POPLAR RIVER SEDIMENT SOURCE ASSESSMENT

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EXECUTIVE SUMMARY

The main goal of this project was to investigate sediment sources for the Lower Poplar River TMDL in more detail than was possible in previous studies. The work plan's initial objectives were to conduct more field investigations of near channel sediment sources, identify a reference reach for the Poplar River and select key storms for modeling total sediment loading to the river. Because of the high sediment loads generated from ski slopes and the lack of sediment production from the channel, the initial work plan objectives were modified. We enhanced our collection of data relevant to upland erosion processes, identified the location and conducted initial modeling of hydrology altering flow paths and did a review of historical land practices.

A large part of our effort focused on collecting targeted data from ravines and slumps that have proven to be difficult to model. The surface areas of these features were delineated using a combination of GPS, total station surveys and transects. Soil tests and a erosion index were also applied to help verify the soil parameters used in the modeling effort.

Because of the high sediment loads reportedly generated by upland sources additional field data (infiltration and soil shear) were collected on ski hills, roads and forested areas to validate or improve upon the modeling assumptions used in previous reports. Infiltration rates were approximately two times greater in the forested areas than the ski slopes and about 40 times greater than ski slopes that were graded. The soil shear data matched well with the values used in the previous modeling effort done by Research Triangle Institute, RTI in 2008.

To determine a similar reference watershed, the Poplar River watershed characteristics were compared to a number of North Shore streams. The main conclusion from the search for a reference reach was that the Poplar is somewhat unique among North Shore streams of similar size. The best fit reference reach was determined to be the Pigeon River.

Historical records and air photos were analyzed and interviews conducted to determine if there were a connection between the historical activities of logging, road building, dams, and channel alterations to the current sediment impairment. This historical investigation yielded little evidence of past watershed activities impacting current day sediment loads to the river.

A number of flow paths (defined as an alterations of flow direction and intensity) generated by road placement were also identified. The identification of these flow paths allows the model to be adjusted to take into account the altered hydrology. Flow paths in the Poplar watershed are mainly generated by roads cutting across steep slopes. The road cut intercepts both surface and sub-surface flows and reroutes flow down slope via the road ditch instead of the flow continuing to disperse across the hill slope and traveling via a succession of numerous small rills and gullies. These flow paths can concentrate flow and deliver sediment in greater concentrations and more quickly to the river. A first attempt at modeling these flow paths showed they do affect watershed hydrology and

could have a affect on the sediment delivery to the river. A more detailed modeling effort to detail the effects on sediment loading to the river will be investigated in a future study.

The streambanks of the Lower Poplar River are armored with boulders over most of 2.7 miles of river. Along this stretch of river are numerous bluffs and three ravine outlets. Due to the natural bank armor and remediation efforts (bank stabilization) at two of the slumps nearest the river, a relatively high stage is needed to directly erode these sediment sources. A modeling effort generated from cross-sectional and flow data was completed to determine the river stage that would access these sediment sources. Preliminary modeling shows that for a 2- year return period, the streambank contribution to sediment loading would be minimal. This is because the rock that protects the streambed also extends vertically for some distance up the streambanks thus protecting them from smaller storm events. As the river stage increases with larger storm events the sediment load from the banks may increase as the river begins to access some of the less protected higher streambanks and floodplain. However, the contribution still would be relatively small as the banks are well protected with vegetation. A future modeling effort will determine what type event and river stage will start to access some of the less well armored streambanks. Preliminary calculations show that a 100 year event would over top the manmade protection at the base of the mega slump and actively start to erode the base of the slump. This suggests that most of the sediment currently generated from the two protected slumps would be due to rainfall generated over slump flows, freeze-thaw-snowmelt processes, ground water interactions and large mass wasting events.

TABLE OF CONTENTS

LIST OF TABLE AND FIGURES

INTRODUCTION

The Lower Poplar River watershed is a beautiful and unique setting that stands out even against the beauty of the Minnesota North Shore. George Nelson appreciated this unique landscape with its four mountains surrounding the valley over looking Lake Superior and realized the unique opportunity that it presented. In 1948 he started building the ski runs that would be the start of the present day Lutsen Mountain Ski Resort. It has remained one of Minnesota's most popular destinations with its unique blend of recreation and natural beauty.

The development of the Lower Poplar River and the large number of visitors it receives every year eventually took a toll on the water quality of the river resulting in it being placed on Minnesota's impaired waters list for turbidity in 2006. The high turbidity is a result of sediment loading to the Lower Poplar River. For this report the Lower Poplar watershed TMDL is defined as the 2.73 mile reach extending upstream from Lake Superior. The Poplar River TMDL process is designed to identify the contributing sediment sources, determine the sediment loads for each source, allocate a sediment reduction for each source and implement best management practices to reduce the sediment loading to an acceptable level. In short, the TMDL process on the Lower Poplar River seeks to establish a link between the varied landscapes of the watershed and the turbidity in the river.

To meet the goals of the TMDL a number of data collection and modeling efforts have been conducted on the Lower Poplar River. In 2005, North American Wetlands Engineering NAWE and in 2008 Research Triangle Institute (RTI) produced reports that supplied a wealth of information on the large number of variables that affect sediment transport to the river and also total sediment loads from the different landscapes. A sediment source summary generated by these reports is shown in Tables 1 and 2.

Table 1. RTI sediment source summary (2008)

Source	Median Sediment Load		Minimum Sediment Load		Maximum Sediment Load	
	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	1%	8	1%	23	1%
Developed	25	1%	13	1%	38	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	1,985		987		2,984	

Table 2. NAWE WEPP model (2005)

Class	Acres	Ton/year
Ski-Trail - Tall Grass	32.6	12.6
Ski-Trail - Short Grass	28.8	24.6
Bare Soils within slump zones	2.6	30
Roads - Lutsen	6.8	84
Roads - Non Lutsen	0.5	10.1
Forest	183.4	12.7
Natural Openings	5.8	0.5
Golf Course	14.4	5.1
Total	274.9	179.6

The RTI report (2008) concludes that approximately 36% of the sediment load is generated by development in the watershed and the remaining 64% is naturally occurring. The major contributors of sediment associated with watershed development were ski runs, trails and roads at 33% of the total load. The major contributor of sediment associated with naturally occurring landscapes was the mega-slump and other landslides at a combined total of 36%.

The sediment loads generated from the upland landscapes of ski runs, trails, roads, development, forested areas, golf course and rill formation on the slumps were all modeled using WEPP (Watershed Erosion Prediction Project, version 2006.5). The sources that WEPP does not model well include ravines, channel banks, toe erosion of slumps and channel migration. These were modeled using a combination of field data, GIS and air photo interpretation. The assessment of these near channel sediment sources done by RTI was limited due to time and money. The challenges of accurately modeling sediment loads from near channel sediments sources and the limited resources available to the previous contractors to do this work persuaded the TMDL stakeholders and MPCA that more data was necessary to better estimate these sources. The MPCA requested that the U of M perform an analysis to further assess the sources of sediment delivered to the impaired section of the lower Poplar River.

The work plans initial objectives were: to conduct more field investigations of near channel sediment sources, identify a reference reach/watershed for the Poplar and select some storms for modeling total sediment loading to the river. Because of the high sediment loads generated from ski slopes and the lack of sediment production from the channel the initial work plan objectives were modified We refocused some of our effort on collecting more data on upland erosion processes and reduced our effort on selecting storm events for the modeling effort. The objectives of the initial work plan we completed along with the additional work we added are listed below and described in more detail in the following report.

- Identified, mapped and measured near channel sources of streambanks, ravines and slumps;
- Collected additional field data on the upland sediment sources ski hills, roads and forested areas;
- Reviewed historical records, air photos and conducted interviews to see if there is a connection between historical activities and the current sediment impairment exist;
- Identified flow paths on the watershed that alter the natural hydrology and the modeling approach;
- Identified a reference reach by comparing the watershed characteristics of a number of other North Shore streams to the Poplar River;
- Analyzed storm event that would over top the protection of the mega slump.

GENERAL WATERSHED CHARACTERIZATION

WATERSHED DESCRIPTION

The Poplar River watershed is located on the North Shore of Minnesota, within the Lake Superior Basin. Located at a latitude of 47º31'23" north and longitude of 90º42'31" west (USGS), within hydrological unit 04010101, including portions of land in sections 20, 21, 28, 29, and 33 of township 60N Range 3 (NOAA 2008). Figure 1 shows a map of the watershed boundaries which contain approximately 114 square miles (72,964 acres). The total stream length is 134.2 miles which includes the Poplar main stem and tributaries.

Figure 1. Topographic map of the Poplar River watershed. Boundaries of the watershed are outlined in blue

The upper 90% of the watershed is densely forested, predominated by a shallow gradient stream draining many wetlands and lakes. Near Lake Superior the river transitions quickly to a steep gradient channel confined by narrow valley walls. . The boundary of this transition is a foot bridge at the top of a 150 foot waterfall. From this waterfall the river is considered impaired all the way to Lake Superior. It covers a total of 2.73 river miles and a watershed area of 1300 acres. This lower section is predominated by steep valley walls with slopes varying between 10 and 25%. The streambed is composed primarily of rock and boulders and varies considerably in slope with an average of about

4%. There are a number of slumps in this section that are the result of the meandering river running up against the steep valley walls. RTI defined the lower portion of the Poplar River as having many characteristics that make it more similar to mountain streams than to other streams in the Midwest. The U of M survey classified the Lower Poplar River as an A2 stream type (Rosgen,1996) which is described as a steep, entrenched high width to depth stream with cascading step-pool formations. It is entrenched within the valley walls with floodplains present only on sections of the river.
The total road length within the watershed is 87.6 miles, a density of 0.8 miles per square mile. Lutsen is the main population center (pop. 420) located near the confluence of the Poplar River and Lake Superior

DATA SOURCES AND MONITORING

Monitoring within the Poplar River watershed has varied throughout time dating back to 1932. Between 1932 and 1968 streamflow data was recorded as daily flows. In 2002 a gaging station (S004-406) was put into place by the DNR/MPCA. Daily flow data for this site is available from April 15, 2002- to the present. Water quality monitoring for turbidity and total suspended solid began at station S00-261 in 1973 and has been recorded monthly. These historical records were not typically event driven, thus the older records do not accurately characterize the sediment exported from the river. To better understand the sediment discharge relationship in the river the MPCA installed two more monitoring stations. (S001-753, S00-406) in 2002. These two sites were equipped with data SONDES to help define the relationship between stage and turbidity. The locations of the current and past monitoring stations are shown in Figure 2. All data sources included in Table 3, are accessible through the MPCA, USGS and DNR web pages.

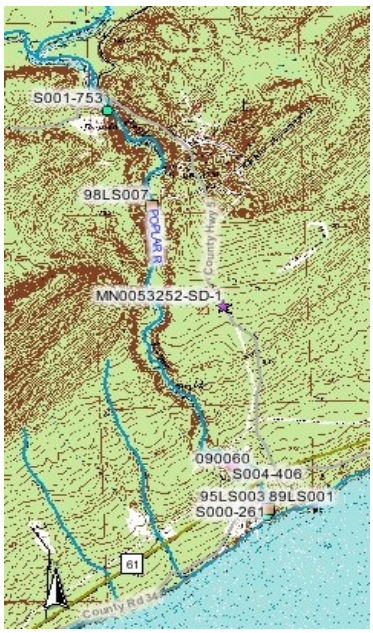


Figure 2 . Monitoring stations along the lower Poplar River (Source: MPCA – Electronic Database - http://www.pca.state.mn.us/data/eda/search.cfm)

Table 3. Poplar River data sources used within this report

Water Quality Data	MPCA – Environmental data Access database (Turbidity, Total Suspended Solids)
	USGS – Historical flow, and stage data
Streamflow Data	USGS- Poplar River at Lutsen, MN gage station (04012500)
	DNR/MPCA – Poplar River near Lutsen, MN station (S004-406)
Soil Survey	MN DNR (Department of Natural Resources) data deli (Cummins and Grigal, 1977), NRCS STATSGO
Model Results	North American Wetland Engineering and SE Group (2005), Environmental Report for Lutsen Mountain, cook County, Minnesota, Report for Lutsen Mountain Resort
	RTI (2008)
Land use	Aerial photos, MN DNR (Department of Natural Resources) Data Deli

MPCA water quality sites (retrieved from MPCA Environmental data access database):

Name of Station	Station ID	Period of Record	Location (Lat/Long)	Water Quality Parameter
Poplar River at Golf Course Bridge in Lutsen, MN	S004-406	2003-2009	47.6402/-90.7107	TSS, Turbidity, Transparency
Poplar River between foot bridges at Lutsen Lodge, Lutsen, MN	S000-261	1973-2009	47.6364/-90.7074	TSS, Turbidity, Transparency
Poplar River on footbridge upstream of Lutsen Ski Hills, Lutsen, MN	S001-753	2001-2007	47.6669/-90.7222	TSS, Turbidity, Transparency
Poplar River 9 miles east of Tofte, MN	90060	1975-1983	47.6397/-90.7086	TSS

Biological Monitoring

In 2008 a MN DNR fisheries report: *Lake Superior Area Status of Coaster Brook Trout in the Minnesota Waters of Lake Superior,* summarized trends on the Poplar River. The highlights of the report are outlined below (data associated to this report can be found in

Appendix E: MN DNR Fish Survey data:). The report maintains that the highest populations of wild brook trout occur in the upper reaches of the river. Below the waterfall, the river supports a spring run of rainbow trout (steel head), fall runs of pink, chinook, and coho salmon, and a fall run of lake-run (coaster) brook trout. The report describes the lower Poplar River (the last 2.7 miles of the river) as an area that is not stocked by the DNR, but may have been privately stocked in years prior. The DNR has minimal sampling within this lower reach (no sampling prior to 1983, with no sampling above the falls prior to 1990), therefore all data is conceived to be in "post-development" where the "lower reach was already disturbed, or impaired". The brook trout population "is small by comparison to population levels farther upstream, and by comparison to other streams in this area". Below the falls summer sampling of juvenile steel head and brook trout are sparse. Lack of spawning habitat within the lower 2.6 miles may limit brook trout and steel head reproduction. Factors such as marginal water temperature, low winter flows, limited area with suitable substrate (coarse gravels) and siltation can greatly affect suitability of habitat. The DNR report suggests the stream bed substrate may have changed significantly from assessments of 1961, 1989 to 1995:

> *"In 1994 and 1995, MNDNR Fisheries crews reported clay and silt sediment knee-deep in places in the pools just above the mouth. Prior to that time the pool areas were relatively clean. In a 1961 survey, that area (Sector I, mouth to the first falls) had a bottom consisting of 67% rubble, 10% boulder, 10% gravel, 10% sand, and 3% silt. Rainbow trout and brown trout were present, and based on visual observation, were described as abundant. In a 1989 DNR Fisheries stream survey, bottom types in the same stretch were reported to have been boulder, rubble, and gravel, with no silt or muck reported."*

CLIMATE

Due to its close proximity to Lake Superior, the Poplar River watershed is greatly affected by the moderating affects of the lake (DNR 2009). This moderating effect results in cooler summers and warmer winter temperatures. Temperatures range from a maximum recorded temperature of 95^{o}F to 40^{o}F below zero. The average temperatures for Lutsen between the years of 1986 and 2006 ranged from 29^{o}F to 46^{o}F. Average annual precipitation at Lutsen is 30.33 inches. During the growing season (May-September) precipitation is 17.48inches and normal summer (June, July, August) precipitation is 10.82 inches.

SOILS

The Poplar River watershed contains many lakes and wetlands in the upper reaches. The soils in the watershed are primarily red lake clay and superior lobe till. Generally soils are highly weathered (over the last 14,000 years), forming as a result of glacial and organic deposits. Soils are poorly drained in depressions and moderately drained on summits and side slopes. Above the 1,000 ft elevation the soils vary considerably in depth from deep to shallow over bedrock and gravelly-loamy glacial till moraines. Below 1,000 ft in elevation, soils are deep to shallow over bedrock and clayey glacial till moraines (DNR 2009).

The Cummins and Grigal (1980) assessment of Minnesota (DNR 2009), describes soils of the Poplar River watershed as primarily forest soils (specified as those with mean temperatures cooler than 47F), and loamy and coarse loamy soils. The upper reaches are comprised of sandy skeletal, and coarse loamy soils. Soils formed in a thin till over bedrock (suborder 322), formed in gray and brown sandy and gravelly sediments, (suborder 323, 330, 331) and mixed sediments from former glaciation (suborder 341) make up the watershed.

GEOLOGY

The geology of the watershed is a product of glaciation. The Great Ice Age formed continental glaciers and subsequent ice streams which eroded underlying rock (DNR 2009). Surface rocks and soils in this area are highly weathered and affected by stream erosion (of glacial and glacial lake deposits). The Superior Lobe moved west-southwestward depositing red clay. The boundary is about three to four miles inland from Lake Superior, crossing the Poplar River at approximately four miles inland from the lake (Grout 1959). The Poplar River (NOAA 2008)) is located on the border of the Rainy Lobe and the Superior Lobe. NOAA additionally reports, the North Shore Volcanic Group underlays the Lutsen area.

LAND USE

NOAA (2008) reported urban land use within the Poplar River watershed totals 3.5%, this watershed has the highest percentage of urban land use of the monitored North Shore trout streams. The watershed contains 134 miles of river, which drains into Lake Superior at Lutsen. There are also 87.6 miles of roads throughout the watershed. The estimated land uses, used by RTI for the watershed are split between forest (77%), wetland (19%), grassland (1%), open water (1%), bare land (1%) and agriculture (1%).

THE U OF M APPROACH

The challenge of using WEPP (version 2006.5) to model a complex watershed such as the Poplar River is accurately capturing the sediment loads generated from near channel sediment sources. Slumps, ravines, streambanks and channels do not model well with WEPP. RTI (2008) did investigate these sources using field measurements, GIS and air photos but did not have sufficient resources to do a comprehensive investigation. The main objective of this project was to gather more information about the near channel sediment sources of streambanks, ravines and slumps in more detail than was possible in previous studies. This additional data will potentially allow the use of smaller models that are specific to individual landscapes. Modeling individual landscapes such as slumps, ravines and streambanks with smaller more specific models would potentially provide a more accurate sediment loading rate. These values could then be incorporated with the broader landscape features that WEPP models well such as ski slopes, the golf course and forested areas to give a total sediment yield for the watershed. Also, because of the potentially high sediment loads generated from ski slopes, additional field data on the upland sediment sources ski hills, roads and forested areas were collected to validate or improve upon the modeling assumptions used in the RTI report (2008).

Increased soil erosion and overbank flooding associated with land use changes following European settlement have proven to be still impacting some watershed today (Magilligan 1985). An additional investigation was completed to determine if historical activities in the watershed, such as logging, could still be impacting present day sediment loading.
An analysis of stream characteristics and water quality was completed to characterize the conditions of the Poplar in reference to other similar North Shore streams.

The following section of the report describes in detail the data and collection methods, sediment sources, historical impacts and some initial analysis of altered hydrology due to roads.

METHODS AND DATA COLLECTION

Each of the nine sediment sources previously listed in Table 1 has unique and different characteristics that influence sediment production. One of the main objectives of this project was to collect field data to improve the modeling effort. On the ground field measurements particular to each sediment source would also allow the use of models developed specifically for a particular sediment source. A variety of different field measurements were used to better define the characteristics of the different sediment sources. The following is a description of the field data collected.

- Area measurements
    - Bluff transects
    - GPS coordinates to delineate areal extent of sediment sources
    - Cross-sections of channels and ravines
    - Slope measurements of ravines and bluffs
    - Sediment source proximity to channel

- Soil tests
    - Particle size
    - Bulk density
    - Hydraulic conductivity
    - Field infiltration
    - Soil shear

- Erosion Measurements
    - Bank Erosion Hazard Index

AREA MEASUREMENT

An accurate description of the surface areas related to erosional surfaces is important to measure sediment loads. To describe the extent or surface area of ravines, slumps, and stream channels a combination of transects, GPS positioning, cross-sectional analysis, slope measurements and approximate source proximity to channel were used. This on the

ground effort was important to map the high variability of these features that are impossible to discern from digital elevation maps.

SOIL TESTS

Particle size, bulk density and hydraulic conductivity tests were conducted in the laboratory from soil samples collected at various sediment sources. They will be used to determine the soil characteristics that are an integral part of most models.

Field infiltration tests were done to improve the runoff calculations of the model. Infiltration rates were determined using a modified Phillip-Dunne (MPD) infiltrometer (Nestigen, 2007) as shown in (Figure 3). The MPD infiltrometer is a falling head technique used to measure the hydraulic properties of the shallow subsurface soil (Philip 1993 Nestigen 2007). The resulting measurements describe hydraulic conductivities of the tested soil layer and capillary pressures at the infiltration wetting front. The instrument consisted of an open ended cylinder constructed out of 2mm thick aluminum pipe with a 10 cm diameter, elbow joint, piezometer tube, and a metric measuring tape to measure hydraulic head.

Figure 3. Measuring infiltration rate using MPD infiltrometer on a ski slope (October 2009)

Soil critical shear stress tests measure the force required to detach soil particles from their undisturbed consolidated condition (Figure 4). These values are useful in determining erosion rates from stream channels, ravines and in this project ski slopes. Soil shear was measured with a Cohesive Strength Meter (CSM). The CSM utilizes a vertical jet of

water to erode the sediment surface within a water-filled 30 mm diameter chamber pushed into the soil surface. The velocity of the jet pulse is increased systematically through time. Bed erosion is inferred from the drop in the transmission of infrared light caused by the suspension of sediment inside the chamber. Variations in transmission are logged and plotted against the increase jet pressure to determine the critical shear stress.

Figure 4. Cohesive strength meter measuring critical shear on a ski slope.

EROSION MEASUREMENTS

Bank Erosion Hazard Index (BEHI) (Rosgen 2006) is an empirical bank erosion model. It takes into account bank geometry and material stability as well as near-bank stresses resulting from flow conditions. BEHI determines annual bank erosion from a single bank using regression relationships from published experimental data sets. The BEHI model was performed on the ravines to provide a measure of bank erosion. This data in combination with a modeling effort will supply the sediment loading to the Poplar River from ravines.

SEDIMENT SOURCES

The RTI group used WEPP (version 2006.5) to generate sediment loads from the various landscapes within the lower Poplar River watershed Table 4. The different landscapes modeled were broken down into two categories upland sediment sources and near channel sediment sources. The WEPP model was used to calculate loads for upland sediment sources. Field measurements and historical air-photos were used to generate estimates for the near channel sediment sources.

Table 4. Sources identified in RTI (2008) report

Sediment Sources
Surface erosion from slumps
(Erosion gullies and ravines)
Ski runs
Golf course
Developed areas
Near channel sediment sources
Channel bed incision
Channel migration
Streambank erosion

To identify sediment sources the U of M team used a combination of field reconnaissance, review of previous reports and interviews with Lutsen ski resort personnel, Cook County SWCD staff, and private residents. Field reconnaissance consisted of visual surveys taken from the roads and walking the ski slopes, the main river channel and forested areas. During this initial investigation each sediment source was identified and GPS coordinates recorded. Utilizing the U of M approach the following nine sediment sources were identified as contributing sediment to the Poplar River (Table 5).

Table 5. Sediment sources identified in U of M investigation

U of M Sediment Sources
Ski slopes
Golf course
Development
Roads
Flow pathways
Slumps
Ravines
Stream channel
Forested areas

The first five sources (ski slopes, golf course, development, roads and flow pathways) arise from anthropogenic introductions into the watershed which have historically proven to increase sediment production over an undeveloped watershed. Slumps, ravines, stream channels and forested areas are naturally occurring sediment sources in an undeveloped watershed, yet the sediment load from each of these sources can be impacted by development in a watershed.

Although our findings are similar to the RTI report some clarification is needed. Roads are not listed in the RTI report as a separate sediment source (Table 4). The sediment load from roads was incorporated into the runoff generated from ski slopes. Additionally, flow pathways are not specific sediment sources but are man made interruptions in the topography that reroute overland flows. These features are too small to be captured on a Digital Elevation Model (DEM). Therefore when modeling occurs, runoff and sediment loads will be calculated based on topographic features of the area and will miss the affect on sediment loading caused by these features. This will result in less accurate interpretations of runoff and the associated sediment delivered to the river.. This issue will be discussed in more detail later in this report.

SKI SLOPES

According to the RTI report 164 acres of ski slopes are present in the lower watershed. Sediment delivery rate was calculated for ski slopes to be 4 tons/acre. Ski slopes reportedly contribute 33% of the total sediment load of the watershed. Forested areas immediately adjacent to the ski slopes having the same slope and soils were reported to produce 0.32 tons/acre or approximately ten times less than the ski slopes. There are several reasons ski slopes produce more sediment per unit area than forested slopes. These include:

- Forested areas intercept and dissipate raindrop energy better than grass;
- Tree roots, organic material and fallen debris in forested areas, reduce runoff energy and promote infiltration;
- Grading of ski slopes exposes less permeable subsurface materials and increase compaction and
- Ski slopes receive an increase volume of water from snow making compared to forested areas. .

Infiltration is an important input into any watershed model because of the significant influence it has on predicting runoff. To better quantify the runoff potential from ski slopes and forested areas thirty-three infiltration tests were completed. The tests were done in pairs with measurements made on the ski slope and in the forested area immediately adjacent to the ski slope runs. Additional infiltration tests were conducted on ski slopes that had been graded. The test results are shown in Figure 5. Infiltration rates were about two times greater in the forested areas versus the ski slopes and about 40 times greater than ski slopes that were graded The much lower value for graded ski slopes is probably due to the exposure of much heavier subgrade soils. The values from all thirty-three tests are found in Table A1, located in the Appendix A. No tests were completed on the areas of the ski slopes that received the fill generated from grading.

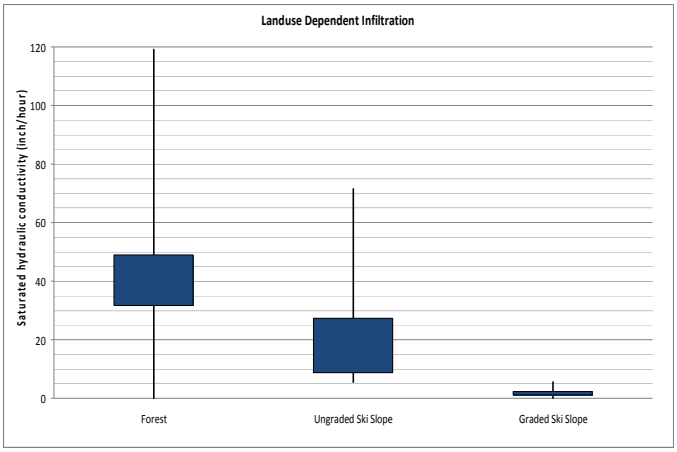


Figure 5. Infiltration rates of forest areas, graded and ungraded ski slopes

Critical shear strength was also measured on three ski slopes (Table 6). The average critical shear value for the three ski slopes was 2.2 N/m^2. This compares well with critical shear value used by RTI of 2.0 N/m^2 as an input for the WEPP modeling of ski slopes.

Table 6. Critical shear strength was also measured on three ski slopes

Site	Type of Site	Individual Test Readings of Shear Strength (N/m^2)	Average Test Readings of Shear Strength (N/m^2)
Lower Bull Run	Ski Run	1.9 2.2 2.1 1.9	2.0
Lower Grizzly Run	Ski Run	2.6 2.4 2.3 1.6 1.8	2.4
Lower Meadows, Moose Mountain	Ski Run	2.7 2.5 2.6 1.8	2.4

GOLF COURSE

The RTI report (2008) listed a sediment delivery rate of 0.25 tons/acres for 61 acres of golf course. This amounts to an annual total of 15 tons which is only 1% of the total sediment transport for the watershed. Because of this small contribution, the ability of the WEPP model to simulate erosion from this landscape and the fact that much of the golf course lies outside of the Poplar River watershed we did not perform any tests on the golf course.

DEVELOPMENT

Development comprises a total of 2.4% of the watershed and 32 total acres (RTI, 2008). The output generated from WEPP used a land use classification of: (developed resort with 50% vegetation). WEPP does not simulate impervious surfaces well. A high shear value with a low infiltration rate was used to simulate an impervious surface. The runoff generated from this surface does contribute to down slope land surfaces. Other than documenting flow paths, this project did not collect any data from developed areas.

The initial ski slopes were built in 1948. Most of the growth of the Lutsen resort took place from 1970 to 2000. This would be the time frame when increased sediment loading due to development most likely occurred. Starting in 1998 specific Best Management Practices (BMPs) were put in place to reduce the sediment loading generated from the development. Following is a time line of development on the watershed and a description of some BMP's put in place to counter some of the sediment loading to the river. This time line was provided by Lutsen Mountain Cooperation.

Development BMP timeline

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 a wealth of growth since this time, and 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 slopes were built on Eagle and Mystery mountains. Moose mountains 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 impact of the resort on the river a number of BMP's were put in place. These include:

- Staff training
- Armoring of the Poplar River stream bank
- The Brule tight line
- The Eagle Mountain storm water system
- Elimination of work roads
- The mega-slump project, the Moose/Mystery Mountain stream project
- The Ullr ditch project
- North road improvements
- The Ullr tight line.

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.

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.

The 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 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.

The riverbank located at the outlet of the pipe is protected by rip rap Parallel to the tight-line is another pipe which collects water below the county road by implementing water bars every 100'. The water from this pipe also flow into the vault and is released into the river in the same manner as that from the tight-line

The 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 short ditch, protected by a rock weir. 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.

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.

The mega-slump project, the Moose/Mystery Mountain stream project
The mega-slump stabilization was the largest project undertaken in the watershed in order to reduce erosion and sediment load into the river.

Although these steps should help to control the erosion within the Poplar River watershed, they do not appear to be solving the problems. One of the goals of the current study is to make recommendations that, along with these steps, will solve the sediment problems within the river.

ROADS

Roads can directly deliver sediment to the Poplar River from the road surfaces, cut banks, ditches and road fills. They also can intercept down slope movement of surface and subsurface flows. The RTI reported that roads made up 0.8% of the land surface in the watershed for a total of 8.8 acres. Because there was no road component in the version of WEPP used by RTI, the surface area of roads was incorporated into the ski run analysis. Roads were reported to make up 5% of the surface area of ski slopes and were modeled as non-vegetated surfaces with different soil parameters than ski slopes. NAWE in 2005 reported a loading rate for roads as 12.4 tons/acre.

An estimate of sediment delivery to the Poplar River from roads within the watershed was completed using a Road Impact Index (RII) (Rosgen 2006) was completed by the U of M. The RII outputs sediment delivery to a stream based on road position in the watershed, acres of roads divided by acres of sub-watershed, and number of road crossings. The results are shown in Table 7.

Table 7. Road impact index (RII)

Position in watershed	Sub-watershed acres	Acres of roads	Number of crossings	Road Impact Index	Tons/ acre	Annual load Tons
Lower	25	2.27	3	0.27	12.6	28.59
Upper	249	15.7	3	0.19	0.42	6.66

The total land surface of roads in the lower watershed was measured as 17.34 acres. This is more than the 8.8 acres report by RTI and the 6.78 acres reported by NAWE. The surface area of the roads used in the calculation of the RII index included the exposed surfaces of the roads plus the ditches and cut banks (Figure 6). Ditches and cut banks are small exposed surfaces that will not be captured by the WEPP model. Incorporating them into the RII index was a way to capture the sediment generated by these features. This could explain the area of roads computed by the RII index being two times greater than reported by RTI. The rate of erosion of 12.6 tons/acre is close to the 12.4 tons/acre-yr report by NAWE. How roads function to intercept and concentrate flow will be discussed in more detail in the section on flow paths.

Figure 6. Shallow ditch and road cut

SLUMPS

Slumps are identified by any exposed, lightly vegetated surfaces that differ from streambanks by extending above the existing high water elevation of the river. They usually occur where the river meanders up against the valley walls. The higher velocities of the outside meanders erode the toe of the valley wall steepening the bank angle which results in mass wasting of the bank materials. Slumps can introduce sediment into the river from bank erosion at the toe, rills and gully formation, overland flow, and mass wasting.

The NOAA 2007 report identified 16 slumped surfaces along the lower section of the Poplar River. The total surface area of the slumps was reported as 2.45 acres, with the mega slump more than half the total at 1.44 acres. RTI reported the slump surface areas as 2.65 acres. The areas where most of the slumps occur are shown in Figure 7.

Figure 7. Slumps (yellow lines) in the Lower Poplar watershed

The U of M team conducted a survey of the slumps in the watershed using a combination of a Trimble model TSCE backpack GPS and a total station. All slumps located in the watershed were outlined with GPS coordinates by walking the perimeter of the slumps. In addition the mega-slump was surveyed with a total station (Figure 8). Seven transects were shot on the mega slump starting at the river and continuing up slope to the top of the slump. The surface area in acres of four slumps surveyed with the GPS over a range of slopes is shown in Table 8. The mega-slump area is not included in Table 8 but is described in the following text.

Table 8. Area of slumps at different slopes.

Bluff	60%	70%	80%	90%
1	1.75	1.84	1.93	2.03
2	0.46	0.48	0.51	0.53
3	0.08	0.09	0.095	0.10
4	0.14	0.15	0.16	0.17
Total all slumps (acres)	**2.45**	**2.56**	**2.69**	**2.83**

Figure 8. Mega-slump

The surface area of the mega-slump was calculated from seven transects shot from the river channel to the top of the slump using a total station in combination with GPS coordinates. The average height of the mega-slump was 83 feet. The average slope was 76%. The surface area was calculated at 2.02 acres. Adding the surface area of the mega slump to the surface area of the other four slumps at an angle of 70% equals a total surface area for all slumps as 4.58 acres. This is 2 acres more than the area used by NAWE and RTI. This difference will factor in the calculation of the sediment load generated from slumps.

The other factor in quantifying slump erosion is the remediation efforts put in place on both the mega-slump and a smaller slump at the base of the ski hill. Stabilization of the toe by placement of large boulders has reduced the effect of toe erosion on these two slumps. Surface erosion and mass wasting are still active on both slumps, particularly the mega- slump where the re-vegetation effort seems to have failed (Figure 9). The effects of the remediation effort will be considered in modeling the erosion from slumps.

Figure 9. Shows sediment deposited down slope, on top of the boulders which were placed to reduce toe erosion. This sediment will be transported down stream during the next high flow event.

RAVINES

Three ravines were identified on the Lower Poplar watershed that could prove difficult to accurately model. They will be identified as Ullr, Ski Hill and Forested ravines. A description of each ravine is given in Table 9 and their locations are noted in Figure 10. Data collection on the ravines consisted of cross-sections, critical shear measurements and particle size analysis.

