Duluth Residential Stormwater Reduction Demonstration Project for Lake Superior Tributaries

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A 319 Demonstration Project Final Report to
Minnesota Pollution Control Agency
Contract Number: B10575
NRRI/TR-2011/36

July 30, 2011

Grant Project Summary

Project title: Duluth Residential Stormwater Reduction Demonstration Project for Lake Superior Tributaries

Organization (Grantee): City of Duluth Dept. of Public Works and Utility Operations

Project start date: 2-27-2008 Project end date: 6-30-2011 Report submittal date: 7-30-2011

Grantee contact name: Chris Kleist Title: Project Coordinator

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Basin (Red, Minnesota, St. Croix, etc.): Lake Superior County: St. Louis

Project type (check one):

- ☐ Clean Water Partnership (CWP) Diagnostic
- ☐ CWP Implementation
- ☐ Total Maximum Daily Load (TMDL) Development
- ☐ 319 Implementation
- ☒ 319 Demonstration, Education, Research
- ☐ TMDL Implementation

Grant Funding

Final grant amount: $167,383 Final total project costs: $157,713

Matching funds: Final cash: $0 Final in-kind: $185,629 Final Loan: $0

Contract number: B10575 MPCA project manager: Karen Evens

For TMDL Development or TMDL Implementation Projects only

Impaired reach name(s): ______

AUID or DNR Lake ID(s): ______

Listed pollutant(s): ______

303(d) List scheduled start date: ______ Scheduled completion date: ______

AUID = Assessment Unit ID
DNR = Minnesota Department of Natural Resources

Executive Summary of Project (300 words or less)

We used paired 2-block street sections in the Amity Creek watershed (Duluth, MN) to demonstrate the effectiveness of homeowner BMPs to reduce residential stormwater flow to storm sewers in an older neighborhood in a cold climate on clay and bedrock geology. Runoff from each street was measured before and after installation of stormwater BMPs. In addition, the knowledge, attitudes, and practices of residents were measured before and after BMP installation. BMPs were installed on properties of willing residents of one street ("treatment"). Most residents (22 of 25 properties) willingly participated. 250 trees and shrubs were planted; 22 rain barrels were installed; 5 rain gardens, 12 rock-sump storage basins, and 2 swales were constructed; and a stormwater ditch was re-dug and had 5 ditch checks installed in it. The post-project survey indicated an increase in understanding by treatment-street residents of where stormwater flowed to and what it affected, and an increase in willingness to accept at least some responsibility for stormwater runoff. Residents who received BMPs were generally satisfied with them and would recommend them to others. Runoff reduction proved more difficult to quantify due to high and inconsistent runoff variability between the paired streets, very few pre-BMP installation rain events, and loss of one control street due to re-paving mid-project. Capacity of installed BMPs is approximately 2.5% of the measured stormwater runoff. There is about a 20% greater reduction in runoff for the treatment street after BMPs were installed than for the control street for small to moderate storm events; while we would like to attribute this completely to our BMPs, we cannot prove that other factors weren't also at work. Peak flows also appear to have been reduced for 1 inch and smaller rainstorms, but we were unable to accurately measure this reduction. The results are available on an existing stream education website and are used to educate neighborhood, city of Duluth, and regional residents on stormwater issues, individual responsibility, and BMP options.

Goals (Include three primary goals for this project.)

1st	Goal:	Install stormwater BMPs on at least 20 residential properties in the treatment neighborhood.
2nd	Goal:	Increase property owner understanding of stormwater issues and individual responsibility
3rd	Goal:	Demonstrate effectiveness of homeowner BMPs to reduce stormwater runoff and runoff peaks from lawns and roofs
4th	Goal:	Train MCC crews, local landscapers, and interested public in rain garden construction and stormwater BMP installation

Results that count (Include the results from your established goals.)

1st	Result:	46 stormwater BMPs were installed on 22 residential properties and City property in the treatment neighborhood/subwatershed, along with 250 trees and shrubs planted.
2nd	Result:	Pre and post-project surveys showed people receiving BMPs increased their understanding of stormwater issues by about 10%, and 17% more people than in the pre-survey said property owners should take at least some responsibility for stormwater runoff (increase from 66 to 83%).
3rd	Result:	Comparison of peak runoff ratio between the control and treatment streets indicates a reduction in peak stormwater flow for rainstorms of 1.3 inches or less. The treatment street had 3% less stormwater runoff after BMP installation than the control street, and calculations show BMPs should have held back about 2.5% of total stormwater runoff.
4th	Result:	30 MCC crew members were trained in various aspects of BMP installation, including rain garden construction and building ditch checks. 15 members of the general public and 2 landscape professionals were trained in rain garden construction.

Picture (Attach at least one picture, do not imbed into this document.)

Description/location:

Numerous pictures included on CD.

Acronyms (Name all project acronyms and their meanings.)

BMP = best management practice

KAP = Knowledge, Attitudes, and Practices. A type of participant survey.

MCC = Minnesota Conservation Corps

MS4 = Municipal Separate Storm Sewer System

SIDMA = Social Indicators Data Management and Analysis Tool

SSL SWCD = South St. Louis Soil and Water Conservation District

NRRI = Natural Resources Research Institute, University of Minnesota Duluth

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Partnerships (Name all partners and indicate relationship to project)

Natural Resources Research Institute, University of Minnesota Duluth – responsible for the stormwater monitoring and data summarization, coordination of the project, data analysis, web page development, and report writing.

Minnesota Sea Grant, University of Minnesota – responsible for coordinating BMP installation and assisting with education, outreach, and data analysis.

Water Resources Center, University of Minnesota – with separate funding for evaluation, assisted with all the survey development and oversaw survey implementation; was responsible for survey results analysis.

Barr Engineering – responsible for creating rain garden engineering designs and planting layouts; assisted with BMP recommendations for each property.

South St. Louis Soil and Water Conservation District – responsible for BMP recommendations for each property, engineering designs for ditch checks, and assisted with general engineering on other BMPs.

Minnesota Conservation Corps – provided manpower for all BMP construction and installation, and provided manpower for door-to-door pre- and post-construction surveys.

University of Minnesota Extension – provided expert to lead the rain garden construction workshops.

Regional Stormwater Protection Team – this partnership of local MS4s provided the moral support and impetus for the project and will help use the results and recommendations from the project.

Lake Superior Streams.org – this website hosts the project webpages.

Work Plan Review

Introduction

The goal of our project was to demonstrate the effectiveness of residential Best Management Practices (BMPs) at reducing stormwater runoff to a tributary of Amity Creek, which flows into Lake Superior on the eastern edge of Duluth. We installed residential stormwater runoff BMPs in a subwatershed in an older residential neighborhood and compared the runoff to that of a similar control subwatershed without stormwater BMPs. The neighborhoods we used are located in the Lester-Amity stream system that is on the Minnesota 303(d) list for turbidity. The tributary receiving the runoff from the targeted neighborhood is being severely eroded by high peak flows and was delivering highly turbid water to the stream. We measured stormwater flow, temperature, conductivity, and turbidity in the storm sewers in the subwatersheds before and after BMP installation. Residents' knowledge of runoff issues, solutions, and responsibilities was also evaluated at the beginning and end of the project.

Background

Duluth's urban streams provide the network for the city's stormwater runoff system, with 500 miles of storm sewer, creeks and ditches, as is typical of other coastal zone communities (Axler and Lonsdale 2003). As such, these streams are important components of the City's Stormwater Management Plan, which lays out strategies and permit requirements to solve Duluth's runoff problems. The Lester River – Amity Creek stream system is one such stream entering Lake Superior within the Duluth city limits. The combined watershed covers 33,300 acres and encompasses 94 stream miles (Figure 1). By itself, the Amity Creek watershed is the largest watershed within the city of Duluth, with approximately 3200 of its 10,000 acres within the city limits. The Lester-Amity system is a designated trout stream that contains native brook trout and is stocked with trout and salmon.

Both Lester River and Amity Creek are on the Minnesota 303(d) list for excessive turbidity. Other Lake Superior North Shore and South Shore streams, and streams elsewhere around the Great Lakes, face a similar problem. In the western arm of Lake Superior, streams nearing the lake often cut through clay soils. These highly erodable soils are particularly vulnerable to excessive stream power caused by high levels of runoff during heavy rainstorms and snowmelt (Anderson et al. 2003). Runoff from residential neighborhoods helps to create these high peak flows, leading to the erosion that creates turbidity in Amity Creek and similar stream systems.

In addition to stormwater runoff being increased simply by the construction of roads, houses, and driveways, along with the corresponding loss of forest cover and water storage, two other things have inadvertently exacerbated the stormwater runoff problem for this area of the city. These are the disconnection of residential footing drains and the inadvertent crossing of watershed boundaries by storm sewer lines.

Recently, residential footing drains throughout the city were disconnected from the city's sanitary sewer system, as required, and sump pumps were installed discharging water to yards and ultimately to the stormwater sewer system. This resulted in an additional 10-20 gallons of water potentially entering the storm sewer system per minute per household during heavy

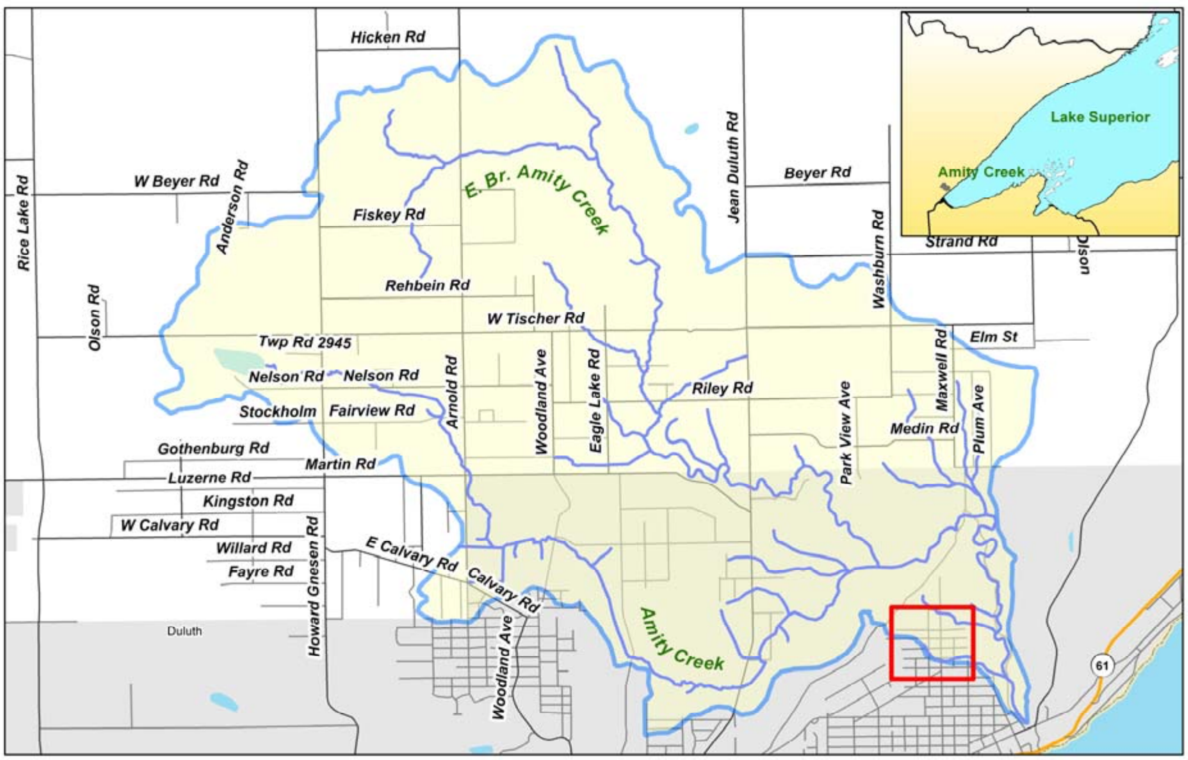

Figure 1. Lester-Amity watershed on the east edge of Duluth, Minnesota. Red square indicates general location of project area.

rains (15,000 – 30,000 gal/hr for a 25-home neighborhood). City staff report many complaints from residents about wet yards and winter icing from sump pump activity. The City is seeking an effective program for addressing this nuisance ponding at the source, and reducing flows to the storm water system and winter icing problems.

Secondly, the neighborhoods were built along a hillside that contained a number of very small watersheds which drained directly to the lake. These tiny streams were mostly captured and their water diverted into storm sewers which run parallel to the lake and into a tributary of Amity Creek (Figures 2 and 3). The inadvertent result of the neighborhood and storm sewer construction is that stormwater that historically ran down small creeks directly to Lake Superior now instead is concentrated and moved across original watershed boundaries to outfall into small stream channels that were not sized to handle the increased flow volumes. This effectively increases the watershed size and flow volume for the affected watersheds. The neighborhood where we are working began to be constructed at least 75 yrs ago, when it is unlikely that engineers realized that they were moving water across watershed boundaries. Instead, they were controlling flow, getting water off the streets, and moving it to the nearest larger streams. However, during large rain events, tens to hundreds of thousands of gallons more water are flowing into the receiving creeks and tributaries.

We discovered this re-allocation of water accidentally when trying to construct true drainage sheds for the streets in our project. Our GIS personnel quickly realized that the flow on the ground did not match the watershed boundaries based on surface topography, nor could correct flow paths be developed without including storm sewers. Figuring out how to force GIS surface-flow programs (e.g., ArcHydro) to account for underground flow through storm sewer pipes was somewhat challenging, but ultimately provided quite interesting results (Figure 2). Investigations of this nature in urban areas with steep topography may help stormwater engineers better understand and plan for flow sizes and water movement.

