Minnesota's Lake Superior Coastal Program

Flute Reed River Water Quality / Quantity Monitoring and GIS Mapping for Problem Reach Identification

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Dave Stark (Stark Enterprises – Contractor)

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Contract No. B29254

This project was funded in part under the Coastal Zone Management Act, by NOAA's Office of Ocean and Coastal Resource Management, in cooperation with Minnesota's Lake Superior Coastal Program.

Introduction

The Flute Reed River discharges to Lake Superior at Hovland, which is located approximately 20 miles Northeast of Grand Marais, Minnesota. The Flute Reed River watershed encompases 10,485 acres and was identified in the Lake Superior Basin Plan as vulnerable, due in large part to the high percentage of private land within the watershed and potential for development.

A group of citizens formed The Flute Reed Partnership (FRP) and obtained non-profit status in 2007. The group has held a number of educational workshops, completed a watershed monitoring plan and a Surface Water Assessment Grant (SWAG) which included laboratory and field parameter testing near the mouth of the river. Analysis of the Flute Reed Partnership's SWAG water quality data indicated that the river was exceeding state turbidity standards. The funding provided by this Minnesota Lake Superior Coastal Program (MLSCP) Star Grant was used to better understand this impairment and achieve these three primary goals:

1. Establish STORET monitoring locations at 6 sites along the river and obtain field water quality samples;
2. Install a staff gauge and develop a preliminary stage discharge relationship to better quanitfy flow in the river; and,
3. Compile GIS layers for the FRP with the ultimate goal of a better map that includes some previously unidentified tributaries.

Work Completed

Task 1: Field Water Quality and Quantity Measurements – This portion of the project trained volunteers in water quality monitoring and probe calibration, set up Minnesota Pollution Control Agency (MPCA) Storet sampling locations, performed a channel survey at Highway 61 which was permitted through the Minnesota Department of Transportation (MN DOT) and installed a staff gauge for stage measurements. Volunteers Rick Schubert, Dick Betz and Glenn Gilyard performed bi-monthly water quality measurements and stage measurements as outlined in the application.

Water quality data was entered into the required excel data sheet for STORET and submitted to Linda Nelson at MPCA. After the data undergoes final review it will be posted to the MPCA environmental data access webpage where it will be available for mapping and download http://www.pca.state.mn.us/data/edaWater/index.cfm. Additionally, the data was graphed in excel to evaluate increasing turbidity values in a downstream direction. A copy of this deliverable is included in **Appendix A - Water Quality Data** and with the CD that accompanies this report.

Water quantity data was entered into an excel spreadsheet developed for this project. The spreadsheet applied Manning's Equation for estimating water quantity (discharge). Survey data from MPCA was imported into Autocad to determine cross sectional areas and wetted perimeter inputs for the equation and published roughness coefficients were applied for channel conditions. The output from this operation was a stage vs. discharge relationship. A

copy of this deliverable is included in **Appendix B - Water Quantity Data** and with the CD that accompanies this report. Data from this operation was compared to hydraulic reports produced by MN DOT. To validate and improve this data two options exist. First, manual field discharge measurements, utilizing the survey for cross sectional areas and an in stream velocity meter, could be conducted. The problem with this technique is that measuring high flows in the Flute Reed River would be dangerous or impossible. The better option would be to contract with MPCA and/or the United States Geological Survey (USGS) to utilize a River Cat, which is a mechanical device that is set up to take these measurements and is controlled from shore. Precision from this method would be much better and safer. Ultimately a formal river gauging station would need to be installed for precise measurements of discharge.