Table 9. Ravine characteristics

Ravine	Drainage area (acres)	Length (feet)	% Slope	Average cross-section area (ft^2)
Ullr	4.6	380	44	280
Ski Hill	155	200	47	188
Forested	232	3500	10	44

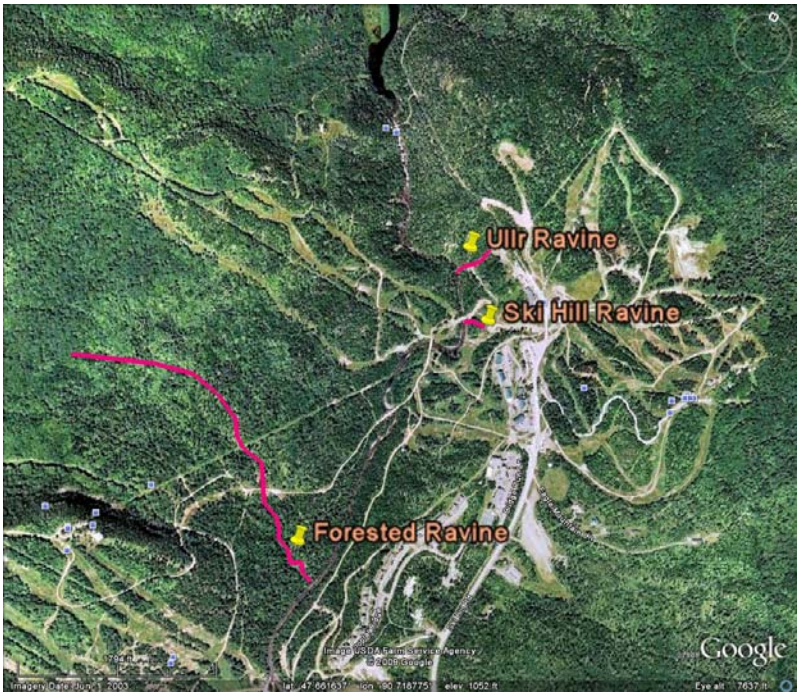


Figure 10. Ravine locations

Both Ullr (Figure 111) and Ski Hill ravines are similar in location on the watershed and their formation. They both have steep slopes top to bottom of 45% to 50% and are connected directly to the river. Both were a result of flow from their upper watersheds concentrating on the near bank steep slopes.

Figure 11. Ullr ravine

Ullr ravine is still active with mostly un-vegetated banks. Its upper watershed is defined as 4.6 acres. However, the actual drainage area is larger than 4.6 acres (See section: *Modeling Flow paths*) because flow rerouted by Ski Hill road and an erosion control ditch also flow into Ullr ravine. The actual drainage area may be closer to 22 acres).

Ski Hill ravine originally had a much larger drainage area of 155 acres than it currently does. The main flow from the sub-watershed now by passes Ski Hill ravine via a tight-line buried below ground. With the reduction in flow the ravine has started to revegetate.

Forested ravine has a drainage area of 232 acres and a length of approximately 3,500 feet. The land use in this sub-watershed is all forested with one main road and a few trails. The main sediment source from this ravine is the channel banks and bed (Figure 12 and 13). The ravine appears to be down cutting into the glacial till with three active head cuts moving upslope in the upper reaches of the watershed.

Figure 12. Forested ravine eroding bank

Figure 13. Forested ravine channel bed

CHANNEL MIGRATION (AIR PHOTO ANALYSIS)

Aerial photos were investigated using photos of the lower Poplar River from, 1969, 1979, 1991, 2003, 2008 and 2009. In addition an 1860 Plat Map was incorporated into general analysis to get a sense of 'pre-settlement' conditions. Each photo was scanned and geoprocessed in order to achieve similar scales. The river was then traced for each photo. Each river line was then overlaid onto the present day map in order to track channel processes such as migration or meander cutoffs. Additional investigations into adjustments of channel width were not completed due to limited time and resource availability.

When analyzing the 1860 Plat Map (Figure 14) with the overlaid present path (blue line indicates 2008 river path), deviations from the former path are found in the northwest (upper left hand corner of map, within Sections 6, 5, 4, 3). Thus indicating the current river has fluctuated greatly from the 1860 survey. Additional major deviations from the 1860 path can be found in Sections 3 and 10, 16, 20, 21, 28 and 33. Without more observations and historical interpretation of the river and climate of the Poplar River, it is impossible to say with certainty what has caused these alterations over a span of 131 years.

Naturally rivers if allowed will meander, resulting in streambank erosion. If the river is in a stable condition the sediment introduced from streambank erosion will closely match that which is redeposited on floodplains and point bars. Most of the channel rerouting observed on the air photo timeline was in the less developed section of the river above the impaired section of the Poplar River. This area has a much lower gradient and wider valley which results in greater meander widths.

The lower Poplar has undergone significant development as compared to historical, 'presettlement' times. These changes in land management and development can affect vegetation type, alter channel routing by introducing new flow pathways, and generates an increase of runoff and sediment from the landscape. Using the aerial photos, Figure 15 describes the Lower Poplar River in its present condition and historically (1969-2008). In 39 years, the record illustrates a relatively stable system, one in which the flow path has for the most part maintained, which could partly be attributed to the considerable armouring of streambanks and channel. If viewed closely, a few "hot spots" do occur in which the present channel shape and location differ from the past. One instance occurs in which the 1969, 1979, and 1991 records do not coincide with the 2003, and 2008 record. Figure 16, and Figure 17, depict locations of the discontinuities in a larger scale.

In conclusion the air photos detail many channel adjustments and land use change or alteration throughout time. Channel migration at times is clearly evident, yet channelization and extreme channel alterations due to land use development were not definitively noted. Some channel discontinuities were found and indicated. Additional air photo analysis is discussed in the sediment source section of this paper, as well as in the Appendix (Appendix C: Aerial Photos).There is less evidence of channel migration and meander cutoffs in this lower section of the river. This is most likely due to the steeper gradient and well armour channel and banks.

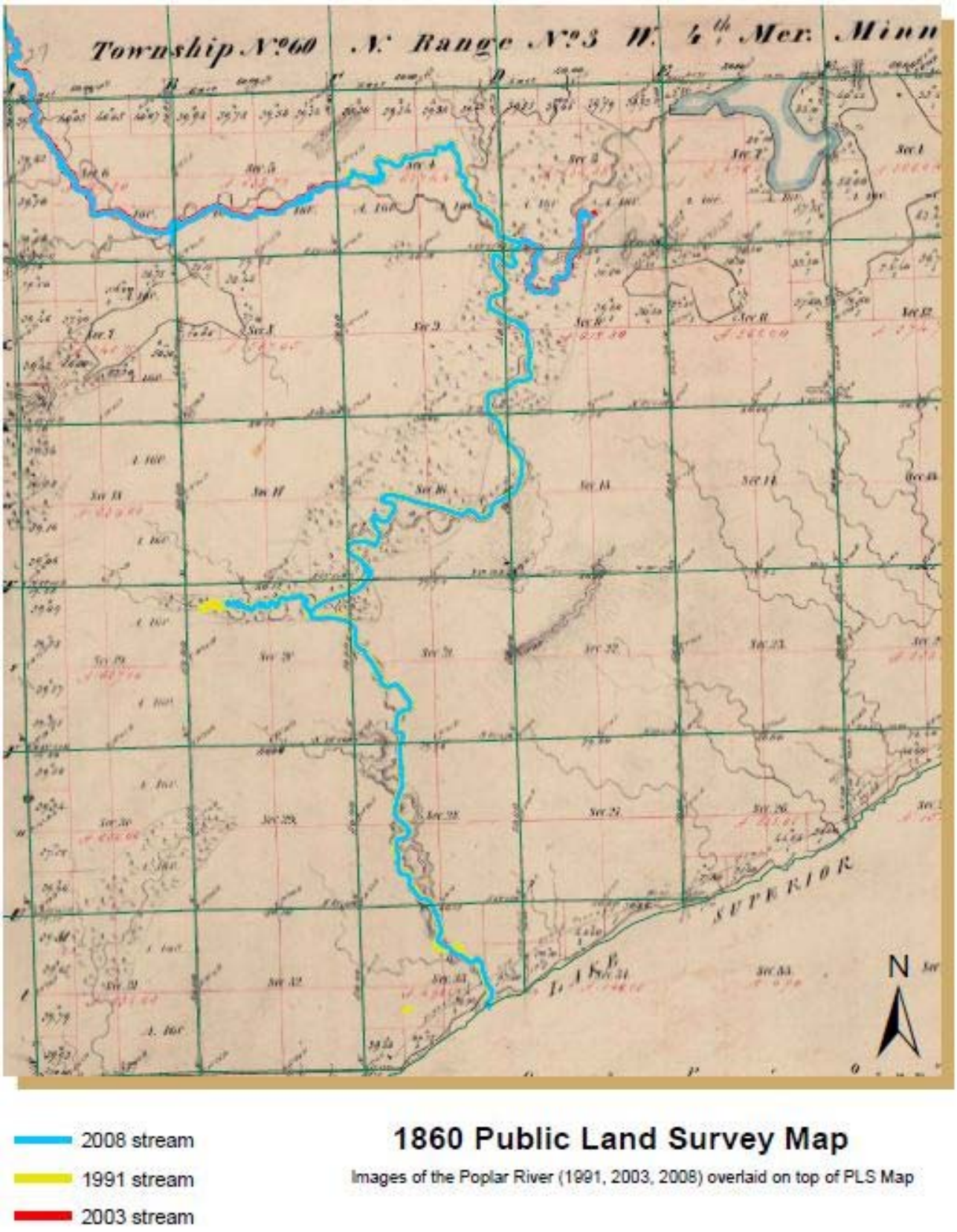


Figure 14. 1860 Plat map of a portion of the Poplar River watershed

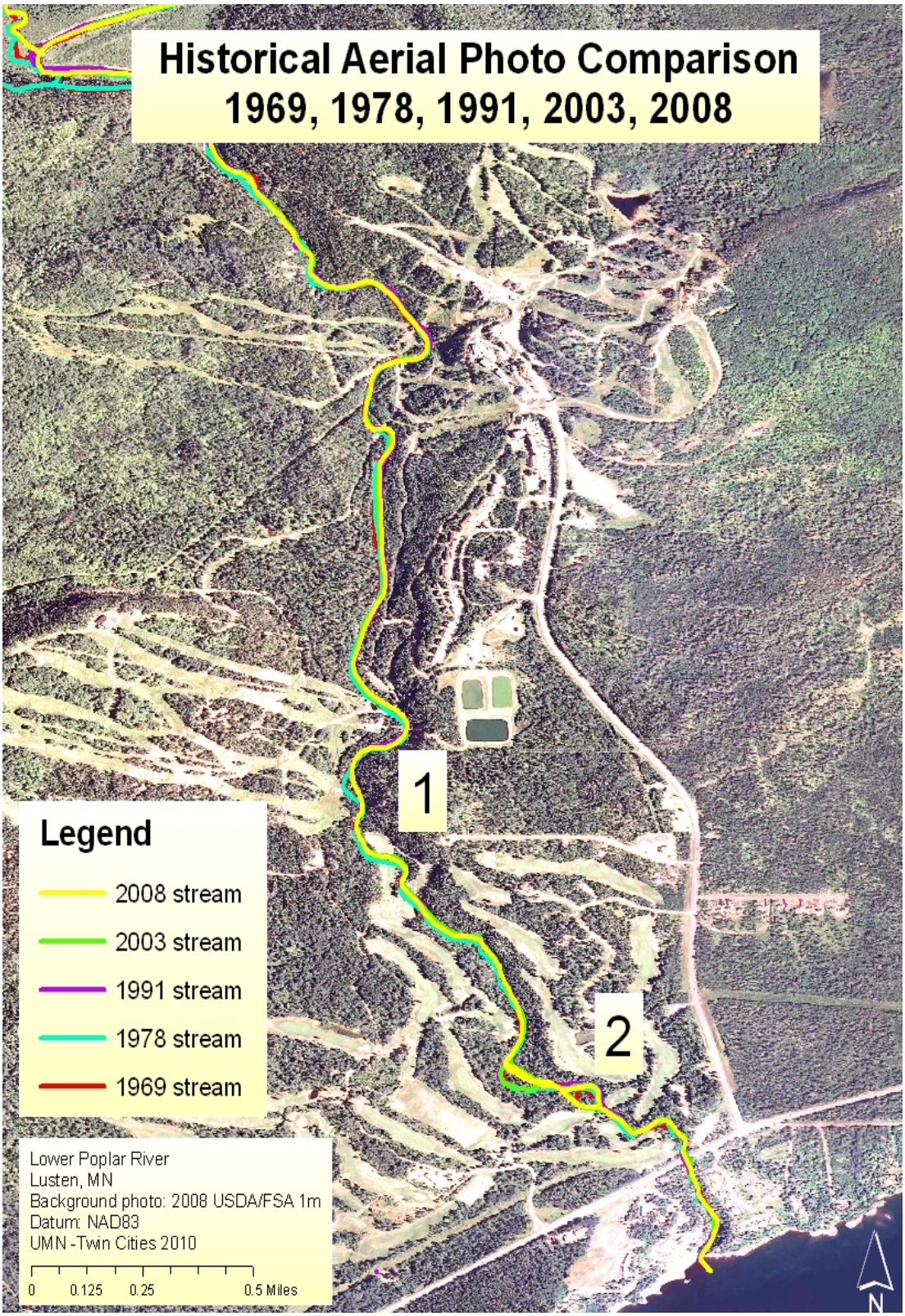


Figure 15. Comparison of Poplar River channel (1969, 1978, 1991, 2003, 2008)

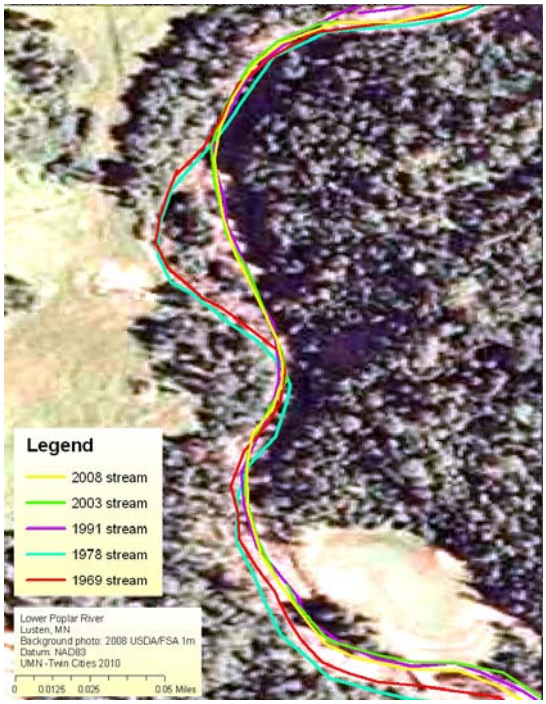


Figure 16. Channel adjustment #1

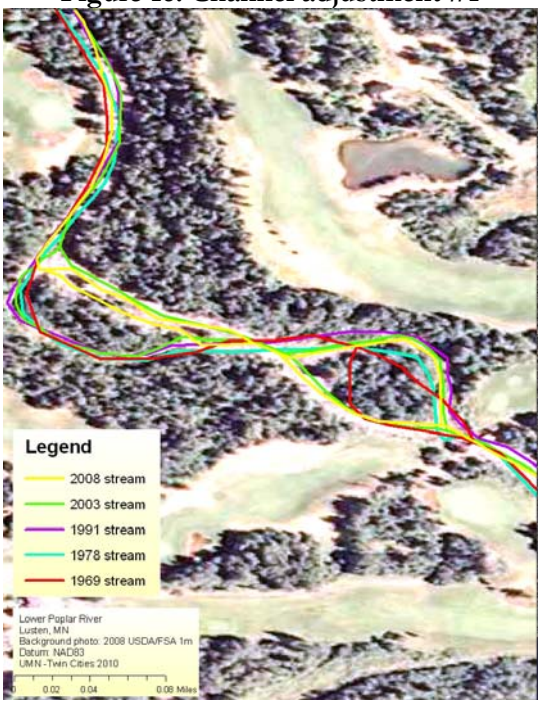


Figure 17. Channel adjustment #2

FLOW PATHS

To get the best output from the modeling effort it is necessary to better understand the effect of flow paths in rerouting runoff. The identification of these flow paths allows the model to be adjusted to take into account the altered hydrology. Flow paths in the Poplar watershed are mainly generated by roads cutting across steep slopes. Roads cutting across slope have a shallow ditch and a road cut on the up hill slope (Figure 18). The road cut intercepts both surface and sub-surface flows and reroutes flow down slope via the road ditch instead of the flow continuing to disperse across the hill slope and traveling downhill via a succession of numerous small rills and gullies. These flow paths can concentrate flow and deliver sediment in greater concentrations and more quickly to the river (Figure 19). The flow paths are capturing water from a number of different landscapes including; roads, ski runs, parking lots and forested slopes.

The topographic detail of the maps used as input for the WEPP model is not detailed enough to pick out theses small changes in topography. The model will assume all flow continues overland down slope in a dispersed fashion. Because of this the effects of these flow paths on the sediment load to the river may have to be modeled separately. The locations of four flow paths are shown in Figure 20. A description of each of the flow paths is given below.

Figure 18. Shallow ditch and road cut running across slope (August 2009)

Figure 19. Runoff generated from flow path from 1 inch snow melt (October 2009)

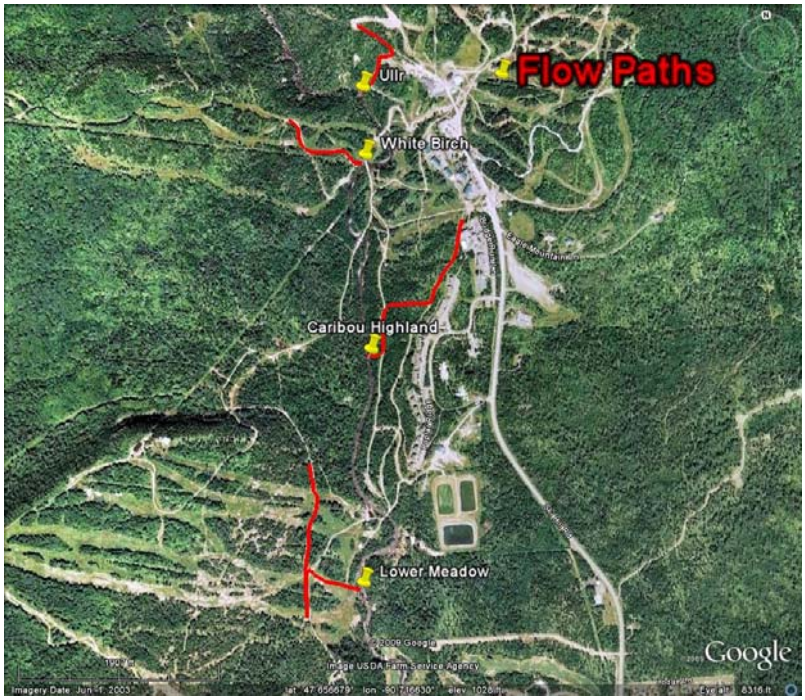


Figure 20. Location of Flow Pathways

Caribou Highlands

Water running down slope off the developed area around Caribou Highlands is intercepted by a service road. The water flows southeast down the road ditch with an exposed upper bank until it passes under the road at a culvert. The outflow end of the culvert is perched six to eight feet above the ground surface (Figure 21). This is causing a scour hole that will eventually threaten the integrity of the road. After leaving the culvert the water down-cuts through an existing forested ravine forming a depositional plume at the base of the slope (Figure 22). At the base of the ravine the water is intercepted by a service road running parallel to the Poplar River. The water flows southeast in this road ditch until it outlets through another culvert directly into the river (Figure 23).

Figure 21. Perched culvert.

Figure 22. Deposition from road cut at base of forested ravine

Figure 23. Culvert flowing directly to river.

Lower Meadow

Water flowing down slope from the area around ski slopes of Moose Crossing, Bob and Cougar is intercepted by a service road running perpendicular to the slopes above. The water flows southeast across slope in an un-vegetated road ditch until it turns east and flows directing down slope over the Lower Meadow ski run. The water has started to cut a two foot deep gully down Lower Meadow (Figure 24). It has cut right through or flowed around the berms.

Figure 24. Gully cutting down Lower Meadow ski run

White Birch

There are two flow paths and one ponded area near the base of Mystery Mountain. One flow path is a road cutting across ski slopes White Birch, Jack Alder and Log Chute. It crosses White Birch ski run, which in the summer serves as a service road, and is starting to cut a gully from the White Birch ski run down a very steep slope directly to the river. The second flow path flows directly down hill on the White Birch service road until it crosses the road at the base of the hill and flows directly into the river (Figure 25). There is also a ponded area that collects runoff water from the Mystery Mountain ski slopes of White Birch, Jack Alder and Log Chute. This pond is shallow and outlets directly into the river when over topped with runoff(Figure 26).

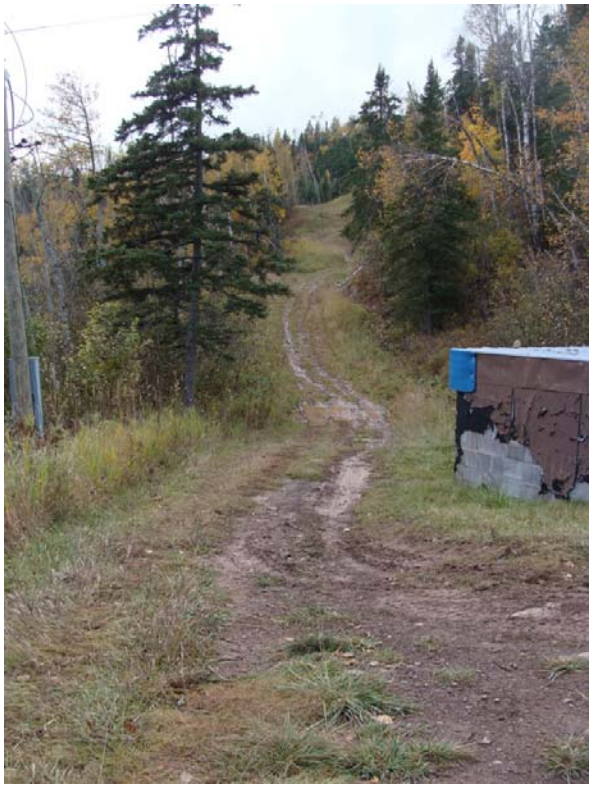


Figure 25. White Birch service road

Figure 26. Ponded area at base of ski slopes with direct access to river

MODELING FLOW PATHS

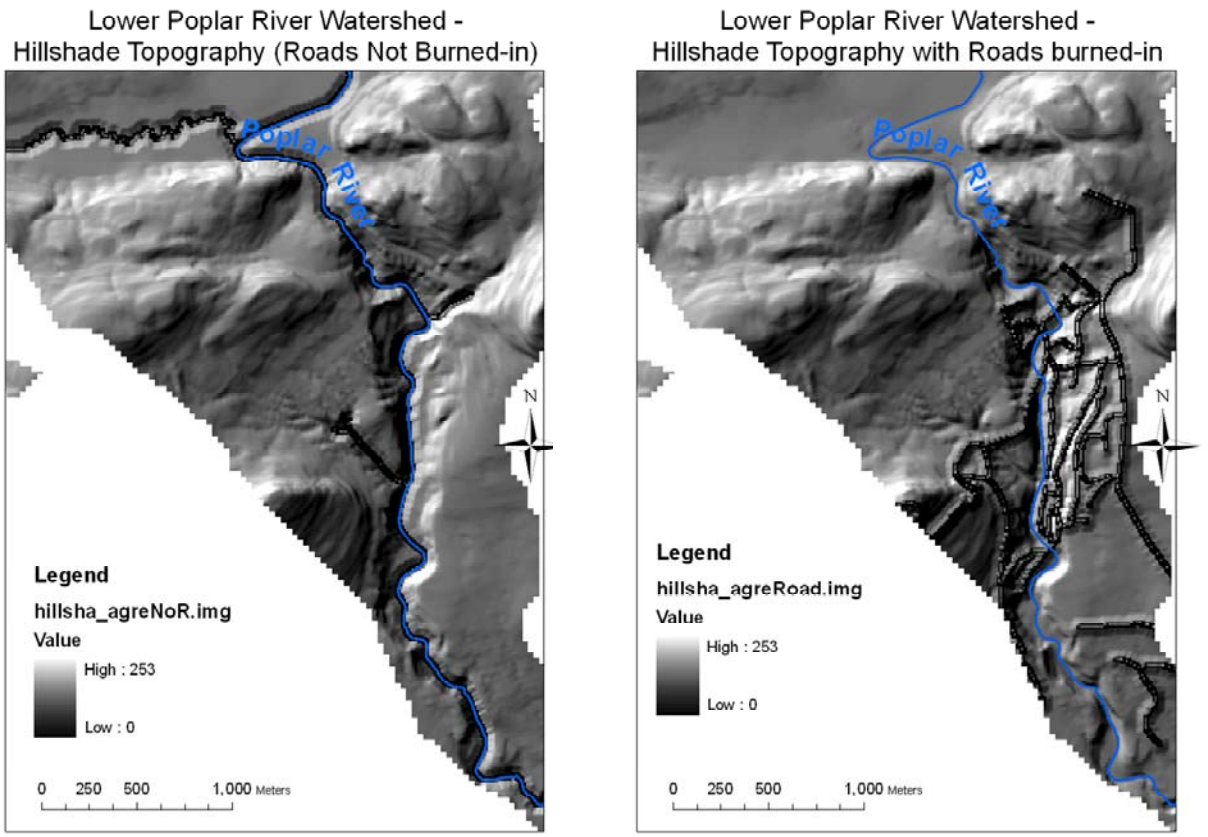
To generate the best output from the modeling effort it is necessary to better understand the effect of flow paths in rerouting runoff. In the Poplar River watershed roads are the main driver for altering natural flow patterns. The effect roads have on the hydrology of the landscape was analyzed using GIS and Arc Hydro tools. The data obtained from this analysis will be applied in modeling sediment yields and deposition in different reaches of the Lower Poplar River. The (WEPP) model will be used in the planned modeling. Archived 10 meter resolution DEM data for the lower Poplar river watershed was downloaded from the "GeoCommunity Data Store" of the United States Geological Survey's (USGS) The data were subjected to a series of analyzes using ArcGIS 9.x and Arc Hydro Tools (v.1.3). Mapped outputs from the processes are presented within this document.

DEM reconditioning

Because presence of roads often alter land topography, it was important to modify the DEM data for the Lower Poplar River watershed to reflect the two situations (with or without modifying effect of roads). The Arc Hydro tools (DEM Reconditioning function) have been applied to modify the DEM data by imposing (burning/fencing) roads onto them. Full detail of this function (an implementation of the AGREE method developed by Ferdi Hellweger at the University of Texas at Austin in 1997) can be referenced at http://www.ce.utexas.edu/prof/maidment/GISHYDRO/ferdi/research/agree/agree.html.

Presence of roads in a region may or may not alter the landscape characteristics of the region. The degree of the impact a given road would have on the prevailing landscape characteristics depends on the nature of its placement. Roads which are constructed on raised foundation would alter the prevailing slope and/or elevation of the land more significantly; than those which are not. Some roads are constructed with frequent surface ditches and multiple culverts aimed at minimizing effect on the land topography and surface hydrology. Roads which cause significant modification to the land surface slope or elevation will impact surface hydrology of the area.

In this analysis, information on location of roads, ditches and culverts within the study area have been collected and incorporated in the DEM reconditioning and other analyzes. Roads with surface ditches which allow surface runoff to cross the structure have been excluded from the reconditioning (assumed absent). Likewise, road sections with culverts installations have the sections at the location of culverts cut out, hence assuming the original land topography. In this analysis, we have assumed that water flow occurs unobstructed by roadway infrastructure at locations with culverts and/or surface ditches. Figure 27 is been presented to demonstrate the resultant differences in terrain morphology following the burning-in (DEM reconditioning) with roads data.



(a) No roads burned-in **(b) With roads burned-in**

Figure 27. Maps of the hill-shade Topography for the Lower Poplar River watershed generated from 10m DEM data with and without burn-in of roads data

Flow direction

The Flow Direction function in the Terrain pre-processing menu of Arc Hydro was used to compute the flow direction grid from the input DEM data. The values in the cells of the flow direction grid indicate the direction of the steepest descent from that cell (lightest to darkest). Figure 28, shows the maps obtained in the analysis.

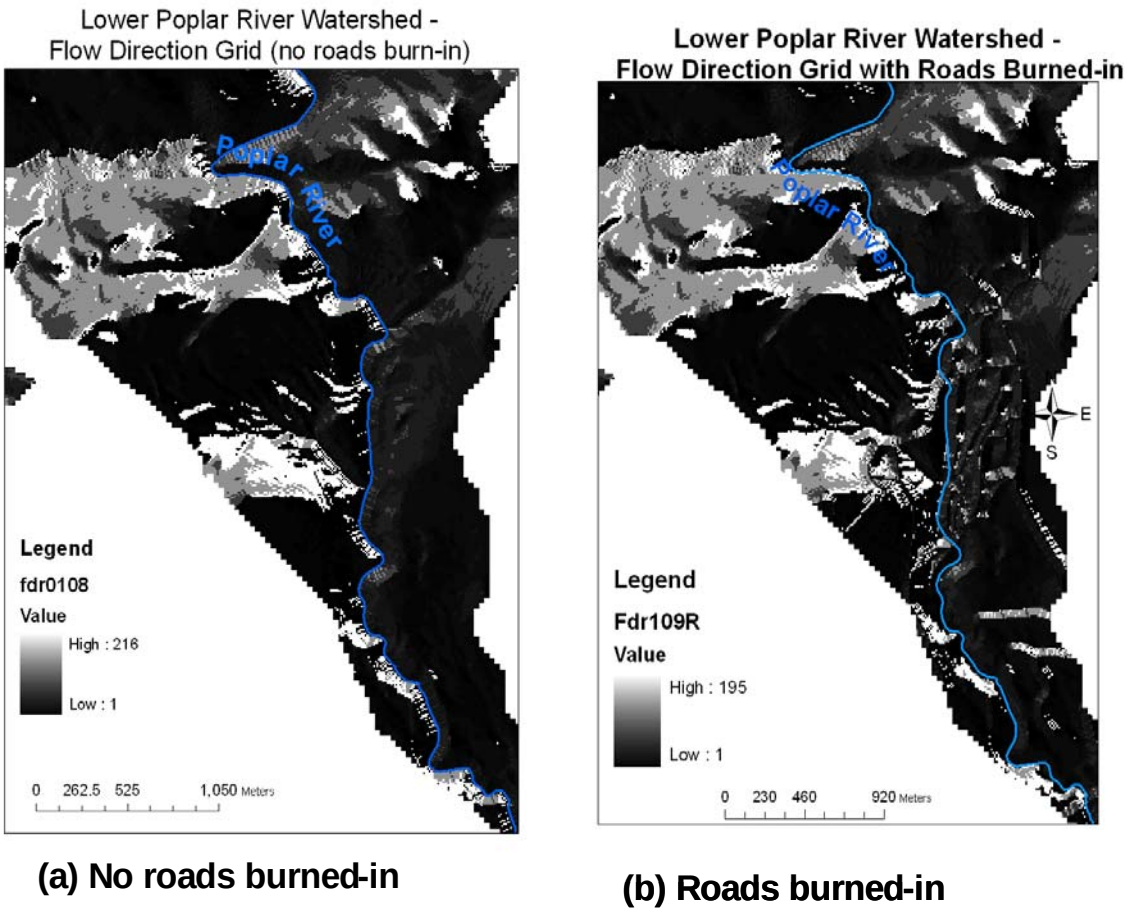
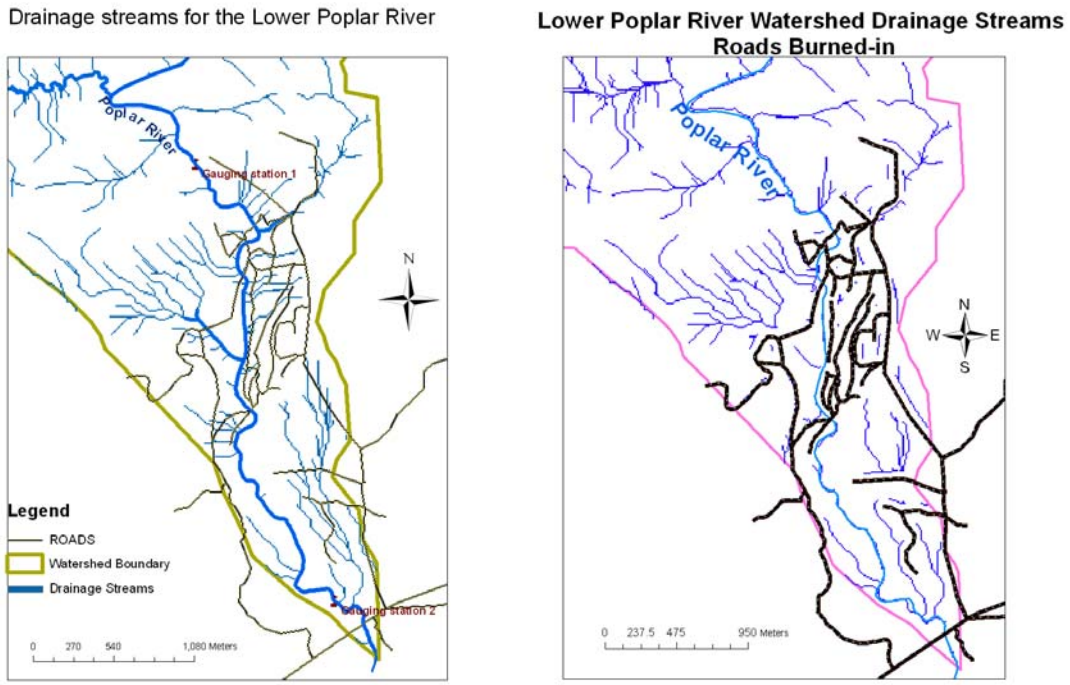


Figure 28. Flow direction grid of the Lower Poplar River watershed generated from 10m DEM data of the area using Arc Hydro Tools 1.30

Stream definition

The Stream definition function in Arc Hyrdo Tools takes a flow accumulation grid as input and creates a Stream for a user-defined threshold. This threshold is defined either as a number of cells (default 1%) or as a drainage area in square kilometers. In this analysis, a threshold of 100 cells (or 0.01 square kilometers) was adopted. The Arc Hydro Tools help specify a general recommended size for stream threshold definition (which in turn defines the sub basin delineation during preprocessing) as 1% of the overall area. For increased performance on large DEMs (over 20,000,000 cells), the threshold may be increased to reduce the stream network and the number of catchment polygons. The stream grid (Figure 29) provides a useful overview of surface flow concentrations and directions at different sections of the watershed.



(a) No roads burned-in **(b) With roads burned-in**

Figure 29. Map showing drainage streams in the Lower Poplar River watershed generated from 10m DEM data of the area using Arc Hydro Tools

Batch sub-watershed delineation

The batch sub-watershed delineation function of Arc Hydro Tools allows delineating sub-watersheds for all specified "pour-in" points. Figure 30, shows the obtained map of sub-watersheds in the lower Poplar River watershed. The indicated numerical labels within sub-watershed are the areas (acres) of each runoff contributing sub-watershed. Figure 31, shows the sub-watersheds of the Poplar River with roads burned in.

