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TECHNICAL MEMORANDUM

TO: Joel Peterson, Nest Lake Association

FROM: Rich Brasch
Chris Meehan

DATE: August 18, 2009

SUBJECT: Evaluation of Curly Leaf Pondweed Management Alternatives for Nest Lake

CC:

1.0 Introduction

This technical memo has been prepared in response to an inquiry from the Nest Lake Association (NLA) to evaluate management alternatives for curly leaf pond weed in Nest Lake. Specifically, the NLA has requested that alternatives on which the evaluation is to focus are mechanical harvesting, chemical treatment, and drawdown. This review is intended to provide a preliminary analysis of the options; if the NLA chooses to pursue one or more options, additional discussions and investigations are recommended to do a more in-depth analysis of the issues particular to any given management alternative. An effort has been made to identify those issues in the evaluations of the individual management alternatives presented later in this memo.

2.0 Background

Nest Lake (ID# 34-0154) is approximately 945 acres in surface area at normal water elevation and has a maximum depth of 40 feet. Approximately 525 acres of the lake (about 56% of the total lake area) are 15 feet or less in depth and therefore considered littoral zone, meaning that under normal conditions there may be enough light reaching the bottom in these locations to support rooted aquatic plant growth. The lake is effectively a reservoir on the Middle Fork of the Crow River. The area of land that drains to the lake is about 78,000 acres and includes both area that drains to the lake directly through county ditches, small creeks, and overland runoff as well as area that drains to the Middle Fork of the Crow River upstream of the lake. The large watershed-area-to-lake-area ratio of about 80:1 means that inflow volume is likely high relative to the volume of the lake. The dominant land cover in the watershed is cultivated agricultural land, which comprises about 44% of the watershed area; and wetland, which comprises about 27%. Urban rural developed land makes up 3.3% of the watershed area. Outflow from Nest Lake is controlled through a 150-year old dam that is owned and operated by the Olde Mill Resort located at the east end of the lake, where the Middle Fork Crow River leaves Nest Lake and continues downstream to Green Lake. Nest Lake is classified by the MN Department of Natural Resources as a General Development lake. There are two public accesses on the lake.

A lake management plan, developed as a cooperative effort between the NLA, the Middle Fork Crow River Watershed District, and the MN Department of Natural Resources (MnDNR) was completed in 2009 (Jacobson, et. al. 2009). Included in the plan are strategies for the following:

1. *Restoration of water quality in the lake.* The plan sets long-term water quality goals for phosphorus, chlorophyll a, and water clarity that exceed the state standards for deep lakes in the North Central Hardwood Forest (NCHF) ecoregion adopted by the State of Minnesota in 2008.
2. *Control of curly leaf pondweed.* The plan lays out actions to monitor and pursue methods to control curly leaf pondweed to reduce its occurrence to non-nuisance levels.
3. *Native aquatic plant protection and restoration.* The plan identifies actions to track, protect, and where necessary restore native aquatic vegetation in the lake.

3.0 Overview of Curly Leaf Pondweed Ecology and Control Methods

The Watershed Management Plan for the Middle Fork Crow River Watershed District (MFCRWD 2007) summarizes the history and issues associated with curly leaf pondweed infestation in Minnesota lakes. That section is presented below:

> Curly leaf pondweed is a non-native aquatic plant that was introduced to North America from Eurasia in the late 1800's. It was first discovered in Minnesota about 1910 and has since been documented in 540 lakes statewide. Curly leaf pondweed is similar in appearance to many native pondweeds found in Minnesota lakes and streams, with 2-3 inch leaves that are somewhat stiff and crinkled. However, it can be easily distinguished from other species by its unique life cycle; it is generally the first pondweed to come up in the spring and dies back mid-summer.
>
> In some lakes, curly leaf pondweed coexists with native plants and does not cause problems. In other lakes, it becomes the dominant plant and causes significant problems. The two main problems associated with curly leaf pondweed are: 1) the formation of dense mats in late spring and early summer which may interfere with recreation and limit the growth of native aquatic plants, and 2) the mid-summer die-off and subsequent decomposition of the plant contributes phosphorus to the lake. Like other aquatic vegetation, the abundance of curly leaf varies from year to year depending on environmental conditions, such as winter snow depth sand water clarity.
>
> Curly leaf pondweed's unique life cycle gives it a competitive advantage over many native aquatic plants. Unlike most native plants, curly leaf remains alive during the winter months, slowly growing even under thick ice and snow cover. Therefore it is often the first plant to appear after ice-out. In mid-summer, when most aquatic plants are growing, curly leaf plants are dying back. Before they die, they form vegetative propagules called turions (hardened stem tips) that disperse by water movement. Turions lay dormant during the summer when native plants are growing, and most germinate in the fall when most native vegetation has died back. Long term management of curly leaf will require the reduction or elimination of turions to interrupt its life cycle.

