Determination of real-time glacier erosion rates through sediment accumulation, suspended sediment fluxes, fluvial discharge, surface temperature and surface precipitation in the Mendenhall Watershed, Juneau, Alaska.

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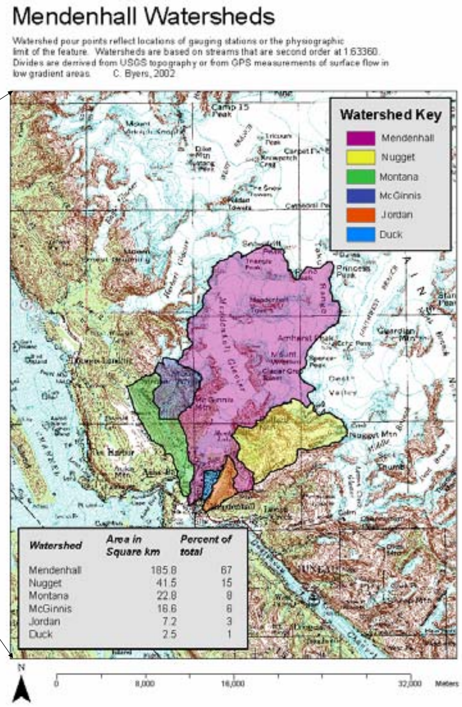
ABSTRACT

We collected daily suspended sediment samples from Mendenhall River over the summer and fall of 2001 and 2002. This stream is the outlet for meltwater from Mendenhall Glacier and proglacial Mendenhall Lake. The surface area of the watershed is approximately 220 km^2. Lake bottom sedimentation was measured for a two-month period, July through August 2002. Bathymetric data were collected in 2000 and 2002, enabling us to track the changing volume of Mendenhall Lake.

Published data for streamflow was compared to measured suspended sediments. Suspended sediment discharge appears to be well correlated with stream discharge. Continued measurement and analysis of suspended sediment loads, combined with published streamflow data from USGS and temperature and precipitation data from the National Weather Service, will facilitate better approximations of erosion rates beneath Mendenhall Glacier and related sedimentation. Data and results from summer 2002 will be reported at this meeting.

Mendenhall Glacier August 27, 2002

During the 20th century the Mendenhall Glacier has receded 3 km. It has thinned in its lower portions 200 m and more since 1909. Between 1948 and 2000 the glacier has lost 5.5 km^3 of ice (Motyka et al 2002). During this time, proglacial Mendenhall Lake has expanded to reach its 2002 volume of 0.07 km^3 and surface area of 3.6 km^2. The lake basin presently traps most of the meltwater silt and supraglacial debris lost at the terminus.



Lake Volume and Area Change with Glacier Recession

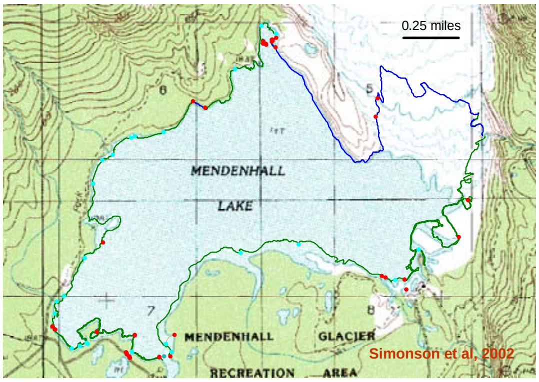
1948 Glacier Terminus

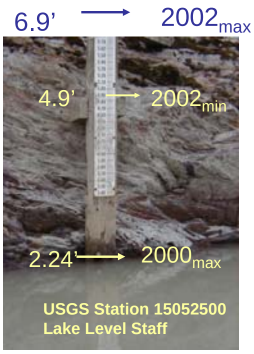
Mendenhall Lake Data 2002

2000 Watershed area 185.8 km^2
2000 Glacierized basin area=120km^2
2002 Lake Volume=.07 km^3
2002 Lake bottom surface area=0.039 km^2
Average concentration suspended sediment (css) in lake
=72 mg/l (surface)
Average summer css in water leaving Lake for Mendenhall River
=0.19 mg/l outlet site
Summer sediment staying in lake (bottom sed rate)=0.5 gms/cm^2/hr
Possible mass of sediment in lake in July (72 mg/l * 7.09 E13
ml)=5.0398E12 mg=5.09E9g=5.09E6kg
Possible mass of summer sediment on lake bottom/hour
0.5gms/cm^2/hour*39,450,530,000 cm^2
=1.9725 E10 g=1.98E7kg

