Restoring impaired Superior tributaries: Stormwater BMP evaluation, education and outreach

Richard Axler, Jerry Henneck, Dan Breneman, Elaine Ruzycki, Andrea Crouse, & Norm Will
Natural Resources Research Institute, University of Minnesota Duluth

Todd Carlson & Chris Kleist, *Stormwater Utility City of Duluth, MN*

Keith Anderson, *S. St. Louis Soil & Water Conservation District*

319 Demonstration Project Final report to Minnesota Pollution Control Agency
Contract Number B10461
NRRI/TR-2011/37

DRAFT July 31, 2011

Grant Project Summary

Project title: Restoring impaired Superior tributaries: stormwater BMP evaluation, education and outreach

Organization (Grantee): Regents of the University of Minnesota

Project start date: Feb 1, 2007 *(actually 2/1/2008 for UM contract w/MPCA)*

Project end date: 6-30-2011

Report submittal date: 7-31-2011

Grantee contact name: Richard Axler

Title: Senior Research Associate

Address: 5013 Miller Trunk Hwy, Natural Resources Research Institute., U. of MN-Duluth

City: Duluth

State: MN

Zip: 55811

Phone number: 218-720-4316

Fax: 218-720-4328

E-mail: raxler@nrri.umn.edu

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: $ 103,553

Final total project costs: $231,028.07

Matching funds: Final cash: **$66,734.48 ???**

Final in-kind: $ 131,028.07

Final Loan: $

Contract number: B10461

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

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Executive Summary of Project (300 words or less)

Duluth, MN trout streams watersheds are generally similar to watersheds along Lake Superior's North Shore with >70% forested, generally similar geology and hydrology, and for Amity Creek, the potential for increased development pressure. Therefore, Duluth's streams can serve as suitable pilots for evaluating restoration, mitigation and planning strategies for use with more pristine, but developing, North Shore streams. Our primary goal was to coordinate with local remediation/BMP projects, the www.*LakeSuperiorStreams.org* (LSS) water quality monitoring and public education effort, and Weber Stream Restoration Initiative (WSRI, *www.lakesuperiorstreams.org/weber*) to assess BMP effectiveness at reducing stormwater runoff problems via upstream-downstream and before-after water quality and biological monitoring. Three projects on impaired streams were identified to have high likelihood for long-term success and potential for educational use and public visibility: 1) Lower Amity-Graves Road Creek restoration– upstream from automated Amity sensors, this intermittent tributary discharged a muddy plume during rainstorms and snowmelt runoff since a 1946 flood destroyed the road. WSRI/LSS partner, City of Duluth carried out a restoration including new culverts, flow rerouting, bank slope reductions, and sediment stabilization; 2) East Branch Upper Amity Creek bank stabilization- Eroding banks were identified from NRRI surveys, and WSRI/LSS partner South St. Louis SWCD led an effort to mitigate two of the largest sediment sources and redirect high flows using J-vanes– the first such project on the Superior North Shore; 3) Miller Creek Sediment Trap- a natural-bottomed trap completed in 2004 below the Miller Hill Mall complex, was evaluated for the first time for its effects on temperature, sediment transport, and protection of aquatic habitat. The overall project was initiated by a gift from a former Duluth resident that created the WSRI with the goal of improving water quality in Lake Superior streams via a collaborative process focused on educating, implementing projects, and critically evaluating restoration efforts.

Goals (Include three primary goals for this project.)

1st	Goal:	Quantify BMP effectiveness in improving water quality, sedimentation, bank erosion, and protection of benthic biological communities on Amity Creek and Miller Creek .
2nd	Goal:	Citizen Volunteer BMP Monitoring (storm events; seasonal; benthic biological communities):
3rd	Goal:	Use LakeSuperiorStreams.org to showcase project results

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

1st	Result:	Three BMPs located on two designated trout streams suffering water quality impairments were evaluated in terms of their performance in removing suspended sediment and turbidity over a period of 1-3 years
2nd	Result:	2-plus years of water quality, stream habitat, aquatic invertebrate ("bug"), and fish data have established a baseline for assessing the performance of the Upper and Lower Amity Creek restoration projects over the long-term, as re-vegetation improvements continue to occur, and as weather conditions change from year to year. Results from the first full year of post-construction surveys indicates so not show significant improvement , presumably for lack of sufficient data. Geomorphic measurements of the eroding banks were made and a UMD Geology class has included these and additional measurements in its annual curriculum.

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3rd	Result:	Water quality and biological surveys upstream and downstream of the Miller Hill Mall area sediment trap indicate that there is relatively little long-term removal of suspended sediment due to the trap. We were unable to locate the original post-construction survey drawings of the trap in order to determine how much sediment has accumulated in the trap since its construction. However, we did conduct two detailed field surveys of bottom sediment depth and sediment characteristics and will continue to work with local agencies (Duluth, Hermantown, and the SSL SWCD) to establish a repeat of these surveys using identical methodology on a regular basis (2-3 years). Biological communities were generally similar upstream and downstream of the trap CHECK FOR WORDING WHEN DAN RETURNS
4th	Result:	This project has been valuable, in combination with related efforts by the LSS and WSRI programs, in leveraging additional funding targeting Superior tributary stream mitigation and restoration efforts. Since the 319 project was developed, NRRI-UMD has generated $2,634,604 in grant activity with its partners focused on related activities. In particular, NRRI-UMD, Sea Grant-UMD, SSL SWCD, and MPCA (the lead agency) have received a large (~ $853,000) grant to further address and evaluate stormwater related impairments in the Amity Creek Watershed along with a continued strong outreach and education program tied to the RSPT and WSRI efforts.
5th	Result:	The project has contributed to the dissemination of: (1) stormwater pollution prevention information; and (2) technical information related to sediment mitigation BMPs in regional streams. Outreach and education activities has been broad, via print , radio, and television media outlets, technical reports, presentations at local, state, and national conferences and workshops, and via the internet and the www.lakesuperiorstremas.org website.
6th	Result:	The project has contributed to the operation and maintenance of the www.lakesuperiorstremas.org website. This website centered project operates and maintains automated flow and water quality sensors in five Duluth area trout streams, collects additional event-based grab samples at each site, disseminates the data in a variety of formats including a unique data visualization tool via the LSS website, relevant maps and mapping utilities, provides detailed interpretational information for the data and additional ancillary information for 43 Duluth streams, 16 North Shore trout streams, and 8 South Shore streams, and is the major on-line education and outreach information "library" for the Superior RSPT. All of the water quality data collected from this 319 project and related projects, and its reports (after being finalized pending MPCA review) are, or will soon be available via the LSS website.
7th	Result:	The project has helped maintain and expand a multi organization partnership focused on science-based assessment of Superior's North Shore cold water streams, development of cost effective stream protection and restoration methods, and improved understanding of the factors leading to sediment generation and erosion in North Shore streams with application to improving the assessment and regulatory framework. The GLRI Award funding further Amity Creek Watershed restoration activities is in part an end product of this CWP/319 grant. The Partnership is also putting the Amity watershed forward as a candidate for inclusion in a new state-wide initiative that would establish a long-term network of sentinel watershed monitoring. The development of this program is being conducted jointly by the U. of Minnesota, MPCA, MDNR and MDA (Agriculture) and had its "kickoff" meeting June 30, 2011 (PI R.Axler was invited).

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Acronyms (Name all project acronyms and their meanings.)

BMP = best management practice

LSS = www.LakeSuperiorStreams.org project and website

WSRI = Weber Stream Restoration Initiative (see www.LakeSuperiorStreams.org/weber)

RSPT = Superior Regional Stormwater Protection Team (see www.LakeSuperiorStreams.org/rspt)

NRRI-UMD = Natural Resources Research Institute at the University of Minnesota-Duluth

Sea Grant-UMD = Minnesota Sea Grant Program at the University of Minnesota-Duluth

MPCA = Minnesota Pollution Control Agency

MDNR = Minnesota Department of Natural Resources

MS4 = Municipal Separate Storm Sewer System (4 S's)

WLSSD = Western Lake Superior Sanitary District

MLSCP = Minnesota's Lake Superior Coastal Program

SWA-NS = Surface Water Assessment – North Shore Streams (an NRRI-UMD project funded by MPCA's SWA grant program

WSRI = Weber Stream Restoration Initiative

GLRI = Great Lakes Restoration Initiative

SWPPP = Stormwater Management Pollution Prevention Program/Plan

AFDW = Ash-Free Dry Weight (a measure of the organic matter content of a sample of suspended or bottom sediment, plant or animal tissue, or detritus (a less expensive surrogate for a total organic carbon or other more specific analysis)

Partnerships (Name all partners and indicate relationship to project)

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

Minnesota Sea Grant, University of Minnesota – assisted with education and outreach, as a major partner in the LSS and WSRI projects since their initiation. Sea Grant staff partners disseminate information throughout the Great Lakes via the Sea Grant Network of Great Lakes State Sea Grant programs that coordinates closely with the Great Lakes Information Network. (GLIN). In regard to this project and stormwater issues, Sea Grant staff have focused on specific user groups in addition to the general public, including students and teachers, elected officials within Local Governmental Units (LGUs), and various business groups (e.g. contractors, landscapers, realtors, and the banking community).

City of Duluth Stormwater Utility - as a major partner in the LSS and WSRI projects since their initiation. Duluth staff worked with NRRI, consultants and contractors to develop the Lower Amity Creek restoration project and funded the actual construction and initial revegetation work. City staff also assist with the maintenance of the Amity stream gauge instrumentation, as well as the other four Duluth stream gauge sites. The City also has contributed a recurring grant to help fund the LSS website and related LSS Team education and outreach activities as related to their MS4 SWPPP.

South St. Louis Soil and Water Conservation District – primary responsibility for the bank stabilization design and construction oversight at the Upper Amity restoration site (East Branch); also provided review of the Lower Amity BMP/restoration and has been an important partner via technical engineering expertise as well as by disseminating RSPT and LSS information about stormwater impact mitigation, and related pollution prevention throughout the western Lake Superior region.

Regional Stormwater Protection Team – this partnership of local MS4s and other regional organizations (26 currently) helped provide context and impetus for the project and will help use and disseminate the results and recommendations from the project via its many outreach education activities.

Lake Superior Streams.org – this website hosts the project webpages; the LakeSuperiorStreams project began via an EPA grant in 2002 to the City of Duluth and the U. of Minnesota-Duluth (NRRI and Sea Grant). It has continued since 2005 via a variety of funding sources. The project operates and maintains automated

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flow and water quality sensors in five Duluth area trout streams, collects additional event-based grab samples at each site, disseminates the data in a variety of formats including a unique data visualization tool via the LSS website, provides detailed interpretational information for the data and additional ancillary

information for 43 Duluth streams, 16 North Shore trout streams, and 8 South Shore streams, and is the major on-line education and outreach information "library" for the Superior RSPT.

Weber Stream Restoration Initiative- The Weber Stream Restoration Initiative, led by the Natural Resources Research Institute with help from Minnesota Sea Grant at the University of Minnesota Duluth, is a unique collaboration of agencies and projects flowing from the overall goal of using the best science available to keep the healthy streams clean and restore damaged systems in the Lake Superior watershed. The WSRI project is unusual in that it was initiated by an unsolicited donation to NRRI at the U. of Minnesota-Duluth with only the general goal of fixing "damaged" Superior Basin trout streams. Mr. Weber worked with NRRI scientists to formulate a WSRI Partnership of scientists and resource managers from more than 25 local, state, and federal agencies and organizations which then determined that the best course of action would be to focus on the impaired Amity Creek and Lester River watersheds as a long-term watershed-scale demonstration project for evaluating restoration and assessment activities. The Amity watershed in particular, would be able to build on pre-existing partnerships (the LakeSuperiorStreams.org project and the Superior Regional Stormwater Protection Team [RSPT]) that had generated one of the more intensive and long-term sets of water quality data and tools and networks for disseminating results to technical and non-technical stakeholders throughout the region. The project intends to reduce sediment sources, quantify the cost effectiveness of sediment and stormwater runoff reduction activities, and communicate results to stakeholders in the watersheds and the greater region of western Lake Superior via web resources and the well established Superior Regional Stormwater Protection Team (RSPT) partnership involving 25 member organizations (http://www.lakesuperiorstreams.org/stormwater/rspt.html). This effort is more fully described at http://www.duluthstreams.org/weber/index.html , a website section that was created to help disseminate information resulting from his initiative.

Professor Karen Gran, Department of Geology, U. of Minnesota-Duluth. - Geomorphology of the Amity Creek and other Superior North Shore watersheds. Dr. Gran has been collecting geomorphology data in the Upper and Lower Amity watershed since 2008. Her work has contributed to basic understanding of channel and bank erosion processes in the watershed as well as by establishing benchmark data for assessing erosional losses over the long-term.

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Project Background

Nationwide, thousands of water bodies are listed as impaired for turbidity. North Shore Lake Superior tributary streams and coastal areas are also threatened by existing problems related to stormwater runoff and erosion and from rapidly increasing urban and rural development. Inadequate planning, design, and land management can modify the hydrologic landscape leading to increased power and "flashier" surface runoff, decreased base flow, increased erosion and sedimentation, increased temperature variability, and impacts from other pollutant loadings. Increased fine sediments caused by fine clay reduces water clarity, thereby reducing in-stream primary production and, at high levels, reducing the ability of predatory fish and invertebrates to see their prey. It also damages sensitive fish and invertebrate gill tissues, and can increase water temperatures leading to direct temperature stress for cold water species, as well as indirect dissolved oxygen stress during low flow periods. Excessive fine sediments can embed coarse gravel and cobble substrates, resulting in reduced habitat quantity and quality for invertebrates and fish. Besides degrading sensitive cold-water aquatic habitats in the streams, this discharge contributes pollutants to the coastal zone and main body of Lake Superior. Currently, 13 northshore trout streams have 303(d) listings for turbidity, and more are likely to be listed in the near future, as more monitoring data is gathered. Two of the most effective methods of protecting and restoring impaired tributaries to Lake Superior occur:

1) through public awareness and education of human impacts and ways to reduce them; and
2) by implementing best management practices (BMPs) that successfully, and cost-effectively reduce stormwater impulses to sensitive streams.

Urban Duluth streams are generally similar to the less developed watersheds of the North Shore with >70% forested, similar geology and hydrology, and in the case of Amity in particular, the potential for increased development pressure. Therefore, Duluth's streams can serve as suitable pilot-watersheds for evaluating restoration, mitigation and planning strategies for potential use in other more pristine, but developing, North Shore streams. Our primary goal is to coordinate with local agency remediation/BMP projects and the existing Chester, Kingsbury, Tischer, Amity and Poplar Creek/River automated water quality monitoring and public education effort carried out by the LakeSuperiorStreams.org (LSS) project (Axler et al. 2003, 2006, 2008, 2010; Granley and Lonsdale 2005, 2007; Lonsdale et al. 2006) to demonstrate their effectiveness at reducing stormwater runoff problems as indicated by upstream-downstream and before-after water quality and biological monitoring.

The LakeSuperiorStreams.org (LSS) project and derivative Superior Regional Stormwater Protection Team (RSPT; www.lakesuperiorstreams.org/stormwater/rspt.html) began in 2002 (EPA-EMPACT grant) to bring together regional scientists, managers, and educators as Partners collaborating to inform and educate the general public about aquatic ecosystems and their connections to watershed land use with the goal of providing both economic and

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environmental sustainability. The use of data, particularly real-time data, is central to the project. The RSPT Partnership strives to protect and enhance the region's water resources via coordinated educational programs and technical assistance.
The Weber Stream Restoration Initiative (WSRI, *www.lakesuperiorstreams.org/weber*) led by the Natural Resources Research Institute (NRRI) with help from Minnesota Sea Grant (Sea Grant) at the University of Minnesota Duluth (UMD), is a unique collaboration of agencies and projects with the overall goal of using the best science available to keep the healthy streams clean and restore damaged systems in the Lake Superior watershed. The WSRI project is unusual in that it was initiated by an unsolicited donation to NRRI at the U. of Minnesota-Duluth with only the general goal of fixing "damaged" Superior Basin trout streams. Mr. Ron Weber worked with NRRI scientists in 2005 to formulate a WSRI Partnership of scientists and resource managers from more than 25 local, state, and federal agencies and organizations which then determined that the best course of action would be to focus on the impaired Amity Creek and Lester River watersheds as a long-term watershed-scale demonstration project for evaluating restoration and assessment activities. It was determined that the Lester River and Amity Creek watersheds at the edge of the city of Duluth should become a demonstration project for mitigating problem areas in trout streams, determining the cost-effectiveness of BMPs, educating the community about its role in reducing stormwater and erosion, and restoring the condition of the impaired streams. The creeks are designated trout streams with native brook trout and historically stocked with trout and salmon. The watersheds comprise 33,300 acres, including 94 stream miles and City and regional several parks, including world famous Hawk-Ridge (www.hawkridge.org). The watersheds are adjacent to each other and Amity Creek empties into the Lester River about 500 meters above the mouth of the Lester on the Lake Superior North Shore.

Work on the Amity Creek watershed in particular, would be able to build on pre-existing partnerships (the *www.LakeSuperiorStreams.org* project and the Superior RSPT that had generated one of the more intensive and long-term sets of water quality data and tools and networks for disseminating results to technical and non-technical stakeholders throughout the region. In addition, the MPCA had established a flow gauging station in the lower Amity in 2001 in collaboration with the USGS and had supplemented the hydrograph with event-based water chemistry sampling and field measurements as part of their Lake Superior North Shore Sediment and Nutrient Loading Study (Anderson et al. 2003). The overall WSRI project intends to reduce sediment sources, quantify the cost effectiveness of sediment and stormwater runoff reduction activities, and communicate results to stakeholders in the watersheds and the greater region of western Lake Superior via web resources and the well established RSPT partnership involving 25 member organizations. This effort is more fully described at www.lakesuperiorstreams.org/weber/index.html , a website section that was created to help disseminate information resulting from the initiative (see also Breneman 2008).

NRRI staff had worked closely with City of Duluth and South St. Louis Soil & Water Conservation District engineers and water quality specialists over the period 2005-2007 to identify major stormwater BMP sites on Duluth area trout streams where a

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comprehensive, multi year assessment of their effect on downstream water quality, aquatic habitat, aquatic macroinvertebrate, and fish communities could be conducted to inform future restoration efforts. Several potential projects were identified in 2006 and 2007 that had a high likelihood for long-term success and a high potential for educational potential and public visibility. These were:

Graves Road Creek restoration (Lower Amity Creek) – Just upstream from the WSRI automated water quality sensors on lower Amity Creek, a small tributary has discharged a muddy plume during rainstorms and snowmelt runoff for decades since Graves Road was destroyed and abandoned after a flood. Another consortium partner, the City of Duluth, had scheduled a three-phase restoration project on the tributary including new culverts, flow rerouting, bank slope reductions, and sediment stabilization.
The road had been washed out by a severe thunderstorm and associated floods that we now believe occurred in 1946 (Figure 1). The City was unable to fund the road's reconstruction and essentially abandoned it. Since then it had eroded a channel cutting a steep sided ravine that flowed intermittently into Amity Creek. Expansion of the Lakeside neighborhood led to additional stormwater runoff being channeled into the drainage which exacerbated the problem and it continued to "bleed" mud into Amity .during spring runoff and large rainstorms. Amity Creek was designated as "Impaired" due to excessive turbidity and sediment by the MPCA and placed on the EPA 303(b) list in 2004. After the creation of the Weber Stream Restoration Initiative (WSRI) in 2005 (), a portion of the Weber gift was used to augment the MPCA's flow gauging station with temperature, specific electrical conductivity (EC25), and turbidity sensors in Amity Creek just downstream from the Graves Rd Creek confluence. This 319 grant provided an excellent opportunity to evaluate the impact of a Graves Rd restoration project on water quality, habitat, and biological communities (macroinvertebrates and fish) at the lower Amity Creek station.

Survey and design elements were outlined by City engineers, with formal engineering design and construction awaiting appropriation by City of Duluth utilities operations or alternative sources of funding. Three erosional target areas in Graves Rd. Creek were ultimately mitigated in late Summer/early Fall 2009 (Figure 2). This approximately 400 foot bank stabilization project included: replacing and extending old concrete culverts on the steepest, critical clay banks sections, to help prevent further headcutting of tributary lower section; then using a combination of facines, wattling and other bio-engineered methods to stabilize the clay sloughing on the other creek sections, and some engineered rip rap to prevent further scour; the City also addressed side channel headcutting and erosion on a side creek just above present culvert location.

2) Chester Creek pond removal and channel rerouting – This project was proposed by the MN DNR and had an overall objective of reducing peak summertime water temperatures in Chester Creek. Their draft plan was to restore 150 m of stream channel to reduce summer thermal stress on brook trout in Chester Creek by removing/modifying a dam, reconstructing the channel, and creating meandering riffle/pool sequences as part of a community based demonstration project within Chester Park, a major recreational area in Duluth.

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INSERT FIGURES 1 & 2 MAPS OF

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3) Miller Creek Sediment Trap effectiveness - This project is to evaluate the effectiveness of a sediment trap installed on Miller Creek in 2004 behind the Miller Hill Mall, an area of high impervious surface discharging to a trout stream known to suffer from high summer temperatures and a depauperate cold water fish assemblage, more recently high salt loading, and potentially sediment and sediment-associated pollutants (MPCA 2010 Impaired Waters L303(b) List , http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/assessment-and-listing/303d-list-of-impaired-waters.html; CITE Bill Herb). Initial effort focused on trying to locate original engineering drawings and design assumptions and identifying potential sampling sites;

(4) Upper Amity Creek bank stabilization - Eroding banks on the East Branch Amity Creek within the Duluth city limits were identified based on initial surveys by NRRI scientists at the beginning of the WSRI project. South St. Louis Soil & Water Conservation District, a member of the North Shore Stream Consortium, has led an effort to mitigate the eroding bank. Multiple agencies are providing in-kind support to approach the problem and reduce soil erosion. Project engineering plans, surveys, and permit development began in 2006. This project was personally initiated by a endowment/gift by a former Duluth resident who provided the foundation for the creation of the Weber Stream Restoration Initiative (WSRI; http://lakesuperiorstreams.org/weber). NRRI secured additional MPCA funding (via their Surface Water Assessment program) to generate an additional year of intensive baseline water quality, sediment load, and biological monitoring data at the site to assess project results and cost-effectiveness.

When the project began in Fall 2007 (EPA approval and initiation of in-kind Match effort, although funding to grantee did not begin began in March 2008), the Chester Creek project was not possible because of insufficient funding from MDNR to carry out the construction activities. Therefore, the Miller Creek sediment trap characterization was substituted for it.

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Task Reports

Program Element #1 – Quantify BMP effectiveness in improving water quality, sedimentation, bank erosion, and protection of benthic biological communities on Amity Creek (two sites) and Miller Creek (1 site).

Unfortunately, there were delays in implementing both of the Amity Creek restoration sites (Lower and Upper), primarily due to engineering design and construction funding issues, and to a lesser extent permitting issues. Therefore, the first three field seasons of the project (2007-2009) were used to establish a multi year baseline set of conditions upon which to evaluate the success of the project. NRRI staff also assisted with the design of the BMP and with associated permitting issues with the Minnesota Department of Natural Resources (MDNR-Fisheries and MDNR-Waters).

Both Amity restoration projects were completed by early November 2009 and the remainder of this element of the program involved continued collection of water quality, habitat, benthic invertebrate, and fish community data upstream and downstream from each restoration project or BMP. Habitat and biological data collections were conducted during late summer in each year (2007-2010) and water quality data was collected during snowmelt runoff, rain storm events, and base flow periods throughout the ice-free field seasons from Fall 2007 through Spring 2011 using funding from this project and a complementary MPCA Surface Water Assessment (SWA) grant; and in 2005 and 2006 using a combination of NOAA/MDNR Coastal Program and internal in-kind Match funding. Note that we have continued event-based sampling for water quality in Summer 2011, and will also be collecting habitat and biological data in late summer 2011 at both Amity sites using additional grant funding from a new NOAA/MDNR Coastal Program grant (funding one year of data collection at both Amity sites; start anticipated for August 2011), and a new EPA-GLRI grant to MPCA/NRRI/SeaGrant/SSL SWCD beginning in July 2011.

Miller Creek sediment trap data collection continued intermittently throughout the period 2008 – 2011 in order to “stretch out” the limited analytical funding to focus on the Amity restoration project assessments. In addition to the proposed water quality, habitat and biological sampling, we also conducted two detailed sediment-depth surveys in Summer 2008 (8/22/08) and Fall 2010 (9/30/10) to better estimate the potential trap efficiency.

