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5.15.1 General Information

Horseshoe Lake is located in the City of Lake Elmo and West Lakeland Township, west of Manning Avenue North (CSAH 15) and north of 10th Street North (CSAH 10). Figure 5.15-1 shows the local Horseshoe Lake watershed.

A major portion of the local Horseshoe Lake tributary area is Tartan Park. Tartan Park is a semi-private park and golf course owned by the 3M Company, located on the north and west sides of the lake. Within the local Horseshoe Lake watershed, single family residential development is present to the northeast side of Horseshoe Lake, while a small portion of the local watershed northeast and southeast of the lake is undeveloped. Future estimated land use for the local watershed includes rural/large-lot or single family residential development for all areas not currently park or preserve land use. Figure 5.15-2 shows the current (2010) and estimated future (2030) land use of the local Horseshoe Lake watershed.

The overall Horseshoe Lake watershed includes a much larger area. Water from the Lake Elmo outlet and the Eagle Point Lake bypass pipe discharge to the ditch downstream of the Lake Elmo outlet and flow to Horseshoe Lake via ponds and drainageways in Tartan Park. Downs Lake, which is landlocked under normal hydrologic conditions, also
overflows to Horseshoe Lake in extreme events.

Although Horseshoe Lake currently has no official public access, the lake is often used by the public. Because the lake is located adjacent to Manning Avenue North (CSAH 15) and Manning Trail North, people park along Manning Trail North and use the road as a walk-on access for canoes. On average, two people per day use the lake for fishing and/or canoeing. The Minnesota Department of Natural Resources (MDNR) has previously expressed an interest in working with VBWD, the City of Lake Elmo and 3M to establish a public access on the east end of Horseshoe Lake.

Tartan Park attendees use Horseshoe Lake primarily for aesthetic viewing. The park notes about 100,000 attendees per year. The park has a 27-hole golf course, driving range, golf clubhouse, restaurant, and facilities for tennis, bocce ball, softball/baseball, horseshoe, volleyball, and archery. Picnic areas and trails for winter snowmobiling and cross country skiing are also provided. Tartan Park has expressed interest in constructing a fishing pier to provide fishing for park attendees.

### 5.15.2 Water Quality Management Plan

Horseshoe Lake is classified as a shallow lake by the Minnesota Pollution Control Agency (MPCA). Horseshoe Lake currently meets the MPCA’s water quality standards for shallow lakes (see Table 5.15-1) and is not included among the MPCA’s list of impaired waters in Minnesota.

The VBWD has classified Horseshoe Lake a Medium Priority waterbody according to the VBWD’s waterbody classification system (see Section 4.1 – Water Quality), due to its MPCA classification as a shallow lake (see Table 4.1-4). This classification is higher than the low priority given to Horseshoe Lake in the 2005 VBWD Plan.

The VBWD has a non-degradation water quality policy which sets “action triggers” for all of its major waterbodies. Section 4.1 – Water Quality discusses the action triggers in more detail. Action triggers for VBWD lakes consider the following water quality parameters (summer average) relative to MPCA water quality standards and prior water quality data (i.e., trend analysis):

- Secchi disc depth
- Total phosphorus
- Chlorophyll a

Although Horseshoe Lake is not included in the MPCA’s impaired waters list, Horseshoe Lake is included among the waterbodies assessed in the VBWD Watershed Restoration and Protection Strategies (WRAPS) study performed from 2012 to 2015. The WRAPS study identified the primary source of phosphorus loading to Horseshoe Lake as inflow from upstream Eagle Point Lake, which accounted for over 80 percent of the total load during the growing season. The WRAPS study also identified possible implementation strategies applicable to Horseshoe Lake. The results of the WRAPS study are described in greater detail in Appendix A-5.15
Specific water quality implementation tasks for Horseshoe Lake are based on the 2015 WRAPS study, and include the following:

1. The VBWD will monitor the water quality of Horseshoe Lake and perform the actions discussed in Section 4.1 – Water Quality for Medium Priority water bodies.

   The VBWD will evaluate the average summertime water quality (total phosphorus, chlorophyll $a$, and Secchi disc transparency) and compare it to applicable water quality standards (Table 4.1-1) and applicable action triggers (described in Section 4.1.7.5). Currently, the water quality in Horseshoe Lake meets applicable standards for shallow lakes.

2. The VBWD will cooperate with the City of Lake Elmo, West Lakeland Township, MDNR, or other entities to manage macrophytes (aquatic plants) in Horseshoe Lake. Treatment of areas containing dense, monospecific growths of Eurasian watermilfoil with an aquatic herbicide (2,4-D, Triclopyr, or low concentrations of Aquathol® K) is recommended to protect Eagle Point Lake’s native plant community. VBWD efforts may include
   - point-intercept surveys of aquatic vegetation
   - preparation of lake vegetation management plans (LVMP)
   - completion of Invasive Aquatic Plant Management (IAPM) Permit applications
   - design of herbicide treatment programs
   - participation in meetings with MDNR staff
   - other technical analysis

3. The VBWD will cooperate with the MDNR to perform fishery surveys in Horseshoe Lake to determine the extent of carp within the lake. Anecdotal evidence suggests a large carp population may be present. Carp can increase internal loading of phosphorus by disturbing the sediments.

4. The VBWD will promote Washington County financial assistance programs for non-compliant or non-functioning subsurface sewage containment systems (SSTS).

5. The VBWD will work with 3M to evaluate the feasibility of expanding water reuse in Tartan Park.

6. The VBWD will continue to implement its Rules and Regulations (2013, as amended) in the Horseshoe Lake watershed. The VBWD Rules address water quality performance standards for development and redevelopment projects, as well as required vegetated buffers around VBWD lakes, streams, and wetlands. The VBWD Rules and Regulations are included in this Plan as Appendix A-4.5.
5.15.2.1 Water Chemistry Data

Water quality sampling has been conducted on Horseshoe Lake since 1979. The VBWD conducted water quality sampling in 1979, 1984, 1986, 1991, 1996, 2000, 2004, and annually since 2007. Water quality samples are typically analyzed for total phosphorus and chlorophyll $a$, while Secchi disc transparency is measured in the field at the time of sampling (see Appendix A-4.1 – Water Quality Background Information).