Task 2: Compile GIS and Map Unmapped Tributaries- The FRP and contractor coordinated with the University of Minnesota (UM) Natural Resources Research Institute (NRRI) and UMD Geographic Information System (GIS) lab to obtain best available land-use, soil, elevation and aerial photography data along with other layers from previous projects. The FRP and contractor completed a field reconnaissance in 2009 and used a Global Positioning System (GPS) to identify mapped and unmapped tributaries flowing into the main stem of the Flute Reed River. This data was imported and geo-referenced along with a previous river survey that was completed in 2006 by Dick Betz and Glenn Gilyard. ArcHydro GIS data, produced by Tom Hollenhorst when at NRRI (currently EPA), was imported into the GIS project and evaluated with the aerial photography and GPS data points. The accumulation values utilized by NRRI produced a stream layer that showed the unmapped tributaries of concern and this was reinforced by overlaying the GPS points that include field notes. Upon further review of the layers, some areas that seemed to be tributaries were actually wetland seeps. A series of base maps were produced for the FRP. An ArcReader application was included so that the Partnership has access to all deliverables. A copy of this deliverable is included in **Appendix C – GIS Data** and with the CD that accompanies this report. The entire GIS project with produced maps and metadata for the new tributaries is included on the CD that accompanies this report.

Goals and Performance Indicators: This project met its original goals by evaluating field water quality measurements along the Flute Reed River where no known data existed and compiling a preliminary stage discharge relationship. By collecting field data and collaborating with NRRI staff, the unmapped tributaries were added to a series of base maps for the FRP. This project involved educational activities and training activities in the area of water quality and hydrology, volunteer monitoring and the data will be utilized by MPCA, SWCD and the FRP for further analysis on the river. A copy of the Performance Indicators Checklist is included in **Appendix D – Performance Indicators Checklist** and is included with the CD that accompanies this report.

Results

The maps and data will be utilized for identifying areas to be remediated, provide additional data to develop a Total Maximum Daily Load (TMDL) and as a set of baseline water quality/quantity parameters to evaluate various land use decisions made in the watershed. Having preliminary discharge data will provide information for calculating the number of tons of sediment being delivered to Lake Superior and can be used for scientific as well as educational

outreach endeavors. The FRP, MPCA, SWCD, DNR and other agencies will benefit by having this baseline information. In addition, MPCA staff completed an exercise utilizing a software program entitled River Morph. This information could be expanded and used to understand the geomorphology of the river. This work illustrates a steady progression in evaluating the impairments to this river, primarily driven by landowner involvement with agency funding, and should position the FRP for future restoration and protection opportunities. Watershed management is a long term endeavor, but information on the hydrology of this river and the increased turbidity will hopefully result in wise land use decisions including protecting sensitive areas of the river corridor through conservation easements and other Low Impact Development (LID) scenarios. This project provided the financial resources for the FRP to hire personnel and have access to the equipment to evaluate this river.

Partnerships

The FRP continues to collaborate with many private and public agencies in an effort to protect the river. In addition to the volunteers that made this project possible, a handful of vital relationships are summarized below:

MPCA –Provided equipment (YSI meter and survey equipment) to complete the project.
Stark Enterprises, LLC – Provided expertise and oversight for data collection and analysis.
NRRI – Provided ArcHydro GIS layers.
UMD GIS Lab – Assisted with GIS data compilation and printing services.
MN DOT – Provided Hydraulics reports and approved permitting.
CC SWCD – Wrote and is executing a driveway and culvert analysis.
SLC SWCD – Provided engineering expertise and analysis of flow information.
Cook County Commissioners – Supported this and the GLRI funding applications.

Leveraged Dollars

This project added additional data to the MPCA's analysis of the river through the SWAG program. The SWAG project budget was $18,978. The project also utilized data that was produced by state agencies and NRRI. The amount spent to produce this data is unknown.

Conclusions

Lessons learned from this project included evaluating the seasonal timing of the grant with what can be reasonably completed on the ground. Problems occurred with the dry season and a few monitoring locations were dry during sampling events, so starting earlier in the year would have been helpful. Preliminary field assessment should occur prior to the grant application with more accurate cost estimates for equipment. Additional resources should have been included for engineering services.

The data produced by this project and the time the volunteers spent in the watershed helped identify and reinforce the needs for remediation and stabilization of bridges and culverts. This information was used in the GLRI application and continues to call on a river erosion survey completed by DNR in 2001.

Future Plans

The Flute Reed Partnership is currently partnering with the Cook County Soil and Water Conservation District (SWCD) through the MLSCP to evaluate driveways and culverts in the watershed and has applied for a Great Lakes Restoration Initiative (GLRI) project to remediate an existing bridge, replace undersized culverts and stabilize failing river banks. The Partnership is involved in a current grant with the Minnesota Land Trust to evaluate potential areas for conservation easements along the river and this spring the will continue their tree planting efforts in the watershed.

