Poplar River Water Quality Restoration

Implementation Plan for Turbidity Reduction
Submitted for approval January 2014

Table of Contents

1.0 Executive Summary p.4

2.0 Watershed and Stream Characteristics p.4

3.0 Summary of TMDL p.7
- 3.1 Impairment Status p.7
- 3.2 Pollutant Sources, Stressors, Estimated Reductions p.7

4.0 Best Management Practices to Reduce Sediment p.10
- 4.1 Completed BMPs (Years 1998-2009) p.10
- 4.2 BMPs in Targeted Locations (Years 2010 – 2014) p.13
- 4.3 BMPs Suggested by University WEPP Model Review p.14
- 4.4 Environmental Review BMPs (AUAR Lutsen area) p.15

5.0 Timeline & budget p.16

6.0 Roles and Responsibilities p. 17

7.0 Monitoring Plan p.19

8.0 Information and Education Efforts p.19

9.0 Interim Milestones and Adaptive Management Strategies p.20

10.0 Water Chemistry Sampling Results 2009-2011 p.20

11.0 References p.21

List of Figures and Tables

Figure 1. Poplar River watershed……………………………………… p.6
Figure 2. Sampling Results 2009-2011/pre&post BMPs………. p.21

Table 1a Estimated sediment sources ……………………………… p.8
Table 1b Summary of sediment delivery estimates…………….. p.8
Table 2 Comparison of annual loads……………………………….. p.9
Table 3 Comparison of monthly loads…………………………….. p.9
Table 4 Average monthly load at downstream site…………. p.10
Table 5 Load reductions needed per flow zone………………. p.10
Table 6 Best Management Practices at Targeted sites………. p.13
Table 7 Best Management Practices Budget ……………………. p. 16
Table 8 Timeline and Partner Roles ………………………………. p.17

1.0 Executive Summary

The lower reach of the Poplar River is impaired by suspended sediment such that the 10 NTU turbidity standard for class 2A trout waters is exceeded. Several studies have been completed to ascertain the sources of sediment to the Lower Poplar River and the conditions that generate the sediment. These studies comprise the final Total Maximum Daily Load report scheduled for final completion in 2011. The first of these studies, entitled the "Poplar River Turbidity Assessment" was completed in partnership with the Environmental Protection Agency (EPA). That investigation set the foundation for understanding general sediment sources affecting the lower river and thoroughly reviewed data collected at monitoring stations over several years.

A second study was undertaken by the University of Minnesota to better quantify sediment sources which were more broadly described in the first report. The second study also identified effective BMPs to implement, assessed likely reference stream conditions relative to minimal upland erosion, and evaluated natural rates of erosion over time. Published in 2009, it is titled "Poplar River Sediment Source Assessment, March 30 2010".

The land uses in the lower river reach were analyzed for sediment loading. These uses included forested land, recreation lands like ski runs and ski slopes, roads and ditches, trails, building sites, gullies, ravines and slumps. The second study also evaluated their potential connections to the river in greater detail. Identification and placement of the most effective best management practices (BMPS) to manage sediment were described. For example, this report indicates ski runs have different water infiltration and runoff rates contingent on their construction methods. Some ski runs are graded runs, and some are not. The compaction of grading affects infiltration. Ski slopes that are forested show the greatest infiltration of water into soil.

Placement and design of roads and trails in the watershed is also important. Not all roads/trails deliver the same rate of sediment. Connection of these features is also important. The connections have been described as flow pathways in which roads, ditches, trails, and ski runs all connect together to move water and sediment more rapidly and directly to the river. Slumps and ravines have also been evaluated in much greater detail and defined by total acres or area cross sections.

Landowners and local resource managers have pursued BMPs for sediment mitigation concurrently with the TMDL investigative studies. Nine major BMPs have been completed, with several more identified from recent investigations. Partners are currently pursuing funds to implement these BMPs. This plan documents past BMP work along with current and proposed BMPS, likely budgets, timelines and effectiveness. The plan is intended as a living document, to be reviewed annually.

2.0 Watershed and Stream Characteristics

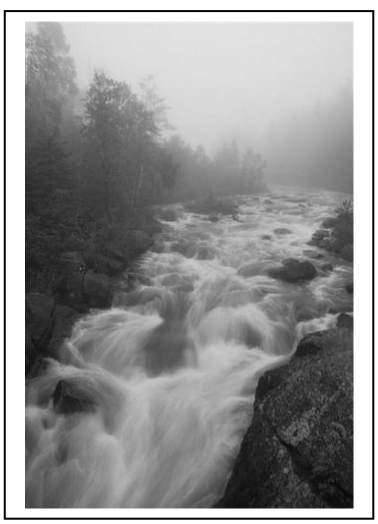
The Poplar River watershed is located in the Lake Superior Basin (northeast Minnesota) near Lutsen, MN (Figure 1). The entire watershed covers an area of approximately 114 square miles with a river distance of approximately 25.5 miles. The Poplar River originates at the Boundary Waters Canoe Area, Hilly Lake area, and ends at its confluence with Lake Superior. Its watershed includes the Tait Lake/Tait River system, Pike Lake, and Caribou Lake (MPCA, 2002).

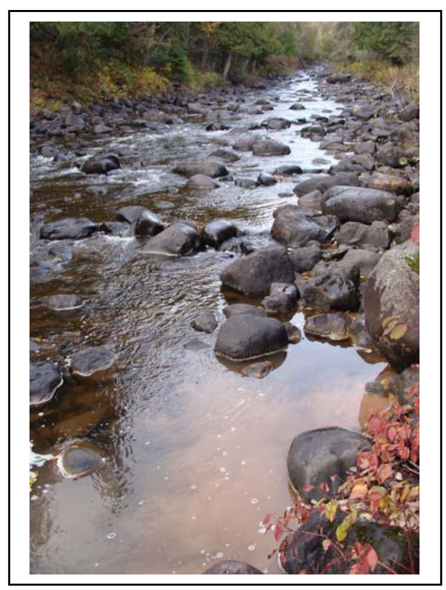
The upper watershed of the Poplar River is located on an elevated plateau. The typical elevation in the upper watershed is about 1,300 feet and the average stream gradient is less than 1 percent. The channel is relatively wide (100 feet or more) and characterized by wide meanders. Dense vegetation consisting of willows, reeds, and other hydrophilic grasses buffer the banks which show little signs of erosion.

