Medicine Lake
In-lake and Watershed Monitoring
Data Review and Summary

Steering Committee Meeting, November 18th, 2008

John Barten
Brian Vlaeh
Randy Lehr
Medicine Lake
Placed on the Impaired Waters Section 303 (d) List for Excessive Nutrients in 2004

Eutrophication Standards

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Water Quality Goals</th>
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<tbody>
<tr>
<td>Total Phosphorus</td>
<td>40 µg/L</td>
</tr>
<tr>
<td>Chlorophyll-α</td>
<td>14 µg/L</td>
</tr>
<tr>
<td>Secchi Disc Transparency</td>
<td>1.4 m</td>
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</table>
**MNLEAP**
Minnesota Lake Eutrophication Analysis Procedure

<table>
<thead>
<tr>
<th>Parameters</th>
<th>MNLEAP Estimates</th>
</tr>
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<tbody>
<tr>
<td>Total Phosphorus</td>
<td>39 µg/L</td>
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<td>14 µg/L</td>
</tr>
<tr>
<td>Secchi Disc Transparency</td>
<td>1.6 m</td>
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</table>
# Medicine Lake Sampling

**1990-2008**

<table>
<thead>
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<th>Parameters</th>
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<tr>
<td>Temperature</td>
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<tr>
<td>Dissolved Oxygen</td>
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<td>Conductivity</td>
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<td>pH</td>
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<tr>
<td>Secchi Depth</td>
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<tr>
<td>Total Phosphorus</td>
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<tr>
<td>Dissolved Phosphorus</td>
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<tr>
<td>Total Nitrogen</td>
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<tr>
<td>Chlorophyll-a</td>
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</table>
Medicine Lake

Total Phosphorus (µg/L)

Water Quality Goal
Medicine Lake

Secchi Depth and Chlorophyll-a

- Secchi Depth
- Chlorophyll-a

Secchi Goal
Chl-a Goal
Monitored Nutrient Loading Sources

- Annual Loading
  - Watershed Loading
  - Internal Loading
    - Physical Mixing
    - Curlyleaf Pondweed
Plymouth Creek Hydrograph
2006

Precipitation Event 6/16/06
Rainfall = 3.27 inches
Volume = 12,336,240 cf
TP Concentration = 300 µg/L
Loading Calculations

Loading Calculation = Volume X Concentration

Loading Calculations for 3.27 inch Precipitation Event from 6/16/2006 through 6/20/2006

\[
\text{Loading} = (3.49 \times 10^8 \text{ L}) \times (6.61 \times 10^{-7} \text{ lbs/L})
\]

\[
\text{Loading} = 230.7 \text{ lbs of Phosphorus}
\]
Watershed Total Phosphorus Loading in 2006

- Plymouth Creek: 2235 lbs
- Parkers Lake: 239 lbs
- Ridgedale Creek: 524 lbs
- Northeast Medicine Lake: 35 lbs
- North Medicine Lake: 345 lbs
- North Bassett Crk: 60 lbs
- South Bassett Crk: 91 lbs
- East Medicine Lake: 40 lbs

Map showing the distribution of phosphorus loading across various water bodies.
Medicine Lake
Watershed Phosphorus Loading 2006
(3330 pounds)

- Plymouth Creek: 62%
- Ridgedale Creek: 15%
- Parkers Lake: 7%
- N Medicine Lake: 9%
- N Bassett Creek: 2%
- S Bassett Creek: 3%
- East Medicine Lake: 1%
- NE Medicine Lake: 1%
<table>
<thead>
<tr>
<th>Site</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
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<th>2005</th>
<th>2006</th>
<th>2007</th>
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<td>3931</td>
<td>2274</td>
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<td>2235</td>
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<td><strong>Fernbrook</strong></td>
<td>1125</td>
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<td>1696</td>
<td>1306</td>
<td>1780</td>
<td>1901</td>
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<td>Ridgedale Creek</td>
<td>276</td>
<td>558</td>
<td>504</td>
<td>472</td>
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Internal Loading
Medicine Lake
Seasonal Changes in Temperature

Medicine Lake: Temperature

<table>
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<tr>
<th>Color Key</th>
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<tbody>
<tr>
<td>Temp (C):</td>
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<tr>
<td>0</td>
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</tbody>
</table>