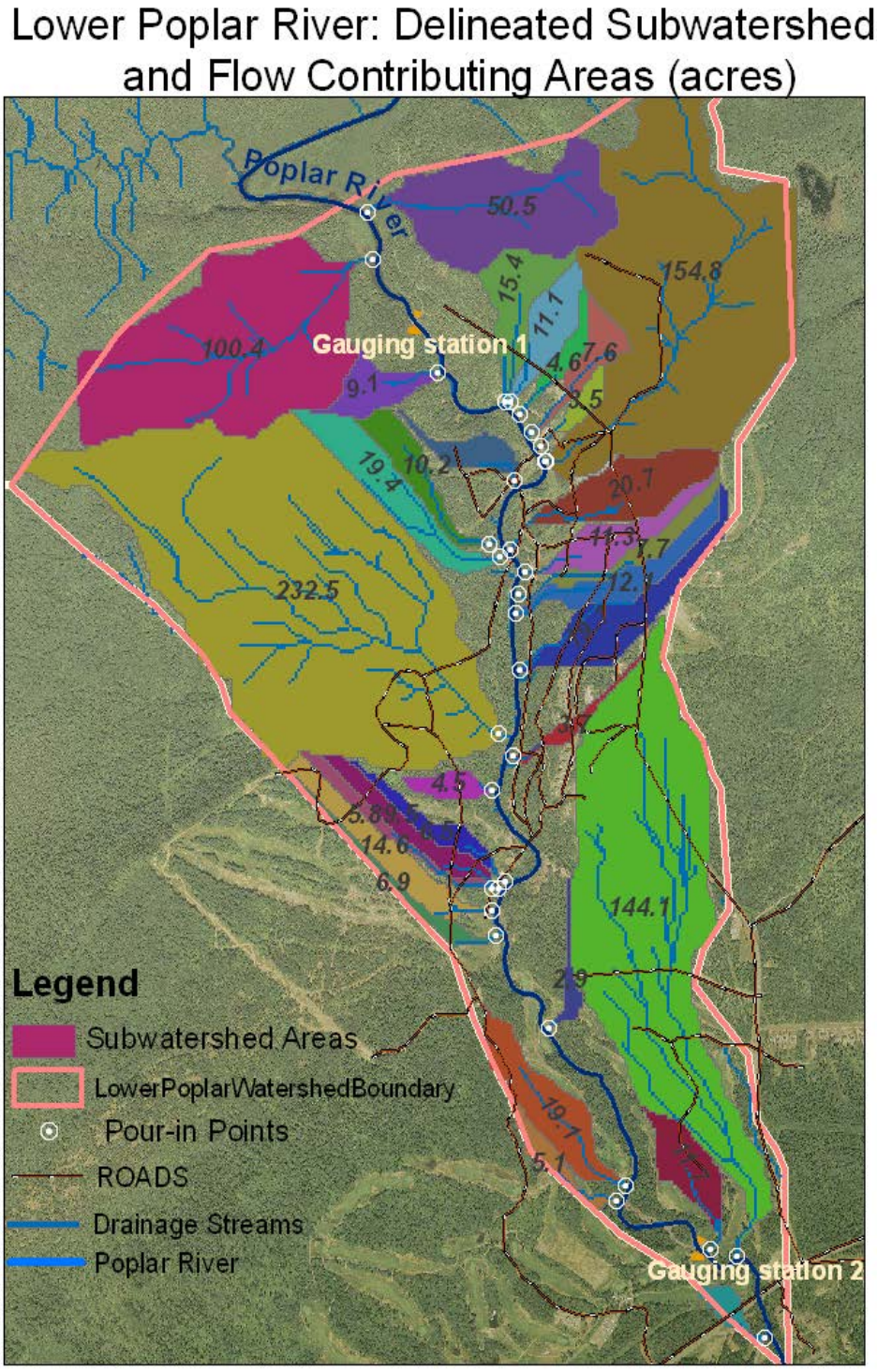


Figure 30. Sub-watersheds and their respective size (acres) in the Lower Poplar River watershed (1,295.5 total acres) generated from 10m DEM data of the area using Arc Hydro Tools

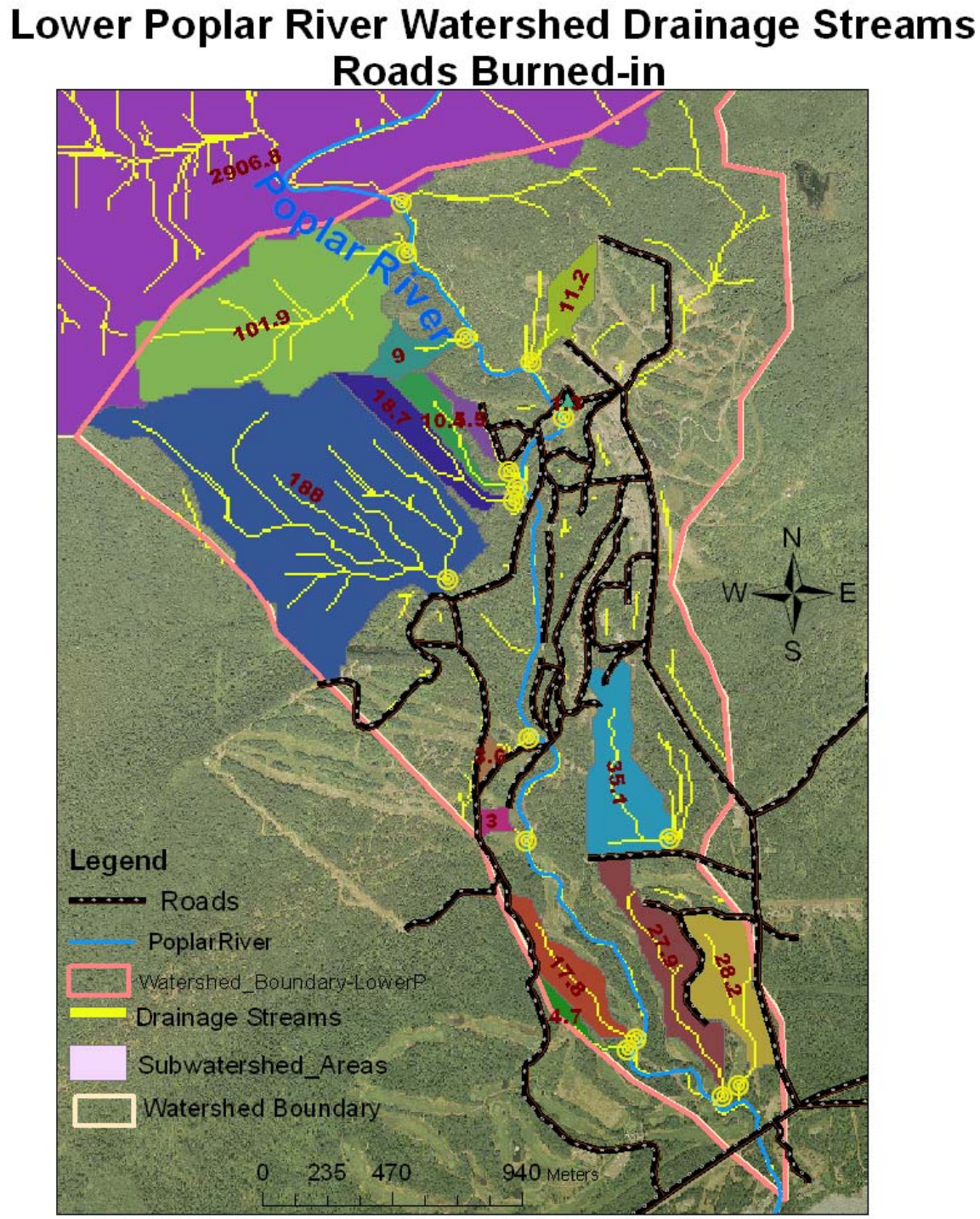


Figure 31. Sub-watersheds and surface drainage streams for Lower Poplar River watershed (1,295.5 total acres) generated from 10m DEM data with roads burned-in (ridged) of the area using Arc Hydro Tools 1.30

The initial analysis of the flow paths has raised additional questions about specific roads and how much they alter the natural hydrology of the watershed. The analysis of altered hydrology due to roads will be further refined with more, ground truthing such that the modeled altered hydrology matches the on the ground observations. The data obtained from this analysis will be further applied in modeling sediment yields and deposition in different reaches of the lower Poplar River. The (WEPP) model will be used in the planned modeling.

HISTORICAL SUMMARY

An investigation to determine if historical impacts to the river could be tied to the current sediment loading in the Poplar River was completed. Provided below is an abbreviated summation and conclusions of information found. For the full document refer to *Appendix B: Historical Perspective, refer to Appendix G: Interview Transcripts,* for transcripts from historical interviews conducted on December 1, 2009.

The Poplar River watershed was used by the Ojibwe tribe, and then the French fur traders, until settlers first arrived around the turn of the century in 1885. The public land survey of 1858 and 1859 notes tree types as well as small details through drawings and measurements of dimension, pattern and profile of the Poplar River. The stream width documented in the original surveys ranged from forty to fifty feet. Recent cross-sectional measurements show an current average width of forty to sixty feet.. This would suggest the river has maintained an approximate channel width for over 100 years without much variability. Many accounts of logging can be found describing turn of the century practices in Northern Minnesota, and along the North Shore. However no information was found indicating the Poplar River watershed had large or drastic alterations of lands (clearcuts, dense forest practices) as compared to neighboring watersheds. With the exception of the Lockport Railroad, forest practices within the Poplar River watershed were much smaller, remote and short lived. Thus historic, long term effects of logging are considered minimal (in consideration to present sediment and hydrology issues).

Additionally, roads, dams, and bridges, have been constructed within the watershed since settlement. Historically roads nearest the river were few (possibly two) not well maintained, had low traffic, some of which are not currently in use. Thus historic, long term effects of roads within the watershed as a source of sediment is considered minimal. Dams were used for hydroelectric power, by the National Paper Company and possibly for log holding area for the Lockport Railroad's saw mill (north of the steel bridge at the waterfalls). Multiple bridges are said to have been constructed along the Lower Poplar waterway in past times, however our investigation could not pin down the number of bridges constructed nor defined locations, other than those currently in place.

There is uncertainty of the effects of daming the river. During the field season of 2009 conducted by the U of M team indications of dams and bridge abutments were not originally noticed or visibly evident. However it was not until the interview process and historical investigation did the team became aware of these details. Thus further investigation is needed to field validate locations and to measure extent of former activity.

Anecdotal reports by Minnesota DNR fish surveys throughout time have indicated a change in particle size and distribution in pooled areas within the lower Poplar River. A 1961 survey described the bottom type as 67% rubble, 10% boulder, 10% gravel, 10% sand, 3% silt; whereas 1994-1995 crews noted silt and sediment had settled into pooled areas at "knee deep" depths. This report suggests the knee deep sediment occurred over a long duration, and to a greater degree than from one large storm event. If a large event

had facilitated movement of sediment into the river, the likelihood of accumulation is low, such that a large amount of the sediment and debris would have washed into the lake due to the high velocity water in the channel.

The U of M team analyzed a rich historical air photo catalog spanning 39 years (1969, 1978, 1991, 2003 and 2008). The photos detail many channel adjustments and land use change or alteration throughout time. Channel migration at times is clearly evident, yet channelization and extreme channel alterations due to land use development were not definitively noted. Some channel discontinuities were found. Air photo analysis is discussed in the sediment source section of this paper, as well as in the Appendix (Appendix C: Aerial Photos).

As this study concerns the lower Poplar River, the only population center of interest is Lutsen Township. As described by the Minnesota State Demographic Center and Metropolitan Council (2009), the average population has increased from 360 in 2000, to 420 in 2008; a 14% increase. Lutsen Township is experiencing population growth).

In summary, historical practices do not appear to be affecting the present day sediment loading to the Poplar River. There is no evidence of floodplain deposition that would suggest a major influx of sediment from logging. Logging was limited in the watershed compared to our North Shore watersheds. Agricultural practices were minimal and small scale. Post settlement deposition is more prevalent in lower gradient streams with wide valleys (Lecce, 1993). The Lower Poplar is high gradient with a narrow valley.

STAGE-DISCHARGE SIMULATIONS USING HEC-RAS

Some near stream sediment sources may deposit material on stream banks where it is not directly accessible by channel flow at all times. For example soil sloughed from bluffs may be deposited onto the toe of a bluff. If the river stage does not overtop the toe, it is likely that most of the soughed material will remain until an event large enough to overtop the banks occurs. Determining the kinds of events that allow channel flow access to these depositional features is of interest. To do this, a hydrologic model of the lower Poplar River was developed using the U.S Army Corps of Engineers Hydrological Engineering Center's River Analysis System (HEC-RAS).

Cross section and longitudinal data from field surveys conducted by the University of Minnesota and RTI were used to develop a model of a segment of the lower Poplar from the upper to lower gauging stations. Because no cross sectional surveys were conducted at the upper station, a v-shaped cross section was created to simulate the gorge immediately below the upper station. Cross sections are presented in Appendix H: Cross section surveys and modeled rating curves. The stationing is the distance from the mouth of the river. Some cross sections were modified because the survey did not encompass enough area to accommodate large events.

Manning's n for the channel was determined to be 0.05 (mountain stream, no vegetation in channel, steep banks, bottom cobbles with large boulders) and 0.06 in the floodplain (light brush and trees). Steady flow simulations were conducted for several discharges. Critical depth boundary conditions were applied to the upper and lower ends. This assumption is valid because there are steep drops at either end of the segment.

Rating curves for various cross sections are presented in Appendix H: Cross section surveys and modeled rating curves. An example of a rating curve at station 7800 which corresponds to the location of the mega slump is shown in (Figure 32). Estimates of the elevation of the top of the rock banks were made for the cross sections surveyed by the University of Minnesota team. Similar observations were not made for the RTI cross sections because the specific location of surveys was unknown.

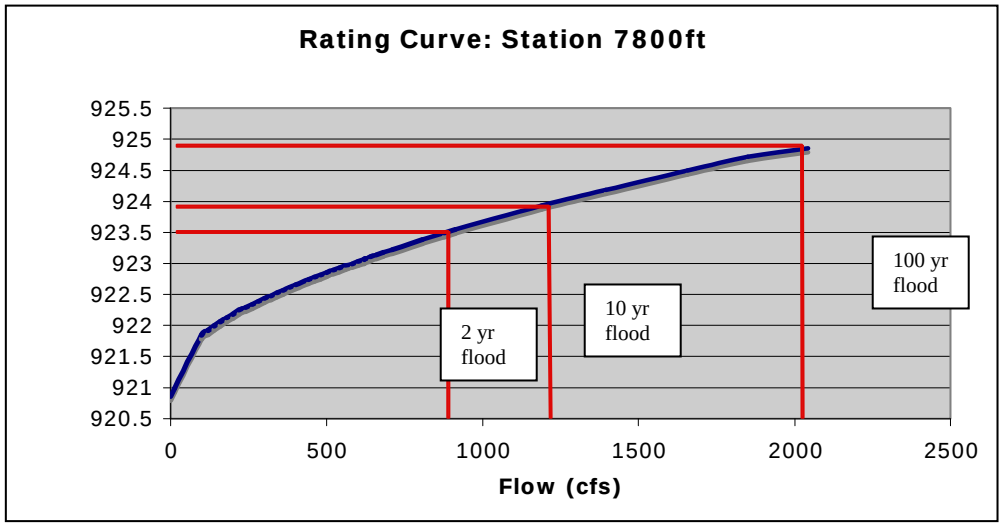


Figure 32. Example of Rating Curve that was developed

It is important to consider the amount of sediment available for transport when the river is at a certain stage. Near stream deposits are located at different elevations relative to the channel bed, and are located in cross sections with different geometries. In some sections of the stream there may be low lying deposits such as the top of point bars, the mouth of a ravine etc that can be accessed when the stream overtops the rock banks. The stream may transport these sources during small flood conditions. Some areas have very large depositional features, but require a very high stage to access. For example the top of the reinforced toe of the Megaslump has a lot of loose sediment from sloughing, but these areas are located approximately 6ft from the bottom of the channel. As shown in the rating curves (Appendix H: Cross section surveys and modeled rating curves), in most places a long the stream the rock banks can be over toped by an event with less than a two-year return period. In the areas where depositional features are more protected, such as the mega slump, it may take an event with a return period on the order of 100 years for direct transport via the channel. The indirect transport of sediment from these depositional features via overland flow to the channel should not be neglected.

REFERENCE WATERSHED

Selecting a reference watershed for the Poplar River has proved to be challenging due to the limitation of available stream flow data. A number of watersheds within the Lake Superior North major watershed were considered, including the Baptism, Brule and Pigeon (Figure 33). It was determined, however, that due to the limited availability of stream flow data, the Pigeon will likely serve as the reference watershed. The Brule does not have consistent data collected at a gauging station; rather occasional field samples were recorded by the MPCA and USGS. Although there are strong similarities with the Baptism River, stream flow gauging data extends only until 1993. Therefore, to estimate current conditions it is best to have a reference watershed with current gauging data. Additional analyses are currently being conducted to identify whether sample parameter data for ungauged watersheds could be referenced to the results observed in the Poplar River watershed.

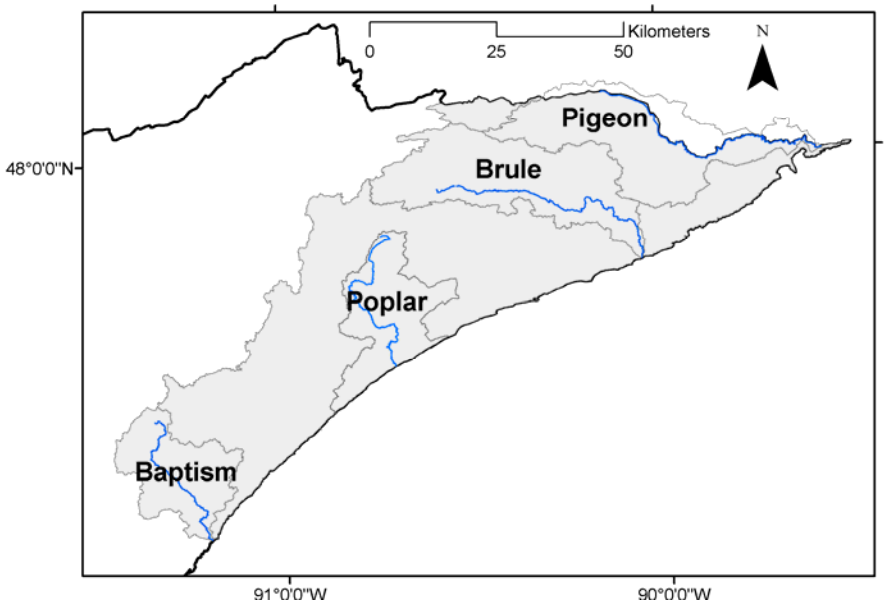


Figure 33. Location of potential reference watersheds

The morphology of the Poplar River watershed is most similar to the Baptism River watershed (Table 10). Because of the meandering of the Poplar River, the main channel covers nearly twice the length of the actual basin length. In addition, 50% of the watershed area drains into the lower third of the Poplar River, whereas the watershed drainage area is more evenly distributed into the Baptism, Brule and Pigeon Rivers (Table 10). This is also exhibited by the higher elongation ratio of the Poplar (and Baptism) River watershed.

Table 10. Comparison of Watershed Characteristics for Brule, Pigeon, Poplar River

Watershed Name	Area	Drainage Density		Average Watershed Slope	Watershed Length	Channel Length	Length to area center	Shape Factor	Circularity Ratio	Elongation Ratio
	(km^2)	Perennial ($km \cdot km^{-2}$)	Intermittent ($km \cdot km^{-2}$)	%	(km)	(km)	(km)			
Baptism	358.4	0.6	0.0	6.9	45.2	41.8	21.2	5.9	0.3	0.7
Brule	687.0	0.8	0.0	8.7	77.9	63.2	44.7	8.7	0.2	0.5
Pigeon	701.1	0.5	0.0	10.3	78.6	66.7	48.7	8.9	0.2	0.5
Poplar	392.6	0.5	0.1	8.0	55.9	55.4	18.8	6.1	0.2	0.8

Stream flow analysis

To gain an understanding of the Poplar River flow trend, data was correlated to the Pigeon River flow characteristics (Gauge 04010500 – Pigeon River at Middle Falls near Grand Portage, MN). The Pigeon River contains the most complete set of consecutive stream flow data for the longest time interval, with daily flow records beginning in July 1923. Intermittent stream flow data collection for the Poplar River began in October 1912 by the USGS (Gauge 04012500 – Poplar River at Lutsen, MN). Daily data was collected through September 1917. Data collection resumed after March 1930 through September 1961, with data breaks in December 1932 through July 1933 and from October 1947 through August 1952. Since 1961, occasional field samples have been collected by the USGS and MPCA (Gauge S004-406). A regression analysis of mean annual stream flow for the Pigeon and Poplar rivers is given in Figure 34.

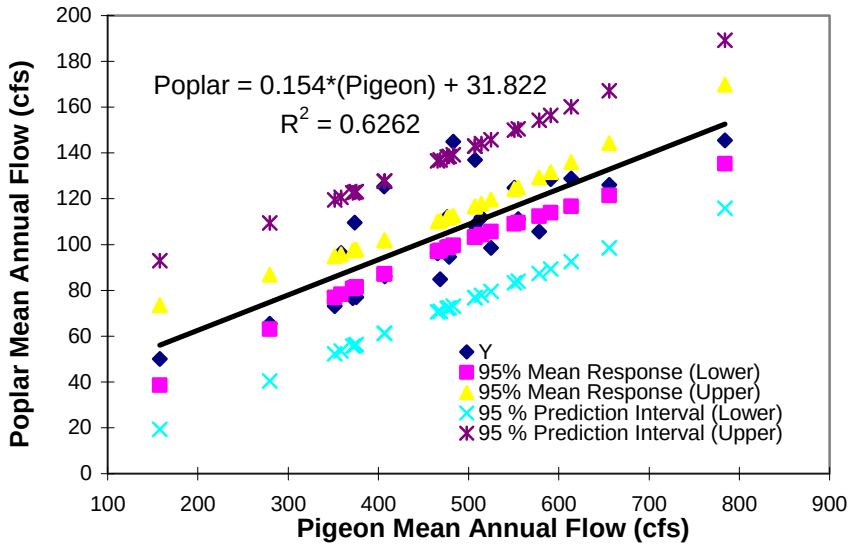


Figure 34. Regression analysis of mean annual stream flow for the Pigeon and Poplar Rivers

Although the r-squared (r2) value for annual flow was 0.63 between the Pigeon and Poplar Rivers, the correlation was much higher for daily (r2= 0.77), monthly (r2= 0.86) and seasonal (r2= 0.87) flow. A total of 25 complete sets of annual stream flow data overlapped between the Pigeon and Poplar Rivers. Using the calculated prediction intervals (95%) and results from the regression analysis, flow data after 1961 was estimated (Figure 35). By reviewing the observed data plotted prior to 1961 (red line), the accuracy of the regression equation (yellow line) could be compared. Unless anthropogenic effects alter stream flow, Poplar River data should continue to fall within the plotted prediction intervals.

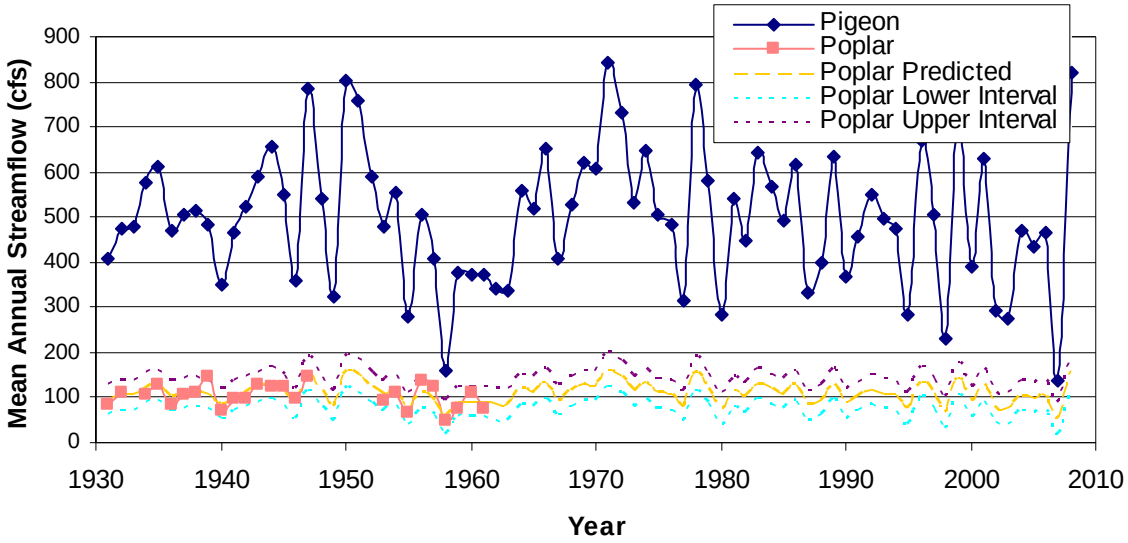


Figure 35. Stream Flow Analysis of Poplar and Pigeon Rivers

Frequency Analysis

A frequency analysis was completed for the Baptism, Poplar and Pigeon Rivers to estimate the stream flow magnitude for a given return period. Daily peak flow data for the period of 1930 through 1960 was analyzed using the Extreme Value Type I distribution method, which provides a conservative estimate. Results are summarized in Table 11. These values are comparable to those estimated by the USGS (Lorenz et al., 1997).

Table 11. Frequency analysis for the Baptism, Pigeon and Poplar Rivers

USGS Gauge	Station Name	Peak flow recurrence intervals, in $ft^3 \cdot s^{-1}$					
		2-year	5-year	10-year	25-year	50-year	100-year
4014500	**Baptism River near Beaver Bay**	2866	4743	5986	7556	8721	9877
4010500	**Pigeon River at Middle Falls near Grand Portage**	4617	6584	7886	9532	10753	11964
4012500	**Poplar River at Lutsen**	877	1189	1396	1657	1851	2043

Precipitation data was reviewed to identify what sized storm events would contribute to the Poplar River peak flow frequency volumes. Prior to 1986, the precipitation station nearest the watershed was in Grand Marais, approximately 24 km northeast from the Poplar River. For data after 1986, the Lutsen precipitation station located within the watershed was used (Figure 36).

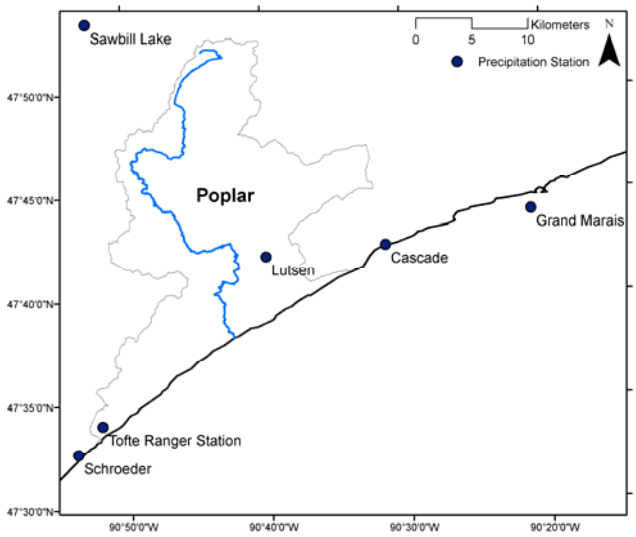


Figure 36. Precipitation stations surrounding the Poplar River watershed.

There are 43 peak flow values recorded for the Poplar River. Most of these events occur in late April or early May, when snow melt is occurring. Looking at the peak flow values that occur after the snow melt season, 6 of the 9 events have 5-day cumulative rain totals of at least 1.24 inches (3.15 cm). The 3 events that do not were from 1930, 1936 and 1943; therefore, some of the rainfall events may not be recorded. Preliminary results indicate that peak stream flow is likely due to the combination of snow melt with back-to-back precipitation events, occurring in spring while soils are thawing. Precipitation frequency analysis results calculated using maximum daily values from 1930 through 2009 and values taken from (Huff 1992) are summarized in Table 12.

Table 12. Precipitation frequency analysis using maximum daily values from 1930-2009

Frequency	North Eastern Minnesota Huff (1992) (inches)	Poplar 1930-1961 (inches)	Poplar 1930-2009 (inches)
2 year	2.54	1.74	1.97
5 year	3.21	2.37	2.71
10 year	3.36	2.79	3.20
25 year	4.08	3.32	3.81
50 year	4.64	3.71	4.27
100 year	5.20	4.10	4.72

To determine a similar reference watershed the Poplar River watershed characteristics were compared to a number of North Shore streams. The main conclusion from the search for a reference reach is that the Poplar is somewhat unique among North Shore streams of similar size. The best fit reference reach was the Pigeon River.

WATER PERMITTING

Lutsen Mountains Corporation is the only authorized user of water from the Poplar River. In previous years the Village Inn and other users once used the Poplar but now use other sources. Lutsen Mountain Corp. (permit #1964-0846) is currently authorized to appropriate 12.6 million gallons per year (MGY) at a rate of 1800 gallons per minute (gpm) (Table 13). An amendment requesting an increase in rate and volume has been given to the MN DNR to meet snow making needs (Personal communication: Cliff Bently DNR Waters - Area Hydrologist). There are no restrictions or seasonal limitations currently in this permit. However MN DNR maintains future permits may require a cutoff provision to protect at low flows. This provision would be defined by the annual Q90, which is the flow that is equaled or exceeded 90% of the time during any given year. The Q90 for the Poplar River is 21 cubic feet per second (cfs).

The total permitted volume of water appropriated for each year stayed at 12.6 Million gallons, at 5.4 gallons per minute. Throughout the years (2004-2008) the total gallons used amounted to a volume far greater than that allotted to the corporation. In 2004, 71.7 MG/Y were used, decreasing in 2005 and 2006 (65.7 MG/Y), to increasing to the highest levels in 2007 and 2008 (87.2 MG/Y, 89.8 MG/Y).

Table 13. DNR water permitting for Lutsen Mt. Corp. (MN DNR 2009).

Permit	Permittee	Use	GPM	MG/Y	2004	2005	2006	2007	2008
1964-0846	Lutsen Mt Corp	273	1.8	12.6	10.4	23	16	22.2	24.9
1964-0846	Lutsen Mt Corp	273	1.8	12.6	21.8	23	16	22.2	24.9
1964-0846	Lutsen Mt Corp	273	1.8	12.6	39.7	47.5	33.7	42.8	40
	Total Use		5.4	37.8	71.7	65.7	65.7	87.2	89.8

The U of M did not investigate the effect of snowmaking on sediment delivered to the river.

MODELING RECOMENDATIONS

This report shows that a significant effort has been invested in the acquisition of data for the Lower Poplar River watershed. Sources of data included previous reports, archived historical documents including historical maps, GIS data including soils, geology, topography, and landuse, and personal interviews with long-time residents of the area. The acquired data is now ready to be used in an effort to model the generation of runoff and sediment production in the lower watershed. This effort will facilitate the identification of critical source areas for sediment production in the lower watershed, a necessary step in the specification of BMPs to reduce sediment loading to the Poplar River.

Modeling activities recommended for the estimation of sediment production in the lower watershed should focus on the application of the WEPP model. This same model was also applied in the NAWE study (NAWE, 2005) and the RTI study (RTI, 2008). The WEPP model will simulate erosion from land surfaces only and not erosion from other features such as the river channel, ravines, gullies, or bluffs (slumps). Other modeling methods will need to be applied to model sediment production from those other sources. For ravines we recommend the use of the CONCEPTS (Landendoen, 2008) model. The CONCEPTS model is also recommended for the river channel. For gullies the Ephemeral Gully Erosion Model (EGEM) was developed (Woodward, 1999) and is recommended for use for the Poplar River watershed. For bluffs, methods for overland flow erosion as well as methods for mass slumping (Sidle and Ochiai, 2006) should be applied.

We also recommend that some watershed modeling for the Lower Poplar River watershed be conducted in addition to the modeling with WEPP. It is recommended that a model that is strongly tied to surface topography, soil type, and vegetation be used. A suggested model is the TOPMODEL developed by Keith Beven (Beven and Kirkby, 1979).

CONCLUSIONS

The Poplar River watershed is one of Minnesota's most popular destinations with its unique blend of recreation and natural beauty. It also provides great economic and employment opportunities to Cook County. The importance of both the natural beauty and economic impact are displayed by the level of effort given forth by all the parties involved in the TMDL process. The State Agencies, Lutsen Mountain Cooperation local stakeholders, and Cook County have all given their best effort to get it right. The state and local agencies have stepped forward with funding to conducted numerous studies and implement BMPs. The local interests in the watershed have donated their time, money and resources to help with the investigation.

Because this investigation was mostly a data collection effort there are few conclusions to report. The remaining conclusions are statement of objects, alterations in work plan, additions to the work plan and some conclusions in regard to reference watersheds and general observations.

The main goal of this project was to investigate sediment sources for the Lower Poplar River TMDL in more detail than was possible in previous studies. The work plan's initial objectives were to conduct more field investigations of near channel sediment sources, identify a reference reach for the Poplar River and select key storms for modeling total sediment loading to the river. Because of the high sediment loads generated from ski slopes and the lack of sediment production from the channel, the initial work plan objectives were modified. We enhanced our collection of data relevant to upland erosion processes, identified the location and conducted initial modeling of hydrology altering flow paths and did a review of historical land practices.

A large part of our effort focused on collecting targeted data from ravines and slumps that have proven to be difficult to model. The surface areas of these features were delineated using a combination of GPS, total station surveys and transects. Soil tests and a erosion index were also applied to help verify the soil parameters used in the modeling effort.

Because of the high sediment loads reportedly generated by upland sources additional field data (infiltration and soil shear) were collected on ski hills, roads and forested areas to validate or improve upon the modeling assumptions used in previous reports. Infiltration rates were approximately two times greater in the forested areas than the ski slopes and about 40 times greater than ski slopes that were graded. The soil shear data matched well with the values used in the previous modeling effort done by Research Triangle Institute, RTI in 2008.

To determine a similar reference watershed, the Poplar River watershed characteristics were compared to a number of North Shore streams. The main conclusion from the search for a reference reach was that the Poplar is somewhat unique among North Shore streams of similar size. The best fit reference reach was determined to be the Pigeon River.

Historical records and air photos were analyzed and interviews conducted to determine if there were a connection between the historical activities of logging, road building, dams, and channel alterations to the current sediment impairment. This historical investigation yielded little evidence of past watershed activities impacting current day sediment loads to the river.