Downstream of this headwaters area, the watershed narrows considerably as it flows over the escarpment. An impressive waterfall, approximately 150 feet high, marks the transition from the upper watershed to the lower watershed. In this lower watershed area the gradient increases greatly and the channel is defined by bedrock, lacustrine beach, and glacial deposits. These most downstream portions of the Poplar River and watershed are characterized as having significant drops in elevation with an average gradient of nearly 4% and containing both forested and cleared steep slopes. For the purposes of this report, the "Lower Poplar River" will describe the watershed area downstream of these rapids.

Predominant soil groups in the lower watershed include Dusler-Duluth and Rock outcrop-Quetico-Barto. Predominant land uses include forest (77%), ski runs (14%), golf course area (4.8%), and other developed area (3%). A detailed description of soils, land use/cover, climate, and topography is provided in Section 4 of the GIS based Watershed Erosion Prediction Program (WEPP) modeling report completed for the Total Maximum Daily Load study. The attached report is titled "Additional Characterization and Estimation of Turbidity Impairment".

The Lower Poplar River has more in common with mountain streams than with the typical lowland streams of the Midwest. Like many mountain streams, the Lower Poplar River does not fall into a general category of braided or meandering streams. A sharp change in bed elevation is noticeable near the mouth where a succession of falls is present (upstream and downstream of Highway 61). Upstream from these falls, the average longitudinal slope is approximately 3 percent and the general shape is flat or slightly convex up. Such longitudinal shapes are common in cases of relatively young rivers developed in glacial valley.





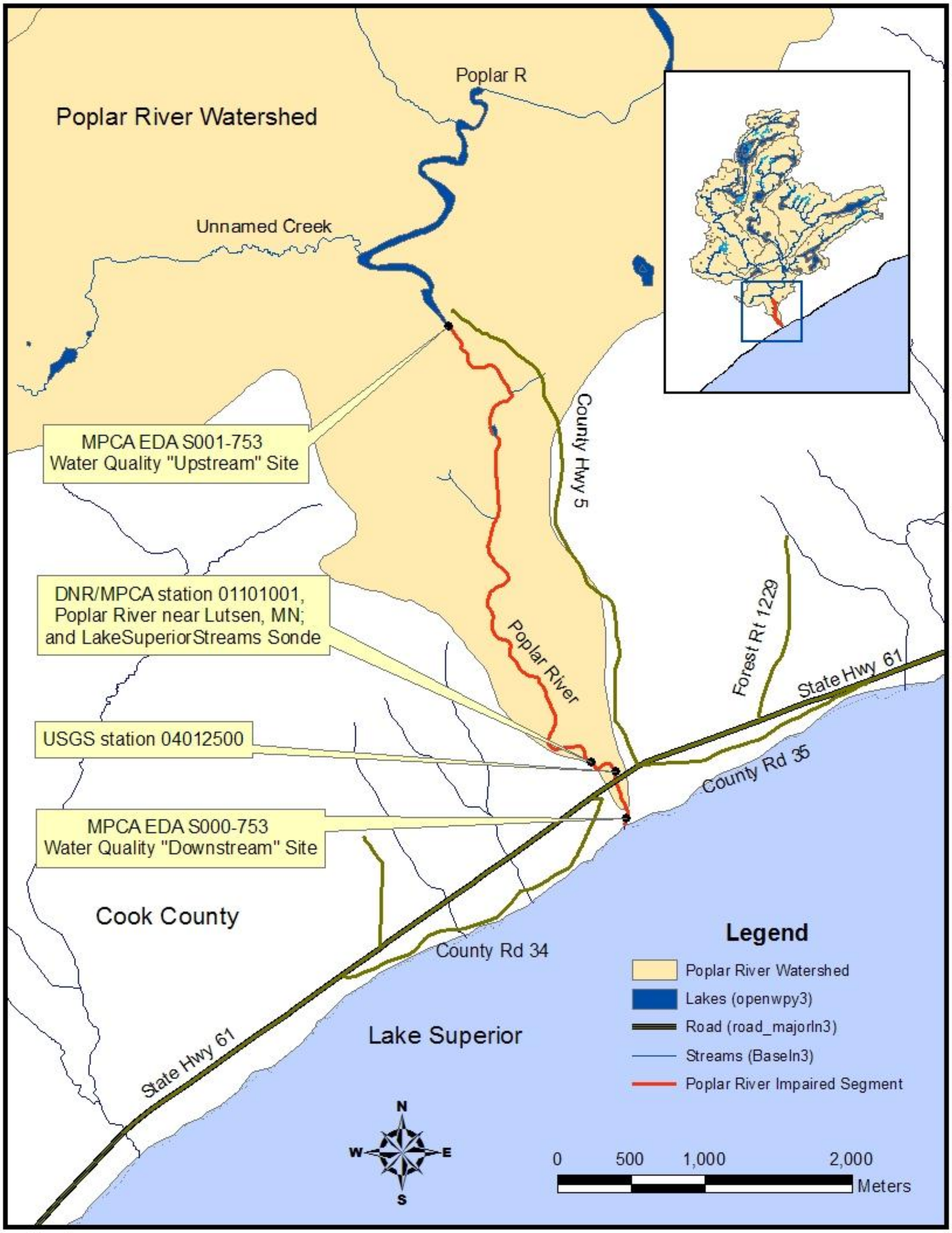


Figure 1. Poplar River watershed (red line highlights the lower river reach)

3.0 Summary of Total Maximum Daily Load (TMDL)

3.1 Impairment Status

The Lower Poplar River is listed as impaired due to exceedances of its 10 NTU turbidity standard. Sampling data demonstrate that exceedances occur frequently at flows greater than 68 cubic feet per second (cfs); the 40% highest flow. Turbidity measurements are highly correlated to sediment measurements, indicating that fine sediment fractions are likely the primary cause of turbidity within the Lower Poplar River. A TMDL study was completed and approved in 2012.

