHGRASS
- 1 B) SWAMP MILKWEED
- 3 C) FIREWORKS GOLDENROD
- 4 D) MISS MANNERS OBEIDIENT PLANT
- 2 E) WOODS PURPLE ASTER - partial
- 3 F) MAGNUS PURPLE CONEFLOWER - partial
- 2 G) SPIDERWORT

Rain Garden #13  
N 40° 45.177' W 096° 35.911'

House

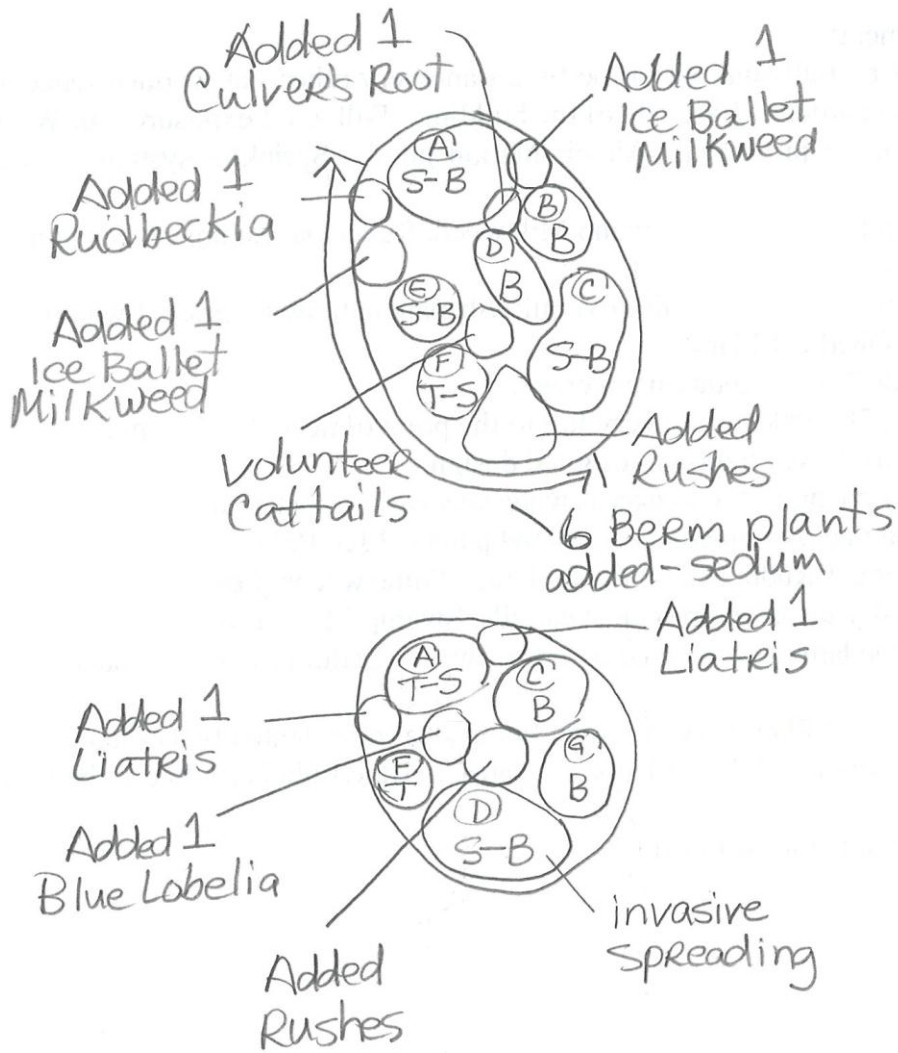
2 buried drains in side yard to street outlet



West bed



East bed



overfilled

### Rain Garden #13

7/28/10

#### First impression:

Two separate backyard gardens, well developed for year 3, receives runoff from neighboring lawns, switching over plants to introduce more moisture plants, nice presentation and growth size.

#### Hydraulic assessment:

- 11) Has it rained within the last 48 hrs?  
No, but this property has running water along the South property line.
- 12) Are any inlet structures clogged?  
For both - No, but some turf encroachment.
- 13) Are any inlet structures misaligned? For both – No, has rock inflow 5' wide.
- 14) Is there any standing water? For both – No, but soil is moist and mulch is gone.
- 15) Bottom assessment  
For both – excessive vegetation, volunteer and invasive plant occurring.
- 16) Bank assessment East – needs edging, berm plants were added.  
West – needs edging, obedient plant becoming invasive.
- 17) Is the overflow structure clogged?  
Both – no overflow present and no signs of overflow issues.
- 18) Is the overflow structure misaligned?  
N/A, garden are placed in areas where there was standing water issues due to neighboring lawn runoff problems.

#### Vegetation assessment:

- Mid-summer. Full sun, but property has an every other slat wooden fence to the South of the gardens. East side of the building. Full wind exposure, but West bed is slightly more protected. Air circulation good. Sprinkler system – Yes, but limited use.
- Plants currently in bloom: Swamp Milkweed, Rubeckia, Echinacea, creeping Sedum, Liatris, Obedient Plant.
- Plants that were especially nice overall: Shenandoah Switchgrass, Swamp Milkweed, Obedient Plant.
- 6) Approximate % of vegetation coverage.  
Both - 90%, 70-80% bottom very full to the point of needing clearing.
  - 7) Compare current vegetation to original design.  
East – many changes due to excess water received. 1 Aster surviving, Echinacea was transplanted by homeowner. Added plants; 2 Ice Ballet Milkweed, 1 Culver's Root, 1 Rudbeckia, 2 Rush plants. Some weeds present; plaintain and thistle. Mostly invasive problems; cattails, Swamp Milkweed, Echinacea and Rubeckia (the latter two planted by homeowner). Sedums added for bank stability.  
West – Obedient Plant very invasive, Echinacea transplanted by homeowner becoming invasive. Added plants: 2 Liatris, 1 Blue Lobelia, 1 Red Lobelia, 1 Rush.
  - 8) Does vegetation appear healthy?

East – Rushes are flopping over. Solidago, Aster, and Obedient Plant overcrowded by surrounding plant material. Culver’s Root overcrowded as well, if needed in the bed to aid with water infiltration, then it should have replaced original plant material. No sign of disease.

West – Rushes are flopping over. Spiderworts are fried. Obedient Plant very invasive. No sign of disease.

9) Is vegetation appropriate density/size?

East – Solidago less dense. Obedient Plant short and less dense.

West – Obedient Plant very wide spread, but very nice. Difference between two gardens is east is totally in the bottom, west is bottom to side placement. East may be to overshadowed/overcrowded from other taller vegetation.

10) Where is vegetation located relative to top/sides/bottom of garden?

Noted on diagram.

Homeowner assessment discussion:

13) Describe current functional garden rating. +48 hrs.

14) Describe current aesthetic rating. 10. Would like better native plant selection.

15) If existed prior to rain garden installation, what drainage problems were solved?

Yes. Drainage is good now, but had the swales taken out.

16) Check for plant information available through homeowner.

Rabbits are an issue. Had to fence the Obedient Plant.

17) Has your rain garden experience enhanced your knowledge and awareness of stormwater management and runoff water quality as important issues in Lincoln?

Well aware, but is more conscience and limits fertilizer use. Participant works in wetlands for the City of Lincoln.

18) Have you educated others and/or made them aware of stormwater management issues? If so, have any of your contacts led to additional rain gardens being installed? Neighbors ask about the gardens.

Participant had valid disagreements:

1) City only wanted to install front yard gardens. My thoughts are this could just have been for the pilot gardens as they want to sell the idea and the gardens would be visible to those passing by.

2) Campbell’s had limited native plant lists. This does need to be addressed as native plant material has more extensive root systems.

3) Turf encroachment was not addressed. I did note that this is a serious issue for most of the participants.

Side notes: This property has at least 4 backyards runoff running through the property. Due to the excess runoff, the homeowner has placed two drains in the side yard. Fully developed garden and now is time to think about size management to allow for air circulation. Homeowner was too anxious for instant plants and needed to wait before adding extra material. Now the site is crowded and not planted en masse for aesthetic effect.

Individual suggestions added to handout: Needs size control, suggested taking down fencing and letting rabbits control Obedient Plant invasiveness.