A number of flow paths (defined as an alterations of flow direction and intensity) generated by road placement were also identified. The identification of these flow paths allows the model to be adjusted to take into account the altered hydrology. Flow paths in the Poplar watershed are mainly generated by roads cutting across steep slopes. The road cut intercepts both surface and sub-surface flows and reroutes flow down slope via the road ditch instead of the flow continuing to disperse across the hill slope and traveling via a succession of numerous small rills and gullies. These flow paths can concentrate flow and deliver sediment in greater concentrations and more quickly to the river. A first attempt at modeling these flow paths showed they do affect watershed hydrology and could have a affect on the sediment delivery to the river. A more detailed modeling effort to detail the effects on sediment loading to the river will be investigated in a future study.

The streambanks of the Lower Poplar River are armored with boulders over most of 2.7 miles of river. Along this stretch of river are numerous bluffs and three ravine outlets. Due to the natural bank armor and remediation efforts (bank stabilization) at two of the slumps nearest the river, a relatively high stage is needed to directly erode these sediment sources. A modeling effort generated from cross-sectional and flow data was completed to determine the river stage that would access these sediment sources. Preliminary modeling shows that for a 2- year return period, the streambank contribution to sediment loading would be minimal. This is because the rock that protects the streambed also extends vertically for some distance up the streambanks thus protecting them from smaller storm events. As the river stage increases with larger storm events the sediment load from the banks may increase as the river begins to access some of the less protected higher streambanks and floodplain. However, the contribution still would be relatively small as the banks are well protected with vegetation. A future modeling effort will determine what type event and river stage will start to access some of the less well armored streambanks. Preliminary calculations show that a 100 year event would over top the manmade protection at the base of the mega slump and actively start to erode the base of the slump. This suggests that most of the sediment currently generated from the two protected slumps would be due to rainfall generated over slump flows, freeze-thaw-snowmelt processes, ground water interactions and large mass wasting events.

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APPENDIX A: ADDITIONAL TABLES AND FIGURES

Table A1. Raw data of infiltration rates from numerous sites within the lower Poplar River watershed.

Site	Type of Site	Infiltration Rate (in/h)	Average Infiltration Rate (in/h)
Jack Alder Slope- Graded Slope	Graded Ski Run	5.6 5.0	5.3
Jack Alder Slope- Forested Slope	Forested Slope	71.6 68.6	70.1
White Birch- graded slope	Graded Ski Run	0.3 0.6 0.6	0.5
White Birch- Forested	Forested Slope	78.9 78.5	78.7
Lynx- ungraded slope	Ungraded Ski Run	10.2 19.2	14.7
Upper Grizzly- Not Graded, very rocky	Ungraded Ski Run	30.5 25.2	27.8
On Ski hill South of Caribou Lodge, Gondola, near stream and concrete pad	Graded Ski Run	0.6 1.7 3.8	2.0
Forested Area near Ravine (Greasy Gulch/Ullr Gully)- Right	Forested Slope/Ravin	69.8 39.4	39.0

Bank of Ravine	e	50.8 34.5 24.5 14.7	
Forested Site near Ravine with BMP/Culvert	Forested Slope/Ravine	0.0 0.2 0.5	0.2
Forested Site near Ravine BMP Mystery Mt culvert towards the golf course	Forested Slope/Ravine	2.3 0.4	1.4
On ski slope Lower Meadows/Bull Access/Wildcat on Moose Mt	Graded Ski Run	0.0 0.0 0.0	0.0
Lower Meadows/Bull Access/Wildcat on Moose Mt	Forested Slope	119.3 38.5 32.0	63.3
Eagle Mt. Intersection of trails across from maintenance shed on ski slope (Eagle Mt. N 47.66533, W 90.7107)	Graded Ski Run	0.4 0.3	0.3

APPENDIX B: HISTORICAL PERSPECTIVE

The Ojibwe tribe controlled much of what is now Northeastern Minnesota. French explorers came to the area around the 1600s, establishing a fur trade until 1840. Soon settlers would arrive, bringing speculators, fisherman, lumberman and homesteaders to the North Shore. In 1854, LaPointe treaty brought copper speculators which resulted in a buyout of North Shore lands. In 1885, Charles A. A. Nelson settled along the Poplar River in an area now known as Lutsen (Raff 1981). Raff (1981) describes the Lutsen area in its early days:
"*Up from the shoreline, the forest also helped to shape the history and daily lives of the settlements. Land had to be cleared, cabins built, garden crops planted. Some logging was underway before the century ended; small sawmills were started.*"

Between the 1870's and 1880's, wagon wheeled trails linked Duluth to the northern shoreline communities. In 1896, Railroad construction began in the area, resulting in many newcomers in the area. This allowed the commercial fishery industry to thrive. In 1926, Highway 61 was completed, which coincided with a decline in commercial fishing. The completion of Highway 61 brought an influx of visitors to the region. The highway helped to initiate an automobile led tourism to the area. For many areas along the North Shore, tourism has become a staple trade for the area. The development of the ski resort began in 1945 by George Nelson, Sr. and George Nelson, Jr, the son and grandson of the founder of Lutsen, C.A.A. Nelson. The ski resort first opened in 1948 with two ski runs. Since its inception, the resort has experienced a large amount of growth, such that currently the resort supports 87 runs, and over 1000 acres of ski-able terrain.

Surveys

The public land survey record notes of June 8, 1858 and July 11-17 1859 describe the Lutsen Township area as covered over primarily with birch, spruce, fir, some cedar and the "sugar tree" (likely maple). There is an extensive spruce swamp described in sections 3, 4, 9, 10, 16 and 17. Field notes show some river crossings were measured in links (a surveyor link equal .6 foot). The river is described along section lines where it had to be crossed. On average the width was 150 links wide. However the range of widths varied from 60-75 links to 200 links in width.

County surveyor records indicate Axel Berglund in 1915 made a simple drawing for a Grand Marais/Lutsen "road". The county road is shown on the east side of the river, data entered appear to be pretty simple compass coordinates along the road, ending on the east side of the river at the dam

Lutsen Light and Power

In 1923, a flume, turbine, and power house were installed in order to bring direct power to the residents of Lutsen. In a February 8, 1940 interview, Norinne Nelson notes, *"…if the current were alternating the whole town of Lutsen which covers a territory of over*

eight miles, could easily be supplied with light." Not all residents had access to Poplar River power. Nelson notes many used diesel pumps to supply power as well. Lutsen power plant was started in 1941, and by 1945 began providing electricity, later becoming Superior North Shore Power company, and finally in 1953 REA bought and renamed it Arrowhead Electric cooperative (Cook County Historical Society, Olga Soderberg interview, unknown date).

Bridges along the Poplar

During investigation of this report many small anecdotal remarks and one photo found at the Cook County Historical Society, describe two if not three bridges historically stretched across the Poplar in the lower reaches. In the interview with Jim Hall it was noted that one bridge "crossed the Poplar above the ski hill", where the current footbridge resides, and another just north of the hike and bike trail where old bridge abutments are said to be located (Hall, 2009 interview). In another interview Marlon Hansen stated there was a bridge where the North Road crossed the Poplar, indicating the ski hill bridge was there when he was a young child, indicating that bridge is now "Bridge run" (Hansen, 2009 interview).

Recreation related

In 1885, Charles "C. A. A." Nelson filed papers for a homestead – after taking an offer with Booth company to locate in the Poplar River areas as a supplier of fish (Raff 1981). On June 29, 1886, C.A.A. Began building a cabin, fish house and dock for small boats on the land where Lutsen Resort stands today (Raff 1981). In 1890, the Lutsen Post office was approved. Although C.A.A. Nelson petitioned for a post office to be established with the name Poplar River, the name was not approved, the second choice Lutsen was then proposed and accepted (Raff 1981). Soon residents would begin to show up, around 1890. One original homesteader to Lutsen, George Leng arrived about that time. Later Leng would live on the present ski run location above Lutsen Resort (Raff 1981). In 1897, C.A.A. built a school in Lutsen, School District No. 4.

In 1893 C. A. A. built the Lutsen House, this resort was located at the mouth of the Poplar River along Lake Superior. This house would become the main attraction to Lutsen for many years. A hunting camp (maintained by Nelson) was another attraction to the area, constituted of shacks, a barn, and large tents, the camp was built into the countryside north of the Lutsen Resort (Raff 1981). The trail to the hunting camp stretched north from the lake shore to the headwaters of the Poplar and Temperance Rivers (Raff 1981). By 1900 the road would extend 14 miles to the Temperance River. In the same year, C.J. Johnson asked the county commission to "*(build) a trail or temporary road from Grand Marais to township 61 and 63. R4.W*." The route followed the Poplar River north, then northwest past Christine Lake and 3 miles farther to Rice Lake (Raff 1981). This trail led directly north. The Moose Road branched off curving toward the northwest passed a mile west of Barker Lake and two miles west of Rice Lake. The U.S. Forest service eventually built an additional 6 miles north, connected the Moose Road to Sawbill Lake (Raff 1981).

Ski resort

After the visions of George Nelson senior and junior, the Lutsen Ski resort began construction in 1945, officially opening in 1948. Two runs were open at this time, Chickadee and Harry Cary (Nelson, Hansen interview, 2009). Ski lift tow ropes were originally powered by an old Ford engine.
"They wrapped the rope around the back wheel, started that baby up and hauled skiers up the hill…'We cleared land, constructed trails, and built a chalet until everything was completed, and the hill was operational'. Nelson's dream came to fruition, with a chalet and a simple rope tow used to pull skiers to the top. Though the primitive, single rope pull marked the first system, they soon expanded to two and three rope lifts power by an old V8 Ford engine." (Ellis 1995, Cook County Herald article)

At the same time (1948-49) Mystery Mountain was built. A poma lift was constructed and runs were put in during the 1950s. By 1959, electrical power was supplied to the ski lifts instead of using the V8 engine (Ellis 1995, Cook County Herald article).

Construction of the ski runs originally began as a hand cut operation, without heavy machinery such as bulldozers (Nelson, Hansen interview, 2009). However the 1960s saw an influx of heavy machinery and subsequent increased grading upon the landscape. In 1964, the Chalet was built followed by a 1965 installation of a chair lift. Snow making machines were introduced in 1964. By 1970 a south chairlift was installed on Eagle Mountain. By 1974, snow making capacity was increased by 30% to improve conditions (Ellis 1995, Cook County Herald article). In 1980 the Nelson's sold their share of Lutsen ski resort to Charlie Skinner and family. Between 1982-1983, Caribou highlands was built and Moose Mountain was further developed. In 1993-1994 Eagle Ridge and the Mountain Inn were built. Presently (Lutsen.com, 2009) the ski resort has 87 runs on 4 mountains.

Timber and the North Shore Railroad

In 1899, C. A. A. Nelson (of Lutsen) discontinued operations at his cedar camp, and also closed his camp at Cascade. Sawmills were spread throughout northeastern Minnesota. One such company, Thomas Lumber, operated off of 15,000 acres of North Shore timberland. Many others worked along the North Shore, including the Pigeon River Lumber Company, Alger Smith Company, Nester Estate and many other small companies including the Lutsen Lumber Company. Descriptions of log removal were found, some reports describe rafting of cuttings, sometimes sites built up a stock of 2 years of cuttings before being moved out via the large rafts. Logging was augmented by the demand for cedar for railway ties, hardwoods for furniture, birch for thread spindles, spruce just beginning as a pulpwood product. Major timber harvest firms located from Two Harbors to Grand Marais, with smaller log tie camps located about every 5 miles. Steamer service makes 25 stops along the Cook County shoreline with one a major dock landing stop.

Before the Civil War, only two small local sawmill operators were cutting timber on the North Shore (King 1981). By the later 1880s and early 1890s logging activity began to pick up, particularly by use of winter sleigh haul. In 1890, due to the depletion of Michigan big white pine stands, lumbermen were seeking new sites. For much of the country, a boom in timber was seen at the end of the Civil War due to an increase in growth of cities. To accommodate the need, extensive logging and lumber camps were established in nearby Wisconsin, and Michigan, with pressures spreading westward. By the 1880s northeastern Minnesota began to see increased logging pressures, so much so that by 1916, many of the big logging operations were in Cook County at Cascade (Harrison 1967, King 1981). However, Northeastern Minnesota does not have the most accommodating terrain, with rocky, hilly and sometimes steep slopes railroads were established to expedite the process. Up until rail lines, transporting logs cut along the North Shore were limited to operations located a few miles inland of Lake Superior. Logs would be stored along the banks along the shore for the winter months and then rafted to Duluth-Superior sawmills in the summer. Log rafts later became a common sight, the largest containing as many as 6 million board feet or the equivalent of 1,200 single tier railroad carloads. Harrison (1967) states over 2,500 miles of logging railroads with over 3,000 cars and 200 locomotives occupied Minnesota.

For 20 years, the primary railroad serving northeastern Minnesota was the Duluth and Northern Minnesota Rail Company (out of Cloquet, MN) via General Logging Company lines (Figure 37). The Duluth and Northeastern Co. constructed over 99 miles of main line and approximately 350 miles of branches and spurs (King 1981). In 1898 a small "Pioneer" railroad was organized and ran northeast parallel to Lake Superior, eventually maintaining passenger service to Finland in 1909. This railroad although short lived (discontinued in 1921) served as a route for shipping freight to other places. Eventually the line was sold to Duluth and Northeastern Rail (Harrison 1967). The line became part of the General Logging company in 1923. Steel was pulled from Cross River to Knife River, however the line from Cross River to Cascade Lake was left intact. The line was connected in 1927-28 to form a line from Hornby to Cascade Junction (111 miles), eventually to Rose Lake on the Canadian border. The line was used until 1938, when the General Logging Company ended.

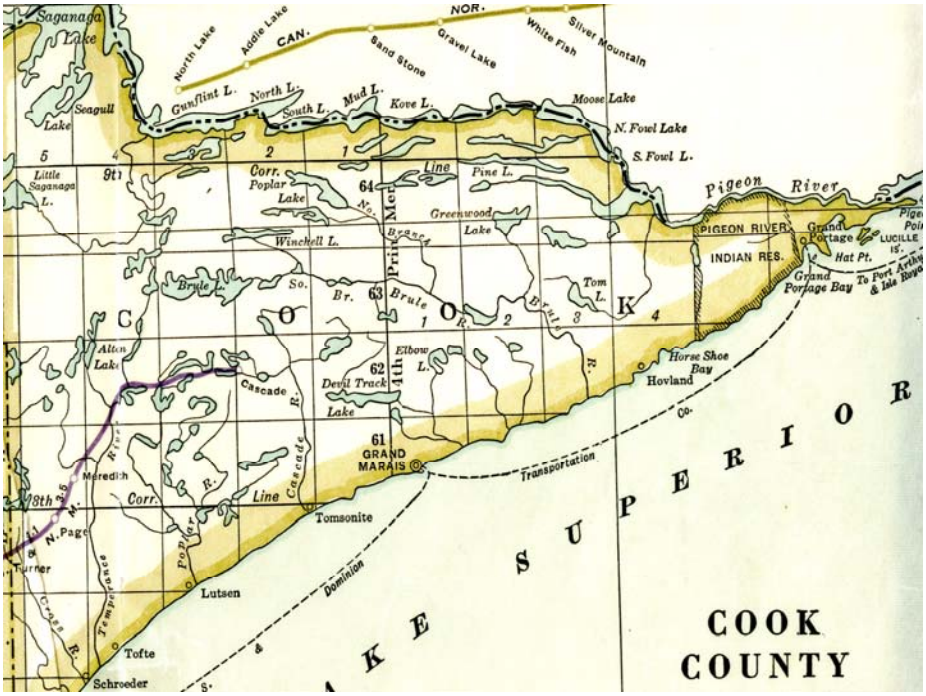


Figure 37. Map of Cook County and the Duluth and Northeastern Company line (1922), (Note: The purple line indicates the rail line).

Lutsen Tie and Post Company

The Lutsen Tie and Post Company is detailed in King (1981).
"Lutsen Lumber Tie and Post Company operated a four mile railroad between a vessel loading dock on Lake Superior at Lockport and its inland sawmill on the Poplar River. This line a lumber carrier rather than a logging railroad operated between 1910 and 1912. Its motive power consisted of a sole Heisler-geared locomotive which, after the operation was abandoned, stood for almost 20 years forsaken on the shore of Lake Superior."

The 4 mile rail line stretches from the current Lockport Market in Lutsen, northwest to the dead-waters of the Poplar River, near the foot bridge and waterfalls nearest the Lutsen ski resort. The particular details of this operation are difficult to find. The The Lutsen Tie and Post Company was owned by John McApline. Jan Holmgren states (Holmgren, "Calpine Murder", Cook County Historical Society) he built a hotel near Lake Superior – large dock at Lockport, and railroad to the "dead waters of the Poplar River to bring down the logs he had cut". The exact dates of operation for the business and railroad varies from source to source, citing King (1981) the rail line operated from 1910-1912, citing "Calpine Murder" (Cook County Historical Society) the business ran from: 1905 – 1910. Regardless the operation was put to a stop on August 14, 1913, when a fifty-eight year old John McAlpine was found dead in his East Duluth home.

The company experienced woes early on, when the first locomotive was brought to Lockport. Unfortunately this machine did not have enough power to get up on the high

ground from the dock. The locomotive was sent back to Duluth and quickly replaced by another machine that could make the trip to the top of the hill. Yet, it made only one trip, due to the death of John McAlpine. Later the locomotive would stay parked at the end of the tracks, unfortunately parked on C. A. A. Nelson's land. Later Nelson would be taxed for the locomotive. With this in mind, C. A. A. went to Duluth and found a person who would scrap the machine and get it off of his property. This man was named Goldfine, and he eventually cut up the locomotive for scrap metal before WW II.

During the interview process, many remarks of "blasting" or "dynamiting" of the Poplar above the waterfalls were made. The blasting is said to have opened up the narrow channel above the waterfalls, in order to accommodate logs (Nelson, Hansen, Hall interviews, 2009). Although the U of M team has not further investigated these claims at this time (due to the winter season), it is believed that in keeping with the practices of the region during that time, there is a probability that this may have occurred. Yet, further investigation is needed to clearly define and clarify this issue.

Logging

Although many communities along the North shore experienced prosperity through fishing, prospecting, or logging, the township at the mouth of the Poplar River prospered more through tourism than a particular trade. This is not to say fishing or logging did not occur within the watershed. Within the northern reaches of the Poplar, historical logging in small amounts may have occurred (Hall interview, 2009) but was not a driving trade within the watershed. Yet the will to bring prosperity via logging to the Poplar can be seen by construction of the railroad stretching from Lockport, a spur owned by the Lutsen Tie and Post Company. As previously mentioned, there are anecdotal remarks of widening the dead-water location of the mill via dynamiting (Nelson interview, 2009), however additional evidence has not been found to further support this. In keeping with the logging techniques used at the time it is believed that logs were "floated" down the river at least to this dead-water location in order to serve the rail line, this action could have created scars on the landscape and severely disrupted stream banks causing erosion.

Due to the limited operation at hand, the Lutsen Tie and Post company is not believed to have created a long term impact on the watershed. In an interview Marlon Hansen (2009) stated there was formally a saw mill on Caribou Lake, as well as other small mills and logging camps within the watershed. The extent, location and length of time for operation of these mills are not known at this time, but are likely to have operated in the upper reaches of the watershed. In other areas of the lower Poplar watershed, evidence of mass clear cutting or dense logging was not found. If mass logging occurred it most likely occurred in the northern limits of the Poplar River watershed. The northern reaches are flat in comparison to the lower reaches, where the slope of the land increases towards Lake Superior. The U of M team was given recent documentation of logging in the Poplar watershed by the Minnesota DNR (Figure 6). In Figure 6, the black line outlines the entire Poplar River watershed, the purple lines outline sub-watersheds within the greater Poplar River watershed, the green cells indicate DNR timber management, the pink cells indicate a Scientific Nature reserve which is not open for timber management.

Using the data provided by DNR, along the main stem of the Poplar River (Township sections T60-3W - T62-3W), 450 acres are shown to have been logged. In comparison to surrounding areas, timber operations within the Poplar River watershed are not nearly as dense (Figure 38).

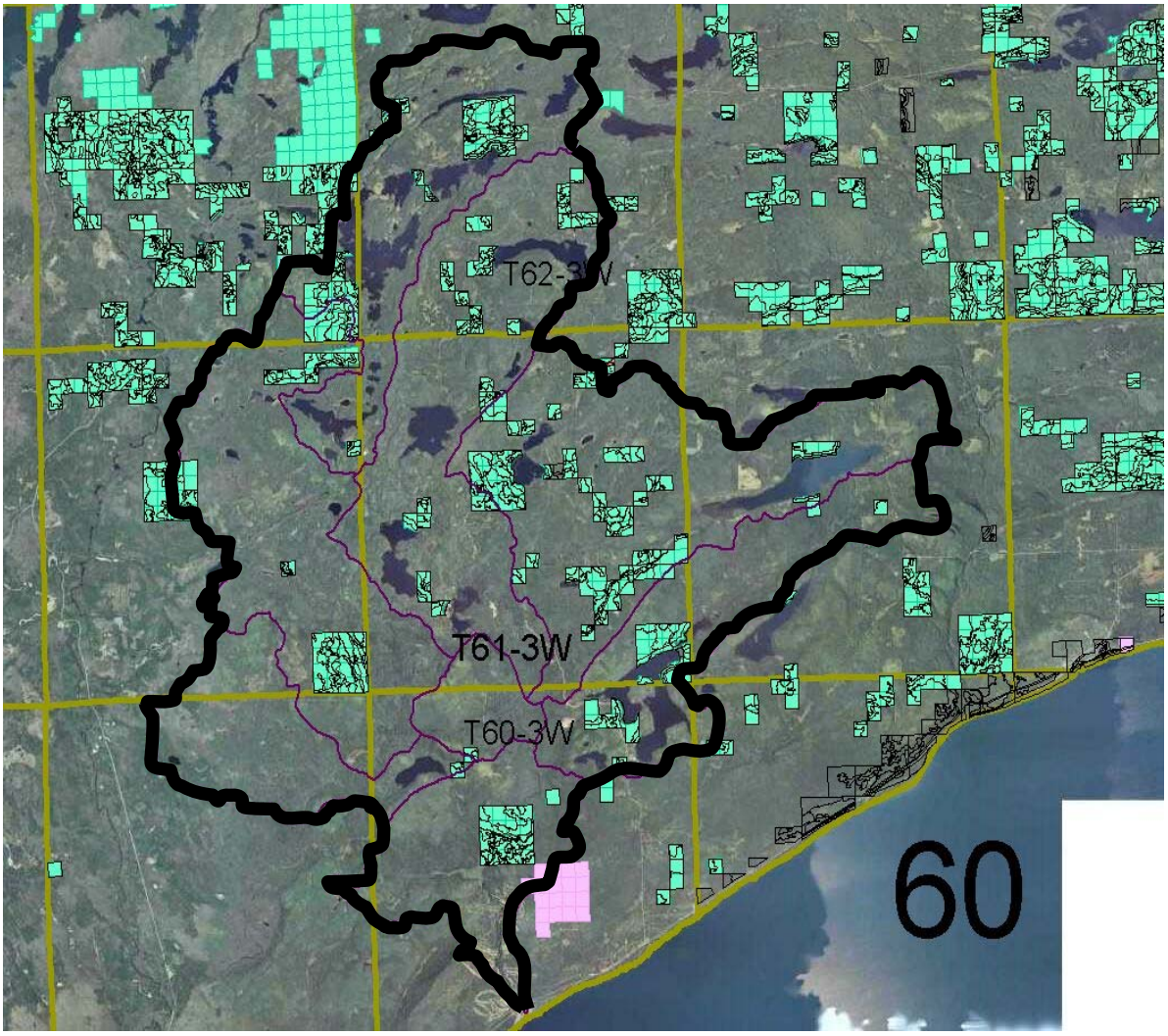


Figure 38. 1993-2006 Logging along the North Shore. Green colored blocks indicate parceled land (mostly private) which was logged during this time period. (Note: BLACK outline – indicates the greater Poplar River watershed, GREEN colored cells - indicates DNR forestry land, PINK colored cells – indicates Scientific Nature area which is not open for timber management. [Source: Doug Rowlett, DNR]. Along the main stem of the Poplar River (Township sections T60-3W - T62-3W), 450 acres are shown to have been logged.)

Fires

Fire warden reports of 1896 and beyond describe fires burning for a variety of reasons. 1896 was a very dry year, as was 1910-11 and 1917-18. In 1896 fires were reported by fire wardens in July and October with comments that all of the summer and early fall had been very dry and dangerous for fire. Wardens also describe the source of fires with many from the various groups of people traveling around the forests. Locally in 1948, two fires occurred at the Lutsen Resort. As noted by the resort, "Early in the year, a dormitory burned to the ground. Then on October 21, a fire swept through the main lodge, destroying the entire building. No one was hurt, but the Nelsons estimated the damage at $200,000. A new main lodge opened in 1949, and another fire destroyed the new building on December 6, 1951. Again, no one was hurt. A new lodge was built, following the Scandinavian design by Edwin Lundie, and it is the same building that exists today." (Lutsen 2009)

Streams/rivers

Many watersheds of the North Shore, experience great changes in elevation, many steeply increase in gradient towards Lake Superior, a striking comparison to the northern reaches which are flat. An instance of a logging operation which tried to traverse this challenging landscape, was with a company which proposed an ambitious project for improvements using dam constructions and dynamite to remove boulders and other stream bed obstructions. They had estimated this would make the Cross River navigable for 20 miles inland and would be cheaper than building a railroad. In 1911-12 Water Resources Investigations report, describe dam operations on rivers relative to logging operations.

From the report "Water Resources Investigation of MN 1911-1912 by the State Drainage Commission in cooperation with the United States Geological Survey", a variety of data was compiled . field seasons May 1909-November 1911. Within the data collected, 1910-1911 was noted as having precipitation far below normal. The report describes log driving, such that a reservoir is operated to store water through the fall and winter for release during a short period of spring and early summer to reinforce flow while logs are driven to saw mills or raft staging areas.

Relatively less logging done in this section than rest of State due to lack of transportation facilities. However on pages 523 –524, specifics are given about the Poplar River, indicating the river has been used somewhat for log driving, with two dams on the river, one located 2.9 miles above the mouth and one at 5.6 miles above the mouth. The nearest dam is owned by National Paper and Pulp Company.

Biological Monitoring

In 1925 a report by the University of Minnesota Geological Survey Bulletin (No. 20, pg 99) describes the Poplar River as a place which does not "afford suitable waters for trout" during the summer months, except for the many lakes in the upper Poplar, and a spring

fed section of the river approximately two miles above Lutsen. This report details catches of trout (brook and brown) around location of a mill, approximately three miles north of Lutsen.

APPENDIX C: AERIAL PHOTOS

In order to spatially register photos, 18 previously obtained points, derived from Google Earth image (2003 USDA/FSA – WGS 84 datum), were used. Points were later transformed to datum NAD 83 UTM 15N (Figure A2 in the appendix). Each aerial photo was spatially referenced to NAD 83 UTM 15N, with datum, D_North_America _1983 (1 meter), and rectified (using Transformation: 1st order polynomial) in order to obtain continuity and spatial relevance for further calculations. The river was digitized with a polyline, tracing the center of the main channel for possible migration or channelization, as well as to document physical alterations and obstructions to channel shape. Aerial photos used date from 1969, 1978, 1991, 2003, 2008. Photo sources were obtained from the Minnesota Geospatial Information office (*http://www.mngeo.state.mn.us/chouse/mnmapper.html*) and from the John R. Borchert map library at the University of Minnesota. RMS error was noted after registration for each image: 1991 (7.67338), 2003 (8.03762), 2008 (8.12498).

Sources:

1. State Wide Air Photos 1969
Sheet No. 314-4
Mark Hurd Aerial Surveys, Inc., Minneapolis, MN
John R. Borchert library at the University of Minnesota, S-76 Wilson Library 309 19th Ave. South, Minneapolis, MN 55455
Scale 1:24,000

2. State Wide Air Photos 1978
Lutsen, N47375-W90375, Sheet No. 314-4
From: Color Infrared Original
Mark Hurd Aerial Surveys, Inc., Minneapolis, MN
John R. Borchert library at the University of Minnesota, S-76 Wilson Library 309 19th Ave. South, Minneapolis, MN 55455
Scale 1:24,000

3. Statewide Air Photos 1991
Federal orthoimagery; black & white
USGS - NAPP 1-meter resolution

4. Statewide Air Photos 2003
Federal orthoimagery; natural color
USDA/FSA 1-meter resolution

5. Statewide Air Photos 2008
Federal orthoimagery; natural color and color infrared
USDA/FSA 1-meter resolution

6. 1860 Public Land Survey Map
John R. Borchert library at the University of Minnesota, S-76 Wilson Library 309 19th Ave. South, Minneapolis, MN 55455

Figure A2. Points used for referencing aerial photos in ArcGIS

APPENDIX D: PREVIOUS REPORTS

1999

- Fact Sheet: Storm-water Management Survey: Lutsen Township Development
    - Prepared by: Lake Superior Coastal Program (DNR)
    - 1 page

August 2003

-An Assessment of Representative Lake Superior Basin Tributaries 2002
    - Prepared by: Anderson, J., Evenson, M., Estabrooks, T., Wilson B., Environmental Outcomes and Regional Environmental Management Divisions, Minnesota Pollution Control Agency.
    - 59 pages

December 22, 2006

- EPA - Poplar River Turbidity Total Maximum Daily Load: Summary of Existing Water Quality Data and Information - Task Order No. 2006-47
    - Prepared by: RTI International
    - 24 Pages

2007

- Historical Changes in Precipitation and Streamflow in the U.S. Great Lakes Basin, 1915–2004 Scientific Investigations Report 2007–5118
    - Prepared by: USGS, US Dept of Interior
    - Part of National Water Availability and Use Program
    - 37 pages

January 18, 2007

- (Draft) (NOAA) Report Slope Stabilization Work Plan For Poplar River Management Board - Minnesota's Lake Superior Coastal Program
    - Prepared by: North American Wetland Engineering, LLC
    - 63 pages
    - Executive Summary is attached

February 20, 2007

- Poplar River, MN (Cook County) 2006 Automated, in situ, Water Quality Data: Preliminary Analysis

    - Prepared by: Richard Axler, Jerry Henneck, Elaine Ruzycki, Norm Will, (NRRI) Center for Water & the Environment, Natural Resources Research Institute, University of Minnesota-Duluth, Duluth, MN 55811

    - 27 pages

March 21, 2007

- Mega Slump Stabilization Project - Design Report
    - Prepared by: EOR (Emmons and Oliver Resources)

    - 8 pages

September 2007

- Summary of E coli test results for the Poplar River 2005 and 2006

    - Prepared by: Dave Stark - Cook County Soil & Water Conservation District

    - 3 Pages

September 21, 2007

- Poplar River Turbidity Total Maximum Daily Load Evaluation of Existing Model Output Task Order No. 2006-47 (WEPP Modeling)
    - Prepared by: RTI

    - 22 Pages

2007

- Poplar River Mega Slump Stabilization Project - Clean Water Legacy fact sheet (1 page)
    - Prepared by: Cook County SWCD

    - 1 Page

2008

- Lake Superior Area: Status of Coaster Brook Trout in the Minnesota Waters of Lake Superior

        - Prepared by: Matt Ward

    - Minnesota Department of Natural Resources Fisheries Division

        - 22 Pages

January 15, 2008

- Poplar River Mega Slump Preliminary Design Meeting Summary

Final Draft of meeting minutes March 2008

Meeting Outcomes

1. Large woody debris component will be taken out of the design.
2. Bankfull elevation is critical and will be field reviewed during spring runoff.
3. The necessity for an EAW is unlikely.
4. Design-Build versus bidding. Process will be explored further between all parties.
5. Overall Phasing of Project (2 week time-frame envisioned by EOR):
    a. Top priority is toe protection (given the soils analysis) with construction of the rock revetment/bench and Bendway weirs.
    b. Run-on will be diverted and additional alternatives for wastewater discharge will be explored.
    c. Slope protection – cost-permitting.

January 14, 2008

- Evaluation of "Paired" Turbidity Measurements from Selected North Shore Streams Using Different Turbidimeters
    - Prepared by: Greg Johnson (MPCA)
    - 8 pages

February 4, 2008

- Poplar River Turbidity Total Maximum Daily Load Additional Characterization and Estimation of Turbidity Impairment Using WEPP 2006.5
    - Prepared by: RTI International
    - 53 Pages

February 25, 2008

- EPA Poplar River Turbidity Total Maximum Daily Load Physical Channel Assessment - Task Order No. 2006-36
    - Prepared by: RTI International
    - RTI International - 3040 Cornwallis Road, Research Triangle Park, NC 27709-2194.

- 52 pages

March 24, 2008

- EPA Poplar River Turbidity Assessment, 336 pages

  - Prepared by: RTI International, URS Corp, Environmental Consulting & Technology Inc, Short Elliot Hendrickson Inc

  - RTI International - 3040 Cornwallis Road, Research Triangle Park, NC 27709-2194.

  - URS Corporation - 600 Montgomery Street, San Francisco, CA 94111-2728.

  - Environmental Consulting & Technology, Inc.- 2200 Commonwealth Blvd, Suite 300, Ann Arbor, Michigan 48105.

  - Short Elliott Hendrickson, Inc.- 6418 Normandy Lane, Suite 100, Madison, WI 53719-1149)

March 31, 2008

- Comments on EPA TMDL Report

  - Prepared by: Lutsen Mountains

  - 14 Pages

January 17, 2009

- EDA Joins Effort to Improve the Poplar River

  - Prepared by: Cook County-News Herald

  - 2 pages

2009

– Integrating Geomorphic Field Assessment and Watershed Modeling for a Turbidity TMDL

- Prepared by: Troy Naperals, Brian Jacobson, Dan Cazanacll, Sanjv Sinha.

- 20 pages

General Information

2007

- Hydrology and water quality in two mountain basins of the northeastern us: assessing baseline conditions and effects of ski area development
    - Prepared by: Wemble, B.
    - 12 Pages

1959

- The Geology of Cook County Minnesota. University of Minnesota, Minnesota Geological Survey Bulletin No. 39.
    - Prepared by: Grout, F.F., R.P. Sharp, and G.M. Schwartz.
    - 163 pp.

1925

- Chapter VIII – Fish and Game Along Highway No. 1 by. A Guidebook to Minnesota Trunk Highway No. 1. University of Minnesota, Minnesota Geological Survey Bulletin No. 20.
    - Thaddeus Surber, Game and Fish Department, in Schwartz, G.M.
    - 128 pp.

1912

- Report of the Water Resources Investigation
    - Prepared by the State Drainage Commission
    - 648 pages

APPENDIX E: MN DNR FISH SURVEY DATA:

Table 1. Electrofishing catch per unit effort (CPUE; fish/minute) for young-of-year (YOY) and age-1 or older (1+) brook trout (BKT) and rainbow trout (RBT) in sampling stations located near the mouth (mile 0.0), below the ski hill (mile 1.0), and within the upper reach (mile 16.2) on the Poplar River, Cook County, Minnesota.