Obj. A- Site selection (includes volunteer siting) – Sampling sites were established for all 3 project areas. A Project Form and Laboratory Documentation for the main project sites were submitted to MPCA (Lynda M. Nelson, State Program Administrator Technical Specialist, Environmental Analysis and Outcomes Division). At least one of these (Graves Rd. Creek) continues to be sampled by a CSMP volunteer that we trained and we will use these data in addition to our own event-based sampling of 3 sites where the ditch/creek enters Amity Creek (see below).

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We conducted a site assessment of the Miller Creek sediment trap with local agency staff (Duluth and SSL SWCD) and MPCA project manager Karen Evens in summer 2008 to discuss evaluation methodology and identify sampling sites (details below). For all three BMP site, the experimental design included *upstream-downstream* sites for evaluating BMP performance over a range of hydrologic conditions during the 3+ year study. In addition, data from immediately downstream from each of the two Amity BMPs will then be used over the long-term to assess performance via *before-after* data comparisons. The combination of these two types of experimental designs can be expected to provide the maximum amount of information possible.

Obj. B- Water Quality (professional + volunteer related effort) – various degrees of sampling occurred during the project. In particular, water quality sampling was reduced during the period Jul-Oct 2007 at the Amity sites relative to previous years because of it being a relatively dry summer (i.e. few storm event samplings), limited funding for sampling being adequate for only 3 not 4 years. Volunteer (MPCA CSMP) transparency tube data for the Graves Rd site has not been received yet.

Water quality data from the each year of the study were submitted to MPCA for posting in STORET and the MPCA EDA database. The Amity Creek site water quality data have also been posted on the www.LakeSuperiorStreams.org website at http://www.lakesuperiorstreams.org/streams/amity.html .

I. Graves Rd Creek (lower Amity site)

Manually collected data: The Graves Rd Creek restoration site involves 3 sampling locations: (1) Graves Rd Creek before it enters Amity Creek' (2) Amity Creek above the Graves Rd Creek discharge; and (3) Amity Creek below the Graves Rd Creek inflow. Data are summarized in Tables 1 and 2 and Figures 3-5 below.

Sampling efforts for the period 2007-2011 consisted of 15 snow melt samplings, 28 storm events and 21 baseline/low flow sampling at each of the three locations for a total of 64 samples; 17 of these include a full suite of water chemistry analyses in addition to the core set of field measurements at the lower Amity site. Graves Creek does not flow, or at least little more than a trickle, during baseflow conditions and therefore, is not sampled except during runoff events. Field parameters were measured at all of these samplings and consisted of specific electrical conductivity (EC25), temperature, dissolved oxygen concentration and % oxygen saturation measurements, field turbidity and transparency tube clarity. Laboratory analyses consisted of turbidity and total suspended solids (TSS), though a few samples (at Graves Rd Creek and the Upper Amity site) were also measured for total nitrogen and total phosphorus concentrations. These samples will be used to begin a longer term assessment of the restoration's effectiveness over the next several years as funding permits. Data summaries are presented below (Figure 4, 5, 6).

Pre-restoration data:

A total of 133 samples were collected between 2007 and 2009 in and around the Graves Rd Creek site. Of these, 102 (34 separate dates) were matched samples where

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all three locations were sampled at the same time. Field parameters were measured at most of these samplings and consisted of specific electrical conductivity (EC25), temperature, and transparency tube clarity. Some field turbidity, dissolved oxygen concentration and percent saturation measurements were also measured. Laboratory analyses consisted of turbidity and total suspended solids (TSS), though a few samples were also measured for total nitrogen and total phosphorus concentrations. Note that a consistent set of water quality analyses for all sampling dates and sites was not possible because of funding limitations. The proposed work plan noted this fact and focused on turbidity and transparency tube measurements as surrogates. Turbidity was particularly important since it was the basis for Amity being designated as "Impaired" by MPCA; transparency tube clarity was included as a low cost surrogate for both turbidity and total suspended sediment (TSS) that could be used by MN Citizen Stream Monitoring Program (CSMP) volunteers for continuing assessment of BMP performance as well as long-term assessment of Amity Creek. When possible, we supplemented these measurements with additional water quality parameters with funding from other projects.

Sampling efforts in 2009 were restricted to only a few unusual hydrologic events due to the anticipated restoration project construction activity that was repeatedly delayed throughout the 2009 field season, and which finally occurred in late summer - early fall. It was also a relatively dry summer in terms of larger rain storms that would trigger garb sampling.

2007-2009 sampling:

- Amity- above Graves Rd Cr: 2007 – 20 dates for temperature, EC25, turbidity, transparency tube; 1-2 dates with additional TSS and nutrient data (TN, TP, NH4-N, NO3/NO2-N); sampling focused on storm events
- Amity- below Graves Rd Cr: 2007 – 33 dates for temperature, EC25, turbidity, transparency tube; 14 dates with additional TSS and nutrient data; sampling focused on storm events
- Amity- above Graves Rd Cr: 2008 – 14 dates for temperature, EC25, DO, turbidity, TSS, transparency tube; sampling focused on storm events
- Amity- below Graves Rd Cr: 2008 – 14 dates for temperature, EC25, DO, turbidity, TSS, transparency tube; sampling focused on storm events
- Amity- above Graves Rd Cr: 2009 – 4 dates for temperature, EC25, turbidity, transparency tube; 1-2 dates with additional TSS and nutrient data (TN, TP, NH4-N, NO3/NO2-N); sampling focused on storm events
- Amity- below Graves Rd Cr: 2009 – 4 dates for temperature, EC25, turbidity, transparency tube; 1-2 dates with additional TSS and nutrient data; sampling focused on storm events

- Amity below Graves Rd Creek also has automated water quality sensors at a station operated and maintained jointly by NRRI, MPCA-Duluth, and City of Duluth staff since 2005 (flow by MPCA from 2002-present). It has flow and water quality sensors for temp, EC25 and turbidity. However due to bridge reconstruction at the site, the gauging station was moved >500m upstream of the project area for most of 2007 and through July 23, 2008, and then was re-located back to its original location. This provides 15 minute frequency data that is uploaded each morning to the www.lakesuperiorstreams.org

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website for on-line interactive viewing (http://lakesuperiorstreams.org/streams/data/Java/SMU_06-08.html).

- Graves Rd Cr 2007- directly sampled 25 times for temperature, EC25, turbidity, transparency tube.
- Graves Rd Cr 2008- directly sampled 14 times for temperature, EC25, DO, turbidity, transparency tube, and TSS. A local homeowner with a strong interest in the health of the stream was recruited and trained as an MPCA Citizen Stream Monitoring Program volunteer in the fall. The CSMP protocols will be augmented by providing him with a portable specific conductivity meter and with sampling bottles for water for turbidity analyses to be conducted at NRRI. The intent is to establish a committed, low-cost source of sediment- and road salt-related data for the long-term at this site(s)
- Graves Rd Cr 2009- directly sampled on 4 dates for temperature, EC25, turbidity, transparency tube; 1-2 dates with additional TSS and nutrient data; sampling focused on storm events

- Data and statistical analyses are shown and discussed below

- All sampling was performed using methods consistent with MPCA Guidelines for stream assessments (A QAPP was approved by MPCA in July 2008 which is now downloadable from the LSS website at http://www.duluthstreams.org/archives/QAPP-SWANS-Ver2-07-21-08FINAL.pdf ; automated gauging station methods follow a QAPP previously approved by EPA – see http://lakesuperiorstreams.org/streams/QA_QC.html).

2010-2011 sampling:

- Amity- above Graves Rd Cr: 2010 – 9 dates for temperature, EC25, turbidity, transparency tube; 4-6 dates with additional TSS and nutrient data (TN, TP, NH4-N, NO3/NO2-N); sampling focused on storm events
- Amity- below Graves Rd Cr: 2010 – 9 dates for temperature, EC25, turbidity, transparency tube; 4-6 dates with additional TSS and nutrient data (TN, TP, NH4-N, NO3/NO2-N); sampling focused on storm events

- Amity- above Graves Rd Cr: 2011 (through the end of June)– 4 dates for temperature, EC25, turbidity, transparency tube; all with additional TSS and nutrient data (TN, TP, NH4-N, NO3/NO2-N); sampling focused on storm events
- Amity- below Graves Rd Cr: 2011 (through the end of June)– 4 dates for temperature, EC25, turbidity, transparency tube; all with additional TSS and nutrient data (TN, TP, NH4-N, NO3/NO2-N); sampling focused on storm events

- Graves Rd Cr 2010-4 dates for temperature, EC25, turbidity, transparency tube; 1-2 dates with additional TSS and nutrient data; sampling focused on storm events
- Graves Rd Cr 2011 (through the end of June)– 4 dates for temperature, EC25, turbidity, transparency tube; all with additional TSS and nutrient data (TN, TP, NH4-N, NO3/NO2-N); sampling focused on storm events

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Pre-restoration observations:

One observation that was evident from all three years of data was higher EC25 values in Graves Rd Creek relative to Amity Creek. This was the only Graves Rd Creek parameter that was different and statistically significant ($p<0.05$) from Amity Creek, either immediately above or below the inlet. The difference between the conductivity values was greater during spring snow melt than in the summer and fall period, presumably due to road salt runoff. This would be expected as Graves Rd Creek is for the most part an extension of the City of Duluth storm drain system and drains much of the Lakeside neighborhood. The turbidity, TSS and transparency tube values from Graves Rd Creek have thus far not been much different than values for Amity itself. Visual evidence indicates that Graves Rd Creek is very flashy and intermittent, and it is extremely difficult to sample at its peak flows when suspended sediment and turbidity are likely to be highest. At moderate flows due to rainstorms, it is often noticeably muddier than Amity Creek, whereas at higher storm associated flows, it may be indistinguishable visually from Amity (see Figure 3 below).

Automated Data (Lower Amity Creek immediately downstream from the Graves Road Creek confluence)

Amity Creek, immediately below Graves Rd Creek also has automated water quality sensors at a station operated and maintained jointly by NRRI, MPCA-Duluth, and City of Duluth staff since 2005 (flow by MPCA from 2002-present). It has flow and water quality sensors for temp, EC25 and turbidity. This provides 15 minute frequency data that is uploaded each morning to the www.lakesuperiorstreams.org website for on-line interactive viewing (www.lakesuperiorstreams.org/streams/data/Java/SMU_Amity.html).

Data from this station are being used to estimate annual and event/seasonal rates of pollutant loading and flow-weighted pollutant concentrations (e.g. Ruzycki et al. 2011; Ruzycki et al. In prep; Axler et al. 2010). The data animations are also useful for education and outreach purposes because they are an interactive tool allowing users to explore data and learn more about the interrelationship of weather, landuse, water quality, and habits for both aquatic organisms and humans.

Screen captures from the *LakeSuperiorStreams.org* Stream Data section are shown below and briefly summarized as follows:

(1) The first *Dataviewer* image below shows the first 6 months of 2010 where turbidity is color mapped. The dark, brown vertical bands are periods of high turbidity and the vertical green bars show the amount of precipitation. The graphic clearly shows a number of turbid flow events, some associated with spring snowmelt beginning in March, including a rain on snow event; and additional rainstorms throughout spring and summer.

(2) The second *Dataviewer* image shows temperature over the same period and illustrates that it was a relatively early, but cool spring, with a period of higher temperatures beginning in July.

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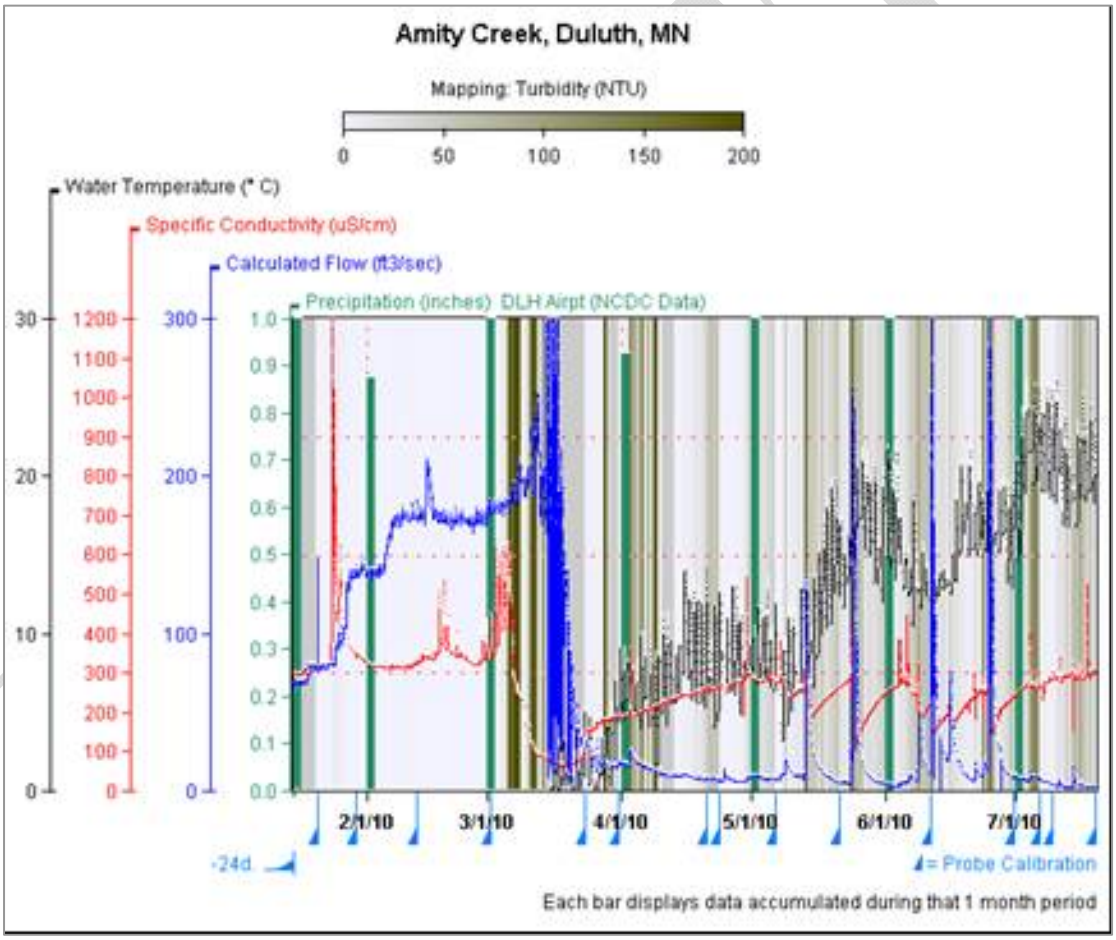
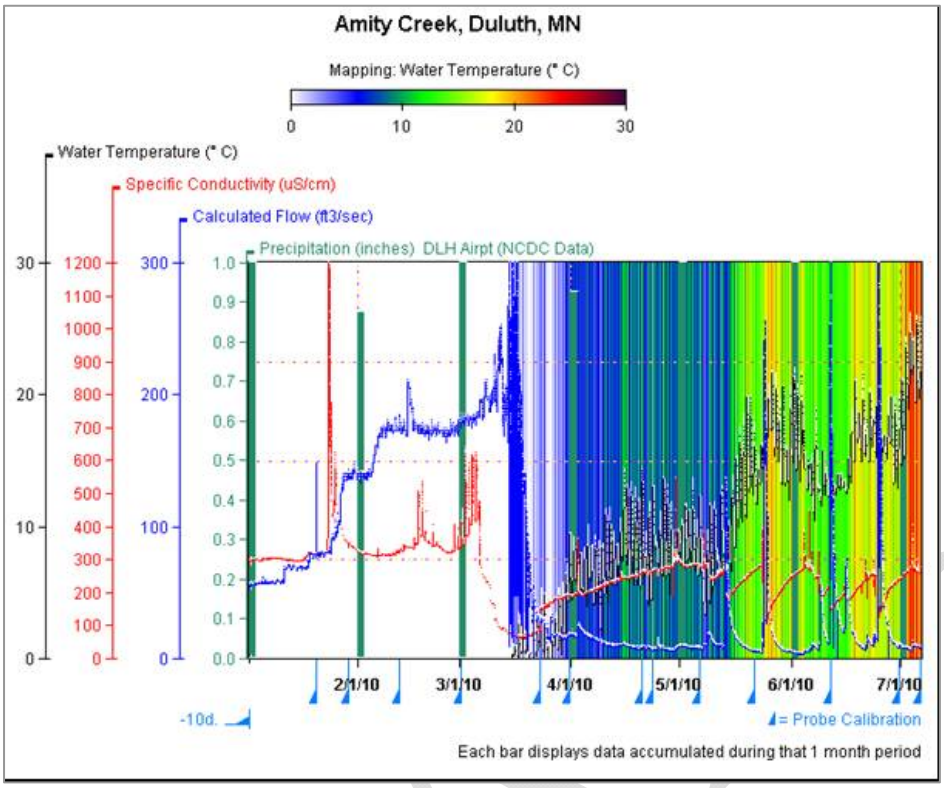
(3) The third dataviewer image shows specific electrical conductivity, a parameter than correlates well with total dissolved salts and the “salinity” of the water, and is a particularly good surrogate for road salt in winter and early spring. The values are lower in winter than measured for more urbanized City of Duluth streams, and indicate a spike in mid-January, presumably from road salt inputs, and then a strong dilution during spring runoff, when the largely rural snowpack melted and essentially diluted the salts in the stream. This dilution effect from rainstorms is typical of all the streams we have gauged since 2002 after a first flush of salt when the snow first begins to melt. This effect was less pronounced in 2010 because of reduced snowfall after mid January, and perhaps due to the gradual runoff in spring.




Amity Creek, Duluth, MN
Mapping: Water Temperature (° C)
0
10
20
30
Water Temperature (° C)
Specific Conductivity (uS/cm)
Calculated Flow (ft3/sec)
Precipitation (inches) DLH Airpt (NCDC Data)
2/1/10
3/1/10
4/1/10
5/1/10
6/1/10
7/1/10
-10d.
= Probe Calibration
Each bar displays data accumulated during that 1 month period

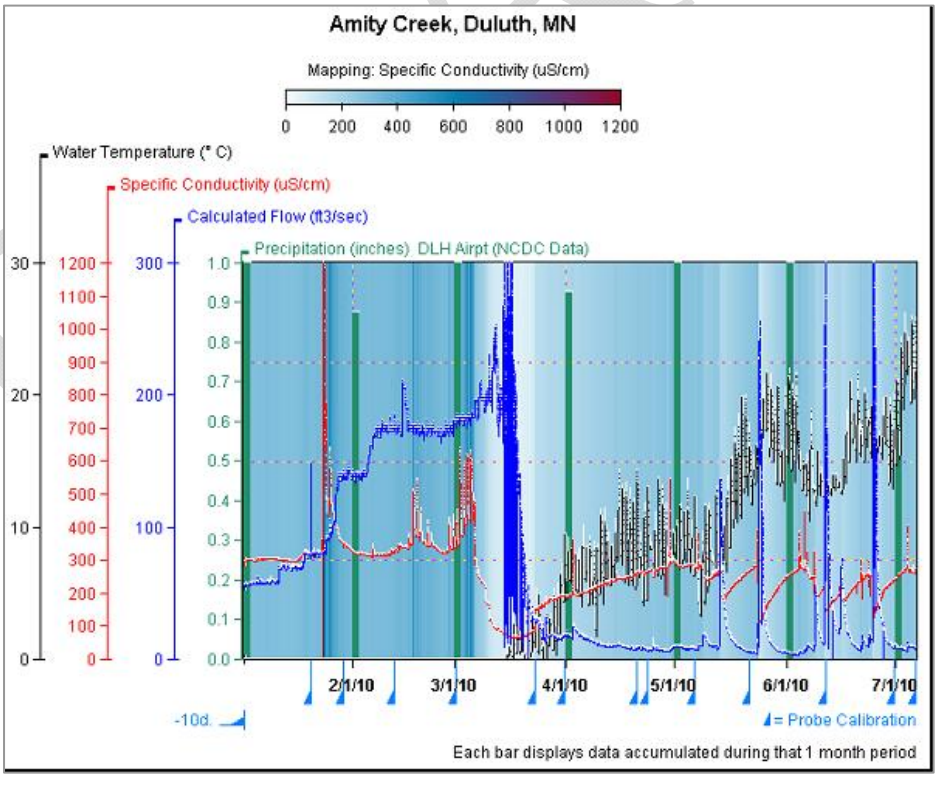

Amity Creek, Duluth, MN
Mapping: Specific Conductivity (uS/cm)
0
200
400
600
800
1000
1200
Water Temperature (° C)
Specific Conductivity (uS/cm)
Calculated Flow (ft3/sec)
Precipitation (inches) DLH Airpt (NCDC Data)
2/1/10
3/1/10
4/1/10
5/1/10
6/1/10
7/1/10
-10d.
= Probe Calibration
Each bar displays data accumulated during that 1 month period

Figure 3. Graves Road Creek inlet (circled) to Amity Creek above the lower Amity Creek gauging station over a range of flows. Photos A and B from late summer pre-construction show a muddy inflow generated by residual stormwater flows following a wet period, but after Amity Creek had returned to "base-flow clarity." Photo C shows Graves Rd Creek looking down towards Amity and the tributary is relatively clear during the latter stages of spring runoff. Photo D was taken the day after an intense rainstorm (>1.5 inches/day) and both are extremely turbid and difficult to distinguish visually.

Temperature differences varied from year to year with Graves Rd Creek temperatures 1.4 ^{o}C cooler on average than Amity Creek in 2007, 0.9 ^{o}C warmer in 2008, and 0.5 ^{o}C warmer in 2009 (although only for two sampling dates). Water quality data was collected as summarized below.

Post-construction 2010 - Spring 2011

The turbidity, TSS and transparency tube values from Graves Rd Creek for 2010 and early 2011, the only post-construction data to date, are not statistically different (in fact they remain somewhat greater) than the values for the adjacent Amity Creek site. This is likely the result of restoration construction-related fine sediment not being fully flushed and that bank and surface re-vegetation has been limited thus far and what has been planted has not been fully established. Additional re-vegetation work has been done in Spring and summer 2011 with funding from a Great Lakes Restoration Initiative (GLRI) project entitled *Duluth Streams Corps: Restoring Duluth's Coldwater Streams* (to *Community Action Duluth, Inc*.), plus additional funds from Mr. Ron Weber, and from donated trees from Mr. Jack Rajala.

The 2010 Graves Rd Creek temperature data were virtually identical to Amity Creek (0.1^0C cooler) at their confluence. The data also show that EC25, turbidity, and TSS were higher in Graves Rd Creek than Amity Creek. The increased EC25, which was mostly during snowmelt runoff sampling actually increasing the Amity EC25 by 15%, from an average of 214 µS/cm upstream to an average of 253 µS/cm below the confluence, undoubtedly due to winter accumulations of de-icing chemicals (salt)(see Figure 5 and Table 2).

It remains unclear how long it will take to see the (positive) impact of the Graves Rd. Creek BMPs, although the relatively normal snowmelt runoffs in Spring 2010 and 2011 and the abnormally high number of intense rainstorms in late summer 2010 and throughout Spring and Summer 2011 are likely to have flushed residual soil from 2009 construction activities and revegetation changes are already noticeable. It already be acting to decrease the discharge rate and volume of the sediment but we cannot easily determine this without a flow monitoring station at the Graves Rd Creek outflow (note-instrumentation was included in the budget of the newly funded Great Lakes Restoration Initiative funded Amity Creek Restoration project, but was unfortunately cut from the budget because it represented “monitoring”, not specifically restoration). The BMPs however, are most certainly reducing the bank erosion in the lowest stretch of the Graves Rd Creek ravine. This is also a difficult situation to sample manually as Graves Rd Creek tends to be flashier than Amity Creek because it is presumed to be predominantly driven by rapid influx of water running off of impervious streets and driveways, getting turbid and clearing up faster than Amity Creek. Grab samples collected early in a storm event may be collected when the tributary is flowing “dirty” while the Amity may not yet have shown the effects of the rain event (or snow melt). Sampling later in the storm event process could show an opposite pattern. Hopefully, the new Amity Restoration project partnership funded by EPA-GLRI will generate additional resources and effort in implementing a more integrative monitoring methodology at this site (e.g. a small weir where automated, data logging sensors could be installed).