Rain Garden #15  
 N 40° 47.285' W 096° 36.969'

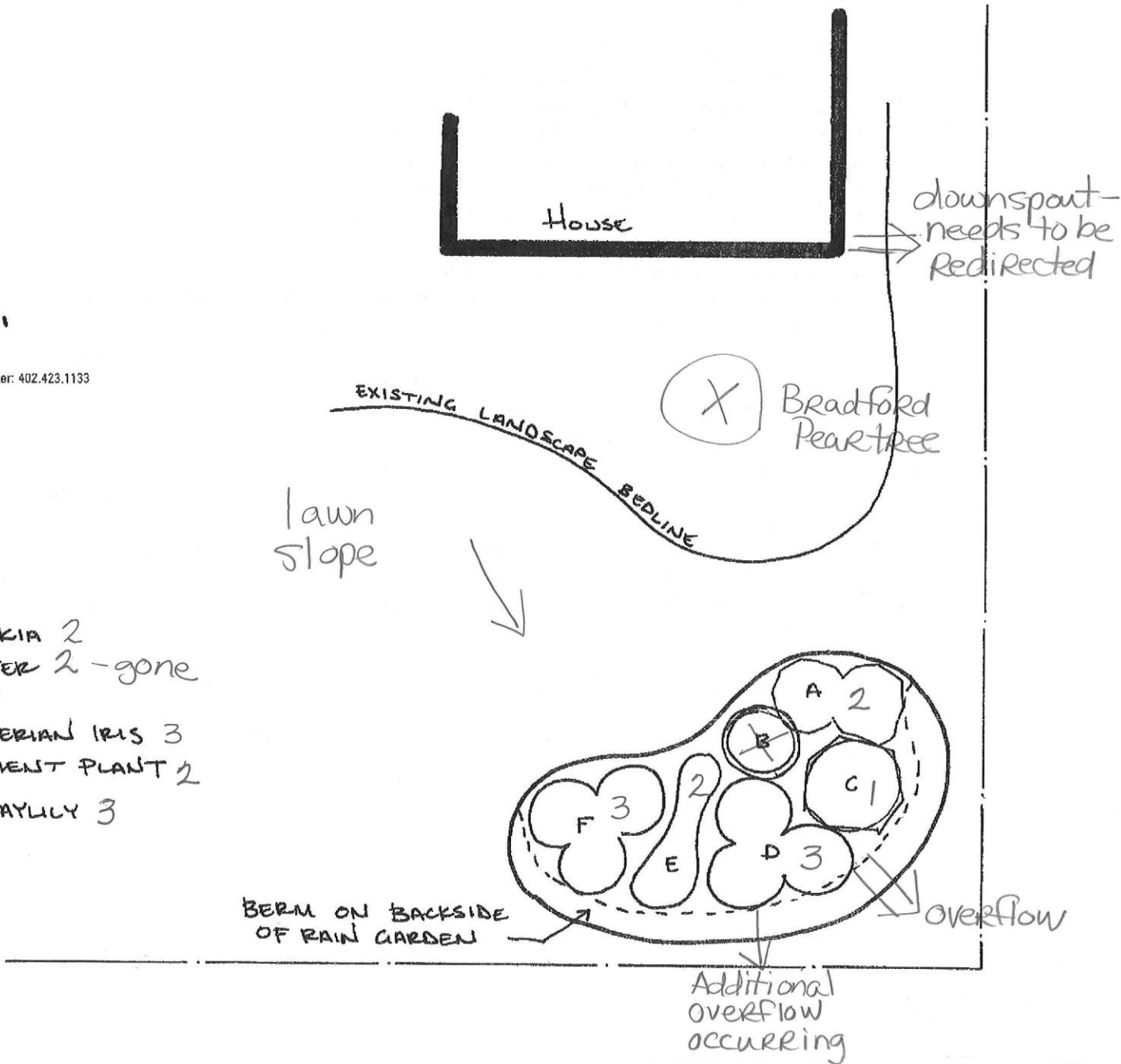
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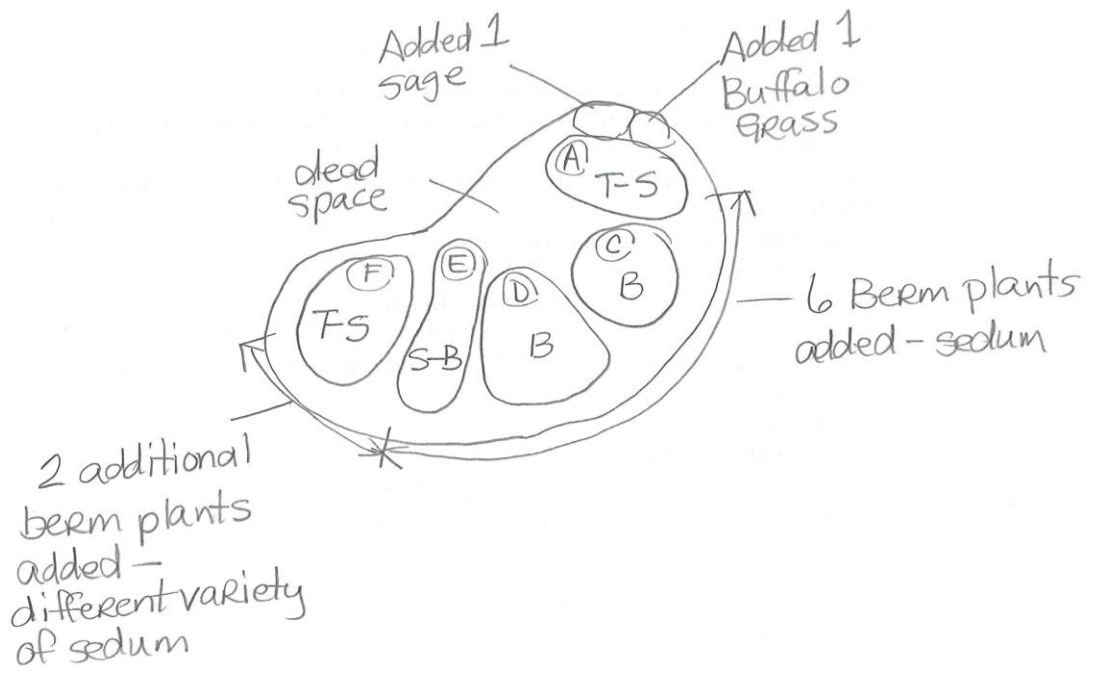
1" = 5'

2.423.4556 Garden Center: 402.423.1133  
 r.com

KEY

- 1 RUDBECKIA 2
- PURPLE ASTER 2 - gone
- WILKWEED 1
- BROS. SIBERIAN IRIS 3
- YERB OBEYANT PLANT 2
- TURNIPS DAYLILY 3





## Rain Garden #15

7/28/10

### First impression:

Very nice street presentation, great neighborhood example of a rain garden, bottom material needs replacing, nicely maintained, but needs mulch.

### Hydraulic assessment:

- 1) Has it rained within the last 48 hrs?  
No
- 2) Are any inlet structures clogged?  
No
- 3) Are any inlet structures misaligned?  
Yes, downspout not directed towards garden. Bulk inflow coming from sloping lawn.
- 4) Is there any standing water?  
No
- 5) Bottom assessment  
Some erosion due to open bottom area where asters are missing.
- 6) Bank assessment  
Sediment overflow into lawn, needs second overflow structure.
- 7) Is the overflow structure clogged?  
No, but mulch needs to be pushed back.
- 8) Is the overflow structure misaligned?  
No, but second needs to be added east of existed as noted on diagram.

### Vegetation assessment:

- Mid-summer  
Full sun, but Bradford Pear may start to give afternoon shade as it matures.  
Northeast side of the building  
Full wind exposure  
Air circulation good  
Sprinkler system – Yes, but has not used yet this season.  
Plants currently in bloom: Rudbeckia, creeping Sedum, Swamp Milkweed, Obedient Plant.  
Plants that were especially nice overall: Swamp Milkweed, Obedient Plant, Daylily.
- 1) Approximate % of vegetation coverage.  
70%, 50% bottom as asters are missing.
  - 2) Compare current vegetation to original design.  
Aster(s) are missing. Sedums added for bank stability. Obedient Plant and Rudbeckia spreading volunteers. Added 1 sage and 1 buffalo grass plant.
  - 3) Does vegetation appear healthy?  
Existing plants are very nice, all bloomed.
  - 4) Is vegetation appropriate density/size?  
Good size and density. Plants are not overpowering the garden.
  - 5) Where is vegetation located relative to top/sides/bottom of garden?

Noted on diagram

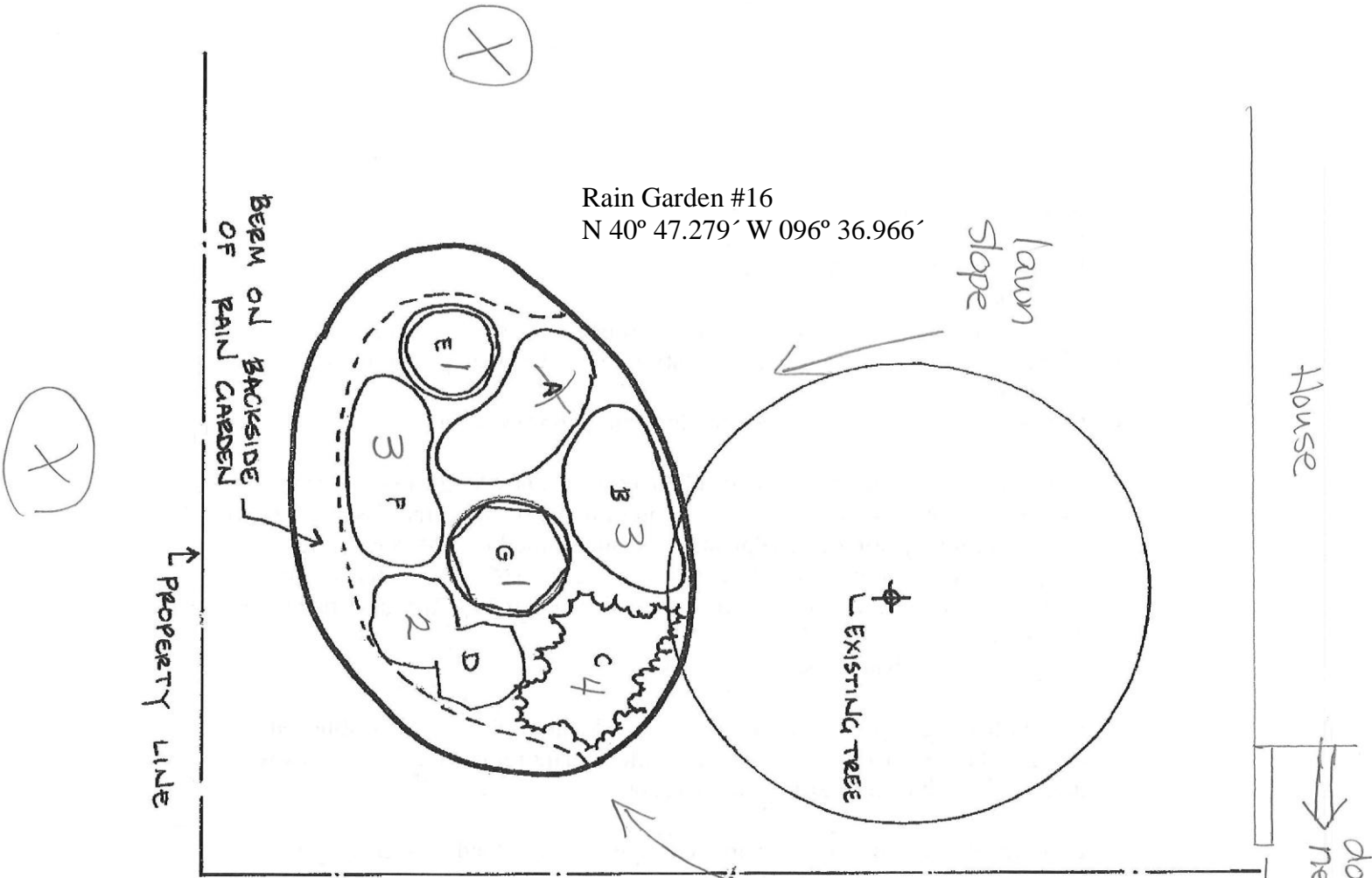
Homeowner assessment discussion:

- 1) Describe current functional garden rating.  
Less than 12 hrs. Within a few.
- 2) Describe current aesthetic rating.  
10. Would change nothing, loves the garden and has not had any problems.
- 3) If existed prior to rain garden installation, what drainage problems were solved?  
No prior issues.
- 4) Check for plant information available through homeowner.  
None.
- 5) Has your rain garden experience enhanced your knowledge and awareness of stormwater management and runoff water quality as important issues in Lincoln?  
Yes. Had little prior knowledge and has since added rain barrels.
- 6) Have you educated others and/or made them aware of stormwater management issues? If so, have any of your contacts led to additional rain gardens being installed?  
Neighbors and visitors ask.

Side notes: This garden is a great example location for newly established neighborhoods, just needs suggested bottom plant replacements. Homeowner does a nice job of promoting rain gardens.

Participant did think that Monarch caterpillars were 'bad' insects and called Campbell's on how to get rid of. Education on expected habitat dwellers is needed.

Individual suggestions added to handout: Needed replacement plant ideas and discussed with participant suggestions that would add color.



- PLANT KEY
- 3 A) WHITE SWAN CONIFLOWER - gone
  - 3 B) HAPPY RETURNS DAYLILY
  - 4 C) AVALANCHE REED GRASS
  - 2 D) GODSTUEM RUDECKIA
  - 1 E) AQUARIAN HIBISCUS
  - 3 F) VARIEGATED IRIS
  - 1 G) SWAMP MILKWEED

inflow directed towards outeredge

overmulched

Shade was underestimated - wrong plant choices

3 trees not indicated on diagram



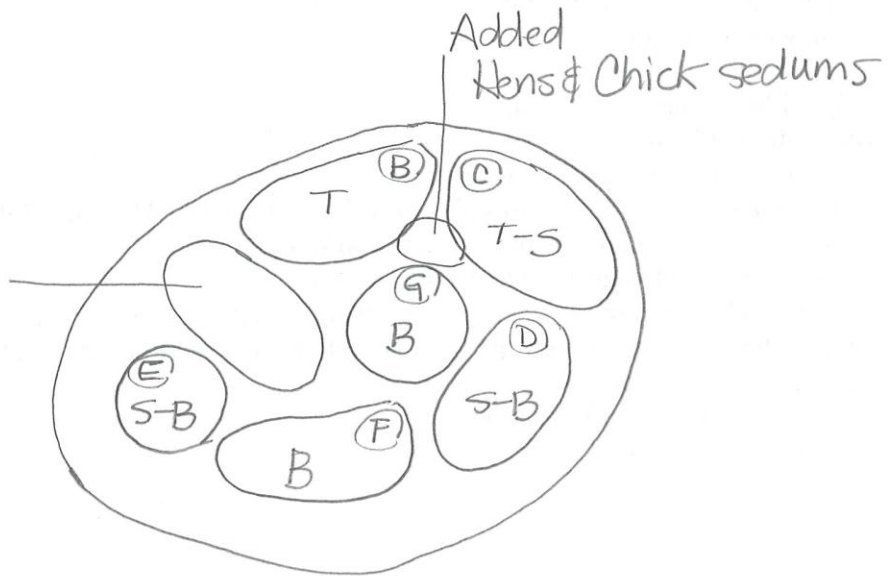
**Campbell's**  
CULTIVATING IDEAS  
SINCE 1912

→ NORTH 1"=5'



plantings are  
very sparse

Added 2  
Heuchera  
(1 coneflower  
barely hanging  
on)



Rain Garden #16

7/27/10

First impression:

Rain garden received shade most of the day, appears to be a dry/shade garden, plants are very small and at least half are struggling, cages around Rudbeckia and Variegated Iris.

Hydraulic assessment:

- 1) Has it rained within the last 48 hrs?  
No
- 2) Are any inlet structures clogged?  
Needs edging, turf just starting to encroach.
- 3) Are any inlet structures misaligned?  
Yes, not receiving all roof runoff because downspout extends past a brick extension on the front of the house. Downspout should be run in front of the extension, as it currently drains the runoff towards the outer edge of garden. Lawn slope is directed into the garden.
- 4) Is there any standing water?  
No, very dry bed area, too dry.
- 5) Bottom assessment  
No weeds, good mulch, but limited plant material.
- 6) Bank assessment  
Back side of berm eroding, turf encroachment, needs berm plants added for stability.
- 7) Is the overflow structure clogged?  
Mulch needs to be moved back, but in good shape.
- 8) Is the overflow structure misaligned?  
No, but could be wider.

Vegetation assessment:

Mid-summer  
Shaded site  
South-east side of the building  
Full wind exposure  
Air circulation good  
Sprinkler system – Yes, limited use.

Plants currently in bloom:

- 1) Approximate % of vegetation coverage.  
30%, bottom area 10%. Two stalks of Milkweed and tiny Heuchera (planted by homeowner) are all that is present in the bottom.
- 2) Compare current vegetation to original design.  
Two coneflowers are missing, so homeowner added two Heuchera, plus hens & chicks between Reed Grass and Daylily. All others need to be changed out for appropriate shade plants.
- 3) Does vegetation appear healthy?  
Rudbeckia is stunted.

Variegated Iris is stunted and did not flower.  
Reed Grass and Daylily are small, but look nice.  
No weeds, no invasives.

- 4) Is vegetation appropriate density/size?  
No, all plants are too small/sparse for year 3. The main issue is lack of sunlight; otherwise the plants would be flourishing.
- 5) Where is vegetation located relative to top/sides/bottom of garden?  
Noted on diagram.

Homeowner assessment discussion:

- 1) Describe current functional garden rating.  
Less than 12 hrs. Has never seen standing water.
- 2) Describe current aesthetic rating.  
7. Would have fenced garden sooner.
- 3) If existed prior to rain garden installation, what drainage problems were solved?  
No prior issues.
- 4) Check for plant information available through homeowner.  
Rabbit issue.
- 5) Has your rain garden experience enhanced your knowledge and awareness of stormwater management and runoff water quality as important issues in Lincoln?  
Yes. No prior knowledge.
- 6) Have you educated others and/or made them aware of stormwater management issues? If so, have any of your contacts led to additional rain gardens being installed?  
Neighbors and friends.

Side notes: Garden looks under developed and sparse. This is a dry/shaded spot and full sun plants are in the original design. Homeowner needs a chance to make this garden work with appropriate plantings from the nursery. Shade may have been underestimated by designer.

Individual suggestions added to handout: Check and/or redirect inflow from downspout, shade was underestimated, so discussed appropriate plant replacements.