Public Relations

The Flute Reed Partnership is one of the first citizen driven watershed groups on the North Shore of Lake Superior. The group has engaged citizens in understanding the land use changes that impact water quality. Watershed groups partnering with agencies and individuals with technical knowledge increases the amount of work completed by all and an informed group of stewards for the watershed. The Cook County commissioners are working cooperatively with the group and realize that this private/public/non-profit model is yielding good results.

Appendices - Deliverables

Appendix A - Water Quality Data
-YSI Data

Appendix B – Water Quantity Data
-Staff Gauge Documentation
-Survey Data
-Manning's Equation Spreadsheet
-Preliminary Stage Discharge Graph

Appendix C – GIS Data
-Base Maps
-Metadata

Appendix D – Performance Indicators Checklist

Appendix A - Water Quality Data

-YSI Data

An electronic copy is included on the CD

	deg C	mg/l	None	mS/cm	<units: required>	<units: required>
Project_Station_ID	Temperature, water	Dissolved oxygen (DO)	pH	Specific conductance	Transparency, tube with disk	Turbidity
Superior Hiking trail	14.30	9.71	7.20	0.052	77.0	5.5
Sam Myers- Trees and Pond	14.39	10.06	7.50	0.053	68.5	6.3
Double Culvert - Just north of north road on camp 20	14.33	9.78	7.55	0.057	56.0	12.6
Ritas - Property due east of Dick Betz	14.25	9.96	7.62	0.066	33.4	21.7
Denny Pechacek - West Bridge on North Road	14.77	9.88	7.73	0.068	35.0	21.0
Middle Bridge on North Road	14.74	9.96	7.68	0.071	43.0	16.8
Superior Hiking trail	17.40	9.35	7.72	0.071	47.5	9.4
Sam Myers- Trees and Pond	16.70	9.74	7.69	0.076	97.0	3.2
Double Culvert - Just north of north road on camp 20	15.90	9.99	7.71	0.083	18.5	33.9
Ritas - Property due east of Dick Betz	16.50	10.10	7.84	0.100	39.5	15.2
Denny Pechacek - West Bridge on North Road	17.10	9.85	7.81	0.100	31.5	18.2
Middle Bridge on North Road	17.00	9.91	7.92	0.105	27.0	22.9
Superior Hiking trail	15.90	9.70	7.58	0.043	37.5	7.3
Sam Myers- Trees and Pond	15.80	9.88	7.42	0.045	24.0	17.7
Double Culvert - Just north of north road on camp 20	16.10	9.92	7.41	0.046	15.5	30.0
Ritas - Property due east of Dick Betz	15.90	10.24	7.53	0.050	15.5	35.2
Denny Pechacek - West Bridge on North Road	16.30	10.11	7.57	0.052	12.5	48.1
Middle Bridge on North Road	16.30	10.26	7.59	0.054	11.0	50.1
Superior Hiking trail	13.93	8.92	7.73	0.112	77.0	8.5
Sam Myers- Trees and Pond	14.58	9.06	7.69	0.109	98.0	4.5
Double Culvert - Just north of north road on camp 20	15.32	8.22	7.59	0.107	28.0	19.7
Ritas - Property due east of Dick Betz	15.15	9.55	7.87	0.142	55.0	10.7
Denny Pechacek - West Bridge on North Road	15.80	9.07	7.79	0.138	25.0	26.6
Middle Bridge on North Road	15.60	9.52	7.92	0.157	37.0	17.0
Superior Hiking trail	15.03	10.37	7.92	0.068	61.0	4.2
Sam Myers- Trees and Pond	14.79	10.44	7.77	0.071	48.0	10.0
Double Culvert - Just north of north road on camp 20	14.70	10.56	7.77	0.072	94.0	2.5
Ritas - Property due east of Dick Betz	14.99	10.63	7.87	0.083	49.0	11.1
Denny Pechacek - West Bridge on North Road	15.24	10.61	7.85	0.083	71.0	6.1
Middle Bridge on North Road	15.36	10.65	7.91	0.087	76.0	6.2
Superior Hiking trail	15.84	9.22	7.79	0.101	78.0	2.6
Sam Myers- Trees and Pond	15.93	9.44	7.83	0.099	74.0	3.3
Double Culvert - Just north of north road on camp 20	15.66	9.43	7.78	0.101	52.0	8.0
Ritas - Property due east of Dick Betz	16.28	9.98	7.92	0.123	69.0	7.3
Denny Pechacek - West Bridge on North Road	17.10	9.78	7.92	0.130	26.0	27.2
Middle Bridge on North Road	16.93	10.01	8.01	0.135	22.0	25.7
Superior Hiking trail	14.39	10.01	7.89	0.081	93.0	2.3
Sam Myers- Trees and Pond	14.35	10.35	7.84	0.084	78.0	5.9
Double Culvert - Just north of north road on camp 20	14.31	10.30	7.79	0.085	88.0	3.5
Ritas - Property due east of Dick Betz	14.25	10.76	7.89	0.096	63.0	8.1
Denny Pechacek - West Bridge on North Road	14.55	10.48	7.85	0.100	67.0	7.8
Middle Bridge on North Road	14.83	10.63	7.91	0.103	62.0	8.3
Superior Hiking trail	16.90	9.42	8.02	0.113	93.0	0.5
Sam Myers- Trees and Pond	17.02	9.58	7.86	0.119	96.0	2.4
Double Culvert - Just north of north road on camp 20	17.58	9.53	7.75	0.119	88.0	2.4
Ritas - Property due east of Dick Betz	17.35	10.05	7.92	0.148	79.0	3.9
Denny Pechacek - West Bridge on North Road	17.81	9.53	7.87	0.158	83.0	2.1
Middle Bridge on North Road	18.04	9.99	7.98	0.169	80.0	1.4
Superior Hiking trail	16.09	9.76	8.30	0.090	95.0	1.3
Sam Myers- Trees and Pond	14.80	9.98	7.97	0.094	77.0	7.2
Double Culvert - Just north of north road on camp 20	15.52	9.73	7.89	0.098	93.0	3.2
Ritas - Property due east of Dick Betz	15.49	9.95	7.96	0.116	68.0	7.7
Denny Pechacek - West Bridge on North Road	15.85	9.98	8.02	0.119	80.0	5.5