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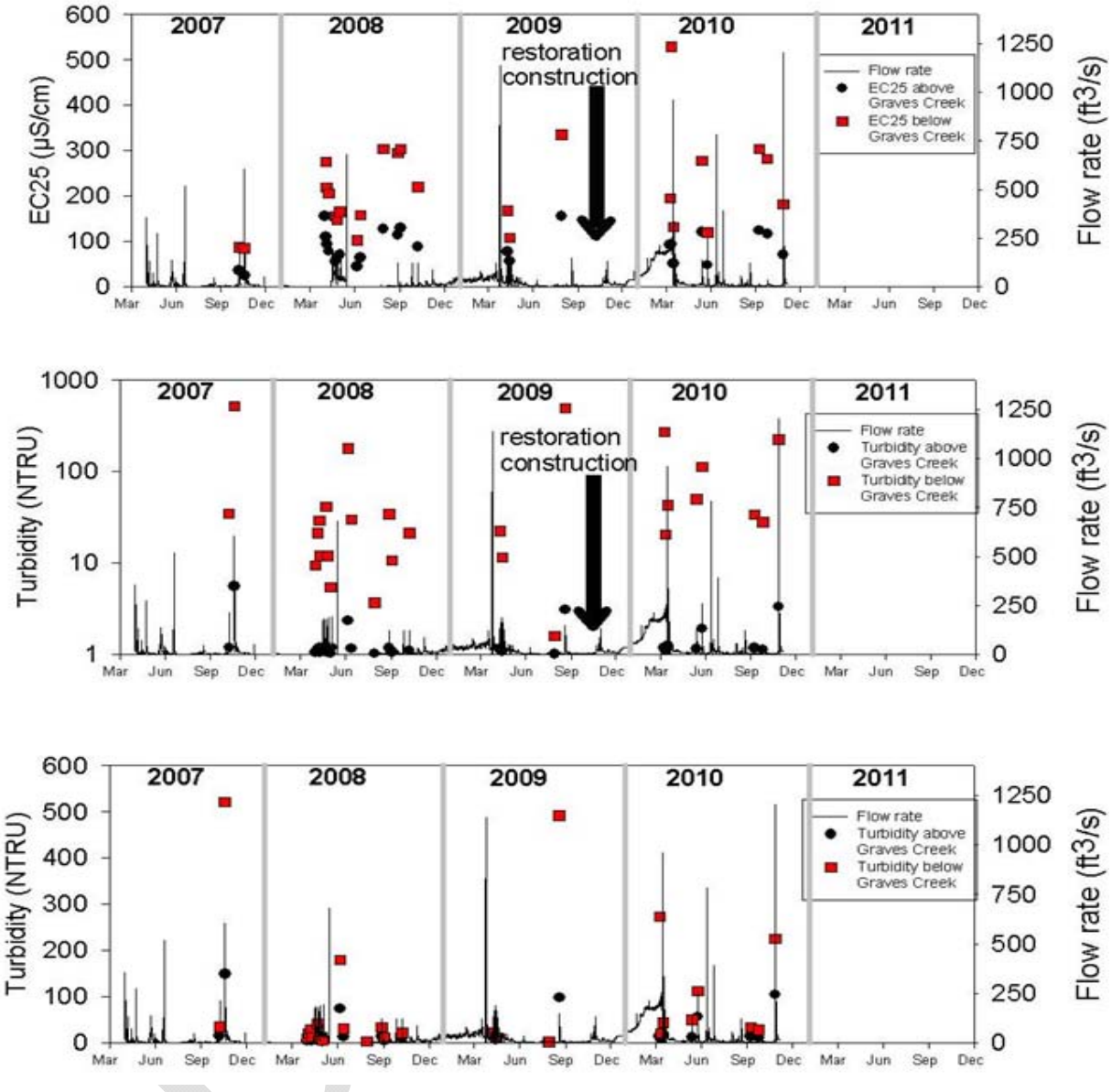

Figure 4. Summary of turbidity and EC25 data collected at the lower Amity Creek station upstream and downstream of the Graves Rd. Creek confluence, 2007-2011. Note that turbidity data is plotted on both a log scale and a linear scale in the middle and lower panels, respectively. Flow rates are provisional and taken from the www.lakesuperiorstreams.org website

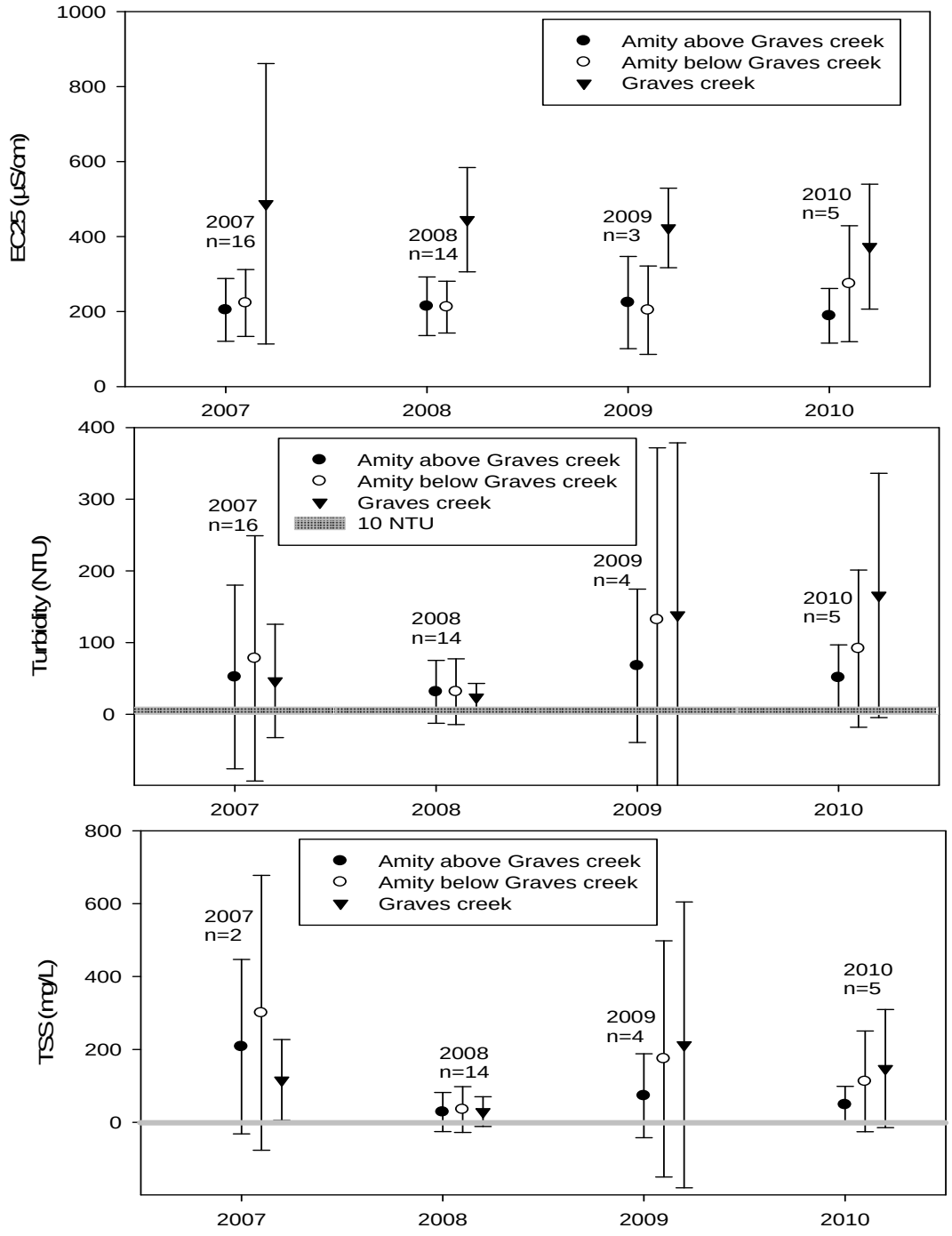

Figure 5. Summary of turbidity, TSS, and EC25 data collected for Graves Rd. Creek and lower Amity Creek stations upstream and downstream of the Graves Rd. Creek confluence, 2007-2010. The complete set of measurements at each site is presented as annual means and standard deviations for "n" measurements during the calendar year. Horizontal shadings denote MPCA regulatory standards.

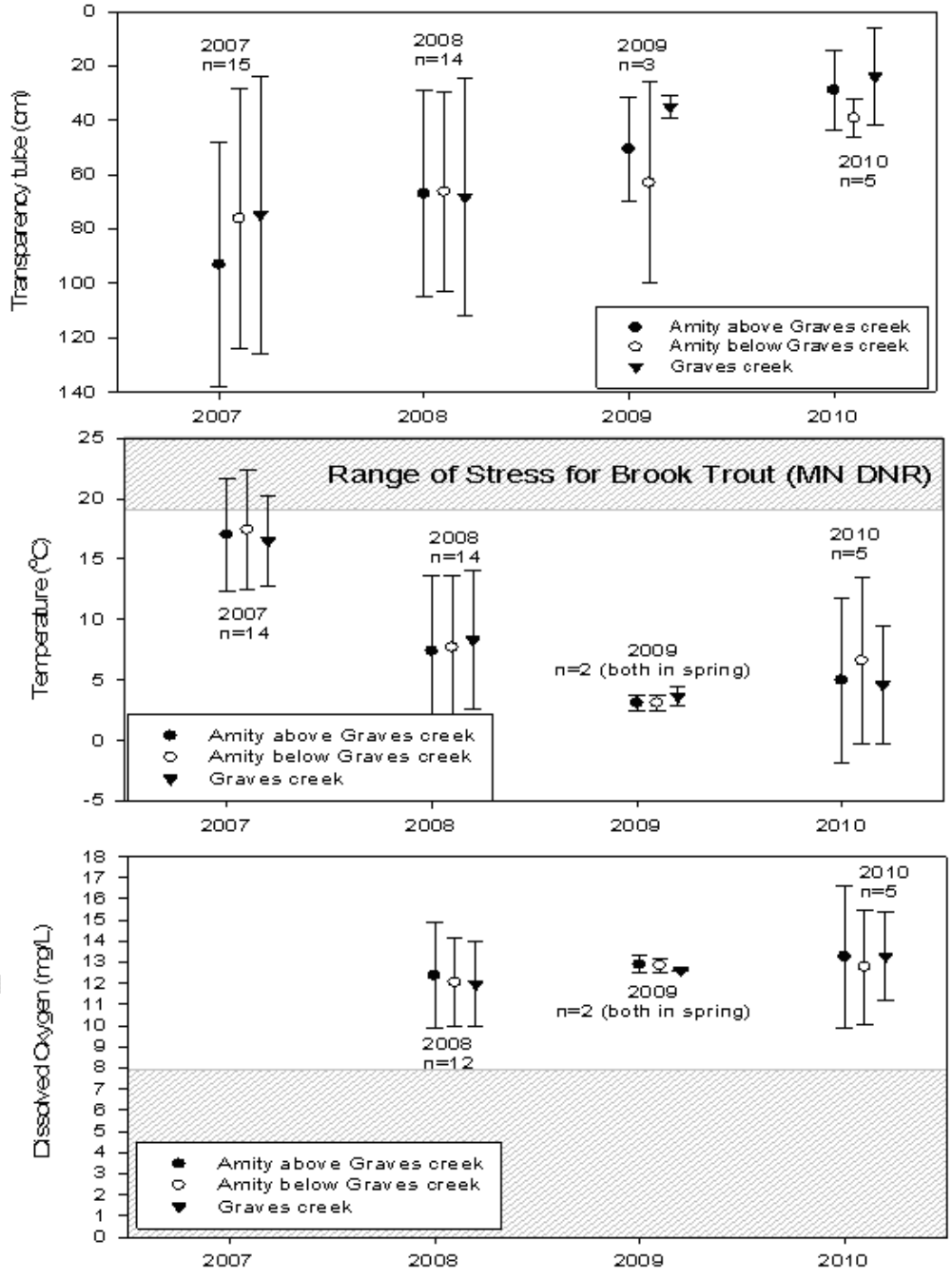

Figure 6. Summary of transparency tube, DO, and temperature data collected for Graves Rd. Creek and lower Amity Creek stations upstream and downstream of the Graves Rd. Creek confluence, 2007-2010. The complete set of measurements at each site is presented as annual means and standard deviations for "n" measurements during the calendar year. Horizontal shadings denote MPCA regulatory standards or guidelines.

Table 1. Summary of pre- and post- BMP construction water quality data at Lower Amity Creek Watershed restoration site. Values reported as mean ± standard deviation (n). Hydrologic regimes are : Snow = snowmelt runoff; Storm = significant rainstorms (generally >2.5 cm/day); Base = summer baseflow.

	Pre- BMP (2007-2009)			**Post- BMP (2010)**		
	Snow	**Storm**	**Base**	**Snow**	**Storm**	**Base**
Above Graves Road Creek						
Turbidity (NTRU)	23.2 ± 12.5 (6)	74.9 ±129.1 (12)	52 ±9.0 (113)	31.8 ±10.3 (3)	65.5 ±74.9 (9)	18.3 (1)
Transp-tube (cm)	58.8 ±32 (6)	67.5 ±48.0 (12)	110.9 ±25.5 (14)	33.4 ±10.9 (3)	28.7 ±16.9 (9)	38 (1)
1/T-tube (cm^{-1} x 100)	2.03 ±0.79 (6)	6.02 ±8.85 (12)	1.05 ±0.70 (14)	3.18 ±0.88 (3)	5.91 ±5.53 (9)	2.63 (1)
EC25 (uS/cm)	219 ±82 (6)	166 ±70 (13)	249 ±71 (15)	184 ±57 (3)	206 ±67 (8)	N/D
Temp (oC)	1.5 ±2.1 (6)	13.1 ±4.4 (3)	16.8 ±5.2 (14)	0.7 ±1.2 (3)	13.6 ±5.1 (9)	N/D
D.O. (mg/L)	14.6 ±14.9 (6)	10.9 ±6.5 (3)	10.8 ±1.1 (4)	16.1 ±0.9 (3)	10.4 ±0.9 (9)	N/D
D.O. (%saturation)	103.8 ±9.2 (6)	100.4 ±6.2 (3)	103.0 ±6.2 (4)	114.7 ±9.3 (3)	101.9 ±4.2 (9)	N/D
TN (ugN/L)	N/D	N/D	N/D	N/D	N/D	N/D
TP (ugP/L)	N/D	N/D	N/D	N/D	N/D	N/D
TSS (mg/L)	18.2 ±15.0 (7)	127 ±136 (8)	8.7 ±10.7 (4)	29.1 ±21.6 (3)	61 ±84 (9)	12.4 (1)
Below Graves Road Creek						
Turbidity (NTRU)	22.0 ±14.1 (12)	83.7 ±151.8 (19)	5.6 ±34.7 (19)	112 ±140 (3)	65.2 ±66.1 (9)	9.9 ±11.0 (2)
Transp-tube (cm)	56.5 ±28.3 (13)	55.8 ±44.7 (19)	102.4 ±33.9 (19)	24 ±19 (3)	25.4 ±14.1 (9)	77.5 ±60.1 (2)
1/T-tube (cm^{-1} x 100)	2.31 ±1.35 (13)	5.74 ±8.06 (19)	1.44 ±1.76 (19)	8.83 ±9.72 (3)	6.42 ±5.87 (9)	1.85 ±1.43 (2)
EC25 (uS/cm)	152 ±62 (11)	193 ±82 (20)	252.8 ±89.3 (20)	285 ±213 (3)	220 ±63 (8)	249.9 (1)
Temp (oC)	1.9 ±1.8 (11)	13.7 ±4.0 (18)	16.7 ±5.1 (16)	0.7 ±1.2 (3)	14.1 ±4.5 (9)	10.0 (1)
D.O. (mg/L)	13.8 ±1.2 (7)	9.9 ±1.2 (9)	10.2 ±1.1 (6)	15.5 ±0.4 (3)	10.4 ±1.1 (9)	11.3 (1)
D.O. (%saturation)	102.8 ±3.6 (7)	93.0 ±8.4 (11)	98.9 ±5.1 (6)	108.7 ±3.2 (3)	101.4 ±4.5 (9)	105 (1)
TN (ugN/L)	751 ±55 (3)	854 ±568 (10)	500 ±306 (4)	1139 ±490 (3)	954 ±394 (8)	452 (1)
TP (ugP/L)	83 ±57 (3)	52 ±120 (10)	23 ±19 (4)	187 ±205 (3)	110 ±96 (8)	30 (1)
TSS (mg/L)	27 ±20 (10)	171 ±252 (13)	31 ±54 (6)	131 ±168 (3)	69 ±80 (9)	8.6 ±10 (2)

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II. East Branch Creek Restoration (Upper Amity)

Water quality data pre- (2008-2009) and post-construction (2010) at the Upper Amity site are summarized in Figure 7 and Table 2. Sampling frequency was lower than for the Lower Amity site because it is logistically much more difficult to reach (~1 km by foot). A total of 20 samples were taken downstream of the restoration site in 2008 and 2009 before the restoration commenced and no samples were taken upstream of the restoration because of funding limitations. In 2010 an additional 12 samples were taken both above and below the restoration site.

2008-2009 (pre-) *vs* 2010 (post-)
Temperature and EC25 were each ~15% lower at the downstream site after the restoration but these differences are likely indicative of naturally occurring year-to-year differences (2008 and 2009 relative to 2010) rather than differences due to the bank and channel reconstructions. As the restoration "matures" in terms of revegetation, and the water quality data set increases, we will have more confidence in using the before-after data to assess BMP performance. We will also continue to seek funding for additional "upstream-downstream" sampling which at least partly avoids the interannual difference problem in interpreting the data. However, as for the Lower Amity Graves Rd. Creek restoration, we would expect erosion to be gradually reduced over the next year as we plant additional vegetation, and the vegetation matures. More sampling over a longer time period should dampen what could be bias due to the timing of rain events and snow melt pulses in relation to grab sampling.

Measurements of sediment/solids and their surrogate metrics showed an increase in their averages after the restoration (2010) as compared to pre-restoration values (2008-2009). TSS increased by 125% from an average of 12 mg/L to 28 mg/L after the restoration work. Transparency tube measurements decreased by 35% (dropping from 104cm to 68cm) and turbidity increased 77% (22 NTRUs) after the restoration. Again, this increase is undoubtedly associated with a small data set being used (inappropriately) to compare water quality where seasonal and interannual differences are the major source of variation.

A comparison between the 12 samples taken in 2010 from above and below the restoration project showed very little difference between the two. The contribution from the restored area appears to be minimal from this analysis.

The data point out the importance of considering annual variability in this system since we did not detect an upstream - downstream change in the 2010 data while detecting fairly large differences at the downstream site when comparing pre- and post-restoration sampling. These differences will presumably disappear over time as the fine sediment created by the construction activity is washed downstream and as the planted vegetation and natural re-vegetation process proceeds. Plants take time to grow and are a vital component of the restoration providing stability, shading and filtering on the newly exposed slope. Vegetation has been slow to propagate on the east facing slope and may take another year for full coverage.

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Comparison of the 2010 and early 2011 (through June) post-restoration data

Including a second year of data comparing upstream-downstream showed that data from 2010 and 2011 were quite similar. EC25, turbidity, and TSS all increased and transparency tube decreased slightly in 2011 over 2010, but the differences were small. EC25, turbidity, and TSS all increased slightly more below the restoration than above it, though the differences are small enough that they likely reflect the annual variability that can be expected in this system.

Table 2. Comparison of paired water quality data above and below the BMP/restoration project at the Upper Amity East Branch site. Post construction data were pooled from 2010 and 2011 (through June), n=17.

Parameter	D.O. (mg/L)	D.O. (% sat)	Temp (^{o}C)	pH	EC25 (µS/cm)	Turbidity (NTRU)	TSS (mg/L)	Transparency tube (cm)
Above slump (BMP)	11.2	99.2	8.7	7.5	193.4	37.3	44	71.4
Below slump (BMP)	11.2	99.6	8.7	7.5	191.9	43.3	50	67.4
change	0 %	<1 %	0 %	0 %	<1 %	-14 %	-12 %	5.6 %

.

Table 3 compares all the pre- and post- restoration data from downstream of the restoration site. None of the parameters indicated an improvement in water quality downstream from the BMPs. The changes varied from slight (temperature and dissolved oxygen) to large increases in sediment associated metrics. We believe this reflects a combination of flushing of construction associated soil, hydrologic differences between years, and immature vegetation at the construction sites. The vegetation is still struggling to grow and coverage of the slope remains minimal. The plant cover is in its second growing season and while it is improving, it still needs additional plantings (some revegetation work was conducted in June 2011 and more will happen in Fall 2011 with funding from the new GLRI-Amity Creek Restoration project, and from WSRI funding and tree donations.

Table 3. Comparison of water quality parameters pre- (2008-2009, n=20) and post- restoration (2010-2011 n =17) from the Upper Amity East Branch "below" site.

	D.O. (mg/L)	EC25 (µS/cm)	Turbidity (NTRU)	TSS (mg/L)	Transparency tube (cm)	Temperature (^{o}C)
2008-2009	11.2	222	11.7	15	104	10.4
2010-2011	10.6	191	32	38	71	11.2
change	-5%	-14%	+173%	+153%	-32%	+7.7%

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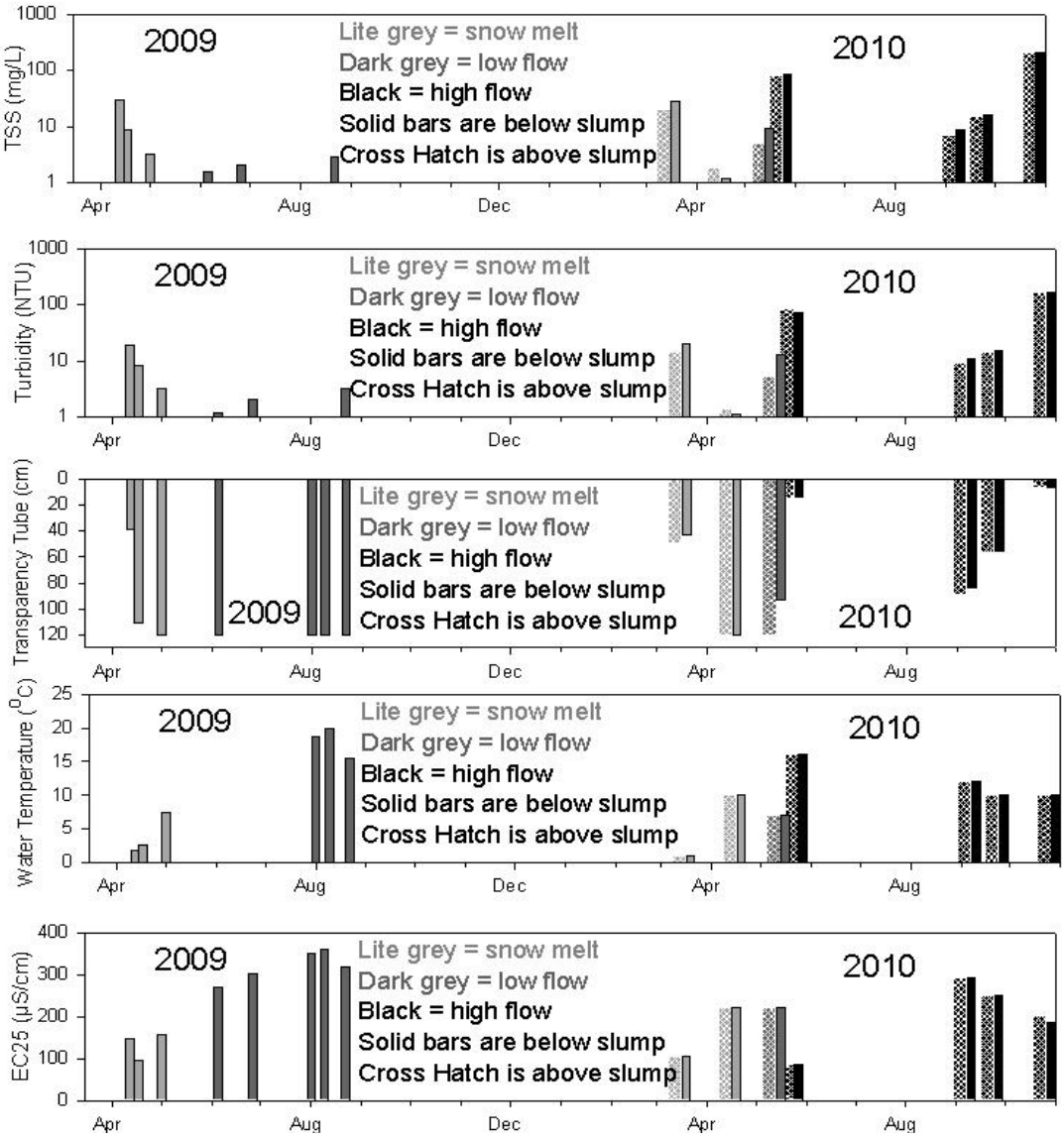

Figure 7. Water quality data collected immediately upstream and downstream of the Upper Amity Creek (East Branch) bank stabilization BMP site, pre- (2009) and post (2010 construction. Bar patterns denote hydrologic regimes at time of of sampling, low (~base) flow, snowmelt runoff, and following rainstorms (>1.3 cm, and usually >2.5cm). sampling, low (~base) flow, snowmelt runoff, and following rainstorms (>1.3 cm, and usually >2.5cm).