PLANT KEY

- 3 A) FIREWORKS GOLDENROD
- 11 B) NORTHWIND SWITCHGRASS
- ~~C) HUSKER RED PENSTEMON - not planted~~
- ~~D) MAGNUS PURPLE CONEFLOWER - not planted~~
- 3 E) WOODS PURPLE ASTER - partial
- 6 F) CAESAR'S BROS. IRIS
- ~~G) ZACCHEO COREOPSIS - not planted~~
- 3 H) FLORESTAN WHITE LIATRIS
- 2 I) NORTHERN SEA OATS - gone
- 7 J) SWAMP MILKWEED
- 3 K) GOLDSTERN RUDBECKIA - partial
- 5 L) BLACK CHOKEBERRY

Actual garden does not match plant key (see sketch)

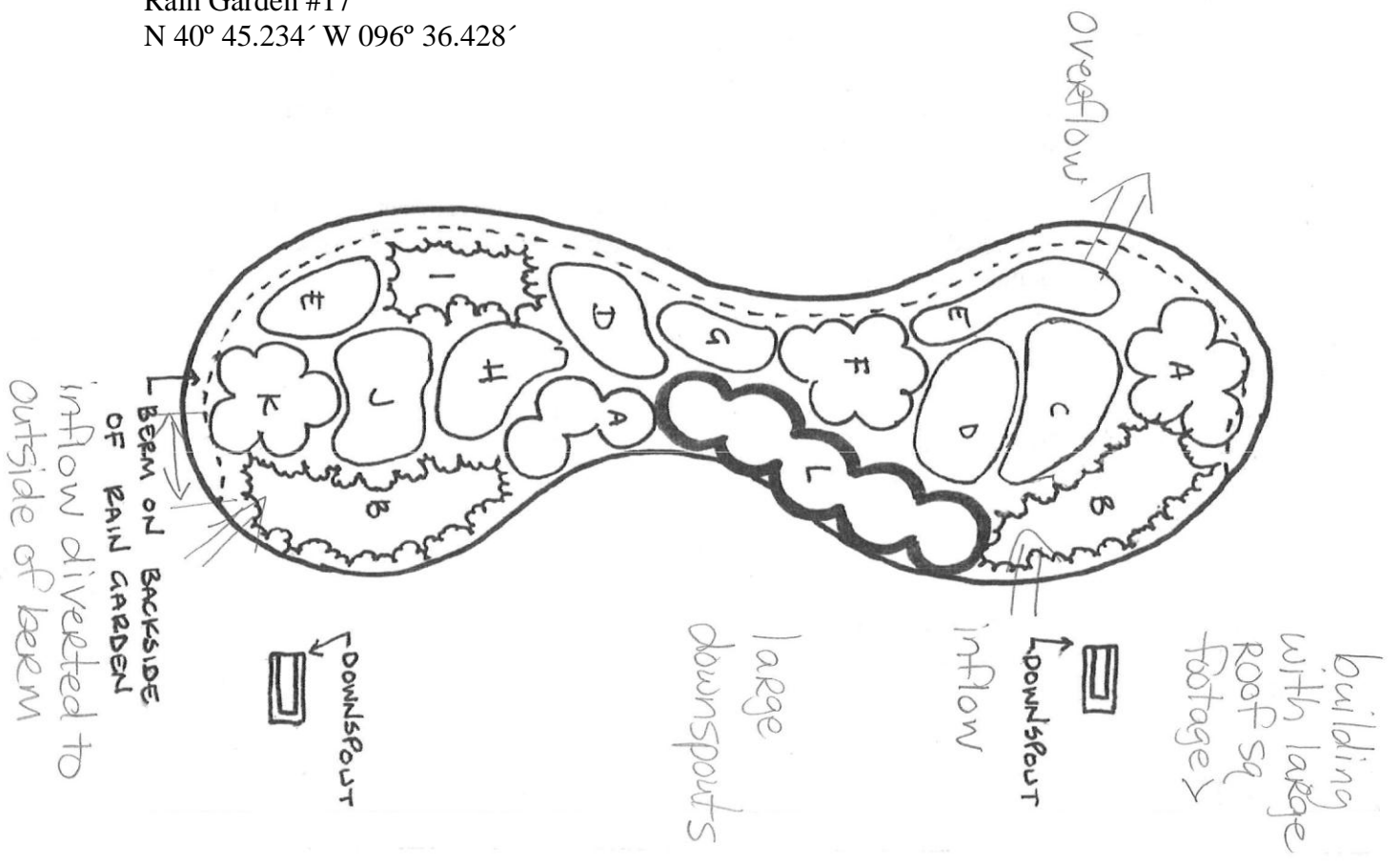
- 12 Obedient Plant
- 7 Daylily

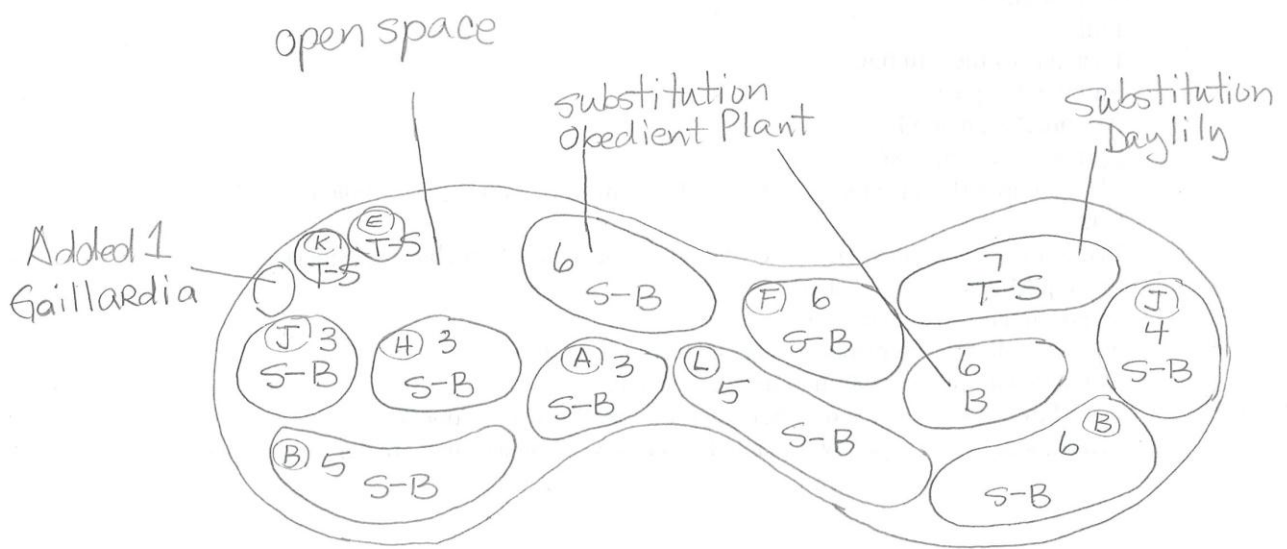
↓ NORTH 1" = 10'



Very large Rain garden

Rain Garden #17  
N 40° 45.234' W 096° 36.428'





## Rain Garden #17

7/30/10

### First impression:

Largest rain garden, too few plants for square footage, has very nice rain garden sign, nice location for presentation/education at school entrance.

### Hydraulic assessment:

- 1) Has it rained within the last 48 hrs?  
No
- 2) Are any inlet structures clogged?  
There are two 6" diameter downspouts; North inlet needs vegetation cleared from opening and needs soil lowered at opening end, South inlet needs vegetation cleared from opening.
- 3) Are any inlet structures misaligned?  
No, but there is some diversion of water on the North end outside of bank area. Berm may need to be set back to allow complete inflow. Both show signs of erosion and channelization at mouth of main inflow structure, as these are large inflow downspouts. The velocity coming from large roof structure runoff is great.
- 4) Is there any standing water?  
No
- 5) Bottom assessment  
Needs weeding.
- 6) Bank assessment  
Needs edging and weeding, but is in good shape.
- 7) Is the overflow structure clogged?  
Has large 6" stones for overflow structure. Mulch is overflowing and needs to be pushed back.
- 8) Is the overflow structure misaligned?  
No, but may need to be widened adjacent to the south side.

### Vegetation assessment:

- Mid-summer
  - Full sun
  - East side of the building
  - Full wind exposure
  - Air circulation good
  - Sprinkler system – No
  - Plants currently in bloom: Rudbeckia, Swamp Milkweed. Chokeberry has berries.
  - Plants that were especially nice overall: Northwind Switchgrass, Siberian Iris, Swamp Milkweed, Chokeberry.
- 1) Approximate % of vegetation coverage.  
50% overall, bottom plants are sparse, but surviving.
  - 2) Compare current vegetation to original design.  
Plant key does not match original diagram. No Sea Oats, Coneflowers, Penstemon, or Coreopsis was planted. Needs weeding as some are very large and

- established. Switchgrass and Swamp Milkweed volunteers that could be moved to densify same plant areas. 1 Rudbeckia needs to be relocated and others added for effect. 1 Aster barely hanging on. Added Gaillardia.
- 3) Does vegetation appear healthy?  
No disease, no pests. Grasses and Chokeberry are very nice and Chokeberry has berries present.
  - 4) Is vegetation appropriate density/size?  
Overall, plants are less dense, but correct height. Could be illusion due to plants being spaced far apart.  
Siberian Iris forming bare centers and yellowing.  
Swamp Milkweeds has thin stands and yellowing.  
Daylily is small and yellowing.  
Obedient Plant is yellowing and has not spread, thus verifying the dryness of the bed.
  - 5) Where is vegetation located relative to top/sides/bottom of garden?  
Noted on diagram.

Homeowner assessment discussion:

- 1) Describe current functional garden rating.  
2-3 hrs. There is no longer any pooling of water that occurred before installation.
- 2) Describe current aesthetic rating.  
10. They are very happy overall with the plant selections and have received many compliments. Weeds also like the garden, but they are quickly removed from the garden area.
- 3) If existed prior to rain garden installation, what drainage problems were solved?  
Swampy pooling of standing moisture for days at a time.
- 4) Check for plant information available through homeowner.  
Garden is getting what it needs from rain events. They have not had to supplement with much hose watering.
- 5) Has your rain garden experience enhanced your knowledge and awareness of stormwater management and runoff water quality as important issues in Lincoln?  
This is a school garden, so it has been incorporated into educational unit plans.
- 6) Have you educated others and/or made them aware of stormwater management issues? If so, have any of your contacts led to additional rain gardens being installed?  
Students have been educated. Not aware of other gardens being installed.