3.2 Pollutant Sources and Stressors

Based on the WEPP modeling report completed for the TMDL study, analysis of the Total Suspended Solids (TSS) data collected at the two monitoring stations on the lower Poplar River indicates that:

- 68% to 85% of the TSS load measured near highway 61 (station number S000-261) is originating from the lower Poplar River watershed.
- 51% of the turbidity exceedances (observed turbidity > 10 NTU) occur during the highest 10% of flows (i.e. flows greater than 260 cubic feet per second (CFS).
- 73% of turbidity exceedances occur during the 40% highest flows (i.e. flows greater than 68 CFS).
- 55% of the total sediment load reaches the stream during April and May of each year, indicating that a distinct seasonal trend is present.

The results of the data analyses, described above, suggest that the primary sources contributing to elevated levels of turbidity in the lower Poplar River originate from the lower watershed, are associated with high flow events, and are most prevalent during the spring. Nine distinct sources of sediment have been identified. These sources include:

<u>Upland Sediment Sources</u>

- Surface erosion from slumps
- Incision along valley slopes (erosion gullies and ravines)
- Localized erosion within the river valley related to land-use alteration, such as,
  - Ski Runs (including bare trails and roads)
  - Golf Course areas
  - Developed area
- Natural forested area

- Altered flow pathways (concentrated upland areas linking sediment to channel)

<u>Near Channel Sediment Sources</u>

- Channel bed incision
- Sudden channel migration (e.g., meander cut-off, channel avulsion, etc)
- Streambank erosion, such as the river impinging on a slump

- In-stream embedded sediment

Analysis of these sources indicated that the upland sources are most likely to occur during precipitation events when there is little vegetative cover and/ or when the ground is saturated. Soil particles are detached from the soil matrix and transported to the river via overland flow. Near stream sources likely occur when flow and stage are high and the stream impinges on the barren valley walls aggravating slumping and/ or mass wasting of existing slumps. Table 1a reports estimated average, minimum, and maximum loads from each source as provided in the first review of sediment sources. A second review was completed by University of Minnesota researchers. Their work identified further refinements among ski runs, trails and roads, and interconnecting flow pathways that are sediment contributors. See Table 1b.

Table 1a. Estimated Sediment Sources Contributing to Turbidity in the Lower Poplar River Watershed

	Median Sediment Load		Minimum Sediment Load		Maximum Sediment Load	
Source	Ton/year	%	Ton/year	%	Ton/year	%
Channel Incision	53	3%	18	2%	88	3%
Megaslump	522	26%	307	31%	737	25%
Other Landslides	204	10%	121	12%	287	10%
Golf	15.2	1%	7.6	1%	22.8	1%
Developed	25.2	1%	12.6	1%	37.8	1%
Ski Runs, Trails, and Roads	661	33%	330	33%	991	33%
Forest	280	14%	140	14%	421	14%
Gullies/ Ravines	225	11%	50	5%	400	13%
Total	1985		986		2983	

Table1b. Summary of sediment delivery estimates for various sediment sources in the Lower Poplar River watershed for two studies.

Sediment Source	RTI (tons/ac/yr)	RTI (tons/yr)	UofM (tons/ac/yr)	UofM (tons/yr)
Developed	0.8	25	0[&]	0[&]
Forest	0.32	280	0.006[&]	5[&]
Golf	0.25	15	0.07[&]	6[&]
Ski	4.03	661	0.98 – 3.93[&]	143 - 575[&]
Roads	--	--	0.72[**]	35[**]
Ravines	--	225[##]	--	243[##]
Slumps, overland flow erosion	--	48[&&&]	61.7[&&&&]	284[&&&&]
Slumps, mass wasting		726[&&]	27.7[###]	188[###]
Channel incision	--	53	0	0
Upland channels	--	--	--	312[&]
Total	N/A	1,985[%]	N/A	938 – 1,370

[&]Estimated with WEPP watershed model (version 2010)

&& Estimated using photos and field observations
&&&Estimated using WEPP hillslope model (version 2006.5)
&&&&Estimated with WEPP hillslope model (version 2010)
**Estimated with Rosgen (2007) roads model
Prior to ravine erosion control work.
###Estimated from the empirical model of Sekely et al. (2002)
%Median estimated total; the range was 986 – 2,983 tons/yr
RTI upland sources estimated with WEPP watershed model (version 2006.5)

Estimated Sediment Load Capacities and Reductions

The following tables show total tons per year of sediment load at each sampling station on the lower Poplar River for the most recent five years of intensive sampling. The range varies from roughly 1000 tons to near 3000 tons per year depending on the snow and rainfall events for that year. The tables also indicate a seasonal loading influence with the majority of loading events occurring in the April-June timeframe. Additionally, a 30 year range of load calculations was estimated and the numbers show a similar seasonal influence with slightly higher loads overall than the smaller 5 year data set. The 30 year data set indicates April and May are the months with greatest seasonal related load. Total load during the spring may range from 900-1200 tons from these estimates.

Table 2. Comparison of annual loads at both sampling stations.

Year	Downstream (Station S000-261)	Upstream (Station S001-753)	Load (tons/year) from lower Poplar River Watershed	Percent of load at S000-261 attributable to lower Poplar River Watershed
2001	3250	1055	2194	68%
2002	1162	169	994	85%
2003	1377	282	1095	80%
2004	1831	474	1358	74%
2005	1592	465	1127	71%

Table 3. Comparison of estimated average monthly loads at the upstream and downstream stations for the 2001 – 2005.

