# Management Plan for Eurasian Watermilfoil (*Myriophyllum spicatum*) in the Okanagan, British Columbia

Okanagan Basin
WATER BOARD

Genevieve Dunbar, BSc.

April 2009

Received

MAY 0 8 2009

102 Industrial Place
Penticton, BC V2A 7C9

# Executive Summary

The goal of the Okanagan Eurasian watermilfoil control program is to minimize environmental impacts while enhancing public enjoyment of Okanagan mainstem lakes using a cost effective and efficient program. As a result of the program, many residents in the Okanagan today are only passingly aware of Eurasian watermilfoil; a sharp contrast from the late 1970s when Eurasian watermilfoil was prominent in public and media discussion.

Managing Eurasian watermilfoil growth in Okanagan mainstem lakes provides many benefits to the tourism industry, the real estate market, and the environment. Clean, weed-free lakes support recreation, contribute to an aesthetically pleasing landscape, and improve water quality and aquatic habitat.

The current Eurasian watermilfoil control program, methods, machinery and techniques were developed by the BC MoE in cooperation with OBWB staff. Several factors were considered during program development, including environmental concerns, public acceptability of control methods, effectiveness of control methods, weed re-growth densities, financial constraints, and local government needs and priorities.

The current program includes rototilling in the late fall and winter and harvesting in the summer. Rototilling is a mechanical control method whereby rototiller blades physically remove the roots of the plant from the bottom sediments of the lake. It is also referred to as de-rooting. Rototilling minimizes interference with water recreation, reduces the spread of viable plant fragments, and eliminates the need to dispose of plant material. Harvesting involves cutting the Eurasian watermilfoil plants at a depth of two metres below the surface. Harvesting takes place in the height of growing season when plant growth has reached the surface. It is much faster than rototilling, but can interfere with recreation and requires disposal of the cut plant material.

This management plan describes the best management practices used to mitigate potential impacts of rototilling and harvesting on aquatic species and habitat, utilities, native vegetation, and lake recreation. These best management practices include the following:

- Harvesting is used instead of rototilling at sites where increased turbidity may be detrimental to sensitive aquatic species or habitat.
- Rototiller operators communicate with local water utility managers to ensure rototilling operations are halted if turbidity levels are high at water intakes.
- To minimize potential impacts to aquatic species and habitats, Eurasian watermilfoil control program staff follow the BC MoE instream work timing windows.
- To reduce the risk of harm to kokanee habitat, control efforts are not conducted near kokanee spawning areas identified by BC MoE staff (see Appendix A).
- The OBWB will work with the BC MoE to develop best management practices that minimize impacts to Rocky Mountain Ridged Mussel and other benthic invertebrates.

- To reduce the risk of harm to native vegetation, areas where plant growth is predominantly native species are avoided.
- To reduce the spread of Eurasian watermilfoil through fragmentation, rototilling is undertaken in the winter when plant fragments are less numerous and not viable.
- To reduce the spread of Eurasian watermilfoil through fragmentation, the harvesters bring cut weeds onto the deck of the machine immediately.
- Rototilling is conducted in the late fall and winter to avoid interference with lake recreation and navigation. Harvesting operations typically occur either in early morning hours and/or at target locations that are low use to minimize interference with recreation and navigation.
- Operators use their extensive experience to determine where larger strips of untreated area are required to avoid water intakes, sewer outfalls, utility cables and geothermal systems.

As a component of this management plan, GIS maps of Eurasian watermilfoil treatment sites were developed for Okanagan mainstem lakes and include BC MoE sensitive kokanee spawning habitat data (see Appendix A). The maps indicate areas of current treatment, both harvesting and rototilling, and previously treated sites. These maps are a new resource for the OBWB, and provide a more comprehensive picture of treatment sites in the lakes.

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# 1.0 Introduction to Eurasian Watermilfoil

## *1.1 Summary of Eurasian Watermilfoil Biology*

Eurasian watermilfoil (*Myriophyllum spicatum*) is a rooted submersed macrophyte inhabiting the shallow waters of lakes in British Columbia and other parts of North America. The species is said to have been introduced from Eurasia in the late nineteenth century, likely in ship ballast, though the first documented occurrence was in 1942 from a pond in Washington, D.C. (United States Geological Survey, 2003). In the Okanagan, Eurasian watermilfoil was first identified in the Vernon Arm of Okanagan Lake in 1970.

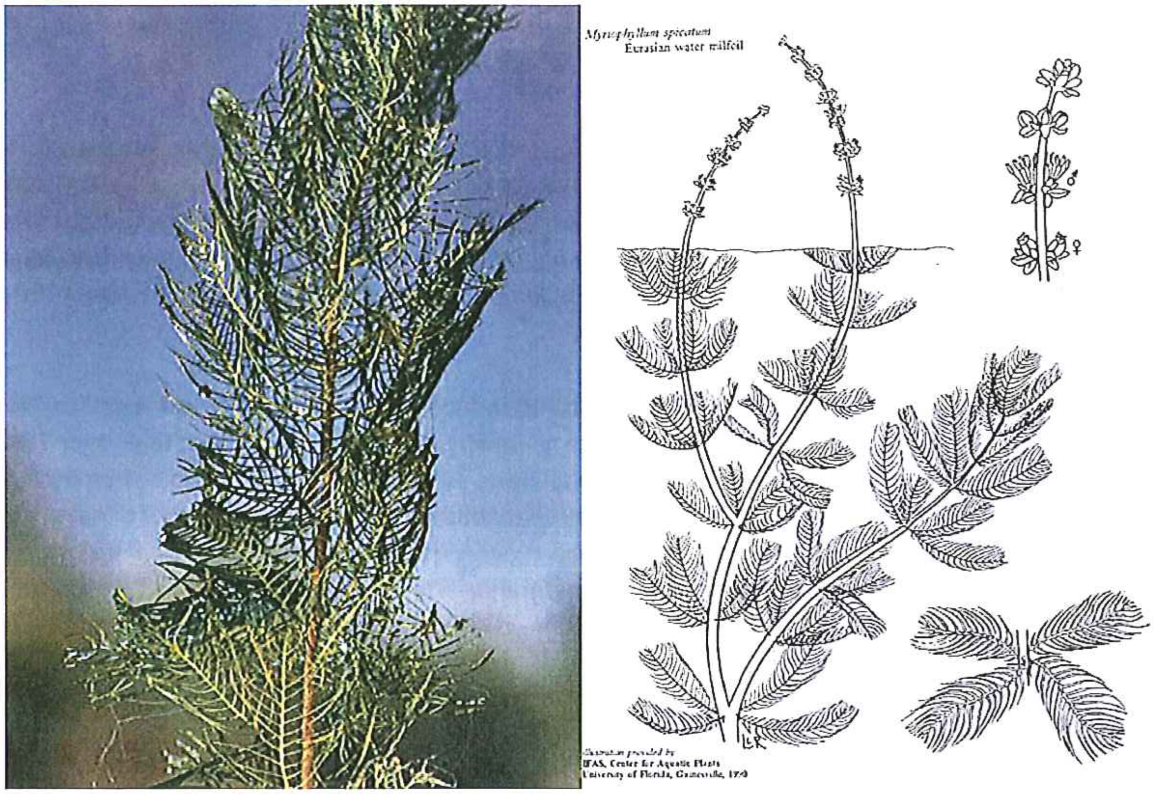
Eurasian watermilfoil is very aggressive and once introduced to a water body will displace native aquatic vegetation in a couple of years. It is a rapidly growing macrophyte that forms thick underwater stands and covers water surfaces (Getsinger, 2005). Colonization of new sites occurs by vegetative fragmentation as the plant develops auxiliary buds that separate at the node (Aiken et al., 1979). Some auxiliary buds have root development even before detaching from the parent plant, allowing new plants to establish quickly. In the summer, stem fragments break off at abscission zones, assisted by natural or manmade wave action. Eurasian watermilfoil also produces emergent flowers, but seeds have not been demonstrated to germinate naturally; asexual reproduction, through the development of fragments is the dominate method of propagation. Figure 1 provides a photo and a drawing of Eurasian watermilfoil.