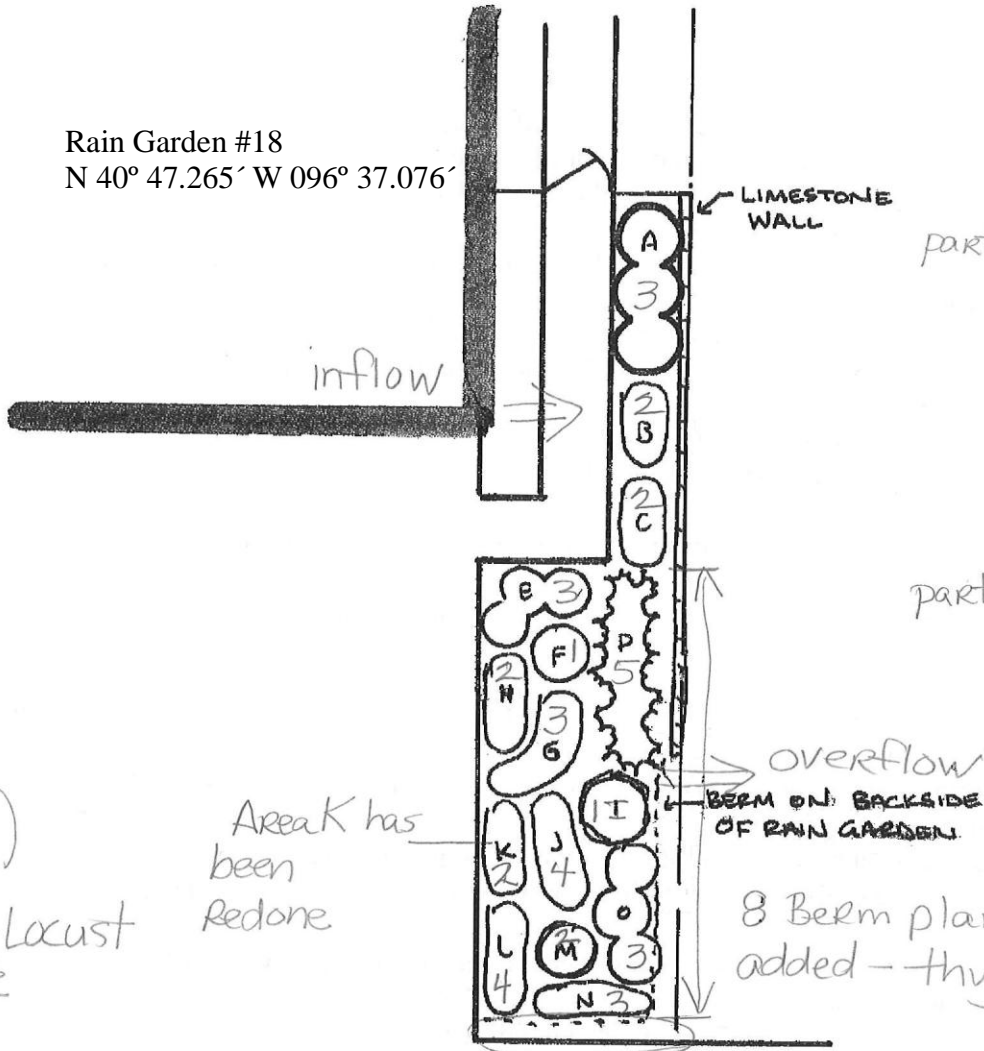
Side notes: Very large garden that needs time and dividing to fill in. Cost was most likely a factor for plant numbers. Participant should make use of existing plants to fill in the open areas and consider adding color to the garden by replacing lost Rudbeckia and adding more Gaillardia.

Individual suggestions added to handout: Garden will fill in, but could divide plants for to use as filler material, move Rudbeckia and Gaillardia from other garden beds to fill in open areas and add more color to the garden.

Rain Garden #18  
 N 40° 47.265' W 096° 37.076'

PLANT KEY

- 3 A) RED SPRITE WIND
- partial-3 B) FLORISTAN WHIT
- 2 C) GOLDSTURM RD
- 5 D) SHENANDOAH SI
- 3 E) MISS MANNERS G
- 1 F) SWAMP MILKWEED
- 3 G) HAPPY RETURNS
- 2 H) ROZANNE GERA
- 1 I) FANTASIA HIBI
- 4 J) HUSKER RED PI
- partial-3 K) MARCUS SALVIA
- 5 L) MAGNUS PURPLE
- 2 M) FIREWORKS GOLD
- 3 N) WOODS PURPLE
- 3 O) CAESAR'S BROS
- 3 P) ZAGREB COREOP
- 3 Q) ROSY RETURNS
- 2 R) WHITE SWAN CO
- 2 S) VARIEGATED IR

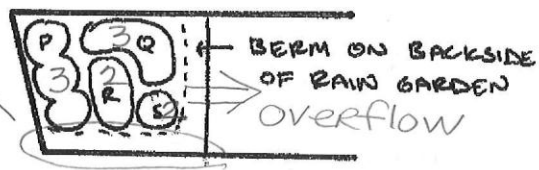


(X)  
 Honey Locust  
 Tree

Area K has  
 been  
 Redone

8 Berm plants  
 added - thyme

New sidewalk  
 was added -  
 berm need to  
 be Redone

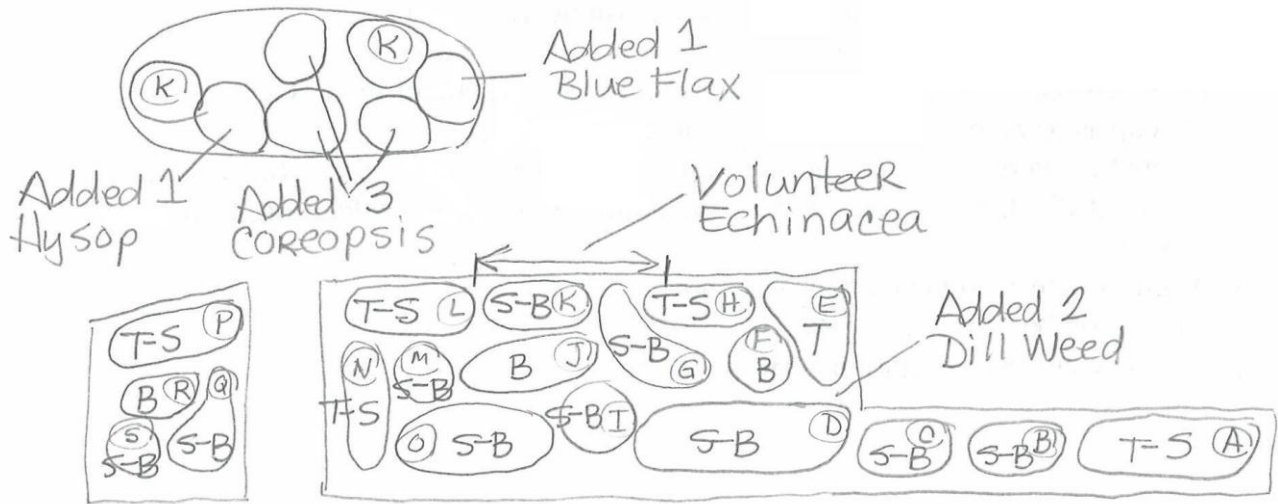


1" = 10'

close to being  
 overfilled



Area K enlarged



## Rain Garden #18

7/27/10

### First impression:

Largest residential rain garden, good street presentation, lots of blooming, owners are avid gardeners, very impressive garden statement, nice combination of plantings, very attractive.

### Hydraulic assessment:

- 1) Has it rained within the last 48 hrs?  
No
- 2) Are any inlet structures clogged?  
No, but volunteer Echinacea along driveway may impede runoff and should be removed.
- 3) Are any inlet structures misaligned?  
No, upper section contained slight washing of mulch due to velocity of input.
- 4) Is there any standing water?  
No, nicely drained.
- 5) Bottom assessment  
Good shape, rather weedy.
- 6) Bank assessment  
The sidewalk was replaced, berms need to be redone. Existing needs weeding, has turf encroachment from neighboring lawn.
- 7) Is the overflow structure clogged?  
North inflow has light mulch and grass that needs to be removed. South inflow is covered with weeds and needs to be cleaned up.
- 8) Is the overflow structure misaligned?  
No

### Vegetation assessment:

Mid-summer

Morning dappled shade from Honey Locust tree on the north, full sun in afternoon.

West side of the building

Full wind exposure

Air circulation good

Sprinkler system – Yes, but it is not used. (indicate as No)

Monarch butterflies present

Plants currently in bloom: Rudbeckia, Milkweed, Obedient Plant, Geranium, Coreopsis, Hysop, Hibiscus, both Echinacea, Daylily.

Plants that were especially nice overall: Winterberry, Gayfeather, Rudbeckia, Obedient Plant, Milkweed, Daylily, Geranium, Echinacea, Goldenrod, Coreopsis, Daylily.

- 1) Approximate % of vegetation coverage.  
90%, good bottom coverage at 70%.
- 2) Compare current vegetation to original design.