Appendix B – Water Quantity Data

-Staff Gauge Documentation

An electronic copy is included on the CD

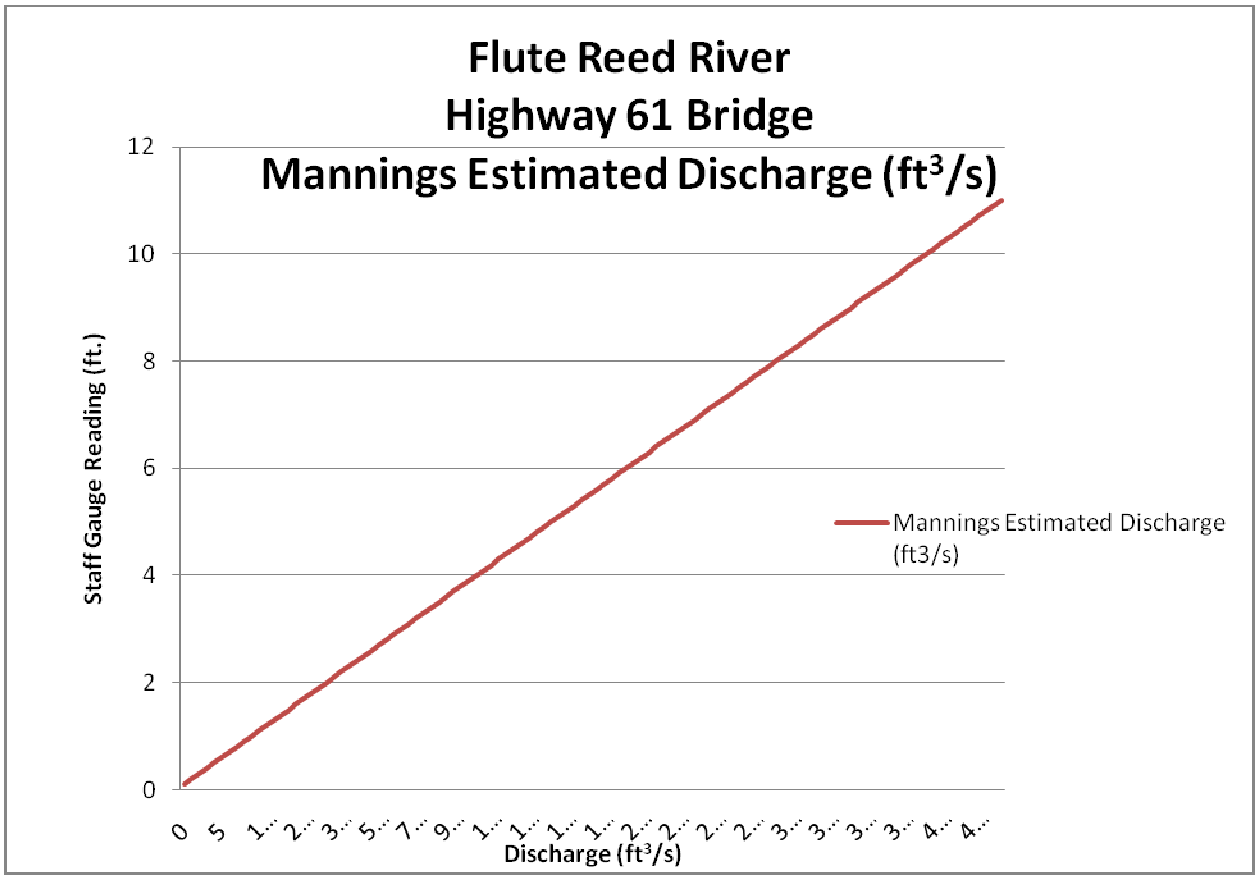
-Survey Data

An electronic copy is included on the CD

Point listing					
Name	Northing	Easting	Elevation	Feature Code	Notes
PT1	1000	1000	5000	CP	(control point)
PT2	933.442	1024.225	4997.587	CP	
1000	1034.632	1005.669	5000.174	bm	(benchmark)
1001	1016.886	1041.204	5002.244	gs	(groundshot)
1002	1031.745	1067.584	5003.64	gs	
1003	972.471	1078.359	5002.72	bm	
1004	986.58	1118.384	5003.189	bm	
1005	957.623	1051.497	5001.518	gs	
PT3	959.491	1095.792	4995.064		
1006	957.852	1051.651	4982.711	XS1RB	(cross-section 1 right bank)
1007	958.805	1054.282	4982.673	XS1	
1008	958.737	1054.599	4981.309	XS1	
1009	959.366	1056.106	4981.272	XS1	
1010	960.283	1056.656	4981.964	XS1	
1011	960.807	1057.848	4981.912	XS1	
1012	961.036	1058.063	4981.236	XS1	
1013	961.802	1059.553	4981.003	XS1	
1014	962.523	1060.895	4980.955	XS1	
1015	963.548	1061.823	4980.876	XS1	