Table 4. Summary of pre- and post- BMP construction water quality data at Upper Amity Creek Watershed restoration site. Values reported as mean ± standard deviation (n). Hydrologic regimes are : Snow = snowmelt runoff; Storm = significant rainstorms (generally >2.5 cm/day); Base = summer baseflow.

	Pre- BMP (2007-2009)			**Post- BMP (2010)**		
	Snow	**Storm**	**Base**	**Snow**	**Storm**	**Base**
Above East Branch BMPs						
Turbidity (NTRU)	14.5 (1)	7.7 (1)	N/D	N/D	34.4 ±51.1 (10)	2.0 ±0.9 (2)
Transp-tube (cm)	49 (1)	N/D	N/D	N/D	64 ±40.4 (10)	117.5 ±3.5 (2)
1/T-tube (cm^{-1} x 100)	2.04 (1)	N/D	N/D	N/D	3.56 ±4.92 (10)	0.83 ±0.87 (2)
EC25 (uS/cm)	104 (1)	N/D	N/D	N/D	201 ±64 (9)	220 (1)
Temp (oC)	N/D	N/D	N/D	1.0 (1)	13.8 ±4.0 (10)	10.0 (1)
D.O. (mg/L)	15.0 (1)	N/D	N/D	15.0 (1)	10.0 ±0.9 (10)	11.3 (1)
D.O. (%saturation)	N/D	N/D	N/D	105.0 (1)	97.1 ± 4.2 (10)	104.0 (1
TN (ugN/L)	N/D	N/D	N/D	N/D	N/D	N/D
TP (ugP/L)	N/D	N/D	N/D	N/D	N/D	N/D
TSS (mg/L)	20 (1)	N/D	N/D	N/D	42 ±66 (9)	2 ±0.8 (2)
Below East Branch BMPs						
Turbidity (NTRU)	11.4 ±8.4 (5)	24.9 ±40.0 (6)	3.0 ±4.5 (9)	19.6 (1)	37.6 ±49.5 (11)	3.7 ±3.6 (2)
Transp-tube (cm)	102 ±35 (5)	85.8 ±49.5 (5)	114.9 ±15.3 (9)	43 (1)	55.9 ±37.8 (11)	117.0 ±4.2 (2)
1/T-tube (cm^{-1} x 100)	1.19±0.77 (5)	2.52 ±3.28 (5)	0.89 ±0.17 (9)	2.33 (1)	3.98 ±4.79 (11)	0.86 ±0.03 (2)
EC25 (uS/cm)	150 ±32 (5)	177 ±87 (5)	282 ±63 (10)	104.0 (1)	188 ±70 (10)	221 (1)
Temp (oC)	3.1 ±2.6 (5)	10.2 ±3.5 (5)	15.0 ±5.0 (8)	1.0 (1)	13.8 ±4.0 (11)	10.0 (1)
D.O. (mg/L)	13.9 ±1.2 (5)	10.7 ±1.5 (5)	10.0 ±0.9 (10)	14.9 (1)	10.0 ±0.8 (11)	11.3 (1)
D.O. (%saturation)	104.5 ±2.9 (5)	95.1 ±6.9 (5)	101.4 ±539 (8)	105.0 (1)	98.5 ±3.9 (10)	104.0 (1)
TN (ugN/L)	628 ±297 (5)	688 ±266 (5)	311 ±168 (10)	N/D	N/D	N/D
TP (ugP/L)	37 ±21 (5)	41 ±27 (5)	10 ±10 (10)	N/D	N/D	N/D

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Amity Creek Synoptic Survey April 2011

The Arrowhead Stream Team is an *ad hoc* organization created a few years ago by hydrologists at the MPCA and MDNR in Northeastern Minnesota assembles local, state, and federal agency hydrologists, ecologists, fisheries scientists, and university researchers with common interests in watershed science and management. At a meeting in March 2011 that was focused on sharing information about the various projects taking place in the Amity Creek watershed, there was a consensus that it would be useful to have a "snapshot" of water quality throughout the watershed during periods of high flows such as the current latter stage of Spring snowmelt runoff. As a result we designed a synoptic survey with help from MPCA and SSL SWCD staff that assembled 5 teams to collect water for analysis of turbidity, transparency tube clarity, total suspended sediment (TSS), specific electrical conductivity (EC25), and TN,TP (the nutrients would be analyzed if additional funding could be acquired). The results of this survey to date are shown in the schematic below (Figure 8).

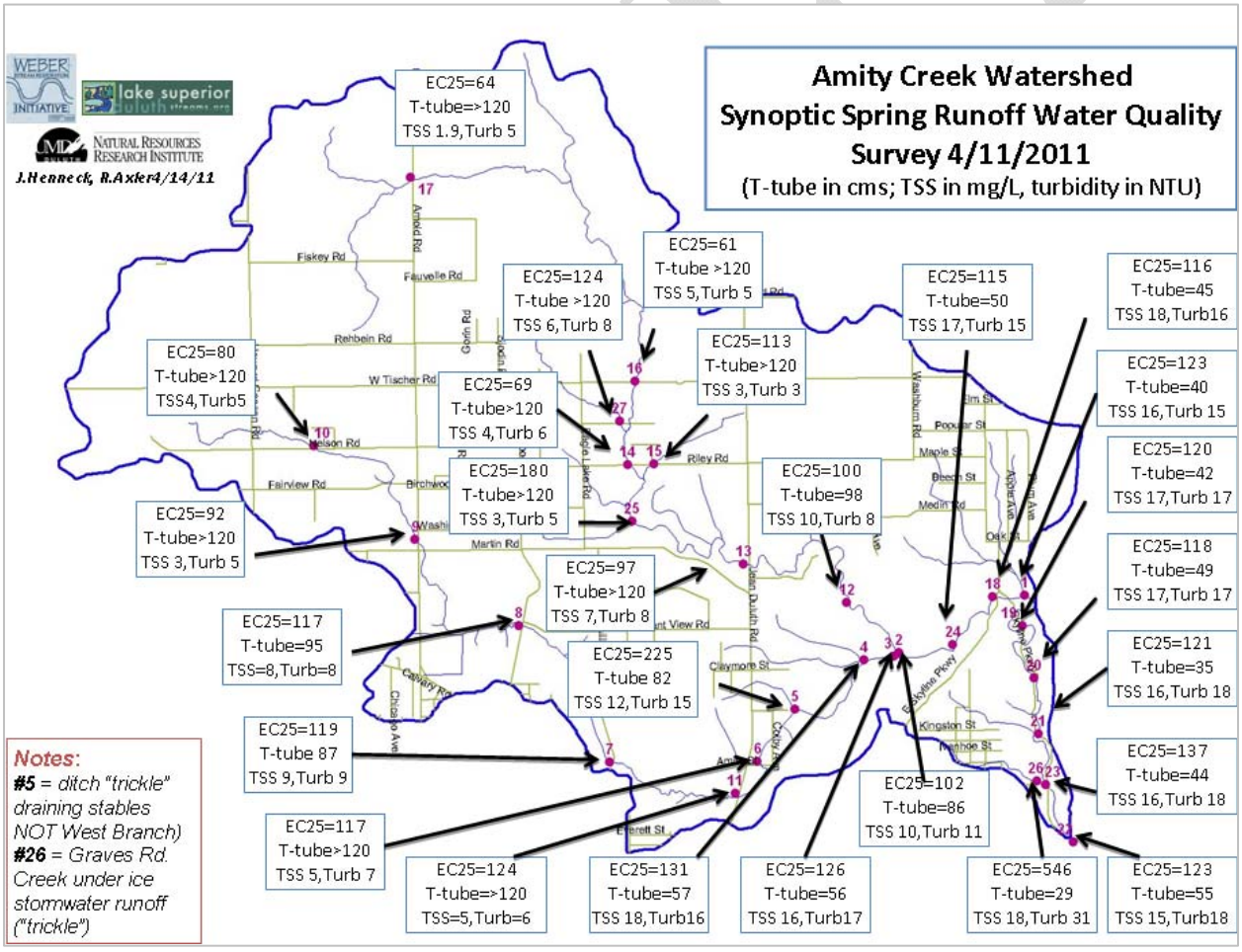

Figure 8. Amity Creek Watershed Synoptic Spring Runoff Water Quality Survey 4/11/2011. Transparency-tube in cms; TSS in mg/L, turbidity in NTU). All samples were collected between 0900 and 1130 hrs CST by using 5 sampling teams.

In addition to water quality parameters, water was also collected for hydrogen and oxygen stable isotope analysis by Dr. J. Magner at MPCA-St. Paul (and the U. of MN Water Resources Science program) for the purpose of better understanding groundwater-surface water interactions. A detailed analysis of these data is beyond the scope of the present grant but is included here to illustrate the distinct patterns found in different sub basins within the watershed. The project has helped maintain and expand Arrowhead Stream Team interest in the Amity watershed as a potential site for focusing agency efforts to improve science-based assessment of Superior's North Shore cold water streams, development of cost effective stream protection and restoration methods, and improved understanding of the factors leading to sediment generation and erosion in North Shore streams with application to improving the assessment and regulatory framework. The "Team" is an informal multi organization partnership of agency and academic water resource scientists that has a core "mission" based on hydrologic understanding of Arrowhead watersheds. The new GLRI Award funding furthering Amity Creek Watershed restoration activities, and managed by MPCA, was aided by interest from this group. The Partnership is also putting the Amity watershed forward as a candidate for inclusion in a new state-wide initiative that would establish a long-term network of sentinel watershed monitoring. The development of this program is being conducted jointly by the U. of Minnesota, MPCA, MDNR and MDA (Agriculture) and had its "kickoff" meeting June 30, 2011.

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III. Miller Creek sediment trap

Figures 9 and 10 depict the location of the sediment trap in the upper Miller Creek watershed.

Figure 9. Schematic of Miller Creek Watershed, Duluth, MN. (Credit: South St. Louis Soil & Water Conservation District, 2008)

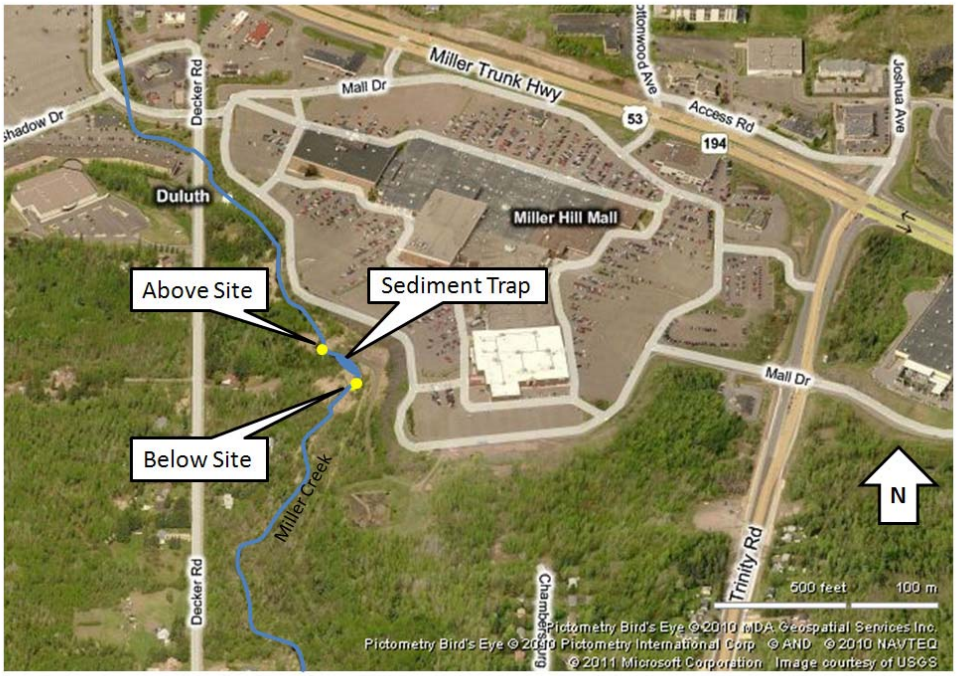

Figure 10. Location of Miller Creek Sediment Trap, Duluth, MN

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Water quality effects

Evaluating the performance of the Miller Creek sedimentation trap in removing suspended sediment and turbidity proved to be more difficult than originally anticipated. The trap had never been "cleaned out" since its construction in 2004 and therefore, it should have been possible to conduct a detailed survey of the sediment that had accumulated in the trap since construction to determine an overall net rate of sediment accumulation per year, integrated over 4-5 years. Unfortunately, despite considerable effort throughout the project period and numerous inquiries to agency staff who managed aspects of the project, and review of boxes of documents pertaining to the project, we were unable to obtain either the original engineering drawings and design assumptions, or a post-construction survey of the as-built sediment trap.

Therefore, we conducted a high flow storm events versus post-snowmelt base flow study based on upstream and downstream grab sampling of stream water that continued throughout the grant period and supplemented the baseline bottom sediment accumulation assessment in 2008 that can now be used as a starting point for determining a true sediment accumulation rate.

Water samples were collected from 2008-2011 on 54 dates (one date was sampled in the AM and PM during a storm event) through the end of June 2011 resulting in a total of 110 samples, one each above and below the sediment trap. Parameters measured include specific electrical conductivity (EC25), temperature, transparency tube clarity,

and laboratory turbidity (NTU). Except for 2 dates during the Spring snowmelt runoff in 2011, all sampling was performed during summer base flow or following qualitatively "larger" rainstorm events.

Data are presented in Table 5 and Figure 11. The sediment trap had no significant effect on grab sample surrogate estimates of suspend sediment - turbidity and transparency tube clarity overall, or for either hydrologic regime. EC25 reflects primarily soluble compounds and so it was not expected to show an effect. The only statistically significant result was the slight warming (~ 0.2 ^{o}C) observed during higher flows (below site > above site).

Bottom sediment survey (August 2008 and September 2010)

Since the trap has never been cleaned out, we conducted an intensive field survey of sediment depth in August 2008 during base flow conditions using a coring device to allow us to also size fractionate the material. The field work included participation of staff from the relevant agencies – the South St. Louis County SWCD, and the City of Duluth Stormwater Utility. It also served to establish benchmarks for future surveys. Should the City and County managers determine that the trap should be cleaned out in the future, they can quantitatively measure the amount of sediment removed and re-survey the contours of the trap.

Water depth and sediment depth measurements were recorded at 6 transects, with 7 point observations at each transect (e.g., Transect T1 downstream to T6 upstream, with points T1-1 left bank to T1-7 right bank; see Figure 12 schematic below from August 22, 2008). Sediment cores (~5 cm deep) from 6 transects with 3 points across each transect were collected to determine particle size profiles (weight in grams) within 7 standard size classifications. Depth of fine sediments was recorded at each point, along with water depth, with a measurement device described in MPCA and NRRI standard protocols (Breneman et al. 2007). Mean water depth overall within the trap was 40 cm, with left and right banks averaging, 25 and 35 cm, respectively. Mid-channel water depth measurements average 44 cm. Mean sediment depth overall was 21 cm, with the mid-channel measurement averaging 25 cm. Left and right measurements of sediment depth averaged 11 and 9 cm, respectively.

Fine Depositional Sediment- Size class distributions within the sediment trap were also compared to fine depositional particles outside the sediment trap (see Tables 6 and 7, below). Site M408 is located just upstream of the trap, and M508 is the furthest upstream site. A downstream site for comparison (M308) is located several kilometers below the trap. Particle size analysis on percent size class (by total weight in grams) of fine sediments was performed using a one-way analysis of variance (ANOVA) PROC GLM command in SAS (1988). Mean values from transects within the trap were only significantly different for one comparison, indicating the sediments were quite similar across the spatial dimensions of the trap. Size particles between 0.5 mm and 0.25 mm were significantly greater ($p = 0.0081$) at the furthest downstream transect as compared

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to the upper most transect. No other differences were observed with any combination of particle size and position within the trap.

The same analysis was performed between the mean distribution of fine particles within the trap and those being deposited at sites M308, M408, and M508. Collectively, the largest particle size (>4 mm) was significantly less within the trap ($p = 0.02$) than compared to the downstream location (M308), but not different than sites M408 (just upstream) and M508 (further upstream). Conversely, the two smallest particle size classifications (0.25-0.063 mm, and < 0.063 mm) were significantly greater within the sediment trap than compared to both the upstream and downstream locations ($p = 0.003$ and 0.002, respectively). This suggests that the sediment trap is collecting more fine particles than depositional areas at either up or downstream locations, but the largest particle deposition within the 'fines' designation occurs at similar rates at both upstream locations.

Unfortunately, we have been unable to find a detailed as-built survey for the sediment trap in order to calculate the exact amount of sedimentation that has occurred since it was constructed. However, we are in the process of estimating this value using our 2008 survey data and an additional bottom depth survey performed in Fall 2010, based on the assumption that the trap was constructed exactly as planned using the original engineering schematics.

INSERT FINAL ESTIMATE IF THIS IS ACTUALLY POSSIBLE. MAY NEED A SURVEYOR FROM THE CITY

This lack of performance information clearly illustrates the need for standardized, fixed interval monitoring of bottom sediments to provide accurate estimates of performance over the long-term. A careful seasonal (~3-4 month intervals) would also be helpful in determining how the trap performs over a range of hydrological conditions. The MS4 RSPT members are now developing plans for monitoring their stormwater ponds as a requirement of new Minnesota stormwater rules and the results from this "mini"- study will be used to help inform the group.

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Table 5. Miller Creek Sediment Trap water quality sampling data 2008-2010. Paired T-Test for dependent samples assuming equal variance (Below-Above) were applied to paired upstream-downstream parameter values. Data are also sub-categorized by high flow and low flow hydrologic regimes. SD = standard deviation for N samples. * Statistically significant at $p < 0.0046$ for storm event related temperatures as shown in shaded cells. No other differences were statistically significant (i.e. $p > 0.05$)

All hydrologic regimes

	Mean Turbidity (NTU)	SD	N	Mean Temp (^{o}C)	SD	N	EC25 (uS/cm)	SD	N	Mean T-Tube (120 cm)	SD	N
Above	8.37	9.98	52	12.09	5.71	46	456	319	54	100	33.6	51
Below	8.28	9.88	52	12.22	5.88	46	446	327	54	101	33.2	51

Storm Event (Q Flow 2)

Above	15.33	14.98	17	**12.97***	4.86	16	302	188	17	77	44.2	16
Below	14.97	14.88	17	**13.17***	4.98	16	300	182	17	77.6	42.8	16

Base Flow (Q Flow 3)

Above	4.86	3.45	33	12.23	5.89	28	546	344	35	111	21.1	33
Below	5.06	3.11	33	12.32	6.1	28	532	357	35	112	21.2	33

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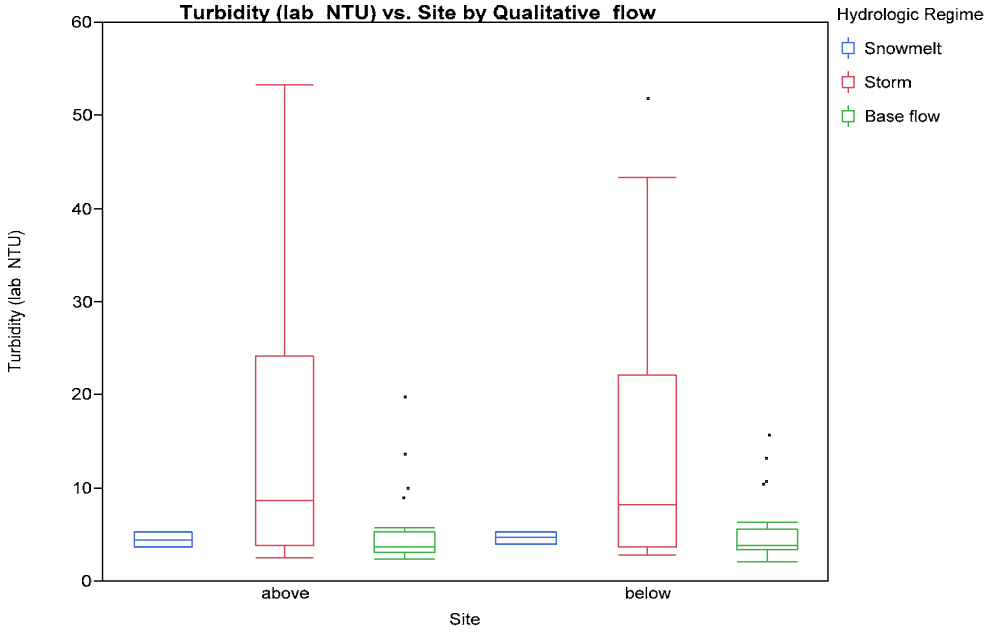
Figure 11. Plots of water quality metric (turbidity, transparency-tube clarity, specific electrical conductivity (EC25), and temperature vs. site, by hydrologic regime. Whiskers extend from 10th to 90th percentiles, box includes the 25-75th percentiles, line indicates median value. Qualitative Flow: 1= snowmelt, 2=storm/rain event, 3=base flow.