The two main challenges associated with management of curly leaf are to minimize damage to native plants and produce long-term control. Curly leaf can be managed using mechanical methods, herbicides, and habitat manipulation. Since curly leaf is generally gone by mid-July, management activities should be undertaken in spring or very early summer to have the maximum effect.

There are a small number of aquatic herbicides that can be used to control curly leaf pondweed. Good to excellent control of curly leaf can be obtained using formulations of diquat (e.g. Reward) and endothall (e.g. Aquathol K). Nevertheless, these herbicides only give control in the year of treatment. There is some evidence that use of endothall-based herbicides in early spring can control curly leaf and stop turion production.

Habitat manipulations, such as water level drawdown and dredging, can also be used to manage curly leaf pondweed. Fall drawdown can kill curly leaf pondweed turions by exposing them to freezing temperatures and desiccation. Dredging can be used to control curly leaf by increasing water depth. In deep water, rooted plants do not receive enough light to survive. Depending upon how much material is removed, dredging can prevent all rooted macrophytes from growing for many years. Dredging and drawdown projects require special permits and coordination among lake managers, lake users, and MnDNR Divisions of Fisheries, Wildlife, and Waters, because these projects can have significant negative effects on fisheries and lake use.

4.0 History of Control Efforts on Nest Lake

In 1986, the NLA purchased a weed harvester to deal with nuisance levels of aquatic vegetation, the most problematic of which were heavy growths of coontail that impeded surface use of large parts of the lake. The harvesting effort diminished, and the harvester was frequently unused for a number of years due to problems with keeping the used equipment in operating condition and finding volunteer labor for the operation. By 2000, curly leaf pondweed had become well-established in the lake to the extent that growths of the plant were interfering with recreation. To deal with the issue, the harvesting program was resurrected by the NLA in 2000. Before the 2009 season, the NLA replaced the engine in the harvester and hired two people to operate the harvester to cut and remove curly leaf pondweed between early May and early June. According to Joel Peterson of the NLA, harvesting operations in 2009 resulted in the cutting and removal from the lake of between 1,500 and 1,800 cubic yards of curly leaf pondweed from approximately a 200-acre area of the lake.

5.0 Overview of 2009 Aquatic Plant Survey Findings

In June 2009, the staff from the MnDNR's Invasive Species Program conducted an aquatic plant survey of Nest Lake using the point-intercept method (Eisterhold, J., and K. Uhler 2009). A draft of the survey results was provided by Joe Eisterhold, the principle investigator for the MnDNR. Key findings from that effort are as follows:

1. Water clarity in Nest Lake at the time of the survey was 15 feet, which is considered exceptionally good for the lake.
2. Curly leaf pondweed was noted growing in water depths between 3 and 20 feet. The maximum depth at which the plant was noted growing is very deep and is likely a consequence of the unusually clear water for this time of year.
3. Plants were sampled on a grid on 264 points in water depths up to 20 feet.

4. Curly leaf pondweed was present at 156 out of the 264 sampling points (63% frequency of occurrence) and was reported as abundant (75-100% coverage) at 77 of the points sampled and common (50-75% coverage) at 25 other points. Figure 1 is from the draft plant survey report and shows the sample grid and abundance of curly leaf pondweed.