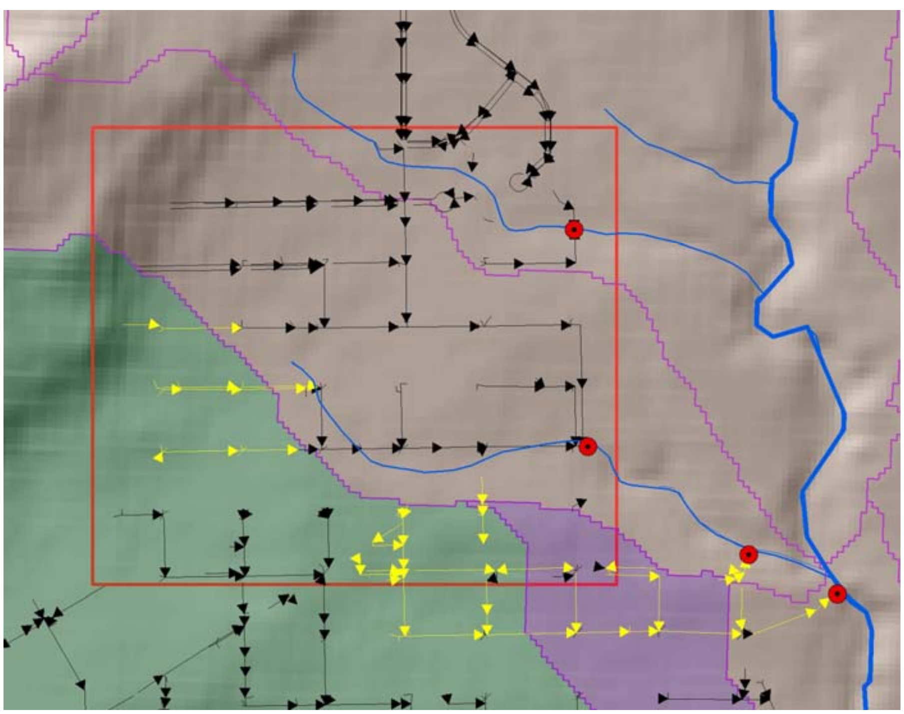

Figure 2. GIS illustration showing how storm sewers (lines and arrows) cross former watershed boundaries (different background colors) in the project area. Wherever the lines and arrows are yellow, this indicates that storm sewer water is being moved across watershed boundaries. Arrows indicate flow direction. Red square outlines general project area. Red circles are storm sewer outfalls into Amity Creek and its tributaries (blue linework). Purple lines are watershed or subwatershed boundaries.

To help alleviate the erosion caused by the "extra" water flowing into the Amity Creek tributary receiving the stormwater runoff from our project area, the city of Duluth recently did major reconstruction and erosion protection on this creek channel (Graves Rd Creek). This effort greatly reduced the tributary's water turbidity and stopped the worst stream bank erosion. Reducing stormwater runoff to this tributary would alleviate more of the pressure on its banks.

In Duluth, total runoff infiltration is typically not feasible due to the clay soils and bedrock, so we anticipated that our main impact would be to reduce peak runoff rates during storm events. We also documented the challenges and solutions to retrofitting older residential areas (50-100 yrs old) with runoff BMPs. Project results are available to the public on the important educational website, www.lakesuperiorstreams.org.

Changes to work plan

Selection of paired watersheds for analysis: Instead of evaluating two different areas within the watershed before selecting the area in which to work, we quickly eliminated one area at the beginning of the project. We determined that the stormwater sewer system in one of the proposed areas was unsuitable for accurate measurement of stormwater flows with the equipment we had available. Thus, we restricted all of our work to a single area in Duluth's Lakeside section.

BMP construction workshop: Instead of holding this workshop as planned to train Minnesota Conservation Corps crews, we determined that they would do better with hands-on on-the-job training. In addition, in 2010 we held two rain garden construction workshops for local landscapers, garden professionals, and anyone else interested. Workshop attendees toured the rain gardens constructed by MCC in the treatment area in 2009.

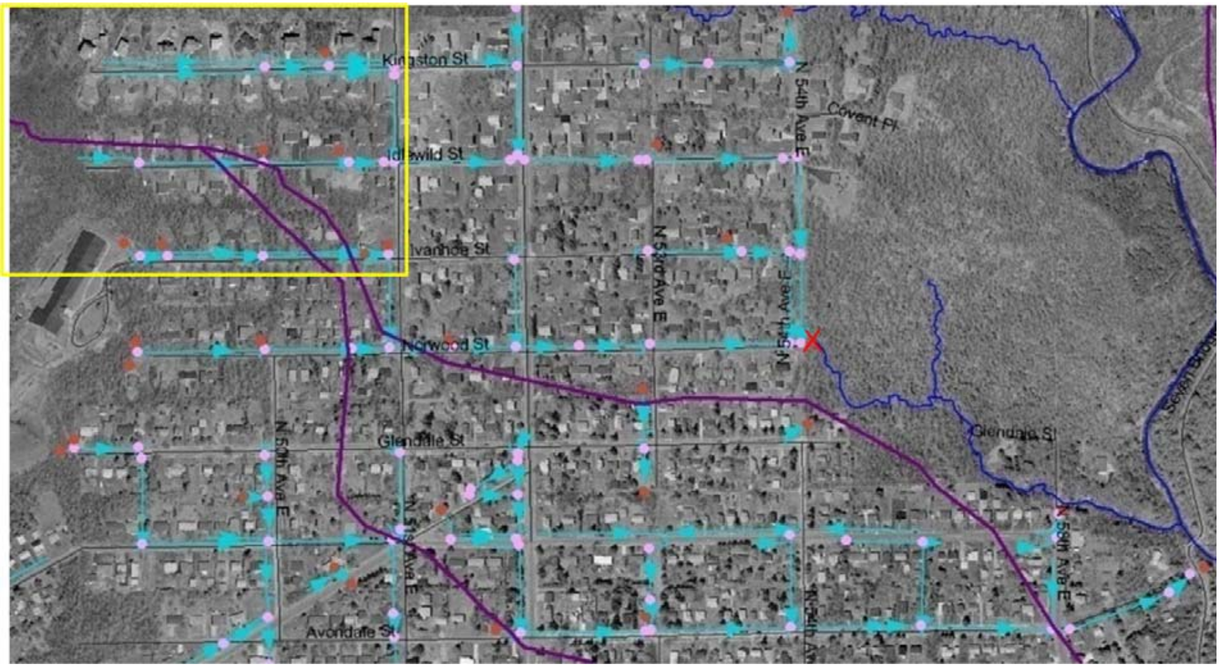

Figure 3. Aerial photo of project area (yellow square) and its relationship to local watersheds (boundaries in purple) and streams (dark blue linework). The light blue lines and arrows indicate storm sewers and their flow direction; brown dots are manholes. The red X indicates where the stormwater from the project area empties into a tributary of Amity Creek (locally named Graves Rd. Creek).

Task reports

<u>Program Element #1 – Pre-installation analysis of paired watersheds</u>:

<u>Objective A – Install monitoring equipment in storm sewers: field season 1</u>

City of Duluth/Utility Operations and UMD Natural Resources Research Institute personnel installed flow loggers and multi-parameter probes measuring temperature, conductivity, and turbidity in the storm sewers of the proposed control and treatment streets, Ivanhoe St. and Kingston St. in the spring of 2008. When a third street was added to the mix (see Objective D), similar equipment was installed in the Idlewild St. storm sewer in the fall of 2008. The equipment was placed in the storm sewer pipes themselves at the bottom of each two-block street section. Upstream flow above the study area did not have to be subtracted out because these blocks were dead-ends, meaning that there was no upstream storm sewer flow to subtract out. Recording equipment was in place in the storm sewers of all 3 streets during the ice-free seasons (typically April – November) of the years 2008-2010.

We also recruited two residents within a few blocks of the area to read the rain gauges, record rainfall amounts, and provide the data monthly to project PIs. These rain gauge readers allowed us to determine that a recording rain gauge located within a mile of the study area (our primary rain gauge) began mal-functioning mid-project. A NOAA National Weather Service forecaster also installed a small weather center in the fall of 2008 at his home within a block of the project area and allowed us to use his rainfall data, which turned out to be the most accurate.

<u>Objective B – Collect baseline stormwater data: field season 1</u>

Flow, temperature, turbidity, conductivity, and rainfall data were collected for one complete field season (2008) prior to stormwater BMP installation for two of the streets (Ivanhoe and Kingston), but only the fall 2008 storm events were captured for the third street, Idlewild. The intention was to establish a pre-installation baseline for each street/subwatershed for flow, turbidity, and temperature, allowing quantitative assessment of the change in these parameters after BMP installation.

Unfortunately, storm sewer flow was much more variable than anticipated, with streets discharging highly variable amounts of storm water for similar-size rainfall events (Figure 4). Nor were the relative amounts of runoff among the streets consistent with each other. Peak runoff amounts switched among streets and through time with no consistent pattern that we could determine even after considering watershed area, impervious surface amount, antecedent rainfall amounts and soil moisture, and season. Turbidity measurements proved even more problematic due to the amount of sand moving through storm sewers, which was unanticipated. Even with weekly cleaning (double to quadruple the amount of cleaning anticipated), sensors could not be kept clean enough to provide reliable turbidity data, and these measurements could not be used or evaluated.

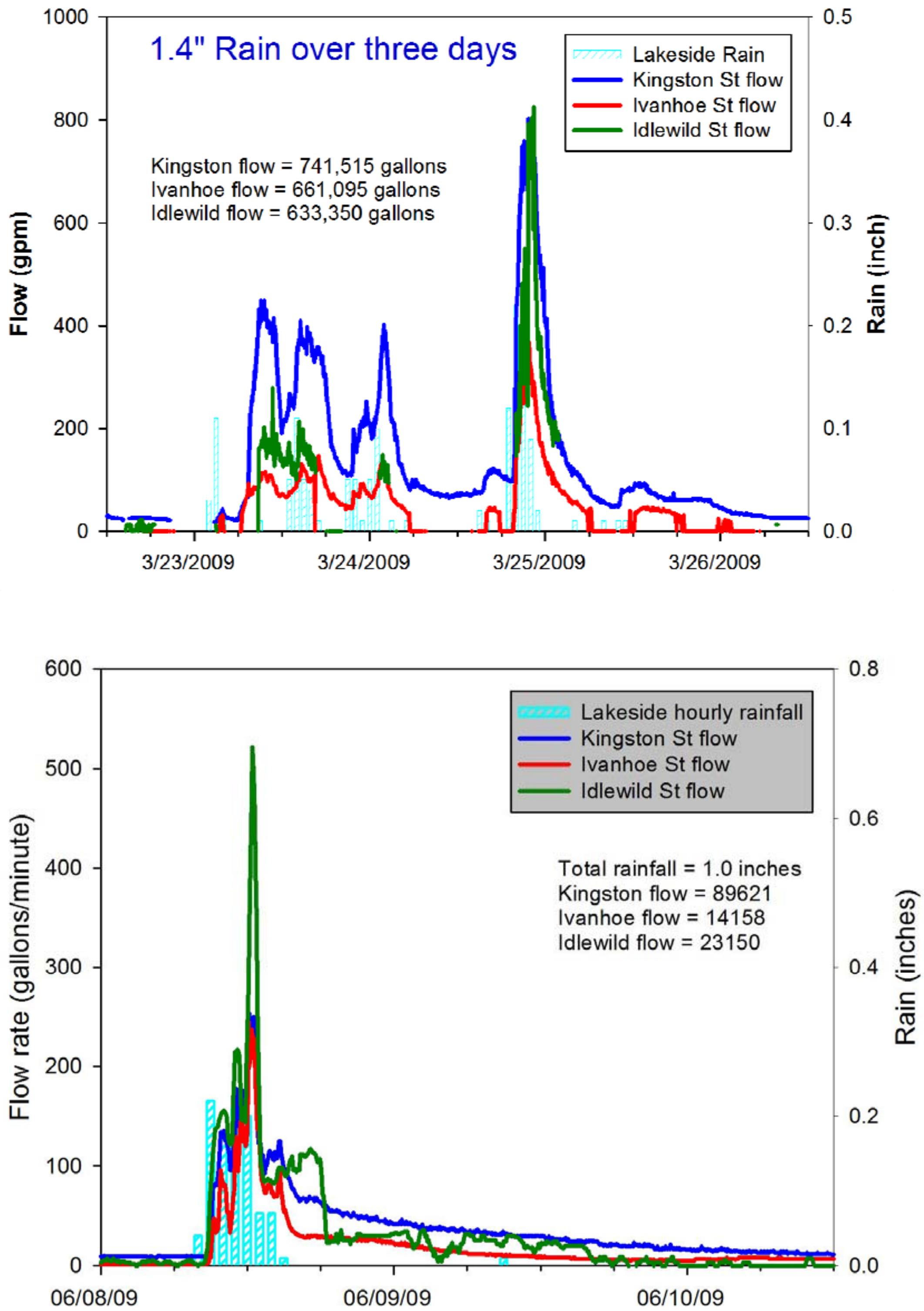

Figure 4. Storm sewer flow in the three project treatment streets during two rainstorms in early 2009 illustrating the variability in runoff from the streets between storm events and as affected by season and antecedent conditions. Note also gaps in the flow data where the water depth was either too low for the sensor, or when the sensor stopped reading for some other reason (e.g., blocked by debris, etc.).

Objective C – Canvass target neighborhoods: field season 1

The Minnesota Conservation Corps college students were trained by Dr. Karlyn Eckman, Water Resources Center, University of Minnesota, to help us do a pre-project survey of residents in the study area. This survey was done in the spring of 2008 and provided a baseline for the stormwater knowledge of study area individuals. We also asked residents if they would be willing to participate in this project and consider accepting BMPs at no cost to themselves (but with a time commitment from them). Many residents indicated that they would be willing to participate.