The April 2001 report, *Hydrologic and Phosphorus Budgets for Sunnybrook Lake, Goetschel Pond, Cloverdale Lake, McDonald Lake, Downs Lake, Horseshoe Lake, and Fahlstrom Pond* (Barr, 2001), estimated a slight (approximately 10 percent) increase in phosphorus loading and resultant concentration for Horseshoe Lake in future land use conditions (relative to 2001 conditions). The report recommended that the VBWD implement general best management practices for the entire watershed and to continue monitoring Horseshoe Lake’s water quality.

Additional water quality data was collected in 2007 and 2008 as part of the *2008 Water Quality Assessment for DeMontreville, Eagle Point, and Horseshoe Lakes* (Barr, 2009). That effort included and assessment of loading sources and recommended actions to maintain nutrient concentrations below the impaired waters listing criteria. The results of the 2008 Water Quality Assessment are summarized in Appendix A-5.15. The most recent 10-year average summer water quality data is presented relative to applicable MPCA and VBWD water quality standards in Table 5.15-1 and illustrated in Figure 5.15-3.

**Table 5.15-1  Summary of Horseshoe Lake summer average water quality**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>10-year Average (2004-2013)</th>
<th>Trend in Average</th>
<th>MPCA Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Phosphorus</td>
<td>ug/L</td>
<td>52</td>
<td>None</td>
<td>60</td>
</tr>
<tr>
<td>Chlorophyll $a$</td>
<td>ug/L</td>
<td>19.6</td>
<td>None</td>
<td>20</td>
</tr>
<tr>
<td>Secchi Disc Depth</td>
<td>m</td>
<td>1.3</td>
<td>None</td>
<td>1.0</td>
</tr>
</tbody>
</table>

The 10-year averages of summer average total phosphorus, chlorophyll $a$, and Secchi disc transparency meet the applicable water quality standards, although the 10-year averages of chlorophyll $a$ and total phosphorus are very close to the standards (see Table 5.15-1). Maximum values of observed within the last 10 years have exceed the applicable standards three times for Secchi disc transparency (2004, 2010, 2013), one time for total phosphorus (2012), and three times for chlorophyll $a$ (2008, 2010, 2013). The most recent 10-years of data identify no statistically significant trends in total phosphorus, chlorophyll $a$, or Secchi disc transparency.
5.15.2.2 Biological Data

Various types of biological data have been compiled and evaluated for Horseshoe Lake, in addition to physical and chemical parameters. Macrophyte (large aquatic plant), phytoplankton (non-rooted floating plants – algae), zooplankton (microscopic aquatic animals), and fisheries data provide insight into the ecological quality of Horseshoe Lake. Section 4.2 (Water Quality Background Information) provides more information about the importance of fisheries and other biological data.

5.15.2.2.1 Fisheries

The Horseshoe Lake fishery is not managed by the MDNR. A 1976 MDNR game survey noted frequent winterkills from the lake and recommended no fisheries management. No surveys or stocking activities have occurred in the past decade. The MDNR last performed a fishery survey of Horseshoe Lake in 1993 the last survey was in 1993. Table 5.15-2 summarizes the results of the 1993 survey.

Table 5.15-2 Summary of 2011 MDNR Fisheries Survey for Horseshoe Lake

<table>
<thead>
<tr>
<th>Fish Species</th>
<th>Numbers</th>
<th>Photograph (Not to Scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bluegill</td>
<td>117</td>
<td></td>
</tr>
<tr>
<td>Pumpkinseed Sunfish</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Black Bullhead</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Northern Pike</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Black Crappie</td>
<td>117</td>
<td></td>
</tr>
<tr>
<td>Largemouth Bass</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Tiger Muskellunge</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>
Table 5.15-2  Summary of 2011 MDNR Fisheries Survey for Horseshoe Lake

<table>
<thead>
<tr>
<th>Fish Species</th>
<th>Numbers</th>
<th>Photograph (Not to Scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow Perch</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

No fish consumption advisories have been issued for Horseshoe Lake.

The MDNR’s Lakefinder website includes the most current data on the Horseshoe Lake fishery and is available at: [http://www.dnr.state.mn.us/lakefind/showreport.html?downum=82007400](http://www.dnr.state.mn.us/lakefind/showreport.html?downum=82007400)

### 5.15.2.2.2 Macrophytes (Large Aquatic Plants)

The VBWD conducted macrophyte surveys of Horseshoe Lake on June 21, 1996, August 22, 1996, June 13, 2000, August 24, 2000, May 25, 2007 August 17 2007, June 3, 2009, and June 4, 2012. Point intercept surveys of curlyleaf pondweed were also performed in 2012, 2013, and 2014. The data from these surveys is collected in Appendix B-5.15. The VBWD has collected macrophyte data to identify the conditions of plant growth throughout the lake. Macrophytes are the primary producers in the aquatic food chain, converting the basic chemical nutrients in water and soil into plant matter through photosynthesis, which becomes food for all other aquatic life. While macrophytes can negatively impact the recreational use of a water body, they are critical to the ecosystem as fish and wildlife habitat.

A comparison of 1996 and recent Horseshoe Lake plant survey data indicate changes in the lake’s plant community have occurred over time. All four submerged species observed in the lake during 1996 are tolerant of poor water transparency. Small pondweed (*Potamogeton pusillus*), curlyleaf pondweed (*Potamogeton crispus*), and coontail (*Ceratophyllum demersum*) are tolerant of turbid conditions and low light (Borman, 1997). Sago pondweed (*Potamogeton pectinatus*) can sometimes be found as the last surviving rooted plant in very turbid water (Borman et al., 1997). These four submerged species continue to be observed (Barr, 2014). However, additional submerged species were also observed, including a clean water species, pipewort (*Eriocaulon spp.*), which requires good water clarity (Borman et al., 1997). The available data suggest the lake’s plant community is sensitive to changes in water transparency, particularly to the minimum water transparency occurring during the summer period. The data suggest management of nutrient loading to Horseshoe Lake is important to the management of the lake’s plant community, and that reductions in Eagle Point Lake nutrient levels may benefit Horseshoe Lake’s plant community. As many as 12 native species have been observed in Horseshoe Lake since 1996, which is fewer than most other VBWD lakes surveyed.