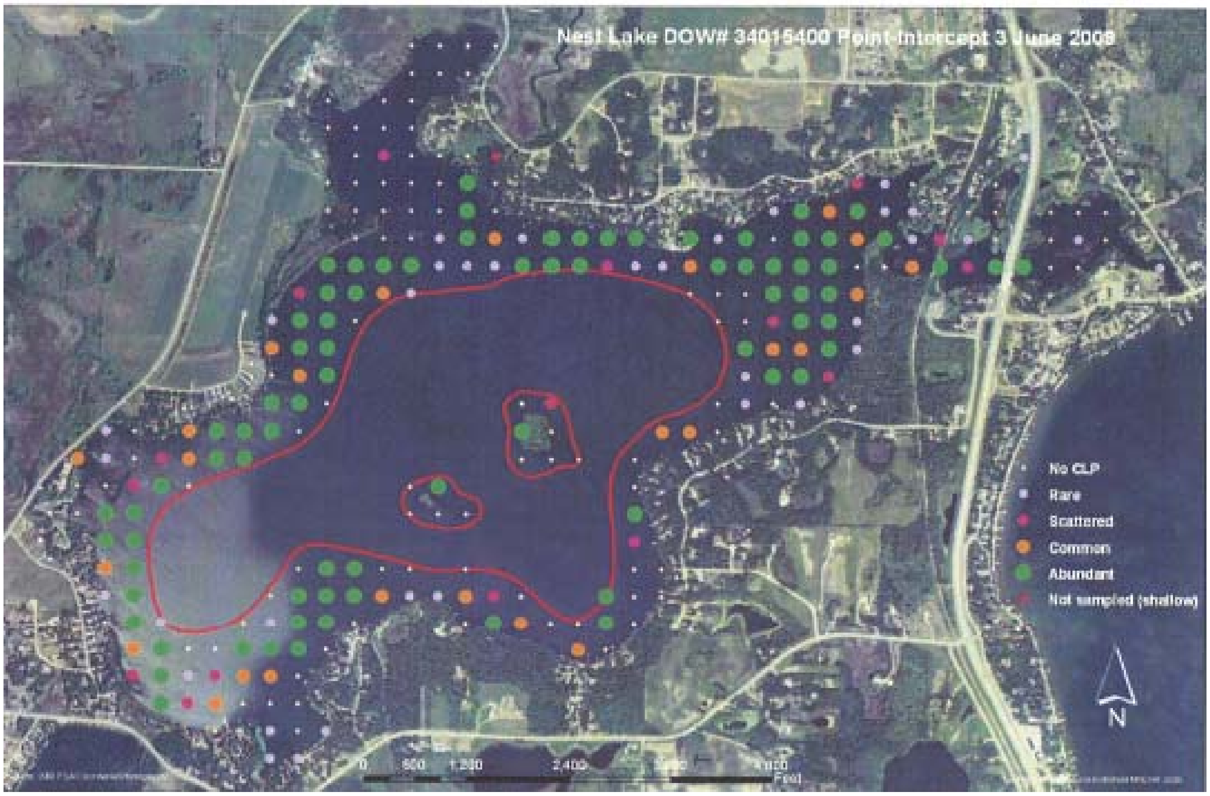

Figure 1. Abundance of Curly Leaf Pondweed On Nest Lake (June 2009) from Eisterhold, J and K. Uhler 2009

5. There were a number of native plants noted as well, including coontail (27% frequency of occurrence), northern water milfoil (21%), flat-stem pondweed (13%), clasping-leaf pondweed (8%), and bladderwort (4%). .

6.0 Description and Evaluation of Treatment Alternatives

The need for additional control efforts directed at curly leaf pondweed is well documented in the 2009 Nest Lake Management Plan and the point-intercept aquatic plant survey conducted by MnDNR staff in June 2009. These reports served as the basis for the NLA desire to evaluate three basic control alternatives. These are:

1. Mechanical harvesting
2. Chemical treatment using endothall
3. Drawdown of Nest Lake

One goal of the evaluation is to provide a method to compare the cost of each option on a comparable basis. To accomplish this, we used a present worth analysis to estimate annual cost and cost per acre. The assumptions used in the analysis are presented for each method.