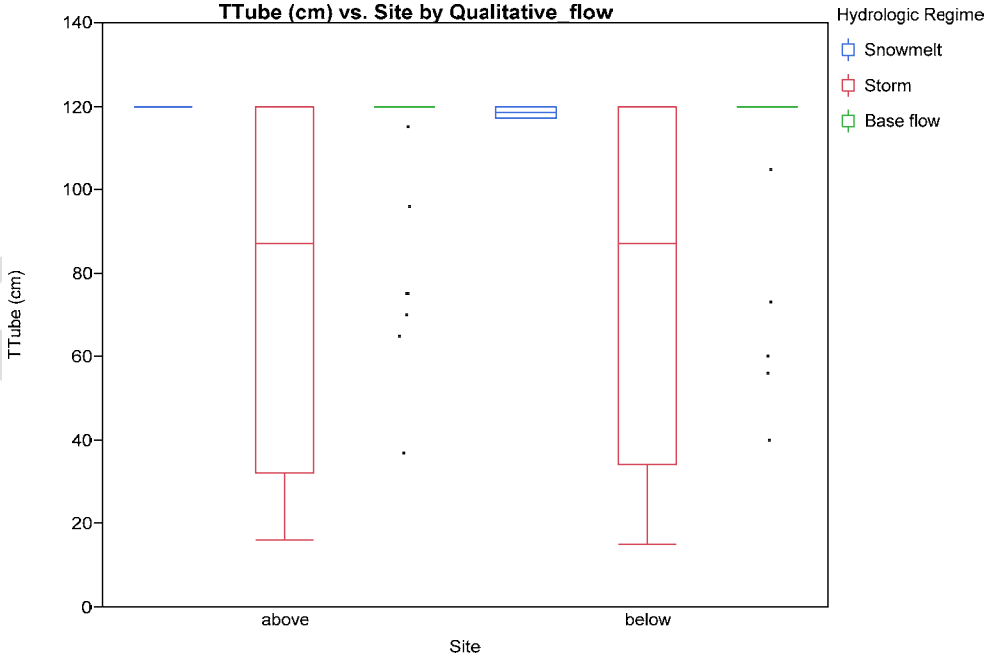
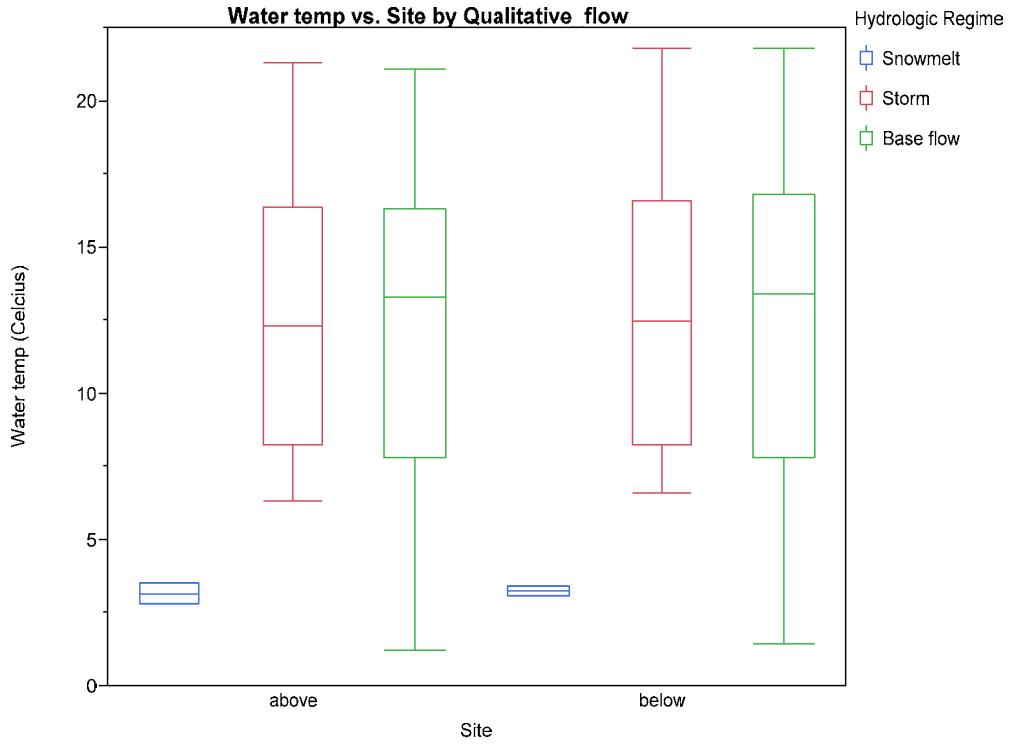
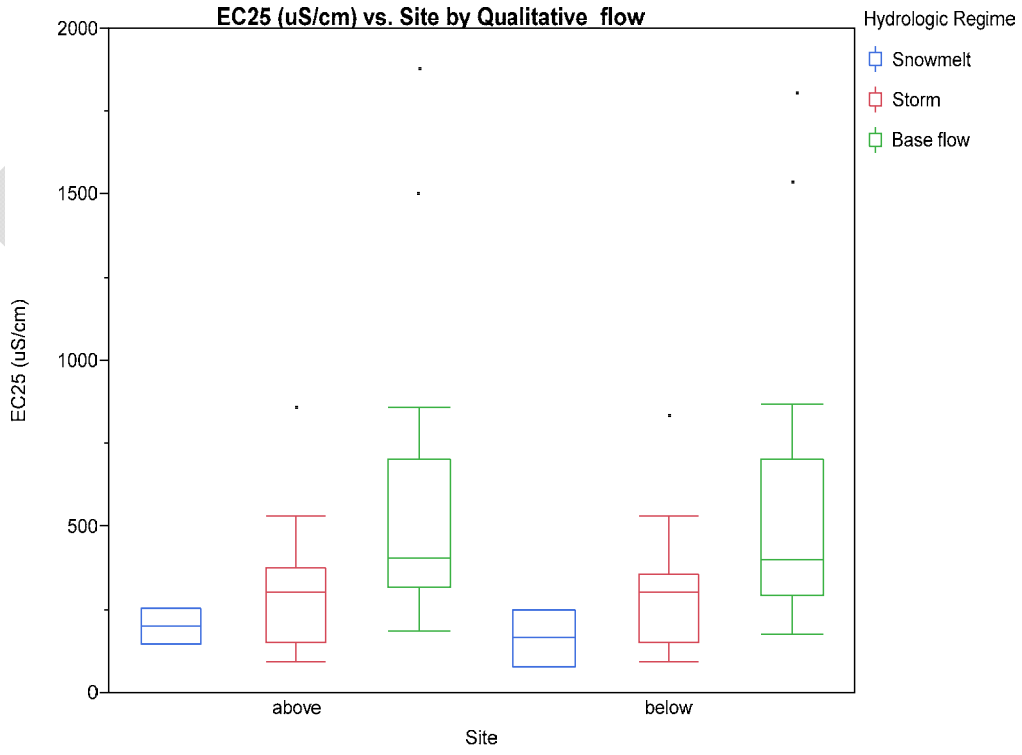


Figure 11 continued. Plots of water quality metric (turbidity, transparency-tube clarity, specific electrical conductivity (EC25), and temperature vs. site, by hydrologic regime. Whiskers extend from 10th to 90th percentiles, box includes the 25-75th percentiles, line indicates median value. Qualitative Flow: 1= snowmelt, 2=storm/rain event, 3=base flow.





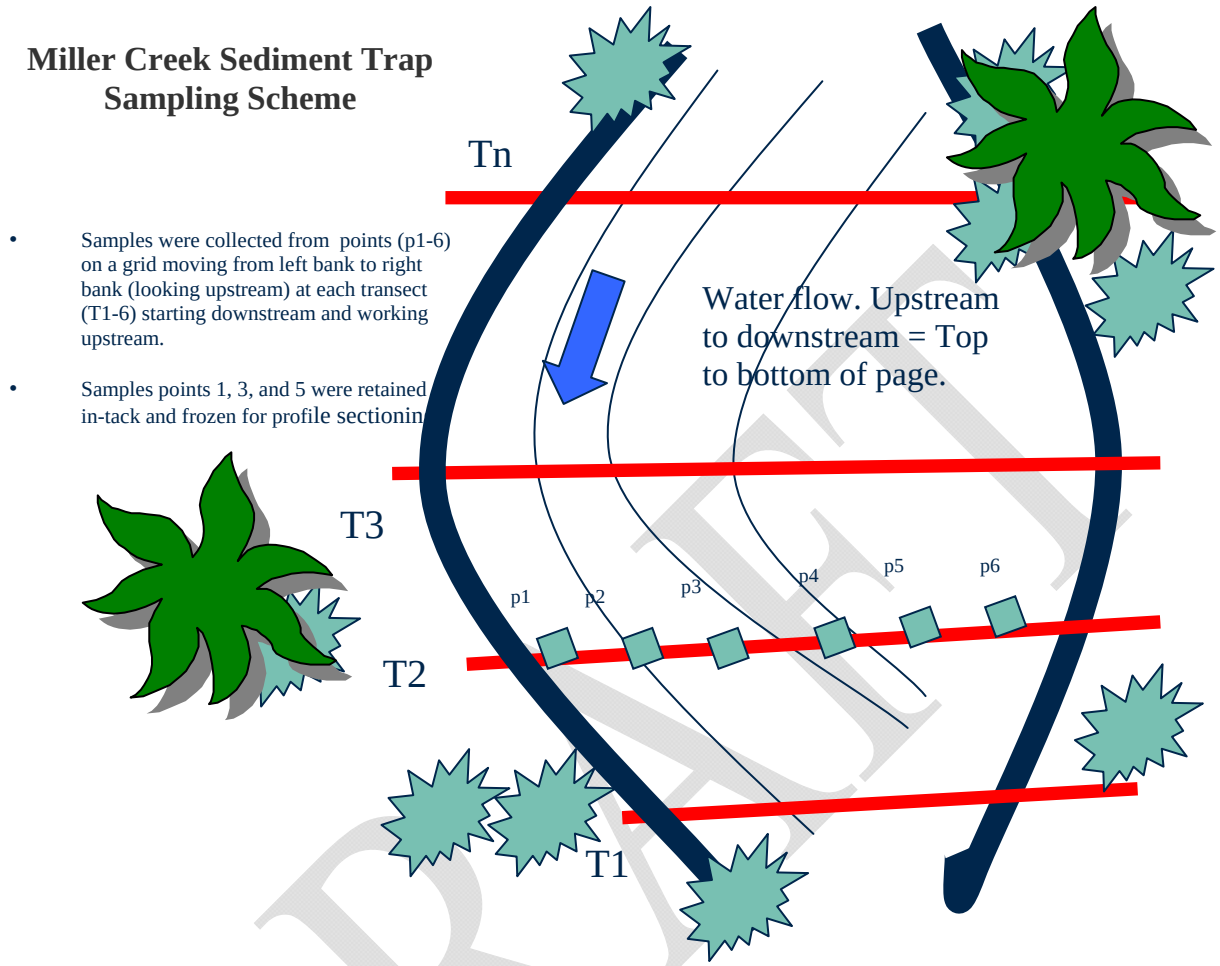


Figure 12. Miller Creek sediment trap schematic and sampling transect placement.

Table 6. Miller Creek sediment trap characteristics based on 8/22/2008 survey. Transects 0 to 7 represent an arbitrary starting point downstream (T0) to an upstream constriction (T7), with distance from T0 and trap with associated with each transect. Data represent mean water and sediment depths at points across each transect.

Transect	Transect Distance (m)	Width (m)	Mean Water Depth (cm)	Mean Sediment Depth (cm)
7	34.00	4.5		
6	25.50	11.3	35.67	11.0
5	21.75	9.6	52.00	15.0
4	17.00	8.6	47.33	23.3
3	12.75	6.9	41.42	34.2
2	8.50	5.9	38.70	21.4
1	4.25	4.8	36.00	15.6
0	0.00	4.3	0.0	0.0

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Table 7. Miller Creek Sediment Trap - depositional particle survey of bottom sediments in the sediment trap (8/22/08) and at nearby upstream and downstream sites (5/28/08).

Date	Transect	Sample	AFDW (g)	>4mm	4-2mm	2-1mm	1-.5mm	.5-.25mm	.25-.063mm	<.063 mm
8/22/08	6	2	0.54	91.70	1.52	0.56	0.44	0.60	0.90	0.19
	6	4	0.47	51.95	14.39	15.11	10.39	4.05	2.00	0.61
	6	6	0.39	28.82	2.19	1.29	1.14	3.59	54.27	6.67
	5	2	3.24	19.20	2.09	5.54	7.91	11.08	15.39	7.08
	5	4	0.79	41.25	16.55	19.54	13.45	4.05	1.87	0.78
	5	6	2.09	41.78	3.59	5.39	7.77	12.78	17.69	8.31
	4	2	0.41	26.40	8.85	4.90	4.73	23.65	29.01	0.80
	4	4	0.99	31.04	18.25	17.82	15.48	9.49	4.55	1.29
	4	6	2.88	0.32	0.70	2.52	11.53	37.87	33.85	9.54
	3	2	0.83	52.33	4.74	4.25	6.44	13.03	13.15	4.13
	3	4	1.00	21.91	19.07	20.23	17.56	11.76	5.40	1.73
	3	6	2.84	3.18	4.94	9.26	15.81	31.18	24.85	7.39
	2	2	1.04	38.10	8.24	10.50	11.89	17.94	9.05	2.25
	2	4	1.53	12.52	19.97	24.99	20.11	12.91	5.52	1.62
	2	6	3.29	26.75	4.03	6.10	10.75	19.29	21.31	8.49
	1	2	2.47	24.65	2.34	1.61	3.69	20.71	33.96	9.83
	1	4	4.52	3.61	1.74	3.55	10.16	33.43	32.38	10.39
	1	6	3.58	19.59	1.98	3.35	10.53	28.91	24.60	7.33
5/28/08	Mall	1	1.05	45.72	15.85	14.22	12.86	7.72	1.56	0.32
	Mall	2	0.98	55.71	13.68	12.40	9.86	5.23	1.14	0.25
	Mall	3	1.02	49.71	15.15	13.44	11.55	6.68	1.36	0.25
	KOHLS	1	0.83	59.81	17.30	12.25	5.54	2.24	0.75	0.20
	KOHLS	2	0.94	53.86	20.74	13.77	6.08	2.51	0.88	0.21
	KOHLS	3	0.76	68.58	14.70	10.35	4.18	1.76	0.56	0.15
	Anders-on Rd	1	1.33	60.62	20.61	10.29	4.05	1.85	0.79	0.21
	Anders-on	2	1.06	67.74	16.23	8.35	3.36	1.61	0.68	0.18
	Anders-on Rd	3	1.11	70.06	15.04	7.76	3.11	1.47	0.63	0.17

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Objective C. Biological Communities

I. Lower Amity (Graves Road Creek) Project

Macroinvertebrate monitoring and stream habitat characteristics above and below the Graves Road tributary were measured in May of 2007 according to standard protocols (Breneman et al. 2007). A limited reach exists from the tributary downstream where the stream flows through bedrock creating a substantial series of falls and plunge pools. This reach is not safe to sample, nor does it provide a minimum reach for conducting a general survey. Therefore, fish assemblage structure on Amity Creek was evaluated only above the tributary in July 2007, then again in August 2008, 2009, and 2010 (we intend to also include a full set of "fish and bug" sampling in late summer 2011. Due to bridge construction on Occidental Boulevard starting in the fall of 2007, return sampling for macroinvertebrates and habitat characteristics was also not possible at the previous downstream location. Only the reach immediately above the Graves Road tributary has received further monitoring.

Sampling was completed by incorporating both qualitative and quantitative gear-types on available run, riffle, and pool habitats (modified Hess), shallow, and depositional habitats (core tubes). Qualitative samples were collected in bank or over-hanging vegetation, woody debris dams, boulder piles or rip-rap, or from sediments and aquatic vegetation in run and pool habitats using a D-frame kick to be consistent with contemporaneous volunteer WAV (Save our Streams) sampling. A Qualitative Habitat Evaluation Index (Ohio EPA, 1987) to rank overall stream condition was also scored and compared to the MPCA'S physical habitat and water chemistry assessment (wq-bsm3-01).

Periphyton algae biomass was also determined from stream substrates randomly selected within each riffle/run/pool sequence. Samples will be used to estimate biomass accrual (expressed as AFDW), and fresh aliquots from the same sampling methods were frozen for potential analysis of chlorophyll-a at a future date should additional funding be secured. Benthic sample processing has now been largely completed using standard protocols described in the QAPP. Biological sampling occurred on Amity Creek above and below the Graves Road tributary on 3 May 2007, with a second sampling effort repeated on 22 May 2008. Sampling on the downstream location did not occur in 2008 due to active bridge construction on Occidental Blvd. Sampling effort on Miller Creek occurred above and below a sediment trap constructed in 2004 along a stream reach near Miller Hill Mall in May 2008.

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Table 1. Biological sample distribution at BMP/Restoration demonstration sites on Amity (Lower) and Miller Creeks in Duluth, MN. Above and *Below* refer to the Graves Rd. Creek inlet to Amity Creek. Additional Upstream - Downstream sampling was performed for the Upper Amity (East Branch) BMP/Restoration site in May 2008 and for the Downstream site again in September 2008 with supplemental funding from NRRI's MPCA SWA-North Shore project.

BMP			Gear Type			
Date	**Project**	**Location**	**Hess**	**Core**	**Dnet**	**Periphyton**
3 May 07	Amity Creek	Above	6		2	15
		Below	6		2	15
22 May 08	Amity Creek	Above	9	3	3	15
29 May 08	Miller Creek	Above	9	3	3	15
		Below	9		3	15
28 May 08		Ref	9		3	15
19 Sep 08	Amity Creek	Above	9		3	15

II. Upper Amity Bank Stabilization Project

Fish assemblage structure was monitored at three locations prior to construction activities in 2005, 2008, and 2009, then post-construction in 2010. Biological and habitat sampling below the Upper Amity bank stabilization project site was also performed in May 2008 using identical methodology. This sampling and analysis is being funded by the MPCA Surface Water Assessment Program grant to NRRI described previously (R.Axler, Project Manager). Invertebrate community monitoring and habitat evaluation (according to NRRI Standard Methods reported in Breneman et al. 2007 available at http://www.duluthstreams.org/northshore/poplar/TMDL/docs/NRRI_TR-2007_16.pdf) occurred at sample locations above and below the proposed SWCD bank stabilization project on this stretch of the East Branch of Amity Creek. Biota collections were also processed from a previous 2005 (unfunded sample survey via the Weber Stream Restoration Initiative). Particle size analysis of fine sediments and channel habitat observations were also completed.

The West Branch of Amity Creek (AW) was first sampled in 2005 above the confluence with the East Branch (restoration site) of Amity Creek. Sample reaches on the East Branch above (AEA) and below (AEB) the bank BMP/construction area, were also sampled in 2005 via WSRI funding prior to the present project. Subsequent sampling has occurred in 2007, 2009 prior to construction, and in 2010 following the bank stabilization efforts.

Fish surveys were conducted with a single-pass back-pack electrofishing unit. All individuals were identified to species, size classed, total length measured, and individual or batch weights recorded. Surveys were timed and distance sampled was recorded to determine a standardized catch per unit effort (CPUE) for each reach.

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Analysis was designed to determine assemblage differences between locations, and data represent mean observations using year as the replicate value.

No significant differences in abundance (i.e. CPUE) for any species were detected between sites either above or below, and before and after construction. With only one sample opportunity conducted post-construction, the small sample size limits confidence in detecting real differences other than by pooling data and comparing locations over multiple years.

However, a few species did show differences before and after bank construction. Mean Blacknose Dace (*Rhinichthys atratulus*) and Sculpin lengths and mass were significantly greater after the construction than compared to before construction at the "below" location (Figure 13). Creek chubs sampled in the "below" reach also showed a significant difference, but mean total length and weight were greater before as compared to after construction of the BMPs (Figure12). Also, mean total weight for Blacknose Dace was significantly greater at the West Branch Amity Creek site than for those collected above the construction location. Both Blacknose Dace and Creek Chubs were significantly longer and heavier in the west branch site than either the above (AEA) or below (AEB) locations (Table 8).

Although Brook Trout (*Salvelinus fontinalis*) and Sculpin (*Cottus sp*.) abundances were not different between sites, both species were observed with greater mean weight and length in the above sample location (East Branch), as compared to the site downstream from the BMP/stabilization efforts. This result is likely not a direct result of the bank erosion, but suggests that habitat conditions are more suitable for larger individuals, with better quality refugia containing cooler, deeper pool habitats with large woody debris.

Table 8. Fish species of interest sampled at three locations on Amity Creek prior to bank stabilization construction. Data represent mean weights and lengths for each species (+/- 1 se) and were analyzed using a one-way Analysis of variance (ANOVA). Values with the same letter are not significantly different based on Duncan's mean comparison.

Common Name	Location	Mean Weight (grams)	Mean Total Length (mm)
Blacknose Dace	Above	4.98+/-0.2 [c]	73.67+/-1.5 [b]
	Below	3.25+/-0.1 [b]	67.10+/-0.7 [b]
	West	5.47+/-0.31 [a]	78.42+/-2.0 [a]
Brook Trout	Above	40.42+/-12.2 [a]	127.26+/-11.7 [a]
	Below	8.38+/-2.3 [b]	82.34+/-4.2 [b]
Creek Chub	Above	4.42+/-1.0 [b]	64.41+/-4.9 [b]
	Below	6.41+/-0.5 [b]	67.72+/-2.0 [b]
	West	8.22+/-1.3 [a]	85.00+/-1.3 [a]
Sculpin	Above	4.33+/-0.6 [a]	62.67+/-3.8 [a]
	Below	3.20+/-0.5 [b]	49.13+/-3.5 [b]
	West	6.35+/-1.1 [a]	71.36+/-6.1 [a]

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Macroinvertebrate communities are often described by common indices including total taxa, or the number of sensitive EPT taxa. Metrics such as these are designed to identify problematic conditions because the individuals used to generate the metrics are sensitive to low dissolved oxygen (DO), fine sediment deposition, increased temperature, or amounts of nutrients. The macroinvertebrate communities observed in samples collected from AEA and AEB were similar in many respects, including total taxa per sample and EPT taxa, as well as more than 30 other taxa traits describing the invertebrate community by taxonomic categories, behavioral characteristics, and mechanistic processes. Midge abundance (Chironomidae: Diptera) and a predatory engulfing metric were the only traits showing a greater percent of individuals (as percent of total abundance) at the AEB site than that occurring at the AEA site. No other abundance-based metrics revealed a difference in community composition between sampling locations, thus suggesting the similarity in habitat and resulting invertebrate assemblage.

III. Miller Creek Sediment Trap Evaluation

A sediment trap constructed in 2004 on Miller Creek near Miller Hill Mall was evaluated in August of 2008 under base flow conditions to determine volume and distribution of fine sediments. Biological sampling and channel characterizations also occurred on Miller Creek prior to the trap evaluation as part of a TMDL survey (Brady and Breneman 2010). Biota and habitat conditions at 5 locations (2 above and 3 below the sediment trap) were evaluated following standard procedures described most recently in the Poplar River TMDL survey Quality Assurance Project Plan (Breneman et al. 2007). Sampling was completed by incorporating both qualitative and quantitative gear-types on available run, riffle, and pool habitats (modified Hess), shallow, and depositional habitats (core tubes). Qualitative samples were collected in bank or over-hanging vegetation, woody debris dams, boulder piles or rip-rap, or from sediments and aquatic vegetation in run and pool habitats using a D-frame kick to be consistent with contemporaneous volunteer WAV (Save our Streams) sampling.

Macroinvertebrate abundance, expressed as mean number per location, was not significantly different between the five sample locations (Figure 14a). Total number of unique taxa collected at each site was not significantly different from one another, and ranged between 51 at the Miller Hill location (Mall) and around 60 taxa at the remaining locations. There was a significant difference in mean number of taxa per sample, with the Miller Hill location (Mall) having fewer than that found at the remaining sample sites (Figure 14b). This is due to a large portion of the invertebrate assemblage being associated with higher quality, more heterogeneous habitats, with fewer, and less diverse assemblages found within other homogenous habitats. For example, the most abundant invertebrates at the Mall locations were represented by midge larvae (Chironomidae: Diptera), and this group is highly adaptable. Significantly greater abundance of midge larvae were observed at Mall ($p = 0.0001$) compared to the remaining sample sites. Although the Chironomidae family would generate large numbers of individuals even in poor quality substrates like depositional sediments, the number of unique taxa within in this habitat type was low.

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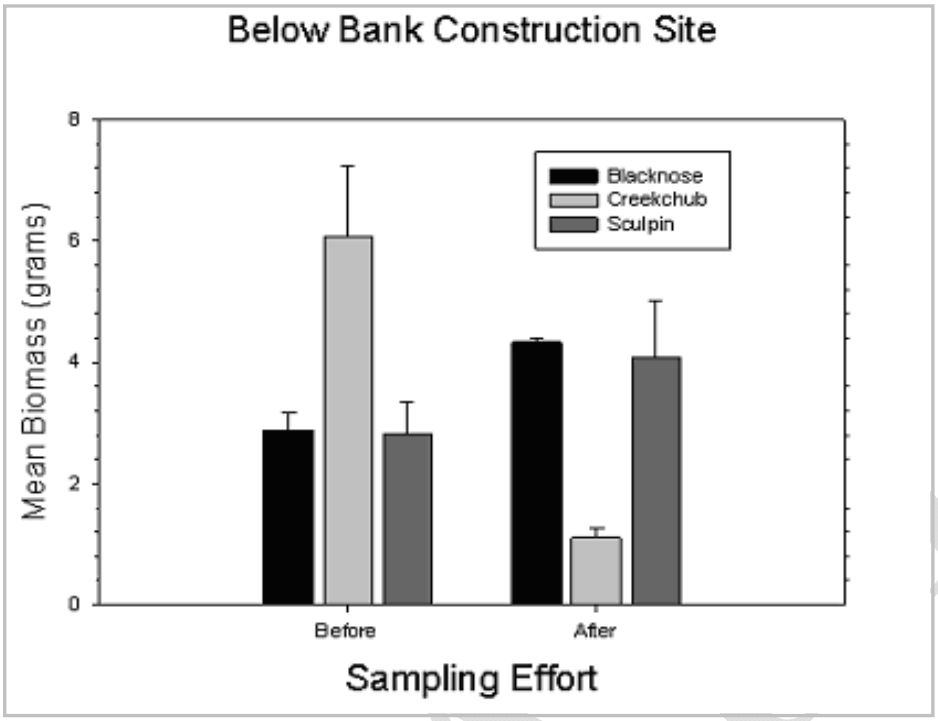

Figure 13. Mean fish biomass of Blacknose Dace, Creek Chubs, and Sculpin from a section of Amity Creek below the Upper Amity (East Branch) bank stabilization project. Weight estimates are based on three sampling surveys before construction (late Summer 2007, 2008, and 2009), and a single sampling post-construction (late Summer 2010). The *p-value* from the overall ANOVA is ≤ 0.05. Mean weight comparisons by species ($\pm$ 1 standard error) are based on Duncan's multiple-range test.