- 7/1/02
- 8/1/02
- 9/1/02
- 10/1/02

meters
feet
Bottom of Lake
Medicine Lake
Internal Loading

Medicine Lake: O2 Concentration

Color Key
O2 (mg/L): 0 3 6 9 12 15+
Medicine Lake
Internal Loading Events 2002

- July 16
- August 7
- August 16
- August 18
- August 20
- September 5
- September 15
- September 16
- September 17-19
- September 20
- September 21
Medicine Lake

Hypolimnetic Phosphorus Concentrations

![Graph showing Phosphorus (ug/L) concentrations in Medicine Lake over dates from March to November with data points for 2005, 2006, and 2007. The graph indicates a peak in Phosphorus concentration in July 2007.]
Internal Loading

• Barr Engineering estimated phosphorus internal loading is approximately 3,986 pounds by measuring nutrient release from Medicine Lake sediment cores in 1995.

• Wilms Modeling estimated phosphorus internal loading is approximately 1200 pounds.

• RUSS unit data indicates that internal loading is dependent upon the number of mixing events. Consequently, there is considerable variation in annual internal loading. Internal loading will be estimated using a mass balance equation.
Medicine Lake
Secchi Depth and Chlorophyll-a

- 04/30/02: 1.2
- 05/22/02: 3.2
- 06/04/02: 0.0
- 06/17/02: 1.0
- 07/09/02: 2.0
- 07/23/02: 3.0
- 08/06/02: 4.0
- 08/20/02: 5.0
- 09/10/02: 6.0

Secchi Depth (m)
Chlorophyll-a (µg/L)
## Curlyleaf Pondweed

### Total Phosphorus Analysis

<table>
<thead>
<tr>
<th>Site</th>
<th>Depth (m)</th>
<th>Stem Density (#Stems/m²)</th>
<th>Biomass (g dry wt/m²)</th>
<th>TP Conc. (mg/g dry wt.)</th>
<th>TP Load (lbs/Acre)</th>
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<tr>
<td>1</td>
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<td>1380</td>
<td>115.5</td>
<td>3.462</td>
<td>3.57</td>
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<td>9</td>
<td>560</td>
<td>51.2</td>
<td>6.131</td>
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<td>6</td>
<td>1260</td>
<td>113.9</td>
<td>2.167</td>
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<tr>
<td>2</td>
<td>9</td>
<td>720</td>
<td>70.3</td>
<td>2.419</td>
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<tr>
<td>3</td>
<td>6</td>
<td>620</td>
<td>98.5</td>
<td>3.639</td>
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<td>3</td>
<td>9</td>
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<td>87</td>
<td>3.813</td>
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<td>4</td>
<td>6</td>
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<td>43.5</td>
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<td>4</td>
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<td>260</td>
<td>33.7</td>
<td>5.940</td>
<td>1.79</td>
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</table>
# Medicine Lake Curlyleaf Pondweed Loading

## 2004

<table>
<thead>
<tr>
<th>Site</th>
<th>Acreage</th>
<th>Average (lbs TP/Acre)</th>
<th>TP Loading (pounds)</th>
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<tbody>
<tr>
<td>1</td>
<td>147.27</td>
<td>3.19</td>
<td>469.8</td>
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<td>2</td>
<td>42.15</td>
<td>1.86</td>
<td>78.4</td>
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<td>3</td>
<td>136.27</td>
<td>3.08</td>
<td>419.7</td>
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<td>4</td>
<td>50.03</td>
<td>1.65</td>
<td>82.6</td>
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<tr>
<td>Total</td>
<td>375.73</td>
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<td>1050</td>
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## 2003

<table>
<thead>
<tr>
<th>Site</th>
<th>Acreage</th>
<th>Average (lbs TP/Acre)</th>
<th>TP Loading (pounds)</th>
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<tbody>
<tr>
<td>1</td>
<td>136.79</td>
<td>3.19</td>
<td>436.4</td>
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<td>2</td>
<td>36.25</td>
<td>1.86</td>
<td>67.4</td>
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<tr>
<td>3</td>
<td>96.49</td>
<td>3.08</td>
<td>297.1</td>
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<td>4</td>
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<td>71.9</td>
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<td>Total</td>
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<td>872.9</td>
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## Medicine Lake