	Mile 0.0				Mile 1.0				Mile 16.2	
	RBT		BKT		BKT				BKT	
Year	YOY	1+	YOY	1+	YOY	1+	YOY	1+		
1983	0.18	0.00	0.00	0.12						
1989	0.02	0.04	0.00	0.02			0.59	0.66		
1990			0.02	0.13	0.54	1.15				
1991			0.00	0.10	1.16	1.70				
1992			0.00	0.00	0.68	0.58				
1994	0.00	0.00	0.00	0.12						
1995	0.00	0.00	0.00	0.11						
1998	0.00	0.09	0.00	0.03			3.40	2.80		
2002	0.00	0.00	0.00	0.00						
2006	0.00	0.00	0.00	0.00	0.00	0.04	0.18	0.66		
2007	0.16	0.08	0.03	0.03	0.00	0.03	0.27	0.12		

Normal CPUE ranges (as indicated by first and third quartile values for the area) for brook trout YOY and 1+ are 0.12-0.92 and 0.14-1.00 fish/minute, respectively. Normal CPUE ranges for rainbow trout YOY and 1+ are 0.99-6.90 and 0.24-1.54 fish/minute, respectively.

Table 2. Annual estimates of fishing pressure (angler-h), rainbow trout catch (number of unclipped fish longer than 16 in), and rainbow trout catch per unit effort (fish/angler-h) in the lower reach of the Poplar River, Cook County, Minnesota, during the spring steel head season.

Year	Fishing Pressure	Catch	Catch Rate
1981	1,394		ND
1982	716		ND
1983	1,170	61	0.052

1992	555	65	0.118
1993	1,347	31	0.023
1994	1,083	139	0.129
1995	732	0	0.0
1996	496	194	0.391
1997	361	12	0.034
1998	478	0	0.0
1999	469	48	0.102
2000	549	122	0.223
2001	168	0	0.0
2002	270	0	0.0
2003	278	12	0.041
2004	424	133	0.314
2005	173	32	0.186
2006	338	87	0.257
2007	548	63	0.116

Table 3 Electrofishing catch per unit effort (CPUE; fish/minute)at various sampling dates (month/year), for young-of-year (YOY) and age-1 or older (1+) brook trout (BKT), rainbow trout (RBT), and small-mouth bass (SMB), and CPUE for long nose dace (LND), sculpins (SCU; mottled or slimy), white sucker (WTS), and burbot (BUB) of all ages in the Poplar River, Cook County, Minnesota, from the mouth to the first falls.

	BKT		RBT		SMB					
Date	YOY	1+	YOY	1+	YOY	1+	LND	SCU	WTS	BUB
8/83	0.00	0.12	0.00	0.18	0.00	0.00	1.50	0.00	0.06	0.42
9/89	0.00	0.02	0.02	0.04	0.06	0.04	0.57	0.02	0.04	0.31
9/94	0.00	0.12	0.00	0.00	0.00	0.02	0.28	0.02	0.19	0.21
9/95	0.00	0.11	0.00	0.00	0.30	0.03	0.00	0.00	0.11	0.08
8/98	0.00	0.03	0.00	0.09	0.00	0.16	0.28	0.00	0.00	0.31
8/02	0.00	0.00	0.00	0.00	0.00	0.41	0.20	0.00	0.00	0.03
8/06	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.07	0.24
8/07	0.03	0.03	0.16	0.08	0.00	0.36	0.78	0.00	0.03	0.16

Normal CPUE ranges (as indicated by first and third quartile values for the area) for small-mouth bass YOY and 1+ are 0.02-0.06 and 0.03-0.12 fish/minute, respectively, among assessments where the species and age group has been collected. Small-mouth bass have been taken in less than seven percent of stream assessments done in this area.

Table 4. Fish species collected in MNDNR summer fish population assessments in sampling stations below the barrier falls (Mile 0.0) and above the barrier falls (Mile 0.1-2.6), on the Poplar River, Cook County, Minnesota, 1983 - 2007.

Species	Mile 0.0	Mile 0.1-2.6
Blacknose Dace		X
Bluegill	X	X
Brook trout	X	X
Burbot	X*	
Central mud-minnow	X	
Common shiner	X	X
Creek chub	X	
Fathead minnow	X*	
Hybrid sunfish		X*
Longnose dace	X	X
Longnose sucker	X*	
Mottled sculpin	X	
Northern pike	X	
Pink salmon	X*	
Pumpkinseed sunfish	X*	
Rainbow trout	X	X
Sea Lamprey	X*	
Small-mouth bass	X	X
Slimy sculpin	X	X
White sucker	X	
Yellow perch	X	X

* - found only at this location in the Poplar River.

APPENDIX F: ADDITIONAL HISTORICAL REFERENCES

List of materials reviewed and some pertinent notes (Cook County News Herald)

1. April 15 1899
CAA Nelson discontinued operations at his cedar camp, also closed his camp at Cascade
Describes mill at "Pork Bay" - story about Thomas Lumber and their 15,000 acres of North Shore timberland

2. July 1899
Stories about tugs rafting logs to Duluth that summer

3.Nov 22 and Dec 2 1899 editions
Stories about cedar in demand for railway ties, hardwoods for furniture, birch for thread spindles, spruce just beginning as a pulpwood product
Duluth district the greatest lumber producing section of U.S - so far pine is the only wood being processed but pulpwood is next

4.May 19 1900
Brook trout fry from state hatchery planted in Flute Reed River

5. January 12 1901
Short notice on Congress
National Park proposed at headwaters of Mississippi River to save the last virgin pine in America
Mentions "The Delineator" assume this is a publication and this is work undertaken by Womens Club of America - general tone is concern about cutting pine and possible slowdown / prohibitions?

6. January 19 1901
Diamond Match - Michigan
Describes - Inspectors and cruisers in woods to estimate white pine for the big match company

7. February 1901
Mentions who is cruising pine

8. March 23 1901
Long article about logging activities
Describes dynamite to be used in streams
Cross River Driving and Boom Company proposes to improve river for log transport by constructing dams, blowing boulders and other obstructions in bed of river.
Cheaper than building a logging railroad and will make navigable for 20 miles inland
6 million feet of logs this winter to move
35 million next winter

Logs driven to Superior, then towed to Ashland
Pigeon River Lumber Company invested about $100,000 in Cook County in pine land in eastern portion of county, describes another land purchase from American Realty Co of Milwaukee

9. March 1901
Sawmill at mouth of river proposed become HQ for logging operations
Mill produce lumber for buildings and dams
Spruce & cedar leading products of Cook County this winter
Logging operations active all winter
Cedar, spruce, pine
Team hauling still predominant in Cook County
Streams on North Shore not adapted for driving due to many cascades and other peculiarities frequent

10, March 23 1901
Describe need for telephone line service
Several large firms between Two Harbors and Grand Marais
Smaller camps about every 5 miles "tie camps"
Describe quite a bit of smallpox that year in camps

11. April 30 1901
Brook trout "fry" shipped for Flute Reed River stocking
U.S. Fish Commission project
10 cans from state hatchery last season to add to attractions of stream as a "sportsman's paradise"

12. June 8 1901
Report of large log rafts arriving at Baraga MI
6 million feet of logs from Gooseberry River NesterEstate
Alger Smith Company held record - 5 million feet Pigeon River to Duluth
Alger Smith had 2 years of cuttings at Pigeon River for towing

13. June 15 1901
Buying pulpwood from Cascade River to harbor
$6000 request to state - commissioners to repair and construct roads and bridges for town of Grand Marais

14. June 22 1901
Big storm - big loss of lumber company logs that were in harbors ready to be towed away

15. July 6 1901
General CC Andrews reprint of a St Paul Globe story in paper on his trip through the wilderness
Describes 8 million ?? In standing pine across scattered localities of Arrowhead.
Cook County only county lacking railroad line - not one full mile of line yet in the county

83 miles of shoreline, steamer makes 25 stops along shore, including 1 dock landing

16. October 12 1901
New bank starts up - Cook County State Bank
Grand Marais acquiring a reputation as a "summer resort"

17. June 21 1902
A Fish Story
Describes fisherman adventure, looking for brook trout at Reservation River, one of the best known streams for trout, every party that fish there get a good catch
Another group described as enthusiastic about fishing on Reservation River (Caught on the Run column)

18. December 5 1903
New mill for Grand Marais
Cook County Manufacturing - Bayfield owner and CJ Johnson, Grand Marais
Capacity 50,000 feet of lumber /day
Manufacture shingles and saw pine off stands that the company owns

19. February 3 1903
Letters to Washington and St Paul legislature to erect hatcheries on North Shore
"The supply of fish has been diminishing year by year"
Describes state law to prohibit fishing during spawning season

20. From the book "Sawbill History and Tales" - Mary Alice Nelson, published 2005
P 121 - CAA Nelson moose camp on Rice Lake, trail hacked out for horses & wagons along the Poplar River past Barker Lake on to Rice Lake
P 32 - trail to back country west side of Poplar River

21. From the book "Pioneer Faces & Places" - Cook County Historical Society, 1979
P45 - Lutsen - photos of forest around Lutsen resort - early 1900s
P48 - Onion River log landing spanning the main North Shore highway, 1910

22. From the book "Early Loggers in MN Volume III", JC Ryan 1980
Describes fire period of 1910- very dry, fires
"hottest driest year on record to date"
1917/18 - also dry & fires
Vol II - 1976 edition - photos of dams/log jams on rivers in northern MN

23. From the book "Pioneers in the Wilderness", Willis H. (Bill) Raff, Cook County Historical Society, 1981
P79,80 - 82
Nelson petitioned for post office to be named Poplar River, denied so Lutsen was tried as next option and approved

Describes 4 foot wide road /trail to be built from Grand Marais to Twshp 61-62 R 4W for 175.00 of county funds, from Poplar River north , northwest to Christine Lake then 3 miles to Rice Lake, references
1903 News Herald article about the Nelson Moose Road - commissioner notes likely

24. From the book "MN Logging Railroads", Frank Alexander King – Lutsen Lumber Company mentioned, Northeast History Center has a couple years of their account records, who was employed there, payments – no evidence there is timber harvest data there or more resource related info

25. From the report "Second Annual Report of the Chief Fire Warden of Minnesota for the year 1896"
Cook County – H.J. Redmyer of unorganized Towns 58 and 59, Ranges 4 and 5 West, Lutsen August 17
Describes a July fire caused by lightning, burned over 25 acres of cedar and spruce. Someone had taken out cedar and left a good deal of brush which ignited. 6 days to extinguish. Weather continued very dry.
Chester Durfee of Grand Marais stated in September the weather had been dry and dangerous for about 3 months that summer, great danger of fires now and October unless considerable rain.
Johnson and (CAA)Nelson – both of Lutsen reported fires in October. Nelson noted dry and dangerous weather past two months.
Also interesting to note who started the fires, gives some idea of who is in the county – explorers, tourists, fishing parties, hunters, woodsmen, surveyors, inexperienced homesteaders, shotguns, mineral prospectors, cruisers starting fires for tea and failing to extinguish

26. From the report "Water Resources Investigation of MN 1911-1912 by the State Drainage Commission in cooperation with the United States Geological Survey"
Report of George A. Ralph Chief Engineer
Variety of data was compiled . field seasons May 1909-November 1911
1910-1911 precipitation far below normal
Describes log driving – reservoir is operated to store water through the fall and winter for release during a short period of spring and early summer to reinforce flow while logs are driven to saw mills or raft staging areas. Comments on dam operation and flows – p520 where there are logging dams, it is probably the summer flow when dams are closed is as low as winter month flow.
Photos and descriptions of log landings, log dams, amount of board feet moving through a river where this data was inventoried in detail like Kawishiwi or St Louis River
P 520 Cook County specific info – fire has swept over large areas, in many places seriously injuring the soil. Relatively less logging done in this section than rest of State due to lack of transportation facilities.

P 523 –524 specifics on Poplar River – has been used somewhat for log driving, two dams on the river, one located 2.9 miles above the mouth and one at 5.6 miles above the mouth.
P528 – some discharge info for Poplar – gage height and discharge measurements, mentions again the artificial control of dams – notes that the nearest dam is owned by National Paper and Pulp Company
P533 – dam elevations at foot and crest
P544 – interesting notes on legal authorities of dam building – state jurisdiction/federal rules etc. Notes that Minnesota dams usually built by corporations.

27. Survey records in the county courthouse

27a. County surveyor records – Axel Berglund – 1915 made a simple drawing for a Grand Marais/Lutsen "road"
County road is shown on the east side of the river, data entered appear to be pretty simple compass coordinates along the road, ending on the east side of the river at the dam

27b. 1859 Public land survey records – June 8 1858 and July 11-17 1859 field notes show some river crossings were measured in links – a surveyor link equal .6 foot
Most of the trees called out by surveyors were birch, spruce, fir, some cedar and sugar tree (maple)
River widths along the section lines where the river was crossed vary from 60-75 lks to the widest at 200 lks. Other note – river generally 150 lks wide, extensive spruce swamp in sections 3,4,9,10,16 and 17 and river runs through this swamp area.
Drawing is interesting in that there appear to be tributaries on the west side of the river

APPENDIX G: INTERVIEW TRANSCRIPTS

On December 1, 2009, three Poplar River watershed residents agreed to an interview with two members of the U of M team. All questions were prepared and sent out to participants prior to meeting, with the exception of one interviewee (An email account was not known for George Nelson at that time, thus questions were provided during the interview process). The U of M team would like to thank each participant for giving their time so graciously and helping with this process. Additionally, each interviewee was asked and agreed to public presentation of the transcripts presented within this document. For historical purposes the interviews were invaluable.

Interviewees: Jim Hall, George Nelson Jr., Marlon Hansen

**The U of M team would like to point out, spelling of locations, persons or businesses referenced within each interview if not asked directly, may not be correct. We did our best while transcribing and apologize for any misspellings.*

JIM HALL

Note: Angie Gorham (A) and Danielle Dutton (D) interviewing Jim Hall (J).

D. Do you want to introduce yourself, tell us about your background a little?

J. My name is Jim Hall; I've lived in Lutsen all my life, 76 years. I've been involved with logging most of my life, I was a logger, and then I spent about 10 years as a County Commissioner. And then now on the Soil and Water Board, Cook county soil and water board. And in between I was the president of the MN Timber Producers Association for couple years now. I've been on the Arrowhead Cooperative Electric Board for 15 years, so I've had a lot of things that I've been elected too.

A. It happens in a small town, when you're involved in everything.

J. Yep. So. And of course I've been married for 53 years.

J. I was looking at one of these old books, “Pioneer places” and I see where when I was in school and we were planting trees north of Grand Marais in 1949, I'm in one of the pictures. Yeah and logging and as far as it’s been, mostly all the logging I did was in Cook County, some in Lake County. And I logged in the Boundary Waters Canoe Area for a number of years.

A. What years did you do logging?

J. Well let's see, 1976 when Miles Lord (Note: name hard to recognize on recording) kicked us out of the Boundary Waters, we were up there north of Kawishiwi Lake. And uhh... but that's all that was uhh... that was quite a few years ago, prior to that I logged for Consolidated Paper Company for many years. Which is now, I guess part of that company is New Page in Duluth. They actually built that mill, and then they were sold out to some sort of holding company.

D. So did you ever do logging in this area?

J. Yes. I did up around Lund Road, mostly farther north than this. I did a little bit up towards north, by Claire Lake, and north on Christine Lake. Which this is Christine Lake here, so I was up in there, and I was further in there. And uh, I've done some logging in there over the years. And there is sort of an interest in here in the 80's, and there was two of us that were up there, traveling.... This is north of Claire Lake.... And then the other one that we ugh, had a page or two was Leo Shultz, and I don't... on the Gunflint... noo. And it made mention of logging on the Poplar River..... Its right here, I just have to... Yeah it actually is where I think he was logging on the Poplar River, was way in the north end near up towards the railroad grade, it was just one or two pictures of him in here.

D. Who was logging primarily, in that you said he was logging up north, or we?

J. No most all of the logging was done up in the northern limits, because down in the lower edge, you know down in the lower edge, you know the chasm here, along the Poplar River I don't remember any logging going on there, except maybe a little bit through the Nelsons who cut some scattered pine and spruce, when they had a little saw mill of their own. And some lumber for the resort.

D. Just for fire?

J. No. No it wasn't for fire, it was for rebuilding after the resort burned down. And then they rebuilt it and I think they sawed a lot of their own lumber for that. And then I know there was logging on the west half for the golf course, some select cutting. They didn't do any clear cuts. But that would not be in the Poplar River watershed again either, because the west part of the golf course, you know, you get over in here and then it actually runs down a different way. It actually runs down in a different way. It would be of interest, I think someone was supposed to look up for you when that burned, the fire. Because that canyon is mostly what I refer to as fire birch and its thick birch that comes in after fires. Except for right now of course it’s dying'. If you have some forestry background you know that, that stuff lives about 70-90 years. And that it dies from old age.

D. Do you remember when the fires were?

J. I would think they would have been around 1920s in that area. I would guess it was in the 1920s.

D. So you're saying judging by the age of the birch now, that they had to of came at that time?

J. Yeah. They would have to be back in that time. I've seen some old pictures of Lutsen resort, and there isn't that many trees around.

A. Oh yeah, I think that one was in the 40s when they had to rebuild the resort, twice. That was in the 40s, were there some before that too?

J. Yeah. The 40s were probably the first one, and then it burned again about 10 years later.

A. It was before your time, but just wondering if you knew anything about this, it was something called the Lutsen Lumber and tie company, I think it was. It looks like it was something that was only around for 2 years.

J. Yep, it's in this book here (Minnesota logging) – flips through pages...

D. I think it's the same one we have...

A. Yes I think it is page 23....

J. You have it?

D. we have 2 copies.

A. not as pretty as yours,

J. Oh mine was in a bookcase. That's out of the library I assume, so you have that, and then the former, forsaken locomotive on the shore, for 20 years...

A. I thought that was interesting, that they just left it there.

J. But prior to that, you know you're talking 1910, and 12. When there was any, and then of course the trees were... still a lot of years since I've been up there, there, there were still whole logs that were lying in the dead waters above the falls. And so there are still some logs. So I don't think they sawed very much of it, just a few loads and that's about all that they ever cut up. Well I'm glad that you've got that book.

D. It's been a great resource. And this book we have as well, this one about Cook County, I've read this one.

J. Yeah you've read that one too? 'The Pioneers in the Wilderness', yeah.

D. Yeah what do you have marked in here?

J.I just uh, a few things, a couple of things that were referring to north shore settlements. And that, if you have that it would be on page 77. And you might find some stuff in there you want to look at. And then I marked … how they changed the post office, and that was in 1890, from Redmeyer to Lutsen, and that's some of the history of it.

A. Was um, sorry to interrupt, but Lockport, was that part of Lutsen, or was it separate?

J. Yeah Lockport has always been called Lockport, the store and... but its Lutsen. And then there was on pg 121, on the bottom of the shoreline. 'Forest also helped to shape the history and daily lives of settlements and land which was cleared for cabins, built garden and crops and some other logging was under before the century ended. Small saw mills were started'. You know go on, if you have this you can … there's the Lutsen, Schroeder, Tofte, and all of that stuff here... but as far as logging in the lower reaches of the Poplar I really don't think there was..

D. The land is so steep.

J. Yeah and you back then you gotta remember with horse, and horses logging.

D. I read in this book, or maybe it was another railroad book, they were saying a lot of logging occurred near the railroad because that was the easiest way to transport to the railroad and then get it out. So that would make sense that it occurred more north.

J. That shows all the different, but I don't think there was any, the railroad, here was to get the lumber, there wasn't shipping logs out of here it was shipping lumber. And the lumber it was sawed and floated in, I suspect it was floated in and ya know, it was sorta like a lake dead waters and probably floated in close by.

A. So you think the logs were just from the upper reaches?

J. Yep I'm sure they were all in the upper reaches. A couple of logging took place, John Bursack (Not sure on correct spelling) later it would have been in the early 90s some private land, 80 acres. And then another one Tom Lovedoll (not sure of name, didn't get verification), cut some in section, I believe its section 60, but that was all up above the dead waters of the Poplar River. But they didn't log up to the river, they didn't log to the river, you know they always left a corridor and... That was probably the first of any clear cuts that took place up in... Mostly aspen.

D. Do you mean the 1990's?

J. Yeah, 1990s. Early 1990s they would have been up in there.

A. Ok, um you said that they had a sawmill? The Hansen's, uh no the Nelsons.

J. They had a small sawmill, just for their own use.

A. where was it?

J. I don't know you could ask George Nelson. He might have some pictures.

D. Oh one thing, I don't know if you know a lot about the lower reaches of the watershed, we were up at the historical society yesterday and were shown pictures of where the old bridges were. She said that there were 3 bridges that used to cross the Poplar. I don't know if you know anything about that?

J. Well there was one bridge that crossed the Poplar, the first one I know of. It crossed the Poplar above the ski hill. Yeah and that was a high, high bridge, with steel beams across. That's gone now. And there's another bridge that is still in existence that goes to south, of the near the waterfalls up there, and that goes west and now it was a homestead in there.

A. Is that the one that is blocked and you can't drive across it; it's just a foot bridge now?

J. Yeah they call it a footbridge. It's pretty old and decrepit. Have you been up to it?

D. Yeah we have

A. Well I don't know if it's the same one, the one we've seen is still in pretty good shape.

D. I think he means it can't carry a big load.

J. Yeah and I know that they the ski hill they drive their ATV's I think even their snow groomers. I think they even cross with their snow groomers up there too.

D. So you only remember 2 bridges, is that what you're saying?

J. Yeah two.

A. Do you know of any other, you know where the sawmill was, but anything that would have been around the river that may tell us where the level of the river was? Past point in time, like old building foundations or any of that stuff?

J. No. the only thing that may have some.... One thing you mention in here about, what was it... Wayne Henchy for the county, he did water surveying for the county and all that, ah benchmarks, he may know where there are some benchmarks you know along the river

D. How do you spell his name?

J. Wayne, 'w-a-y-n-e', I think it's 'h-e-n-c-h', its either 'e' or 'y'. You know Karen Evans? That's her husband.

D. Oh she's been really close helping to get stuff done for this project.

J. There are footnotes; I would think you could find some footnotes on the original survey at the courthouse. In Grand Marais, he probably has some on them too that he's pulled out. But you should be able to find some.

D. I guess we figured we could just go to the historical society, and they would have that.

J. I don't think the historical society would have any benchmarks, at all.

D. Ok. Is there anything that you had...?

J. Well you had any notes or photos, and all I've got are some of these books and stuff. And ugh. Well I was never a skier, downhill, but I did some cross country but not up there, we've got ski trails right past our house in Lutsen here so. One thing you were questioning about, did I ever notice any years back, and when they cleared the hill they just bulldozed everything off of it. And it got to be some years before anything grew back, and it'd be a year or two before you'd see any grasses and stuff ya know. They are doing a much better job today then they were, then it happened in the past. In fact even George Nelson, he started it about 1960?

A. The ski resort? The first run opened in 1945 I think.

J. Really?

A. Yep, there were only 2 runs. But I don't know how quickly it progressed after that. I have construction that started in 1945, and two runs opened on Eagle in 1948. And Mystery wasn't developed until the 70s, and Moose wasn't until the 80s.

J. By the chalet, in that one gulley, down through there every spring there used to be big wash outs. By that bridge, you know?

D. Where they just put that bridge in?

J. Yeah it's ah; it's the bridge going up to the chalet. and down there used to be, that's the one that was very noticeable in the spring there'd be big gulleys that rushed out, and of course everything goes down to the river ya know.

D. Do you think that's why they built that, they straightened the road?

J. No the road originally ya know, laid around on the outside, no that was done so they could run the ski hill, ski run, they call it, it isn't the bridge run. I don't know...

A. Yeah but the ski building goes right over that bridge...

J. Now they go right under the bridge, they ski under the bridge? From up on the hill up on to east and they go down through there. There's were they've done quite a bit of work

this year too, putting in a new building and stuff on the west side of the road. There was a new. I don't know what they're using it for, it's not a condo or. Probably, well I think they put in a new ski lift in there so ah. You're wondering about the gullies and stuff. I don't know that, them gullies have probably been there forever you know the steep eroding banks. And from what I understand, and I seen some pictures of now from where they've done surveying around here, there's actually 3 channels, the mega slump you've heard of that, you're familiar with that. And ah, you can see it if you go up there and look at it. You can see, I've been up there and looked at it, where the river is gradually working in, its meandering. And the river is meandering, they all do that. But yet from what I understand there isn't a percentage of silt going in from them are not that great, you probably the last that I've seen that, the university what is it the main one, that the older guy, and uh what they've been doing, they walked the whole river.

A. I actually...

J. You walked it? Well ok. And there you can see the slumps. They put those weirs in there, I guess those rock weirs that pushing them away, and I think that they'll work. I'm sure that they'll keep it and slow down the slump. But they're still looking at 65% of the silt is coming off of the ski runs. And you can understand that because, you know you don't have the tree cover. Originally it was all covered, and that's one thing with logging is that it's a short period of time before its reforested again, nature does a good job if its reforesting if it's not gullied or anything, and most of the logging up in the north was probably done in the winter on frozen ground and snow so you don't really rut up anything and get deep ruts or anything like that. And prior to that in the 40s it was mostly all horse logging, ya know...

D. The disturbance....

J. The disturbance, it just doesn't disturb it as much. I don't know, on Crescent lake on the south end of the lake, you can see, that's one of the headwaters to the Poplar, you can see on both sides where it's been built up like it's been used for holding water at one time, but that would have been back you know, in the 10s or 20s and I have no idea what the water was used for unless it was run that they wanted more water in the Temperance River. Because by raising that they pushed, they pushed the water into the Temperance River and that has been damned off by now, so the water can't go that way, so if you get a high ice load, it damns up the outlet, so it still comes down the Poplar River and ugh, and I know there was some logging in between Claire Lake and Christine Lake in a, 1940s in there, and that was some pine, because as far as close to lake superior there is little white pine and there never was any great amount of white pine down there. That was a couple of I guess you call them portable saw mills that were moved around to cut pine. They didn't clear cut the pine because you go back there today and there are still a lot of old growth pines because they there were a select cut type of thing.

A. Do know what year the roads were put in here? When highway 61 got put in? Was it in the 20s?

J. Oh, well I know when my dad and grandfather came up in 19-1 there was no road. And I suppose with the present right of way, as I heard it 1937 - but then there was some roads winding around prior to that too. There was an old bridge abutment above, it's on the Poplar River, and as you go north, you know they put that hiking and bike trail in there now, just north of that the old abutments are there from the original bridge, and that would have been probably in the late teens or 20s when the put that. And it was all gravel roads.

D. So you're saying in 1937, that as the first paved road?

J. '37.

D. That was the first paved road?

J. Well it was probably some parts that were gravel, but it was paved they were trying to put blacktop down.
A. And that's where the current 61 goes through right?

J. Yeah, yeah.

D. We were just wondering because, I was reading this book, you know, he talks a lot about from Duluth to Grand Marais, the road was built at different times, so we know that in 1923 there was really extensive road building but it doesn't say when the road was built specifically built for this reach, because they had to blast rocks and do a lot of different construction, that's what we were wondering.

J. That's what I remember my dad telling, about 1937 when they did the final. If you went passed about 3 miles down, and about a mile inland. The old, what they call the cascade beach now, the road that goes down and around, that actually is the old highway.

D. That's what I was wondering

A. And just a question, if you remember any of the construction on the mountains, or stories about construction on the mountains, or how they maintained slopes, those sorts of things...

J. They probably didn't' worry too much about back sloping and filling at that time.

D. What was your role as the county commissioner? Did you have to ok permits for construction?

J. That's one thing that's kind of misleading when you're on a county board. The state and federal governments have their own jurisdiction. And they do all that themselves. The county has no jurisdiction over what they do. County roads you do. But not on state and federal roads. It's like the Forest Service, if they want to put up a building they don't have to go to the county to get a building permit, they can just go ahead and do it.

D. So what years were you on the county board?

J. ‘91 to 2001

D. Did you, from your personal experience, did you see an increase in permitting during a certain time of your tenure on the board, was it really crazy in the early ‘90s, or did they ask for more permitting later, what was your impression?

J. They would have to go through, if they wanted to do something, they would have to go through the planning and zoning first, and get approval for that and then eventually if planning and zoning approved it then it would go through the county board for final approval. That's all that it was. And they would have nowadays, even in the ‘90s you would have to have slope and re-vegetate, and gravel pits, they have to be permitted each year and they still do that. There is one large gravel pit on the east branch coming out of Caribou Lake. Up here there's a....that would be in here.... I suppose it’s a... And that's still being used today. And it’s that opened area here, and it isn't really near the river and then it goes down and around and then comes down into the Poplar and then around to there. But that's probably the only close gravel pit; you don't have the roads going up. Or to what I refer to as the Tate Lake Road there's a number of gravel pits up there, farther north. But they're not on the river, you know they're federal pits. They have to get permits from us. Forest Service and then they purchase the gravel and the restoration has to be according to whatever the federal specs are and that so. Some of the private pits they have to follow county rules and regulations on it.

A. The grading on the slopes, when they cleared the slopes, you said it didn't really re-vegetate for a couple of years. Do you know how much of the slopes were graded so that they were flatter compared to what they were originally?

J. The ski hills?

A. The ski hills, because some of them we know are graded, because we can tell but we don’t have an actual number any records, do you have any idea was on each mountain?

J. No

A. Was that anything that had to be permitted?

J. Probably not, it’s more today that you. But I don’t its private land you're allowed to clear land without special permits.

D. We were just wondering, throughout the years, you can see that some of these, the ski slopes become more pronounced, maybe they become a little bit wider, so we were wondering if that was something that had to be permitted?

J. As far as I know they aren't doing that anymore. You know up in here, of course they tried to restore some of the gully, but hit rock, and deep clay, and then of course you have found that there is actually quite a bit of silt coming from farther north where nothing has been disturbed. I don't think there's... yeah there's I mean when you disturb that much area and its steep, where as the golf course is relatively flat. So it's natural that you're going to get some running in. and then there is one gully up here too, that's starting to form. I know you know just above papa Charley's restaurant.

A. The one by Ullr?

J. Where they put that tight line in? I know that one had some really the last few years had some really big slumps taking place. But I was kind of surprised because it's on the north side there's nothing really, there's nothing really that's been developed north of that. And yet there is a whole landslide that is sliding into that valley. But of course the reason they want the tight line in there is because they hope to build more buildings on the other side of the road. And that course, when you put roofs and blacktops in, you're going to get more much quicker run off, and they needed some way to collect that. Have you ever read the AUR? Have you looked at that? There was an AUR done for that ski hill ya know. When they wanted to put some more construction done up there. You might, could find that up at the court house at planning and zoning they have some copies of that, and see if you could, I don't think it's been permitted yet.

D. Well since you are a resident, did you ever fish on the resident?

J. Very little, I was down there with George Nelsen one time, and that was in earlier years. And there were brook trout.

D. Was it in the upper reach?

J. I've fished the upper reach, years ago, and there was brook trout.

D. Is there a change where you've just never seen fish down here,

J. The fish have pretty well disappeared down here.

A. Is that where you and Nelson fished?

J. It's been many years, I was fairly young, 20 or 30 years, I remember when we went we were fly fishing. I don't remember if we caught any or not. But if you go up the Poplar River I have to follow it around, it makes a big loop up here. I've fished a lot in here. Honeymoon trail crosses it up here. And these flow in from up on the side into the river. This lake, Barker Lake that flows into the river.

A. Do you remember any stories; say from your parents, that there used to be more fish around there, in the lower reaches?

J. Yeah I think there were more fish in the lower reaches. From what I understand there is too much, the silt is a problem, and also some of it was held up I suppose they put, if you remember there was a hydro damn below the resort.

D. Yeah do you have any idea where that was located?

J. Yeah it was below highway 61. You walk across a footbridge and you can see some concrete abutments, and that's where it was.

A. Do you know what years it was there?

J. I remember it being there into the 40s, they were using it. There was a concrete damn barrier. So I think fish had a hard time going over it. And it was a hydroelectric dam. And the building where generators sit, that's still there the building is there but there is nothing in it of course.

A. and this was to power the resort that was down by the lake?

J. Yep.

A. Oh ok.

J. It was just for light purposes, it was like a private power.

A. I was just under the impression it was for up on the ski hill for some reason.

J. No. no. I don't know when the saw mill was running. In fact up there at Niagara the Post and Tie Company and I wondering if they used water power, because they could have used some water power to run the saw mill at the time. But I really can't say for sure.

D. You were saying the Niagara post and tie?

J. Yeah the Niagara that would have been right there. That's where their saw mill was, the saw mill would have been. I don’t know what that clear area is for.

A. There used to be a homestead that's north of the ski resort. Would that have been the saw mill?

D. That could have been right here is that what that's showing

J. I suppose just right above that. See that that's dead water you could paddle a canoe right up through there.

A. Just don't go past it.

J. And they probably had, they may have had a little damn at some time. While they would want something to catch the logs. And then the bridge went across, I suppose that/s where the old road went in. there was an old field, Hedberg farm was in there, and then there was I suppose 160 acres and that was sold to the ski hill.

A. Do you remember any point in your lifetime, or your parents talking about, a point where river getting more opaque, or have more silt in it, about what time it was?

J. Getting more opaque?

D. When the river changed color

A. When it wasn't rain and it would get more brown, is that more recent, or has it always done that?

J. There was probably always been little bit down there, but during the spring runoffs you know, the high water, it’s going to create. I can't put a year on that. It'd be pretty hard for me.

A. Do you remember it changing in your lifetime?

J. Yep. And the other thing, is that sometimes, the ice dams create in the river, whether that ever happened before.

A. What do you mean by ice damns?

J. Well they pump water out of the river, they create a low flow going south ya know, for making snow, and when you do that the river has a tendency to freeze down deeper, or maybe to the bottom, and then I know there has been years, when they've had to dynamite the river. The ice build up and then they stop the damning and flooding.

A. Is that something that the county would do, or would the resort itself do this?

J. Well actually their water permits come from the state of Minnesota.

A. The DNR?

J. Yep the DNR. And I don't know, I can't say that they violate their permit, or how much they're pumping or not, but I know that there has been some question about lowering the water level to the point during the winter that it freezes down and you lose the aquatic life. So I think that's one thing where I can see where that's happened.

A. You were talking about dynamiting the damns, is that something that they still do? Or used to do, or how often?

J. I don’t know that they’ve done that in the last few years, but I know that they did it, and it’s not that many years ago.

A. When did this happen? … Sometime in the ‘90s?

J. Well yeah. Because I know we almost lost the bridge for the golf course, because we had all of a sudden all of this ice dammed up.

A. Oh wow that’s a lot.

J. So that's one, it’s a problem that comes in the spring and ya know and all of a sudden all of this ice starts floating down and backs up the hill too.

