

## 7.0 Conclusions

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Detailed water quality monitoring data indicate that Crystal Lake did not meet the BDWMO's water quality goals in 2002, while Keller lake met the goals established in the BDWMO *Water Management Plan*. Model simulations of Crystal and Keller Lake watersheds assuming full-development, indicate that the predicted in-lake phosphorus and chlorophyll *a* concentrations and Secchi disc transparency do not meet the water quality goals.

Cost-effective BMPs should be implemented to prevent the degradation of the lakes' water quality and mitigate the effect urbanization has on the lakes. As shown in Tables 6-3a, 6-3b, 6-3c and 6-4a, 6-4b, 6-4c, options are available that would provide effective treatment of stormwater and meet BDWMO's water quality goals. Several options are also presented to meet Burnsville's more aggressive water clarity goal for Crystal Lake. Additionally, the reduction in the total phosphorus loading to the lake due to nonstructural BMPs may also assist in reaching the goals. The following summary describes the main conclusions of this study:

1. The analysis of seasonal trends in total phosphorus, chlorophyll *a*, and Secchi disc transparency during 2002 indicated there is considerable temporal and spatial variability in water quality among the five basins of Crystal Lake. For instance, the respective spring total phosphorus concentrations are 21, 22, 17, 18 and 27 µg/L for the main basin of the lake, Mystic Bay, Bluebill Bay, Buckhill Bay, and Maple Island Bay. These concentrations are characteristic of eutrophic conditions in Maple Island Bay and of mesotrophic conditions in the main basin of the lake, Mystic Bay, Bluebill Bay, and Buckhill Bay. However, due to summer inputs of additional phosphorus, primarily from watershed runoff, the die-back of curlyleaf pondweed, and biochemical release by anoxic lake sediments, the corresponding fall overturn concentrations rise to 68, 36, 39, 28 and 81 µg/L. The latter total phosphorus concentrations would classify Crystal Lake as eutrophic in Mystic, Bluebill, and Buckhill Bays, and as hypereutrophic in its main basin and in Maple Island Bay. The summer algal blooms caused by these elevated phosphorus concentrations interfere with recreational-use of Crystal Lake, and changes in watershed land use threaten to exacerbate this situation.

A trend analysis of Crystal Lake's historic water quality data was completed to determine if the lake had experienced significant degradation or improvement during the years for which water quality data are available. The trend in a variable was considered significant if the slope of the regression was statistically significant at the 95 percent confidence level.

Summer water quality data has been collected for Crystal Lake periodically since 1973. Summer average values (the typical averaging period was late-May through early-September) were calculated and analyzed in a trend analysis (i.e., linear regression and analysis of variance). Although the trend analyses of historical water transparency data for Crystal Lake indicates no long-term (over the 29-year period of record) water quality trends, the lake's overall condition has generally degraded during the past 12 years at a rate of roughly 0.1 meters of Secchi disc transparency per year. This degradation is most likely due to the concurrent transition of natural open lands into low-density residential and commercial development. Although the analysis found no significant trends over time for chlorophyll *a* and total phosphorus, both of these water quality parameters have generally deteriorated over the last 12 years.

2. Water quality measurements for 2002 indicate that Keller Lake is a hypereutrophic system. During the spring overturn period (early-April), the total phosphorus data collected were in the hypereutrophic (i.e., very poor water quality) category. This was likely the result of significant amounts of phosphorus added to the lake water by anoxic lake sediments during winter and by spring snowmelt runoff. The remaining data collected during 2002 also placed the lake in the hypereutrophic category. The epilimnetic (surface water, i.e., 0-2 meter depth) phosphorus concentration increased from the lake's spring steady-state concentration (59 µg/L) to the lake's summer average concentration (70 µg/L). This increase was due to additional phosphorus inputs from a combination of stormwater runoff and internal sources. The 2002 data did not indicate the extremely high total phosphorus concentrations during summer that have been observed historically which may be the result of wind induced mixing and additional flushing caused by the abnormally wet summer period.