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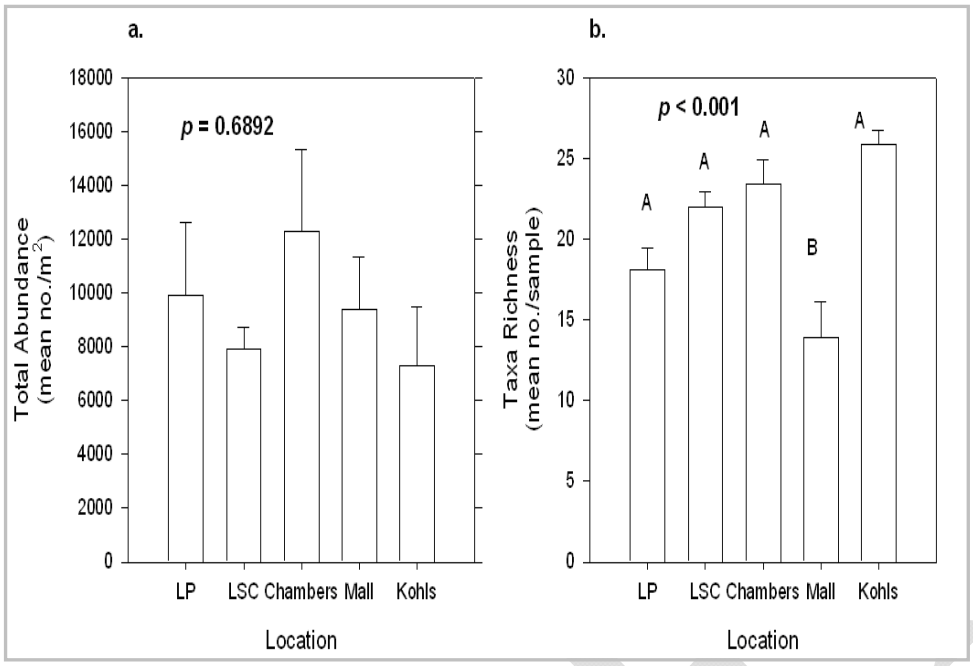

Figure 14. Invertebrate community samples collected at 5 locations along Miller Creek from downstream (LP) to furthest upstream (Kohls Dept. store, Figure 9) where: a) Mean number of invertebrates per samples; and b) Mean number of taxa per gear type used to sample all habitats within each sample location. Values represent means $\pm$ 1 standard error. Value *p* is from the overall ANOVA. Columns with the same letter are not significantly different based on Duncan's multiple range test.

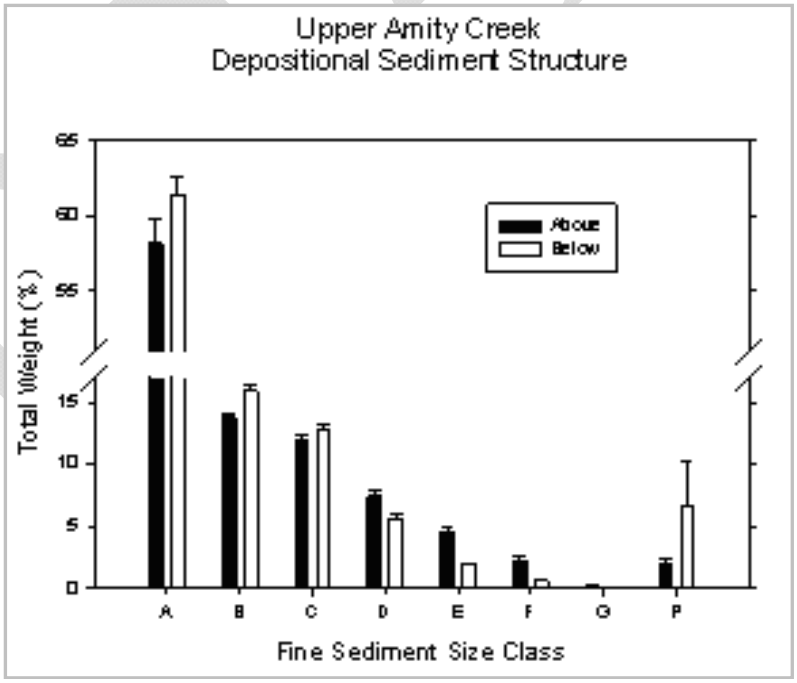

Figure 15. Distribution of fine depositional particles from above and below the Amity Creek bank stabilization construction. Fine particles are separated into 8 size classifications, and expressed as percent of total sample weight. A) > 4mm B) 4-2mm C) 2-1mm D) 1-0.5mm E) 0.5-0.25mm F) 0.25-0.063mm G) <0.063mm P) AFDW.

Obj. D Bank & channel erosion

I. Amity Bank Stabilization Project

A limited effort, due to funding constraints, was originally proposed to directly estimate bank erosion at the two Amity Creek project sites. Instead, we have developed a collaboration with Dr. Karen Gran, a geomorphologist who was relatively new at UMD when this project was first developed in 2006 and interested in developing applied research projects, to greatly expand this effort. She is supervising a graduate and undergraduate student regarding erosion in North Shore streams who are including our Amity project sites in their studies. She also used the venue of her new Advanced Stream Geomorphology class in Fall 2008 to collect much more intensive data at the Upper Amity (East Branch) site. Throughout this project she has continued to work collaboratively with SSL SWCD and MPCA (Duluth and St. Paul) staff on the Amity watershed and is now a co-Principal Investigator on the new GLRI funded Amity Creek Restoration project.

Dr. Gran and Keith Anderson, South St. Louis Soil and Water Environmental Engineer, collaborated on pre-construction evaluation of the proposed bank stabilization area. Banks were intensively surveyed in July 2008 using a new, high resolution instrument purchased by the MPCA. In collaboration with hydrologist Tom Schaub (MPCA-Duluth), a detailed survey was conducted of the upper slump including a series of cross-sections in the stream longitudinal profiles. In addition, a series of historic air photos from 2003, 1991, 1972, and 1939 were collected and georeferenced. Locations of streams were identified along with estimates of confidence level in both the georeferencing and in stream channel identification. Benchmarks were also installed. The survey included 9 cross-sections, a long profile, and as much of the upper slump as possible. These surveys can be reoccupied later to track changes, but at a coarse resolution. The group is also georeferencing air photos and tracking meander migration rates on this reach and nearby reaches to compare migration rates (and estimate volumes of sediment mobilized through meander migration) in these areas. A total station survey was also conducted and these data could be used to track changes through time. These surveys were intended to provide baseline measurements to detect changes during an as-built survey that is scheduled for Summer 2011. The cross-section data will be used to calculate shear stress and estimate how it might change given upstream changes in land use.

The investigators also coordinated a student project culminating in a detailed report (University of Minnesota Duluth, Geology 5260, Fall 2008) that included georeferencing air photos and tracking meander migration rates on this reach and nearby reaches. This task was completed in order to compare migration rates (and estimate volumes of sediment mobilized through meander migration) in these areas. The lab was intended as an introduction to ArcGIS, while doing a simple analysis of channel change through time. The stream was moving at a relatively high velocity (~0.4 – 0.8 m/yr) into the bluff and students were able to measure the rate of movement and the volume of sediment eroded due to this lateral migration. A second class visit focused on floodplain mapping

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and measuring flow in two bends (the slump site and the bend upstream of the beaver dam). They had an additional lab on a site in lower Amity to learn basic survey techniques, and spent a lab period doing a full walking survey of most of the long profile of the creek in pairs to do a quick map of channel type, grain size, vegetation, and width. Students compiled all observations into a long profile map and wrote reports on the Amity Creek watershed. A similar set of measurements was made with this same UMD class in Fall/Winter 2010/11 in order to help set a new baseline for post-restoration banks and channel.

Dr. Gran also took her Geology 3210 class to the Upper Amity slump site to investigate slumps. They used handheld GPS units to map the top and bottom of the slump, measured the height and slope of the slump, and used a shear vane and tensiometer to measure slump geotechnical properties to be fed into an infinite slope model program.

A third geomorphologic study was also initiated in 2008 and directed by Drs. Karen Gran and Elizabeth Minor at UMD with lab assistance from NRRI via the Weber Stream Restoration Initiative (WSRI). Their goal is to characterize the nature and timing of suspended sediment moved during storm events of different sizes and more importantly, to track the change in suspended sediment load from the top of Seven Bridges Road down the steep gradient reaches to the mouth of the stream into the Lester River just above Lake Superior. The increase in sediment concentration from the upper to the lower sampler will yield useful information about sediment sources (upper watershed vs steeper lower reaches). In addition to the storm samples from the Sigma samplers, they also collected samples at additional places between the samplers during several storm events to better characterize the longitudinal changes and expect to do this for a few more storms. Note- this work complements the grant but is funded via investigator in-kind match (not reported as Match for this CWP/319 project) and technical support from NRRI via the Weber Stream Restoration Initiative.

Two Sigma Max automated event-samplers were deployed at the lower Amity gauge site and above the Upper Amity project site (East Branch) to sample storm events hourly in summer 2008 in order to establish a pre-project baseline for the entire reach of stream. Samples were collected from six (6) storm events. Both samplers successfully triggered in 4 events, although one sampler died before the flood peak on one of those events. During two storms, samples were collected from 5-6 locations along the 4 km length of stream, giving a total of 3 long profiles. Approximately 186 samples were analyzed including: TSS (172 samples), TSVS (150 samples), turbidity (120 samples), TOC (70 samples), DOC (20 samples), and UV-VIS spectra (103 samples). Select samples were saved to determine carbon isotopic composition.
Two Sigma Max automated event-samplers were again deployed in Spring 2009 by Drs. Gran and Minor from UMD to sample storm events hourly to establish a pre-project baseline for a large reach of the stream.

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II. Lower Amity/Graves Road Creek site –

Our intent was to use similar surveying techniques using the same instrument in Fall 2008 after leaf-fall but this was unfortunately not possible. Although some preliminary work has apparently been carried out in terms of mapping the eroding banks on this site, further work of this kind will need to be included in the Amity-GLRI restoration project, presumably in Fall 2011 after leaf drop.

III. In-stream habitat conditions

Based on substrate coverage estimations, fine sediment depth, water depth, and other channel characteristics, with the exception of boulder-size substrates, no other significant differences were found between the sample locations above and below the Upper Amity Creek bank stabilization construction. Occurrence of boulders in the "above" reach was twice that observed in the "below" reach, and when boulders where observed, they covered on average 10% more surface area than observed below the bank construction. Distribution of fine depositional sediments were significantly different for the 4-2mm fraction, with the below site containing more of that fraction than the above location (Fig. 3). For the remaining size fractions (1-0.5 mm, 0.5-0.25 mm, 0.25-0.63 mm, and <0.63 mm) where a significant difference was observed, the "above" site contained higher values than those attributed to the below sample location (Figure 15).

<u>Program Element #2</u> – Citizen Volunteer BMP Monitoring (storm events; seasonal; benthic biological communities)

Obj. E <u>Amity & Miller Creek Remediation Sites</u> (includes recruitment, sampling, analyses, QA/QC)

After the present project was funded, NRRI was able to hire a volunteer monitoring coordinator and trainer has who had extensive experience in this area (Amy Eliot) and who had been working with the Wisconsin WAV citizen scientist/volunteer stream monitoring program and the MPCA's Citizen Stream Monitoring Program (CSMP) to facilitate common methodologies when possible for all Lake Superior volunteer stream monitoring. Funding was included in an MPCA Surface Water Assessment grant to R.Axler et al. at NRRI-UMD to sample Lake Superior trout streams for water quality, habitat, macroinvertebrates, and fish. A volunteer monitoring recruitment component was included in the project, and therefore it was "combined" with the volunteer monitoring effort proposed in this CWP/319 grant. Via the *LakeSuperiorStreams.org* project we had previously collaborated with MPCA's Citizen Stream Monitoring Program (CSMP) and the St. Louis River Watch Program directed from Fond du Lac Tribal and Community College (see *http://www.lakesuperiorstreams.org/citizen/volunteermonitor.html*), the Minnesota Waters program (via Courtney Kowalczak), and more recently additional CSMP related efforts from the St. Louis River Citizen's Action Committee (now called the St. Louis River Alliance "SLR Alliance"). This coordination has continued in order to avoid overlap. In particular, a strong collaboration has evolved between the SLR Alliance and

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MN Waters where the Alliance is taking a lead role in encouraging local (i.e. Duluth area, but only in Minnesota) participation, especially by schools, and MN Waters has targeted state-wide training of volunteers, lake associations, and watershed groups. This training includes macroinvertebrate sampling and in some cases identification.

Finding additional volunteers for the Upper Amity Creek and Miller Creek sediment trap site has been unsuccessful. However, we are optimistic that additional volunteers will be found as additional restoration work on Amity Creek continues via new GLRI funding and the media attention that individual projects will generate. The Upper Amity site is problematic because of the difficulty in accessing the site. The confluence of the East and West Branches is a better choice but is still a significant walk for a volunteer – especially in poor weather and in the Spring. However, the most critical CSMP parameter is the transparency tube in the context of sedimentation and turbidity related impairment, and we will continue to generate these data via the assessment component of the GLRI Amity project.

Over the long-term, we believe it will be advantageous to work with Lake Superior College to secure resources for their new gauged site and establish an LSC directed CSMP site(s) that become a part of curricula at the college and so would persist over the long-term. Trap site monitoring could be included. We have continued to discuss this with Glenn Merrick, the Biology instructor at LSC who is extremely knowledgeable about Miller Creek and its impairments. We have been working with LSC to train their Sustainability Coordinator to take over their stormwater program activities (2009-present) and in particular to take over routine maintenance of their automated data logging sensors at a site near campus that lends itself to a CSMP effort. We have continued to assist her, and to post their intensive water quality and flow monitoring data on the LSS website. Of late the College has undergone a major shift in leadership with a new Chancellor and Vice Chancellor for Operations coming to office in 2011, and this will present additional challenges because we (PI Axler) had previously had quite a bit of interaction over the past 10 years with the departing officials.

Program Element #3 – Administration, Outreach & Education: Use LakeSuperiorStreams.org to showcase project results

Obj. F <u>Outreach & Education</u>

Key elements of this element are the overall *www.LakeSuperiorStreams.org* community education project and the related Weber Stream Restoration initiative *www.lakesuperiorstreams.org/weber/index.html* . Both of these efforts contribute to the Education and Outreach focus of the Superior Regional Stormwater Protection Team *www.lakesuperiorstreams.org/stormwater/rspt.html* . Specific aspects of this effort that relate to the 319 project during the grant are listed below based on semi-annual reporting periods. In addition, a detailed compilation of outreach and education activities associated with this project is included as Appendix A to this report.

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- Oct 2007 – June 2008:

1. Coordinating Miller Creek sampling efforts by the SSLSWCD, the St. Louis River Citizens Action Committee, the City of Hermantown, and NRRI. An agreement was made that all of the various data sets would ultimately be available via the LSS website along with descriptive project information and results as they become available. A Miller Creek TMDL Study section was created at *www.lakesuperiorstreams.org/streams/millerTMDL.html* to house this information or link to agency websites.
2. An automated stage height/flow and water quality sonde was installed downstream of the sediment trap at Lake Superior College. This site will provide similar data to that being collected for 5 other LSS streams and will be automatically uploaded to the LSS website each day. The station is now in operation although there are telecommunication "bugs" that are still to be eliminated.
3. An annual report summarizing the activities associated with the Weber Initiative was written with descriptions of the three 319-related projects. This was circulated among the key WSRI Partner organizations
4. An article on the Graves Road Creek restoration project was written for the Spring 2008 issue of *Stream-Line*, a WSRI semi-annual newsletter that is posted on the LSS website and direct mailed to >2000 residents of the Amity-Lester watershed (*http://lakesuperiorstreams.org/weber/StreamLine.html*). An article describing stressor identification using GIS land use and other data sets was included in the Fall 2007 issue. The Fall 2008 issue included an article describing the channel geomorphology and bank erosion work that began in summer 2008 on Amity Creek.
5. It should also be noted that the Graves Rd Creek restoration is closely related to the 319 Project entitled *Duluth Residential Stormwater Reduction Project for Lake Superior Tributaries* (Project Managers Chris Kleist, City of Duluth and Valerie Brady, NRRI-UMD) that began at the same time. This project involves a paired neighborhood design where retrofitting one area with on-site stormwater reduction features is being evaluated directly via storm sewer flow and volume monitoring. Stormwater from these neighborhoods is discharged into lower Amity Creek via Graves Road Creek. The extension and outreach efforts for both projects are being closely coordinated by Partner Minnesota Sea Grant, by R.Axler being a co-PI on that grant, and by NRRI technical staff overlap.

- July 2008 – Jun 2009:

1. A major outcome during this period was coordinating Miller Creek sampling efforts by the SSLSWCD, the St. Louis River Citizens Action Committee, the City of Hermantown, and NRRI. An agreement was made that all of the various data sets would ultimately be available via the LSS website along with descriptive project information and results as they become available. A Miller Creek TMDL Study section was created at *www.lakesuperiorstreams.org/streams/millerTMDL.html* to house this information or link to agency websites. We met with MPCA staff to discuss delays in obtaining MPCA's certification of the past two years of Miller Creek data from their

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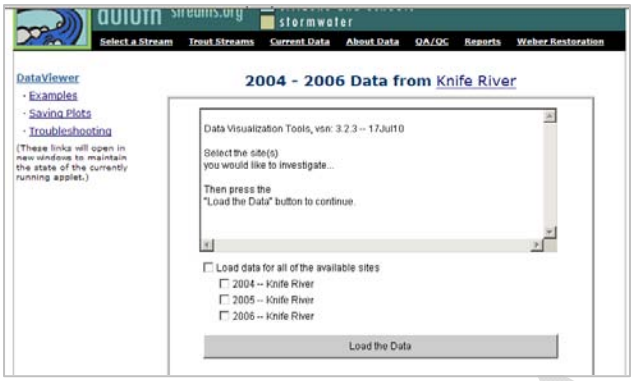
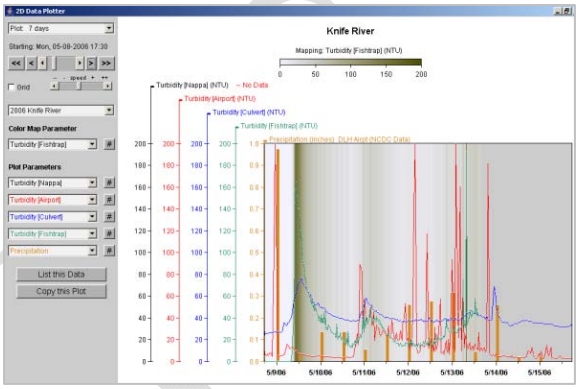
TMDL study in part carried out by the SSL SWCD. In addition to posting reports and tables of water quality data, we developed plans for importing the automated intensive sensor data from 3 TMDL funded sondes for viewing via the DataViewer animation tool on the LSS website. Knife River data from water quality data logged sensors operated from 2004-2006 in the Knife River TMDL study (also impaired due to excess sedimentation and turbidity) was also obtained for the same reasons (screen captures shown below). Knife River TMDL materials were also incorporated in the Knife River websection along with the Poplar River TMDL and Miller Creek TMDL websections.



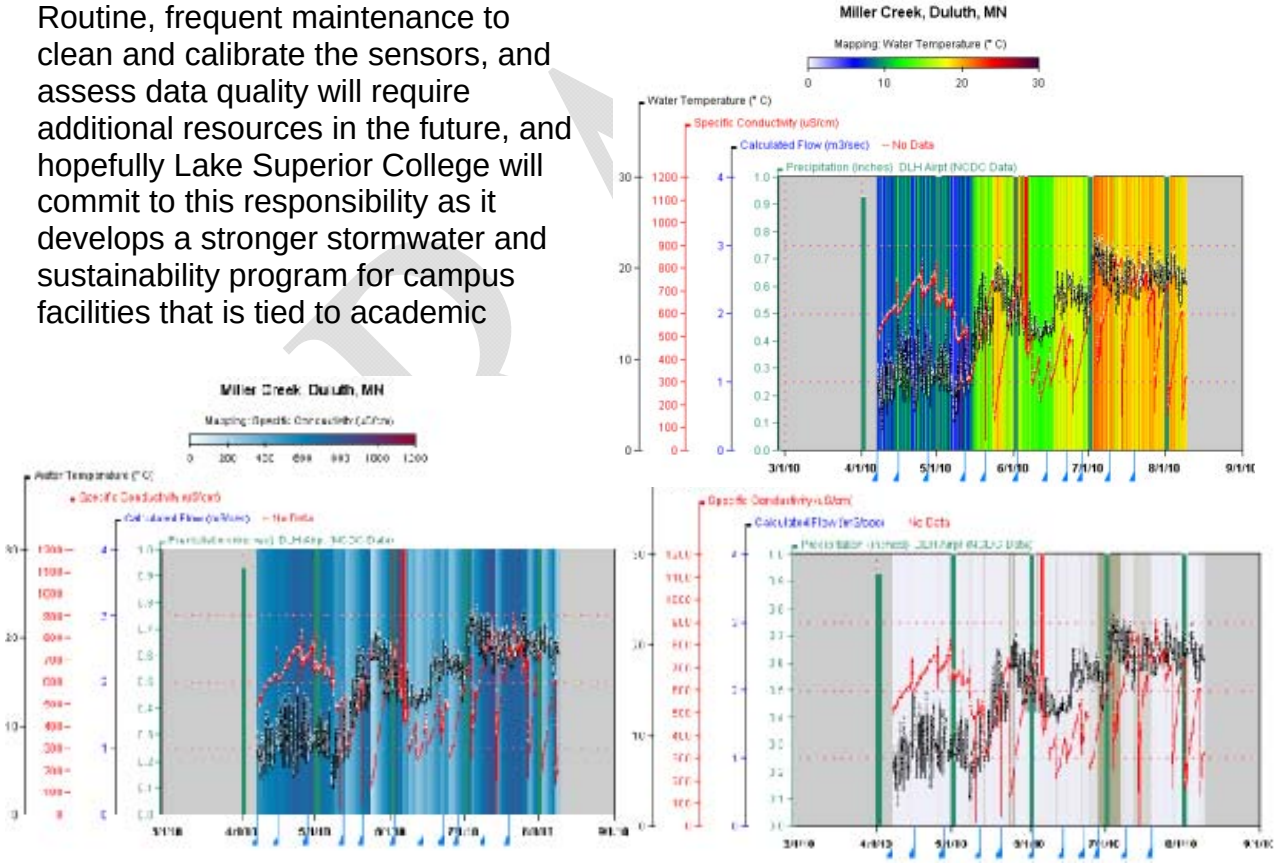


2. An article about all three Amity Creek restoration Projects that were accomplished in Summer was written for the Fall/Winter 2009 issue of *Stream-Line*, a WSRI semi-annual newsletter that is posted on the LSS website and direct mailed to >2000 residents of the Amity-Lester watershed (*http://lakesuperiorstreams.org/weber/StreamLine.html*). The Fall 2008 issue included an article "Why is Amity Creek so muddy?" that further described the impairment and the restoration and mitigation projects underway. Another article was included in the Spring 2009 issue describing the channel geomorphology and bank erosion work that began in summer 2008 on Amity Creek, the LSRP project, and related efforts by other agencies. Additional extension and outreach efforts for all of these projects is ongoing via NRRI and Partner Minnesota Sea Grant talks and articles. In addition there were comprehensive newspaper articles in the Duluth News Tribune for each of the three Amity projects, in July, September and November 2009. Related end products from the Stream-Line series of newsletters are listed in the Outreach & Education Activities Appendix.

- July 2009 –Jun 2010:

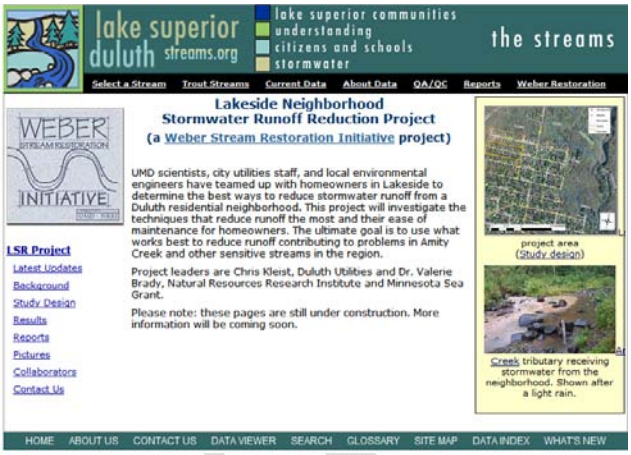
1. Miller Creek data and Miller Creek TMDL section – We acquired MPCA data from 3 automated "TMDL" gauging stations from 2006-2009 and made it available for interactive viewing on LSS via the data visualization tools. We continued to add information about the Miller Creek TMDL Study to our LSS websection (*www.lakesuperiorstreams.org/streams/millerTMDL.html*) as we discover it.