Summary of survey results (see appendix A for full questions and summary): Sixty three households completed the survey; this is a total response rate of 72%. Most respondents (67%) understood that stormwater drains from their property through storm drains to Lake Superior, but few (22%) knew that the stormwater first enters Amity Creek before reaching the lake. In addition, only 50% knew that there was a stream 5 blocks away, and many of these folks incorrectly identified it as the Lester River (which is the next stream over). However, most (55%) knew that stormwater and sanitary sewer water are treated separately in Duluth. In more free-form responses, residents discussed basement flooding, reporting that their basements had flooded several times in the last 10 years. Many residents used sump pumps (65%), and a number use drains and tile to direct water off their property into storm sewers. Survey crews found little evidence of stormwater management using rain gardens, rain barrels, or similar stormwater retention BMPs. Most respondents understood that development uphill resulted in greater stormwater flow downhill. Most residents said that what they knew about stormwater was from the TV news or weather. Only 38% of respondents thought that stormwater might cause a problem for Lake Superior. Very positively, 79% of respondents were interested in learning more about this project, and 64% said that they would be willing to install a BMP on their property if most of the cost and effort were covered by the project.

Objective D – Select target neighborhood: Off-season 1

Because we only evaluated one area for the project location instead of the planned two (see Changes to Workplan), the only decision to be made was which 2-block street segment should be the treatment and which the control. Initially, we were only considering Ivanhoe and Kingston streets because their storm sewers were configured identically according to city sewer maps. However, when we held a neighborhood meeting that fall (2008) to introduce the project and determine which street had more willing participants, many residents of Idlewild Street (the street between Kingston and Ivanhoe) came and lobbied to be the treatment street because of the stormwater runoff problems they had on their street. In addition to the residents being more interested in the project, a consultant from Barr Engineering also recommended to us that we use Idlewild as the treatment street. The engineer, who has done a lot of residential stormwater BMP work in the Twin Cities, walked all three streets with us and gave us several reasons why Idlewild St. would be the better street for stormwater BMPs. First, Ivanhoe had more trees, shading, and a lot of very cracked pavement that was already helping water infiltrate and keep it cool. Second, Kingston St. was very new and had some stormwater runoff controls built in; in addition, the highly manicured lawns of the residents and their lack of participation at the public meeting suggested that getting them to accept BMPs might be more difficult. This left Idlewild St. as the best treatment street option, and it had the benefit of having residents who wanted help with stormwater runoff problems.

Thus, Idlewild St. was selected as the treatment street. After walking the street and looking at the configuration of the storm drains and storm sewers, the Barr Engineer and the PIs reached agreement that the somewhat different configuration of storm sewer pipes between this street and the other two would likely not be a significant problem. This left two control streets (Kingston and Ivanhoe) instead of only one. This also meant that we would not be able to use the elementary school as one of the public demonstration treatment areas. However, closure of the school by the city had recently been announced, so it is unlikely we would have been working at or with the school in any case. The school closed at the end of the 2009-2010 school year.

The NRRI GIS lab used ArcHydro to create actual drainage areas (i.e., subwatersheds) for each of the three two-block streets in the study (Figure 5). These drainage areas showed that we could not simply think about "streets" as the study units. Because the streets are built on hills in two directions, north and west, water flows diagonally through the neighborhoods. Storm sewer water on each street comes from the hillside into which the street dead-ends to the west (known as Hawk's Ridge, the runoff from yards and driveways on the upslope side of the street (north); and runoff from the backyards of the houses on the street "above" the street in question (uphill to the north). Houses on the downhill side of each street (south side) contribute very little or nothing to each street's runoff; instead, their runoff flows into the backyards of the people behind them on the next street downslope, or in some cases into ditches and or tiny streams that flow between the backyards parallel to the streets.

Based on this information, we elected to offer our most intensive BMPs to those residents whose properties contributed to the stormwater of the treatment area. However, we also offered simple BMPs (e.g., rain barrels, yard aeration) to any resident of the street we called the "treatment" street in a show of good will.

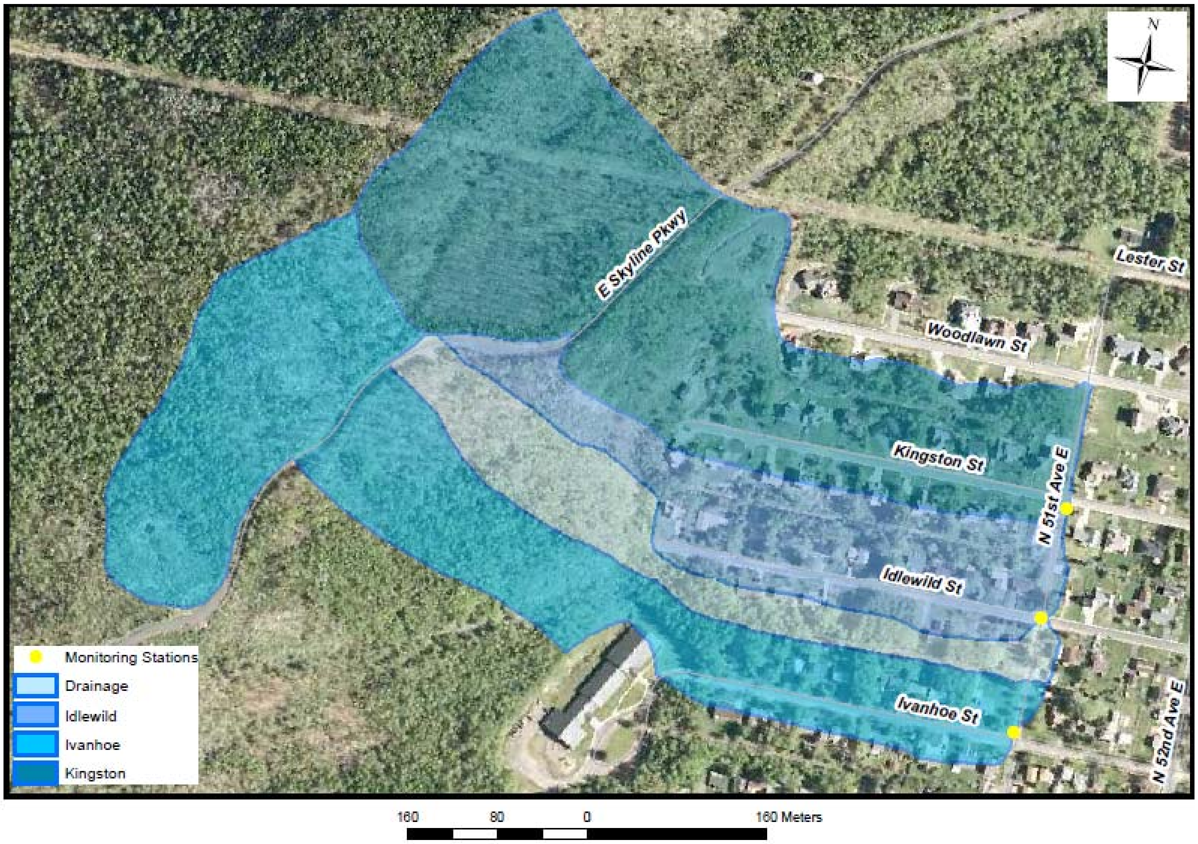

Figure 5. Aerial photo of project area with GIS overlays showing drainage areas for each street's storm sewer system (in various shades of blue). The lightest color (labeled "drainage" in the key) is the drainage area of a small stream that flows between the streets and is not captured by the storm sewer system. Yellow dots show locations of monitoring equipment.

Program Element #2 – Stormwater BMP Installation:

Objective E – Design property-specific BMPs: Off-season 1

City personnel, SSL SWCD staff, staff from Barr Engineering, and Minnesota Sea Grant and NRRI research staff worked one-on-one with willing property owners to select and design an appropriate BMP for each property. BMPs included rain gardens, grassy and rock swales, rain barrels, rock-filled sumps, trees and shrubs, and lawn aeration. Carol Andrews, Barr Engineering, created engineering designs, plant lists, and planting diagrams for most of the rain gardens, working with property owners to determine the size and type of rain garden and plantings that would be acceptable. Keith Anderson, engineer for SSL SWCD, created engineering designs for ditch checks in a stormwater ditch in the treatment area, and helped determine the engineering for two swales. Jesse Schomberg of Minnesota Sea Grant worked with property owners to determine types and locations to plant trees and shrubs, and on rain barrel placement and swale design.

Objective F – Conduct BMP Training Workshop: Pre-season 2

After discussion with Minnesota Conservation Corps leaders, we determined that on-the-job training would be a better fit for the MCC youth corps who would be constructing most of the BMPs. In addition, spring and early summer were the busy season for local landscapers and garden professionals, and their interest in attending a workshop at that time was low. Thus we postponed the workshop and instead worked with MCC crews in a less formal manner for the BMP installations occurring during the summer of 2009. MCC college corps crews assisted in planting trees and shrubs in May, including fencing them to protect them from deer. They received on-the-job training by Jesse Schomberg, Minnesota Sea Grant, and were assisted by a UMD Environmental Studies intern and NRRI staff. MCC youth corps were given on-the-job training in the construction and planting of rain gardens, construction of ditch checks, construction of swales and proper citing of drainage tile, and construction of ditch checks. Training was provided by Valerie Brady (NRRI), Carol Andrews (Barr Engineering), Keith Anderson (SSL SWCD), and Jesse Schomberg (Minnesota Sea Grant). All crews were given overviews of the project and a presentation on the environmental issues relating to stormwater by Valerie Brady, who researches stormwater issues as they relate to Duluth and north shore streams.

In the summer of 2010 Minnesota Sea Grant hosted two 8-hr rain garden workshops for the general public and local landscape professionals and gardeners. Each workshop was attended by 8-10 people, mostly local gardeners. We had two master gardeners and two landscape professionals attend. Workshops were run by Eleanor Burkett, University of Minnesota Extension Service. Sea Grant staff were also available to answer questions and offer advice about other stormwater BMPs in addition to rain gardens. Both classes were given tours of the BMPs installed by this project in 2009 and participated in planting two additional rain gardens.

Objective G – Install Stormwater BMPs: Field season 2

BMPs were installed during late June and early July of 2010. Manpower was provided by various Minnesota Conservation Corps college and youth groups, while supervision and instruction was provided by NRRI and Minnesota Sea Grant researchers and staff, SSL SWCD engineers, and staff from Barr Engineering. The City of Duluth provided equipment and coordinated materials deliveries, and the University of Minnesota Duluth Buildings and Grounds Department also loaned equipment to the project.

Property owners were asked to either provide a $200 cash match or work with the crews as BMPs were installed on their properties. All property owners chose to volunteer their time during installation and in maintenance of the BMPs. We decided against having participants sign a formal agreement as we did not want to discourage participation. Instead, residents were offered a pledge to sign to help protect their local creek by protecting their storm drain and doing as much as they could to reduce runoff from their property. Three property owners signed this formal pledge. Aside from the funding/labor match, all other costs for material and labor were provided as part of the grant. Participants agreed to take ownership of the completed BMP(s), take care of them in an appropriate fashion, and participate in an evaluation of effectiveness (part of the post-project survey).

Sixteen property owners chose to have trees and shrubs planted on their properties, and a total of 250 trees and shrubs were planted by MCC college students in May of 2009. All plantings were fenced to decrease deer depredation. Seventeen residents asked for their properties to receive lawn aeration (plug removal). Twenty two rain barrels were installed on 17 properties. Five rain gardens were constructed on four properties (average cost estimated at $30/sq. ft with at least an extra $30/sq ft of donated labor and equipment). Four ditch checks were installed in a stormwater ditch running between Idlewild and Kingston streets between the back yards, and this ditch was re-dug where it had filled in with sediment, so that it could better handle the volume of stormwater it was receiving. Two properties had stormwater swales constructed on them to better direct stormwater and spring flow to create fewer problems with wet basements and yards and to hopefully help reduce significant street icing problems. Icing on the upper portion of Idlewild often led to significant quantities of salt being applied by city crews, according to residents. Finally, 12 rock sump storage basins were constructed as extra stormwater storage. Most of these storage basins were right along the edge of the street where basement sump water was daylighting or to create extra storage for rain gardens when they overflowed. See summary in Figure 6.

Figure 6. Summary of stormwater runoff BMP treatments installed in the treatment area, by property. Yellow rectangle shows approximate drainage area (although it extends further to the left than the scope of this picture). A = lawn aeration; B = rain barrel (number indicates number of more than 1); D = stormwater ditch; G = rain garden (number if more than 1); M = location of monitoring equipment; N = treatment refused; S = rock sump; TS = trees and shrubs planted.

Program Element #3 – Evaluation of BMP Effectiveness:

Objective H – Collect post-installation stormwater data: field season 3

City of Duluth/Utility Operations and UMD Natural Resources Research Institute personnel installed flow loggers and multi-parameter probes measuring temperature, conductivity, and turbidity in the storm sewers of the treatment street (Idlewild) and the control streets (Ivanhoe and Kingston) in the spring of 2010 and left until Nov. 2010. As before, the equipment was placed in the storm sewer pipes themselves at the bottom of each two-block street section. The equipment took measurements every 5 minutes.

The same two residents who live within a few blocks of the area read the rain gauges, recorded rainfall amounts, and provided the data monthly to project PIs. We again used the weather center at the home of the NOAA National Weather Service forecaster as the most accurate record of local rainfall.

Questions about the BMPs were also included on the post-project door-to-door survey, with recipients being asked how they liked the BMPs, how difficult they were to care for, and whether or not they thought the BMPs were working. All recipients thought their BMPs were probably functioning as intended, and several attributed reduced water problems in their homes or on their properties to the BMPs. However, they said they had no way to access whether or not the BMPs were actually helping reduce stormwater runoff peak flows. Most indicated that the BMPs were not difficult to maintain. Some who accepted rain gardens seem to have had to do more weeding and care than they had anticipated. Nonetheless, most BMP recipients said they would recommend their BMP to friends and neighbors.