The chlorophyll *a* data, including the summer average concentration (20.7 µg/L), indicate nuisance algal blooms (greater than 20 µg/L chlorophyll *a*) likely occurred during 2002, resulting in recreational use impairment. The 2002 Keller Lake summer average chlorophyll *a* meets the BDWMO's goal.

A trend analysis of Keller Lake's historic water quality data was also completed to determine if Keller Lake had experienced significant degradation or improvement during the years for which water quality data are available. There was a noticeable improvement in water clarity from 1996 to 1998, and then a marked decline in the water quality between 1999 and 2002. This improvement in 1998 was likely partially the result of the Crystal Lake hypolimnetic

withdrawal project, as previously mentioned. Keller Lake water clarity has remained relatively unchanged, ignoring the 1998 summer average Secchi disc transparency. As a result there is no statistically significant trend in Keller Lake water clarity, total phosphorus, or chlorophyll *a*.

3. A 2002 macrophyte survey did not detect the presence of Eurasian water milfoil in Crystal Lake. However, another exotic weed species, curlyleaf pondweed, was detected during the June survey. Curlyleaf pondweed is of special concern because the plants die-back and decay towards the middle of the summer, it appears to represent a significant source of internal phosphorus loading to the lake. Due to their shallow depths, the various bays in Crystal Lake were fairly well covered with submerged weeds. The density of macrophytes significantly interfered with recreation during past years.
4. Land use patterns show that some land areas within the Crystal Lake watershed, primarily in Lakeville, that are currently vacant/open space will be developed into residential, high-density residential, and commercial/industrial areas. This is especially true along the I-35 corridor southwest of the lake.
5. Crystal Lake receives approximately 34 percent of its annual phosphorus load due to release from its bottom sediments and die-back of curlyleaf pondweed (under 2002 climatic conditions). Phosphorus released by the bottom sediments builds up in the hypolimnion and is: (1) slowly released into the epilimnion during the course of the summer, and/or (2) delivered to the epilimnion during fall turnover. Of the remaining 66 percent of the annual phosphorus load, 13 percent is from direct atmospheric depositions and 53 percent is from watershed inflows.
6. Water quality simulations completed with the P8 model indicate that as development proceeds in the watershed, concentrations of total phosphorus and total suspended solids in stormwater runoff will increase. For existing (2002) and full-development land use conditions, the overall phosphorus loadings from the watershed to Crystal Lake are 0.18 lbs./acre and 0.19 lbs./acre, respectively. Assuming 2002 climatic conditions, the watershed phosphorus loading to Keller Lake (0.27 lbs./acre) will not likely change in the future because the watershed is essentially fully developed.
7. The study results indicate that under 2002 climatic conditions several individual BMPs or BMP combinations would produce Secchi disc transparencies that would meet the

BDWMO's summer average water clarity goal (1.6 meters) for Crystal Lake (see Figures 6-2a, 6-2b, 6-8, and 6-9). However, only Management Options III.12 and III.13 would result in Secchi disc transparencies that would meet the City of Burnsville's water clarity goal (2.6 meters). In addition, some of those goal achieving management options involve new and experimental chemical treatments or are extremely expensive.

Implementation of an option that involves watershed BMPs to control external phosphorus sources in combination with in-lake BMPs to control internal phosphorus sources will ensure that the BDWMO's goals are met. Implementation of these options will also alleviate the problems associated with several of the sediment deltas that have formed at two Keller Lake inflow locations and extend the longevity of any in-lake treatments.

8. After extensive input from the BDWMO Board, City staffs, and neighborhood residents Management Option III.14 was determined to be the most feasible goal achieving alternative. Model simulations indicate that following the implementation of the BMP elements of Management Option III.14 would result in summer average total phosphorus concentrations of 30 µg/L and 32 µg/L in Crystal and Keller Lakes respectively (see Figures 6-8 and 6-9). These concentrations would translate into summer average Secchi disc transparencies of 2.1 meters and 1.8 meters respectively, thus achieving the BDWMO's goals for both lakes.
9. While BMPs recommended in this Plan will serve to decrease total suspended solids and phosphorus loads to both Crystal and Keller Lakes, additional nonstructural BMPs should be implemented to protect and improve the water quality in lakes and ensure that the BDWMO's water quality goals are consistently met.