2. Miller Creek @ Lake Superior College is the newest of the automated sites. The equipment was purchased by Lake Superior College and was installed by NRRI-UMD in summer 2008 but had communication issues between the sensors and the datalogger, communication issues between the datalogger and the modem, and communication issues between the modem and the NRRI home base server. Most telecommunication, QA, and operation and maintenance issues were resolved during this period. Unfortunately, the flow (stage height) sensor failed and LSC took a long time before agreeing to purchase a new sensor. Routine, frequent maintenance to clean and calibrate the sensors, and assess data quality will require additional resources in the future, and hopefully Lake Superior College will commit to this responsibility as it develops a stronger stormwater and sustainability program for campus facilities that is tied to academic



curricula. Data is being collected throughout the ice-free season of 2010 as indicated in the graphics shown above and below for different water quality parameters. These data are now viewable at http://www.duluthstreams.org/streams/data/Java/SMUplotter.html. Exemplary screen captures of these data via the DataViewer tool are shown here.

3. Weber Stream Restoration Initiative - An annual report summarizing the activities associated with the Weber Initiative in 2009 was prepared, and included more detailed descriptions of the three 319-related projects and summaries of prospective projects for the future (attached to this report as an Appendix).



4. *Lakeside Stormwater Reduction Project (LSRP) webs*ection *(*funded by the EPA/MPCA 319 program (Kleist, Brady, Schomberg, Axler, PIs) at http://lakesuperiorstreams.org/weber/projects.html . The project section of WSRI will be re-designed in Fall 2010 to feature the actual restoration and implementation projects such as the Lakeside project, the Graves Rd Creek tributary to Amity restoration, and the Upper East Branch Amity bank stabilization project.

The LSRP project involves runoff that delivers water to Graves Rd Creek and so the two 319 projects are closely related and build on each other. This websection will be accessible from: (1) the major STREAMS section via the WSRI websection and also the Amity Creek websection; (2) the major CITIZENS & SCHOOLS section as a demonstration project); and via the major STORMWATER section in the Site Design Toolkit as a Case Study/Demonstration Project www.duluthstreams.org/stormwater/toolkit/index.html. Individual BMPs that are constructed as part of the project will then be featured in the relevant Case Study section. This section is now in the process of being modified to include an atlas of local and regional low impact development (LID) stormwater practices, and will include specific reference to the LSRP. A long-term goal of the Superior Regional Stormwater Protection Team (RSPT) is to seek funding to track the performance of BMPs used in the region over the long-term.

The LSRP websection will include separate sections for the various aspects of the project, including project Background, Methods (e.g. fact sheets for homeowners, Findings (including Knowledge-Attitudes-Practices survey results, flow, water quality, and qualitative information), Links to relevant resources, etc. Some of these materials were already created for the public information meeting in September 2008 and from other presentations. Automated flow and water quality data that are logged at 3 stormdrain collection sites and automated precipitation monitoring data will be periodically fed into the LSS DataViewer to animate these data. Several "representative" storm events will be developed into vignettes (mini-stories) to help website users and outreach staff to interpret the data. Vignettes will be displayed on-line but also will be available as downloadable powerpoint and pdf presentations. The vignettes pieces have not yet been finalized as this grant comes to an end because the website has been undergoing a variety of internal programming modifications.

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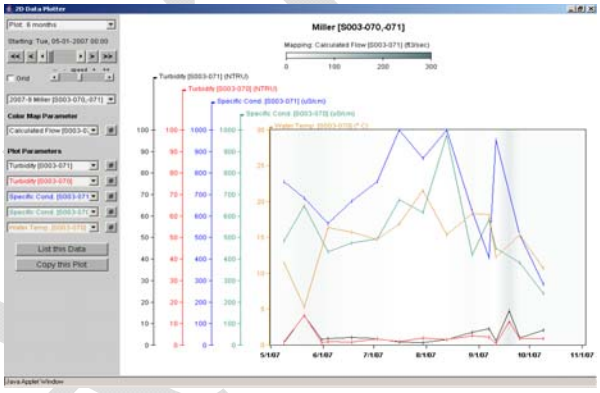
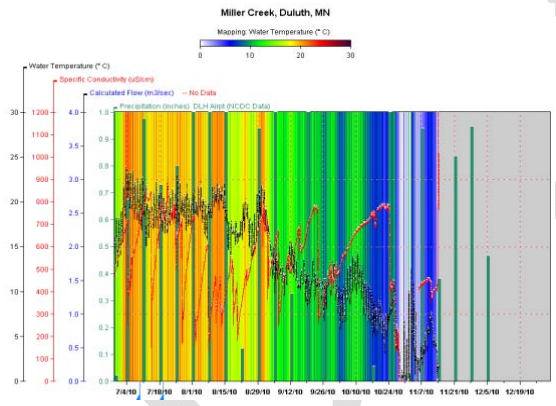
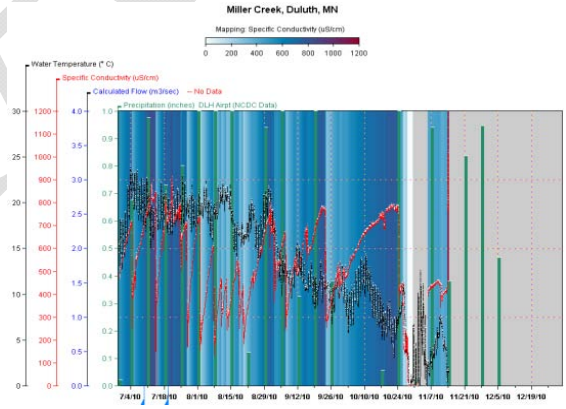
- <u>Jul 2010 – Jun 2011:</u>

1. *Miller Creek gaging station data operated by South St. Louis SWCD and MPCA-Duluth for the Miller Creek TMDL study*. We have now uploaded MPCA's all of their automated stream monitoring data from 1999, and 2007-2009 so that it can be accessed via the data visualization tools on LSS (see screen captures below). A Miller Creek TMDL Study section was created at *www.lakesuperiorstreams.org/streams/millerTMDL.html* to house this information and link to agency websites and we have added information as we discover it.

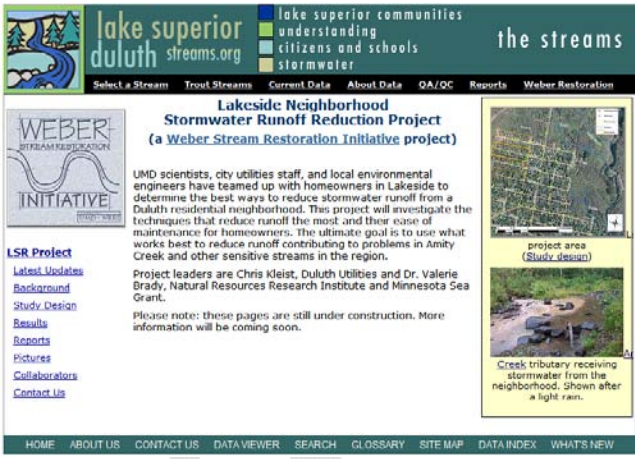






2. Miller Creek @ Lake Superior College continued to operate throughout the ice-free season of 2009 and 2010 as indicated in the graphics shown previously. These data are viewable at http://www.duluthstreams.org/streams/data/Java/SMUplotter.html . It is a difficult monitoring site due to its location in a gorge with relatively poor solar exposure and intermittent cell phone signal. Most issues have been resolved though the data must be collected manually during the cold months to prevent excess battery drainage from calling the modem.

3. An annual report summarizing the activities associated with the Weber Stream Restoration Initiative in 2009 was created in June 2010 and will soon be available on the website. We are currently in the process of updating the Weber Stream Restoration Initiative section at http://www.lakesuperiorstreams.org/weber/index.html to include progress and descriptions of all Amity restoration activities. Updates from the *Lakeside Stormwater Reduction Project (LSRP)*, funded by the EPA/MPCA 319 program (Kleist, Brady, Schomberg, Axler, PIs) were completed in June - July 2011.



4. Many presentations have been given about this project and complementary projects by Project Manager R.Axler, and NRRI staff (V.Brady, D.Breneman, E.Ruzycki), Partners from MN Sea Grant (J.Schomber, C.Hagley), from SSL SWCD (K.Anderson), and the City of Duluth Stormwater Utility (C.Kleist, T. Carlson). These are listed in the Outreach & Education Activities Appendix.

Obj. G Grant administration and reporting

This report, website materials, ongoing monitoring, continuing collaboration with multiple organizations and agencies to continue the stormwater BMP performance assessment elements of this grant, together represent the reporting requirement for this project. Final invoices have been submitted for payment and fiscal reports are being finalized for budget close-out.

FINAL RECOMMENDATIONS TBD

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Lonsdale, M., T.Carlson, R.Axler, J.Walker, C.Hagley, J.Schomberg, M.Granley and G.Host, Linking data, public outreach and education: The City of Duluth Stream Outreach Program - www.lakesuperiorstreams.org. Water Environment Federation Proceedings of Annual Meeting: WEFTEC.06 - The Water Quality Event, 79th Annual Conference and Exhibition, Oct 21-25, 2006, Dallas, Texas USA. INVITED.

Ruzycki, E.R., R.P. Axler, J.R. Henneck, N. Will and G. Host. 2011 (In press). Estimating mercury concentrations and loads from four Western Lake Superior watersheds using continuous in-stream turbidity monitoring. Aquat. Ecosystem Health and Management.

Ruzycki, E.R., R.P. Axler, J.R. Henneck, N. Will, and G.Host. In final draft. *Estimating sediment and nutrient loads in three Western Lake Superior streams: Continuous turbidity monitoring versus spot sampling and modeling*. For submission to J.Amer. Water Resources Association. NOTE- Also presented at Ecology of Lake Superior Conference, Duluth, MN , May 3-5, 2010.

SAS. 1988. *Statistical Analysis System,* SAS Institute Inc.

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July 29, 2011

***Restoring impaired Superior tributaries: Stormwater BMP evaluation, education and outreach* 319 Grant and *Lakeside Stormwater Reduction Project* 319**

Outreach/Education Activities Jul 2007-Jun 2011 (Axler's Lab and spinoffs)

2011

1. *LakeSuperiorstreams.org: Making stormwater and stream data come alive for citizens, students, teachers, contractors, resource agencies, decision-makers and scientists*. Axler, R.P, Host, G.E., Will, N.J., Henneck, J.R., Ruzycki, E.R., Sjerven, G., Hagley, C.A., Schomberg, J., Carlson, T., Kleist, C., Tuominen, T., Anderson, J., Westerbur, A., and Anderson, K. International Association of Great Lakes Research (IAGLR) 2011 Conference, Duluth, MN June 2011.

2. *Weather, Water, and People: Stream, lake, and beach water quality data animations to protect Lake Superior streams and coastal zones*. Axler, R.P., G.Host, N.Will, J.Henneck, E.Ruzycki, G.Sjerven, C.Hagley, J.Schomberg, T.Carlson, C. Kleist, J.Austin, N.Dobiesz, and R. Hecky. International Association of Great Lakes Research (IAGLR) 2011 Conference, Duluth, MN June 2011.

3. *Land Use/Land Cover and Hydrologic Effects on North Shore Superior Tributary Water Quality*. Crouse, A., R.Axler, J.Erickson, G.Host, E.Ruzycki, and L.Johnson. International Association of Great Lakes Research (IAGLR) 2011 Conference, Duluth, MN June 2011.

4. *Estimating sediment and nutrient loads in three Western Lake Superior streams: Continuous turbidity monitoring versus spot sampling and modeling*. Ruzycki, E.R., R.P. Axler, J.R. Henneck, N. Will, and G.Host. International Association of Great Lakes Research (IAGLR) 2011 Conference, Duluth, MN June 2011.

5. *Spring Watch in the Watershed*, Axler, R. and J.Kallestad. *Hillsider Weekly Newsletter.* Duluth, MN. March 2011

6. *Clear Running Waters?* Andrea Crouse (NRRI-UMD) Sea Grant Files interview, KUMD, Aired 3/30/11.

7. *Hold the Salt: Winter Road Maintenance and Water Quality*: Connie Fortin, Fortin Consulting, Inc. with local help from A.Crouse, C.Kleist, and R.Axler, NRRI-UMD. Sea Grant Files interview, KUMD Aired 3/2/11.

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8. *The Weber Stream Restoration Initiative and Stormwater Issues*. D. Breneman radio interview. Via Lake Superior Bi-National Forum. Northern WI regional broadcast . Feb 18, 2011.

9. *The Weber Stream Restoration Initiative and Stormwater Issues*. R. Axler radio interview. KUMD– Feb 23, 2011.

10. Graduate student A. Crouse and PI R.Axler developed media stories with Northlands News Center (KBJR News) meteorologist J.Edmonson to help inform people about regional water quality issues and their relation to watershed activities and weather. Feb. 17, 2011, "Sidewalk Salt Dangers" http://www.northlandsnewscenter.com/lifestyle/your-green-life/Sidewalk-Salt-Dangers-116410609.html

11. *Estimating mercury concentrations and loads from four Western Lake Superior watersheds using continuous in-stream turbidity monitoring.* 2011 (In press). Ruzycki, E.R., R.P. Axler, J.R. Henneck, N. Will and G. Host. Aquat. Ecosystem Health and Management.

12. Ruzycki, E.R., R.P. Axler, J.R. Henneck, N. Will, and G.Host. In final draft. *Estimating sediment and nutrient loads in three Western Lake Superior streams: Continuous turbidity monitoring versus spot sampling and modeling*. (In near final draft). For submission to J.Amer. Water Resources Association. NOTE- Also presented at Ecology of Lake Superior Conference, Duluth, MN , May 3-5, 2010.

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

14. Technical Advisory Committee activities related to Amity/Miller 319 Project Stormwater related impacts:

- Member, Miller Creek Temperature TMDL Technical Advisory Group 2007-2011 (1-2 meetings per year attended by PIs R.Axler and D. Breneman and usually 1-3 other NRRI staff scientists and graduate students.

- Member, Poplar River Turbidity TMDL Technical Advisory Group 2006-2011 (intermittent activity since 2009; web page development with MN Sea Grant for http://www.lakesuperiorstreams.org/northshore/poplar.html

- Member, U. of Minnesota-Duluth Stormwater Steering Committee (since inception

in 2003; reviewed various BMPs and other documents and engineering plans)

- Member - Arrowhead Regional Stream Team (providing hydrologic and geomorphologic technical assistance and training in the Lake Superior and Rainy River Basins) – Grand Rapids, MN and Duluth, MN (4 meetings from 2009-2011, each requiring presentations in Duluth, MN (lead speaker for Mar 28, 2011 that was almost entirely about the Amity Creek Restoration project)

15. *Superior Stream Data for Discovery and Decision-Making*. Axler, R. U. of Minnesota Duluth, Integrated Biological Sciences Graduate Program Colloquium, April 19, 2010.

16.. *Superior Stream Data for Discovery and Decision-Making*. Axler, R. U. of Minnesota – St. Paul, Water Resources Science Seminar Series, Integrated Biological Sciences Graduate Program Colloquium, April 9, 2010.

17. *The LakeSuperiorStreams.org project*. Axler, R. Minnesota Sea Grant Advisory Board, Duluth, MN, April 21, 2010

18. *Weather & Water: Stream, lake, harbor, and beach water quality data animations to protect the Lake Superior coastal zone*. Axler, R., G.Host, N.Will, J.Henneck, E.Ruzycki1, G.Sjerven, C.Hagley, J.Schomberg, T.Carlson, C.Kleist, J.Austin, and N. Dobiesz. St. Louis River Estuary Summit, Feb 7-8, 2011. Superior, WI.

19. Sugarloaf Creek Board of Directors, E. Ruzycki (NRRI-UMD) is now serving (Spring 2011) on this Board specifically to help the group take advantage of existing data and information resources via the LakeSuperiorStreams.org, Superior RSPT, and Weber Stream Restoration Initiative projects.

20. *The Lakeside Stormwater Reduction Project: Evaluating the impacts of a paired watershed study on local residents*. K.Eckman, V.Brady, J.Schomberg, and V.Were. International Association of Great Lakes Research (IAGLR) 2011 Conference, Duluth, MN June 2011.

21. Winter Parking Lot and Sidewalk Maintenance Workshops MN and Winter Maintenance with Reduced Environmental Impacts Training Classes 2008-2011 (1-2 per year in Twin Ports area) Parking lot road salt and sand use to minimize stormwater impacts; assisted Fortin Consulting, Inc, with data vignette slides from LSS.org used at >20 other training sessions state-wide). R. Axler has been a cooperator on this 319 Grant (adapt Workshop materials for use on LSS.org and provide animated gifs of salt-spikes in area streams. Our data vignettes were also included in a *Minnesota Water*

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Newsletter in Spring 2010 that is distributed state-wide.

22. Erickson, J. 2011. *Determining the effects of urbanization on Stream metabolism of Duluth streams*. M.S, thesis, Water Resources Science, University of Minnesota (MS was supported in part by the Amity 319 project).

23. Black, B. In prep*. Landscape effects on stream temperature in Minnesota streams of the Lake Superior Basin.* M.S. thesis, Integrated Biosystems, U. of Minnesota (MS supported in part by projects in which LSS was a partner; he's still finishing 2007-2010)

2010

1. *Data for discovery and decision-making: LakeSuperiorStreams.org.* Axler, R., N.Will, E.Ruzycki, G.Host, C.Hagley, J.Henneck, T.Carlson, J.Schomberg, G.Sjerven, C.Kleist. 2010. NRRI Tech. Report NRRI/TR-2010/08. Natural Resources Research Institute, U. of Minnesota-Duluth, 5013 Miller Trunk Highway, Duluth, MN 55811 USA. Submitted to Minnesota's Lake Superior Coastal Program (includes many items related to this 319 Grant and in part cost-shared)

2. *Water Quality 101: How do Minnesota's Lakes & Streams "work"*. R. Axler. UM-Duluth University for Seniors, April 2010 (R. Axler with a 50% focus on regional streams, stormwater impacts, and citizen watershed actions)

3. *Stormwater's Biotic Impacts and Human Solutions*. V. Brady, NRRI-UMD, keynote address to the Minnesota Wastewater Operators Association. July 28, 2010, Grand Rapids, MN. (~150 attendees).

4. *Lakeside, Duluth Stormwater Reduction Project.* V.Brady. Northland Innovative Stormwater Management Conference, Nov 17, 2010 (~50 attendees).

5. Northland Innovative Stormwater Management Conference, Duluth, MN. R.Axler (NRRI-UMD (Organizing/Agenda Committee) and J.Schomberg (SeaGrant-UMD, Chair). Nov 17, 2010, Duluth, MN. (~125 attendees) and a bus tour of innovative stormwater BMPs.

6. *Lakeside Stormwater Runoff Reduction Project.* Valerie Brady, NRRI-UMD, Karlyn Eckman, Water Resources Center-UM, Jesse Schomberg, Minnesota Sea Grant-UMD, and Chris Kleist, City of Duluth Utilities. presentation at the North Shore Stormwater Workshop, Duluth, November 2010.

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

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

9. *Using Spatially Explicit Land Use and Biophysical Data to Interpret In-Stream Responses. 2010.* L.Johnson, D.Breneman, R.Axler, J.Erickson. NRRI-UMD. Ecology of Lake Superior Conference and Workshop, Duluth, Minnesota, May 3-4, 2010 (~ 125 attendees)

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

11. Ruzycki, Elaine M., 2010. Estimating sediment, nutrient, and mercury loads from four western Lake Superior watersheds using continuous in-stream turbidity monitoring. M.S. Thesis, Water Resources Science, University of Minnesota, Duluth, MN.

12. Graduate student A. Crouse and PI R.Axler developed media stories with Northlands News Center (KBJR News) meteorologist J.Edmonson to help inform people about regional water quality issues and their relation to watershed activities and weather.

- Part 1: Keeping our streams clean : http://www.northlandsnewscenter.com/greenlife/Keeping-our-Stream-Clean-98595069.html

- Part 2: Protecting-Our-Local-Streams http://www.northlandsnewscenter.com/greenlife/Protecting-Our-Local-Streams-98596209.html

13. Interactive web-based data visualization for discovery and decision-making: LakeSuperiorStreams.org . Richard Axler1, George Host1, Norm Will1, Cynthia Hagley2, Jesse Schomberg2, Jerry Henneck1, Gerry Sjerven1, Elaine Ruzycki1, Todd Carlson3, and Chris Kleist 3. Natural Resources Research Institute1 and Minnesota Sea Grant College2, University of Minnesota, Duluth, MN, 55811 USA; City of Duluth Stormwater Utility3, Duluth, MN, 55802 USA. Minnesota Land Conservation & Clean Water Summit. Sep, 2010.

14. E.Ruzycki & R.Axler. MN Waters (the NGO) Data Interpretation (Volunteer Monitoring) workshop, Feb 16, 2010 at Fond du Lac Tribal & Community College (E. Ruzycki presentation and participation in the all day workshop)

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15. Anderson, Keith (SSL SWCD). 2010. Amity Creek Bank and Habitat Restoration. *Midwest Stream Restoration Symposium* (p. Poster). Lacrosse, WI: Partnership for River Restoration Science in the Upper Midwest.

16. Anderson, Keith. 2010. Amity Creek Bank and Habitat Restoration. *Sea Grant Stormwater Conference* (p. 49 Slides). Duluth: MN Sea Grant.

17. Anderson, Keith. 2010. Amity Creek Bank Stabilization and Habitat Restoration. *NRCS, BWSR Joint Engineering Conference* (p. 50 slides). Duluth: NRCS, BWSR.

2009

1. *The LakeSuperiorStreams.org and Weber Stream Restoration Initiative Projects at the head of the Great Lakes*. R. Axler et al. Great Lakes Restoration Conference, Duluth, MN Sep 10-12, 2009 (~450 attendees).

2. Superior Regional Stormwater Protection Team's third Lake Superior Watershed Festival, LSS/DS *Lake Superior Streams.org* and WSRI Booth and Poster, June 4, 2009. Hermantown/Duluth, MN (~ 600 attendees).

3. WSRI *Stream-Line* contributor and Assistant Editor (w/ Editor June Kallestad and Dan Breneman, NRRI-UMD). Autumn/Winter 2009, In this issue: Shoring up the Amity; When it rains, it pours (into Amity Creek); Muddy waters cleared at historic Graves Road wash-out site;
Ron Weber - NE Conservationist Award; Great Lakes to get federal funding for protection and restoration

4. WSRI *Stream-Line* contributor and Assistant Editor (w/ Editor June Kallestad and Dan Breneman, NRRI-UMD). Spring/Summer 2009. In this issue: Beach Watch Warnings; Hot secrets of the Chester Creek Ponds; A reserve to preserve: The St. Louis River Estuary; Targeting pollution- Minnesotans say "yes" to clean water and land

5. WSRI *Stream-Line* contributor and Assistant Editor (w/ Editor June Kallestad and Dan Breneman, NRRI-UMD). Autumn 2008, In this issue: Correcting Duluth's Overflows; Forests role in keeping water clean - Plant a tree; What you don't know about your watershed streams; Why is Amity Creek so muddy?

6. WSRI *Stream-Line* contributor and Assistant Editor (w/ Editor June Kallestad and Dan Breneman, NRRI-UMD). Spring 2008, In this issue: Spring watch in the watershed; Can you make a difference for cleaner streams? ; Beyond rain barrels; Lessons learned from Miller Creek;
Bank stabilization project.

7. WSRI *Stream-Line* contributor and Assistant Editor (w/ Editor June Kallestad and Dan Breneman, NRRI-UMD). Autumn 2007, In this issue: Beauty and the tarmac; From run-off to rain garden; Are we 'stressing out' the Lester-Amity?; Charrette? You bet!; A development design for everyone; Spot a problem? Let us know!

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

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

10. Member (R.Axler (NRRI-UMD), Flute Reed River Watershed Partnership, Cook County, MN. Collaborating via consultation, development of website section on www.lakesuperiorstreams.org, and review of materials and reports. Ongoing since Summer 2007.

11. Miller Creek Temperature TMDL Technical Advisory Group. Members R.Axler , D. Breneman, (NRRI-UMD), 2007-2011 (~ 5 meetings)

12. Poplar River Turbidity TMDL Technical Advisory Group 2006-2009 (No meetings in 2009; web page development and review with MN Sea Grant for www.lakesuperiorstreams.org)

13. *Robo-researching Lake Superior Streams.* E.Ruzycki, NRRI-UMD interview. Sea Grant Files, Aired 4/8/09

14. R.Axler. Lake Superior Youth Symposium (International), May 15, 2009, Duluth, MN (CSS). Organized two activities, a streamside and pond survey of water quality and benthic invertebrates at Chester Creek and Chester Park (w/J.Lindgren [MDNR], V.Brady [NRRI], and T. Carlson[City of Duluth]) and a computer lab (alone) using *www.Lakesuperiorstreams.org* for high school students.