1016	964.503	1063.119	4981.103	XS1	
1017	965.441	1064.17	4980.876	XS1	
1018	966.282	1065.346	4980.82	XS1	
1019	967.167	1066.916	4981.001	XS1	
1020	967.677	1067.892	4981.114	XS1	
1021	967.993	1068.606	4981.465	XS1	
1022	968.621	1069.82	4980.751	XS1	
1023	969.047	1071.058	4980.755	XS1	
1024	969.906	1072.27	4980.805	XS1	
1025	970.615	1073.274	4980.667	XS1	
1026	971.015	1074.111	4980.776	XS1	
1027	971.146	1074.378	4982.168	XS1	
PT	953.187	1053.092	4982.692	CP	
1028	972.765	1076.948	4982.24	XS1LB	(cross-section 1 left bank)
1029	972.912	1076.951	4982.233	XS2LB	(cross-section 2 left bank)
1030	972.553	1074.113	4982.182	XS2	
1031	972.194	1073.944	4981.06	XS2	
1032	971.886	1072.626	4980.709	XS2	
1033	971.681	1071.435	4980.899	XS2	
1034	971.621	1070.035	4980.832	XS2	
1035	971.311	1068.411	4981.118	XS2	
1036	970.921	1067.261	4980.858	XS2	
1037	970.753	1065.674	4981.119	XS2	
1038	970.023	1064.291	4980.847	XS2	
1039	969.59	1063.054	4981.514	XS2	
1040	969.181	1062.18	4980.983	XS2	