2000-2002 Lake Parameter Increases
Volume=35,770 m^2 (>0.05%)
Bottom surface area=283,332 m^2 (>7.7%)
Lake surface area= 371,900 m^2 (>10%)

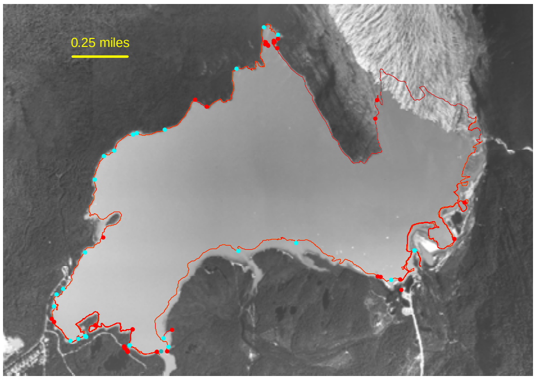
1982 Glacier Terminus
2000 Shoreline

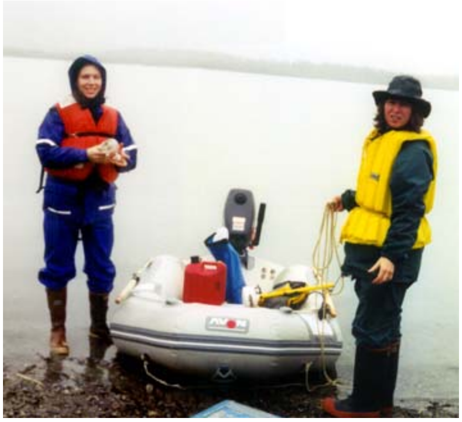


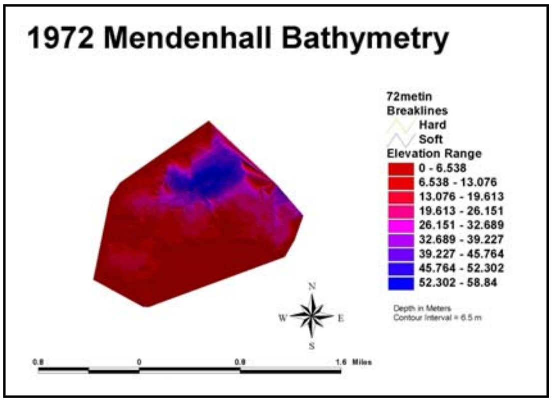


Shoreline Measurements
2002 Shoreline Jul & Aug
USGS Lake Staff hgt
max=6.7' min=4.9'
USGS 1982 JUNB2HY
(GIS coverage)
2000 Shoreline measured Oct
USGS Lake Staff hgt max=2.24'
(Simonson et al 2000)

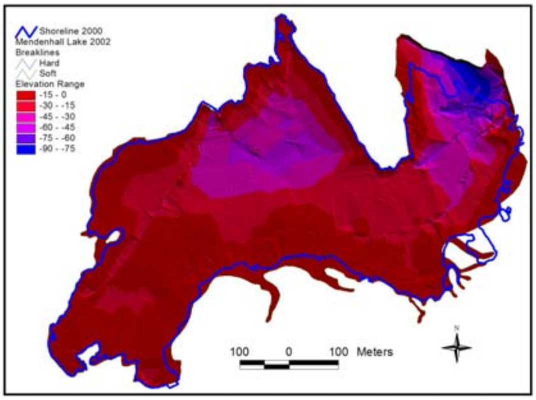
1998 Glacier Terminus with
2000 shoreline