15. K.Gran. 2009. The role of local geology and topography on suspended sediment and organic carbon in a Minnesota North Shore bedrock stream. Poster, American Geophysical Union Annual Conference, San Francisco, CA .

2008

1. *Real-Time Data to Estimate Sediment, Nutrient, and Hg Loading from Northshore Lake Superior Streams*. 2008. Axler, R., N.Will, E.Ruzycki, G.Host, C.Hagley, J.Henneck, T.Carlson, J.Schomberg, M.Lonsdale, G.Sjerven, C.Kleist, and D.Stark. 2008. NRRI Tech. Report NRRI/TR-2008/09.

2. Axler, R. *Superior Stream Data for Discovery and Decision-Making*. U. of Minnesota Duluth, Integrated Biological Sciences Graduate Program Colloquium, April 28, 2008.

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3. Hagley, C., R.Axler, E.Ruzycki, G.Sjerven and G.Host. *Data for Discovery: Understanding Storm and Land Use Effects on Stream Quality.* Two workshop, teacher training presentations of curriculum lessons at Minnesota State Teachers Association Annual Conference, Duluth, MN. March 31-April 1, 2008.

4. Johnson,L. and R. Axler. *Measuring the effectiveness of the TMDL process*. Minnesota Impaired Waters Symposium, Water Resources Center, U. of MN-St. Paul, MN Feb 11-12, 2008.

5. R.Axler. Participant, State of the Lake Superior Coast 2008. Workshop sponsored by North Shore Management Board & Arrowhead Regional Development Commission, emphasizing Conservation/Low Impact Design. May 1, 2008. Duluth, MN.

6. R.Axler, Participant & Presenter, MDNR Shoreland Rules Update Project, June 16, 2008, Duluth, MN

2007

1. Gross, H. and R. Axler. 2007. Website Uses Data to Paint Picture of Lake Superior's Watershed. NOAA Coastal Issues 10 (Issue 6 Nov/Dec): 8.

2. Axler, R. *Visualizing Water Quality and Watershed Data from Superior Streams*. Minnesota High School Volunteer Stream Monitoring Program - 7th Annual River Summit, Science Museum, Minneapolis, MN, Nov 15, 2007.

3. Ruzycki, E.R., R.P. Axler, G.Host, J.R. Henneck and J. Mayasich. *Estimating sediment, nutrient, and mercury loads from four Western Lake Superior watersheds using continuous in-stream turbidity monitoring.* Poster. Making a Great Lake Superior Conference, Duluth, MN October 29-31, 2007.

4. Axler, R., G.Host, N.Will, C. Hagley, J.Schomberg, J.Henneck, G.Sjerven, E.Ruzycki, T.Carlson, J.Reed and M.Lonsdale*. Interactive web-based data visualization for discovery and decision-making: LakeSuperiorStreams.org.* Making a Great Lake Superior Conference, Duluth, MN, October 29-31, 2007.

5. Ruzycki, E.R., R.P. Axler, J.R. Henneck, N. Will, and G.Host. *Sediment and nutrient load measurements in Western Lake Superior streams: In-stream turbidity sensors versus grab sampling and modeling.* Minnesota Water Resources Conference, St. Minneapolis, MN October 23-24, 2007

6. Axler, R., C.Hagley, J.Schomberg, M.Lonsdale, T.Carlson, G.Host, N.Will, J.Henneck, J.Reed, E.Ruzycki, and G.Sjerven*. Lakesuperiorstreams.org: Making Stormwater and Stream Data Come Alive for Citizens, Students, Teachers, Contractors, Resource Agencies, Decision-Makers and Scientists.* Minnesota Water Resources Conference, St. Minneapolis, MN October 23-24, 2007

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7. Axler, R, G.Host, N.Will, C. Hagley, J.Schomberg and L.Johnson. *Interactive web-based data visualization for discovery and decision-making: LakeSuperiorStreams.org* . Invited paper - NABS 55th Annual Meeting: session: "Innovative Techniques to Inject Ecological Knowledge into Water Management", N. American Benthological Society Annual Meeting. Charleston, SC. Jun 2007.

8. Ruzycki, E., R. Axler, D.Breneman and J. Kallestad. *LakeSuperiorStreams.org and Weber Stream Restoration Initiative Projects.* Poster at Second Annual Regional Stormwater Protection Team (RSPT) Water Festival -Zaagidawaa, Jun 2, 2007, Duluth, MN.

9. R.Axler articipated in a sponsored Coastal Ocean Sciences Excellence in Education (COSEE) Great Lakes “teachable moment,” in which 33 teachers from MN, WI, MI, and Ontario had a lunch meeting with scientist – presenters at Making a Great Lake Superior Conference, Oct 28-Nov 1, 2007. Teachers were encouraged to attend their talks and then discuss their research and possible classroom applications.

10. Ruzycki, E., R. Axler, D.Breneman and J. Kallestad. LakeSuperiorStreams.org and Weber
Stream Restoration Initiative Projects. Poster at Second Annual Regional Stormwater Protection Team (RSPT) Water Festival -Zaagidawaa, Jun 2, 2007, Duluth, MN.

11.E. Ruzycki. *Creating Data Vignettes for Education and Outreach in Great Lakes Coastal Ecosystems*. Presentation at the Great Lakes Observing Systems Best Practices in Education and Outreach Workshop held April 10-11, 2007, Traverse City, MI.

12. R.Axler, Participant, Stormwater Roundtable, South St. Louis Soil & Water Conservation District Workshop, Duluth, MN 6/4/07.

13. R.Axler Participant, MPCA-St. Paul Stormwater Policy Focus Group, Duluth, MN 9/19/07.

14. R.Axler, Participant, Stormwater BMP Assessment Training Workshop, UM-WRC/SAFL project, Hermantown, MN 3/28/07.

15. Participant- “Re-establishing Connections to Our Waterways: Visioning and Alternatives to Protect Water Quality “ that developed a charette for a low impact conservation development design by the Minnesota Chapter of the American Institute of Architects for an Upper Amity Creek Watershed parcel of tax-forfeit St Louis County land. Jan – May, 2007.

16. R.Axler, Member, Flute Reed River Watershed Partnership, Cook County, MN. Collaborating via consultation, development of website section on

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www.lakesuperiorstreams.org, and review of materials and reports. Ongoing since Summer 2007.

17. LakeSuperiorStreams and Regional Stormwater Protection Team Booths at UMD-Theatre Performances of “Urinetown”, October 19 & 20, 2007.

18. UMD Tech Fest Poster Presentations – *LakeSuperiorStreams.org* and *Weber Stream Restoration Initiative* Projects all day, March 30, 2007 (w/N. Will, E. Ruzycki and J. Ameel)

Website Activity and Awards/Honors (cumulative for web-based projects related to the Amity-Miller 319 Project). The formal and community water resource understanding and protection educational curricula on the *LakeSuperiorStreams.org* and associated websites produce about 2.5 million server requests (~ “hits”)/month. Portions of these curricula are being used in at least 5 courses at the UM-TC campus (Baker, Cottner, Sterner, Newman, Finlay) and at least 6 at UMD (Hicks, Gallup, Guildford, Hecky, Branstrator, Shannon, Stark, Werne).

Weber Stream Restoration Initiative received the Lake Superior Binational Forum 2010 Award for Stewardship. Presented by Great Lakes Restoration “Czar” Cameron Davis, July 2010.

LakeSuperiorStreams.org nominated for National Sea Grant Association award for 2010

Weber Stream Restoration Initiative received the 2008 Milton Pelletier Environmental Stewardship Award By The St. Louis River Alliance, 01/21/09. The award was given for the initiative's efforts to enhance habitat and biodiversity in Lake Superior tributary streams by protecting and restoring watersheds along the North Shore.

LakeSuperiorStreams.org received the 2007 Lake Superior Binational Program – Environmental Stewardship & Education Award. July 15, 2007 and presented again at the making a Great Lake Superior Conference, October 29, 2007

LakeSuperiorStreams.org was a finalist (of 3) for the 2007 Minnesota Environmental Initiative Award for Environmental Education (http://www.mn-ei.org/awards/finalistswinners.html) May 18, 2007

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www.LakeSuperiorStreams.org usage

Jan 1, 2010 – Dec 31, 2010
Page Requests: 1,192,549 Total Requests (visits): 4,620,818

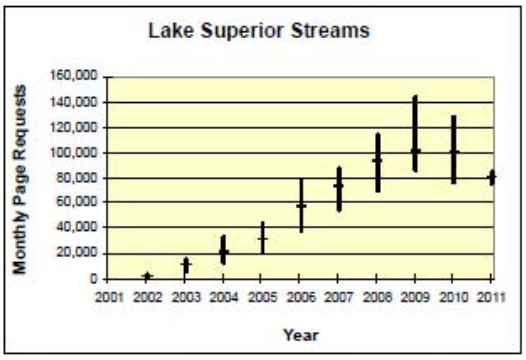
LakeSuperiorStreams.org -- Usage Since 2002

General Summary

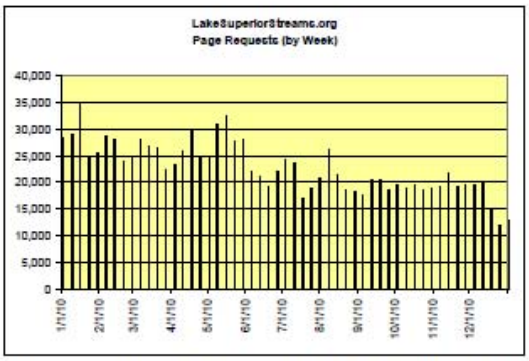
The General Summary provides a quick overview of the general statistics for the entire web site during the report time frame.

General Summary		
1.	Successful server requests	28,105,273 Requests
2.	Successful requests for pages	6,157,682 Requests for pages
3.	Failed requests	326,468 Requests
4.	Redirected requests	10,060 Requests
5.	Distinct files requested	16,255 Files
6.	Distinct hosts served	684,717 Hosts
7.	Total data transferred	430.191 GB

This report was generated on June 14, 2011 18:13.
Report time frame March 22, 2002 20:38 to May 31, 2011 23:59.



Minimum, Maximum, and Mean # of Page Requests, by Year



Weekly Page Requests, by Month-2010

www.LakeSuperiorStreams.org usage has leveled off in the past 2 years. It still exhibits high usage in Spring, presumably in part due to student/teacher usage cycles. Overall website activity in 2010 totaled 4.6 million requests (similar to "hits") and 1.19 million page requests (i.e. webpages downloaded).

R.Axler, NRRI-U. of MN-Duluth 6/16/11

APPENDIX B.

1. Amity Creek (East Branch) Bank Stabilization Project Description

Prepared by N.Schroeder and K.Anderson, S.St Louis SWCD, 12/9/2009

The following is a brief project description explaining the basics of the project.

What and Why: The project is addressing two banks that are approximately 10-20 feet high that are un-vegetated and composed of clay soils. The banks are near an old abandoned farm field on City of Duluth property behind Hawk Ridge where the East and West Branches of Amity Creek come together. In the process of its natural meander pattern the creek has intersected the valley wall. The valley wall is composed of clay and eroding into the stream. The cause of the erosion is two fold. One cause is by the stream intersecting the and eroding the bottom of the slope therefore causing the banks to be very steep. This combined with surface and groundwater has made the banks unstable and results in periodic large inputs of clay into Amity Creek from these banks. This input of clay soils results in stream turbidity (water is red colored versus clear) and can impact the fisheries and aesthetics of the creek. The banks historically were also weakened by the removal of large conifers and other trees that counteracted the forces of the river. Currently small aspen are growing near the banks which do not have the root mass compared to large white pine or spruce that may have been present prior to the old farm being established.

How: The project will reduce the input of clay sediments into the river and in the process create fisheries habitat through the creation of pools and additional woody debris. This is accomplished through the use of stream vanes, a bankfull bench, root wads, riparian plantings, and excavation of the banks to a more stable angle. The stream vanes will be constructed of rock and placed in the stream in such a manner and angle as to direct the high (bankfull and above) flows away from the eroding bank. This will also create a depositional flat above the vanes further helping to stabilize the banks. The bankfull bench will be created at the bottom of the unstable slope and will also help in spreading out of the high flows before they are able to affect the toe of the slope. The root wads placed into the stream banks will further enforce the banks and allow for fisheries habitat through the placement of the woody debris. Finally, the banks will be excavated, seeded, and planted such as to create a more stable bank angle. In the future long lived conifer trees will be planted on the slope.

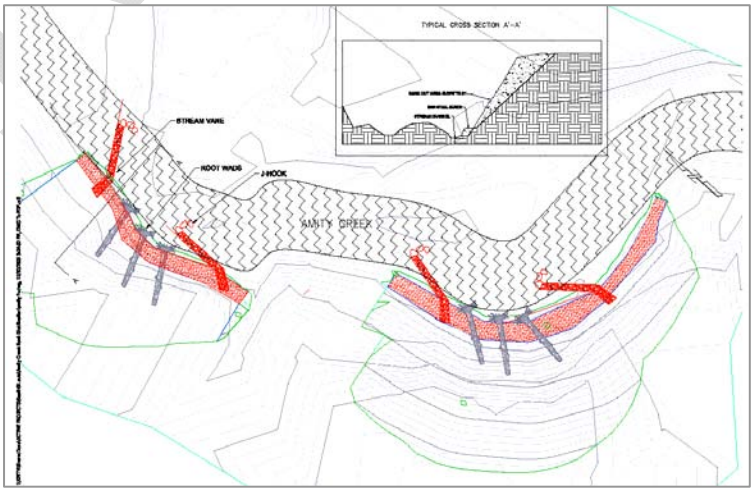


Figure 1. Plan View

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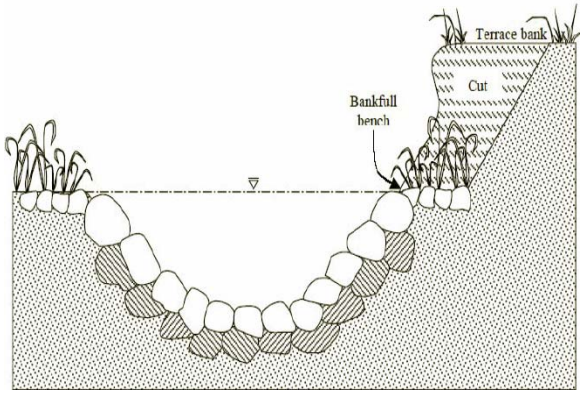

Figure 2. Bench schematic

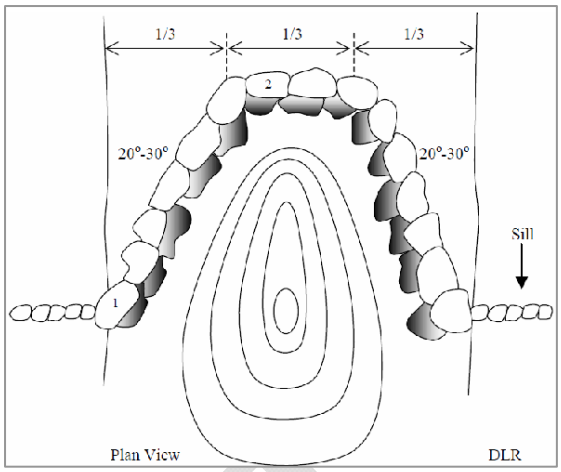

Figure 3. Cross-section, profile and plan view of a Cross-Vane

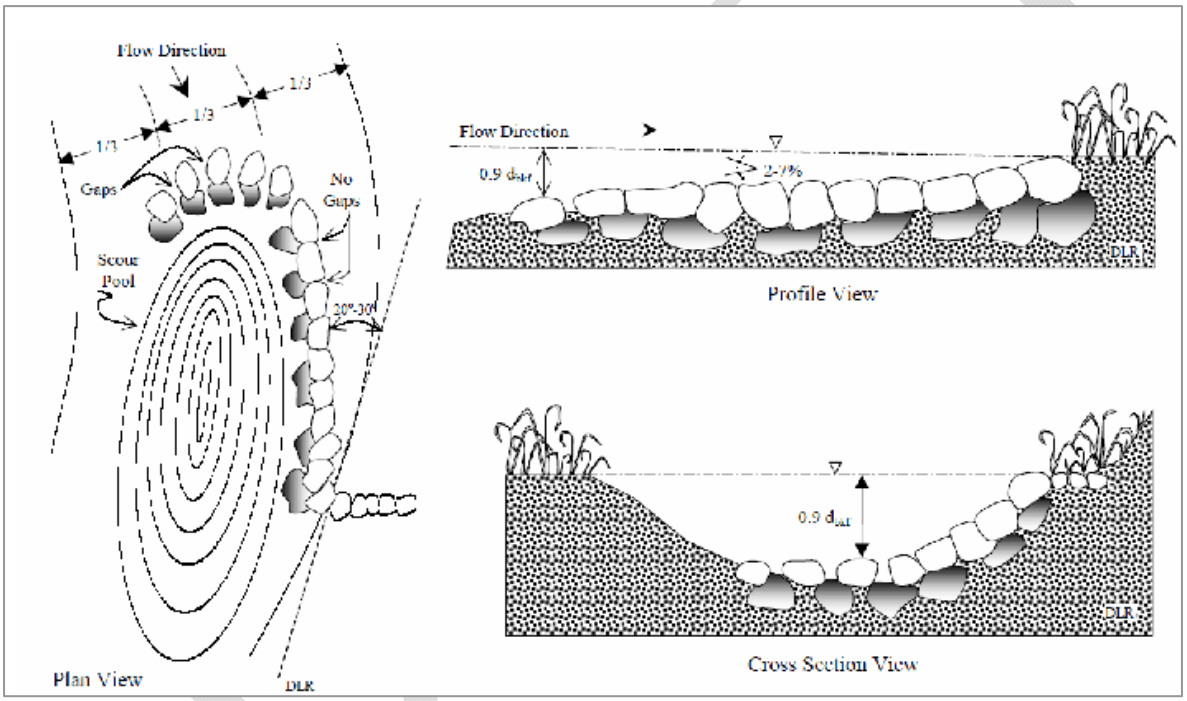

Figure 4. Cross-section, profile and plan view of a J-Vane or J-Hook

Alternatives:

1. Do nothing: This alternative would result in further bank slumping and sediment delivery to the creek. Therefore this alternative was not selected.

2. Rip Rap banks: This alternative was not selected due to the limited habitat improvements gained from such a solution. While effective at bank stabilization in banks in question, rip rap if improperly applied can have negative effects downstream.

3. Move channel away from the banks: This alternative was considered during preliminary design. In discussions with DNR Fisheries and others it was decided that not enough information was known regarding the geomorphic stability of the stream. Therefore this alternative was not selected.

Reason for selecting chosen alternatives:

The reason for selection of the bankfull bench with root wads and logs along with stream vanes are the following:

1. This option will allow the stream thalweg to be redirected away from the banks and therefore taking the main erosive force away from the banks.
2. The bankfull bench will allow for bank protection while providing habitat with the root wads and large woody debris.
3. The stream vanes along with redirection of the thalweg will allow for the formation of a pool area downstream of the j-hook portion of the vane. This will create additional pool habitat for the trout species present in the stream.

DRAFT

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- Select a Stream
- Trout Streams
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WEBER STREAM RESTORATION INITIATIVE

- Detailed Initiative Goals
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STREAM-LINE

News for residents of the Lester-Amity rivers watershed

Autumn / Winter 2009

In this issue:

- **Shoring up the Amity**
- **When it rains, it pours (into Amity Creek)**
- **Muddy waters cleared at historic Graves Road wash-out site**
- **Ron Weber - NE Conservationist Award**
- **Great Lakes to get federal funding for protection and restoration**

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- **Hot secrets of the Chester Creek Ponds**
- **A reserve to preserve: The St. Louis River Estuary**
- **Targeting pollution**
- **Minnesotans say "yes" to clean water and land**

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- **Why is Amity Creek so muddy?**

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  From run-off to rain garden
- **Are we 'stressing out' the Lester-**

Amity?

- **Charrette? You bet!**
  A development design for everyone
- **Spot a problem?**
  Let us know!

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Spring 2007

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- **Fish tales from the past**
  Lester River hatchery was “first class” operation
- **Get to know the Lester-Amity Watershed**
- **Be a North Shore Ambassador**
- **Go with the flow!**
  Follow a raindrop down Amity Creek
- **Working together:**
  The Regional Stormwater Protection Team

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what's new

Lake SuperiorStreams / DuluthStreams & Regional Stormwater Protection Team Awards

Related awards & recognitions received by our team are listed on our sister site -- Water on the Web.

7/22/2010

NRRI stream collaborative wins environmental award (4.3 mb PDF)

In July, a Duluth-based stream restoration collaborative received national recognition - make that *bi*-national recognition, from the U.S. *and* Canada.

U.S. Environmental Protection Agency Senior Advisor Cameron Davis presented the 2010 Environmental Stewardship Award to Ron Weber whose private donation to NRRI started the Weber Stream Restoration Initiative. Each year, the Lake Superior Binational Forum recognizes people who make a “superior” effort to protect or restore the lake's natural environment.

"The Weber Initiative was highly scored by the binational judging panel because it represents a partnership of scientists and resource managers from more than 25 different groups that has culminated in at least 13 stream-related projects along Lake Superior's North Shore," said Lissa Radke, U.S. coordinator for the Forum.

Started in 2005 with endowment funds and garnering almost $2 million in externally funded grants, the Weber Stream Restoration Initiative's goal is to enhance habitats and biodiversity in Lake Superior tributary streams by protecting and restoring watersheds along Minnesota's North Shore.

"We believe that protection and restoration of these streams will be successful only if both the root causes of damage, as well as the symptoms of disturbance are addressed," said Rich Axler, lead investigator on the project. "That's why we depend on a consortium of professional resource managers, academic scientists, and the public in cross-disciplinary communication about ongoing activities in the North Shore watersheds."

The Lake Superior Binational Forum is a multi-sector stakeholder group of U.S. and Canadian volunteers that work together to provide input to governments about lake issues and educate basin residents about ways to protect and restore the lake. More about this organization is at www.superiorforum.org.

5/20/09

Todd Carlson (left), an Environmental Specialist with the City of Duluth Stormwater Utility and a member of the LakeSuperiorStreams team and Regional Stormwater Protection Team (RSPT) since their inception, received the **2009 Central States Water Environment Association Collection System Award** in recognition of outstanding contributions in advancing collection system knowledge resulting in direct or indirect improvement in water quality. The presentation was made at their annual meeting in Chicago, IL.

4/6/09

Richard Gitar with nominator Joanne Christie and receiving his 2009 National Wetlands Award from Michael Shapiro, Acting Assistant Administrator for Water, U.S. Environmental Protection Agency.

Rick Gitar, the Water Regulatory Specialist from the Fond du Lac Band of Lake Superior Chippewa, received a **2009 National Wetlands Award** for State, Tribal, and Local Program Development. Rick built a successful tribal wetlands program across 44,000 acres of wetlands in Northeastern Minnesota. He is the Band's representative to the Superior Regional Stormwater Protection Team.

1/21/09

The St. Louis River Alliance

Milton Pelletier Environmental Stewardship Award (Organization)

The Weber Stream Restoration Initiative in recognition of the collaborative efforts to enhance habitats and biodiversity in Lake Superior

tributary streams by protecting and restoring watersheds along Minnesota's North Shore.

7/15/07

LakeSuperiorStreams.org received the 2007 Environmental Stewardship Award in the Community/Organization category for the United States from the Lake Superior Binational Forum.

The award was presented on July 15, 2007 — Lake Superior Day.

Get the details!

5/17/07

LakeSuperiorStreams.org and the **RSPT** were jointly a Finalist for the Minnesota Environmental Initiative 2007 Education Award. Find out more **here**.

2/3/06

Candice Richards and Erik Larson receiving a **2005 Environmental Stewardship award** for the U. of Minnesota Duluth Facilities Management Department's Stormwater Pollution Prevention Program from the St. Louis River Citizens Action Committee, Jan 25, 2006. Find out more about their Glensheen Parking Lot, Lake Superior shoreline protection, and rain garden projects and keep checking this website for more UMD pollution prevention projects.

11/10/05

LakeSuperiorStreams.org (formerly called ***DuluthStreams.org*** before broadening its scope to include the larger Western Lake Superior Region) received a Technical Excellence Award in recognition of "Outstanding Research in Stream and Lake Restoration, Protection and Management" from the North American Lake Management Society (NALMS).

For details read this.

3/30/05

DuluthStreams.org receives an Environmental Leadership Award for education and outreach at the 4th Annual Road Salt Symposium, March 30, 2005 in St. Cloud.

Get the details.

1/26/05

DuluthStreams.org receives the 2004 Environmental Stewardship Award for Media from the St. Louis River Citizens Action Committee. **Get the details**.