- All original plantings are present, except one Salvia. Homeowner added more Echinacea that will become too invasive and dense for the garden design. Bottom section is weedy, slight in other sections. Swamp Milkweed and Echinacea volunteer occurring. Homeowner added additional plants within areas K and J, which are bottom portions; they thought the existing plants were too sparse. Although Penstemons (J) were doing well in the bottom area. Thyme added for bank stability.
- 3) Does vegetation appear healthy?  
Sweetshire had some yellowing of leaves.  
Liatrix was too tall and flopping over.  
Obedient Plant too leggy and flopping over, but should fill in for better support.
  - 4) Is vegetation appropriate density/size?  
Overall, very size/density appropriate.  
Two of three Siberian Iris are short and small, but should fill in.  
Rudbeckia larger than year 3 expectation, but is a very impressive specimen and has plenty of room for spreading.
  - 5) Where is vegetation located relative to top/sides/bottom of garden?  
Noted on diagram

Homeowner assessment discussion:

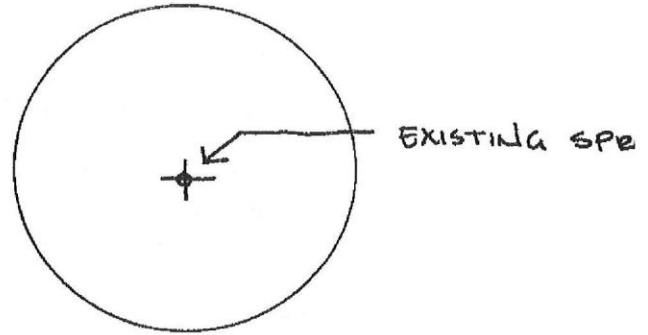
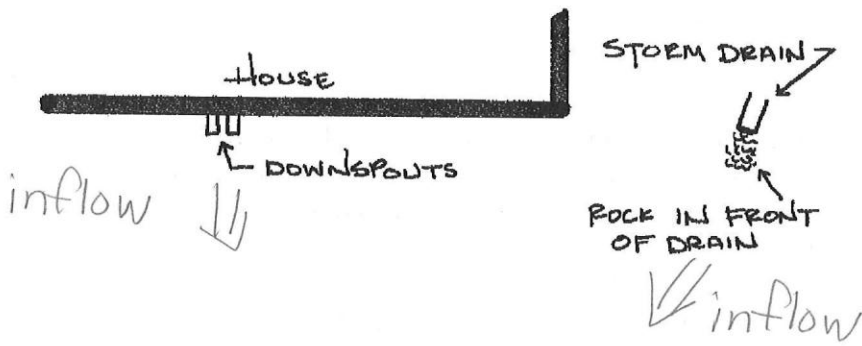
- 1) Describe current functional garden rating.  
Less than 12 hrs. No standing water.
- 2) Describe current aesthetic rating.  
10. Lost berm due to sidewalk being redone and needs to repair.
- 3) If existed prior to rain garden installation, what drainage problems were solved?  
Mucky under trees before they were removed. Water would stand.
- 4) Check for plant information available through homeowner.  
Normal issues. Participant has noticed some type of fungus on the Rudbeckia and other heat related issues.
- 5) Has your rain garden experience enhanced your knowledge and awareness of stormwater management and runoff water quality as important issues in Lincoln?  
Yes. Knew about the problem with Holmes Lake.
- 6) Have you educated others and/or made them aware of stormwater management issues? If so, have any of your contacts led to additional rain gardens being installed?  
Yes. Neighbors and people stopping by when walking, and talk at work.

Side notes: All plants are doing very well, as this is a well tended garden. However, homeowner needs to be careful about adding too many new plants, as the area will become overcrowded, decreasing air circulation. Owner added bark mulch for stability.

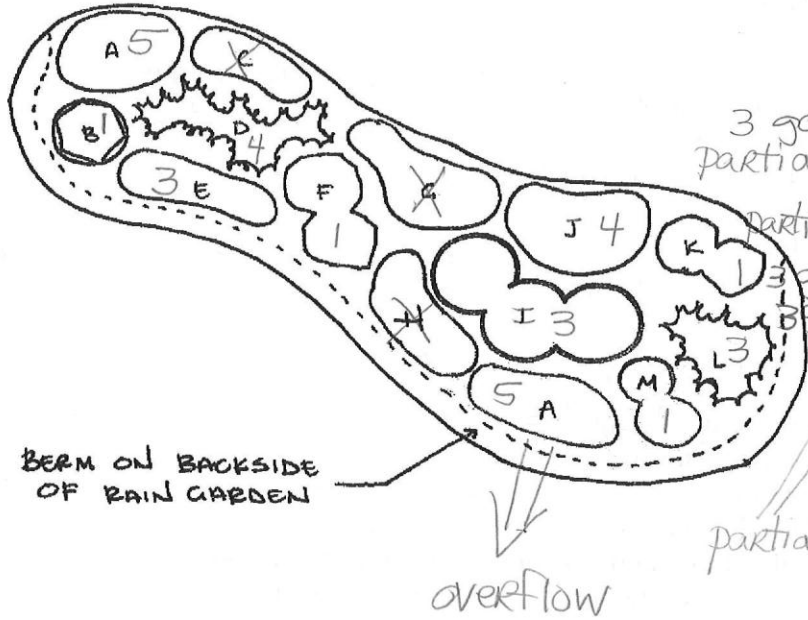
Participant suggested a plant sharing program to use as plants mature and need to be divided.

Individual suggestions added to handout: Redo berm next to replaced sidewalk, watch for overflow of plants, need to maintain good airflow.





PLANT KEY



- 10 A) HAPPY RETURNS DAYLILY
- 1 B) COPPER KING Hibiscus
- 3 gone - C) WOODS PURPLE ASTER
- partial - 5 D) KARL FOERSTER REED GRASS
- 3 E) VARIEGATED IRIS
- partial - 2 F) GATEWAY JOE-PYE WEED
- 3 gone - G) MAGNUS PURPLE CONEFLOWER
- 3 gone - H) MISS MANNERS OBEDIEN
- 3 I) BLACK CHOKEBERRY
- 5 J) CAESAR'S BROS. SIBERIAN IRIS
- 2 K) FIREWORKS GOLDENROD
- 3 L) NORTHWIND SWITCHGRASS
- 2 M) SWAMP MILKWEED

**Campbell**  
CULTIVATING IDEAS  
SINCE 1912

under estimated runoff -  
turning into wetlands

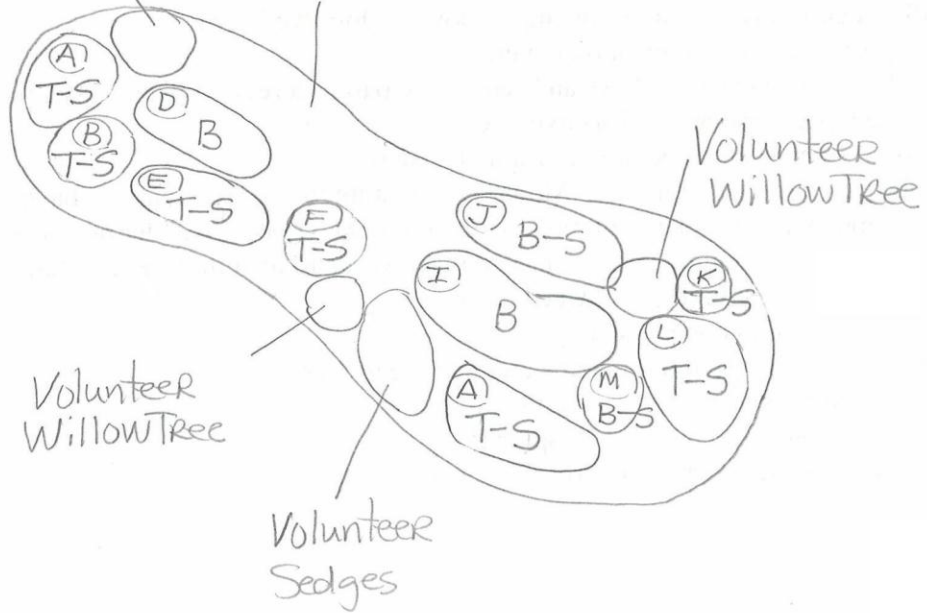
1" = 10'

Rain Garden #19  
N 40° 46.967' W 096° 37.664'



Added 3  
Monarda

open space



Rain Garden #19

7/23/2010

First Impression: Great location to capture a lot of run off, nice large plan, but needs additional plantings to fill out the design, needs mulching, weeding and edging.

Hydraulic assessment:

- 1) Has it rained within the last 48 hrs?  
No
- 2) Are any inlet structures clogged?  
No, but inflow rock drain has standing water.
- 3) Are any inlet structures misaligned?  
No
- 4) Is there any standing water?  
No, but very soggy turf around the rain garden area, some muckiness. Sprinklers could have been run prior to inspection.
- 5) Bottom assessment  
Too much open space, very weedy, invasive cattails, sedges, and willows.
- 6) Bank assessment  
Turf encroachment.
- 7) Is the overflow structure clogged?  
Yes, mulch overflow and some weeds, turf and plant litter present.
- 8) Is the overflow structure misaligned?  
No, but needs to be widened to the west.