According to Aiken et al. (1979), the maximum depth where rooted plants are found will vary with the depth of light penetration; for Eurasian watermilfoil in the Okanagan this is typically about 5 to 6 metres deep, with some plants found up to 8 metres deep. Eurasian watermilfoil is well adapted to rooting in a variety of substrates, from sandy bottom to very silty substrate. Gravel substrates are not preferred by Eurasian watermilfoil.

Eurasian watermilfoil will flourish in habitats enriched with nutrients, though it is often also found in oligotrophic environments similar to the Okanagan lakes system. Unlike many other aquatic plants, the limiting nutrient for Eurasian watermilfoil is nitrogen, not phosphorus (Chambers et al., 1999).

Eurasian watermilfoil is tolerant of low water temperatures, though most growth occurs in water temperatures 15°C and above. In the Okanagan, Eurasian watermilfoil dies back to the root crowns in the winter, with vegetation decomposing on the lake bottom. Winters in the Okanagan have been warmer in recent years and it has been observed that this extreme die back does not always occur and, while not exhibiting growth throughout the winter season, much of the plant will remain green (Horner, personal communication). Spring growth of Eurasian watermilfoil often begins in advance of native plant species, quickly growing to the surface to overtop and shade out the surrounding vegetation (Getsinger, 2005).

**Figure 1: Photo and drawing of Eurasian watermilfoil (*Myriophyllum spicatum*) showing feathery appearance of the leaflets**




## *1.2 Potential Impacts of Eurasian Watermilfoil*

Dense growth of Eurasian watermilfoil along the shoreline can negatively impact fish and wildlife. As an invasive species, it does not create 'natural' habitat. The dense growth and occupied surface area can deplete dissolved oxygen levels in shallow areas when the plants decay in fall (Honnell et al., 1992). The dense canopies also limit light penetration and decrease water flow (Chambers et al., 1999). Eurasian watermilfoil has less food value for waterfowl than native vegetation. There may also be a lower abundance and diversity of invertebrates in the foliage when Eurasian watermilfoil grows in high densities (Keast, 1984). Research in Cultus Lake indicates that Eurasian watermilfoil can be detrimental to sockeye populations because the dense growth prevents access to spawning sites. The northern Pikeminnow, a sockeye predator, takes refuge in dense stands of Eurasian watermilfoil, potentially increasing predation and reducing the success of sockeye (COSEWIC, 2003).

Eurasian watermilfoil has an impact on nutrient levels in Okanagan lakes. Phosphorus and nitrogen releases from Eurasian watermilfoil tissue sloughing during the growing season are significant (Ference Weicker & Company, 1991).

Uncontrolled Eurasian watermilfoil infestation can also detract from the aesthetic appeal of the shoreline and decrease the desirability of the residential areas adjacent to the water. It can also interfere with opportunities for water-based recreational activities, including motor boating, water skiing, sailing, swimming, and shore-based angling.