-Manning's Equation Spreadsheet
An electronic copy is included on the CD

	V	k_n	n	A	S	P	R	Q
Stage Elevation (ft)	**Cross Sectional Average Velocity (ft/sec)**	**Conversion Constant for U.S. Units**	**Manning Roughness Coefficient (Unitless)**	**Cross Sectional Area of Flow (ft^2)**	**Slope (ft/ft)**	**Wetted Permeter (ft)**	**Hydraulic Radius (ft)**	**Mannings Estimated Discharge (ft^3/s)**
0.1	1.0	1.486	0.05	0.3	0.025138	3.2	0.09375	0.3
0.2	1.5	1.486	0.05	0.6	0.025138	3.4	0.176471	0.9
0.3	1.9	1.486	0.05	0.9	0.025138	3.6	0.25	1.7
0.4	2.2	1.486	0.05	1.2	0.025138	3.8	0.315789	2.6
0.5	2.5	1.486	0.05	1.5	0.025138	4	0.375	3.7
0.6	2.7	1.486	0.05	1.8	0.025138	4.2	0.428571	4.8
0.7	2.9	1.486	0.05	2.1	0.025138	4.4	0.477273	6.0
0.8	3.1	1.486	0.05	2.4	0.025138	4.6	0.521739	7.3
0.9	3.2	1.486	0.05	2.7	0.025138	4.8	0.5625	8.7
1	4.5	1.486	0.05	27	0.025138	29	0.931034	121.3
1.1	4.8	1.486	0.05	29.7	0.025138	29.2	1.017123	141.5
1.2	5.0	1.486	0.05	32.4	0.025138	29.4	1.102041	162.9
1.3	5.3	1.486	0.05	35.1	0.025138	29.6	1.185811	185.3
1.4	5.5	1.486	0.05	37.8	0.025138	29.8	1.268456	208.7
1.5	5.8	1.486	0.05	40.5	0.025138	30	1.35	233.1
1.6	6.0	1.486	0.05	43.2	0.025138	30.2	1.430464	258.4
1.7	6.2	1.486	0.05	45.9	0.025138	30.4	1.509868	284.6
1.8	6.4	1.486	0.05	48.6	0.025138	30.6	1.588235	311.7
1.9	6.6	1.486	0.05	51.3	0.025138	30.8	1.665584	339.6
2	6.8	1.486	0.05	54	0.025138	31	1.741935	368.4
2.1	7.0	1.486	0.05	56.7	0.025138	31.2	1.817308	397.9
2.2	7.2	1.486	0.05	59.4	0.025138	31.4	1.89172	428.1
2.3	7.4	1.486	0.05	62.1	0.025138	31.6	1.96519	459.1
2.4	7.6	1.486	0.05	64.8	0.025138	31.8	2.037736	490.8
2.5	7.7	1.486	0.05	67.5	0.025138	32	2.109375	523.1
2.6	7.9	1.486	0.05	70.2	0.025138	32.2	2.180124	556.1
2.7	8.1	1.486	0.05	72.9	0.025138	32.4	2.25	589.8
2.8	8.3	1.486	0.05	75.6	0.025138	32.6	2.319018	624.1
2.9	8.4	1.486	0.05	78.3	0.025138	32.8	2.387195	659.0
3	8.6	1.486	0.05	81	0.025138	33	2.454545	694.5
3.1	8.7	1.486	0.05	83.7	0.025138	33.2	2.521084	730.5
3.2	8.9	1.486	0.05	86.4	0.025138	33.4	2.586826	767.1
3.3	9.0	1.486	0.05	89.1	0.025138	33.6	2.651786	804.3
3.4	9.2	1.486	0.05	91.8	0.025138	33.8	2.715976	842.0
3.5	9.3	1.486	0.05	94.5	0.025138	34	2.779412	880.2
3.6	9.5	1.486	0.05	97.2	0.025138	34.2	2.842105	918.9
3.7	9.6	1.486	0.05	99.9	0.025138	34.4	2.90407	958.1
3.8	9.7	1.486	0.05	102.6	0.025138	34.6	2.965318	997.8
3.9	9.9	1.486	0.05	105.3	0.025138	34.8	3.025862	1037.9