Vegetation assessment:

- Mid summer  
Full sun with no shade during the day  
South side of the building  
Full wind exposure  
Air circulation good  
Sprinkler system – Yes  
Plants currently in bloom:  
Plants currently in bloom: Swamp milkweed, Joe-Pye Weed
- 1) Approximate % of vegetation coverage.  
50%, maybe 60% is willows and sedges are part of a revised plan. Bottom area is lacking plant material, 30% coverage.
  - 2) Compare current vegetation to original design.  
Obedient plants are missing. Monarda substitute for asters. Plantings have not become invasive and are within bounds, if anything they are under developed. Missing plants and open space has allowed weeds to be introduced; cattails, cottonwood, mulberry, dockweed, sedges.
  - 3) Does vegetation appear healthy?  
Plants show signs of too much water and are undersized.  
Chokeberry is nice, but crowded by invasives.  
Solidago undersized with 1 ft. spread.  
Joe-Pye Weed undersized with 2 ft. spread.

- Swamp milkweed is being crowded by cattails.  
Variegated Iris is barely hanging on.
- 4) Is vegetation appropriate density/size?  
Chokeberry, Solidago, Variegated Iris and Monarda undersized.  
Variegated Iris and Monarda show signs of stress.  
Surprisingly, no signs of mildew considering high moisture content.
  - 5) Where is vegetation located relative to top/sides/bottom of garden?  
Noted on diagram

Homeowner assessment discussion:

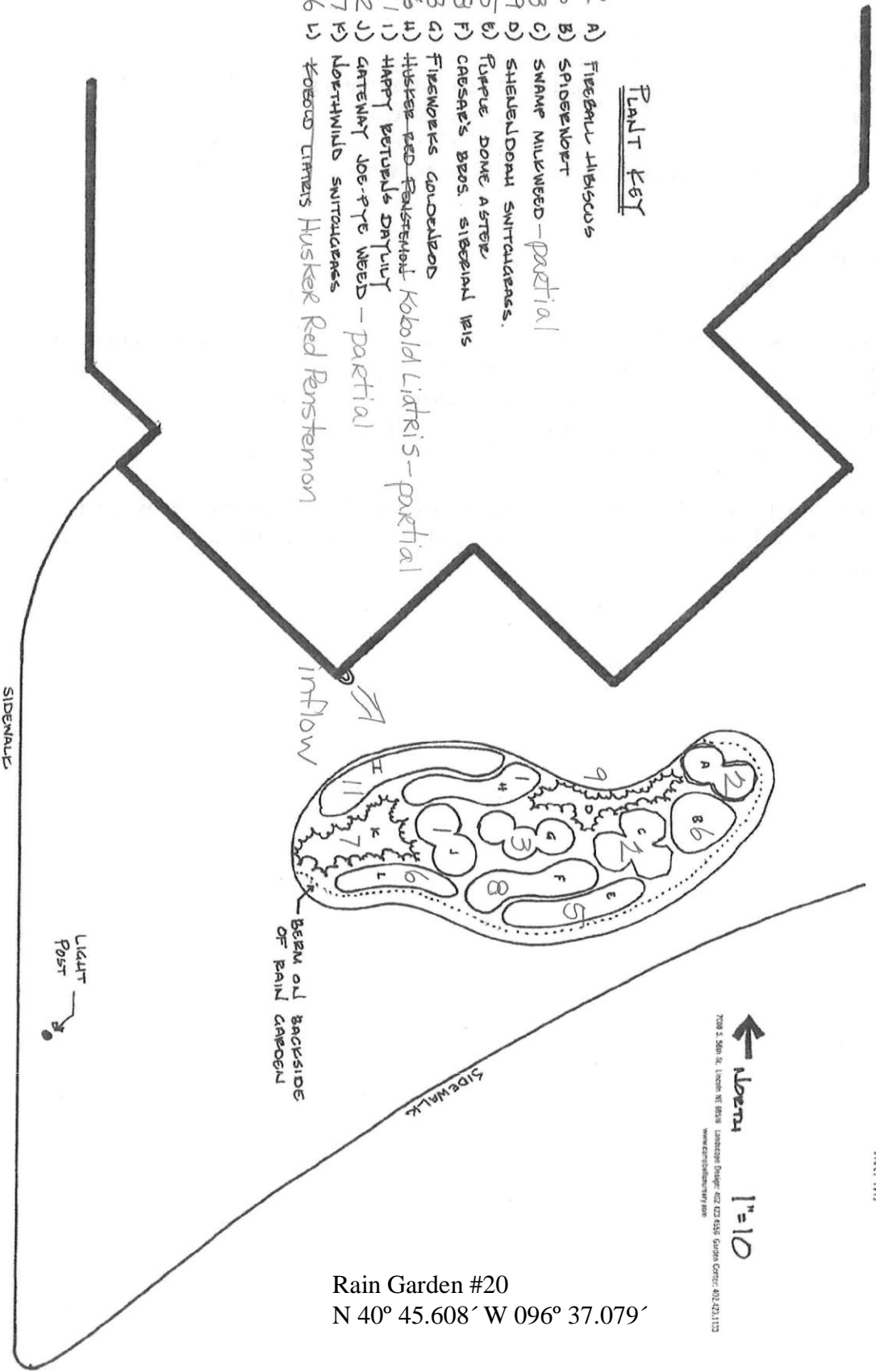
Did not participate.

Side notes: Due to high moisture content and high run off volumn, bottom plants need to be added that can stand wet feet. Many plants from the original design have died and have not been replaced. Open spaces are providing opportunity for invasive plant material. Garden is evolving into a swamp/wetland setting. The amount of run off may have been underestimated by designer.

Individual suggestions added to handout: Replace bottom plants, remove and /or relocate volunteer plants to create more fullness, suggested more water tolerant plants.

North  
1" = 10'  
700 S. 5th St., Lincoln, NE 68508  
Landscape Design: 402.433.6535 Garden Center: 402.423.1133  
www.campbellshome.com

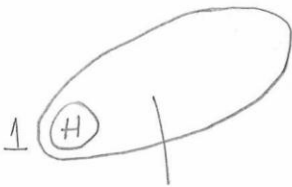
- Plant Key
- 2 A) FIREBALL Hibiscus
  - 6 B) SPIDERNET
  - 3 C) SWAMP MILKWEED - partial
  - 9 D) STELLEDOAM SMTALACEAE.
  - 5 E) PURPLE DOME ASTER
  - 8 F) CAESAR'S BROS. SIBERIAN IRIS
  - 3 G) FIREWORKS GONOLABOD
  - 6 H) ~~HUSKER RED PENSTEMON~~ Kobold Ligris - partial
  - 11 I) HAPPY BUTTERFLY DAYLILY
  - 2 J) GATEWAY JOE-PYE WEED - partial
  - 7 K) NORTHWIND SMTALACEAE
  - 6 L) ~~KOBOLD LIGRIS~~ Husker Red Penstemon



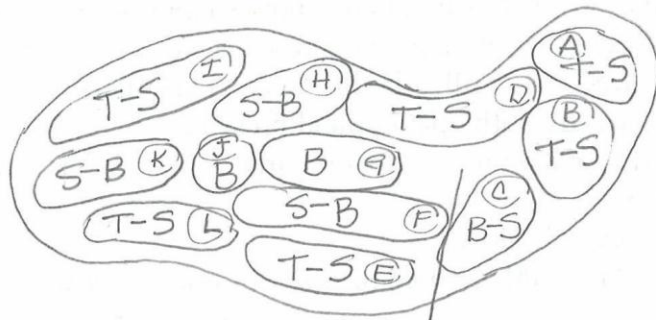
Rain Garden #20  
N 40° 45.608' W 096° 37.079'



Area H  
enlarged



open  
space  
with  
volunteer



open  
space

Rain Garden #20

7/22/10

First impression:

Very nice aesthetically, looks healthy and full, needs basic maintenance (weeding, mulching, edging), plants very nice overall, good design.

Hydraulic assessment:

- 1) Has it rained within the last 48 hrs?  
Yes
- 2) Are any inlet structures clogged?  
No, downspout feeds directly into garden.
- 3) Are any inlet structures misaligned?  
No
- 4) Is there any standing water?  
No
- 5) Bottom assessment  
Good shape
- 6) Bank assessment  
No bank vegetation planted, some erosion, signs of overflow on the west end.
- 7) Is the overflow structure clogged?  
No overflow structure built, one should be added.
- 8) Is the overflow structure misaligned?  
N/A

Vegetation assessment:

Mid-summer

Full sun with no shade during the day

South side of the building

Full wind exposure

Air circulation good

Sprinkler system – No

Plants currently in bloom: Swamp Milkweed, Joe-Pye Weed, Hibiscus, Daylily, Liatris, and Penstemon.

Plants that were especially nice overall: Swamp Milkweed, both Switchgrass, Aster, Siberian Iris, Goldenrod, Daylily and Joe-Pye Weed

- 1) Approximate % of vegetation coverage.  
70% Area H is missing.
- 2) Compare current vegetation to original design.  
H and L area plants are switched. H area, now supposed to be Liatris had only 1 plant survive. Weeds (foxtail, mare's tail, dockweed, white clover, sunflower) and invasive Milkweed have filled in this area. H area needs to be redone.  
Daylilies are very weedy with open ground present.  
Swamp Milkweed is invading into Spiderworts, Asters and Siberian Iris areas.  
1 aster did not survive.
- 3) Does vegetation appear healthy?  
Overall appearance is healthy, noted plants with issues below.