D. Is this something that frequently happened?

J. I can’t tell you but it’s probably not to frequent, but it does happen a few times.

D. So, who do you think the best person would be to find out more about the ice damn and dynamiting?

A. Was this after Nelsons time pretty much? So he wouldn’t know

J. Yeah, yeah. It wouldn’t have been when the nelsons were there. Because when he was there he really didn’t have that many ski runs, didn’t need that much water, so he probably wasn’t. Have you ever contacted the DNR about how much water they are allowed to pump out? And do you have any idea how much water they are using?

D. Yeah, they're about, I think it’s about, every year it’s been increasing; we only have data I think for 2000s. We do know that they're up to about 80 million gallons.

J. I think that’s a big concern because I think that also have been looking at the possibility of pumping out of Lake Superior through the golf course. I’m on the EDA so I’m on the golf course committee whether we’re pumping, were’ pumping at our limit. We originally have a permit from the river too. Way back but we found we couldn’t use it because we found in the summer when we needed the water there wasn’t enough flow that the DNR permit wouldn’t allow to take it out of the river during the summer months so we canceled it. The golf course does not take water out of the river anymore.

D. So how do you guys make sure? Do you have records?

J. Yeah we have the pump. You can [pump so many gallons per day, and then you can go by how many days you’re pumping and like in the summer we pump it into holding ponds, we have a lot of holding ponds up there. It pumps all night and then they can water and certain greens during the day. Mike Diddities over there at the golf course. And he’s a grounds man, and he probably could tell you exactly how much. Because I know we’re right up to our limit.

A. Do you know who keeps track of that for the ski hill?

J. No. I don't know. They would have to be one of their own up there, and do they have a record? I've often wondered with all of that snow, and all of that water they pumped over there. Now they claim that spring melt doesn't have that great of an influence on the river at a time, I kind of wonder when you have all of that snow…

D. Oh it does, when you're looking at hydrology, especially if you're looking at just logging, where the logging as occurred, it creates a discontinuity, it changes the timing. So what we will see where normal runoff occurs, flows will increase and then decrease. But then when you have increased storage on the landscape due to logging or fields, they melt at a different rate and creates another peak. So that will all have very different changes on a landscape, especially a river that has to accommodate those flows. You may see more carving, out in the river, it can really change the river a lot faster over time without management occurring.

J. I would think so. You know, they said that it's really not affecting it much, but I still maintain that when you put that much water up there and you get a warm spring and the snow all of a sudden melts, you're going to increase that flow.

D. They are very lucky that they are near Lake Superior in the way that if they were higher up in the watershed, this could create large flooding areas. It could really cause a problem if they were higher up.

J. Where you have more flat ground.

D. Right, especially that, because it would just spread out over a while, whereas here it's so steep.

J. Oh yeah of course it's really confined into there, but of course it will go into some of those slumped areas, and then.. It was kind of interesting the first time, before they built these I was up in the Yukon in along the highways and up there, and I seen these weirs or rocks or root wads built into the river along the road. The road is right on the river banks, and they had these rock jetties that pulled the water and forced it away from the road so it didn't carve out the road.

D. Undercut it, and then it fails and you don't have a road.

J. Yeah it was sort of interesting to see that. I stopped and had a look. And now I, of course it must work because the road isn't washed out.

D. Well yeah, as long as you can decrease that flow and the pressure, then you won't cause so much undercutting. I mean even if you go down to the mega slump you can see that it has helped create a little bit to deflect it.

J. It’s going to help, it’s going to help.

GEORGE NELSON

Note: Angie Gorham (A) and Danielle Dutton (D) interviewing George Nelson Junior (G), additionally Mike Larson (Mike) joins later in the process.

A. I don't think I sent you questions right? I don't have your email to send them to you. Well a lot of what we want to do today is just to find out about any changes in the Poplar River watershed that have happened that would have caused changes in the river that added to the sediment load or any of that sort of thing. So obviously the ski resort has changed a lot of the landscape, and you probably know a lot about that since it was your idea to from what I've gathered, to create the ski resort, right?

G. Yes indeed.

A big part of our conversation, it’s not supposed to be too technical, there are a lot of gaps in the data, and we were kind of told that a lot of information and good resources are anecdotal. We were wondering if you know we were looking at road construction, logging, railroad, logging, the Lutsen tie... Lutsen Tie and Post Company. We heard about ice jamming (whether with dynamiting that may have occurred). So we are just looking for any information.

A. I can read the questions that I sent to the other guys.

G. Sure

A. Questions were: Do you believe logging influenced or altered the river? Do you know of any old benchmarks might be, such as a survey point that might help us locate where the river channel was in the past? We have heard there was an old mill on the river as well as hydroelectric dams; do you have any memories or documents about these? Do you have any old notes, maps, photos or other documents that reference the river elevation or the area around the river? What changes have you noticed in the river and the bluffs and gullies within the watershed? Do you remember how the slopes were originally cleared for skiing or how maintenance was done on the slopes, if you have any pictures that would help as well.

G. Those were the questions?

A. Those were the questions we sent them; we have others that build on those.

G. Well of course I'm a 3rd generation. My granddad C.A.A. Nelson came to Lutsen in 1881. And as I understand it he was just a young man, a captain of a small fishing outfit working out of Duluth on the North Shore of Lake Superior. As he was fishing from this tug he viewed I guess a, possibly studied the various different rivers and the possibility of a home set for him and his hopeful to be family, and he needed a family that would provide shelter for small boats, small harbor of some sort. In those days as he investigated the north shore, he found the Poplar River, which in later years proved to be, I guess ugh, I guess it always has been, the river of the North Shore with the greatest watershed and consistent flow. That had nothing to do with his decision, his decision was because he could come to the mouth of the Poplar River and either dock his boats or pull them on a ramp of some sort. I think he did both. But I remember hearing just as a young man, was that the Poplar River had absolutely gravel as it presently has. It had no beach gravel what so ever. And the river was open so they could bring their boats right into the river. Where the first foot bridge and house is built is generally the area where they would dock or tie up their boats. I think they tied them up. And as I understand it the way they did it, the bow line would be tied to something out stream and the current would basically keep the boat safely upstream and away from the waves of Lake Superior. And there would be a line of the river that they could pull the boat up the side and then use it. That was just my assumption. I think it's correct with the stories that I've heard. What impressed me, and what I think changed the river forever. What impressed me is that there was no gravel beach at the base and so that has occurred since that time.

A. Was that put in since then?

D. No no it just occurred.

G. No it just occurred as I understand it because of the logging operation that you mentioned, I don't know. The what, was the name of that?

A. Lutsen Tie and Post

G. Lutsen Tie and Post . As I understand it they had a dock and port here at Lockport.

A. OK.

G. Is that what you understand? Or did you know that?

A. The only thing that we had heard about it, is that it had a 4 mile track and that it went from Lutsen farther north from the lake. And no other details really from that.

G. Well Lockport is where the dock was. And there was a real road grade. And I think it was complete with ties and steel rails, all the way up to the area above the ski area where it levels up. Where the river is level and forms a dead water. That's where the mill was built. That's where the old concrete abutments.

D. We wanted to provide these for you. I forgot to bring this up earlier. But just in case you needed to visually show us, or if it helps to see the watershed, this is the close up of the ski slope and golf course, and this is the lower reaches of the Poplar watershed.

G. The area that I'm talking about now, is way up here at the end of this rather dead water area.

D. Its right in this area?

G. That's correct, there is an old steel bridge there now.

D. OK

G. And just above that, there was a young man. There was a whole many acres of logs floating in the river and the log damn was just logs that were chained together that would keep the logs from flowing down. And these logs were what the mill would have to provide its product whatever that was, which in turn would be put on this railroad and trucked down to Lockport where there would be access to lake superior. It's approximately 4 miles like what you've said. And to make this all work to have enough water flowing down in the spring of the year so that the logs that were harvested during the winter could flow to this damn they had to have the operator, the logger, had to have the river run rapidly to float the logs. And to do that as I understand it, they dynamited the river. And dynamiting the river as I understand it took out the big boulders out of the center, just made it so the water would rush in a sluice way, to where the trees were harvested all winter and flow down to the high water spring melt down and come down to the mill down below. And my dad and my grand dad said that is what made all of the gravel at Lutsen resort now. And changed that setting forever. Far different from what it was when they first arrived in the mid 1880s. I believe this was in the 1900s or 1901. I think it would be easy to check the record both the cook county news herald (or whatever preceded that) or the newspaper in Duluth because the principal behind this logging operation, was I understand murdered the first day he operated, and he was in a hotel in Duluth, that's the story I heard. And with that, the mill was shut down; the logs were never processed, and never put on the railroad and never shipped down Lake Superior. And the belief that I have and I think others locally that know this history is that's the principal reason that caused the mega slump, that everyone is talking about.

A. The dynamiting?

G. The dynamiting upstream. If you look for dynamiting below where the damn was, you won't see it. And that frankly for many years mystified me, when my dad talked about dynamiting the river, and as a kid I would walk the river and fish it and saw no signs of it. so finally it dawned on me, that they didn't have the dynamite that part of the river, they had to dynamite the part of the river upstream of the where the damn would be to facilitate floating the logs down at high water. And I think that's what happened. I have not investigated upstream to see if there, to see where that was done I just assume it was done. And when that happened the river would flow heavily I'm sure, and start

undermining any part of the shore that was exposed. And the mega slump was the major undermining of the shore which occurred. It must have had a huge amount of turbidity at that time and I think it continues to be. The water washes in from that mega slump and picks up dirt and flows downstream. Above that I don't have an answer. But I would guess the dynamiting above it created erosion above and that also created turbidity above this point.

D. So when did you start working on the ski slopes?

G. Oh 1948.

D. Was it your property at that point, or were you just working there?

G. Our family owned the property, I owned some of it, my dad owned and we owned it together

A. For what we understand there were 2 runs open then?

G. There was 1 operating, then first then 2, I think there were 2 runs the first year, we added a 3rd run the next year. And these were all cleared by hand.

A. No bulldozers or anything?

G. No bulldozers at that time. And no chainsaws at that time.

D. Where were the first slopes, I don't know if you can see it well on this map?

G. I know it pretty well

D. And so in 1948 is when it first opened?

G. The winter of '48.

D. OK.

G. OK, it was what's called Harry Carry. I think that was the first slope and then the next year, Chickadee was opened and they both operated through 1 rope tow assisted by pulleys which we found was not very satisfactory because it couldn't handle very many people.

D. True.

G. And the next year a second rope tow was put in. We cut the slopes acting against erosion. Because erosion is deadly to a ski area.

D. We were just asking where the first ski slopes were put in and where?

G. These were cut off as low to the ground as you could with a cross cut. Usually a 2 man cross cut saw. Basically only an inch or two above the soil and you use gloved hands and get the dirt away from the tree. Saw it down and leave the stump which was only an inch higher or so, to prevent erosion and I guess bulldozers were available but we didn't have any at the time. And then we also tried to leave trees to prevent erosion from wind. Wind erosion on snow is horrendous. The Wind comes in from the east, or south east, or northeast, and is followed by a high wind from the northwest. And even though these slopes would have 12 or 18 inches of snow, you had to have it packed down to prevent the wind from blowing it off. And you did this by keeping trees in key spots to try to keep the wind off of the snow. And we improvised some portable snow fences which were kind of Mickey Mouse and they did work. With high cost of labor and that sort of thing. There was no, we had no snow cats as there are today, in fact no snow cats at any time. We'd ski pack to pack the snow, or in some cases snow shoe packing, snow shoeing back and forth. But it helped to keep the snow. That's just the way the ski area started.

A. Did you guys, we saw something that you didn't have snow making right away but would shovel snow, how did that develop?

G. There would be bare spots, because there really isn't enough snow without snow making to facilitate much skiing you'd think there is when you see the woods full of snow but once you open the slopes up and the wind gets at it, it takes it off. And also the skiing preserves the snow and packs it down and makes it firm. So to be at all successful you had to conserve that snow. In many cases there would be moguls as we know them today, and there would be bare spots in between moguls or thin spots. And we'd have men that would shovel snow from the deep snow into the shallow snow. Much the same as the snow cat today. And that would have to be packed down. Sometimes the back of the shovel would pack it down and freeze and help make it stay there. In some cases we had a fellow, a laborer who was a great guy, he would actually take a wooden bushel basket fill it with snow out in the woods where there'd be ample snow out in the woods that'd blow out there and drift, carry it back dump it on these spots that were thin or bare,. And that's the way ski area operated until snow making, snow making came in around 1964, 1960s.

D. At that time did you have more than just Harry Carry and Chickadee?

G. Well actually at that time we had 5 rope tows and Ullr, you know the runs, Ullr, greasy gulch which is no longer there, bridge run, upper and lower bridge run, Logan, after Logan David,

D. And that was primarily in this area?

G. Also up here and down to the river. But none of this. Mystery Mountain was built around 1948 or 1949 with a pull lift.

A. At Ullr, at Mystery?

G. Mystery

A. You said that was in the 40s?

G. The late 40s I think. The first lift on bridge run was also a poma lift, there was a bridge that to take the skiers across the road, and a bridge to bring them down as skiing down, much as it is now, they don't need a bridge now because they have a chair lifts. So we had 2 poma lifts, and about the same time we put a t bar lift on hairy carry and cuckoo.

D. Did you have, there are some cross country ski trails around the river, did you have any of that?

G. We had quite a bit of cross country on both sides of the river it was all from the higher elevation to the lower elevation. I don't think anyone ever went from the lower elevation to the upper. But this would be a pleasant way to end the day, a half hour, hour before sunset, a group, usually not individuals, a group that went to ski down the resort. In those days we had a shuttle bus, rather than taking the shuttle they'd ski down.

A. So, then Mystery was starting to be developed in the 40s, or just the lift was there?

G. The runs were all put in along with the lift in the late 50s. I think 58 actually. Which Mystery mountain appeals to some people and not others because it's relatively long and relatively flat and only the lower parts are much more challenging. But what it did do, it served people who wanted to take a longer run, it was the longest run in the Midwest, perhaps it still is, not quite … might be longer. But it would take quite a bit of time to come down, so if we had a peak day and the lifts were maxed out, people could go up and it would accommodate a greater proportion of skiers than other lifts might.
A. and then, Moose when was that developed?

G. After 1980.

A.OK

A. So you guys when you did the clearing originally, they just chopped it down so it had a very small stump so you could just go over it, did you continue to do it that way the whole time you were there?

G. No we used bulldozers and again being very aware of the erosion because again it's very deadly. We put water bars. A water bar is a small ditch that runs across the slope to drain the water off. Many people feel that you dig the dirt off of one side and lay it down hill. But you have to have the bottom of the trench lower than the ground level because the soil put above the ground level just washes away. So great care was use to put in the water damn. And immediately after a slope was completed by bulldozing we would seed it and put hay scattered around. And the seed would have rye, so within 10 days there

would be vegetation. We were very astute and I think successful. I don't really know of any erosion, there might be a ditch a foot deep, but basically nothing. I don't think it had any varying impact on the water of the river. I think it had zero.

A. I was just wondering, we had noticed some of the slopes have been graded

G. Have been graded?

A. Yeah so the slopes are flatter, did you guys do that when you built it, or was that later?

G. A lot of work has been done on the slopes since we had it. Say 29 years.

A. You guys sold it in the 80s?

G. 1980. Other people know more about that than I do.

D. Were you guys involved in any grading when you owned it?

G. Well you grade it when you're building it, contrary to a contour. Required and of course when you design the run or cut the run you try to figure that in, so there's natural ways for the water to run off. So you that you wouldn't doze out. Leave the vegetation in and I think we were very successful in water erosion. We became successful in wind erosion as we got smarter.

D. One thing that we did hear that was really interesting. Is that the water in the Poplar would create ice jams and jam it up and there were a few instances when dynamiting had to occur to decrease the increased levels in the River.

G. I don't think in my lifetime there has been any dynamiting. I don't know of any. I've heard of people talk about dynamiting rivers but never the Poplar. I don't think it ever happened.

A. We had heard actually, it was probably after the time that you had owned it. But just when the ice jammed up...

G. I really really doubt it. I don't think it really ever happened. Do you know mike?

Mike. I don't think so.

G. There's no reason to do it.

D. We were just wondering.

G. I remember hearing, being at the resort hearing it roar coming like a freight train coming down right on top of you. The ice had broken loose up above and was coming down that narrow gorge on the highway bridge; I mean it really gushed down. It was not

dynamite, nature took care of that. And people would inquire what areas along the river were in danger of high water. I always said the answer was look on the trees and see where the ice might have..

D. Markings

G. Marked the tree which you don't see very often but once in a while there's one area where the water was this deep and this deep. And high water occurs I think only during ice and the ice damns up and it occurs.

D. When you were designing the slopes, do you have any benchmarks of where the water was? Do you know of any good spots?

G. Never. The level of the river had no effect on us.

A. Do you know of any benchmarks on the river? Say the old hydroelectric dams we found about where that is. Does the mill still have any foundation?

G. Down by the highway bridge the DNR had a small damn maybe about this high. And they had a little building that you might still be there.

D. Where was that?

Mike. Above the highway bridge

A. By the bike bridge?

Mike. Yeah up a little bit

D. So in this area?

G. I don't think it's there. It's right about in here. When I was a kid I can't remember why I did, but I, but I got paid about a quarter a month or something. I think what I did was I had to wind a clock and that recorded on the paper the level of the stream

A. Oh yeah and it has a pen on it...

G. And I think what happened they had an underground pipe coming out to the building it had a float in there and the damn out there in the front that stopped the water, that would be DNR. That record is someplace.

Mike. The DNR records go back for a long time.

D. I think they went through a process of stopping and changed locations

G. They had another station, below the highway above the damn there which was used for the hydro operation that one was on a cable that went across. Maybe it's still there. And somehow they would use the cable, and go down to the level of the river and meet upstream from this damn and the hydro dam.

A. You said that when you were a kid you used to fish on the river and whatnot. Do you remember when the decline of the fish happened, and when that changed?

G. Well I guess there's not an instance when that really happened.

D. Well OK a better question is what kind of fishing did you do? Did you do it in the upper reaches, or maybe down here?

G. Only in the lower part of the river.

D. What kind of fish were you catching.

G. We catch brown trout, and a few speckled trout.

D. Do you haven't seen any decline or an increase?

G. Nobody fishes it. Haven't seen anybody in the last 10 years.

D. We've heard about the upper reaches having some good fishing up there.

G. Down below there are some big fish. I mean about like that. I only caught a few but I broke one of my rods trying to catch it. Almost always brown. My dad was a fishing guide in his youth for a while. He always said, if you want to catch brown trout you have to fish before the sunlight hits the river.

A. That's why I'm not good at it.

G. That's why nobody goes out there. Nobody's in there fishing you have to be in the summer up at 4 o'clock fishing by 430 and it's all over by 7. Some go fishing by 9 or 10 and by noon they give up. I'm not convinced there aren't any in there. I don't know.

D. Have you ever noticed a change in the color of the river.

G. Emphatically no.

D. So from your earliest recollections...

G. It always looked like coffee. From the iron ore up in the range and its vegetation. I was not aware of
The word turbidity until about 5 years ago. It's always coffee colored.

D. Even compared to the other rivers

G. There always the same. I mean you people know more about this than I do.

Mike. Isn't it from the tannic acid of the Aspen trees?

A. That could be part of it. I mean there's turbidity in the river; whether or not it's changed we are trying to figure out.

D. It's important for us to ask out about fishing, and about personal recollections because the sampling is really sparse. We have sampling that goes back to the like the 30s I think or the 50s but it's of different time periods like once every 3 years somebody took a sample and we don't know if that's during a high level or during a storm or not.

A. Obviously during a storm, I mean we look at pictures. I've been here on days and it's nice and clear and I've been here when it just rained and there is brown spots coming in the water.

G. After a heavy rain it seems the most turbid. Like a mile and half down the road I live half way there. The currents makes it run counter clockwise and there will be a just a brown strip of water about a quarter a mile wide but that's not uncommon for all of the streams. I mean they all kick this stuff out and its all into Lake Superior. And in that way I think its creation I think.

A. And I know one of things as well, is they've been talking about turbidity, is that they are also trying to determining, trying to do a study on determining whether the current regulations are appropriate for streams up here.

D. I'm sure you already know this. That the state of Minnesota has pretty much 2 types of turbidity, either have a trout stream, a trout supporting stream then you have a more stringent turbidity so 10 NTUs. If you have a regular stream let's say southern Minnesota its 25 NTU. The whole state abides by it regardless of the processes that created these lands so we're in an area where there is different soil types then there are would be in southeastern Minnesota, so is that OK that the 2 places have to abide by the same rules. So, that's the study that she is referring to is that they are going to look at the whole state, and say if I'm in the red river of the north is that be the same as if I'm here.

A. And so it's important to for us to connect all of these things and have people who remember, and ask has it always been like this or not?

G. I don't think there is any change. All of the years has it looked like coffee all of the years after a rain? Its brown water for a quarter of a mile about 3 miles down the lake. And that happened before the ski area. I really think the ski area has very little effect. When I was there wasn't any. And I think they've' done a good job with their water bars and drainage and I don't think there is any effect I really don't. It almost makes me angry all of this fuss. And it's all because of that logging in 1900 the dynamiting of the river

which washed the gravel down to the Lutsen resort filled up the basement where they used to dock their boats. To me it's just black and white. And I think there are people that don't wanna hear that, they want to blame it on somebody blame it on something. You can blame it on that guy who was murdered in 1900 or whenever it was. Because he had the stream dynamited before that I would guess the stream was much the same. Because the megaslump has been there forever. And the water rushes down in spring, the dynamiting the river created more, proven by the fact that the gravel is in front off of the river where it wasn't before. So now we have that and I think a new … and it's been like this.

D. Have you seen changes in the rock types down at the beach, the gravel beach, was it always the same type, or was it, now are you seeing larger rocks

G. I think it's forever been like this. When I was a kid we used to skip stones and you can go down there today and skip stones the same way I don't think anything's changed. They're all round. And you know what happens the lake washes them back and forth I guess. And the gravel comes down the river round and for some reason, not big square chunks its rounded rock.

A. On Mystery and Moose Mountain there is a ravine that runs down it that they've done some work on. Was that there when you were...

G. Between the two.

A. Was that there before.

G. Well sure that's a natural drainage

A. Was it about the same size then, or has it grown do you think? Or have you not been up there?

G. Well I have, but I haven't studied that. I mean. If you go in there and look upstream. Maybe you know something that I don't know but there's nothing to have changed it. It's fully vegetated, it's a rather steep little ravine I've hunted some deer on it, I've walked it, I've snow shoed it. And I know where that peninsula that sticks out of the stream. There used to be a residence in there. Did you ever know that?

D. Where was that?

G. I can show you pretty exact. OK, where do you think the drainage is in between the two?

A. This is the ravine

G. Between Mystery and Moose, I can tell you exactly where it is. This is the peninsula north of the ravine that was you perhaps might find a little clearing. I don't know how it

relates to the road but let's say it's about like that. The old log still lying in the ground where there was at least 1 or 2 building. And if you're asking me if that changed. I'd say elementally no. I'm not a student of it but what would make it change? This? No I mean you've got a little bit of drainage there, this one coming down.

D. Can you draw on there where you, I think I can see what you're trying to show, you're pen might be a little better it's a marker.

G. No mine is ugly. OK this must be the drainage. I don't see where it goes into the river.

D. This is a 2008 picture so things may have changed

G. Oh no. I don't see where, it looks to me like that. Like that's the high ground, that's high ground and that's low ground. I don't see how it goes down to the river I don't see that. But if this is the high ground I would say the old buildings are about there. There are also other old buildings that I'm sure you've found. Right there and still another one. Another one there is an old road that goes up here to the headwaters.

D. What was this building?

G. That was a hunting shack; I think it's perhaps still there.

D. Is this is the original area, where were the original hunting shacks of Poplar Road. I remember reading about those, do you remember? Where they used to take hunters, you're grandfather...

G. It's called the Moose road. And actually this is it right here. That's the river there and this is it.

D. Alright.

G. And this is it. Here it circumnavigates and...

Mike. We found some ties out there - George remember?

G. Pardon me

Mike. People found some old road bed ties, right in here.

D. I've been reading about it extensively in that pioneers of the wilderness book by Raff.

G. It goes basically like this. If you go back there and study it you can see where the ditches were and where the road was leveled in fact I have often thought for a hiking trail that goes 18 miles back to Sawbill Lake. I think it could still be followed. I'd be interesting to have that built it would make a great hiking trail. That was the main access

from Lake Superior to the inter forest. You can find the old trail there through several places through the golf course.

D. I think right in here where you were saying the ravine goes?

G. OK let’s see here

D. I was just marking what I could see right here.

G. Looks like some drainage here too.

D. Yeah that goes into that, feeds into that

G. Have you explored that area?

A. We've walked the ravine, from where the road crosses it all of the way down.

G. Tell me, (points to map) where have you walked? In the railroad now?

A. No the road that goes through where they have the culvert now.

G. You mean one of their service roads?

A. Yes

G. I would guess this.

A. I think that's it but I'm not sure.

A. We've walked all of the way down to the river. And we walked a little ways up but not all of the way. But I don't think we've got to this.

Mike. That's the gondola so you probably did

A. If that's the gondola then we definitely did, so maybe a little ways past but not too far up.

G. Over on this side there's also a slump that most people don’t know is there. I don't think it affects the river at all.

A. I think we may have found it, but I'm not sure.

G. Lutsen skiers have gotten over there and hacked it, about 3 turns on a rather steep slope because there were no trees it was void. I don't know I guess it was void because it was slick.

D. This is where Moose road was? Closer to the river?

G. I think it’s there... and over..... It started from here, and again

D. It probably took that trail right here.

Mike. You took the service road probably

D. We were asking where the original Moose road was with all of the hunting

A. We've driven all over the service roads...

G. You should have came to me first. I would guess that this is it here.

D. Somewhere on this trail, they had the place where the people would stay?

A. No. that was somewhere up in the wetlands, correct?

G. No way back in here, this trail goes 18 miles it could be anywhere back there. And actually this trail branches off and I don't know where that was it goes off to the northeast. And they had their Moose hunting trail. But this was the main artery.

D. And this was one of the main roads built it Lutsen going north, right? Its, in the Pioneers of the Wilderness book, He references it to sometime in the early 1900s; I think they were able to build north but I didn't know exactly where it was.

G. You can't really see here just lines in between these two hills. It’s in the lowest part of the valley and walk which perhaps you won't do. But, go to the lowest part of the valley go where it’s undisturbed by any ski area influence, I think I could pick it up; there's a ditch about this deep on both sides.

G. The story is that the old grand dad, I guess there must have been some talk locally or in the county about accessing the Gun flint trail. And he proposed a road from Lutsen to Gun Flint Lake which is due north of Lutsen by far the shortest. And politically it was shot down, and went down to Grand Marais.

Mike. You drive to Grand Marais and you drive all of the way back, and if you look at Lutsen it’s a straight shot.

A. Oh geez politics.

D. So is there anything else that you have?

A. Have you noticed any changes in any of the ravines or he slumps along the river, have those been there your whole life?

G. I think they've been there forever

A. Do you have any pictures of the development of the ski area, construction?

G. I'm sure they're there. But the best source is a photographer in Grand Marais who passed away by the name of M. J. Humphrey; somebody must have the old inventory.

Mike. Pat.?

D. We do a lot of research, but she didn't have any of the aerial photos on hand, or any construction. So the only aerial photos. There actually in the public domain if you go to the map library at the University of Minnesota, you can look at 1936? But they tend to be spotted on the landscape, it's a partial flyover, it seems that much of Cook County has partial flyover. I can look at a giant picture of the 1940 ones but I don't have the actual file to actually digitize, so there are some from the 60s and 1979, 1982, 1991, 2003, 2008 those are the complete fly overs. So we're always asking if you have even a small building that you have an aerial photo of, it really helps.

Mike. You should also take a look at, you know George right above river #2 bridge where the river splits. Now that river ran on both sides and then it was the storm of 7 or 8 years ago where so much debris came down, it blocked the easterly side of that river and it's just dry today,

D. Is that in the lower reach?

Mike. Yes

D. Yeah I saw that I actually digitized that and from 1991 to 2003 the river completely changes. Where it once went east in the same shape it now goes west so we were wondering what happened.

Mike. Yeah, that was a big rain storm that knocked out our bridge.

G. Likely that has happened in other years before. So it's just back and forth depending on...

A. We found a plat map from the 1870s of the area. So we digitized that along with the new ones from 1991, 2003, 2008 so it's really interesting to see the differences from all of the channels. We did actually; you can see the mega slump in the map from 1860.

D. It's really interesting, it's a confined valley type down here, up here is a little more low and can meander more freely although it hasn't too much. So when you get down here it will hit the sides and it will go back and forth that's something that just will happen. There are some really interesting turns in the river in comparison to 1860, and it happened from the top to the bottom of the river it's just changing. Well I don't know if

you have any others, I think you've satisfied all of our questions if there is anything you'd like to speak more about please go ahead.

G. She mentioned dams and hydro, are you aware of the plant down by the resort, are you aware of the years and that sort of thing? I think C.A.A. the founder my grand dad had this lodging resort that's growing from the 1880s, and I think back in 1918 the first drivable road came up the north shore.

D. I wanted to ask you that. Was that the cascade beach road or is that nearest where 61 is now?

G. Well over here. And way down here. County highway 34 and 35. Before that there was a road that you had to ride horseback up the trail. You can see the bridges over here as you drive along the highway.

A. What highways? 34 and 35?

G. I think that was what they called old number one. I think that's the first highway that automobiles came up in 1918. But with that the grand dad could see there was surge in tourism with up until then all came by boat, so there could be a need for more rooms and food service. And his genius or whatever he realized that the Poplar river there was maybe a 30 or 50 ft vertical in about 100 yards. So he built the damn above the second bridge which is now the dam is partly collapsed and then built the cause one... and two comstockgoing down into the building below. And that supplied electricity lighting, cooling, refrigeration, and could run furnaces for the resort and for the year round homes that belonged to his children which would be my aunts and uncles and at least 2 maybe 3 vacation homes, which is in those days strictly summer only. So there was a little nucleus in here that had electricity. I think the next electricity was at two harbors going west and Grand Marais going east. And I don't know of any in between. Maybe he was before some of them; I don't know when Grand Marais got its electricity. But that had a great impact on tourism in the north shore and the Lutsen resort in particular.

A. So he put that in, in 1918.

G. The resort ran on that power. No the REA. But what was called the Lutsen Light and Power. You got hat? By the name of Arthur Porter. He had Porter electric in Minneapolis. He came up and built a diesel powered generating system. And with that they disbanded the hydroelectric plant.

A. Do you remember what year that was?

G. I think it was 1940. So for those years the resort had an edge on its competitors. The rest of them had outhouses and lanterns. So there weren't many of them. But the resort had electricity.

D. So what year did the road go in?

G. It was built in 1930 and 31. I think it was paved in 32. It stayed much the same until the changes that are now being made.

D. Where was the old railroad line?

G. Well mike's lodging establishment is almost sitting on top of it. Mike is this you here. This is the parking lot here.

Mike. Ah yes.

G. Let's see. Just south of your place, this must be the little development. It would be there, and I think here. And then, again you can easily follow this there's even a road here that you can drive a car on.

D. Is that the Lockport railroad?

G. Yes. You know it ended up at a higher elevation now where the bridge is.

A. So it went through where the resort is now pretty much?

G. Is this were the road would have been Mike?

Mike. Yep I think so.

G. And this is where the mill is. You can still see the concrete abutments.

D. So what was the primary function of this railroad?

G. To take lumber from this point down to here, to be shipped on water to bring supplies up.

A. But it was never used because of that guy?

G. It wasn't ever used it was shut down the first day it operated because the guy was murdered.

A. We had heard that your family had a small sawmill that you used to get logs for the resorts.

G. And before the resorts too

A. Where was it, on the river?

G. No they didn't use the river. Logs were trucked in. it was right where number one fairway river has its mounds. There was also a horse stable there at one time.

MARLON HANSEN

Note: Angie Gorham (A) and Danielle Dutton (D) interviewing Marlon Hansen (M).

D. Would you mind stating your name?

M. Are you recording me already?

D. Yeah

M. My name is Marlon Hansen. I was born here in Lutsen, not too many of us can say that are left, they're all born somewhere else.

D. Oh, were you born in your home?

M. On the east edge of town.

D. Well, we have… just in case you need help.. we brought some maps. These are the map, of the greater area, and this is just up close, just in case. This actually worked fairly well for Jim and for George.

M. Actually it's… of course Bub grew up here too and he was at the ski hill, and he owned the ski hill and all, so he knows a lot about that area. And his dad George Senior was really something else. You know whatever resources were around he uses and whatever was left over from the old bridges, whatever, the old logs and whatever he made use of them for whatever, and of course Bub knows that. And Jim Hall is a logger so he has logged most of this stuff, so he's been out in the woods a lot it seems. And I'm just a roamer.

D. Well do you want to tell us a little about yourself?

M. Well ok. I was born here in Lutsen. I'm 71 years old, and having grown up here, educated here, graduated from the University of Minnesota – Duluth; taught for 7 years – bio, physics, chemistry, earth science, that sort of stuff. Then I got called home to work in construction, b/c my dad and brother had a construction company which is Hansen's sons True Value Repair. My middle name is Isaac and it says Isaac Hansen, we're not in it anymore so that's fine, I left it a while back, that's another little story. So anyway, besides being in construction I've been on a lot of places because I was doing costing for buildings and designing, and that type of stuff, so it took me out in the field quite a bit. So that's another one way that I got out. Then I went into real estate that's another whole

deal, we got into formed a company with another guy in town, and we ended up contacting with lime timber company to sell and dispose of 36,000 acres of Cook County land for Lime Timber Company for the trust for public land, and it was up to us to decide whether which land should be in public ownership like state of Minnesota if there was something next to a state park it should go to them, ya know free of charge, or something that was plain to the federal USDA and that land should go to them and what was left over and useable or saleable we'd sell. And so that made me wander all over this county and literally motorcycles, snowmobiles, wheelers, airplanes, cars, trucks whatever, you name it - snowshoes, skiing. So I've been to an awful lot of places around here one way or another, also canoeing or boating. So I've got to know a lot of slots around here plus with my wife and I like to go camping or canoeing, so then we get to a lake and go out and you can't fish all the time, you can't sit around feed the fire or read books so we'd go around exploring. We'd find old logging camps that used to be back here. Which, not a lot of them are in the Poplar River watershed - that's where you guys are interested? So anyway after that, being in that, I was in too many high pressure jobs, so I decided, hey there's an opening up at the assessor's office in the courthouse, I'm going to see if I can get that so I got that and worked for 5 years as an Accessory for the county. So that meant every 4 years I had to cover 25% of the properties, had to go look at them, and photograph them and measure do whatever. I had the greater Cook County and ended up with also GrandMarais and then my boss he just kept the gunflint trail as commercial, but I ended up there quite a bit anyways, but that didn't count for what you needed to hear anyways. So besides having to roam around, and love to hunt and fish and other stuff, I know the area pretty well. And you're looking for where there might have even dams in the watershed.

A. Yes. Or any type of landmarks that would maybe tell us where the water level was, or where the river may have meandered at some point.