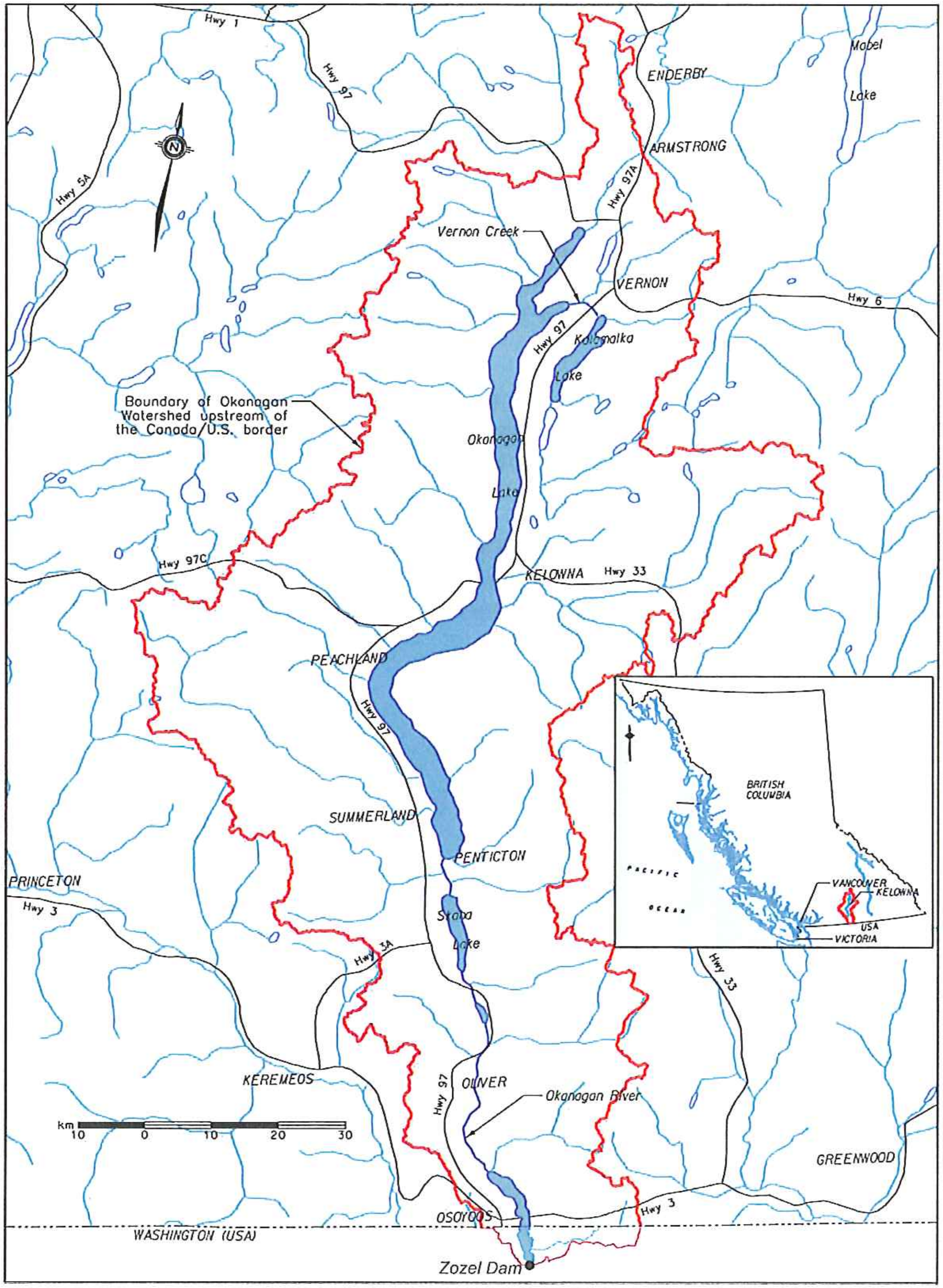
## *1.3 Eurasian Watermilfoil in the Okanagan Lakes System*

Okanagan Lake is the largest of the mainstem lakes in the Okanagan Valley, stretching 135 kilometres along the valley bottom. Other large lakes in the area include Vaseux, Osoyoos, Skaha, Swan, Kalamalka and Wood lakes. With the exception of Swan Lake, all of these lakes are known to have Eurasian watermilfoil infestations. The Okanagan River, south of Okanagan Lake, is also infested with Eurasian watermilfoil.

The central portion of the Okanagan Valley is the most populated, with Kelowna being the largest city in the valley. Other major centres in the valley are Penticton in the south and Vernon in the north. The map of the basin in Figure 2 illustrates the basin's north to south alignment and comparatively small east to west spread.

In 1974, four years after Eurasian watermilfoil was first identified in Okanagan Lake, the invasive plant was established in all of the mainstem lakes of the valley. The BC Ministry of Environment (BC MoE) quickly initiated Eurasian watermilfoil eradication attempts and control efforts in partnership with the Okanagan Basin Water Board (OBWB).

**Figure 2: Map of Okanagan Basin**



# 2.0 Overview of Current Eurasian Watermilfoil Control Program

The current Eurasian watermilfoil control program, methods, machinery and techniques were developed by the BC MoE in cooperation with OBWB staff. Extensive work and research by the BC MoE and the OBWB has identified treatment options and management practices that are both effective and publicly acceptable, while minimizing environmental impacts.

## *2.1 Program Goals*

The goals of the Okanagan Eurasian watermilfoil control program are to minimize environmental impacts while enhancing public enjoyment of Okanagan mainstem lakes in a cost effective and efficient program that benefits the regional economy. The program is an exercise in adaptive management - experience gained from more than 30 years of managing Eurasian watermilfoil in the Okanagan has resulted in many adjustments through the years. Several factors are considered in program development, including environmental concerns, public acceptability of control methods, effectiveness of control methods, weed re-growth densities, financial constraints, and local government needs and priorities.

## *2.2 Priorities, Funding and Managing the Program*

Priorities for weed control are established by Okanagan local governments (i.e., municipalities and regional districts). Beaches, boat launches, and other recreational areas are given highest priority. Other priority areas are those with a high visual impact (e.g., areas that a tourist would see upon first arriving in the Okanagan). Weed control in areas used for special events, such as the Iron Man Triathlon in Penticton and the Kelowna Apple Triathlon, are also a priority.

The Eurasian watermilfoil control program operates year round, with late fall/winter rototilling from October to May and summer harvesting from June to the end of August.

All Okanagan residents benefit from weed-free recreation areas and attractive lakes, therefore the Eurasian watermilfoil control program is funded through a property tax levied on residents in the Okanagan watershed (approximately $3 a year per household in 2007). The annual budget is approximately $500,000 (2007). The program is delivered in a cost effective manner as machines are serviced by staff and few services are contracted out.

Beginning in 1972 and extending to 1999, cost sharing agreements between the OBWB and the BC MoE for the operation of the Eurasian watermilfoil control program were in place. In 1993, the BC MoE contributions were reduced to less than 50% of total program costs (previous contributions were at least 75% of program costs). The cost sharing was terminated by the Province in 1999 and the OBWB is now responsible for all costs associated with the program.

When scheduling permits and priority areas are controlled, fee for service work has been occasionally been undertaken in areas that do not pay into the OBWB program (e.g., leased reserve properties and areas outside of the Okanagan Valley).

## *2.3 How Eurasian Watermilfoil is Removed: Machine Operation*

### 2.3.1 Rototilling Operation (Rotovater)

Rototilling is a mechanical control method whereby rototiller blades physically remove the roots of the plant from the bottom sediments of the lake. It is also referred to as de-rooting. This method is not selective and areas dominated by native species are avoided.

Rototilling operations reduce the density of weeds in a given area, but rapid re-infestation creates a need to rototill the area every year. Annual winter rototilling keeps the density of Eurasian watermilfoil plants low.