6.1 Mechanical Harvesting.

As mentioned previously, the NLA has conducted an aquatic weed harvesting program since 1986, when it purchased a used harvester that was manufactured in 1973. Since 2000, the effort has been focused on using harvesting to cut and remove curly leaf pondweed from high-priority areas of Nest Lake. In 2009, 1,500 to 1800 cubic yards of curly leaf pondweed were harvested from approximately 200 acres of the lake, (personal communication from Joel Peterson, Nest Lake Association, to Rich Brasch). This represents the most aggressive and productive harvesting operation conducted on the lake to date, and it may have been helped by cooler than normal water temperatures during the growing season, which allowed the single harvester in operation to keep up with new growth of curly leaf pondweed. Based on estimates for tissue phosphorus content, there is perhaps 0.95-1.2 lbs. of phosphorus /ac for heavy growths of curly leaf pondweed (Sauk River Watershed District 2004). If all the tissue-bound phosphorus were removed in the harvested area (a liberal assumption, since only part of the plant is generally removed by harvesting), up to 250 pounds of phosphorus may have been removed from the system as a result of the harvesting operation. This compares with an external load of 4,200 pounds of phosphorus and a total load (internal and external) of over 6,600 pounds estimated by MPCA staff for 2004 (Wilson, B. et. al. 2004) Thus, phosphorus removal associated with curly leaf pondweed harvesting and removal is likely no more than 3-4% of the total annual phosphorus load affecting the lake.

There are a number of limitations characteristic of harvesting operations that need to be accounted for in assessing the cost-effectiveness of this control method. First, the permits required from the MnDNR that allow harvesting may limit harvesting activities to a portion of the littoral zone of the lake. This means that complete control of curly leaf in the lake via harvesting will likely not be possible, since the turion-producing capability of the unharvested areas will be undiminished. Second, the cutting depth of the current machine is limited to about 5 feet (maximum depth of cutting for most machines is usually no more than 7 feet), and cutting and removal of plants in water depths of less than 5 feet is difficult. Third, the window of time when the curly leaf pondweed is robust enough for harvesting but is not yet in senescence is a fairly narrow period between early May and late June.

Following are the assumptions used to estimate a cost for this effort:

- Assume that the NLA would continue to operate its current harvester and purchase another used harvester to operate in tandem. It was also assumed that one used barge transporter would be purchased to support the operation, as would one trailer. The ratio of two harvesters to one transporter to one trailer is based on vendor recommendation (Sauk River Watershed District 2004).
- Capital costs (2009 dollars) were assumed to be $110,000 for an additional harvester, $100,000 for a new motorized transporter/barge, $35,000 for a trailer and $15,000 for a used truck. These costs came from the NLA.
- Annual operations and maintenance costs of $30,000 per year were assumed for the expanded operation (two harvesters, the transporter, the trailer, and the truck) for years 1-5 of the 15-year operations period. Thereafter, it was assumed that control efforts could be cut back by 75% and focus on limited problem areas.
- Assumed 20% downtime.
- Harvesting scenario assumed a 40-hour work week with four staff (one for each harvester, one for the transporter, and one for the truck/trailer hauling equipment).

- Assumed a 6-week period (mid-May to late June) of aggressive harvesting for curly leaf pondweed.
- Assumed harvesting rate of 0.5 acres per hour per harvester, which accounts for 20% downtime and that half the littoral zone of the lake can be harvested in any given year..
- Costs were evaluated based on equipment (capital) costs and operations cost over a 15-year operations period to provide a total present worth.
- A 4% discount rate was used in the present worth calculations

Following is a summary of the cost for this alternative:

1. Total Cost = $454,400
2. Acres treated = 260 acres
3. Cost/acre/year = $116/acre/year
4. Annual Cost = $30,300

6.2 Treatment with Herbicide.

Chemical treatment with an endothall product (e.g. Aquathol K) has shown good promise in controlling curly leaf pondweed (Crowell 2003). Recent research indicates that early-season low-dose applications of Aquathol K have been effective at killing curly leaf pondweed and reducing or eliminating turion production in the treated areas. This method of treatment also appears to have less-negative impacts on native aquatic plants than treatments done later in the summer. Previously, herbicide applications have generally been limited to no more than 15% of the littoral area of a lake. Again, however, recent research has suggested that carried out properly, early-season low-dose applications of herbicides over most if not all the littoral area may be an acceptable management strategy that has minimal negative impact on the native plant community and provides more effective long-term control of the invasive. Guidelines from the MnDNR suggest that in order to deplete the bank of turions in the lake sediment and have a reasonable possibility of long-term control of curly leaf pondweed, a lake should be treated for several years in succession (MN Department of Natural Resources 2008).As with all chemical treatments, these types of treatments require a permit from the MnDNR Division of Fisheries.