The growth of the following exotic (non-native) species in Horseshoe Lake is of concern:

- Curlyleaf pondweed (*Potamogeton crispus*)
• Eurasian water milfoil (*Myriophyllum spicatum*)

Curlyleaf pondweed (CLP) was not observed during the June 21, 1996 survey, but a light growth of CLP was observed on the west side of the lake during August 22, 1996. Increased coverage and density over time resulted in light to moderate CLP throughout the lake’s periphery during 2000, growing to depths of three to four feet. CLP was also observed in the August 2007 survey, the June 2009 survey, and the June 2012 survey. Because CLP dies off in early summer, it was likely present in the lake in the May 2007 survey and simply not observed. CLP was observed at a frequency of about 5 percent in 2013 and 8 percent in 2014. Once a lake becomes infested with CLP, this plant typically replaces native vegetation, thereby increasing its coverage and density. CLP begins growing in late August, grows throughout the winter at a slow rate, grows rapidly in the spring, and dies in early summer. Native plants that grow from seed in the spring are unable to grow in areas already occupied by CLP, and are displaced by this plant. CLP die-off in early summer releases phosphorus to the lake, causing increased algal growth for the remainder of the summer.

Eurasian water milfoil (EWM) was first observed in Horseshoe Lake in the June 2012 survey and was also observed in 2013 and 2014. The 2013 survey described the incidence of Eurasian water milfoil (EWM) as low in frequency (10 percent coverage of the lake) but forming dense stands in some areas, particularly in the southwest bay of the lake. Like curlyleaf pondweed, EWM is difficult to completely eradicate once it is established. EWM frequency increased significantly in 2014, reaching 40 percent. Recommendations for management of EWM are discussed in 5.15.2.

Floating-leaf aquatic plants were observed in the 2007 surveys but were not recorded in the 2009 or 2012 surveys; all plant varieties in those surveys were either emergent (such as bulrushes and reeds) or submerged. The submerged aquatic plants that are common in Horseshoe Lake, including coontail (*Ceratophyllum demersum*) and native varieties of pondweed (*Potemageton sp.*) are tolerant of the lake’s low transparency.

The VBWD will continue to provide technical assistance to entities seeking to manage aquatic invasive species.

**5.15.2.2.3 (Non-Rooted, Floating Plants - Algae) and Zooplankton (Microscopic Aquatic Animals)**

The VBWD collected phytoplankton samples from Horseshoe Lake during 2000 and phytoplankton and zooplankton samples in 2007. Appendix C-5.15 and Appendix D-5.15 present the survey results for phytoplankton and zooplankton, respectively.

Phytoplankton derive energy from sunlight and use nutrients dissolved in lake water. They provide food for several types of animals, including zooplankton, which in turn are eaten by fish. A phytoplankton population in balance with the lake’s zooplankton population is ideal for fish production. An inadequate phytoplankton population reduces the lake’s zooplankton population and adversely impacts the growth of the lake’s fishery. However, excess phytoplankton, especially blue-green algae, can interfere with recreational usage of a lake and is considered problematic.
The moderate numbers of phytoplankton observed in Horseshoe Lake during 2000 were adequate to support the lake’s zooplankton community, yet low enough to correspond to an average summer chlorophyll concentration (19.25 µg/L) that is slightly below the threshold of nuisance algal blooms (20 µg/L).

The total maximum phytoplankton count for Horseshoe Lake in 2007 was just under 50,000 per mL. This is a four-fold increase from the maximum count in 2000, which was approximately 11,000 per mL. Throughout the 2007 sampling season, blue green algae (Cyanophyta) were by far the most populous group of algae in Horseshoe Lake. The World Health Organization developed guidelines to determine risks from blue-green algae, and low adverse health effects, such as skin irritations and gastrointestinal illness, may occur when more than 20,000 blue-green algae are present per mL. Horseshoe Lake exceeded this threshold in 2007 from approximately mid-July through early September.

Dominance by blue-green algae is undesirable because they are often inedible to zooplankton due to their large size. Furthermore, blue-green algae generally float on the waters’ surface where they are particularly objectionable to lake users. Blue-green algae are best managed by reducing the lake’s phosphorus concentration. Increases in the lake’s phosphorus concentration would likely cause increased growth of blue-green algae. However, blue-green algae limit their own growth by shading when their growth levels are very high. High growth levels may adversely impact the lake’s plant community by limiting growth through shading. Judicious management of the lake’s phosphorus concentration is recommended to prevent objectionable algal blooms and to prevent adverse impacts to the lake’s plant community due to shading by algae.

The zooplankton community in Horseshoe Lake is more diverse than the phytoplankton community. All three groups which are commonly found in freshwater lakes (rotifera, ropepoda, and rladocera) were present throughout the 2007 sampling season. Late in the season, rotifera are particularly dominant, indicating higher nutrient availability. While these animals provide food for the lake’s panfish community, they are unable to control the lake’s algae community due to their small size. Because fish predation generally determines the numbers of large- and small-bodied zooplankters in a lake, increasing the numbers of large-bodied zooplankton is unrealistic. Because zooplankton grazing will not control the lake’s phytoplankton community, phosphorus loading to the lake solely determines Horseshoe Lake’s algae community. Hence, phosphorus management will provide the best management measures for the lake’s phytoplankton community.

5.15.3 Water Quantity Management Plan

The VBWD will perform the following water quantity management actions:

1. The VBWD will continue to annually inspect and maintain and operate the Horseshoe Lake outlet structure. As approved by the MDNR, the VBWD can lower the discharge elevation of Horseshoe Lake by a maximum of 5.2 feet by removing stoplogs. Stoplogs may only be removed between February 15 and April 15 and the water content of the snowpack is greater
than 3 inches. (See Section 4.7.7 for details regarding the operation of Project 1007. Appendix E-5.15 includes the operation plan.)

2. VBWD will continue to monitor Horseshoe Lake water levels at approximately monthly intervals and supply the information to the MDNR. The VBWD will include the water level measurements in its annual report, which is posted to the VBWD’s website.