Rototilling is more effective than harvesting (discussed below) because it removes the root of the plant. Rototilling became an integral part of the Eurasian watermilfoil control program in the 1980s; the ratio of rototilling to other control methods has changed over time (see Section 2.4). Harvesting Eurasian watermilfoil continues to be part of the control program in areas where rototilling is not possible.

The rototillers used in the Okanagan are custom designed and built locally. Over the course of the program, design of the machines has been refined by staff input—improving operation, performance, comfort and ease of use. The rototiller is powered using paddlewheels that can operate in shallow water and will not get choked with weed fragments, unlike a propeller, which can become entangled with weeds. Depending on the machine, the rototiller head is between 2.44 metres (8 feet) and 3.35 metres (11 feet) in width and has limited mobility around obstacles and narrow areas such as private docks and marinas, or underwater hazards such as anchors, pipelines and water intakes.

When in operation, the rototiller arm is lowered to the lake bottom to a maximum depth of 4.5 metres (15 feet). Figures 3 and 4 show the structure of the rototilling machine. The blades settle into the substrate so that they dig in between 12 centimetres (5 inches) and 23 centimetres (9 inches) to dislodge Eurasian watermilfoil roots. The operator determines the appropriate depth of penetration for the blades based on the substrate type (automatic blade depth adjustment mechanisms were tested and found to be ineffective). When roots are dislodged, they either float to the surface and wash up on the beach or they sink in deep water. Some roots remain in the treated area. Rototilling is typically conducted at water temperatures of 10 °C or below to ensure the viability of the roots and plant fragments is limited.

**Figure 3: Rototiller arm of weed removal machine – roots are pulled from the bottom of the lake as blades turn in the sediment**

**Figure 4: Rototiller from side, showing paddlewheels toward bow and enclosed cab at stern and rototiller from rear showing rototiller blades at stern of machine**

The rototiller operating speed depends on the substrate type. The blades move faster in hard packed sandy conditions than softer silty conditions because the revolving tiller head propels the machine forward. Multiple passes over a treatment area are required. OBWB rototiller operators, who have more than 20 years experience, estimate that the first pass of a rototiller will bring up just less than half of the roots in a given area (Field, personal communication). Extra passes of the machine will ensure as many roots as possible are removed from the bottom sediments. Multiple passes on hard packed sediment (some sands for example) will loosen the substrate and the roots lodged within. In soft sediments, multiple passes are needed to ensure that roots are not 'turned under' into the sediment by the blades.

Treatment areas are marked with floats and the substrate is tilled either parallel or perpendicular to the shore, depending on the size and shape of the area, density of weeds and wind speed and direction.

Repeat annual rototilling applications reduce the weed density substantially. Eurasian watermilfoil re-growth is uneven and difficult to predict at rototilled sites. Stand dynamics for Eurasian watermilfoil appear to be changing. The Eurasian watermilfoil control crew reports active plant growth later into the fall, but the plants are not growing as fast or as tall as in the past (Field and Horner, personal communication).

The length of rototilling season is reduced if machines become stuck in the ice when the lakes freeze over. Warmer winters in recent years have reduced the frequency of this occurring. Other factors affecting how much control is accomplished in a season are the amount of plant re-growth from the previous year, increased growth of previously sparse areas, and weather patterns.

### 2.3.2 Harvester Operation

Harvesting is primarily used in areas that cannot be rototilled, where rototilling was not effective and where re-growth has reached unacceptable levels. The Eurasian watermilfoil plants are cut at a depth of two metres below the surface. The purpose of cutting the plant is to open up areas for boat navigation and retain beach aesthetics and recreation opportunities.

Cut weeds are collected with a conveyor, and stored on the machine (see Figure 5). The material is deposited on shore and then trucked away. The piles of weeds can be unsightly and interfere with beach recreation. Appropriate locations to unload and dispose of harvested Eurasian watermilfoil on shore are diminishing as the lakeshore is developed. This increases travel distances and reduces the efficiency of the operation.

Harvesters are not as effective in very shallow water (less than 1.5 metres), though harvesting can occur in depths of less than a metre (approximately 2 feet depth). Plant growth must reach the surface in order to harvest effectively (Horner, personal communication). Harvesting leaves behind a large amount of organic material from the portion of stem that cannot be cut. It also creates viable Eurasian watermilfoil fragments during the growing season thus increasing the risk for spread of the plant to uninfested areas.

Harvesting can cover an area faster than rototilling, but also has a much shorter operating season. Two cuts per season may be needed due to rapid plant re-growth. Two harvesters are operated from late June until early September. Factors affecting how much control is accomplished in a season include the amount of plant re-growth from the previous year, increased growth of previously sparse areas, extent of water recreation interfering with access to areas, and weather patterns.

A summary of the advantages and disadvantages of rototilling and harvesting are presented in Table 1.

**Figure 5: Photo of harvester working near Kelowna foreshore, circa approx 1980**

**Table 1: Advantages and disadvantages of harvesting and rototilling Eurasian watermilfoil**

| | Advantages | Disadvantages |
|---|---|---|
| **Harvesting** | • More rapid treatment than rototilling<br>• Cheaper per unit area but two cuts per season may be needed.<br>• Minimal disturbance of lake bottom sediments<br>• Removes plant biomass from the lake | • Causes direct interference with water recreation activities<br>• Disposal costs of plant material are high<br>• Short operating season<br>• Greater risk of plant re-infestation from fragments<br>• Two cuts per season may be needed. |
| **Rototilling** | • Done in the winter when plant fragments are not viable and risk of re-infestation is reduced<br>• Minimal interference with recreation<br>• Longer operating season so more area can be treated<br>• Staff are retained as full time employees, no need to continually train new equipment operators<br>• Re-growth of native plant species can occur after removal of Eurasian watermilfoil (sites may be re-infested by Eurasian watermilfoil)<br>• One treatment per season | • Cost is higher per unit area and the treatment takes more time<br>• Creates a temporary increase in turbidity<br>• Not selective in removing plants<br>• Potential impact to benthic invertebrates |

## 2.4 Changes in Rototiller to Harvester Operating Time Ratios

Rototilling is the primary method for Eurasian watermilfoil control in the current program. The emphasis has changed over the years from almost total reliance on harvesting to more reliance on rototilling because of the longer term effectiveness of rototilling and the extended operating season. In 1981, 1,828 machine hours were logged by four harvesters, with only 100 hours of rototilling. By 2001, the program consisted of 1,650 hours of rototilling and only 250 hours of harvesting. The ratio of harvesting versus rototilling has been consistent from 2001 to 2006.