### Curlyleaf Pondweed Estimated Internal Loading

<table>
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<tr>
<th>Year</th>
<th>Concentration Change (µg/L)</th>
<th>Curlyleaf Loading (pounds)</th>
<th>Curlyleaf Internal Loading</th>
<th>Curlyleaf Total Loading</th>
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<td>1998</td>
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<td>1064</td>
<td>27%</td>
<td>12%</td>
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<tr>
<td>1999</td>
<td>15</td>
<td>470</td>
<td>12%</td>
<td>5%</td>
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<tr>
<td>2000</td>
<td>13</td>
<td>407</td>
<td>10%</td>
<td>5%</td>
</tr>
<tr>
<td>2001</td>
<td>11</td>
<td>483</td>
<td>12%</td>
<td>6%</td>
</tr>
<tr>
<td>2002</td>
<td>21</td>
<td>921</td>
<td>23%</td>
<td>10%</td>
</tr>
<tr>
<td>2003</td>
<td>21</td>
<td>657</td>
<td>17%</td>
<td>7%</td>
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<tr>
<td>Category</td>
<td>2004</td>
<td>2005</td>
<td>2006</td>
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<tr>
<td>--------------------------------</td>
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<tr>
<td>Herbicide Application</td>
<td>May 8-11</td>
<td>April 19-21</td>
<td>April 18-20</td>
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<tr>
<td>Amount of Herbicide Used</td>
<td>1,668 Gallons</td>
<td>1,400 Gallons</td>
<td>1,357 Gallons</td>
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<tr>
<td>Area Treated</td>
<td>317 Acres</td>
<td>325 Acres</td>
<td>320 Acres</td>
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<td>Pre-Treatment Quadrant Survey</td>
<td>May 06</td>
<td>April 22</td>
<td>April 24</td>
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<td>Post-Treatment Quadrant Survey</td>
<td>June 14</td>
<td>June 02</td>
<td>May 25</td>
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Average Stem Density
Depth 6 ft

Average Stem Density
Depth 9 ft

Data Collected by Steve McComas and Jo Stuckert, Blue Water Science
Medicine Lake

Total Phosphorus (µg/L)

2003

4/18/2003
5/7/2003
5/20/2003
6/3/2003
6/17/2003
7/1/2003
7/15/2003
7/22/2003
8/3/2003
8/10/2004
8/18/2004
9/9/2003

2004

4/27/2004
5/11/2004
5/24/2004
6/9/2004
6/21/2004
7/7/2004
7/19/2004
8/2/2004
8/16/2004
9/7/2004
9/27/2004

Total Phosphorus (µg/L)
Medicine Lake

Total Phosphorus (µg/L)


Water Quality Goal
Medicine Lake
Estimated Annual Loading Percentages

Watershed Loading 60%
Internal Loading 40%
Estimated Loading Reductions to Achieve Water Quality Goals
## Medicine Lake

### Estimated Change in TP with Loading Reductions in 2002

<table>
<thead>
<tr>
<th>Loading Conditions</th>
<th>Medicine Lake 2002</th>
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<tbody>
<tr>
<td></td>
<td>Total Loading (Pounds)</td>
</tr>
<tr>
<td>Observed</td>
<td>8838</td>
</tr>
<tr>
<td>20% Reduction</td>
<td>7478</td>
</tr>
<tr>
<td>30% Reduction</td>
<td>6797</td>
</tr>
<tr>
<td>40% Reduction</td>
<td>6117</td>
</tr>
<tr>
<td>50% Reduction</td>
<td>5437</td>
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</tbody>
</table>

2002 preliminary estimates are representative of above average conditions.
### Medicine Lake

**Estimated Change in TP with Loading Reductions in 2003**

<table>
<thead>
<tr>
<th>Loading Conditions</th>
<th>Total Loading (Pounds)</th>
<th>Loading Difference (Pounds)</th>
<th>TP Change (µg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed</td>
<td>5495</td>
<td>-</td>
<td>45</td>
</tr>
<tr>
<td>20% Reduction</td>
<td>4646</td>
<td>849</td>
<td>36</td>
</tr>
<tr>
<td>30% Reduction</td>
<td>4225</td>
<td>1270</td>
<td>32</td>
</tr>
<tr>
<td>40% Reduction</td>
<td>3802</td>
<td>1693</td>
<td>28</td>
</tr>
<tr>
<td>50% Reduction</td>
<td>3379</td>
<td>2116</td>
<td>24</td>
</tr>
</tbody>
</table>