Month	S000-261	S001-753	Load (tons/year) from lower Poplar River Watershed	Percent of load at S000-261 attributable to lower Poplar River Watershed
Jan	6.0	6	0	3%
Feb	5	5	0	3%
Mar	6	6	0	3%
Apr	568	195	373	66%
May	511	159	351	69%
Jun	309	48	261	84%
Jul	141	17	124	88%
Aug	96	11	85	89%
Sep	53	6	48	89%
Oct	92	11	82	88%
Nov	11	10	0	3%
Dec	10	10	0	3%

Note: The 3% difference for winter months is based on the flow percentage assumption only. The same concentration is assumed for both sites.

Table 4. **Estimated average monthly load at the downstream station (S001-261) for 1973-2006.**

Month	Load (Tons)
January	7
February	6
March	8
April	469
May	571
June	277
July	189
August	113
September	89
October	122
November	14
December	10

Table 5 provides some information on reductions required under each flow zone based on the Load Duration Curve (LDC) approach. The table provides an estimate of the reductions needed to remove the Poplar River from the MN impaired waters list for turbidity. The numbers are only rough estimates to help in evaluating proposed Best Management Practices and should not be confused with the allocation targets calculated to meet the 10 NTU standard on all days.

Table 5. Load Reductions Needed for Each Flow Zone Based on Load Duration Curve Approach

	Flow Zone				
	High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Flow Interval (CFS)	> 260	260 – 68	68 – 41	41 – 18	< 18
Flow Interval (%)	0 – 10%	10 – 40%	40 – 60%	60 – 90%	90 – 100%
Capacity in lbs/day (tons)	25,297(13)	7,532 (4)	3,281(<2)	1,904	736
Current Load in lbs/day[1] (tons)	240,623(120)	23,853(13)	28,607(14)	1,956	207
Reduction in tons	107	9	12	<1	None

[1] Current Load is equal to the 90th percentile value for each flow zone.

4.0 Best Management Practices to Reduce Sediment

4.1 Completed practices (Years 1998-2009)

Starting in 1998 specific Best Management Practices (BMPs) were put in place to reduce the sediment loading generated from area development. Sediment sources were prioritized based on the loadings, proximity to the river, and estimated cost of BMPs. The following summary is a time line of development within the watershed and a description of major BMP's put in place to counter sediment loading to the river. This time line was provided by Lutsen Mountain Corporation staff.

The development of the ski resort was started in 1945 by Charles Nelson's grandson and son, George Nelson, Sr. and George Nelson, Jr. The ski resort was opened in 1948, with two ski runs available. The resort has experienced much growth since then, currently has 92 runs, and over 1000 acres of ski-able terrain. The first ski slopes were built on Eagle and Ullr mountains. In the early 1970's more ski runs were added to Eagle and Mystery mountains. Moose Mountain ski slopes were built in 1983. The last ski slopes were constructed on Moose Mountain in 2000. Lodging improvements were made in 1982-83 (Caribou Highlands) and 1993-94 (Eagle Ridge and the Mountain Inn).

This development led to increased sediment delivery to the Poplar River. To reduce the sediment impact to the river a number of BMP's were put in place. These include:

1. Staff training
2. Armoring of the Poplar River stream bank
3. The Brule tight line
4. The Eagle Mountain storm water system
5. Elimination of work roads
6. The Poplar River "mega-slump" project
7. Moose/Mystery Mountain stream project
8. The Ullr ditch project
9. North Road improvements

A short description of each activity follows:

1. Staff Training

Awareness of BMPs is an important step for any area that has experienced changes to the natural landscape or that is having erosion or pollution problems. Staff training at the Lutsen Mountain Resort started in 1998, and has included formal and informal training and education on soil disturbing activities and the BMPs that should be implemented around these activities. Two members of the staff (an owner and an employee) have been certified by the University of Minnesota Erosion and Sediment Control Program as inspectors and installers. The rest of the staff has been trained by these two members. As a result of this training, many BMPs have been implemented in the watershed, including silt fences, erosion control blankets, staples, and native seed mixtures. Materials are maintained in inventory, ready for use, and native seed mixtures with deep root structures are used on all steep terrain.

2. Armoring of the Poplar River stream bank

In 1998, the resort noted that a slope was eroding at a bend in the Poplar River. After consulting with the SWCD, it was decided that the bank should be protected by rock, in order to prevent further erosion at the site. Large rocks from nearby the site were used for rip rap in armoring the bank. This solution was successful initially, but recently erosion has been noted at the end of the rip rap, and it is possible that an extension to this rip rap is necessary to redirect the flow and prevent more erosion.

3. Brule tight-line

The Brule tight-line was put into the valley between Ullr and Eagle Mountains in 2005 and 2006 to prevent erosion to the Poplar River riverbank. Before the tight-line was installed, the topography in the area caused the flow to be constricted within a steep valley, and the water was forced to flow into a steep and eroding riverbank. Currently, the tight-line is a pipe that is 36” in diameter that runs from just above the county road to an energy dissipating concrete vault near the bottom of the slope. The vault contains a baffle, which forces the water to be redirected, thus decreasing its velocity. The tight-line collects surface water just above the county road and delivers it to this vault. After the water has gone through the vault, it is free to flow into the river through a single pipe and over a large rock apron. The riverbank located at the outlet of the pipe is protected by rip rap. Parallel to the tightline is another pipe which collects water below the county road by implementing water bars every 100’. Each water bar directs water to drop inlets which are all connected to a secondary pipe. The water from this pipe also flows into the vault and is released into the river in the same manner as that from the tight-line.

4. Eagle Mountain storm-water system

The Eagle Mountain storm-water system was implemented in 2006, and was completed in 2007. This project was implemented to protect the same riverbank mentioned in the Brule tight-line project, as well as some of the lower ski runs. This storm-water system cuts across the lower third of Eagle Mountain, running southeasterly from the tight-line inlet location. The system is composed of a series of rock lined ditches and drop inlets to pipes, which allow larger flows to be shunted from the ditches. The system discharges near the river into a stormwater settling pond, then discharges via a rock weir into a short ditch. The water from the system then follows an old river channel, which directs it into the current river channel. According to the resort owner, this project has decreased slumping significantly.