## 2.5 Socio-Economic Benefits of Eurasian Watermilfoil Control

The benefits of the Eurasian watermilfoil control program in the Okanagan Valley are well documented in the 1991 report *Evaluation of the Socio-economic Benefits of the Okanagan Valley Eurasian Watermilfoil Control Program*, commissioned by BC Ministry of Environment, Land and Parks. Benefits outlined in the report are still relevant today. In fact, the program has become even more beneficial with the rise of the Okanagan tourism and recreation sector, increased shoreline development, and population growth throughout the valley.

A major conclusion of the report is that "the [aquatic weed control] program has promoted further economic development in the Okanagan". People live in the Okanagan because of the lakes, the favourable climate and the pastoral setting. Tourism is a major economic driver in the Okanagan and clean beaches and lakes play a big role in tourism. Without a control program, Eurasian watermilfoil would have established extremely dense populations, interfering with many shoreline and water-based recreation activities and detracting from the aesthetic appeal of the lakes.

Ference Weicker & Company (1991) also concluded that the Eurasian watermilfoil control program positively affects property values in the Okanagan. Average housing prices more than doubled from 2001 to 2007 across the Okanagan Valley (Landcor, 2007). Premium prices have resulted for waterfront real estate, and the median price for a waterfront residential property as of July 2007 in the Central Okanagan is $1.65 million and $1.35 million in the North Okanagan (Okanagan Mainline Real Estate Board(a) and (b)). Without the control of Eurasian watermilfoil it is unlikely that these properties would be worth as much as they are today.

Other conclusions and recommendations from the 1991 Ference Weicker & Company report are that: "funding for the delivery of the Okanagan Valley Eurasian watermilfoil control program should continue to be provided" from the Province of BC and that an increasing emphasis should be placed on derooting (rototill) operations rather than harvesting to control Eurasian watermilfoil. Economic reasons are similar to operational ones: rototilling is performed in the off season when plant biomass is reduced and water based recreation is minimal.

Table 6.1 from the Ference Weicker & Company report is provided in Appendix C to illustrate the benefits of Eurasian watermilfoil control in 1991. Further information is available in the Ference Weicker & Company report (available on request from the OBWB).

# 3.0 Mitigating Potential Impacts of the Eurasian Watermilfoil Control Program

## *3.1 Turbidity*

Best management practice: **Harvesting is used instead of rototilling at sites where increased turbidity may be detrimental to sensitive aquatic species or habitat.**

Rototilling creates turbidity (cloudiness caused by suspended sediment) in the water column as a result of turning substrate to release root crowns.

Increased levels of suspended sediment can adversely affect fish and other aquatic species by:

- reducing light penetration;
- increasing water temperature due to heat absorption by sediments;
- clogging gills and causing asphyxiation;
- filling spaces between gravel substrate that are used as rearing and habitat areas by juveniles fish and invertebrates;
- smothering eggs deposited in gravel substrate; and
- interfering with filter feeding organisms.

The length of time sediment remains suspended in the water column and the travel distance of suspended sediment has been evaluated by the OBWB (see sidebar and Appendix B). The results showed that turbidity at the treatment site can be high, but sandy sediment settles out of the water column quickly and turbidity returns to background levels within 100 metres of the treatment site.

Harvesting produces less turbidity than rototilling. But, it is important to consider that harvesting must be conducted during the growing season (mid-June to end of August) and can therefore spread viable Eurasian watermilfoil fragments and interfere with lake recreation. Harvesting also presents challenges in

**Turbidity Sampling Programs**

In spring 2007, the OBWB undertook a sampling program to characterize turbidity in the treatment zone during rototiller operation. Conclusions of the program included: turbidity levels can be high during treatment; sediment typically settles out rapidly; and 50 to 100 metres outside the rototiller work area turbidity values are typical of background levels. Sampling program details are included in Appendix B.

The conclusions of the 2007 program were similar to those of a turbidity sampling effort undertaken in 1982. Samples were taken before passage of the rototiller, 30 seconds after passage, and 5 minutes after passage. Turbidity values were found to increase after one pass of the machine, however, the increase was small and values dropped below pre-treatment levels after 5 minutes (Bryan and Armour, 1982).

terms of disposal of plant material. The OBWB is committed to working with the BC MoE and other groups to identify sites where it may be appropriate to harvest rather than rototill (e.g., the south end of Skaha Lake where sockeye re-introduction has occurred).

Best management practice: **Rototiller operators communicate with local water utility managers to ensure rototilling operations are halted if turbidity levels are high at water intakes.**

Increased turbidity can impact municipal water supplies. Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites, and bacteria. The effectiveness of water treatment and disinfection may be decreased under high turbidity levels.

Local water utilities contact the OBWB if turbidity spikes are experienced at water intakes. If rototilling is occurring near the water intake, it is halted immediately. A good example of this occurs at the north end of Kalamalka Lake with Greater Vernon Water; when turbidity levels increase past a specified point, the rototiller operator is contacted via cell phone to determine the area he is working in. If current rototilling work is occurring within the vicinity of the Greater Vernon water intake then work in that area is halted until turbidity levels are acceptable to the utility.

### 3.1.1 Methods to Minimize Turbidity That Are Not Feasible for the Okanagan

Several methods of minimizing turbidity during control operations have been proposed over the course of the program, including placing a hood or screen over the rototiller head, using a silt curtain behind the rototiller, and changing treatment locations over the season. Reasons as to why these methods are not suitable for the Okanagan are presented below.

[Herbicide Application: Aquatic herbicides are widely used in the western United States as a means to control Eurasian watermilfoil without rototilling. Due to very strong public sentiments against herbicide use in drinking water sources, and lack of regulatory support, herbicide is not an option.]

*Hoods or Screens*
Placing a hood or screen over the rototiller head has not been found to reduce the amount of turbidity produced but merely delays the release of sediment into the water column. Placing a hood on the rototiller head can also decrease the efficiency of operation (e.g., increasing the frequency of plant material becoming entangled in the blades and the associated staff time needed to remove it).

*Silt Curtains*
The use of a silt curtain behind the rototiller is not feasible because it would hinder raising and lowering the rototiller arm. A silt curtain would also prevent the machine from moving in reverse, which is necessary in most treatment areas as multiple passes are completed.