Objective I – Analyze pre and post-installation stormwater data: Off-season 3

Going into this project, we knew that data analysis would be difficult. However, the data proved even more problematic than we had anticipated. We had counted on being able to develop a relationship of runoff amounts between the treatment and control streets using the storm flow measured during the pre-treatment period (2008). In other words, while we did not expect the runoff amounts from the streets to be the same, we did expect that they would be proportional to each other and that this proportionality would be reasonably stable across various size rainstorms and seasons. Unfortunately, this proved not to be the case, with runoff amounts from each street behaving quite differently even given similar rain events in the same season (see Figure 4). For example, in one rainstorm, one street would have 10x the runoff of the other streets, but in the next rainstorm, a different street would have much higher runoff than the other streets (see data appendices).

Despite numerous attempts to determine the reasons behind these differences, we have yet to discover the cause(s) and we cannot tell if the differences are real (i.e., if runoff really is that variable) or if something about the sewer pipe environment caused the meters to mis-read flow in such a way that the data look “real” but are actually inaccurate. We have investigated antecedent conditions (time since previous storm and amount of previous storm), season, and drainage area size, and none were able to remove or greatly reduce this variability. Because we had doubts about the accuracy of some of the data, we decided to drop rain/runoff events from the dataset in which any street's measured runoff was more than 100% different from the average runoff from all three streets for that runoff event. This was done after standardization of the runoff amount for the watershed area of each street, and after small rain events which could not be accurately measured (see below) had already been dropped. We dropped 5 events (2 pre-installation and 3 post-installation) based on these criteria.

We also determined that the flow measurement equipment did not work well for small flows. Thus, stormwater flows that created less than 1.5 inches of flow depth in the pipes could not be measured accurately, and we had to drop all of these smaller stormflows from the dataset used for data analysis.

Another complication was that one control street (Ivanhoe) was resurfaced at the same time that the BMP treatments were being installed on the treatment street. Thus we had to drop this street from use as a control street because the resurfacing seems to have increased the runoff from this street (Figures 7 and 8).

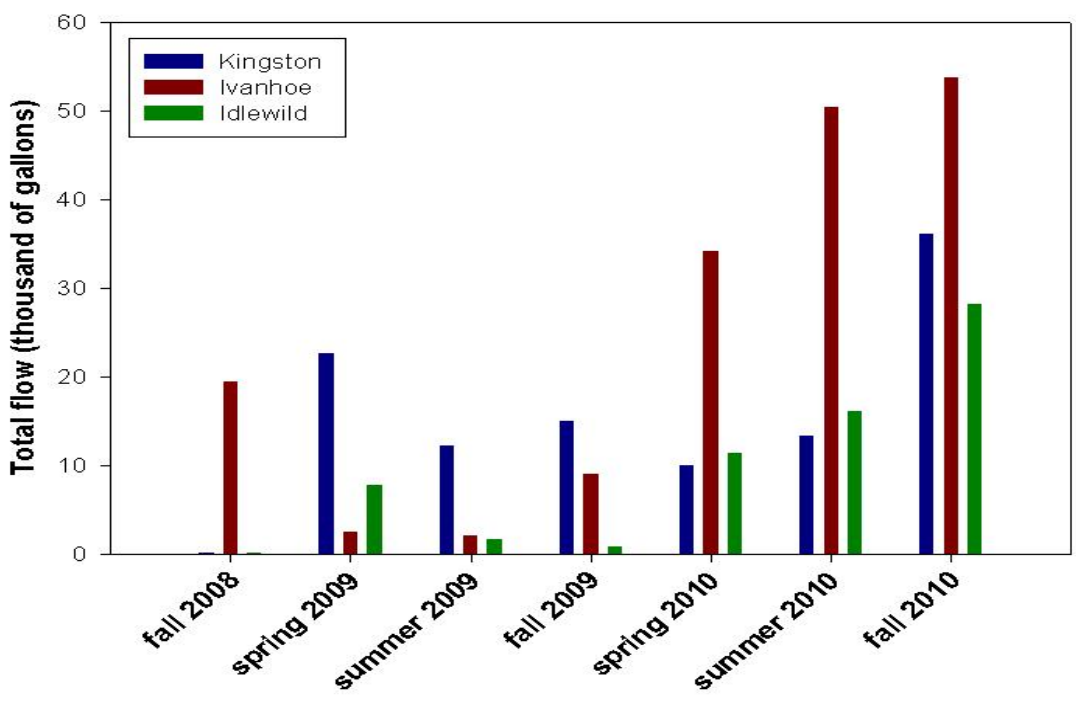

Figure 7. Summary of stormwater runoff by season from each street. Idlewild is the treatment street and BMPs were installed in the summer of 2009, which was very dry. The control street Ivanhoe was resurfaced during the summer of 2009 and this appears to have greatly increased the amount of stormwater runoff from this street. Thus, we dropped using this street as a control.

Also troubling, but less difficult to deal with, the flow measurements were periodically interrupted during many storms (see data gaps in Figure 4). We were unable to determine the cause of this interruption, but we suspect that debris temporarily blocked the sensors and then were eventually swept away by the flow. Flow meter care crews noted much greater amounts of debris were moving down the storm sewers than we had anticipated, including sticks from a beaver who tried to build a dam inside the storm sewer pipe on the treatment street. We were able to generate reasonably-accurate volumes for the flow in these cases by interpolating for the missing data. However, as mentioned above, it is also possible that the meters kept reading but were “tricked” into providing inaccurate readings; we have not been able to figure out how to determine this within the dataset.

As mentioned previously, the turbidity sensors could not be kept clean enough to provide accurate data despite weekly cleaning, due to the amount of sand and silt moving through the storm sewer pipes. Thus, these data are not considered trustworthy and have been dropped from consideration.

Despite all the issues with the data, we have attempted to determine whether overall stormwater flows in the storm sewer system of the treatment street were reduced by the BMPs we installed. Because we could not establish a relationship between the primary control street (Kingston) and the treatment street (Idlewild), we instead compared runoff differences between the two streets before and after the BMPs were installed. If the treatments made a difference, then the runoff from the treatment street should be less, while the runoff from the control street should stay the same when comparing pre and post-treatment runoff. After we removed the very small runoff events, those in which the runoff from one street was an outlier from average of all 3 streets, and finally, removed storms from the post-treatment period that were much larger than those occurring in the pre-treatment period (< 1.3 inches of total

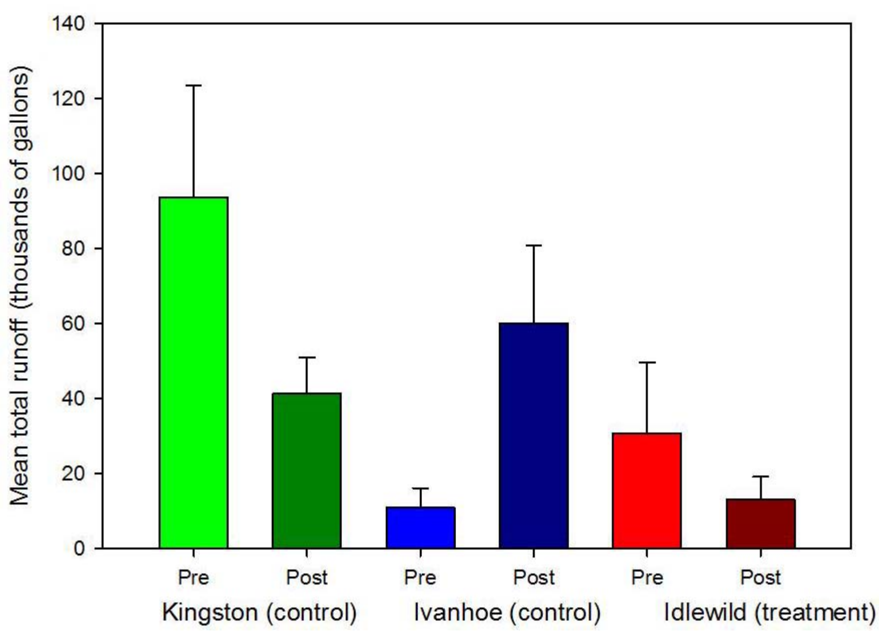

Figure 8. Mean total stormwater runoff in thousands of gallons from each street before and after BMP installation, including standard errors. Valid comparisons are pre and post runoff for each street alone, not among streets except as a relative or percent difference.

rainfall), we were left with 5 pre-treatment events and 15 post-treatment events.

Mean runoff decreased between the pre and post-treatment periods for the primary control street (Kingston) and the treatment street (Idlewild), but increased greatly for the control street that was resurfaced (Ivanhoe) (Figure 8). Mean runoff on Ivanhoe increased by 80% after resurfacing. This is probably not only due to increased runoff from the now-perfect pavement, but also because the resurfacing would have corrected any situations in which runoff was being shunted around storm drains and evading our monitoring devices. Mean runoff from the other control street (Kingston) decreased by about 56%, and mean runoff from the treatment street (Idlewild) decreased by about 59% (Figure 8). Interestingly, this difference in the decrease in runoff amounts (3% greater decrease for the treatment street) is approximately the same percentage as the calculated amount that the stormwater BMPs could capture (Table 1).

When calculated as mean percentage of rainfall that ran off of each street, the percentage of rainfall running off Kingston Street was 68% lower, on average, in the post-treatment period, and was 79% lower on Idlewild Street. The amount of rainfall running off Ivanhoe Street in the post-treatment period, on the other hand, increased by 3.5 times, or 350%.

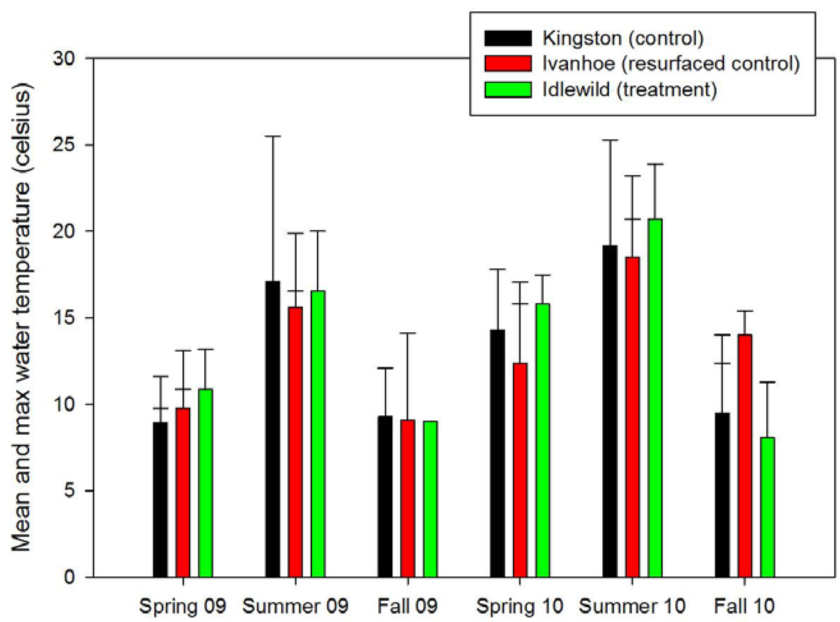

Figure 9. Mean and maximum water temperature in street storm sewer pipes, compiled by season for each of the three streets in the study area.

Temperature changed predictably among seasons, but little difference was seen among streets (Figure 9). Given that Kingston Street had the least amount of tree cover and Ivanhoe the most, we would anticipate runoff temperatures varying accordingly, but other than higher summer maximum temperatures in Kingston, there was little signal in the data related to tree cover.

Thermal loading represents the total amount of heat carried by the runoff. Volumes and temperatures were measured simultaneously in the storm sewers. We estimated thermal loading by multiplying the volume of water running through the storm sewers by its temperature for each of the storm events we used to compare volume (see above paragraphs), although we had to deal with a few instances of missing data from each street.

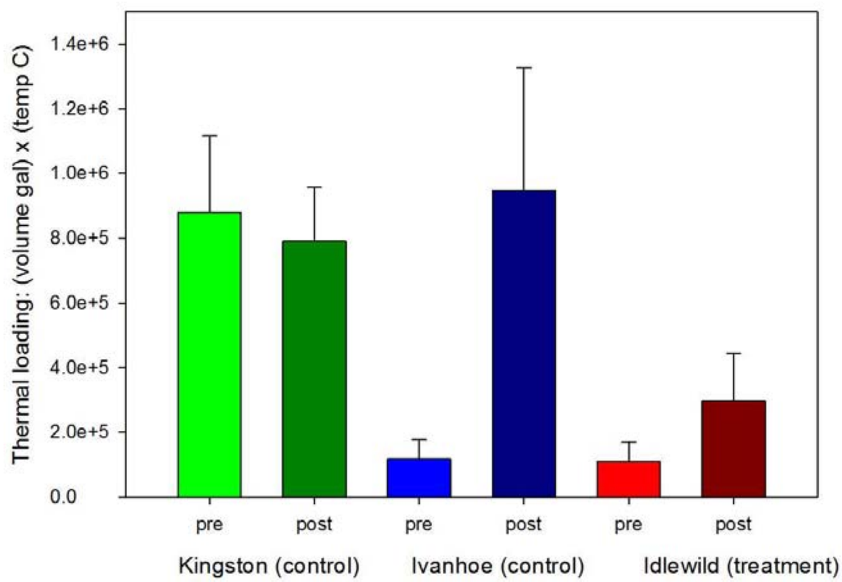

Figure 10. Mean and maximum calculated thermal loadings for the water in the project area storm sewers from pre and post-BMP installation storm events. Thermal loading was calculated by multiplying storm sewer runoff volume by the temperature of the water.