5.15.3.1 Drainage Patterns and Outlet Information

Prior to construction of Project 1007, water discharged from Horseshoe Lake through a culvert under Manning Avenue North and a ditch between Manning Avenue North and 10th Street North. The new outlet control structure is located at the most easterly bay of the lake, west of Manning Avenue North, on Tartan Park property. Figure 5.15-4 shows the outlet structure. The control structure consists of 48-inch diameter piping into and 42-inch diameter piping out of a manhole. Inside the manhole is a concrete and stoplog weir which controls the water level of Horseshoe Lake at Elevation 875.0 (NGVD29 datum) under normal conditions (see the Lake Elmo Subwatershed Management Plan, Section 5.13 for a discussion about benchmark corrections). The VBWD MDNR-approved operating plan for the Horseshoe Lake control structure calls for drawdown of the lake’s water level when snowmelt runoff greater than three inches is anticipated. The maximum allowable drawdown is to Elevation 870.0 (NGVD29 datum).

The MDNR set the Ordinary High Water level (OHW) at Elevation 876.8 (NGVD29 datum) and the normal water level at Elevation 875.6 (NGVD29 datum). The 100-year flood elevation for Horseshoe Lake was lowered 0.6 feet, to Elevation 877.4 (NGVD29 datum), as a result of the new outlet constructed as part of VBWD’s Project 1007. A volunteer for the VBWD measures the Horseshoe Lake water level monthly. Except for one measurement in 1969, the VBWD measurements began in 1976. Figure 5.15-5 shows the historical water levels. For approximately 20 years following the construction of Project 1007, water levels in Horseshoe Lake fluctuated between approximately Elevation 874 and 877. In 2010, water levels declined to as low as Elevation 869, before rebounding to the approximate outlet elevation in 2011.

Water from Horseshoe Lake flows downstream by means of a ditch and pipe system to the north pond of the West Lakeland Storage Site. As part of Project 1007, VBWD abandoned the portion of the existing ditch from Horseshoe Lake to a point approximately 450 feet south of 12th Street North, where the new drainageway intersects the existing ditch. From that point to 10th Street North (and the north pond of the West Lakeland Storage Site), the existing ditch was widened and deepened.

5.15.3.2 Water Quantity Issues

In 2013, the National Oceanographic and Atmospheric Administration (NOAA) published Atlas 14, Volume 8 (see Section 4.7.6). Atlas 14 contains updated precipitation data for Minnesota and supersedes data sources used in establishing the 100-year flood level for Horseshoe Lake. Over the next several years, the VBWD will update its hydrologic-hydraulic modeling of major subwatersheds, including Horseshoe Lake. Updated modeling will incorporate the most recent
precipitation data (see Section 4.7.7) which may increase 100-year flood levels relative to the existing value.

5.15.4 References


Borman, S., R. Korth, and J. Temte. 1997. Through the Looking Glass … A Field Guide to Aquatic Plants. Wisconsin Lakes Partnership (Cooperative Extension of the University of Wisconsin—Extension and the Wisconsin Department of Natural Resources). Stevens Point, WI.


Figure 5.15-2
HORSESHOE LAKE WATERSHED CURRENT (2010) AND FUTURE (2030) LANDUSE
2015-2025 Watershed Management Plan
Valley Branch Watershed District

Source: Metropolitan Council 2010
1 inch = 2,000 feet

Current (2010) Land Use
- Farmstead
- Seasonal/Vacation
- Single Family Detached
- Manufactured Housing Park
- Single Family Attached
- Multifamily
- Retail and Other Commercial
- Office
- Mixed Use Residential
- Mixed Use Industrial
- Mixed Use Commercial and Other
- Industrial and Utility
- Extractive
- Institutional
- Park, Recreational or Preserve
- Golf Course
- Major Highway

Future (2030) Land Use
- Agricultural
- Rural or Large-Lot Residential
- Single Family Residential
- Multifamily Residential
- Commercial
- Industrial
- Institutional
- Mixed Use
- Multi-Optional Development
- Park and Recreation
- Open Space or Restrictive Use

Rights-of-Way (i.e., Roads)
- Railway (inc. LRT)
- Airport
- Vacant or Unknown
- Open Water

1 inch = 2,000 feet

Horseshoe Lake Subwatershed
Major Subwatershed Boundary
VBWD Legal Boundary
Figure 5.15-3

Horseshoe Lake Water Quality
2015 - 2025 Watershed Management Plan
Valley Branch Watershed District
NOTES: 1. STEPS NOT SHOWN: PLACE STEPS ON DOWN STREAM SIDE OF WEIR
2. APPLY EPOXY BONDING AGENT TO ALL WEIR-PRECAST JOINTS

SECTION: STRUCTURE 3
SCALE: 1/2"=1'-0"

HORSESHOE LAKE OUTLET
Valley Branch Watershed District
Figure 5.15-5

HORSESHOE LAKE WATER LEVELS
2015 - 2025 Watershed Management Plan
Valley Branch Watershed District

Elevations in NGVD29 datum

Date

Project 1007 Completed

Spring Drawdowns
Appendix A-5.15  Additional Water Quality Information
Appendix A-5.15 Additional Water Quality Information

2007-2008 Water Quality Assessment of Horseshoe Lake

Water quality modeling was conducted for 2003, 2007, and 2008 using monitoring data and a mass balance model (see 2008 Water Quality Assessment for DeMontreville, Eagle Point, and Horseshoe Lakes, Barr, 2009). Stormwater inflow data was not available for these years, but outflow from Lake Elmo and Eagle Point Lake was estimated using lake level data. Lake level data was available for all years, thus, outflow was able to be calculated. Year 2003 was considered an average year in terms of climate, while 2007 and 2008 were mainly dry years (winter through mid-summer) with wet late summer and fall conditions.

Assessment of nutrient loading revealed the following:

- The local watershed to Horseshoe Lake is small and is not generally connected directly. The lake receives the majority of stormwater input via Lake Elmo and Eagle Point Lake outflows, which flow through Tartan Park and enter the lake via a submerged pipe. During both 2007 and 2008, flow into Horseshoe Lake was low and the lake had some of the best water quality on record. Table 12 above shows that external loading to the lake was between 8% and 15% for years 2007 and 2008 of the external load entering the lake during the wet year, 2003.