*Moving Between Treatment Locations During A Rototilling Session*
Switching back and forth between treatment locations during a rototilling session (to let the sediment settle in between passes) would reduce efficiency of the operation. The time required to

complete rototilling in a given area would be greatly increased, potentially reducing the amount of work that can be completed over the length of a rototilling season. In addition, large distances between some treatment sites make it impossible to move between areas during a day-long rototilling session.

## *3.2 Sensitive Aquatic Species and Habitats*

Best management practice: **To minimize potential impacts to aquatic species and habitats, Eurasian watermilfoil control program staff follow the BC MoE instream work timing windows.**

The BC MoE sets out timing windows that must be followed when conducting instream and nearstream work. The timing windows are considered to be that time span presenting least risk of harm to fish, including their eggs, juveniles, spawning adults and the organisms upon which they feed.

Best management practice: **To reduce the risk of harm to kokanee habitat, control efforts are not conducted near kokanee spawning areas identified by BC MoE staff (see Appendix A).**

The OBWB has compared Eurasian watermilfoil treatment site locations with kokanee shore spawning sites identified by BC MoE staff (see maps in Appendix A). In general, gravel substrates frequented by spawning fish do not support dense aquatic weed growth; potential treatment sites and spawning areas seldom overlap and operators keep distances of 500 m or greater from high sensitivity fish habitat. Shore spawning kokanee typically spawn in mid-October, which is later than stream spawners. Fry emergence occurs in late March to early April, depending on water temperature. Eurasian watermilfoil rototilling activities begin after kokanee have spawned, but while eggs are incubating and emerging. Migration of juvenile kokanee typically occurs as rototilling operations are ceasing for the season, at the end of April to early May.

Best management practice: **The OBWB will work with the BC MoE to develop best management practices that minimize impacts to Rocky Mountain Ridged Mussel and other benthic invertebrates.**

Rototiller machines can potentially dislodge organisms, such as benthic invertebrates, buried in the sediment. Current information on distribution and population of benthic invertebrates, including the Rocky Mountain Ridged Mussel, in the Okanagan lakes system is limited. More information is needed before the OBWB can determine if rototilling operations affect invertebrates and, if so, what best management practices should be implemented. The OBWB is committed to working with the BC MoE to develop best management practices for benthic invertebrates.

## *3.3 Native Vegetation*

Best management practice: **To reduce the risk of harm to native vegetation, areas where plant growth is predominantly native species are avoided.**

The ecology of Eurasian watermilfoil (and most other invasive species) means that it is typically the predominant species in areas it establishes because it crowds out other vegetation. It is an opportunistic species and is adapted for early spring growth before native vegetation to form a dense canopy that shades out the native species in an area (Wisconsin Department of Natural Resources, 2009). Treatment is focused on areas in the Okanagan that are dominated by Eurasian watermilfoil with little to no native plant material.

Rototilling is carried out over the dormant season; therefore it is very unlikely that native plants (also dormant at this time) will colonize the treated areas. Native plants will not grow in harvested sites because the entire Eurasian watermilfoil plant is not removed.

## *3.4 Spread of Eurasian Watermilfoil Through Fragmentation*

Best management practice: **To reduce the spread of Eurasian watermilfoil through fragmentation, rototilling is undertaken in the winter when plant fragments are less numerous and not viable.**

Fragmentation is the primary method for Eurasian watermilfoil propagation. Fragmentation involves the breaking off of large mature vegetative parts or the abscission of the plant tips. The fragments may float for several days until sinking to the bottom of the lake where they may develop root shoots. Rototilling in the winter reduces the spread of Eurasian watermilfoil via plant fragmentation as the plant stem has mostly died back and it is dormant.

Best management practice: **To reduce the spread of Eurasian watermilfoil through fragmentation, the harvesters bring cut weeds onto the deck of the machine immediately.**

The type of harvester machines used by the OBWB have a continuously running conveyor belt that immediately draws the cut weeds onto the deck (holding area) of the machine to reduce the number of Eurasian watermilfoil fragments in the water.

## *3.5 Lake Recreation and Navigation*

Best management practice: **Rototilling is conducted in the late fall and winter to avoid interference with lake recreation and navigation. Harvesting operations typically occur either in early morning hours and/or at target locations that are low use to minimize interference with recreation and navigation.**

The Okanagan is known as a tourist destination, especially in the summer months. Lake recreation is an extremely valuable and high priority part of the regional economy. Eurasian watermilfoil control is of tremendous importance to the Okanagan as lake users expect clean shorelines, and open shallow areas for wading and boat access at the lakeshore.

Rototilling is performed in the late fall and winter months when plant biomass is reduced and water based recreation is minimal. Harvesting operations tend to occur in low use areas, such as shallow water boat access areas and along the foreshore in front of residences and other areas where rototilling isn't feasible. Most high use recreation and tourist areas are feasible rototilling sites due to sandy sediments, little to no utility infrastructure or water intakes, and less desirable fish habitats.

## *3.6 Utility Infrastructure*

Best management practice: **Operators use their extensive experience to determine where larger strips are required to avoid water intakes, sewer outfalls, utility cables and geothermal systems.**

Water intakes, sewer outfalls, utility infrastructure and geothermal systems are often located within the rototilling area and must be avoided. Small hazards are given a 'machine width' of clearance and large hazards are given a wider berth. Shoreline signage in many cases is absent or inaccurate. Operator experience is essential to avoiding these underwater hazards.

Figure 6 shows the area around the Vernon city sewer outfall that cannot be rototilled. The untreated zone is visible as a large swath of mature Eurasian watermilfoil. Untreated zones such as these increase the risk of Eurasian watermilfoil re-infestation in the surrounding area.

**Figure 6: Aerial view of Vernon Arm, Okanagan Lake illustrating movement patterns of the rototiller and an underwater hazard that cannot be rototilled**

# 4.0 Other Control Alternatives for Eurasian Watermilfoil

Harvesting and rototilling are the only control methods currently used in the Okanagan (see Section 2.3). A variety of physical, biological, and chemical control methods are available for managing invasive aquatic plants and are used in other areas of the world. This section describes several options, including those that have been used historically in the Okanagan, and discusses the advantages and disadvantages of each option.

## *4.1 Physical Control*

*Mudcat Dredge*

From 1972 to 1974, a Mudcat dredge was used in the Okanagan to remove the roots of Eurasian watermilfoil. In the process, the dredge stirred up malodorous sediment, which was discharged to a nearby settling pond. Residents living near the settling pond were not happy with the stench and unsightliness of the pond.