The following assumptions have been made to assess the cost of treating Nest Lake with Aquathol K for curly leaf pondweed control

- The entire littoral zone of the lake between the shoreline and the 15-foot depth contour would be treated, an area of about 525 acres.
- Three consecutive years of treatments of the full littoral zone would be implemented, starting in 2010.
- A Minnesota licensed herbicide applicator would be hired to provide the treatment service at a cost of $260/ac. in 2010 dollars (assumes a 1 ppm concentration of the chemical to estimate the per acre cost).
- After intensive 3-year treatment, it was assumed that spot treatments every other year would be necessary to maintain long-term control for the remainder of the 15-year life cycle (assumed cost of $10,000 per spot treatment effort).

It should be noted that the MnDNR currently administers a grant program to provide funds to partially offset the costs for pilot projects to control curly leaf pondweed on a lake-wide basis for ecological benefits. Based on a cursory review of the eligibility criteria for that program, it appears that a treatment effort of the type outlined above on Nest Lake may be eligible for funding. Guidance for the 2009 program suggests that a control effort on 525 acres of littoral zone could attract a grant of $25,000, though it appears that the amount can vary based on project-specific factors. Grant applications for funding under the program are due no later than January 30, 2010. Assumptions regarding grant funding were not specifically taken into account in the cost analysis for this management alternative.

Following is a summary of the cost for this alternative:

1. Total Cost = $436,500
2. Acres treated = 525 acres
3. Cost/acre/year = $56/acre/year
4. Annual Cost = $29,100

6.3 Lake Drawdown.

For Nest Lake, the strategy would be to draw the lake down in the fall prior to freeze-up, then keep the lake level down through the winter and allow it to fill up again during the spring runoff period. The drawdown would be intended to expose the lake sediments first to drying, then freezing conditions to decrease the viability of the turions in the exposed lake sediments. The Three Rivers Park District in Hennepin County has conducted fall/winter drawdowns to two of their lakes, in part for curly leaf pondweed control. Their experience has been that when the sediments are dry, then frozen, mortality of curly leaf pondweed turions is high. If the sediments are wet when freezing occurs, turions will survive, reducing the effectiveness of the drawdown (Brian Vlach, Three Rivers Park District, personal communication to Rich Brasch).

Based on communication with the operator of the privately-owned dam at the outlet of Nest Lake (personal communication from Mike Radunz to Rich Brasch on August 5, 2009), it appears that gravity drawdown of the lake by between 5 and 6 feet may be feasible simply by removing the weir boards in the outlet structure. The level of the lake is controlled by two side-by-side sets of 10-foot long weir boards that extend down to approximately 6 feet below the normal water elevation of the lake. The operator believes that if the boards are removed, at least a 4-foot drawdown of the lake could be achieved in 10-14 days. This alternative would not control much of the curly leaf pondweed in the lake, but it could be a viable control mechanism for those areas of the lake where harvesting is problematic because of shallow water. It could also be used to decrease the area that needs to be treated with herbicide.

We were unable to confirm the existence of plans for the outlet structure, and additional work should be done to evaluate the feasibility of this alternative. The evaluation should also address at least the following:

- whether the configuration of the channel between the lake and the dam has any restrictions that would limit the drawdown potential;
- what type of impacts there would be on the use of the lake by shoreland owners and the recreating public as a result of the drawdown and how best to minimize those impacts;
- what historic flows through the system would suggest about the length of time needed to draw down and refill the lake;
- whether there would be restrictions on the minimum or maximum outflow rate during lake dewatering and refilling, what those rates would be, and how that would affect the drawdown period and/or re-fill period for the lake; and

- what the likely impacts on Green Lake would be and how best to avoid or minimize those impacts.

In addition, because the dam is privately owned, the cooperation of the owner would be needed. Finally, permits would be needed from the MnDNR for this alternative. Based on recently passed legislation, signatures from 75% of the riparian landowners would likely be needed to obtain the permit to move ahead with the drawdown. Aside from the time to work cooperatively with interested/affected parties on the specifics of implementation (which are likely to be significant) and assuming no modifications to the channel between Nest Lake and the dam are necessary, the main costs for this option appear to be associated with permitting and monitoring of water level recovery, both of which could be relatively minor (<$5,000). It was assumed a partial drawdown would be necessary every five years.