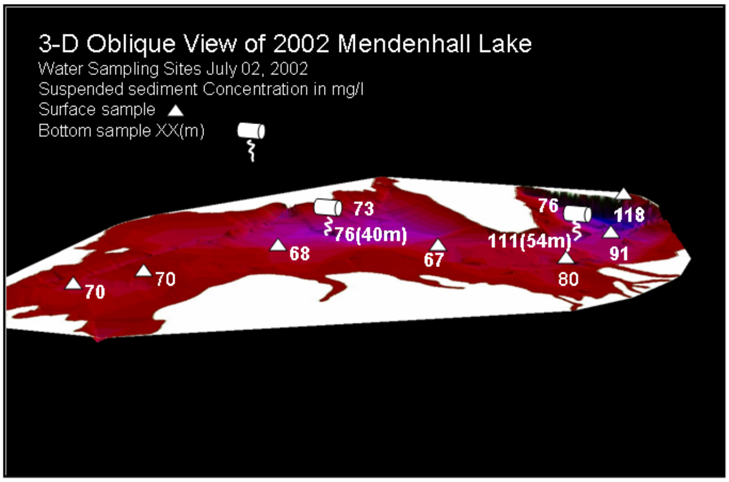


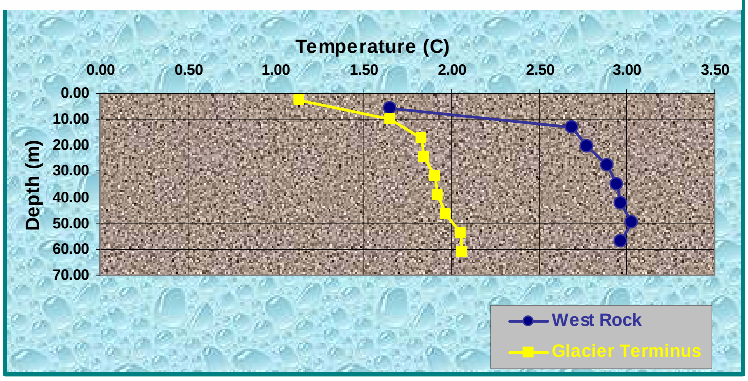


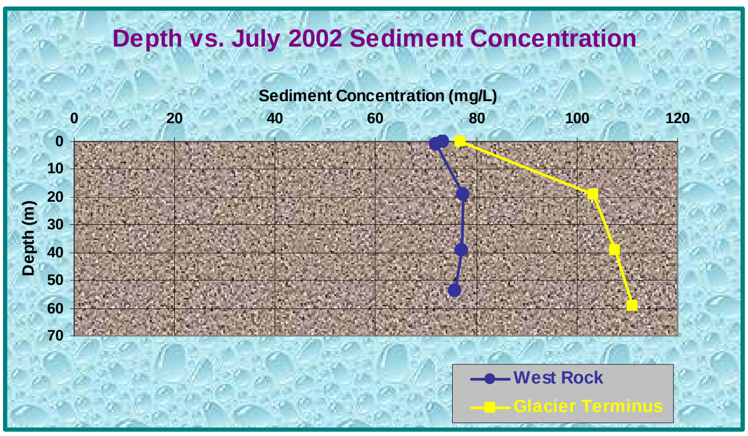
2002 Glacier Terminus & Lake Bathymetry
2000 Shoreline