5. Elimination of work roads

A new vehicle routing system has been implemented to minimize the amount of work roads and traffic necessary for maintenance. According to the owner of the resort, approximately 50% of the roads existing before 2007 have been eliminated. The roads no longer in service have been re-vegetated. Also, several changes have been made to the roads being used, including enhanced storm water handling and treatment facilities. Staff has been trained to use only prescribed routes and keep vehicles off vegetated areas as much as possible. No “ATV/4wheeler” signs have also been purchased and posted on abandoned routes to encourage compliance with the policy.

6. The Poplar River “mega-slump” project

The mega-slump stabilization was the largest project undertaken in the watershed in order to reduce erosion and sediment load into the river. It was completed in 2008. Eight “bendway weirs” were constructed in the stream to move the river energy away from the base of the slump, allowing the slump to naturally stabilize and revegetate. A stone revetment along the toe of the slope was installed behind the weirs to prevent damage to that sensitive area of the slope. The slumping bank was re-vegetated with willow bundles and trees. A diversion swale was installed at the top of the slump to reduce water flows down the denuded slope of the slump and reduce potential erosion from the upper surfaces.

7. Moose/Mystery Mountain Stream Project

A small tributary to the Poplar River runs in the valley between Moose and Mystery Mountains. This tributary crosses a ski trail which contained an old culvert that failed during a five inch rain event on June 5, 2008. Considerable erosion was taking place at the site, aggravated by very fine soil conditions. The proximity of this site to the river made it a high priority project to complete. Following a design prepared by SWCD civil engineer Keith Anderson, the culvert was replaced and set at the original channel elevation. Weirs were added to control the flow.

8. Ullr Ditch Project

A stormwater ditch on mid-Ullr Mountain was repaired with a conventional rock-lined ditch. The original ditch consisted of half-culverts set in the ground which had become undermined and were not functioning properly. The design of this system was prepared by SWCD civil engineer Keith Anderson and work was completed in 2009.

9. North Road Improvements

As part of the improvement of a short section at the end of the North Road (part of CSAH 5), stormwater improvements were installed. This road was very primitive, and existing culverts and ditching were undersized and in poor condition. A design was provided by SE Group which included rock-lined ditches, stormwater holding ponds built into the ditches, and a small 2-bay detention pond. This pond is located at what will become the entrance to the planned Ullr Tightline (see section 4.2). The Ullr ditch project (# 8 above) feeds directly into this section of road.

4.2 Targeted Location BMPs (Years 2010-2014)

Although the BMPs described in 4.1 should help to control erosion within the Poplar River watershed, they do not appear to have fully solved the sediment input problem. The following additional BMPS have been proposed to further address ravine/gully erosion, eroded road conditions and connecting flow pathways along the river banks and sensitive near shore area. See Table 6 for details. Completion of these projects reduces sediment load to the river by an estimated 400 tons per year. This list was provided by the PRMB engineering firm, Golder Associates, and reviewed by SWCD staff, MPCA staff and University researchers. Several of these projects were recently constructed.

Table 6. Best Management Practices at Targeted Locations

Project	Outcomes	Project status	Expected Results
Ullr Tightline	Repair a 10' x 40' x 350' gully	Funded via GLC/ completed 2012	Sediment load reduction expected - 90 tons per year. Will handle 100yr event. Tightline (enclosed pipe) is a permanent solution. Gully repaired, slope stabilized, and vegetation becomes established in and beyond riparian corridor with habitat values. Overland flows managed. Phosphorus load to river and Lake Superior reduced
Caribou Highlands Stormwater Corridor	Storm water flow paths from large resort re-aligned and armored; eroded ski run restored and storm water flows controlled	Funded via GLC/completed 2013.	Sediment load reduction expected - 80 tons per year. Improves riparian corridor with habitat values. Overland flows managed. Phosphorus load to river and Lake Superior reduced
Lower Eagle Mountain Road and Flowpath	Road improvements - surface covered in aggregate material, cross-sections repaired and improved, cut banks repaired and vegetation restored.	Funded via GLC/completed 2013	Sediment load reduction expected- 75 tons per year. Overland flows managed. Improved groundwater recharge. Phosphorus load to river and Lake Superior reduced

Lower Mystery Mountain Flow Path	Flow Path re-alignment and armoring and revegetation of riparian corridor.	Funded via GLC/completed 2013	Load reduction expected - 30 tons per year. River bank restored. Riparian corridor improved with habitat values. Phosphorus load to river and Lake Superior reduced
Sediment Basin/s	Water collection system to control runoff from hillslope areas of Moose Mtn. A sediment basin structure will control runoff and collect sediment	Funded via GLC/Expect completion 2014	Sediment load reduced. Overland flows managed. Improved groundwater recharge. Phosphorus load to river and Lake Superior reduced
Mystery Mountain Road	Road improvements - surface covered in aggregate material, cross-sections repaired and improved, cut banks repaired and vegetation restored.	To be funded at future date	Load reduction expected - 40 tons per year. Overland flows managed. Improved groundwater recharge. Phosphorus load to river and Lake reduced.
Moose Mountain Summit Road	Road improvements - see above.	To be funded at future date	Load reduction expected - 30 tons per year. Overland flows managed. Improved groundwater recharge. Phosphorus load to river and Lake Superior reduced
Eagle North Face Road	Road improvements - see above.	To be funded at future date	Load reduction expected - 20 tons per year. Overland flows managed. Improved groundwater recharge. Reduced phosphorus load
Ullr Road	Road improvements - see above.	To be funded at future date	Load reduction expected - 20 tons per year. Overland flows managed. Improved groundwater recharge. Phosphorus load to river and Lake Superior reduced
Timberwolf Road	Road improvements - see above	To be funded at future date	Load reduction expected - 10 tons per year. Overland flows managed. Improved groundwater recharge. Phosphorus load to river and Lake Superior reduced
Lutsen Resort Trails Project	Pedestrian trail restoration. Eroded sections of trail repaired.	To be funded at future date	Will create safe public access to the river and beach area, and reduce trail erosion. Estimated load reduction is 5 tons per year. Phosphorus load to river and Lake Superior reduced

Table 6 continued.