Following is a summary of the cost for this alternative:

1. Total Cost = $12,800
2. Acres treated = 240 acres
3. Cost/acre/year = $4/acre/year
4. Annual Cost = $860

Significantly greater drawdown of the lake would require either pumping or siphoning of water from the Nest Lake. We have not evaluated the physical feasibility or costs of this option, but can do so as a supplemental effort if the NLA desires that it be pursued.

6.4 Another Option: Partial Drawdown and Chemical Control.

This option would involve reliance on an approximately 5-foot drawdown of Nest Lake to control curly leaf pondweed between the shoreline of the lake and the 5 foot contour, supplemented with a chemical control effort for areas of the lake between 5 and 15 feet deep. The appeal of this option is that the drawdown method could be relatively inexpensive to implement for reasons explained previously and could decrease by over 200 acres the area that would need to be chemically treated. The following assumptions have been made to evaluate the cost of treating Nest Lake with a combination 5-foot drawdown and an Aquathol K treatment for areas of the lake between 5 and 15 feet deep:

- The 5-foot drawdown would be effective at controlling curly leaf pondweed in areas of the lake less than 5 feet deep (about 240 acres). Costs for the drawdown were assumed to be $5,000 in year 2010 and it was assumed a 5-foot drawdown of the lake would occur every 5 years.
- Aquathol K would be applied to control curly leaf pondweed between the 5- and 15-foot depth contour, an area of approximately 285 acres.
- Three consecutive years of treatments of the littoral zone between 5 and 15 feet deep would be necessary, starting in 2010.
- A Minnesota licensed herbicide applicator would be hired to provide the treatment service at a cost of $350/ac. in 2010 dollars (assumes a 1 ppm concentration of the chemical to estimate the per acre cost).
- After intensive 3-year treatment, it was assumed that spot treatments every other year would be necessary to maintain long-term control for the remainder of the 15-year life cycle (assumed cost of $8,500 per spot treatment effort).

As with the cost analysis to treat the entire littoral zone of the lake with Aquathol K, possible grant funding through the MnDNR's pilot project curly leaf pondweed control program were not specifically taken into account in the cost analysis for this management alternative.

Following is a summary of the cost for this alternative:

1. Total Cost = $336,830
2. Acres treated = 525 acres
3. Cost/acre/year = $43/acre/year
4. Annual Cost = $22,460

6.5 Summary.

Table 1 presents a summary of the costs and acres treated for each of the four control options presented above.

Table 1. Management Alternative Cost Comparison

Alternative	Acres of Control	Cost/Ac./Yr.	Annual Cost	Present Worth of Annual Cost[1]
Harvesting	260	$114	$29,600	$444,000
Herbicide	525	$56	$29,100	$436,500
Drawdown (partial)	240	$4	$860	$12,800
Partial drawdown and herbicide	525	$43	$22,460	$336,830

[1] Assumes 15-year life cycle; discount rate of 4%

Following are the key findings based on this analysis:

1. Harvesting is the most expensive option on a per acre annual cost basis, even with the favorable assumption that five years of intensive harvesting would be enough to significantly decrease the viability of curly leaf pondweed infestations in Nest Lake for the remainder of the 15-year life cycle. This is a consequence of both the high capital and operations cost of the equipment needed to implement the harvesting program as well as the limited area over which harvesting would likely be conducted and effective. Even if the area of harvesting could be doubled for the same cost, the cost/acre/year would still be greater than the "herbicide only" and "partial drawdown and herbicide" options, which treat comparable areas.
2. The "herbicide" option is next most expensive on cost/acre/yr. basis. Most of the costs associated with this option are early in the 15-year life cycle based on the assumption that three consecutive years of treatment of the entire littoral area of the lake would be necessary to achieve control of the curly leaf pondweed.
3. The "partial drawdown and herbicide" option is the third lowest cost on a cost/acre/yr. basis. This is mainly due to the reliance on drawdown as a potentially inexpensive method of controlling curly leaf pondweed on areas of the lake between 0 and 5 feet in depth, which in turn decreases the area and volume of the lake that needs to be managed with the more expensive herbicide option.
4. Drawdown is the cheapest option, but as presented here would only provide curly leaf pondweed control in less than 50% of the littoral area of the lake due to the limitations on

gravity-driven water-level reduction imposed by the current outlet configuration at the dam.