M. I don't think there have been much changes of water level within the Poplar River watershed, except maybe there at the bridge right above the ski hill. They may have dynamited that. You have to remember where the logging took place in Minnesota, most of the logs they were after were white pine logs. And we didn't have that many up here. It's a mix. having read some of the, because I had to locate corners and so forth for all of these 40 acre parcels, that were out there in the field, out there in the woods, just as - if you're going to sell something you had to tell the people approximately where the land is. So we had to shore all of the corners, if there were any, well, all of the surveying were done back in 1870s, late 1880s and a lot of it was very poorly done, maybe they were driven crazy by mosquitoes or drank too much I'm not quite sure. Some of the survey points are way off by so far, you know 600-800 feet which is a big deal if you're a surveyor. So we had to go out and find these things in order to sell the property to someone and say, well this is your approximate corner here, this is corner here, da da da da, this is where the road we think goes through the property, if you build anything on this property try to build the property as close to the center of the 40 as you can. Because the lines would shift up to 600 to 700 feet, that's what they're finding out now. We would, there was just no logic, but anyways that was all in the east end of the county. So as far as what I know about...I need a bigger map.

D. Maybe you could bring it up online.

M. I have a lot of old maps. This is a forest service map.

(A lot of noise, shifting maps, folding maps, finding maps)

A. Can we help you?

M. I'm trying to find the right spot here. Ok here's. Crescent lake drains, no that comes down into the… there isn't a damn here. Um to keep the level up in Crescent Lake, that's been there a long long time. The other one is right here, where that old steel bridge crosses. There used to be an old bridge there, this is the old North Road. the old North Road used to go all the way up here, way clear up to Ham Core Lake (Note: not sure of the spelling, the recording was hard to hear)? or up to Clara? I've tried to find some of these old roads, if you don't use them, they disappear! You can find embankments and stuff, you can't walk because you get up to the alders, they just form a mesh and you can't get through.

D. So the North Road is that what that was called?

A. Is that the same as Moose Road?

M. Who said Moose Road?

D. Um, one of the original roads through the watershed, George was saying was 18 miles and it came up on this side.

M. Ok that's another one.

D. So you're saying it was actually on this side?

M. North Road was on this side and it went up, and Bub remembers for sure, but I think there was probably a road that went up on the left side, because it was tough to cross some of these rivers, so they'd go up both sides.

D. So the road he was talking about, I believe it started somewhere in here and it kind of went up and then up, and continued.

M. You'll never see it on the aerials. So what else do we have here?

D. So do you know of any logging that occurred on the watershed? Or when you were out?

M. Oh yeah, not much logging. Most of the logging was done here around 1910, 20s and 30s that's when the logging, that heavy pine logging because that's when the railroads

was up here. and all of these little railroads they were temporary railroads, they'd build them out to a stand that was worth logging, and when they were done there they'd take the tracks up and go someplace else, so it worked pretty good. I didn't realize that until I was reading a book about it. One that Jim Hall has about the old locomotives that they used, I told your boss, y our professor about that. It's fascinating.

D. It's a great resource.

A. So this logging that you were talking about, was this right near the ski slope?

M. No this is going to be pretty much off a way from there. There was a large sawmill here, sawmill bay on Caribou Lake, which is part of the Poplar River watershed and here's the old map that shows it coming right down into there. there's been some, there's been some others up in here a little bit later that was the Schmikes's brothers had a logging camp up in here, this one I don't even remember but I remember seeing the open meadow and some of the logs lay in the bottom of the lake in here. Um this used to be the old Native American camp for summer up here right at the narrows. there's still a designated portage here across because of them and other logging, this is more recent but I think that's it, here's Barker Lake road coming down, ok, and here's a big opening that I believe there which is where there was a logging camp, mainly for logging white cedar. And that was probably in the 50s, 40s, and 50s. This is a good area for hideouts, there were several people from Chicago came up here and hid, had shacks. Clarence Henderson and his wife were one of them, they on Barker lake for 2, 3 years before they came out, they were from Chicago and was a very active political labor union guy, he had to get out of Chicago or he wasn't going to last very long, so that's where he ended up. He ended up being a plumber and living up down here on the highway, they survived just fine. There was someone else too, who lived here in a cabin, and they called the Louis and Clark cabin, which is still there. There's someone else, some other person who lived out there for a while, and up here's the old first log cabin in Cook County was right there, it was the game warden's cabin. There might be little remnants there. But thinking about others. Huge gravel pit operation here, right along the watershed, one there and one right here. There is a smaller one right here.

D. What's this road?

M. That is a power line that goes... The honeymoon relay tower microwave... tower.

D. We used that for, as one of my georeferencing spots, to try to make sure all of the maps were in the same scale, when I was digitizing and just I didn't know what it was.

M. It's a power line, that's why its so dang straight, it goes up and over.

D. Yeah, it's been there in a lot of photos dating back pretty far. So. This map is 2008. The one that I printed and I think the one on Google map is 2003.

M. It's just that old?

D. It's ok; as it gets closer it registers.

M. They keep updating it, because there have been changes since I've been looking at it.

D. Yeah there's a history button and you do the aerial photos that they have, and they have the 1991 posted, and the 2003.

M. Ok so where we're at... Pike Lake drains to from here. and it all comes down to here, and caribou comes down into… crosses here… ok there are 2, 3 main roads that crossed up here, they were called lower, middle and upper Helmerson roads – those were all logged over, I mean those were logging roads built in the late 30s, or 40s for logging, but mostly for balsam or spruce.

D. What was the name again?

M. Helmerson. They were 3031 and 3032.

A. Were they forest roads?

M. Yeah. There minimum maintenance roads, you wouldn't want to take a car in there, but you could take an SUV or something like that.

D. Yeah I had talked to the forest service and they gave me a map of logging that had occurred in the last 15 years. It's really simple, it has some color denotes where it was. So I don't know the extent but it looks like it primarily occurred in this area, much north of this area.

M. They don't log in the boundary waters so; it's very restricted as to who can go in there. So a lot of it will be in the Poplar River basin, just as it splits to where temperance takes over, between the two…. there was logging spread out all over in through here. You can see where the current logging is, where they wind drove areas and then plant in between. Ok now from Lockport which is right in here, there was an old railroad that went up quite a ways in here, and that was for logging.

D. I guess you could zoom in on that too.

M. You can't see it; I've never been able to find it. I know where it's supposed to be, and I know where it ended up, because it ended up at the dock – in front of Lockport where you can still see the pilings.

A. Is that where the Lockport marketplace is?

M. Yes.

A. So was that like his depot originally?

M. Just a dead end line. It started at Lockport went up into the woods and back. And that was it. There's probably a little donkey engine that they ran, not a real locomotive because they couldn't get it there. It was not connected to anything else; it was all a little railroad all by itself. Most of the stuff, a lot of the stuff down by the lakeshore had burnt over, and you've got some information on that I'm sure.

D. What years were the fires?

M. They were in early 1900s, all the way from 1910 and 20s in that area, people weren't as careful with fires, and sometimes they just burnt off the brush and it got away from them. And the railroads they were all wood and coal fired so a lot of sparks, a lot of that stuff.

A. Was that railroad used a lot?

M. It was probably used about 20 years from what I can figure out.

A. Oh the Lockport one?

M. What? No the bigger one that went to Clearwater lake.

A. What about the Lockport one?

M. Oh the Lockport one was probably used about 5 years at the most. That's a speculation.

D. We can look into it further.

M. Now there, I was going to tell you other places to look that has historical information on a lot of this, you'll have to pick through it. The Schroeder museum has a lot of stuff, have you heard of it?

A. I contacted them but no one responded.

M. Oh, interesting. They should respond to that, Darrell Fisher kind of runs it. They have someone else but I don't know who it is. Darrell Fisher and Jim Tweekrum, and Carol Tweekrum are the ones you should contact if you want to get more information from them.

A. How do you spell Tweekrum? The last name?

M. Tweekrum? T-w-e-e-k-r-u-m. That's pretty close anyway. I'm a horrible speller. But Carol will help I know darn well she will so will Jim. The Tofte museum that's a fishing museum, the historical society in GrandMarais will have... have you contacted them?

A. We went there yesterday...

M. Did you get anything worth while?

D. Well we got some good articles, but primarily from the Cook County Star and the Cook County herald.

A. We just haven't had a chance to read them; we were just going through and copying anything that we thought we might need.

M. There should have been quite a bit of information there; I don't know where it is I haven't been in there for a long time.

D. Yeah I don't know that they were… Carrie mentioned any leads that we needed tracked down she would help us find that information. Pat said she had some photos but we couldn't really get our hands on them.

A. Photos would be super helpful but we haven't had much luck on that. Just because even photos, of like buildings and stuff, the background could be helpful so we could see what it looked like back in the day.

M. Well a lot of those logging camps that were back there that you'd like photographs of the old things, the forest service destroyed them totally – they'd go back out and burn them down if there were some buildings left, burn them up and get rid of it. I can prove that… I have a gazillion photographs…

D. Is that your family in that picture? Of the child and the...

M. That's my wife and my mother in law and father in law.

D. It is the neatest.

M. They had a cabin a half mile away from here. And we grew up together but we never met.

D. In Lutsen? It's such a small area!

M. Never met her...I grew up a half mile that way.

D. Did you guys go to the same school at all?

M. I knew all of her friends and she knew all of my friends.

D. What other schools are there around here though?

M. Oh just Cook County schools and then I got in; through skiing you get to meet everybody all over, because if you're a skier you get to meet all kinds of skiers all over. So I got to meet all of her friends, cousins and stuff like that.

A. Who gave this to you guys? What was it for?

M. That - Nancy's mom had the picture, and um when she retired from the ski hill, she was a bookkeeper up there

A. Oh ok.

M. We had that done.

D. Um, so if your wife was in charge of, or she was the bookkeeper… did you ever get the inclination that they took really good records about how much water they were taking out of the river or just records on grading the landscape, ya know making ski slopes, stuff like that?

M. Um probably, if you could get your hands on them, if they're there someplace, a folder, every year they put out a brochure. Ok? And on those brochures they always have a lay out of the ski area. They started out with one run and now there I don't know a gazillion of them all over the place. You know every little trail they go through has a name for it. When the, I was one of the original ski patrol persons up there, and that was my life back then, I had a whole 'nother life then, that's all I did was ski – ski and go to school. But when I started skiing there was Harry Carry which was the main hill, and then they built Chickadee and they built Cuckoo, and there was just one, two tows, rope tows. And they were not bulldozed, they were just cut, the stumps were cut close cut. And it was pretty well protected in those early days. It's when the d7 appeared that they reshaped the hills. The d7 is a Caterpillar, dozer.

D. We were wondering when that came about?

M. That's after Bub and Patty sold out. And Charlie took it over. he had run ski hills out East, so he knew what he was doing, but I never agreed with him on the bulldozer work that he did was…. he was cutting into those hillsides with clay and destroying the mat.. The grass mat which held...

D. Well that's what we've been finding, because we've been doing infiltration studies, and so we're looking at how fast the water is infiltrating into the ground so we've done a lot of them right on the ski slope and then directly right next to it on the treed area, on the forested area, and it is just, you can't even time it it's so fast in the forested areas, you have to do a lot of different tests. And then if you were to do it on the ski slope it would take me about an hour.

A. No no no. the longest one that we did, um. We had it, we did the same amount pretty much for all of them, we took measurements for like 3 hours and that moved for over like

a quarter of an inch, we went to lunch and came back and it moved another half of an inch.

D. And that's because of the clay.

M. You got down to the clay layer...

D. That's our big question is about the grading...

A. Do you have any idea how much was graded?

M. Cuckoo which is the main, or original, not original, second chalet is. Those two hills to the east, Cuckoo which is the left, had a lump in the middle of it. It was really nice because you build a take off, and you know pull your feet back from the ice and fly right over there, you know you could go 100-110 feet through the air, and still land on your skis. If you went any further than that you'd hit the flats and your skis tip. So that whole lift was cut down and it was sculptured, because it was hard to hold snow there, he just dozed that sucker down then there was a nice, when you came down up to the chalet there was a nice gully, so you could come just sailing down, or you could just lay out and turn up, up, on the hill so you'd ski up, that was always fun. But he knocked that all down. Um, Raven, or Cliff, or one on the right, Harry Carry, that had the gully in the middle of it. And that was an erosion gully that formed under one bad storm. But it seeded itself and it stabilized and it was good from then on, ah but that was fun too, you could go down and do this, and it was a natural trough for skiing. But he got rid of all of that, he bulldozed all of that off.

D. It must have been too much fun, in that little machine, in the cat.

M. Ullr which is to the left of Papa Charlie’s area up, up the hill, that one used to go down, across the road and then down the hill to the river. And, that one they cut it into a hell of a lot of clay bank, now that may not, was not a good thing to do, but that's what they did do. I don't remember what years that was, but that was when I was still skiing anyway...

A. So maybe in the 80s? Or 70s?

M. Probably in the 80s, around there someplace. And then of course, well eventually of course the bridge got built most of the rest of the runs weren't really dozed, they were just cleared. And some of them even started to um, when they cleared for a new run they just knocked the trees down, cut the limbs off and let the stuff lay there like as a mat so as to not destroy the soil so they didn't get that erosion problem it was a smarter way of doing things, it was just that one area.

A. Were the erosion control...

M. There wasn't any erosion control happening, none of those things, I mean yeah if you're a person building a ski hill you don't want erosion to happen, and you try to do the best you can, and there's nobody overseeing it to say “why did you do that?.. You gotta do this” you did what you wanted to do because it was...

A. What kind of things did George or Charles or any of them, do, if any, for erosion control, that you can remember?

M. Main thing was that they didn't use a dozer for most of the runs. There's just a couple of them that got dozed pretty heavy, and those are the ones that had the problems. But they got them stabilized, there stabilized as much as I could tell, where the erosion is now the gullies from the road on down, the number of roads that they have and stuff, the roads are, of course not that stable because they're exposed to the elements. Um.

A. Do you have any sort of timeline for when each of the mountains were developed?

M. Yeah, when Bub came back from the war was 47 or 48, and his dad had the idea, and he got the hill going I think by the late late 40s, my sister used to go up skiing, I was too small at the time, too young and they didn't have ski patrol or anything there was no packing of the slopes or anything you went up and side stepped. It was kind of fun because everyone had traps, or the old steel traps with the cable in the back... so that was late 40s, and then from then on every year they added at least 1 more run. And It was Harry Carry, then I think Chickadee and then Cuckoo and then they added Ullr, Steps, and Cliff and Raven, it was all in that area were most of all of them... Moose was later, Moose was much later. It was all in this area here. Ullr became very popular that was a fun run. And then they developed Mystery Mountain, but Mystery Mountain was, you rode the poma lift up and then you got to the top and you felt like you were walking most of the way to the river’s edge, then it was fun you'd go down, but it was you just glide slow you know mmmmm so it wasn't that much fun. So I didn't ski over there that much, a lot of people like it now, but I think he may have done some dozer work over there but i'm not sure. Um, then I think it was the Skinners that developed the Moose mountain area, and they, you could do that now, because of the change you could make snow … didn't have anything like snow making.

A. do you know when they started doing snow making? What years?

M. It was, must have been 70s they started.

A. So right in the later years that George had it,

M. Yeah, they were gasoline powered, Volkswagen engine blowers and stuff like that instead of electrical run. Yeah that would be about right, because that was right around the time that I didn't ski anymore. Anyways I was working 6 days a week, long hours and then sometimes on Sunday and if it snowed out, I'd ended up going out to the shop and plowing and all of that other crap. But I didn't get to do what I wanted, I couldn't afford it

anyway. And they didn't have the national ski patrol up here yet, that came later I knew about the national ski patrol but they didn't really invade up here for quite a while.

D. What's that?

M. Its uh, you go to an area and ski for free. But you wear your jacket and you are certified and trained as a basically a first responder when you're out there on the hill, and something happens you get a radio call and you go take care, or haul the dead off of the hill.

D. Oh I've seen those people. And that's really neat.

M. Yeah you can go, you can go ski anywhere in the country, on a ski hill. You call up and say do you need any ski patrol or for the week or whatever, they'll say yes or no. but you have to, there's rules to follow - when they want you to go up the hill or mountain then that's what you do. But that was... on Moose Mountain I don't think they did any grading over there to speak of. because my son Neil he was up there working for a while, and he did the, about the snow making and stuff, and he said some of those trails are really hard to get around until you got enough snow on, because of the logs and stuff on them, so you have to have two feet of snow on the mountain runs before you could actually move on them with the snow... But now they have a pretty good system up there, man they can really make snow.

A. Do you know why haven't been making any yet?

M. Because it's too cold out. It takes you know, through 25 and on down until it gets too cold and then they start getting freeze ups in the nozzles and stuff like that and then you gotta go around. It's a uh, they use twirl meters to go around the hills and um you break out the water lines from under the snow so you don't get iced in, and the electrical lines so they can move stuff. It's a very hard job, its 24 hours a day, all night long whether its 10 below or 20 below you're out there. Those guys they work hard, they work darn hard.

D. Ok we have a few more questions.

A. The benchmarks that we were talking about earlier, were there any on the river?

D. Or do you know of any as an accessor? Do you know of any good benchmarks?

A. That we could use to determine water levels or how it meandered in the past, like dams/

M. You can see some little meanders, but that river is pretty well entrenched in solid rock except that some of it, where it's up against the bank and that's a natural thing, but it's been disturbed at the top which doesn't help anything at all. It agitates it. Anyway I wanted to look for the... ah here we go... well there was a large camp on, we'll see which one it is... um...

A. Um also for the logging that was done, do you think it influenced or altered the flow or depth of the river or channel features?

M. They may have done some altering but the erosion, we've basically wiped out any indication of it, if you leave something alone up here for any length of time vegetation basically takes over, and the erosion destroys any evidence of human beings. Its unbelievable what used to be up here, up in Cascade Lake there was a town of 1100 people, and if you know where to look you can find little concrete foundation stuff. But it's all buried. An old railroad went through, there were trestles, you can still see a crossing on the Temperance River, just upright pilings that's all that's left - the cross pieces are all rotted out now.

A. Do you know if they used any blasting on the river for logging, or for ice jams? We had heard possibly…

M. There has been some blasting done, it was done on the Cross River that I know of it was in one of the articles that I read not too long ago. They put in dams like south fall up on the Pigeon River and the dam is still there, there's a dam on Crescent Lake, there has been some alterations going on.

A. Did the Poplar though at all, that you've heard, any blasting?

M. Not on the Poplar River, I don't know. But I'm guessing that at that little narrows there at the bridge there may have been some blasting there, but I don't know. Unless you can get down and see where the, left over drill marks then you'll know if it's blasted. But if you can't find drill marks you won't know. And, or if there is any still driven into the rock someplace, steel pins, there's a few of those along the lake shore where they used to drive log booms, tied up like at sugar loaf landing, that's all grown up now you wouldn't know anything was there, but when I was a kid there'd be thousands and thousands and thousands of cords of wood stacked there. And then they'd take and put them into boom logs and they'd pull with tugs across the lake. It was pretty neat. Oh here's some, this is on the Temperance River some of the old pilings. That's a relatively recent photograph. And that's looking across the river, I'm on one end of it, and here's that's where the railroad continued on there... there's another shot of it... here we go that's what I'm looking for, on what the heck, I'm trying to remember that lake.... looks like there must have been one heck of a camp, these are all bed frames, they burnt the bunk house, because the large size of the trees have grownup through the bed frames.. So if you need any steel which is pretty hard? Ok here's another one... it's fascinating to see some of this old stuff. And when I was a kid mom and dad would take me around in their old '38 ford and we'd cross some of these trestles because that's the road that you drove. We'd go across some of these trestles and the one on the Poplar River where the North Road crossed there used to be two high beams left across there and my brother and I would go up there, he was much older and dumber than I was. He would drive across with tires on each of the beams; there was nothing else there but the beams.

A. And where was that bridge located? How far was it from that foot bridge that's down there?

M. Yeah that's where it is, Senior took the beams out to build the bridge over the road for a...

A. George? Or Charlie?

A. George senior... for bridge run.

A. Also, have you noticed any changes in the river in your lifetime, whether there was a time when it started to get brown more often, when it rained, or floods...

M. It gets brown after it rains.

A. Has it always been brown after it rains, that you remember?

M. For as long as I can remember there's always, when it rains hard it does erode down the banks, there's always been erosion banks somewhere and it doesn't take much to put sediment into the river. And after a storm you can drive into town, even right now on streams that are really clean there's nothing on them, until they go out into Lake Superior. And this last one that we had pretty heavy rain it was red all the way down the shoreline from here to Grand Marias.

D. So did you ever fish the Poplar growing up?

M. I have been down on the Poplar River, I've fished down by the mouth of the river, often the river changes, every year its different, we used to go down and fish for snelp and that was a big deal, you could just about walk across the river on the snelp's backs and just, you could down there with a flashlight and it was solid black with hundreds of thousands of snelp, you dip a net in, a dip net, and it'd be over half full, you could hardly lift it, they'd take out tons and tons of snelp use it for cat food and dog food. It didn't work for fertilizer; it wasn't too good because the cats would dig it all up. But people would come up from down south, you know the old bull head fisherman, if you can get a lot of fish then you get a lot of fish and fill up the whole back of a pickup with snelp. Because when I was in college in the late '50s, that's when they were, it was really picking up then, the snelp was coming in strong, we'd go up to Park Point and there'd be bon fires all along, just one party after another, college kids and so forth. And it used to be a real screaming wild time. And then you'd come up the river and you'd take your turn dipping, you walk down dip and then the next one dips, the Poplar River was very busy.... Ok, the fishing, my dad was a fisherman; he came up from Norway ok? He came up and fished on Isle Royale and ended up settling 3 years later here in Lutsen. That's where he met mom because she came up from Duluth on a hard rock farm, oldest of 7 girls and dad was the youngest of 7 girls and a brother from Norway, there was no reason, he couldn't stay in Norway because there's nothing for him, the oldest son gets everything, so you're just worthless, so he followed his oldest sister back to the united states, because she had

married some guy from Chicago and that's when he came and he heard about fishing up here, so that's a why he ended up here. And then mom came up to work at Holstances store which is now clear view, and that's where the met and they got married.

D. Did you ever fish in the upper reaches or in the lower?

M. In the still waters yes, once. Once because it's kind of a lot of work to get in there, to the still waters. When the road was good yeah it was easy, but then in the later years when I took my boys up there we went by canoe, and uh, there'd be beaver dams across, so you had to go over the beaver dams... we had a pretty good system figured out for getting backed up and over the little beaver dams, if the water wasn't too much different, we'd have the bow person move back and paddle as hard as you can to get the bow up and over the dam and then the bow person go into the bow, and it tips the canoe, and back and just keep on going. It worked really good I was really impressed. But yeah we fished up there and it was brook trout.

A. And any up by the ski hills are now or no?

M. I never fished the river valley that was tough to get down. I only had a '47 Chrysler I couldn't get down the roads were gravel and steep and with two wheel drive, you're just asking for trouble.

A. We've driven all over those roads in a van, it was pretty interesting. That van's been through a lot. Do you remember any changes to the bluffs or ravines? From when you were younger, we've heard stories of Greasy Gulch, or Ullr gully.

M .Greasy Gulch that one has been modified the most. And that was the one that was the most detrimental to river problems, I'm guessing. That was manmade.

D. So what was the history of Greasy Gulch?

M. Well they wanted to lengthen Ullr down to the river, so you'll get a longer run, so then they could say 'now we have so many feet of vertical drop'.

A. So when you were saying earlier that it went over the road, it went into that?

M. It went over the road and down to the river; it was a pretty steep hill.

A. And that was directly where the ravine is now, or was it off farther?

M. Just to the right of Papa Charlie's, just beyond papa Charlie's where Ullr comes down, it went right over the road and down to the river. And now that one, vegetation was all cleared off, and that's where they went into clay. That was a mess, it was bad.

A. And when did that happen, do you know?

M. Probably late ‘60s, early ‘70s. I think Bub did that, that was, when you're competing for ski dollars and you have to have something to brag about, and every year you have a new run for people, have to have something new for them to look at so you don't become old hat. You know what you're looking for when you want to go ski. So that's what you have to do. And sometimes something else has to pay.

A. I guess there was maintenance shed up there, is that correct?

M. There was a maintenance shed up there but that is no longer there. They tore it down. And then there was one, there was a maintenance shed by the bridge over the road. The whole building burned down, so they never replaced it.

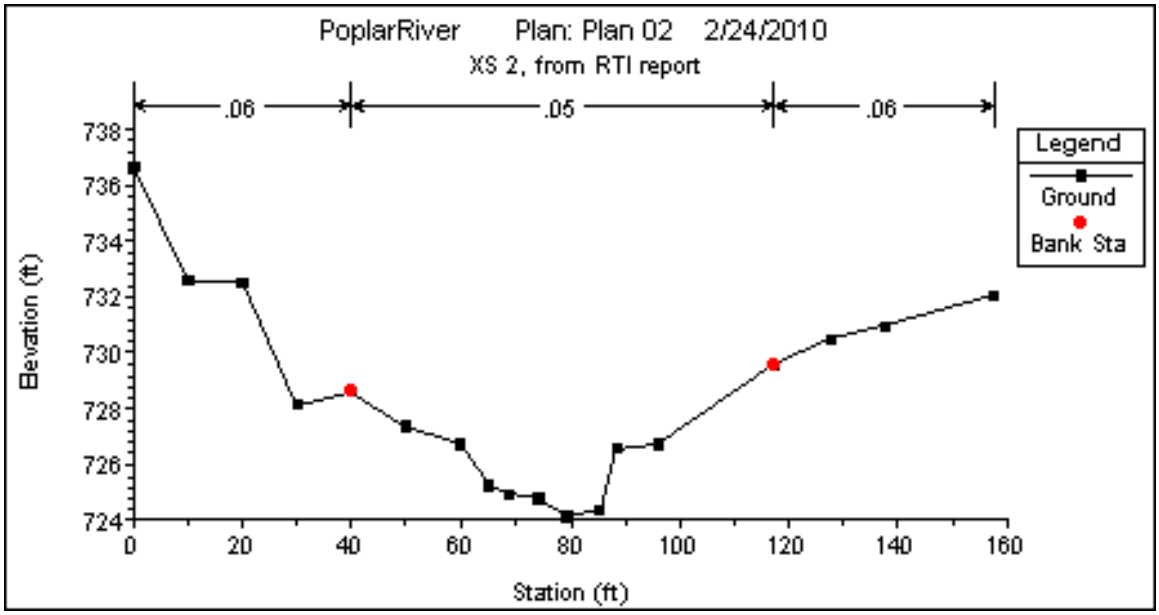
A. How old is the megaslump, or any of the other ravines, like the one that's on Moose and Mystery Mountain, the one on that project, or any of those?

M. Well I’ve been down there and looked at a few of those. That's an oxbow in the river by the megaslump, the megaslump is being cut by the river, the old river channel is off to the west and you can still see that it’s a regular new movement of the river, and then they put in the weirs for controlling erosion and that seems to be working good. As far as anything else on that river, or in that part of the channel I really don't know too much about it because I haven't spent any time roaming around there just in the recent years because I'm on the Lutsen town board. We got people saying stuff about the river and stuff like that, that's why all of this money is being spent to study the river. If you just leave things alone it heals and it gets back to norm. Just like if you go back into the woods and there's roads all over the place, look if you don't use em they just disappear. You might find the grades but they're tough to follow. You know what, right now, when we first started going up to Brule Lake which is our favorite lake, for canoeing, we started up there with a boat before the boundary waters, and we'd take the kids up there and one of the things to do was to find the old logging sites. I think we found 7 or 9 logging sites on that lake. And there's one spot up there where you can still find a 40 by 40 log foundation, that's about 6 feet thick, 2 layers of logs and it’s filled up with gravel in between. And out of the south, southwest, southeast corner, there's a spruce tree growing that's about that big around out of the corner of the foundation. If you were to core the tree and see how old the tree was you could tell when that building was torn down. There'd be a few extra years added in there.

APPENDIX H: CROSS SECTION SURVEYS AND MODELED RATING CURVES

CROSS SECTIONAL SURVEYS

Station 2200ft



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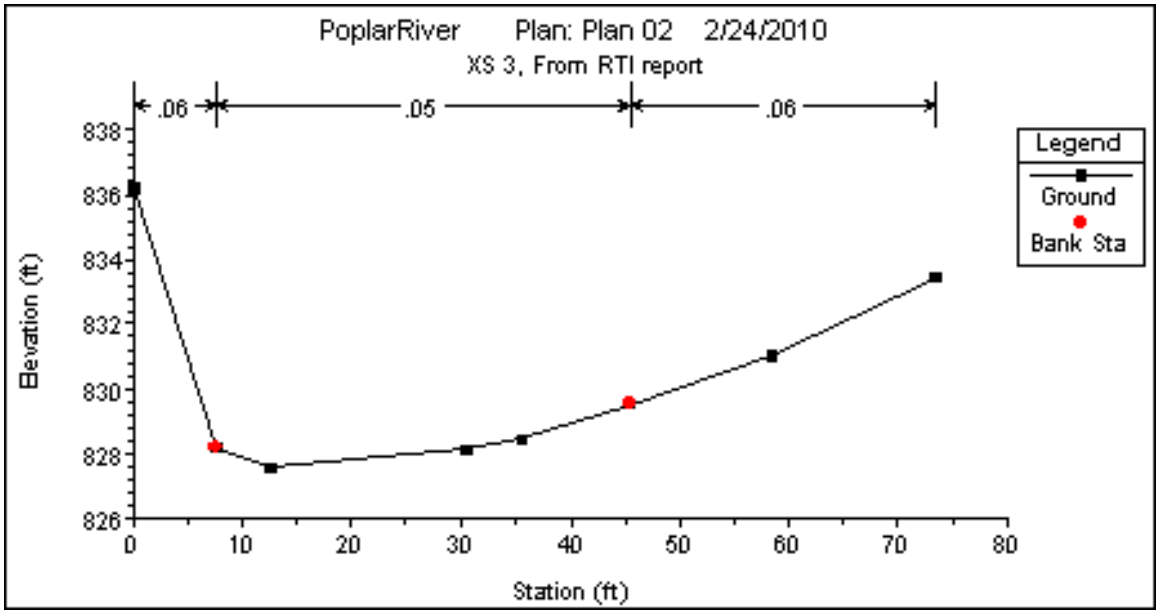

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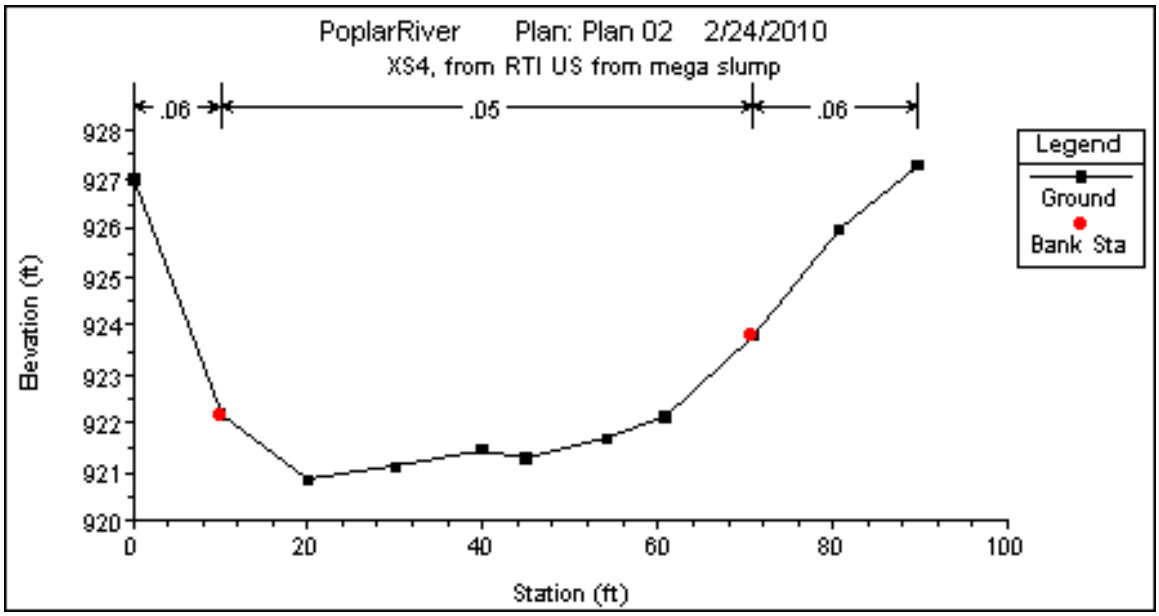

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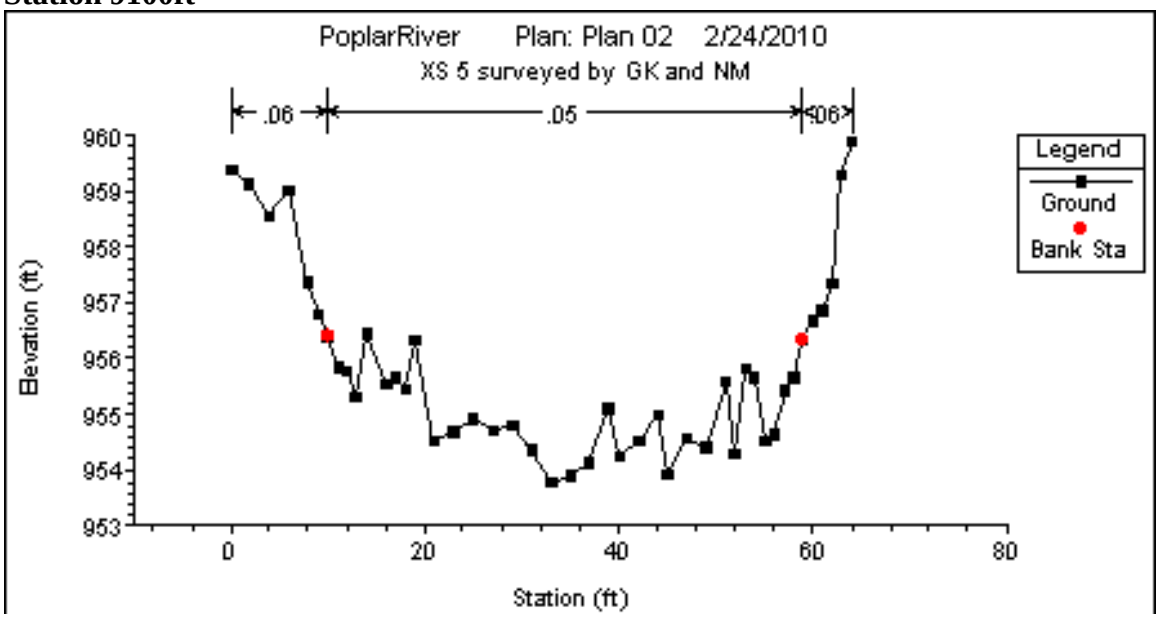