*Water Jetting*

In 1976, water jets were used in the Okanagan to remove Eurasian watermilfoil at the root. A floating barge, with a pump mounted on top to power the water jets, would work the Eurasian watermilfoil beds in winter when the plant had died back. This method proved ineffective because the jetting device continuously lodged in the sediment and was difficult to remove.

*Diver Operated Dredges*

Diver operated dredges were used in the Okanagan to remove small patches of Eurasian watermilfoil. A team of divers, using a four inch suction hose would "vacuum" the lake bottom. Eurasian watermilfoil roots were sucked up and discharged into a mesh basket on the dredge platform. Sediments would pass through the basket, retaining the Eurasian watermilfoil fragments. Diver dredging was discontinued due to workplace hazards and the large expense associated with maintaining the dive crew.

*Containment Booms*

During the initial trials for rototilling in the Okanagan, booms were constructed to contain Eurasian watermilfoil fragments uprooted to the surface. Each boom consisted of expanded polyethylene logs and a one-quarter inch mesh net that draped down with a lead line along the bottom edge. Unfortunately, the booms became easily entangled and dislodged with wind and current, and therefore required great time, effort, and cost to maintain.

*River Screens*

Large screens were constructed at several points on the Okanagan River channel to prevent Eurasian watermilfoil fragments from being introduced to downstream lakes. Screens had to be continuously tended as they trapped woody debris, trash, and other vegetation.

*Bottom Barriers*

Another physical control method used in small areas of infestation in the Okanagan was the installation of bottom barriers; a geotextile material that acts much like landscape fabric to suppress light, nutrients and physically prevent weed growth. Geotextile fabrics are created for roadbed stabilization and are much heavier than regular garden weed control fabrics. The material has a couple of advantages: it is not buoyant and it allows gases from decomposing plants to pass through so the fabric remains in place. The barriers are not practical for large areas and they must be installed and removed by a dive crew of four people, which is very expensive. Also, sediment settles on top of the barrier, allowing plants to re-root. Use of the bottom barriers was discontinued in the early 1990's. Since that time, the BC MoE has adopted a policy of not using bottom barriers for aquatic weed control because of the potential isolation of the benthic environment (sediment and lake bottom) from the pelagic (water column) environment and the resulting impacts to fish species and invertebrates.

## *4.2 Biological Control*

Biological control has never been used for Eurasian watermilfoil in the Okanagan. Biological control is the use of a predator, pathogen or parasite to suppress the population of a target species (Getsinger, 2005). In Canada, biological control measures are restricted to using native organisms to reduce a target population. The federal government does not permit the introduction of non-native biological control organisms for fear the control agent itself may become a pest.

The Eurasian watermilfoil weevil (*Eurychiopsis lecontei*), native to North America and the Okanagan, lays its eggs in the stems of Eurasian watermilfoil. The larvae bore down through the stem of the plant; introducing diseases that suppress growth, reduce root carbohydrate stores and cause the plant to sink (Tamayo et al., 2000). The effectiveness of the weevil is inconsistent in regions where it is used. In nature, insects rarely reach densities high enough to cause widespread damage (i.e., control) over a nuisance plant. The insect must be artificially reared and introduced to the lake in sufficient quantities to work effectively, which increases the cost.

Another insect native to the Okanagan that will damage Eurasian watermilfoil plants is the chironomid (midge) larva, *Cricotopus myriophylli*, also known as the milfoil midge. Laboratory rearing and introduction attempts of this midge to lakes in BC were unsuccessful, but the midge is found throughout the Okanagan mainstem lakes naturally, though not always in populations large enough to control milfoil (Kangasniemi et al., 1993). Natural populations of midge larva in the Okanagan lake system damage Eurasian watermilfoil in small localized areas, but do not provide an acceptable level of control.

A native pathogenic fungus, the *Mycoleptodiscus terrestris,* significantly reduces plant biomass in laboratory trials (Sorsa et al., 1988). Field results have not shown the same level of effectiveness because the fungus does not damage the plant root system. This method of biological control is also expensive and shows inconsistent viability (Getsinger, 2005).

The Chinese grass carp (*Ctenopharygodon idella*) is an herbivorous fish that will consume large quantities of aquatic plants. The carp also eats many native plants and will even avoid Eurasian watermilfoil on occasion (Lloyd, 1989). They are a non-native species, and in order to prevent grass carp from spreading only triploid sterile fish are used. Grass carp for biological control are successful in small lakes or ponds where stocking rates are affordable and fish are confined to the problem areas (Pauley & Bonar, 1995). In larger water bodies the carp may not remain in the treatment site or feed on the targeted species. Department of Fisheries and Oceans Canada and the BC Ministry of Environment do not support the introduction of grass carp for the control of Eurasian watermilfoil because they are a banned species under the Federal Fisheries Act section 5, schedule VIII and are considered to be a species with serious impacts and risks to biodiversity (Mitchell, personal communication)

## *4.3 Chemical Control*

Herbicides limit the growth of or kill plants. There are two categories of herbicides: contact herbicides, which act immediately on the tissue it touches and cause extensive damage at the point of uptake, and systemic herbicides, which are taken up and moved throughout all tissues, eventually causing mortality for the whole plant (Getsinger, 2005). Contact herbicides are faster acting than systemic, but damage is often limited to the tissues coming into direct contact and does not affect roots or root crowns. Herbicide application is one of the primary control measures used in the United States.

During the 1970s, the Ministry of Environment briefly tested the use of 2,4-D and diaquat to control Eurasian watermilfoil in the Okanagan (BC Ministry of Environment, 1986) . 2,4-D is a systemic herbicide and is the same active ingredient that is found in many lawn weed killers. In the Okanagan, 2,4-D was applied in granular form. Granules were preferred to liquid because they dissolve slowly, sink to the substrate to target the root, and are less likely to be carried by current than the liquid form. Diquat is a contact herbicide that is the chemical equivalent of removing the top growth of the plant and does not affect the root. Widespread use of chemical control was not pursued because of the potential hazard to applicator personnel, public concern for water quality, and the need for repeat applications for the chemicals to be effective.