7.0 Impact on Fish and Fish Habitat of Curly Leaf Pondweed Control

A brief description of impacts of curly leaf pondweed control (both positive and negative) was completed to address environment impacts on fisheries, fish habitat, and water quality and is presented below.

7.1 Environmental Impacts on Fisheries and Fish Habitat

Aquatic plants are an important part of lake ecosystems, and the value of maintaining aquatic plants in fostering diverse aquatic ecosystems has been well documented. Aquatic plants are an important component of fish and wildlife habitat. The Aquatic Ecosystem Restoration Foundation (2003) states that aquatic and littoral vegetation provides fish, waterfowl and some mammals with:

- Oxygen
- Habitat
- Food sources
- Breeding areas
- Refuge for predators and prey
- Stabilized bottom sediments and nutrients.

These resources are not only important for good sport fisheries, but also for other recreational activities, aesthetic enjoyment of water resources, and maintenance of healthy aquatic and littoral ecosystems.

Nest Lake has extensive coverage of aquatic plants. However, much of this coverage contains curly leaf pondweed (see Section 5.0). The 2009 survey by the MnDNR represented in Figure 1 estimated the frequency of occurrence of curly leaf pondweed at about 63% of the area of the lake between 0 and 20 feet deep (roughly 590 acres of the lake area).

The presence of curly leaf pondweed is a concern for fish habitat for the following reasons:

1. Curly leaf pondweed is an invasive exotic (i.e., non-native) plant. Curly leaf pondweed starts growing in the fall and with the onset of spring has a competitive advantage over native plants. It can grow to have very dense canopy-forming mats that greatly reduce other aquatic plants species. This reduces aquatic ecosystem diversity and fisheries habitat complexity. Dense growths can also interfere with feeding by large predators.
2. Curly leaf pondweed dies in early July. In areas where the curly leaf pondweed growth is dominant and prevents native plants from growing, the die-off of curly leaf in early July can leave areas devoid of aquatic plant growth, and associated habitat benefits, for much of the growing season.
3. The die-off of curly leaf pondweed has water quality implications, which are discussed in more detail below. These implications include decomposition of the plant, which can consume oxygen leading to low oxygen conditions less conducive to fisheries. The die-off and decomposition can also contribute to internal phosphorus loads through release of phosphorus in the plant tissue and changes at water/sediment interface. This can accelerate eutrophication, which can increase fisheries productivity in terms of fish biomass, but under hypereutrophic conditions that favor rough fish.

Harvesting can moderate these affects. However, the operation of harvesting equipment may impact lake fauna. Physical disturbance of bottom sediments can occur in shallow areas, turbulence caused by the motor can suspend sediments, and harvesting is not selective for specific plant species within the targeted area. In other words beneficial plants as well as nuisance plants may be harvested. These impacts can affect fish and fish habitat. However, the negative impacts of harvesting could be largely limited by doing the following:

- Limit harvesting in water depths less than 3-4 feet, where fish spawning typically occurs in shallow areas. This limitation would also limit the potential for resuspension of bottom sediments.
- Avoid harvesting in areas where the dominant macrophytes are native.
- Limit harvesting in areas within 150 feet of the shore to cutting pathways for access from docks and boat turn-around areas.

The use of early-season low-dose applications of endothall compounds like Aquathol K to control curly leaf pondweed is expected to have virtually no negative impact on fisheries and fish habitat. The compound is a selective contact herbicide that disrupts biological processes unique to plants, such as interfering with plant respiration and disrupting plant cell membranes (USEPA 2005). Further, the early season application proposed is designed to avoid impacts to native plants and maximize effectiveness in controlling curly leaf pondweed, since curly leaf is the first aquatic plant to grow in the spring. Finally, endothall compounds do not bioaccumulate in fish or hydrosoil.