- Phosphorus is elevated in April due to external loading and then it decreases one loading to the lake stops in mid-April. Internal phosphorus loading begins in mid-June when oxygen decreases above the sediment and ends in mid-August due to mixing and adequate oxygen at the sediment surface.

- The sediments in Horseshoe Lake are consolidated and relatively low in mobile phosphorus, meaning internal loading is low in the lake. The model results confirm this, with a range of 44 to 54 pounds of phosphorus released in 2003, 2007, and 2008. However, it appears that sediment and phosphorus in the inflows coming from outside the lake appear to be causing phosphorus accumulation in the sediment near the inlet to the lake.

The 2008 Water Quality Assessment for DeMontreville, Eagle Point, and Horseshoe Lakes (Barr, 2009) recommended the following actions for Horseshoe Lake to maintain water quality in the lake and prevent impairment due to nutrients:

- Implement phosphorus reduction strategies for Eagle Point Lake to reduce phosphorus loading in lake outflow that enters Horseshoe Lake

- Monitor the flow moving through Tartan Park to determine the effect upstream phosphorus reduction strategies have on phosphorus loading to Horseshoe Lake

- Continue to monitor the macrophyte community in Horseshoe Lake, specifically monitoring the presence of Curlyleaf pondweed
MINLEAP Modeling

The Minnesota Lake Eutrophication Analysis Procedure (MINLEAP) is intended to be used as a screening tool for estimating lake conditions and for identifying “problem” lakes. MINLEAP is particularly useful for identifying lakes requiring “protection” versus those requiring “restoration” (Heiskary and Wilson, 1990). In addition, MINLEAP modeling by has been done in the past to identify Minnesota lakes which may be in better or worse condition than they “should be” based on their location, watershed area and lake basin morphometry (Heiskary and Wilson, 1990).

Results of MINLEAP modeling done by the VBWD in 2014 for the direct, contributing watershed to Horseshoe Lake suggests that the lake should experience slightly “better” water quality than is currently observed. For Horseshoe Lake MINLEAP predicts a growing season mean total phosphorus concentration of 48 µg/L versus 52 µg/L (observed from 2004 to 2013); a chlorophyll a concentration of 18.8 µg/L versus 19.3 µg/L (observed from 2004 to 2013); and summer average transparency of 1.4 meters versus 1.3 meters (observed from 2004 to 2013). The predicted phosphorus concentration has a standard error of 17 µg/L. The results of this analysis suggest that the VBWD water quality goal for total phosphorus is realistically attainable for Horseshoe Lake.

Vighi and Chiaudani Method

Vighi and Chiaudani (1985) developed another method to determine the phosphorus concentration in lakes that are not affected by anthropogenic (human) inputs. As a result the phosphorus concentration in a lake resulting from natural, background phosphorus loadings can be calculated from information about the lake’s mean depth and alkalinity or conductivity. Alkalinity is considered more useful for this analysis because it is less influenced by the modifying effect of anthropogenic inputs.

Based on the Vighi and Chiaudani method, the predicted phosphorus concentration from natural, background loadings should be about 22 µg/L. This predicted phosphorus concentration is lower than the average observed phosphorus concentration from 2004 through 2013 and suggest that better water quality can be attained in Horseshoe Lake.

Watershed Restoration and Protection Strategy (WRAPS)

Horseshoe Lake is included in the VBWD WRAPS study, which addressed several VBWD waterbodies. One of the key components of the WRAPS study is to understand the sources of phosphorus contributing to the existing nutrient loading. Sources evaluated for Horseshoe Lake in the WRAPS study (and the associated percentage of phosphorus loading during the growing season) include:

- upstream loading from Eagle Point Lake (88 percent)
- internal loading (6 percent)
- upstream loading from Lake Elmo (2 percent)
- direct watershed runoff (3 percent)
• aquatic vegetation (<1 percent)
• subsurface sewage treatment systems (SSTS) (<1 percent)
• atmospheric deposition (1 percent)

**Modeling Methods**

The P8 (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds) Urban Catchment (computer) Model (Version 3.4) was used to estimate watershed runoff and total phosphorus loads from the Horseshoe Lake watershed. Noncontributing areas of the watershed, as identified by the VBWD, were not included in the P8 model. In-lake modeling for Horseshoe Lake was accomplished through the creation of a mass balance model that tracks the flow of both water and phosphorus through the lake for the critical water quality growing season as well as the year prior (to establish a steady-state initial condition).

The key input parameters for the in-lake mass balance model included direct precipitation data, evaporation data, runoff loads from the lake’s watershed (as predicted by the P8 model), the lake storage and outlet rating curve, estimated groundwater exchange, and in-lake water quality monitoring data. Additional data, including sediment core data and macrophyte survey information, were used to verify that model estimates of internal phosphorus loading were reasonable.

**Implementation Plan**

As approximately 90 percent of the nutrient loading to Horseshoe Lake comes from upstream waterbodies, strategies implement in the Eagle Point Lake and Lake Elmo watersheds will have a significant residual effect on Horseshoe Lake water quality. Local watershed implementation strategies recommended in the WRAPS study include:

• Continue to implement the VBWD rules
• Evaluate the potential to expand water reuse in Tartan Park
• Promote Washington County’s financial assistance programs for non-complaint/non-functioning SSTS
• Continue routine monitoring of water quality and macrophytes
• Work with the MDNR to perform fishery surveys of Horseshoe Lake
Appendix B-5.15 Additional Macrophyte Information
No Macrophytes Found in Water > 2.0' - 3.0'

Macrophyte Densities Estimated as Follows: 1 = light; 2 = moderate; 3 = heavy

Submerged Aquatic Plants:
- Pondweed
  *Potamogeton pusillus*
- Sago pondweed
  *Potamogeton pectinatus*
- Potamogeton pusillus
- Potamogeton pectinatus
- Scirpus spp.
- Polygonum spp.
- Typha spp.