4.3 BMPs Suggested by University WEPP Model Review

The WEPP model estimates of sheet and rill erosion, and open channel flow erosion in the upland areas, along with estimates of sediment generated from established ravines, roads, and slumps add up to a value similar to estimates based on monitored stream flow and turbidity during the period 2002 to 2005. The study indicates that the primary sources of sediment in the lower Poplar River watershed include sheet and rill erosion from the ski runs, ephemeral upland channel and ravine erosion, and mass wasting from slumps.

Ski slopes are a potentially significant source of sediment in watersheds due to their high slope angle and large length. Modeling indicated sediment could range from 143 to 575 tons per year depending on ski slope management. One method to reduce erosion from the ski slopes is to reduce the effective length of the slopes. As demonstrated by the simulations with the WEPP 2010 model presented in this report, reducing the effective length of a slope dramatically reduces the soil erosion from the slope. Water bars have been constructed into the ski slopes at Lutsen to cause this effect. Locations of these water bars were not mapped during the field study reported by RTI (2008) or by Hansen et al. (2010). To fully account for the cumulative beneficial effect of these water bars on erosion reduction from the ski slopes it will be necessary to map the locations of the water bars. It is recommended that such a map be produced.

A second method for reducing erosion from ski slopes is to manage the vegetation on the slope to promote high biomass production. Increased live standing vegetation, and high cumulative surface residue, has a dramatic effect on the reduction of sediment production from steep and long slopes, as demonstrated by the simulations with the WEPP 2010 model presented in this report. Detailed measurements of vegetation density were not conducted by RTI (2008) or Hansen et al. (2010) although many photographs of the vegetation were acquired. Those photographs illustrated that there is a wide variation in soil cover provided by the standing vegetation and the cumulated residue. To better characterize the spatial distribution of live standing vegetation and residue cover on the ski slopes surveys should be conducted during at least one complete season. Such a survey would provide quantitative information on how the standing vegetation and residue cover vary from the time of snowmelt until first snowfall.

4.4 Lower Poplar River Areawide Environmental Review BMPs

The Poplar River was listed on the MPCA state 303(d) list in May 2004 for exceedances of the Minnesota mercury water quality standard and turbidity standard associated with sediment. Water runoff volumes and runoff rates are increased due to human activity (land use change) in the valley. Increased development, if not properly mitigated, could increase erosion by exposing erodible soils and increasing impervious surfaces (roads, roof tops and parking lots). In 2005, a development review document was prepared to assess the impacts of future projects in the lower Poplar River watershed. A mitigation plan was also developed and approved as a tool for future management.

The Lower Poplar River Areawide Urban Assessment Review (AUAR, an alternative form of EAW) represented potential development scenarios for the 1,317 acres of the Resort Commercial/Residential (RC/R) development zone class. The review and approved mitigation plan will guide development of the 1317 acres. Much of the developable land is already developed or has been approved for development. However, 140 acres of undeveloped land in the watershed was identified by property owners as having potential for future development under RC/R zoning. The AUAR assessed the current environmental setting (the "base case") and superimposed development under these scenarios:

1. The base case, which includes current land uses and approved developments
2. Developable land is limited to land that is not already developed or approved for development. Under this scenario, landowners indicated potential future development plans.
3. All developable land is developed at the reasonable maximum residential density taking into account the area requirements of suitable wastewater systems, the presence of screened slopes, wetlands and required open space under current zoning standards.

4. All developable land is developed at the reasonable maximum commercial density taking into account the same area requirements and natural features as described in the residential scenario.

A "Mitigation Plan" was also developed as part of the AUAR process to reduce the impacts of likely future development. In addition to reinforcing the diligent and consistent use of county permit and ordinance authorities, specific items of the mitigation plan address "enhanced" erosion and sediment control. These include use of "Low Impact Development" practices like narrower roads, narrower and shorter driveways, and roof drainage that is managed by rain gardens and other small on-site devices or vegetation practices. The mitigation plan is a binding document for the new development in the lower watershed and is reviewed and re-authorized at 5 year intervals. Continued adherence to the plan should ensure reduced impacts from upland generated sediment. The document was recently reviewed and re-authorized.

5.0 Budget and Timeline

The estimates for construction work to complete the projects are listed by project in the table below. The estimated costs listed for each project are the "construction only" costs. Additional costs for engineering design and project oversight, along with contract administration of grants by the local government unit are estimated separately. Those salary and miscellaneous costs add approximately 30-50% to the total cost of the projects. Projects with asterisks have been constructed within the last three years.

Table 7. Best Management Practices Budget – Estimates and Actual

Project	Estimated	Actual cost for completed BMPs
1. *Ullr Tightline	$270,000	$193,242
2. *Caribou Highlands Stormwater Corridor	$253,963	$195,471
3. *Lower Eagle Mountain Rd	$50,016	$29,656
4. * Lower Mystery Mountain Flow Path	$15,000	$18,107
5. * Sediment Basins	In development	
5. Mystery Mountain Road	$60,000	
6. Moose Mountain Summit Road	$97,000	
7. Eagle North Face Road	$49,000	
8. Ullr Road	$58,000	
9. Timberwolf Road	$33,000	
10.Lutsen Resort Trail Rehabilitation	$10,000	
11. Ski slope evaluations vegetation/water bars and new installations or repairs	$300,000	
12. Critical areas repairs, slumps/ravines/flowpaths to be evaluated and prioritized	$700,000	
13. Education –contractor training on practices/website video productions, etc.	$5,000	

6.0 Roles and Responsibilities of Partners

Table 8. Timeline and Activities for Ongoing Roles and Responsibilities of Cooperating Partners