Extremely warm water with little runoff is much different than somewhat warm runoff coming in large volumes. Considerable variability, again, hampered our efforts at quantifying changes based on our work; this is exemplified by the slight reduction in heat loading on Kingston Street during the project, and the increased heat load on Idlewild (Figure 10). The order or magnitude increase in thermal loading on Ivanhoe Street may indicate that the new pavement is playing a role in this. Note that in the actual temperature measurements, we don't see notably warmer water in Ivanhoe (Figure 9), but due to the increased runoff volume from this street, more heat is being carried through the Ivanhoe storm sewer (Figure 10).

Conductivity was also measured simultaneously in the storm sewers. It measures, in large part, the concentration of dissolved salts carried by the water. Spring concentrations may tell us more about road salt use and fate than the data from other seasons. Idlewild Street had known icing issues in the winter and spring, which we discussed with the residents. The spring maximum conductivities for Idlewild indicate the severity of icing problems and reflect the additional road salt applied to deal with this issue (Figure 11). The data do show a reduction in both peak and maximum conductivity in Idlewild relative to the other two streets during the spring period after BMPs were installed. While several BMPs were designed to also help with the icing problems on Idlewild, icing issues vary considerably from one year to the next due to the variability in winter weather (T. Carlson, City of Duluth Utilities, Personal Communication). Thus, while our efforts may have helped, and one resident claims they reduced icing somewhat, the reduction in conductivity in the treatment street between spring 2009 and spring 2010 cannot be directly attributed to this project.

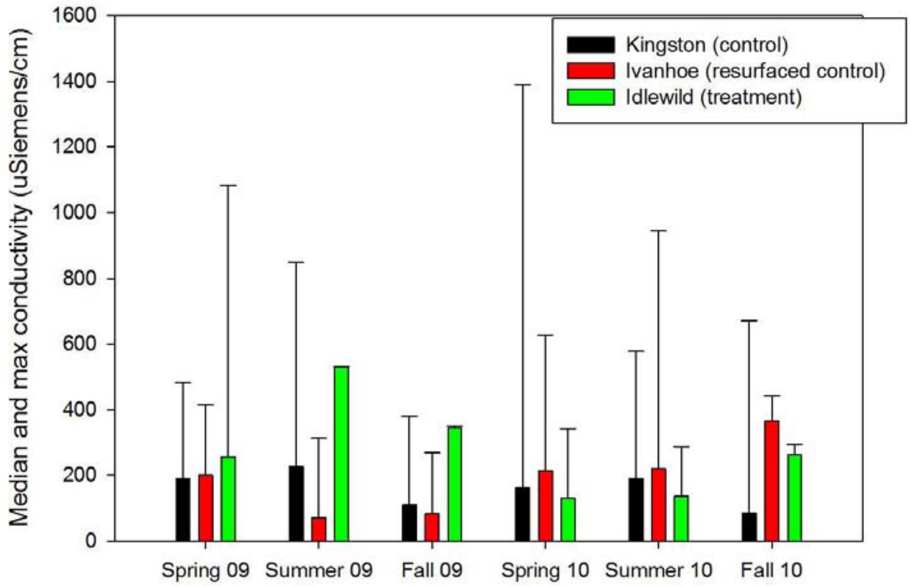

Figure 11. Mean and maximum conductivity in street storm sewer pipes, compiled by season for each of the three streets in the study area.

In addition, the flow volume must be considered when evaluating the total load of dissolved salts running through storm sewers and into Amity Creek. Conductivity loading is an indication of the total salt content of the runoff. As with temperature loading, the total amount of material flowing past the monitoring station is a function of the concentration (as measured here by conductivity), and the volume of water. We estimated conductivity loading by multiplying the volume of water running through the storm sewers by its conductivity for the same storm events we used for the stormwater volume and thermal loading calculations.

The only patterns in evidence from this analysis are with the increased conductivity loading for Ivanhoe Street (Figure 12). While we did see higher average and maximum conductivity measurements in 2010 in Ivanhoe (Figure 11), once again the increased flow is likely driving this change.

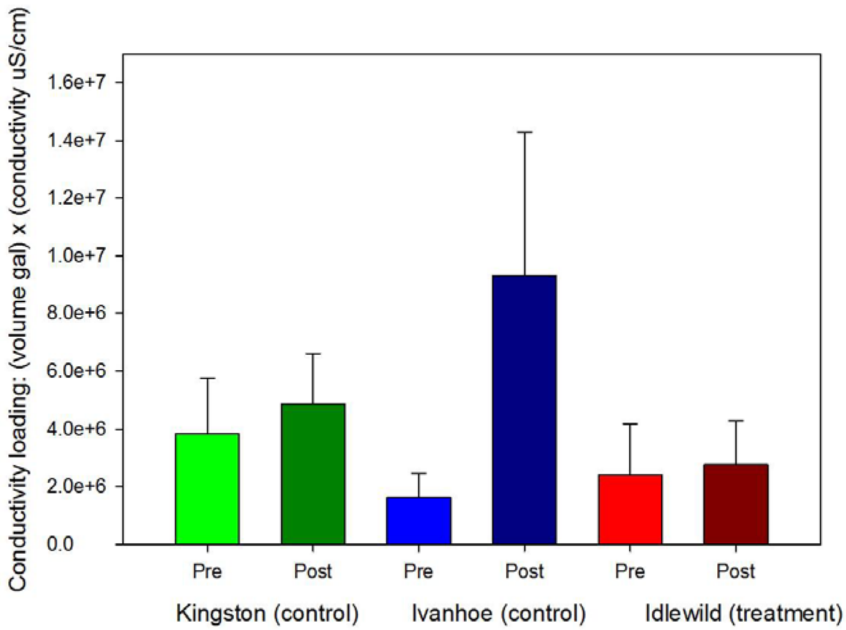

Figure 12. Mean and maximum calculated conductivity loadings for the water in the project area storm sewers from pre and post-BMP installation storm events. Conductivity loading was calculated by multiplying storm sewer runoff volume by the conductivity of the water.

Program Element #4 – Administration, Outreach, and Evaluation:

Objective J – Education, outreach, and evaluation

Education, outreach, and evaluation have taken place through a variety of items built into this project. These include the pre- and post-treatment surveys, neighborhood meetings, extensive contact with treatment recipients during the design and installation phases of the project, training and education of a half-dozen MCC crews, two rain garden construction workshops, and a number of presentations to a variety of audience types. Finally, the BMPs are now beginning to be included in stormwater treatment tours given by various groups.

The Lake Superior Streams website is hosting the web pages for this project (http://www.lakesuperiorstreams.org/weber/LSRP/index.html). Here, we are posting results and interpretation, project pictures, background, and context.

The pre- and post-project door-to-door surveys provided both an evaluation tool and an education and outreach mechanism. The surveys allowed us to evaluate changes in knowledge, attitudes, and practices of the project area residents at the beginning and end of the project, and also to evaluate the effects of close contact with treatment-street residents.

Results of the first door-to-door survey were provided to project area residents at the first project meeting in the fall of 2008, and were also provided during various interactions with residents throughout the next two years. Results of the post-project survey were prepared for the post-project meeting with residents, but no one attended that meeting. The results have been posted on the website, have been the subject of several presentations, and a scientific manuscript on the survey and its results is in preparation.

This project also resulted in increased staff knowledge for Minnesota Sea Grant, allowing them to better assist other property owners in stormwater BMP installations.

Objective K – Grant administration and reporting

Grant administration took significantly more time than anticipated when the proposal was being written due to the PIs being unfamiliar with the reporting requirements of a 319 grant, which are quite different from those of a typical research grant. Thus, it took some time for the PIs to become familiar with the reporting requirements, and for the University to figure out how to meet these requirements. Reimbursement requests were submitted monthly throughout the project, and narrative and expenditure reports were submitted every 6 months.

Grant Results

Evaluation plan results and measurements

Resident Surveys

We evaluated both the neighborhood residents themselves as well as stormwater runoff for this project. The residents were given door-to-door in-person surveys before and after the main project period. We were greatly assisted with the surveys by Dr. Karlyn Eckman (Water Resources Center, University of Minnesota), who had separate funding related to the SIDMA survey project to assist several 319 projects in Minnesota, including ours. The SIDMA survey questions did not fit our project well, so Dr. Eckman helped us design a Knowledge, Attitudes, and Practices (KAP) survey with questions specifically targeted to the information we wanted to track for our project. Our goal was to determine whether or not residents of our control and treatment neighborhoods increased their knowledge about stormwater runoff, or changed their attitudes or practices relating to stormwater because of our project. We expected that we would see changes in the treatment neighborhood because we would have a lot of contact with these residents, but we were unsure whether or not there would be any change with the residents of the control neighborhoods, with whom we would have little contact. To determine whether or not such changes would take place, we needed to survey residents at the beginning and end of the project.

The pre and post-project KAP questionnaires are attached at the end of this document, along with a summary of the results. Minnesota Conservation Corps (MCC) college students were trained in door-to-door survey techniques and then went door-to-door in the study area under the supervision of Drs. Eckman and Brady in the spring of 2008 and the fall of 2010, at the very beginning and toward the end of this project period. To help ensure a better response rate, letters describing the survey crew and its task were sent to all residents the week before the survey, and survey crew members wore clothing and insignia clearly identifying them as part of the MCC/University of Minnesota survey crew.

We achieved 72% (pre-project survey) and 76% (post-project survey) response rates for the 9 city blocks that were surveyed (about 80 households). We were very pleased with this high response rate. Results of the pre- and post-project surveys were compared with each other to see changes in response, but for some questions we separated treatment households, which had much more contact with project personnel, from households in the control area to help determine whether any changes in response were likely due to the project itself, or to some other circumstances.

Correct answers to stormwater knowledge questions increased by about 10% across the entire project area (control and treatment households) at the end of the project. The relatively high number of correct responses on general stormwater knowledge in the pre-project survey indicates that the Regional Stormwater Protection Team (RSPT) has done a good job of raising awareness about stormwater runoff and providing basic information. What respondents lacked was specific knowledge, i.e., were, exactly, did their stormwater flow to; what watershed did they themselves live in, etc. (see appendix A for complete list of survey questions and a summary of all responses). There was a 30% increase within the treatment area of respondents who said that both the City and the property owner should be responsible for stormwater control, but only a 15% increase in this response within the control areas. These results indicate that contact with the project team resulted in a 15% increase in willingness of property owners to take some responsibility for the stormwater runoff from their own properties. In the post-project survey, respondents from the treatment area were much more likely to say that they had heard or seen information about stormwater in the newspaper, on TV, or on the radio, probably indicating that the project made them more aware of and attuned to stormwater runoff issues. Many respondents also cited project personnel as being a significant provider of stormwater information. In contrast, respondents in the control areas had much smaller increases in reporting that they had heard about stormwater issues (see appendix A).

Control households also reported some changes relating to stormwater control. In the post-project survey, more control households reported that they did not have stormwater problems than they reported in the pre-project survey. This may have been due either to differences in weather between these two years, or because the post-project survey was given in the fall, which is typically drier, while the pre-project survey was given in the spring shortly after snowmelt, when runoff issues may have been more recently obvious to property owners. At the end of the project, a few more property owners in the control area reported that they were working to control stormwater runoff on their own than was reported during the pre-project survey. This increase may have been some of the people who approached project crews during construction with requests to be included in the project and were turned away because of the study design. One property owner in the control area was inspired to install his own 400 gal rainwater storage tank.

Finally, we asked treatment-area property owners to evaluate the BMPs they received during the project. Most of them believed that the BMPs were working although they noted they had no way to verify this. They would recommend their BMPs to friends, and many reported that their neighbors and friends were interested in the BMPs. The vast majority reported that maintenance was not difficult, and all rain barrel owners declared that they were emptying their rain barrels between rain events, but this was not independently verified by survey crews.

Stormwater Monitoring

Isco area-velocity flow logging units were placed in the stormwater catch basins at the base of each two-block long street for most of the ice-free seasons of 2008 – 2010, with the exception of the treatment street basin, which was not instrumented until the fall of 2008 (see site selection, above). In addition, Hydrolab MS5 multi-parameter sondes equipped with temperature, turbidity and conductivity probes were also placed in catch basins. All units recorded data at 5 min intervals. Monitoring units were downloaded and tended weekly. Unfortunately, the data for turbidity proved unusable because, even with weekly cleaning, the sensors could not be kept clean enough to provide reliable data.

BMP Installations

Twenty-two of the tweny-five property owners approached in the two-block treatment area agreed to have some sort of stormwater BMP applied to their property. The most commonly-accepted BMPs were trees and shrubs (250 planted and fenced), lawn aeration (16 properties), and rain barrels (22 rain barrels installed). Other BMPs included the digging of 20 rock sump stormwater storage holes, the construction of 5 rain gardens, the building of 4 stormwater ditch checks, and the construction of 2 stormwater swales. The rain barrels, rock sumps, and rain gardens have an estimated collective storage capacity of 2820 gallons per storm event. Once the trees and shrubs mature, in 15-30 years, they are expected to reduce stormwater runoff by approximately 675,000 gal per year through interception, evapotranspiration, and infiltration (Asadian 2007). See summary in Table 1.

We did not include the ditch checks or stormwater swales in the runoff volume reduction calculations because the ditch checks retain very little water (instead, slowing it down), and the swales direct water into the stormwater system rather than infiltrating it. The runoff reduction for trees and shrubs seems very large, and we actually reduced the numbers by 50% to make them more believable in our climate. However, these are the published runoff reduction capacities used by other groups in estimating the impact of urban trees.