Floating Leaf:
- Water smartweed
  *Polygonum spp.*

Emergent:
- Cattail
  *Typha spp.*
- Bulrush
  *Scirpus spp.*

No Aquatic Vegetation Found:
- Approximate Scale in Feet

HORSESHOE LAKE
MACROPHYTE SURVEY
JUNE 21, 1996
- No Macrophytes Found in Water > 2.0' - 3.0'
- Macrophyte Densities Estimated as Follows: 1 = light; 2 = moderate; 3 = heavy

Submerged Aquatic Plants:
- Curlyleaf pondweed
- Pondweed
- Sago pondweed
- Coontail

Floating Leaf:
- Water smartweed

Emergent:
- Cattail
- Bulrush
- Arrowhead

No Aquatic Vegetation Found:

Comments: Young Potamogeton crispus observed growing from nodes in shallow areas (sporadic)
No Macrophytes Found in Water > 3.0'-4.0'

Macrophyte Densities Estimated as Follows: 1 = Light; 2 = Moderate; 3 = Heavy
No Macrophytes Found in Water > 3.0’-4.0’

Macrophyte Densities Estimated as Follows: 1 = Light; 2 = Moderate; 3 = Heavy

Submerged Aquatic Plants:
- Curlyleaf pondweed
- Pondweed
- Sago pondweed
- Coontail
- Elodea
- Water star grass
- Busy pondweed and naiad
- Pipewort
- Buttercup

Floating Leaf:
- Water smartweed

Emergent:
- Cattail
- Bulrush

No Aquatic Vegetation Found:
HORSESHOE LAKE
MACROPHYTE SURVEY
JUNE 14, 2004

No Macrophytes Found in Water > 3.0'-4.0'
Macrophyte Densities Estimated as Follows: 1 = Light; 2 = Moderate; 3 = Heavy

Common Name | Scientific Name
---|---

**Submerged Aquatic Plants:**
- Pondweed
- Sago pondweed
- Coontail
- Pipewort
- White water crowfoot

**Floating Leaf:**
- Water smartweed

**Emergent:**
- Cattail
- Bulrush

**No Aquatic Vegetation Found:**
- Typha sp.
- Scirpus sp.

- Potamogeton pusillus
- Potamogeton pectinatus
- Ceratophyllum demersum
- Polygonum spp.
- Ranunculus longirostris

- Potamogeton pusillus
- Potamogeton pectinatus
- Typha sp.
- Scirpus sp.
- Ceratophyllum demersum
- Eriocaulon spp.
- Ranunculus longirostris

- Potamogeton pusillus
- Potamogeton pectinatus
- Typha sp.
- Scirpus sp.
- Polygonum spp.
- Water smartweed

- Potamogeton pusillus
- Potamogeton pectinatus
- Typha sp.
- Scirpus sp.
- Oenothera biennis

- Potamogeton pusillus
- Potamogeton pectinatus
- Typha sp.
- Scirpus sp.
- Polygonum spp.
- Water smartweed

- Potamogeton pusillus
- Potamogeton pectinatus
- Typha sp.
- Scirpus sp.
- Polygonum spp.
- Water smartweed

- Potamogeton pusillus
- Potamogeton pectinatus
- Typha sp.
- Scirpus sp.
- Polygonum spp.
- Water smartweed

- Potamogeton pusillus
- Potamogeton pectinatus
- Typha sp.
- Scirpus sp.
- Polygonum spp.
- Water smartweed

- Potamogeton pusillus
- Potamogeton pectinatus
- Typha sp.
- Scirpus sp.
- Polygonum spp.
- Water smartweed

No Macrophytes Found in Water > 2.0-3.0’.

Macrophyte Densities Estimated as Follows: 1 = Light; 2 = Moderate; 3 = Heavy

Common Name | Scientific Name
--- | ---
Pondweed | Potamogeton pusillus
Sago pondweed | Potamogeton pectinatus
Coontail | Ceratophyllum demersum
Pipewort | Eriocaulon spp.
White water crowfoot | Ranunculus longirostris

Submerged Aquatic Plants:

Floating Leaf:

Emergent:

No Aquatic Vegetation Found:
**HORSESHOE LAKE MACROPHYTE SURVEY RESULTS**

May 25, 2007

Valley Branch Watershed District

**FIELD NOTES:**
- Macrophyte densities estimated as follows:
  - 1=light; 2=moderate; 3=heavy
  - Densities generally not noted for emergent and floating leaf plants
  - No macrophytes found in water >3’
  - Water level low
  - Carex sp., Eleocharis sp. and Polygonum sp. found along entire shoreline

**Legend**
- Emergent Plants
- Floating Leaf Plants
- Submerged Aquatic Plants
- No Aquatic Vegetation

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>coontail</td>
<td><em>Ceratophyllum demersum</em></td>
</tr>
<tr>
<td>pondweed</td>
<td><em>Potamogeton sp.</em></td>
</tr>
<tr>
<td>water crowfoot</td>
<td><em>Ranunculus sp.</em></td>
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<tr>
<td>water smartweed</td>
<td><em>Polygonum sp.</em></td>
</tr>
<tr>
<td>cattail</td>
<td><em>Typha sp.</em></td>
</tr>
<tr>
<td>common bur-reed</td>
<td><em>Spartanium eurycarpum</em></td>
</tr>
<tr>
<td>green bulrush</td>
<td><em>Scirpus atrovirens</em></td>
</tr>
<tr>
<td>hardstem bulrush</td>
<td><em>Scirpus acutus</em></td>
</tr>
<tr>
<td>river bulrush</td>
<td><em>Scirpus fluviatilis</em></td>
</tr>
<tr>
<td>sedge</td>
<td><em>Carex sp.</em></td>
</tr>
<tr>
<td>softstem bulrush</td>
<td><em>Scirpus validus</em></td>
</tr>
<tr>
<td>spikerush</td>
<td><em>Eleocharis sp.</em></td>
</tr>
</tbody>
</table>

**Common Name**

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>pondweed</td>
<td><em>Potamogeton sp.</em></td>
</tr>
<tr>
<td>water crowfoot</td>
<td><em>Ranunculus sp.</em></td>
</tr>
<tr>
<td>water smartweed</td>
<td><em>Polygonum sp.</em></td>
</tr>
<tr>
<td>cattail</td>
<td><em>Typha sp.</em></td>
</tr>
<tr>
<td>common bur-reed</td>
<td><em>Spartanium eurycarpum</em></td>
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<tr>
<td>green bulrush</td>
<td><em>Scirpus atrovirens</em></td>
</tr>
<tr>
<td>hardstem bulrush</td>
<td><em>Scirpus acutus</em></td>
</tr>
<tr>
<td>river bulrush</td>
<td><em>Scirpus fluviatilis</em></td>
</tr>
<tr>
<td>sedge</td>
<td><em>Carex sp.</em></td>
</tr>
<tr>
<td>softstem bulrush</td>
<td><em>Scirpus validus</em></td>
</tr>
<tr>
<td>spikerush</td>
<td><em>Eleocharis sp.</em></td>
</tr>
</tbody>
</table>

**Emergent Plants**
- Typha sp.
- Carex sp.
- Scirpus acutus
- Scirpus fluviatilis
- Scirpus validus
- Eleocharis sp.

**Floating Leaf Plants**
- Potamogeton sp.
- Sparganium eurycarpum
- Carex sp.
- Scirpus atrovirens
- Scirpus validus
- Eleocharis sp.