Time Period	Objective	Lead	Cooperating Partners	Objective measurements/Outcomes
2010 - 2015 and beyond	BMPs as identified in GLC grant proposal 400+ tons sediment reduced	Area landowners Cook County SWCD	BWSR, MPCA, DNR	5/6 projects completed in 2010-2014. Remaining projects are associated with road/work trail improvements.
2010 and ongoing	Completed BMPs are assessed annually, maintained per schedule	Landowners	SWCD	Annual checklist completed. Repairs completed as needed.
2013 - 2015	Determine key BMPs for best ski slope management. Implement BMPs.	Landowners, associated specialist from University, engineering firms	SWCD, MPCA, DNR,U of MN	Review/evaluate WEPP model report for additional critical sources to target. Evaluate data provided on ski slope vegetation and length of slopes. Prioritize new projects and continue to implement BMPs.
2013-2015	Determine critical area BMPs related to slumps, ravines, and tribs or yet to be identified flow paths.	Landowners, associated specialists, SWCD and engineering partners	SWCD, DNR, U of MN, USFS, MPCA	Assess, review and evaluate critical features for BMP improvements. Prioritize projects by highest value criteria, sediment management, and water quality improvement. Select BMPs to implement.
2010 and ongoing	Erosion/stormwater ordinance enforced	Cook County Zoning	MPCA	100 % Permits issued meet code. 100% Inspection reports complete and in compliance
2010/11 - 2015 (5 year review intervals)	Lutsen AUAR mitigation plan elements enforced for new developments	Cook County Zoning	AUAR committee, landowners	New developments defined by mitigation plan standards/limits. Special strategies are tracked e.g. the number of Low Impact Development practices installed

6.0 Roles and Responsibilities of Partners continued				
2013 and ongoing	Monitoring data collected and evaluated. Biological data collected in 2013/14, stream flow and chemistry ongoing	MPCA, DNR	SWCD, landowners	Stream chemistry, flow, biology, geomorphology collected and assessed via Intensive Water Monitoring protocols. Reports associated with IWM shared with stakeholders for future BMP work discussions. DNR Fisheries data collected at five year intervals. MN DNR Fisheries plan updated.
Ongoing	Landowner education and engagement	PRMB landowner organization, SWCD	SWCD, MPCA, DNR	# of projects completed, PRMB regular meetings well attended, represents broad stakeholder group, SWCD info/planning and outreach efforts include Poplar River, training certifications up-to-date, website updates/tours
2012 - 2014	Re-route of the wastewater lagoon discharge pipe, eliminate the surface erosion on the mega-slump face	PRMB landowner organization, Caribou Highlands Resort	SWCD, MPCA, DNR	Re-route is installed and functional, slump surface is re-vegetated and stable
Ongoing	Upper watershed managed for continued high water quality	Upper watershed landowners, USFS, county offices, lake associations	SWCD, DNR	Periodic water quality monitoring and fisheries reports indicate high quality water. Agency staff share info/data with PRMB, local stakeholders
Ongoing	Annual review of progress	SWCD, PRMB, Cook County Zoning	DNR, MPCA, USFS, Lake associations	Convene organizations and evaluate progress. Review BMPS installed, monitoring report, development permits, all indicators of progress.

7.0 Monitoring Plan

Monitoring will include water quality and flow sampling of the river, fish and invertebrate assessments, and routine inspection of the permanent stormwater best management practices.

A flow monitoring station is managed by the MN Department of Natural Resources and is identified on the map as Station 01101001. Water samples are collected at this site for the MPCA Intensive Watershed Monitoring Program. Under the protocol of that program, approximately 25-30 samples are collected each year across a range of flow and precipitation events. Water quality sampling will also occur periodically at the upstream station to ensure the upper watershed continues to be protected and managed sustainably. Data from samples collected at Station 01101001 is evaluated through the MPCA Watershed Load program and load totals are routinely published on the MPCA website. Wastewater permit data is collected annually and evaluated each year. Lake associations in the upper watershed collect lake specific water quality samples annually. Specialized monitoring projects may include periodic sampling at tributaries.

DNR fisheries sampling is scheduled for years 2012 and 2013 at river miles 0.0, 1.1, 13.5 and 16.2. Following data collection and assessment, the fisheries management plan will be updated and revised. Annual temperature monitoring occurs at river mile 13.5 and occasional monitoring at other sites. Fish population assessment will occur at regular intervals including the anadromous reach, the stream within the development corridor and upper stream reaches. Depending on workload and staffing, assessment occurs every five years and spans two years of consecutive monitoring. Coaster brook trout are surveyed in the anadromous reach at five year intervals. Annual creel surveys are completed in the anadromous reach. For successful completion of this monitoring program, Grand Marais Fisheries management staff estimate a required budget appropriation of $6000 for the current five year period.

MPCA biological monitoring of the river is scheduled for 2013 through the Intensive Watershed Monitoring program. Data collected and evaluated will include extensive game and non-game fish and macroinvertebrates. Stream channel characteristics and embeddedness identified in the 2008 University of Minnesota NRRI biological report will be evaluated. A more thorough habitat evaluation is a future project the area landowners want to engage in upon completion of proposed Best Management Practices.

Current and future stormwater structures and best management practices will be inspected and evaluated during each field season. A standardized checklist will be used to generate a work order of maintenance and/or corrective follow-up actions. See attached list of suggested inspections and reports.

8.0 Information and Education Efforts

Poplar River Management Board (PRMB), which meets bimonthly, is a group that formed in response to the lower Poplar River becoming listed on the MPCA Impaired Rivers List in 2004. The PRMB meetings are open to the public, and regular participants include the principal landowners in the lower Poplar River valley as well as representatives from the MPCA, the Cook County SWCD, the MN DNR, local media personnel, and scientific and engineering experts. These meetings allow for landowner and public education on any upcoming BMP projects, public outreach events, and MPCA monitoring or modeling updates. PRMB is in the process of updating, expanding and publicizing the exiting PRMB website as another educational resource for the public.