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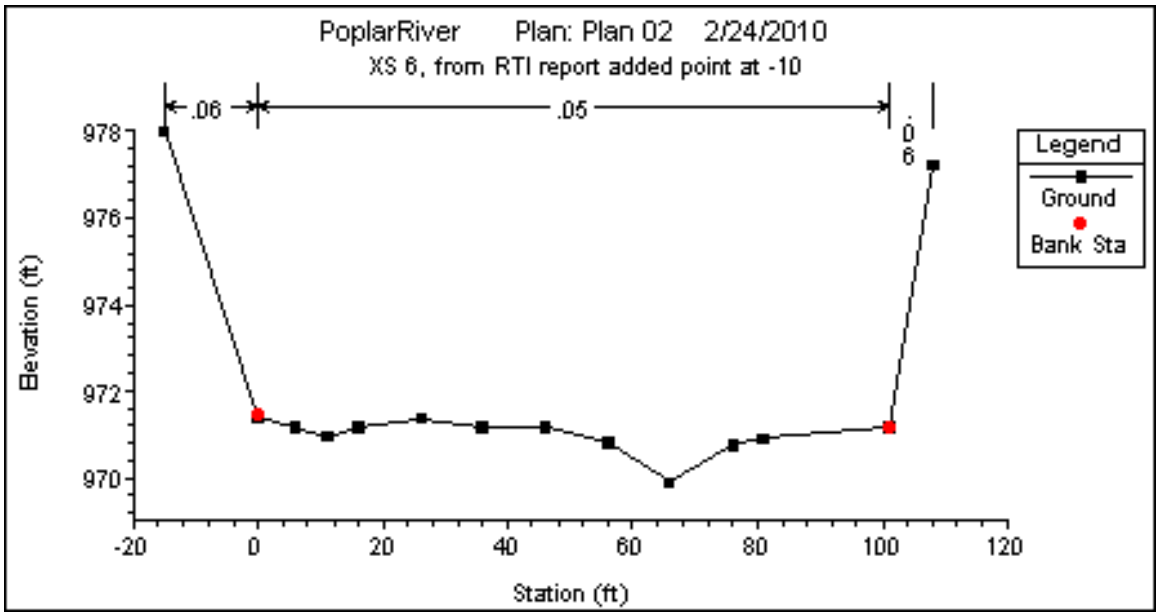

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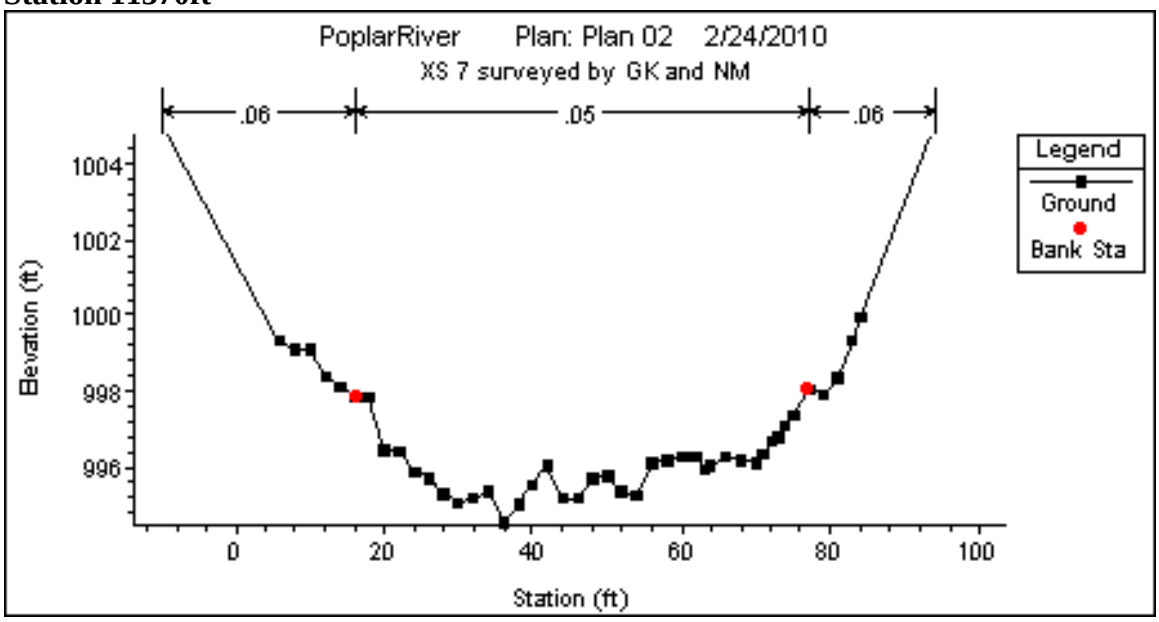

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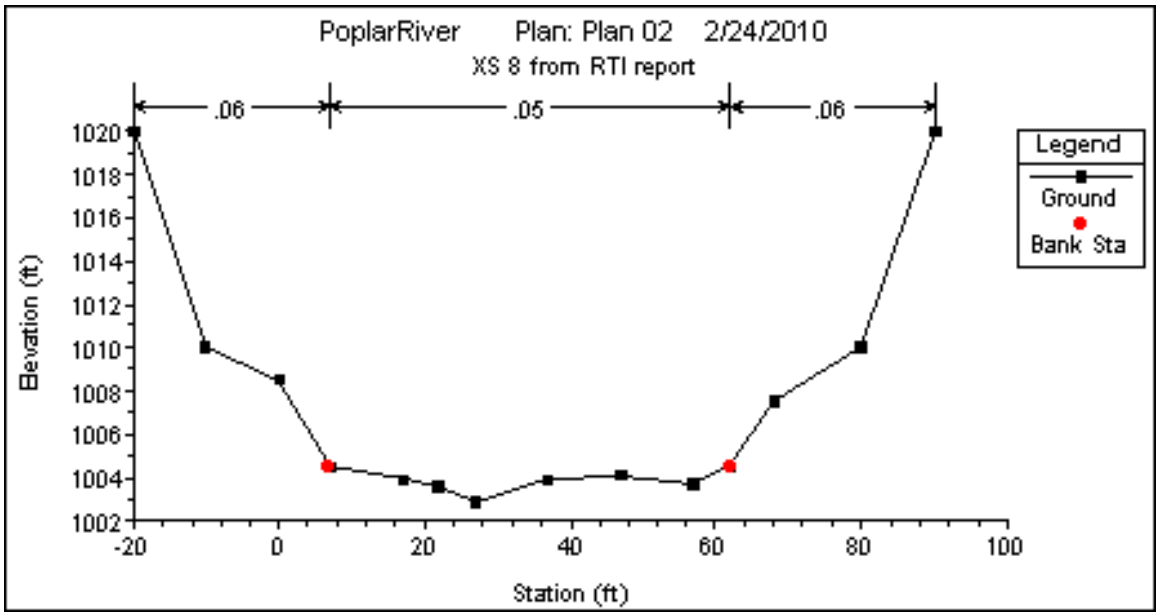

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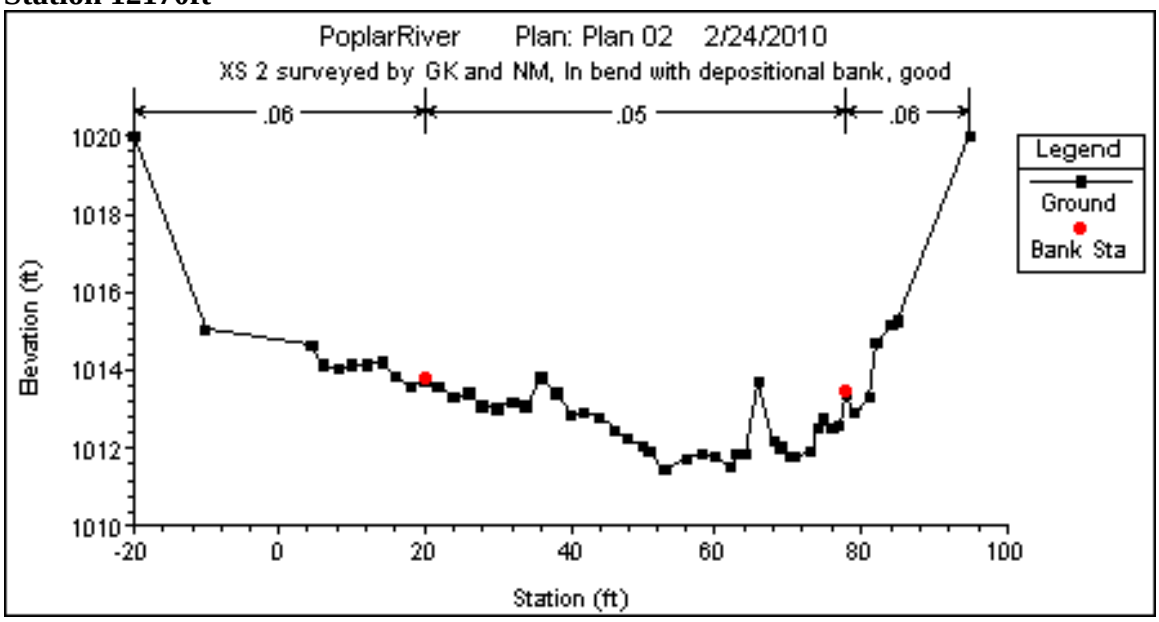

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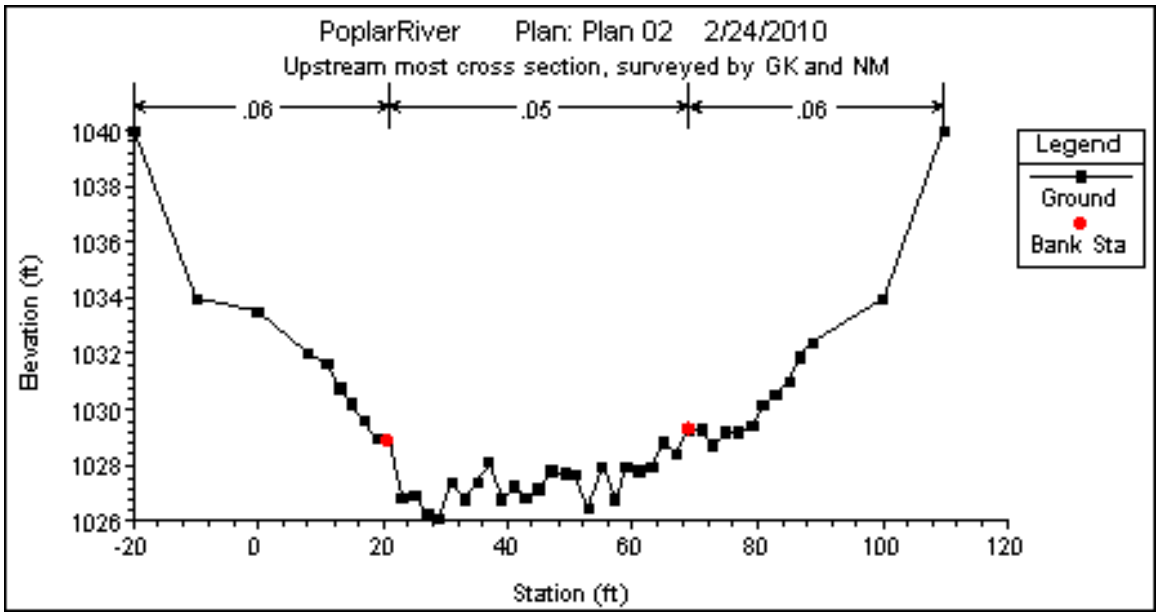

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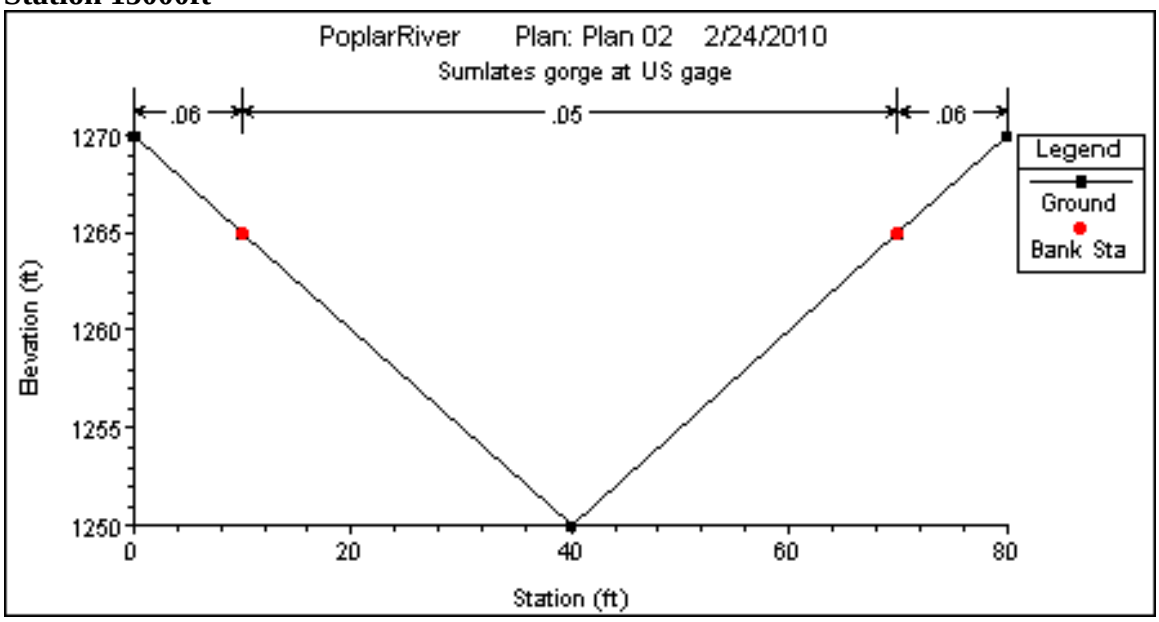
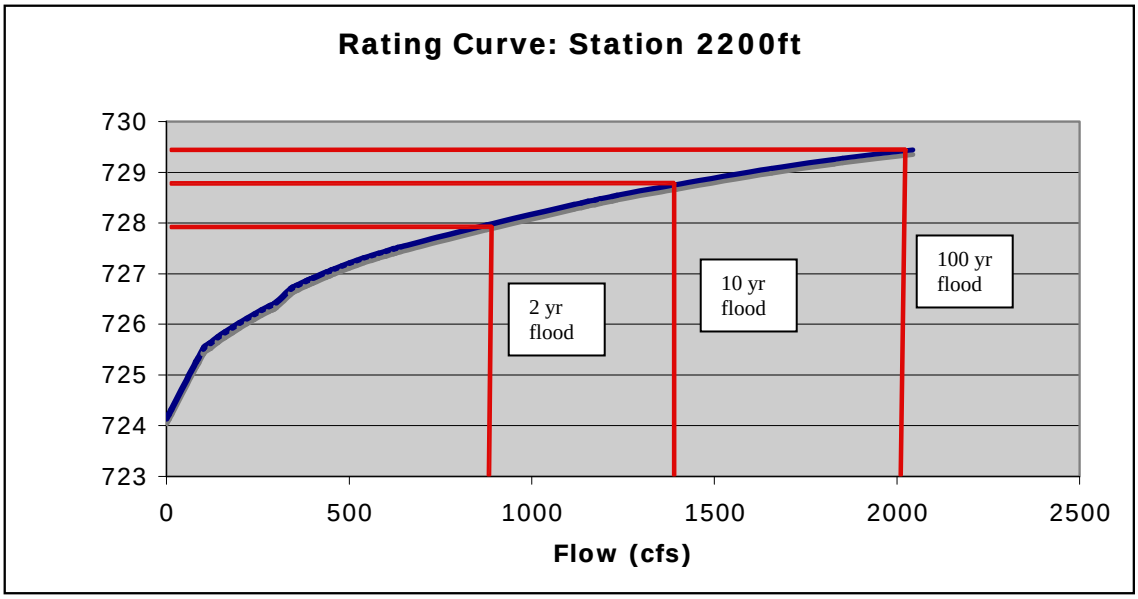
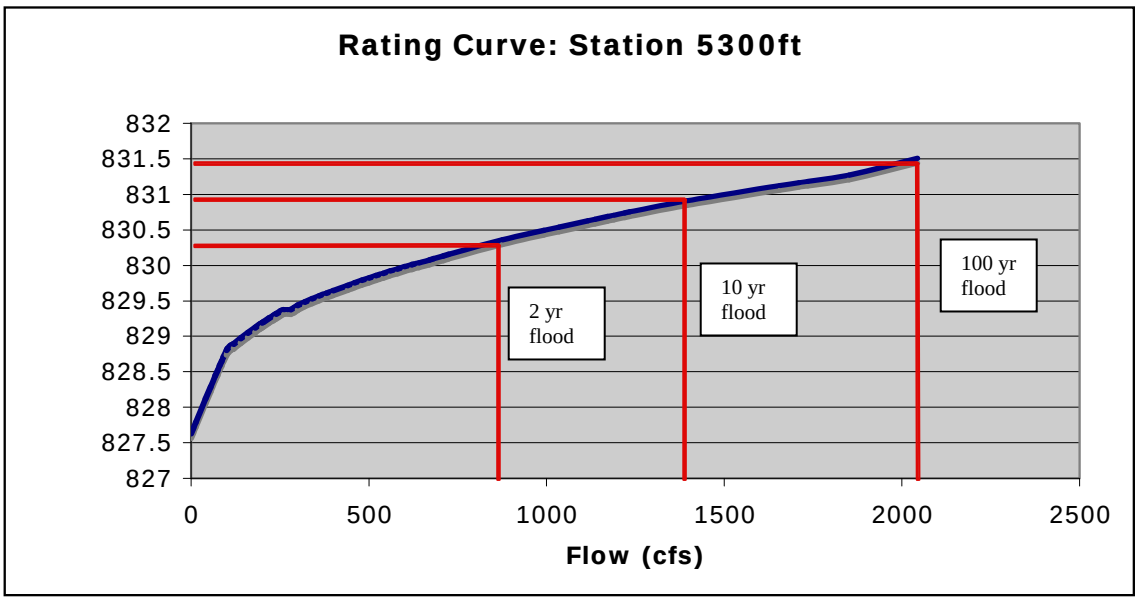
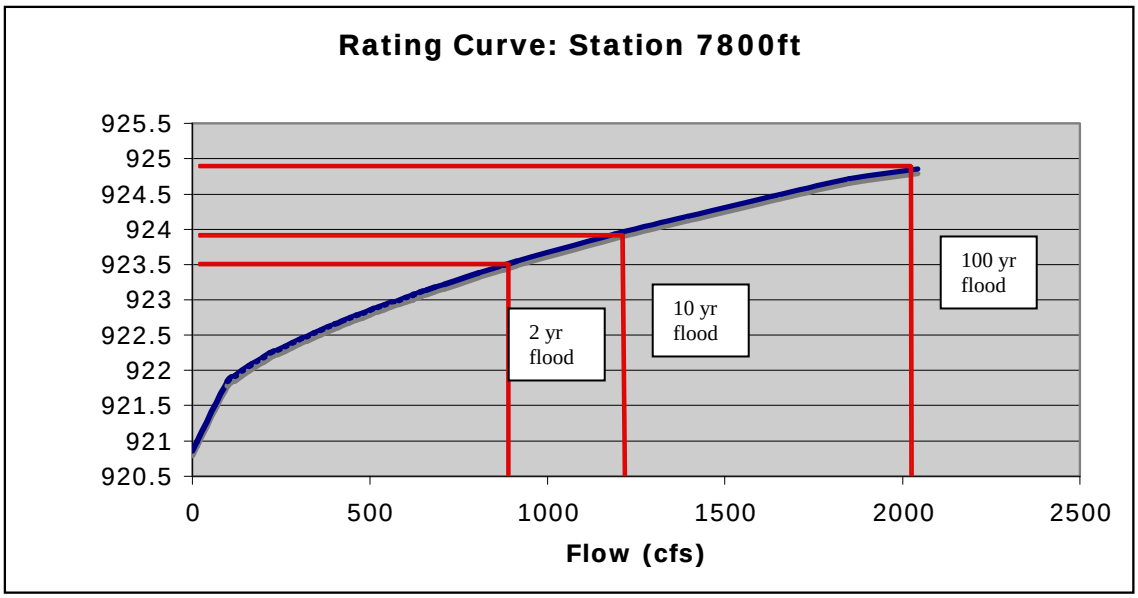


RATING CURVE



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925.5
925
924.5
924
923.5
923
922.5
922
921.5
921
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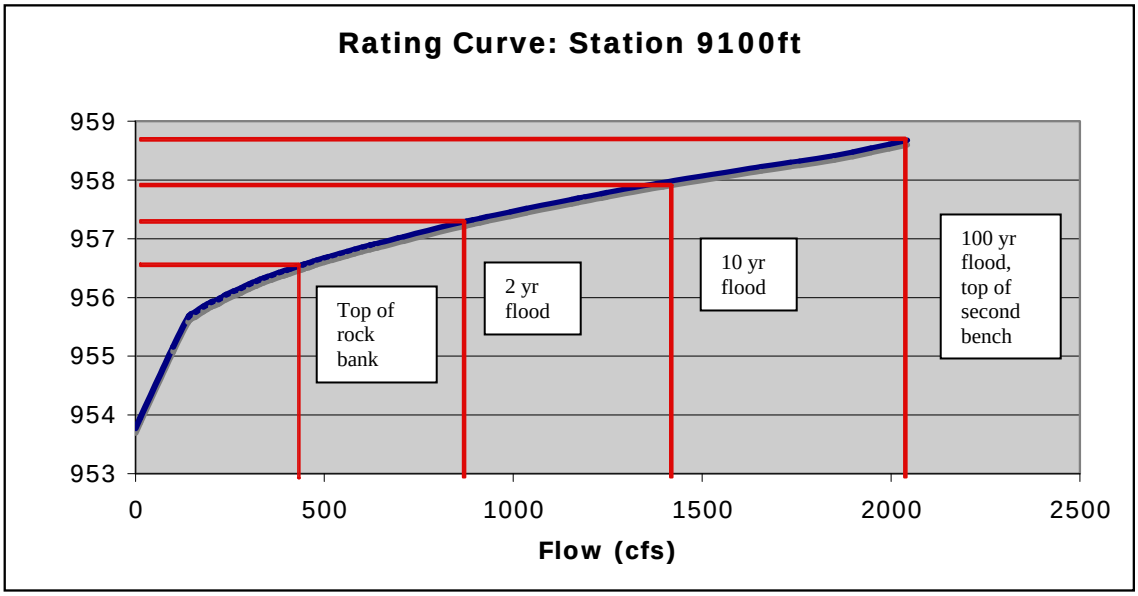
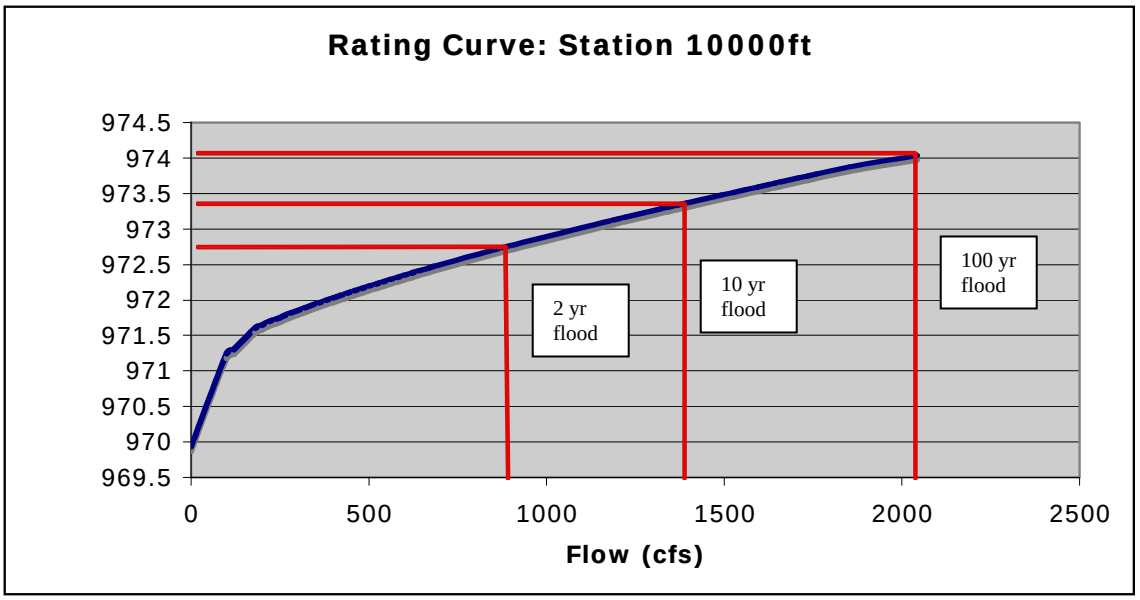
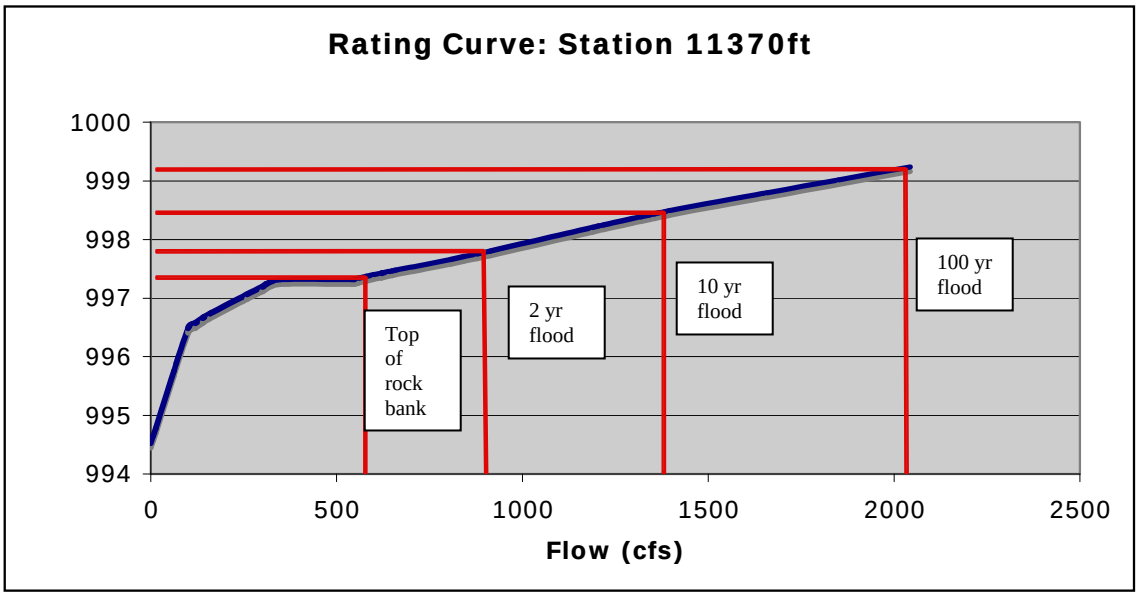
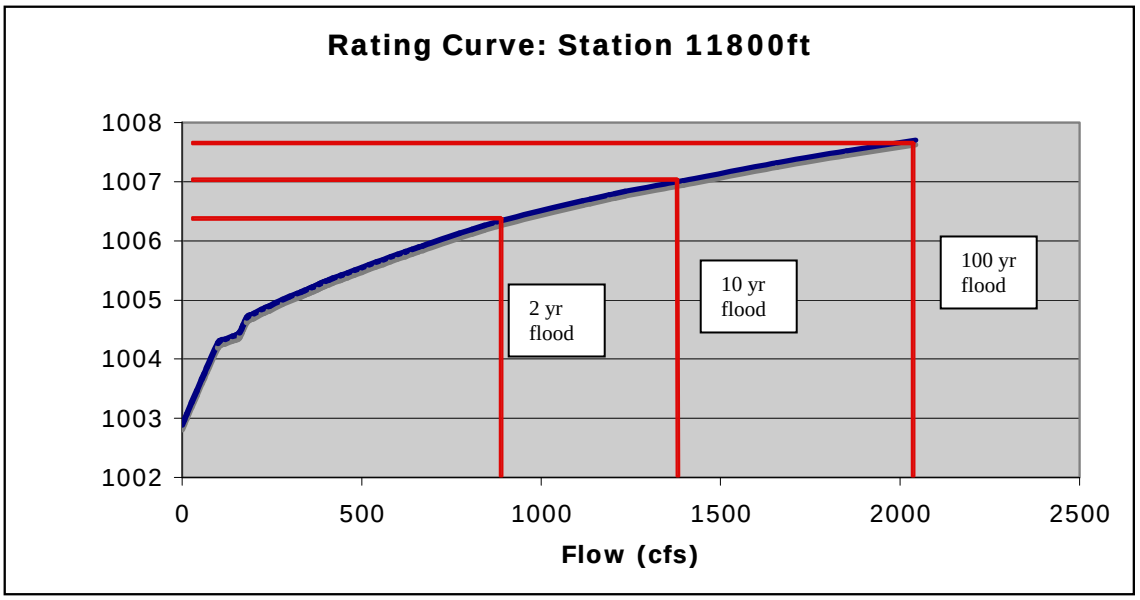
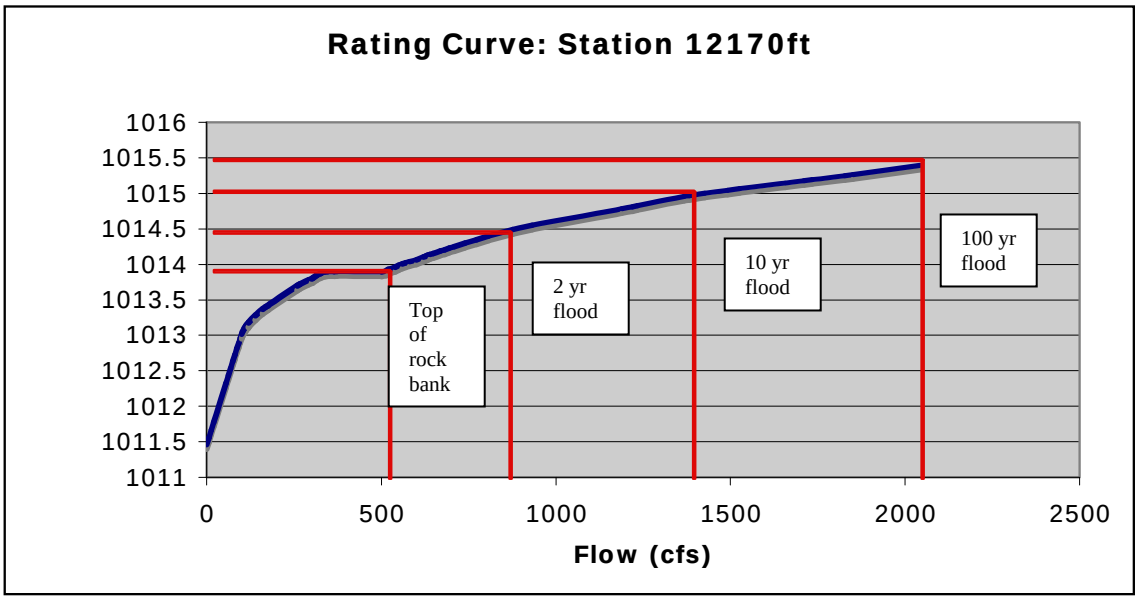
0
500
1000
1500
2000
2500
Flow (cfs)
2 yr flood
10 yr flood
100 yr flood

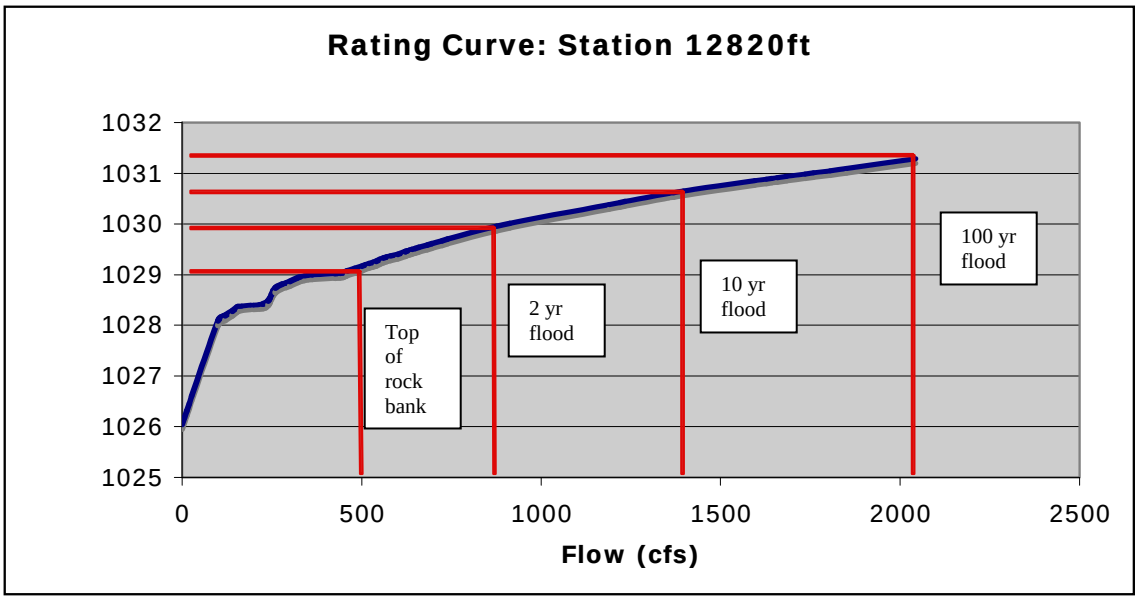

Rating Curve: Station 9100ft
959
958
957
956
955
954
953
0
500
1000
1500
2000
2500
Flow (cfs)
Top of rock bank
2 yr flood
10 yr flood
100 yr flood, top of second bench


Rating Curve: Station 10000ft
974.5
974
973.5
973
972.5
972
971.5
971
970.5
970
969.5
0
500
1000
1500
2000
2500
Flow (cfs)
2 yr flood
10 yr flood
100 yr flood


Rating Curve: Station 11370ft
1000
999
998
997
996
995
994
0
500
1000
1500
2000
2500
Flow (cfs)
Top of rock bank
2 yr flood
10 yr flood
100 yr flood


Rating Curve: Station 11800ft
1008
1007
1006
1005
1004
1003
1002
0
500
1000
1500
2000
2500
Flow (cfs)
2 yr flood
10 yr flood
100 yr flood


Rating Curve: Station 12170ft
1016
1015.5
1015
1014.5
1014
1013.5
1013
1012.5
1012
1011.5
1011
0
500
1000
1500
2000
2500
Flow (cfs)
Top of rock bank
2 yr flood
10 yr flood
100 yr flood


Rating Curve: Station 12820ft
1032
1031
1030
1029
1028
1027
1026
1025
0
500
1000
1500
2000
2500
Flow (cfs)
Top of rock bank
2 yr flood
10 yr flood
100 yr flood