We attempted to calculate the percent of stormwater runoff from just yards and roofs that our rain barrels, rain gardens, and rock sumps could intercept. However, we were not able to calculate a believable volume for runoff from roads and driveways that we could subtract out of the total measured runoff volume. We carefully measured the area and slope of each section of street and of all the driveways, as these are critical measures in the runoff calculation. We estimated the amount the pavement absorbs using published impervious depression storage values for cracked asphalt, but even after adjusting this parameter upwards, the calculated runoff from roads and driveways was still too high (see Figure 13). Thus, all we are able to say is that we believe our BMPs are intercepting at least 5% (and probably much more) of the runoff from yards and roofs, but we are unable to properly estimate this amount with the data we have available.

Table 1. Lakeside BMPs installed and their estimated capacity per event and for the 2010 ice-free season based on actual rain events.

BMP	Estimated capacity	Number installed	Capacity per event (gal)	Total capacity based on 2010 events (gal)
Trees and shrubs	5390 gal per yr[a]	250		673,750
Rain barrels	50 gal	22	1100	15,400
Rock sumps	11 gal	20	220	3080
Rain gardens	300 gal (avg)[b]	5	1500	17,500
Total			**2820**	**709,730**
Total storm sewer flow				**1,116,400**
Percent held, no trees				**2.5%**
Percent held, w. trees				**64%**

[a] From: http://www.fs.fed.us/psw/programs/uesd/uep/TreesInOurCity/Trees_in_Our_City-MidW.swf. Capacity reduced by 50% for the capacity per year since many shrubs were planted and the soil has a high percentage of clay.
[b] Gardens were of various sizes and capacities, so the average was used in calculations.

Products

The project has web pages on the Lake Superior Streams website (http://www.lakesuperiorstreams.org/weber/LSRP/index.html), and newsletter articles about the project are available on these web pages. We are also providing a CD of project photographs.

We created a summary of the results of our pre- and post-construction survey of the control and treatment neighborhoods. Highlights of the survey results are reported above, and the summary is attached (Appendix A) as a stand-alone product.

Our rain gardens were used as examples in a YouTube video created by St. Louis County, and we assisted them with the text for the narrative to help ensure accuracy (http://www.youtube.com/watch?v=Wi6HhMh0GN0&feature=player_embedded).

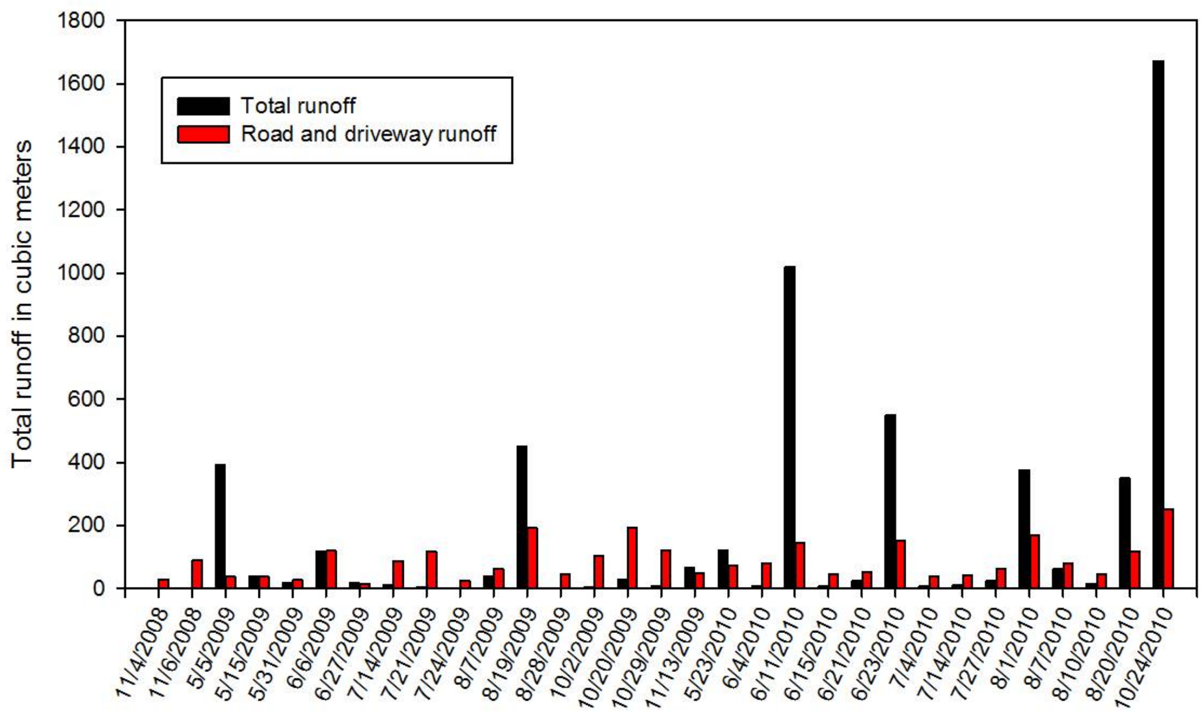

Figure 13. Comparison of measured total stormwater runoff in storm sewers on the treatement street (Idlewild) with the calculated runoff just from the road and driveways. Only rain events large enough to generate at least 1.5 inches of flow depth in the storm sewers are included because only these events could be measured accurately. Note that calculated runoff from the road and driveways is greater than measured total runoff for almost all small runoff events.

Public outreach and education

This project received coverage in local news outlets during the stormwater BMP installation phase (Duluth News-Tribune, local TV stations, Minnesota Public Radio). Newsletters have also run stories on various aspects of the project (NRRI Now, Stream-Line newsletter, Minnesota Sea Grant Seiche). The Lake Superior Streams website is hosting web pages devoted to the project and its results (http://www.lakesuperiorstreams.org/weber/LSRP/index.html). Several training presentations were made to various groups who helped with the project; these include 3 different Minnesota Conservation Corps groups of college and/or high school students over 3 years (a total of about 30 students), and the college students working with Green Duluth in 2009 who assisted with wildflower planting in the neighborhood (10 students).

Formal training was provided to MCC students, who assisted with a variety of activities related to this project. College corps students were trained in tree and shrub planting and fencing (for deer protection), and in door-to-door interview survey techniques to conduct the pre- and post-construction surveys for this project. High school corps students were trained in rain garden construction and planting, swale construction, ditch check construction, and proper installation of drain pipe. All students assisting with the project were given an overview of the project and information about stormwater runoff and the problems it creates for Duluth-area streams and Lake Superior.

Formal training in rain garden construction was also provided to interested property owners and lawn, garden, and landscape professionals. This training was provided through two intensive workshops, during which participants learned the calculations and techniques required to site and build a proper rain garden, toured the rain gardens constructed for this project, and then helped to plant a rain garden that was being built. Sixteen people were trained during the two workshops. The instructor was Eleanor Burkett of the University of Minnesota Extension Service. In addition, Candice Richards, UMD Facilities Management, gave a rain garden construction presentation to the Duluth Lakeside Garden Club.

<u>Formal presentations about this project include the following:</u>

Chris Kleist and Todd Carlson, City of Duluth Utilities, gave the presentation *Lakeside Stormwater Reduction Project* to the Minnesota Erosion Control Association on March 4, 2011, with an attendance of about 175.

Valerie Brady, Natural Resources Research Institute, gave the keynote address to the Minnesota Wastewater Operators Association on July 28, 2010 in Grand Rapids, Minnesota. *Stormwater's Biotic Impacts and Human Solutions*. There were about 150 people in attendance.

Valerie Brady, NRRI, Karlyn Eckman, Water Resources Center, Jesse Schomberg, Minnesota Sea Grant, and Chris Kleist, City of Duluth Utilities, presented the poster C*hanges in Stormwater Knowledge, Attitudes, and Practices* at the Water Resources Conference, Minneapolis, MN, Oct. 19-20, 2010.

Valerie Brady, NRRI, Karlyn Eckman, Water Resources Center, Jesse Schomberg, Minnesota Sea Grant, and Chris Kleist, City of Duluth Utilities, gave the presentation *North Shore Streams and Stormwater* to the MPCA in Duluth, October 2010.

Valerie Brady, NRRI, Karlyn Eckman, Water Resources Center, Jesse Schomberg, Minnesota Sea Grant, and Chris Kleist, City of Duluth Utilities, gave the presentation *Stormwater Impacts and Solutions for North Shore Streams* to the Duluth Township Homesteaders in March 2011.

Valerie Brady, NRRI, Karlyn Eckman, Water Resources Center, Jesse Schomberg, Minnesota Sea Grant, and Chris Kleist, City of Duluth Utilities, gave the presentation *Stormwater Impacts and Solutions for North Shore Streams* to the North Shore Rotary Club in March 2010.

Valerie Brady, NRRI, Karlyn Eckman, Water Resources Center, Jesse Schomberg, Minnesota Sea Grant, and Chris Kleist, City of Duluth Utilities, gave the presentation *Stormwater Impacts and Solutions for North Shore Streams* to the Save Lake Superior Association July 2009.

Valerie Brady, NRRI, Karlyn Eckman, Water Resources Center, Jesse Schomberg, Minnesota Sea Grant, and Chris Kleist, City of Duluth Utilities, gave the presentation *Lakeside Stormwater Runoff Reduction Project* at the Northland Innovative Stormwater Management Conference, Duluth, November 2010.

Valerie Brady, NRRI, Karlyn Eckman, Water Resources Center, Jesse Schomberg, Minnesota Sea Grant, and Chris Kleist, City of Duluth Utilities, gave the presentation *Lakeside Stormwater Runoff Reduction Project* to the Green Duluth Corps, Duluth, July 2009.

Karlyn Eckman, Valerie Brady, Jesse Schomberg and Valerie Were. *The Lakeside Stormwater Reduction Project: Evaluating the Impacts of a Shared Watershed Study on Local Residents.* Paper presented June 3 2011 at the 2011 IAGLR Conference – 54th Annual Conference on great Lakes Research, Duluth.

Karlyn Eckman, Valerie Brady, Jesse Schomberg and Valerie Were. *The Lakeside Stormwater Reduction Project: Evaluating the Impacts of a Shared Watershed Study on Local Residents*. Saint Paul: Water Resources Center.

Karlyn Eckman. *Community Assessment Workshop*. Training workshop held at the Minnesota Pollution Control Agency, March 29 2011. Saint Paul: Water Resources Center.

Karlyn Eckman, Kimberly Nuckles, Erika Rivers and Valerie Were. *Adapting Interdisciplinary Methods to Evaluate Social Outcomes of Environmental Programs: Five Lessons From Minnesota.* Paper presented November 10 2010 at the American Evaluation Association 2010 Annual Conference, San Antonio, Texas.

Karlyn Eckman. *Evaluating Outcomes of Water Resources Projects on target Audiences.* Presentation given at the Watershed Partners Meeting, October 13 2010, at the Capitol Region Watershed District.

Karlyn Eckman. *KAP Study Workshop.* Presentation prepared for Conservation Corps of Minnesota training workshop, Duluth, September 13 2010.

Karlyn Eckman. *Evaluating Social Outcomes in Water Resources Projects: Lessons from Minnesota.* Presented at the 2010 UCOWR/NIWR Conference July 13 2010, Seattle.

Karlyn Eckman. *Minnesota's Experience in Testing Social Indicators to Measure Behavior Change.* Presentation on February 10 2009 at the 2009 USDA – CSREES National Water Conference, Saint Louis, Missouri.

Karlyn Eckman. *Understanding Target Audiences in Water Resources Projects.* Presentation at the 2009 UCOWR Annual Conference, Chicago, July 9 2009.

Karlyn Eckman. *Minnesota's Experience in Testing the Social Indicators Evaluation Framework.* MPCA Leadership Meeting, September 10 2009, MPCA Saint Paul.

Karlyn Eckman. *Impact Assessment for Natural Resources Projects.* Presentation at the October 13 2009 Muffin Meeting, NRRI Duluth.

Karlyn Eckman. *KAP Study Workshop.* Training workshop at the Minnesota Pollution Control Agency, December 2 2009, Saint Paul.

Karlyn Eckman and Rachel Walker. July 2008. *Knowledge, Attitudes and Practice (KAP) Survey Summary Report For the Duluth Lakeside Stormwater Reduction Project (LSRP).* Saint Paul: University of Minnesota Water Resources Center.

Long-term results

While there are no funds available to continue installing stormwater runoff reduction BMPs in the Amity Creek watershed of Duluth, we do expect that many of the BMP recipients will continue to use and care for their BMPs for the foreseeable future. The rain gardens were given to folks who are already gardeners, and many of the people receiving rain barrels have told us that they like having the water available for watering plants. Finally, it is the trees and shrubs that will most contribute to runoff reduction as they mature, and these should now be well-enough established to require little care. Their stormwater runoff reduction capacity will increase over the next 10 to 30 years, providing the true long-term runoff reduction of this project.

Capacity Building

This project has helped us build capacity in several ways. First, we better understand how much stormwater runoff can reasonably be captured with relatively simple BMPs installed on residential properties in city neighborhoods that address runoff only from roofs and yards. Second, project staff gained a great deal of knowledge and experience in constructing and installing BMPs, giving us much greater capacity to assist with stormwater runoff reduction in the future. This has resulted in at least one similar proposal being submitted by Minnesota Sea Grant staff for funding residential rain garden construction further up the north shore of Lake Superior. Third, project staff received extensive instruction on creating and administering surveys for outreach and evaluation that we will be able to put to use in future projects. Fourth, we have a much better understanding of homeowner's needs, their understanding of water quality and stormwater issues, and their acceptance of stormwater BMPs. This knowledge will significantly help us and our partners with future public education efforts and demonstration projects.