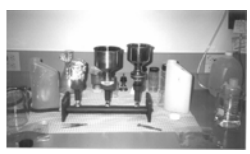


Suspended Sediment Transport From Glacier Into Lake









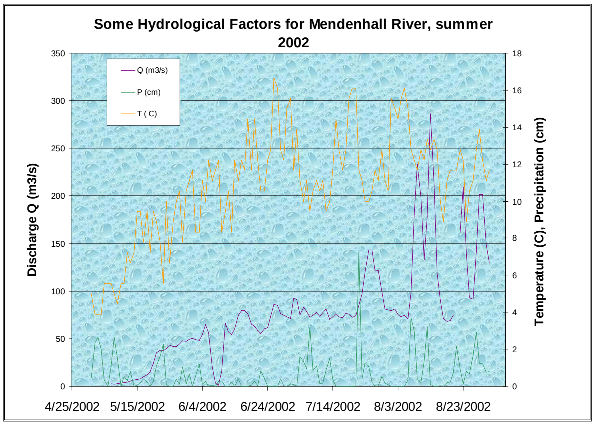
Discussion

Nine 500 ml water samples were collected across the lake surface on July 02, 2002. The concentration of suspended sediment in surface water averaged 72 mg/l. In the northeastern most corner of Mendenhall Lake, the glacier terminus is discharging silt-laden meltwater and releasing these suspended sediments into relatively shallow water (15-30m). This plume of concentrated surface water can be traced to the south before it is diluted near the southern shore of the lake. We also collected 500 ml water samples along two vertical profiles at 20, 40 and 60 meters and measured contemporaneous water temperatures along the northern lake shore.

The site near the glacier terminus showed increasing sediment concentration with depth. This trend was not seen in the profile along the NW shoreline where the glacier terminates on bedrock and is no longer in contact with the lake.

Suspended Sediment Leaving Mendenhall Lake

Comparison of Air Temperature, Rainfall, Stream Discharge and Suspended Sediment Concentration

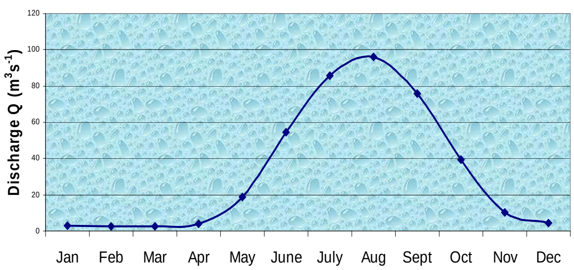


Discussion

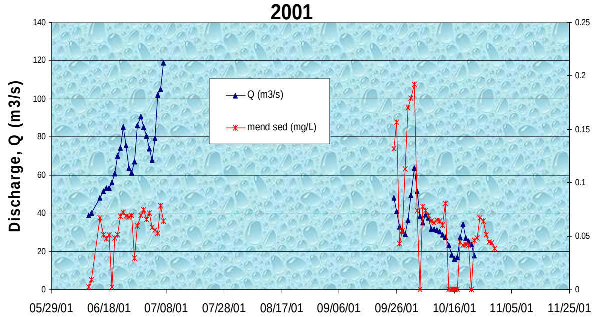
There is a general accordance of suspended sediment concentration and discharge. At values of Q=50 m^3/sec in May and June, sediment loads are much lower than later in the summer suggesting the river runs at less than its sediment carrying capacity.

However there are unassociated concentration jumps and concentration variability in both the 2001 and 2002 samples that are not obviously driven by flow. These events may represent pulses of glacier sediment that are released at the glacier terminus and then propagated through the lake basin to be discharged down the river. The rapid decrease in sediment concentration in September river samples suggests that the source of sediment has been depleted or is no longer accessible as flow drops off.

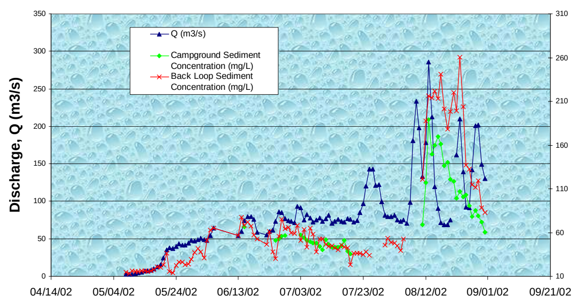
Mendenhall River Average Annual Hydrograph 1966 to 1999



Mendenhall River Discharge and sediment concentration 2001



Discharge and sediment over time, Mendenhall River 2002



Future Work

Further data reduction will enable us to begin to determine the volume of sediment moving from the glacier into the lake on an annual basis. We should also be able to estimate Q for glacier meltwater when we eliminate lake tributary water inputs from Nugget Creek (not available until later this year), Steep, and McGinnis-draining creeks and output discharge from the Mendenhall River.

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