Penstemons are wilting, falling over, and have yellowing leaves.  
The 1 Liatris is falling over due to inadequate sunlight, overshadowed by the Joe-Pye Weed.

Both Hibiscus is leggy and falling over, needs support.

Spiderworts are fried.

- 4) Is vegetation appropriate density/size?

The plants are filled in nicely, with exceptions noted below.

Penstemons are too small and leggy; the area has open ground for weeds to invade.

Liatris should have done well, but only 1 plant survived.

1 aster plant should be replaced to fill out the area for full effect.

Siberian Iris are 6 ft, which is overshadowing the Goldenrod.

Milkweed plants invasive into other areas could be replanted back into there area to create a fuller look.

- 5) Where is vegetation located relative to top/sides/bottom of garden?

Noted on diagram

#### Homeowner assessment discussion:

- 1) Describe current functional garden rating.

6-8 hrs. Drains well.

- 2) Describe current aesthetic rating.

Perfect location.

- 3) If existed prior to rain garden installation, what drainage problems were solved?

No prior problems.

- 4) Check for plant information available through homeowner.

No problems noted.

- 5) Has your rain garden experience enhanced your knowledge and awareness of stormwater management and runoff water quality as important issues in Lincoln?

Yes. This has helped control roof runoff to the sidewalks and this is no longer an issue.

- 6) Have you educated others and/or made them aware of stormwater management issues? If so, have any of your contacts led to additional rain gardens being installed?

This is used for their primary students as a part of the outdoor source program.

Side notes: This is a very large rain garden and the expense of adding plants may be too great. Transplanting plants out of bounds or dividing would help to fill in open areas. Participant noted great planning with Campbell's nursery.

Have some very large weeds that need to be removed. Note – these are the best asters seen in all the gardens and by fall were 3-4 ft. across.

Individual suggestions added to handout: Replace plants in open area, relocate volunteer milkweed to create fuller look.



## Appendix H: Original native and cultivated perennial planting list

### 2007 Diagram Plantings

Anemone, September Charm  
Aster, Purple Dome  
Aster, Woods Purple  
Astilbe, Visions in Red  
Bee Balm, Fireball  
Bee Balm, Marshall's Delight  
Catmint, Walker's Low  
Chokeberry, Black  
Columbine, Blue Shades  
Coneflower, Magnus Purple  
Coneflower, White Swan  
Coreopsis, Zagreb  
Daylily, Happy Returns  
Daylily, Rosy Returns  
Fern, Japanese Painted  
Geranium, Rozanne  
Goldenrod, Fireworks  
Grass, Avalanche Reed Grass  
Grass, Japanese Red Baron  
Bloodgrass  
Grass, Karl Foerster Reed Grass  
Grass, Northern Sea Oats  
Grass, Northwind Switchgrass  
Grass, Shenendoah Switchgrass  
Hibiscus, Fantasia  
Hibiscus, Fireball  
Hibiscus, Kopper King  
Hibiscus, Aquarian  
Iris, Caesar's Bros.  
Iris, Variegated  
Joe-Pye Weed, Gateway  
Liatris, Floristan White  
Liatris, Kobold  
Milkweed, Swamp  
Miscanthus, Morning Light  
Obedient Plant, Miss Manners

### Scientific Names

*Anemone x hybrida* 'September Charm'  
*Aster novae-angliae* 'Purple Dome'  
*Aster dumosus* 'Wood's Purple'  
*Astilbe chinensis* 'Visions in Red'  
*Monarda didyma* 'Fireball'  
*Monarda didyma* 'Marshall's Delight'  
*Nepeta x faassenii* 'Walker's Low'  
*Aronia melanocarpa* 'Elata'  
*Aquilegia* 'Blue Shades'  
*Echinacea purpurea* 'Magnus'  
*Echinacea purpurea* 'White Swan'  
*Coreopsis verticillata* 'Zagreb'  
*Hemerocallis* 'Happy Returns'  
*Hemerocallis* 'Rosy Returns'  
*Athyrium niponicum* 'Pictum'  
*Geranium* 'Rozanne'  
*Solidago rugosa* 'Fireworks'  
*Calamagrostis x acutiflora* 'Avalanche'  
  
*Imperata cylindrica* 'Red Baron'  
*Calamagrostis x acutiflora* 'Karl Foerster'  
*Chasmanthium latifolium*  
*Panicum virgatum* 'Northwind'  
*Panicum virgatum* 'Shenandoah'  
*Hibiscus* 'Fantasia'  
*Hibiscus* 'Fireball'  
*Hibiscus* 'Kopper King'  
*Hibiscus* 'Aquarian'  
*Iris siberica* 'Caesar's Brother'  
*Iris pallida* 'Variegata'  
*Eupatorium maculatum* 'Gateway'  
*Liatris spicata* 'Floristan White'  
*Liatris spicata* 'Kobold'  
*Asclepias incarnata*  
*Miscanthus sinensis* 'Morning Light'  
*Physostegia virginiana* 'Miss Manners'

Penstemon, Husker Red

Phlox, Volcano Pink

Phlox, Volcano White

Rudbeckia, Goldsturm

Salvia, Marcus

Sedge, Variegated

Spiderwort, Red Grape

Summersweet, Hummingbird

Sweetspire, Little Henry

Winterberry, Red Sprite

*Penstemon digitalis* 'Husker Red'

*Phlox paniculata* 'Barthirtysix' Pink

*Phlox paniculata* 'Barthirtysix' White

*Rudbeckia fulgida* var. *sullivantii* 'Goldsturm'

*Salvia nemorosa* 'Marcus'

*Carex stylosa*

*Tradescantia x* 'Red Grape'

*Clethra alnifolia* 'Hummingbird'

*Itea virginica* 'Sprich'

*Ilex verticillata* 'Red Sprite'

# Appendix I: Basin placement of variety plantings

Original Design

Plant	RG 1	RG 2	RG 3	RG 4	RG 5	RG 6	RG 7	RG 8	RG 9	RG 10	RG 11	RG 13	RG 15	RG 16	RG 17	RG 18	RG 19	RG 20
Anemone, September Charm				1 T-S		1 T-S		1 B										
Aster, Woods Blue				1 T														
Aster, Woods Pink																		
Aster, Woods Purple	3 B	3 B	1 B		3 B		3 B		3 S-B	3 B								
Asrble, Visions in Red						1 S-B		1 T-S										
Bee Balm, Fireball																		
Bee Balm, Marshalls Delight			1 B		1 T-S													
Bloodgrass, Red Baron		1 T-S	1 B															
Catmint, Walker's Low																		
Chokeberry, Black																		
Columbine, Blue Shades						3 B		1 T-S										1 B
Coneflower, Magnus Purple							3 T-S		3 S-B	1 T-S		2 T-S						
Coneflower, White Swan													3 S-B					
Coreopsis, Zagreb																		
Daylily, Happy Returns				1 S-B	1 T-S	1 S-B			1 S-B		1 S-B		1 T-S	1 T	1 T-S	1 S-B	1 T-S	1 T-S
Daylily, Pardon Me										1 T-S								
Daylily, Rosy Returns	1 T-S	1 S-B	1 S-B				1 S-B											
Fern, Japanese Painted																		1 S-B
Geranium, Rozanne					1 B													1 T-S
Goldenrod, Fireworks	3 S-B	1 S-B	1 T-S				1 T-S		1 T-S	1 S-B	1 S-B	1 S-B		1 S-B	1 S-B	2 T-S	1 B	
Hibiscus, Aquarian			1 T-S						1 T-S					1 S-B				
Hibiscus, Fantasia																		
Hibiscus, Fireball					1 S-B													1 T-S
Hibiscus, Kopper King																		
Hrs, Caesar's Bros.	1 S-B	1 B	1 S-B		1 S-B		2 S-B		1 T-S	1 T-S	1 S-B					1 B	1 S-B	2 S-B
Hrs, Variegated																		
Joe-Pye Weed, Gateway																		
Liatris, Floristan White																		
Milkweed, Swamp					1 S-B				1 S-B	1 B		1 B	1 B	1 B	1 S-B	2 S-B	2 S-B	2 S-B
Miscanthus, Morning Light	3 S-B				3 S-B		1 T-S											
Obedient Plant, Miss Manners	2 B	1 B	1 S-B		1 S-B		2 B		1 B	1 S-B		1 B	1 S-B		1 B	1 T	3 T-S	
Penstemon, Husker Red											1 B							1 T-S
Phlox, Volcano Pink	3 B																	
Phlox, Volcano White								1 T-S										
Reed Grass, Avalanche																		
Reed Grass, Karl Foerster																		
Rudbeckia, Goldsturm		1 T-S	1 T-S		3 T-S		3 S-B		1 B				1 T-S					2 B
Salvia, Marcus																		
Sea Oats, Northern								1 T-S										
Sedge, Variegated					1 S-B													
Spiderwort																		
Summersweet, Hummingbird										1 T-S								1 T-S
Sweetshire, Little Henry				1 T-S														
Switchgrass, Northwind																		
Switchgrass, Shenandoah																		
Winterberry, Red Sprite										1 T-S	1 T-S	1 T-S						1 T-S

Variety planting survival rating:  
1-All 2-Partial 3-Missing

Variety placement within garden:  
T Top

T-S Top to side  
S-B Side to Bottom

B Bottom