2003 preliminary estimates are representative of average conditions.
South Bassett Creek Pond

- Pond was constructed the summer of 2004.
- Treatment device was constructed as a two-celled water quality pond.
- Storm sewer system was diverted to the water quality pond.
- Estimated nutrient removal—approximately 55 pounds of phosphorus.
- Water quality pond was estimated to reduce nutrient loading by 60%.
East Medicine Lake Park Pond

- Constructed in 2004
- Located west of the parking lot for the East Medicine Lake Park
- Captures run-off from industrial area
- Estimated nutrient removal—approximately 15 pounds of phosphorus
  - The pond reduces nutrient loading by 50% during high flows
  - The pond reduces nutrient loading by 30% during low flows.
County Road 9 Channel Improvement
Project Completed in 2008

- North Medicine Lake Sub-watershed contributes approximately 9% of the total watershed phosphorus loading.
- Estimated Reduction in Nutrient Loading is Currently Unknown.
Woods Creek Channel Improvement Project Completed in 2008

- Woods Creek contributes approximately 2% of the total watershed loading.
- Estimated Reduction in Nutrient Loading is Currently Unknown.
Plymouth Creek

- Plymouth Creek provides approximately 60% to 70% of nutrient loading to Medicine Lake.
- Water flowing from Parkers Lake Sub-watershed (18th Ave Monitoring site) was diverted to Plymouth Creek.
- A pond is proposed on Plymouth Creek prior to flowing to Medicine Lake.
- Construction is to begin the winter of 2008.
- Construction of pond is estimated to provide 350 pounds of phosphorus removal.
## Medicine Lake

**Estimated Change in TP with Loading Reductions in 2002**

<table>
<thead>
<tr>
<th>Loading Conditions</th>
<th>Total TP Loading (Pounds)</th>
<th>Loading Reductions (Pounds)</th>
<th>Anticipated Future Load Reductions (Pounds)</th>
<th>Remaining Future Load Reductions (Pounds)</th>
<th>TP Change (µg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed</td>
<td>8838</td>
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<td>420</td>
<td>940</td>
<td>58</td>
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<tr>
<td>20% Reduction</td>
<td>7478</td>
<td>1360</td>
<td>420</td>
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<tr>
<td>30% Reduction</td>
<td>6797</td>
<td>2041</td>
<td>420</td>
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<tr>
<td>40% Reduction</td>
<td>6117</td>
<td>2721</td>
<td>420</td>
<td>2981</td>
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<tr>
<td>50% Reduction</td>
<td>5437</td>
<td>3401</td>
<td>420</td>
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<td>33</td>
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</table>

2002 preliminary estimates are representative of above average conditions.
**Medicine Lake**

**Estimated Change in TP with Loading Reductions in 2003**

<table>
<thead>
<tr>
<th>Loading Conditions</th>
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<td>5495</td>
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<td>429</td>
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<tr>
<td>20% Reduction</td>
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<td>849</td>
<td>420</td>
<td>429</td>
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<tr>
<td>30% Reduction</td>
<td>4225</td>
<td>1270</td>
<td>420</td>
<td>850</td>
<td>32</td>
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<tr>
<td>40% Reduction</td>
<td>3802</td>
<td>1693</td>
<td>420</td>
<td>1273</td>
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<tr>
<td>50% Reduction</td>
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</tbody>
</table>

2003 preliminary estimates are representative of average conditions
Acknowledgements

- City of Plymouth - Derek Asche and Bob Moberg
- Minnesota Department of Natural Resources - Dave McCormick & Niel Vanderbosch
- U.S. Army Corps of Engineers - John Skogerboe
- Blue Water Science - Steve McComas & Jo Stuckert
- Three Rivers Park District - James Johnson, Dean Almquist, & Monica Zachay
- Lake Restoration - Kevin Kretsch
- AMLAC
- City of Plymouth Environmental Quality Committee
- Aquatic Vegetation Management Group
- Bassett Creek Watershed Management Commission
- Barr Engineering- Greg Wilson and Len Kremer