Partnerships

This project helped us develop a strong partnership with the Minnesota Conservation Corps. Our experience using these college and high school students was so positive that we plan to use them on other projects whenever possible. The other real plus in using MCC is that the students all get trained in some aspects of the environmental issues in question and how to solve them.

The project also strengthened the partnership between the Natural Resources Research Institute (UMD), Minnesota Sea Grant (UMD), and the City of Duluth Utility Operations.

The knowledge and information gained about surveys and what they can tell us about what residents know has already been used by the Regional Stormwater Protection Team to design a stormwater survey of local MS4 community residents.

Lessons-learned

Storm sewer flow measurements

The flow meters we used in the storm sewers are designed for stream work, not confined pipe work. They would have performed better and provided us with better data on the runoff from small rain events if we had somehow been able to build weirs within the catch basins to concentrate the flow and direct it evenly past the meter's sensor. However, building such weirs is difficult, doubly so in such a confined space as a tiny catch basin-sewer access box. We are not sure this was even possible in these systems, and we could not have afforded it on this project's budget, but similar projects should probably investigate this possibility.

Secondly, we were rather taken aback by the sediment and debris flowing through the storm sewers. We had one meter actually smashed by a rock or something similar that came through the storm sewers, and the other meters had to be continually cleaned on a schedule 2-4 times more often than what was planned. Even with the increased cleaning, we could not keep the turbidity sensor clean enough to get good data. In addition, a beaver moved into one sewer catch basin and attempted to build a dam (we had it removed by a professional trapper).

Challenges of an older neighborhood

We found several challenges in working with in an older neighborhood (versus one being newly constructed). First, there was little opportunity to address stormwater flow from the street itself (see impervious surface flow, below). Second, we had difficulty working around gas pipes already in place in the neighborhood. We had hoped to install some French drains across driveways to direct runoff into rain gardens, but gas pipe locations thwarted this and also caused us to have to re-locate at least one other rain garden from its planned position. Third, the condition of the pavement was highly variable depending on street age. This made it impossible for us to calculate the percentage of runoff coming from the streets themselves because we could not estimate how much runoff was flowing through cracked pavement. Additionally, pavement heaving allowed a small but unknown amount stormwater to flow past the stormdrains and catch basins on Idlewild and Ivanhoe streets, preventing us from completely capturing total storm runoff. Finally, the storm sewer maps proved to be somewhat inaccurate for the older streets.

Impervious surface flow

This project focused on working with property owners and reducing runoff from their lawns and roofs. However, a large proportion of the runoff from the neighborhood consisted of runoff from the road and driveways, which we were not able to address. Our calculations of flow from impervious surfaces indicates that, for smaller rain events, probably all, or nearly all, the runoff came from the roads and driveways, with almost nothing coming from roofs and lawns (Figure 13). Large reductions in stormwater runoff would require a larger project and the property and/or space to create curb cuts to large (or long, linear) rain gardens, or holding ponds, or underground storage tanks, etc. In order to achieve significant reductions in stormwater runoff in a residential neighborhood, runoff from streets and driveways must be addressed.

Public participation

We had a difficult time enticing residents of the project area to come to our meetings even though the meeting locations were very close to the project area, refreshments were provided, and post card invitations were sent. However, going door-to-door after sending an introductory letter by mail worked very well for both the two surveys and for contacting residents about participating and accepting BMPs. Following this, word of mouth within the project area did the rest and residents called us asking to be included. These residents helped us make contact with difficult-to-reach residents, and they also put peer pressure on residents who were reluctant to participate. At least 4 additional property owners (15%) signed up for BMPs because of contacts by their neighbors.

Residents were much more likely to accept BMPs, and to except more substantial BMPs, if they had water problems on their property. The possibility of having some of their own water problems reduced was a great enticement for participation.

Grant administration

We were not prepared for the amount of time required for grant administration and project money tracking required by this grant. This is probably because we had little previous experience with 319 grants and so were unaware of the different reporting and grant tracking requirements relative to grants geared more for research. It also seems that 319 grants may be a poor fit for research and demonstration projects. There is a (mis)perception that allowing flexibility within a grant budget means that the grantees cannot as easily be held accountable for their expenditures. We contend that we can show that time and money spent on this project, although differing from the original budget, was all used to meet the overall project goals.

Research and demonstration projects require flexibility. For example, this project had an education component built in to measure the changes in knowledge, attitudes, and practices by BMP recipients and control street residents. This required that project area residents be kept deliberately uniformed about the project until the first survey could be done in order to document their starting (baseline) knowledge, attitude, and practices relating to stormwater. Thus, we had to write the proposal and project budget, and then start the project 18 months later, while having no idea how many residents would be willing to participate or what BMPs they would accept. Thus, our initial budget lines for BMP materials costs, labor costs, and staff time all had to be best estimates.

This project faced a number of other challenges that required us to be flexible, including:

- Resurfacing of a control street halfway through the project
- Large amounts of sand and debris moving through pipes that should have been relatively clean
- Closure of the school where we had planned to do demonstration BMPs

We were able to deal with all of these challenges and uncertainties, but this required that we move money around in the budget lines. On typical research grants, small amounts of money can be moved around the budget to provide flexibility, and movement of large amounts of money requires only email permission from the grant officer. With 319 grants, however, the system was much more rigid, requiring much greater amounts of hands-on management by the PIs and the project officer, but with no observable increase in accountability.

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Attachments:
Final Expenditures (budget; see separate Excel files)
Survey questions and survey results summary
Images (on CD)
Data Files (separate multiple Excel files)

Duluth: Lakeside Stormwater Reduction Project

1. Introduction

Hi. I'm (your name) and this is (partner's name). We're from the Minnesota Conservation Corps. We're helping the University of Minnesota Duluth and the City do a survey about rain and stormwater in this area of Lakeside. You may have heard something about a project, and we'll have more information about it at the end of the survey.

Could you take 10 minutes to answer some questions? (If yes, give survey. If no, or hesitation, say) If this is a bad time, we'd be happy to come back later at a time of your choosing (try to get them to name a reasonable time this week or this weekend).

2. Default Section

1. Do you know if a stream runs near your neighborhood?

Yes

No

Not sure

Other

2. What is the name of the stream in your neighborhood?

3. We're going to ask some questions about stormwater. If you are familiar with the term "stormwater," can you describe what it means to you?

Allow respondent to reply. If answer is incorrect, give correct answer before proceeding: 'Rainwater is called stormwater after it lands on the ground.'

4. When stormwater runs off people's lots, where does it go?

Check all that apply

a. Other peoples' properties

b. The street

c. Storm drains

c. Not sure

d. Other

5. Have you noticed too much rain water in the streets after a heavy storm?

Yes

No

Not sure

Other

6. What do you think happens to stormwater that runs into the storm drain on your street?

Check all that apply

a. It goes to the creek

b. It goes to Lake Superior

c. It goes to a wastewaste treatment plant

d. Not sure

e. Other (write in response)

7. Where do you think too much stormwater can cause problems?

Check all that apply

a. On my property

b. On neighbors' properties

c. In Amity Creek

d. In Lake Superior

e. All of the above

f. Not sure

g. I don't think that it causes a problem

h. Other

8. Whose job is it to manage stormwater flowing onto and off of your property?

a. The City

b. The property owner

c. Both a. and b.

d. Not sure

e. Other

9. We're trying to find out if people know the difference between stormwater and sanitary sewer water. Can you describe sanitary sewer water?

MCC will read correct answer:

Sanitary water is what we used to call raw sewage. It's the water that is collected by toilets, sinks, showers, laundry drains, homes and businesses. It also includes waste water from paper mills and factories. It all drains to the wastewater treatment plant called WLSSD (Western Lake Superior Sanitary District). It treats the water before discharging it into the harbor near Blatnik Bridge at 27th Avenue West.

10. Do you think stormwater and sanitary sewer water go through the SAME treatment process, or are they treated DIFFERENTLY?

a. Same

b. Different

c. Not sure

d. Other

11. Where have your heard about local stormwater issues?

Check all that apply

a. Public service announcements

b. TV news or weather

c. Streamline (the Newsletter for Lester-Amity Creek residents)

d. Internet or website

e. Newspaper articles

f. Flier in utility bill

g. Sign or billboard

h. Rex the Watershed Dog

i. Other

j. Not sure that I have heard about stormwater

12. Do you know how your stormwater utility fees are used?

a. Yes

b. If yes, how? (open-ended)

c. No

d. Not sure

e. Other (open-ended)

13. Are you aware that muddiness and erosion in Amity Creek have caused it to be placed on a state list of "impaired" streams?

After responding, interviewer to show respondent the TMDL map, and say:
An impaired listing requires that the municipality must develop a plan to improve its water quality.

a. Yes

b. No

c. Not sure

d. Other (open-ended)

14. Have you ever done anything to manage stormwater on your property?

Check all that apply

a. Sump pump

b. Rain barrel

c. Rain garden

d. Landscaping to manage stormwater

e. Native plants

f. Other (open-ended)

g. No

15. What prevents you from managing stormwater on your property?

Check all that apply

a. Stormwater is not a problem on my lot

b. I'm not aware of any information that would help me

c. I'm not sure what to do

d. There's a cost involved

e. My physical ability limits me

f. I haven't had time

g. Don't know

h. Other (open-ended)

16. The University of Minnesota Duluth and the City are working together to study stormwater problems in this neighborhood. Are you interested in learning more about this?

a. Yes

b. No

c. Not sure

d. Other

17. If the costs and effort were mostly covered, would you be willing to try something to manage stormwater (such as a rain garden or rain barrel) on your property?

a. Yes

b. Maybe, but I'd like to learn more about it

c. No

d. Not sure

e. Other (open-ended)

18. Note any observations or comments here:

***19. What is the respondent's address?**

3. Thank you

That's the end of the survey. Thank you very much for taking time to talk to us. Your opinions are important for this project. You will get information in the mail later this summer about a community meeting after Labor Day to explain the project and survey results. The project will be starting this fall. Do you have any questions right now that we could answer for you? In the meantime, if you have questions or concerns, here is the contact information for one of the project coordinators (give Val's business card).

Duluth LSRP KAP #2 WORK AREA

1. Property address?

USE THIS QUESTIONNAIRE FOR:

- Idlewild 4800 to 5000 blocks;

- 4856, 4864, 4902, 4912, 4920, 4930, 5024 Kingston

2. Do you know if a stream runs near your neighborhood? (check only one response)

- ◯ Yes
- ◯ No (skip to question 4)
- ◯ Not sure (skip to question 4)
- ◯ If other, skip to question 4)

Other (please specify)

3. What is the name of the stream in your neighborhood?

4. We're going to be asking about stormwater. Can you describe stormwater?

(After the respondent answers, MCC crew to state "Stormwater is rainwater after it hits the ground")

5. When stormwater runs off people's property, where does it go? (check all that apply)

- ☐ Other people's properties
- ☐ The street
- ☐ Storm drains
- ☐ Not sure

Other (please specify)

6. Have you noticed too much rain water in the streets after a heavy rainstorm? (check only one response)

- ◯ Yes
- ◯ No
- ◯ Not sure

Other (please specify)

7. What do you think happens to rainwater that runs into the storm drain on your street? (check all that apply)

- ☐ It goes to the creek
- ☐ It goes to Lake Superior
- ☐ It goes to a wastewater treatment plant
- ☐ Don't know

Other (please specify)

8. Where do you think too much stormwater can cause problems? (check all that apply)

- ☐ On my property
- ☐ On my neighbors' properties
- ☐ In the creek
- ☐ In Lake Superior
- ☐ All of the above
- ☐ Not sure
- ☐ I don't think it causes problems

Other (please specify)

9. Whose job is it to manage stormwater flowing onto and off of your property?

- ◯ The City
- ◯ The property owner
- ◯ Both the City and the property owner
- ◯ Don't know

Other (please specify)

10. We're trying to find out if people know the difference between stormwater and sanitary sewer water. Can you describe sanitary sewer water?

11. Do you think that stormwater and sanitary sewer water go through the SAME treatment process, or are they treated differently?

- ◯ Same
- ◯ Different
- ◯ Not sure

Other (please specify)

12. Where have you heard about local stormwater issues?

- ☐ Public service announcements
- ☐ TV news or weather
- ☐ Streamline (the Amity Watershed Newsletter)
- ☐ Internet or website
- ☐ Newspaper articles
- ☐ Flier in utility bill
- ☐ Sign or billboard
- ☐ Another Watershed Moment or Rex the Watershed Dog
- ☐ I haven't heard about stormwater

Other (please specify)

13. Do you know how your stormwater utility fees are used?

- ◯ Yes
- ◯ No
- ◯ Not sure

If yes, how?

14. Are you aware that muddiness and erosion in Amity Creek have caused it to be placed on a state list of "impaired" streams? ("Impaired" basically means "polluted" or "damaged").

After the respondent has given an answer, MCC to read the following:
Amity Creek has been on the MPCA "impaired water" list for a couple of years now due to high turbidity (or muddiness) of its water. Most of this muddiness seems to be due to erosion of the stream banks during high water flows, such as after heavy rainstorms.

- ◯ Yes
- ◯ No
- ◯ Don't know

Other (please specify)

15. Was anything done on your property to reduce stormwater runoff as part of this project?

- ◯ Yes (skip to question 18)
- ◯ No

16. Would you be interested in doing something in the future to reduce stormwater runoff?

- ☐ Yes
- ☐ No

If yes, what?

17. Why are you interested in doing that?

18. What was done on your property through the project?

19. Do you think those treatments have helped to reduce stormwater runoff from your property?

- ◯ Yes
- ◯ No
- ◯ Don't know

Other (please specify)

20. Did you have water problems on your property before this project started?

- ◯ Yes
- ◯ No
- ◯ Don't know

If yes, did the project's work help to reduce water problems on your property?