Flute Reed River
Highway 61 Bridge
Mannings Estimated Discharge (ft3/s)
Staff Gauge Reading (ft.)
12
10
8
6
4
2
0
Discharge (ft3/s)
Mannings Estimated Discharge (ft3/s)

Appendix C – GIS Data
-Base Maps
-Metadata

Appendix D – Performance Indicators Checklist

An electronic copy is included on the CD

MINNESOTA'S LAKE SUPERIOR COASTAL PROGRAM
PERFORMANCE INDICATORS CHECKLIST
Please check all that apply

Grantee: Flute Reed River Watershed Partnership

Project Title: Flute Reed River Water Quality / Quantity Monitoring and GIS Mapping for Problem Reach Identification

Reporting Period: From: June 29, 2009 **To:** December 31, 2009

Government Coordination & Decision-Making			**If Yes, Please fill in below**	
1. Involves Educational Activities	**YES**	**NO**	**Number of Activities**	**Number of Participants**
A. Government Coordination & Decision-Making	☐	☒		
B. Public Access	☐	☒		
C. Coastal Habitat	☐	☒		
D. Water Quality	☒	☐	2	5
E. Coastal Hazards	☐	☒		
F. Coastal Dependent Uses & Community Development	☐	☐		
G. Involves training activities	☒	☐	2	5
H. Involves marine debris stewardship activities	☐	☒		
2. Involves Training Activities	**YES**	**NO**		
A. Government Coordination & Decision-Making	☐	☒		
B. Public Access	☐	☒		
C. Coastal Habitat	☐	☒		
D. Water Quality	☒	☐	2	5
E. Coastal Hazards	☐	☒		
F. Coastal Dependent Uses & Community Development	☐	☒		
Public Access	**YES**	**NO**	**Number of Sites**	
1. Provides a new public access site	☐	☒		
2. Provides an enhanced, existing public access site	☐	☒		
Coastal Habitat	**YES**	**NO**		
1. Involves the protection of coastal habitat acquisition or easement	☐	☒	**Number of Acres**	
A. Wetlands	☐	☒		
B. Beach/Dune	☐	☒		
C. Nearshore Habitat	☐	☒		
D. Other Key Habitat	☐	☒		
Habitat Type:				
2. Involves the restoration of coastal habitat	☐	☒	**Number of Acres**	
A. Wetlands	☐	☒		
B. Beach/Dune	☐	☒		
C. Nearshore Habitat	☐	☒		
D. Other Key Habitat	☐	☒		
Habitat Type:				
	YES	**NO**	**Number of Activities**	**Est. Pounds of Debris**

Water Quality	**YES**	**NO**	**Number of Activities**
1. Involves volunteering monitoring activities	☒	☐	12
2. Involves the development and update of polluted runoff management ordinances, policies, or plans	☒	☐	1-Watershed Plan
3. Involves completed project that implement polluted runoff management plans	☐	☒	
Coastal Hazards	**YES**	**NO**	**Number of Communities**
1. Involves completed projects to reduce future damage from coastal hazards	☐	☒	
2. Involves completed projects or campaigns to increase public awareness of coastal hazards	☐	☒	
Coastal Dependent Uses & Community Development	**YES**	**NO**	**Number of Communities**
1. Involves the development or update of local plans that incorporate sustainable growth coastal management practices	☐	☒	
2. Involves the development or implementation of a waterfront redevelopment policy, ordinance, or plan	☐	☒	
3. Involves a completed a project to implement a port or waterfront redevelopment plan	☐	☒	