The Cook County SWCD also provides website updates regarding BMP projects completed in collaboration with the PRMB. In addition, with local media attending the PRMB meetings, articles in the local newspaper work towards keeping the public informed on Poplar River updates. Poplar River updates are also provided by Cook SWCD staff at the monthly Cook SWCD Board meetings and the monthly Cook County Water Advisory Committee meetings.

9.0 Interim Milestones and Adaptive Management Strategies

Adaptive management is an approach to water quality restoration efforts where BMP implementation efforts are combined with an on-going evaluation of the water quality issues. Effects of implemented BMPs are reflected by adjustments to the resource goals, implementation plan and/or implementation efforts when need ed. Adjustments are made to incorporate the knowledge gained through the combined efforts.

Adaptive management—sometimes referred to as adaptive implementation—is critical when various uncertainties are significant in a watershed (Shabman et al., 2007). This approach is essentially a “learning while doing” approach. It means that uncertainty is not forgotten once implementation begins. Rather, a focus is placed on reducing the uncertainty present through implementation, monitoring and evaluation, research and experimentation. The knowledge gained through these efforts is then focused on reducing the uncertainties in the TMDL, the implementation approaches and/or water uses and criteria. As this work is completed, the TMDL implementation goals, priorities and BMPs will be examined and revised, as needed.

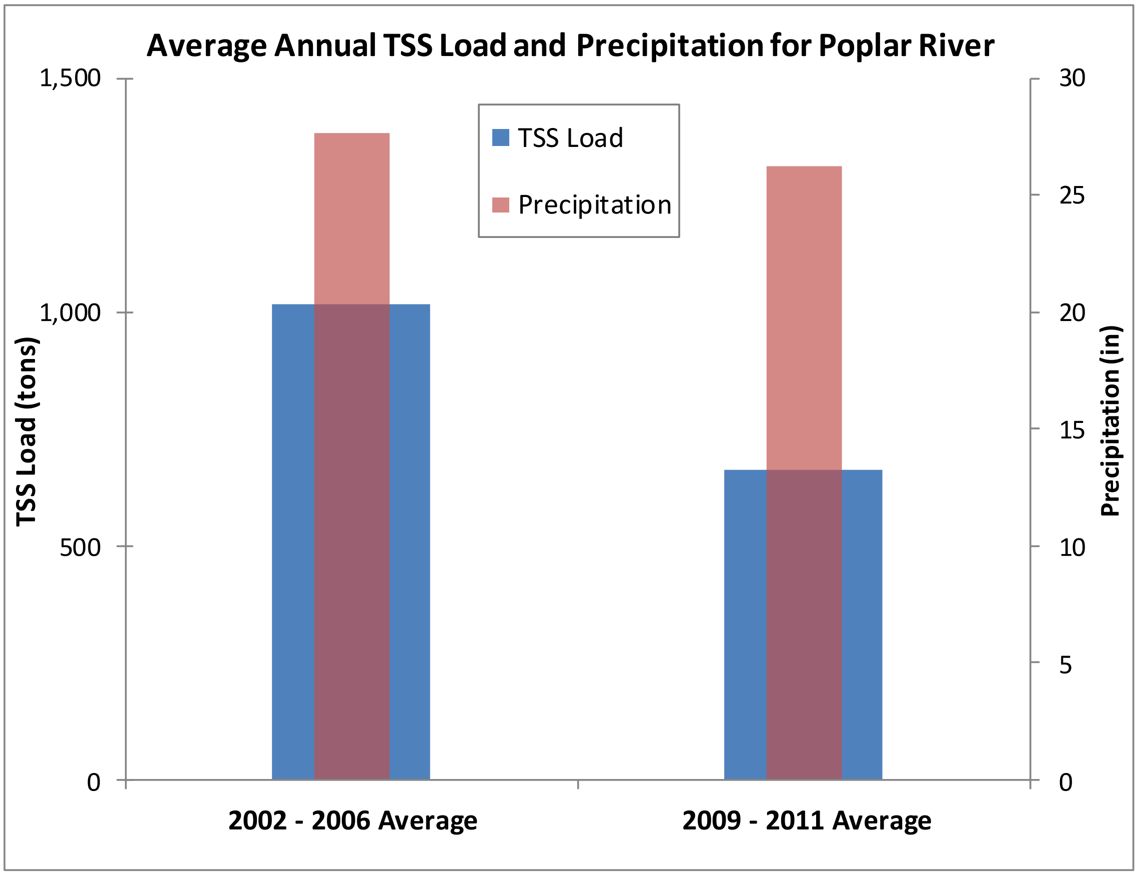
Stream water chemistry data and wastewater monitoring reports are available for review annually. Annual work planning of local oversight boards like SWCD, County Water Advisory Committee, and the Cook County Planning Commission evaluate progress being made in better management of land and water in the watershed. Special management plans like the Areawide Urban Assessment Review process are evaluated every 5 years. The 10 year anniversary of this review process may trigger a complete evaluation of likely development plans and new model runs to assess potential impacts. Lake associations in the upper watershed meet at least annually, and participate in annual water chemistry assessments of their lakes. Some have additional development codes and lake management plans to ensure continued protection of lake health.

10.0 Water Chemistry Sampling Results 2009-2011

The calculated annual total suspended solids (TSS) loads have been lower in recent years than in the first half of the decade. This difference is shown in the attached graph where the average TSS load for the years 2002 through 2006 was about 1,000 tons per year while the average load for the years 2009 through 2011 was about 660 tons per year. This difference suggests that the TSS load has decreased about 35 percent. In contrast, the average annual precipitation for the two periods is fairly similar (26.3 versus 27.7 inches).

This simple comparison suggests that the BMPs implemented since 2006 have resulted in improved water quality conditions in the Poplar River. With the maturing effect of BMPs implemented in 2011 and 2012 along with implementation of additional BMPs currently planned, a continued decrease in sediment loading should be expected.

Figure 2. Sampling results and load comparisons



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