21. Do you think that the treatments provided by the project has helped to reduce stormwater runoff from your property?

- ◯ Yes
- ◯ No
- ◯ Don't know

Other (please specify)

22. Have you spent any time maintaining the things you received from the project?

- ◯ No
- ◯ Yes

Time spent

23. Was this maintenance difficult?

- ◯ Yes
- ◯ No
- ◯ Don't know

Other (please specify)

24. Do you plan to maintain these things in the coming year?

- ◯ Yes
- ◯ No
- ◯ Don't know

Other (please specify)

25. Would you recommend any of these to your friends?

- ◯ Yes
- ◯ No
- ◯ Don't know

If yes, which ones?

26. Is there anything you wish had been done differently?

- ◯ Yes
- ◯ No
- ◯ Don't know

If yes, how?

27. Did the project make it easier for you to manage stormwater than before?

- ◯ Yes
- ◯ No
- ◯ Don't know

If yes, how?

28. Did you notice that other residents became interested in the changes on your lot?

- ◯ Yes
- ◯ No
- ◯ Don't know

Other (please specify)

Duluth LSRP KAP #2 WORK AREA

29. Condition of installations done on the respondent's property:

Duluth LSRP KAP #2 WORK AREA

Thank you very much for taking the time to answer our survey questions. The project leaders will be inviting you to a neighborhood meeting later this fall to show you the preliminary results from this project. We really appreciate your time.

Lakeside Neighborhood Stormwater Reduction Project
Comparison of pre and post-surveys of residents
May 2008 and Sept. 2010

Survey group: Nine blocks in Duluth's Lakeside neighborhood.
Households participating: 72% (pre-project) and 76% (post-project). This is a very high response rate.

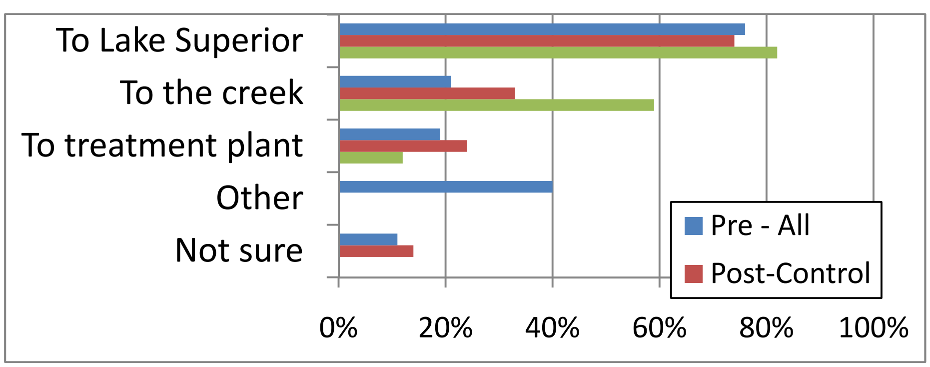
Responses to questions:

Knowledge questions (shortened)	Target answer	Correct (pre)	Correct (post)
• Do you know if a stream runs near your neighborhood?	Yes	47%	82%
• Describe what the term "stormwater" means.	Rain water after it hits the ground.	83%	94%
• What is the difference between stormwater and sanitary sewer water?	Sanitary sewer water is from household use (bathroom, laundry); stormwater is rain water.	76%	89%
• Do stormwater and sanitary sewer water go through the same or different treatment processes?	Different treatment processes (sanitary sewer water is treated by WLSSD, stormwater is not treated at all).	76%	65%
• How are your stormwater utility fees used?	For work on the City's stormwater system.	17%	20%
• Did you know that Amity Creek is on the MPCA impaired streams list for muddiness?	Yes	13%	NA

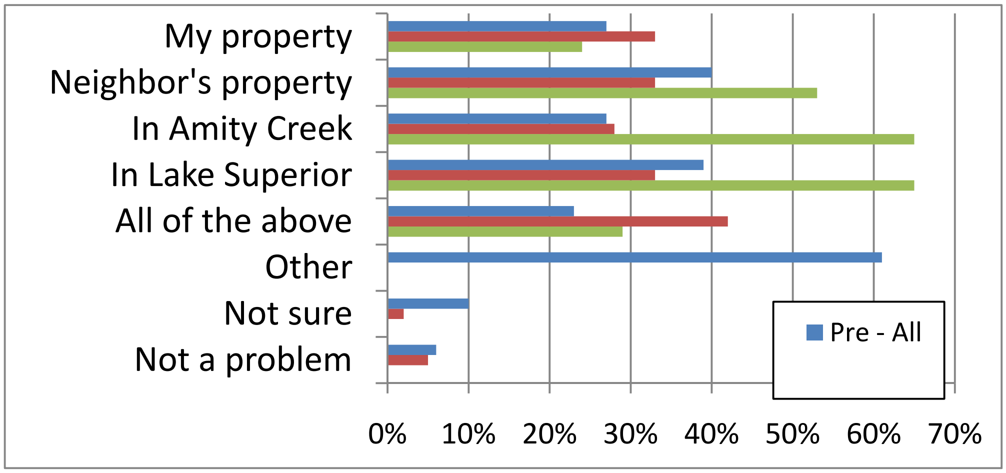
Opinion questions	Yes (pre)	Yes (post)
• Have you noticed too much water in the streets after rain?	56%	43%

Open-ended questions

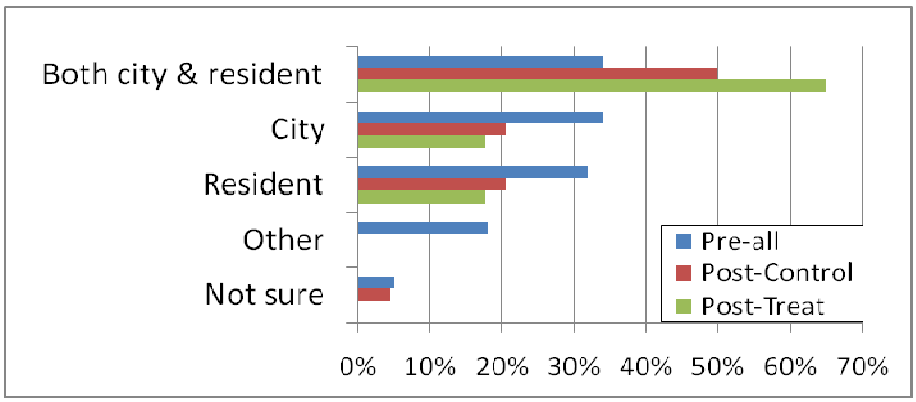
- What happens to stormwater that runs into the storm drain on your street?



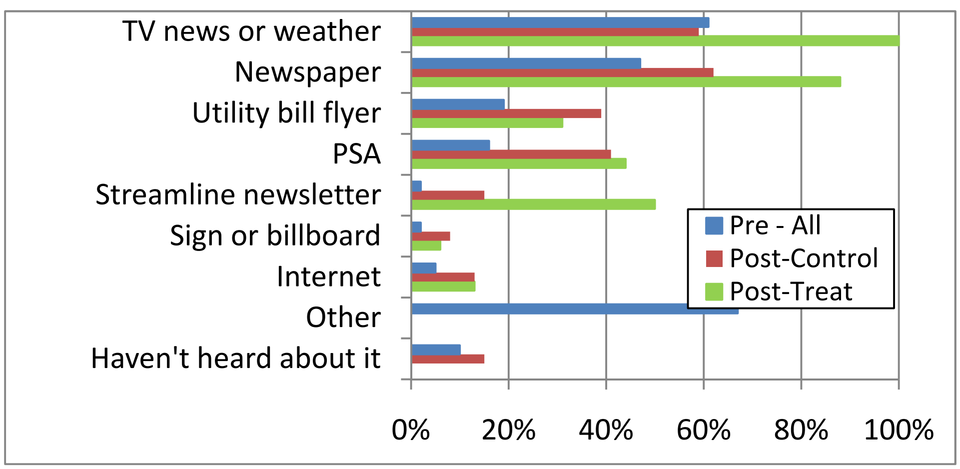
- Where can too much stormwater cause problems?



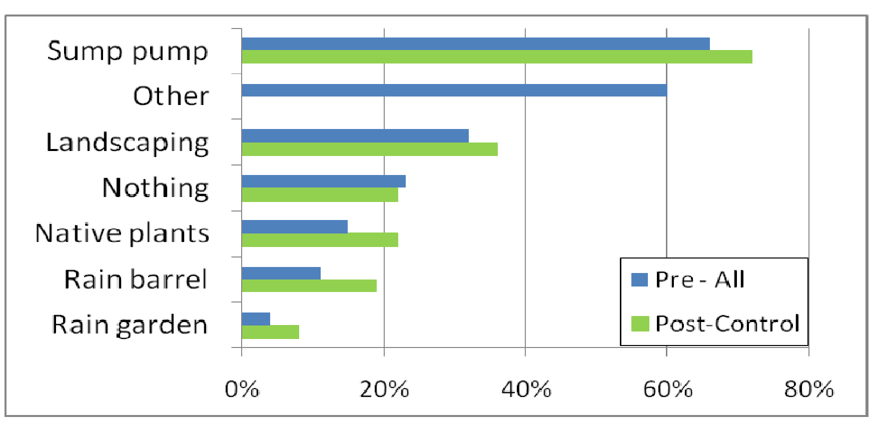
- Whose job is it to manage stormwater flowing onto and off of your property?



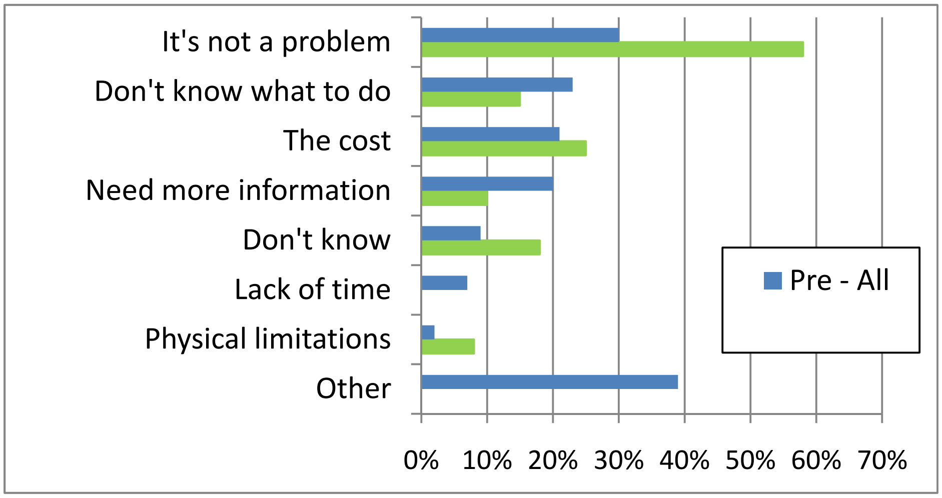
- Where have you heard about stormwater issues?

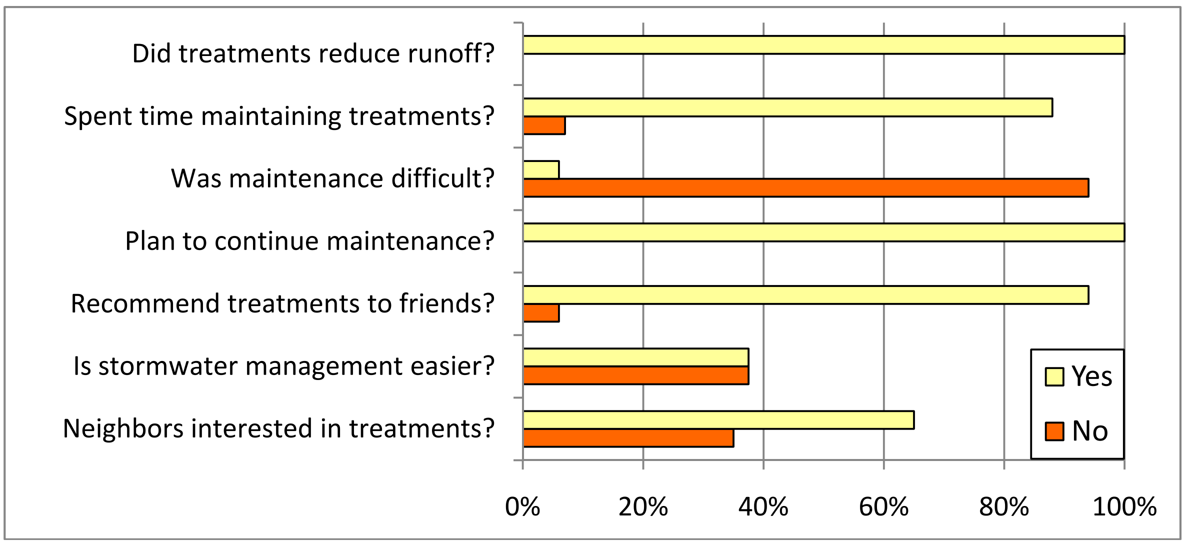


- What have you done to manage stormwater on your property?



- What prevents you from managing stormwater on your property?





Take-home points:

- Residents were very cooperative and patient in taking the survey, and are interested in helping out with stormwater issues if they can.
- Most residents understand that differences exist between stormwater and sanitary sewer water and its treatment.
- Most residents understand that stormwater can cause problems on people's properties and negatively affect the environment.
- Residents who got treatments seemed to like them, could maintain them relatively easily, and would recommend them to friends and neighbors. They were unsure about whether or not the treatments were actually helping reduce stormwater effects.
- Residents need more information out about:
  - How stormwater fees are used
  - What to do about stormwater
  - Where the storm sewer pipes actually go

- What the nearest stream is, what stream watershed they live in, and why they need to know this
- Where to look for information about stormwater and stream quality issues