**Submerged Aquatic Plants**
- *Ceratophyllum demersum*
- *Potamogeton sp.*
- *Ranunculus sp.*
- *Polygonum sp.*
- *Typha sp.*
- *Scirpus atrovirens*
- *Scirpus acutus*
- *Scirpus fluviatilis*
- *Carex sp.*
- *Scirpus validus*
- *Eleocharis sp.*

**No Aquatic Vegetation**

Imagery Source: 2006 AE
**HORSESHOE LAKE MACROPHYTE SURVEY RESULTS**

August 17, 2007

Valley Branch Watershed District

**FIELD NOTES:**
- Macrophyte densities estimated as follows:
  1=light; 2=moderate; 3=heavy
- Densities generally not noted for emergent and floating leaf plants
- No macrophytes found in water >3.0 - 4.0’
- Water level low
- Carex sp., Eleocharis sp. and Polygonum sp. found along entire shoreline

**Legend**
- Emergent Plants
- Floating Leaf Plants
- Submerged Aquatic Plants
- No Aquatic Vegetation

**Common Name** | **Scientific Name**
--- | ---
coontail | Ceratophyllum demersum
curlyleaf pondweed | Potamogeton crispus
pondweed | Potamogeton sp.
sago pondweed | Potamogeton pectinatus
water crowfoot | Ranunculus sp.
water stargrass | Zosterella dubia

**Emergent Plants**

**Common Name** | **Scientific Name**
cattail | Typha sp.
common bur-reed | Sparganium eurycarpum
green bulrush | Scirpus atrovirens
hardstem bulrush | Scirpus acutus
river bulrush | Scirpus fluviatilis
sedge | Carex sp.
softstem bulrush | Scirpus validus
spikerush | Eleocharis sp.

**Floating Leaf Plants**

**Common Name** | **Scientific Name**
water meal | Wolffia columbiana
duckweed | Lemna sp.
greater duckweed | Spirodela polyrhiza

**Submerged Aquatic Plants**

**Common Name** | **Scientific Name**
water meal | Wolffia columbiana
duckweed | Lemna sp.
greater duckweed | Spirodela polyrhiza
**FIELD NOTES:**
- Macrophyte densities estimated as follows:
  - 1=light; 2=moderate; 3=heavy
- Densities generally not noted for emergent and floating leaf plants
- No macrophytes found in water >3'
- Water level low
- Carex sp., Eleocharis sp. and Polygonum sp. found along entire shoreline
- Extremely low water level

**Legend**
- **Dry**
- **Emergent Plants**
- **Floating Leaf Plants**
- **Submerged Aquatic Plants**
- **No Aquatic Vegetation**

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
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</thead>
<tbody>
<tr>
<td>coontail</td>
<td><em>Ceratophyllum demersum</em></td>
</tr>
<tr>
<td>curlyleaf pondweed</td>
<td><em>Potamogetum crispus</em></td>
</tr>
<tr>
<td>pondweed</td>
<td><em>Potamogeton sp.</em></td>
</tr>
<tr>
<td>sago pondweed</td>
<td><em>Potamogeton pectinatus</em></td>
</tr>
<tr>
<td>water crowfoot</td>
<td><em>Ranunculus sp.</em></td>
</tr>
<tr>
<td>scirpus atrovirens</td>
<td><em>Scirpus atrovirens</em></td>
</tr>
<tr>
<td>hardstem bulrush</td>
<td><em>Scirpus acutus</em></td>
</tr>
<tr>
<td>river bulrush</td>
<td><em>Scirpus fluviatilis</em></td>
</tr>
<tr>
<td>sedge</td>
<td><em>Carex sp.</em></td>
</tr>
<tr>
<td>softstem bulrush</td>
<td><em>Scirpus validus</em></td>
</tr>
<tr>
<td>spikerush</td>
<td><em>Eleocharis sp.</em></td>
</tr>
</tbody>
</table>

*Note: Bold red name indicates extremely aggressive/invasive introduced species.*
FIELD NOTES:
- Macrophyte densities estimated as follows:
  1=light; 2=moderate; 3=heavy
- Densities generally not noted for emergent and floating leaf plants
- No macrophytes found in water >5-6'
- Carex sp., Eleocharis sp. and Polygonum sp. found along entire shoreline
- High water level
- Algal mats present near shore

HORSESHOE LAKE MACROPHYTE
SURVEY RESULTS
June 4, 2012
Valley Branch Watershed District
Appendix C-5.15  Additional Phytoplankton Information
### Horseshoe Lake

**SAMPLE: 0-2 METERS**  
**STANDARD INVERTED MICROSCOPE ANALYSIS METHOD**

<table>
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<tr>
<th>DIVISION</th>
<th>TAXON</th>
<th>06/20/00</th>
<th>07/19/00</th>
<th>08/08/00</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>units/mL</td>
<td>units/mL</td>
<td>units/mL</td>
<td>units/mL</td>
<td>units/mL</td>
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<tr>
<td>CHLOROPHYTA (GREEN ALGAE)</td>
<td>Ankistrodesmus Brauni</td>
<td>21</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td></td>
<td>Chlamydomonas globosa</td>
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<td>1,011</td>
<td>156</td>
<td>351</td>
<td>379</td>
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<td></td>
<td>Closterium sp.</td>
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<td>0</td>
<td>39</td>
<td>39</td>
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<tr>
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<td>Elakotolith gelatinosa</td>
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<td>0</td>
<td>39</td>
<td>84</td>
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<td>Oocystis parva</td>
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<td>42</td>
<td>117</td>
<td>78</td>
<td>84</td>
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<td>Pediasastrum duplex v. clathratum</td>
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<td>63</td>
<td>0</td>
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<td>Anabaena spiroides v. crassa</td>
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<td>Aphanizomenon flos-aquae</td>
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<td>Coelosphaerium Naegelianum</td>
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<td>PYRRHOPHYTA (DINOFLAGELLATES)</td>
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2000 Horseshoe Lake Phytoplankton Data Summary