As presented above, a partial lake drawdown would primarily affect the in-shore habitat in depths of water from 0 to 5 feet. A rapid drawdown or one that occurs during ice cover increases the potential that fish and other aquatic organisms could be stranded in shallow in-shore areas that are dewatered and cut off from the main water body, thereby increasing the mortality for those organisms. Further, the in-shore areas affected by the partial drawdown are used by a variety of species for spawning in the spring, starting with northern pike that spawn in shallow connected wetlands adjacent to the Middle Fork Crow River in April in normal years, and followed by sunfish and bass that typically spawn in in-shore areas in May and June. To minimize these impacts, it is anticipated that the partial drawdown would occur as follows:

- Drawdown of water in the lake would occur gradually over a period of 2-3 weeks in the fall (likely starting in late September or early October), and be completed well before ice cover forms on the lake. This would give fish and other mobile aquatic organisms a chance to migrate out of the affected areas of the lake.
- The weir boards in the outlet would be replaced starting in late winter or early spring, with the objective of returning the water level in the lake to its normal water elevation by April, in time for spring spawning by northern pike. A flow analysis should be conducted to provide more specific guidance on how this would be accomplished.
- Impacts to areas below the dam while Nest Lake is being filled should be evaluated. If needed, a bypass flow should be considered to minimize impacts associated with filling Nest Lake, although the bypass will prolong the time period needed to completely refill Nest Lake.

7.2 Impacts on Water Quality

Water quality impacts of curly leaf pondweed control may be both positive and negative. For harvesting, the biggest negative impacts are related to the potential for suspending sediments. The impacts associated with the harvesting project in Nest Lake should be minor because of the limited amount of cutting in shallow areas (i.e., areas less than 5 feet deep).

Positive water quality impacts of curly leaf pondweed control via harvesting occur because nutrients in the plant tissue are removed along with the harvested plant materials. James, et al. (2001) found lake-wide curly leaf pondweed dry weight biomass of 31.1 g/m^2 and 25.4 g/ m^2, uncorrected and corrected for harvesting, respectively. They also found an average dry weight phosphorus content of 0.43%. Using these values curly leaf pondweed tissue contains an average of 0.95 to 1.2 lbs/ac of phosphorus at medium to heavy densities. Not all of this is removed with harvesting since plants may be cut off at some distance above the sediment and there are some materials that are not captured. As cited in Section 6.1, it appears that up to 3-4% of the total phosphorus load affecting Nest Lake could potentially be removed via control of curly leaf pondweed through mechanical harvesting. To the extent that repeated, aggressive harvesting of curly leaf pondweed leads to a decrease in the long-term abundance of the plant, prevention of negative impacts can also occur with this control method. .

Controlling the distribution and abundance of curly leaf pondweed by minimizing turion germination and/or plant growth soon after germination can also prevent negative water quality impacts associated with the life cycle of curly leaf pondweed. According to James, et al. (2001), the plants can directly recycle phosphorus from the sediments through root uptake, incorporation into plant tissue, and subsequent senescence (i.e. decomposition). They can also indirectly recycle phosphorus from the sediments by increasing pH in the water column through photosynthetic activities. Phosphorus release from sediments can be enhanced at high pH as a result of ligand exchange on iron oxide contained in the sediment. In addition, senescence/decomposition of the plant material can contribute to low dissolved oxygen conditions at the sediment water interface. Low oxygen conditions contribute to weakening of the iron-phosphate bond leading to phosphorus release from sediments. Phosphorus loads from plant senescence and sediment effects cannot be estimated without detailed study. However, it can be significant, particularly when curly leaf pondweed grows at densities that block out other plants. In these cases, when curly leaf pondweed dies in early July, it can leave areas devoid of aquatic plants. The subsequent release of phosphorus from senescence can then be used by algae leading to nuisance algae blooms. In the Oxbow Lake study by James, et al. (2001), they estimated that curly leaf pondweed decomposition provided about 26 percent of the measured internal phosphorus load during the summer. More importantly this load was released in a 2-week period at the height of the growing season and is largely dissolved phosphorus available for algae uptake. Thus, effective control options – whether based on mechanical harvesting, early-season low-dose Aquathol K treatments, lake drawdown or a combination of these – should have an overall positive effect on water quality and the native plant and animal community in Nest Lake.

8.0 References

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