No. Per Milliliter

<table>
<thead>
<tr>
<th>Date</th>
<th>CHLOROPHYTA</th>
<th>CHRYSO PHYTA</th>
<th>CYANOPHYTA</th>
<th>BACILLARIOPHYTA</th>
<th>CRYPTOPHYTA</th>
<th>OTHER</th>
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<tbody>
<tr>
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<td>4,000</td>
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<tr>
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2007 Horseshoe Lake
Phytoplankton Data Summary
Appendix D-5.15  Additional Zooplankton Information
2007 Horseshoe Lake
Zooplankton Data Summary

No. Per Square Meter

Date

2007 Horseshoe Lake
Zooplankton Data Summary
VALLEY BRANCH WATERSHED DISTRICT
OPERATING PLAN FOR HORSESHOE LAKE
May 25, 1988

INTRODUCTION

This plan is submitted by Valley Branch Watershed District in fulfillment of Condition 19 of Permit 86-6266, issued August 1, 1986. It will set an operating plan for the Horseshoe Lake outlet structure.

GOALS

The goals of this operating plan are as follows:

1. To reduce the threat of flooding on Horseshoe Lake and upstream lakes.

2. To manage Horseshoe Lake as a wildlife preserve by further lowering of the lake.

PROCEDURE

The plan of operation will be adopted tentatively for a period of one year and reviewed at that time before permanent adoption. It will be reviewed thereafter on a two-year basis.

HYDROLOGY

The tributary area of Horseshoe Lake is 7757 acres and the area of the lake itself is 96 acres. The normal operating level of the lake is 875.9 ft. Denoting the water equivalent of the snowpack as "x" inches, the volume of water stored in the lake above Elevation 875.9 ft and in the

HLOP/327,0
snowpack can be expressed as inches of water over the watershed in the following manner:

Inches of water over the watershed = x + 0.1485 * (Lake Elevation - 875.9)

PROPOSED PLAN OF OPERATION

1. Except as noted below, the control elevation shall be 875.9 ft.

2. During the period from February 15 to April 15 of each year the level of Horseshoe Lake may be lowered. Drawdown levels shall be determined from Table 1, based upon snowpack measurements and upstream lake levels. Snowpack and upstream lake levels shall be measured before drawdown and continued at weekly intervals during drawdown. Drawdown target elevations shall be adjusted according to Table 1 as snowpack and storage change. The regional hydrologist shall be notified five working days prior to initiation of drawdown.

3. Water levels on Horseshoe Lake will be increased according to Table 1, as the water equivalent of the snowpack decreases. When the water equivalent of the snowpack is reduced to 3 inches or less, the normal water level will be restored.

RESPONSIBLE PARTIES

It is anticipated that operation will be relatively infrequent. The Board of Managers will direct the operation of the control structures. Actual operation will be carried out by the City of Lake Elmo crews, if available, or by a District representative.
In the event of emergency, the following persons may be contacted, in the order indicated.

<table>
<thead>
<tr>
<th>Name</th>
<th>Address</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allen Dornfeld</td>
<td>2867 Hamlet Ave. No.</td>
<td>777-5590</td>
</tr>
<tr>
<td></td>
<td>Oakdale, MN 55119</td>
<td></td>
</tr>
<tr>
<td>Russell Kirby</td>
<td>13131 40th Street No.</td>
<td>439-4319</td>
</tr>
<tr>
<td></td>
<td>Stillwater, MN 55082</td>
<td></td>
</tr>
<tr>
<td>Ray Brenner</td>
<td>2525 E. 18th Ave. No.</td>
<td>777-3241 (h)</td>
</tr>
<tr>
<td></td>
<td>No. St. Paul, MN 55109</td>
<td>540-9607 (w)</td>
</tr>
<tr>
<td>William Rohrer</td>
<td>2989 Lake Elmo Ave. No.</td>
<td>770-2806 (h)</td>
</tr>
<tr>
<td></td>
<td>Lake Elmo, MN 55042</td>
<td>227-6500 (w)</td>
</tr>
<tr>
<td>Gordon Moosbrugger</td>
<td>13956 10th St. No.</td>
<td>436-5522 (h)</td>
</tr>
<tr>
<td></td>
<td>Stillwater, MN 55082</td>
<td>224-3879 (w)</td>
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<tr>
<td>Nels Nelson</td>
<td>Barr Engineering Co.</td>
<td>830-0555 (w)</td>
</tr>
<tr>
<td></td>
<td>7803 Glenroy Road</td>
<td>926-4252 (h)</td>
</tr>
<tr>
<td></td>
<td>Bloomington, MN 55435</td>
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TABLE 1
VALLEY BRANCH WATERSHED DISTRICT
PROPOSED PLAN OF OPERATION
FOR
HORSESHOE LAKE OUTLET STRUCTURE
February 15 - April 15

<table>
<thead>
<tr>
<th>Water Equivalent of Snow, Inches*</th>
<th>Drawdown Target Elevation**</th>
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<tr>
<td>6 or more</td>
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</tr>
<tr>
<td>5</td>
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<tr>
<td>4</td>
<td>873.0.</td>
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<tr>
<td>3</td>
<td>875.9.</td>
</tr>
</tbody>
</table>

REMAINDER OF YEAR

Control structure will maintain the lake level at Elevation 875.9 ft.

*To be determined in accordance with VBWD "Snowpack Monitoring Plan" dated February 2, 1988.

**All elevations are referenced to local MNDNR datum as described in permit. This may not coincide with USGS 1929 Mean Sea Level Datum.