## *4.4 Education*

*Roadside Boat Check Points*

During the summers of 1979 to 1981, boat and trailer checkpoints were set up at various locations in the Okanagan to try to prevent Eurasian watermilfoil from being introduced to other lakes. Boats and trailers were examined for Eurasian watermilfoil fragments and to educate boaters about Eurasian watermilfoil. These checkpoints were discontinued because they took a great deal of time and effort to conduct and did not seem to curb the spread of the plant (Eurasian watermilfoil was introduced to Christina and Cultus lakes and several small lakes on Vancouver Island while the checkpoints were underway).

Printed brochures and pamphlets were created by the BC Ministry of Environment over the years as a component of public education programs and were distributed in government offices and appropriate public spaces such as boat launches and parks. Throughout the Okanagan and other parts of BC signage was put up at public boat launches informing boaters of Eurasian watermilfoil and directing them to thoroughly clean boats and trailers of all plant fragments. While no new signage or brochures have been created in the last few years, much of this information is still available.

## *4.5 Approaches in Other Jurisdictions*

### 4.5.1 Washington State

A variety of strategies are used to eradicate and/or control Eurasian watermilfoil in Washington State, including:

- Hand Pulling and Bottom Barrier Installation
- Selective Aquatic Herbicide Treatment (2,4-D and Triclopyr-TEA)
- Whole Lake Fluridone (Aquatic Herbicide) Treatment
- Triploid (sterile) Grass Carp
- Diver Dredging
- Harvesting
- Rotovation
- Water Level Drawdown
- Endothall (Aquatic Herbicide) Treatment

In Washington State, homeowners are encouraged to control invasive aquatic plants in local areas. Local control options include hand pulling, cutting, raking, bottom barriers, weed rollers, diver dredging, and spot treatment with herbicides. The Washington State Department of Ecology website provides information about each of these options, including a description of the method, the advantages and disadvantages, permit requirements, costs and vendors. A Citizen's Manual for Developing Integrated Aquatic Vegetation Management Plans has been developed by the Department of Ecology and is available online at www.ecy.wa.gov/programs/wq/plants/management/manual.

The Washington State Department of Fish and Wildlife requires a free permit called a "Hydraulic Project Approval" for all activities taking place in the water (including physical control methods of aquatic plants). The form to apply for an HPA is called a Joint Aquatic Resources Permit Application (JARPA). JARPA is an application form that consolidates fourteen permit application forms for federal, state, and local permits. JARPA requirements include general plans for project, complete plans and specifications for the proposed construction or work within the ordinary high water line in fresh water, and complete plans and specifications for the proper protection of fish life. If the project as proposed will adversely affect fish habitat, it may be approved with certain conditions attached, such as timing and construction methods, to prevent damage. If the project cannot be accomplished without significant adverse impacts on fish, shellfish, or their habitat, it may be denied. Of the approximately 6,000 applications received per year, less than one percent are denied. (Washington Department of Fish and Wildlife, 2009)

Other permits are required for certain activities. These include:

- State Environmental Policy Act (herbicides, grass carp stocking)
- Short-term Modification of Water Quality Standards (herbicides, rotovation, dredging)
- State Shoreline Management Act (bottom barriers, rotovation, harvesting, diver dredging)
- Natural Heritage Program Letter (any control activity)
- Fish Stocking Permit (grass carp stocking)
- A Section 404 permit from the U.S. Army Corps of Engineers for diver dredging.
- A general National Pollutant Discharge Elimination System (NPDES) permit (application of any aquatic herbicides). Only state-licensed applicators may legally apply aquatic herbicides.
- Local permits, which may include Shoreline Management, Growth Management Act/Sensitive Area Ordinance (activities vary by jurisdiction). (Gibbons et. al., 1994)

### 4.5.2 Idaho State

In April 2006, the Idaho State Legislature and the Governor approved $4 million for the purpose of eradication of Eurasian watermilfoil from water bodies in the state of Idaho. In 2007, an additional $4 million was appropriated for this program, which is administered by the Idaho State Department of Agriculture (ISDA).

A statewide strategic plan for Eurasian watermilfoil was completed in 2008. The purpose of the plan is to present a set of strategies that when implemented can lead to the eradication of Eurasian watermilfoil for an Idaho waterbody (ISDA & IISC, 2007).

Counties receive grants from the ISDA to manage Eurasian watermilfoil. The methods of control used in Idaho vary by County, and include:

- bottom barriers
- diver hand-pulling
- herbicides (2,4-D, diquat, triclopyr, Floridone, and endothall)
- surveys and mapping of infestations, and
- education and outreach (e.g., signs at boat launches, public notifications, brochures, waterway signage)
- boat washing stations

Licensed professional applicators need to be consulted before an aquatic herbicide is used in Idaho. Specifically, there is a Short Term Activity Exemption, issued by the Department of Environmental Quality, with strict guidelines to be followed before herbicides may be used.

# 5.0 Other Water Quality Initiatives of the Okanagan Basin Water Board

In addition to the Eurasian watermilfoil control program, the OBWB coordinates or supports several initiatives that contribute to overall water quality and ecological health of the Okanagan basin.

*Investments in Nutrient Reduction*

- The Sewerage Assistance Grant Program, started in 1975, has contributed over $40 million to upgrading sewage treatment plants in Okanagan municipalities. Nutrient removal through increased sewage treatment has virtually eliminated algal blooms, reduced Eurasian watermilfoil and other aquatic plant growth, and increased dissolved oxygen in Okanagan Lake. Phosphorus concentrations resulting from human activities were down by more than 90% in 1997 compared to the 1970s. Prior to the grant program, most Okanagan municipalities had only secondary or rudimentary tertiary treatment. The standard now is tertiary treatment with a sophisticated polishing phase.

*Quantifying Streamflows for Better Management*

- The OBWB is coordinating the Okanagan Water Supply & Demand Project; a scientific study that will provide an urgently needed assessment of current and future water supply and demand in the Okanagan Basin. Estimating minimum instream flows for fish is a significant component of this study. The study will ultimately develop a model to calculate water balance for the basin at 81 key points.

*Small Grants for Environmental Protection*

- The Water Conservation and Quality Improvement (WCQI) grant program is an annual funding initiative by the OBWB designed to assist local government in addressing issues that enhance valley-wide sustainable use of water. Between 2006 and 2008, the OBWB distributed $1.1 million to grant recipients for tangible, on the ground, water quality and conservation improvements in the Okanagan Basin. Many of these grants were able to leverage additional funding to expand project benefits.

*Sensitive Habitat Inventory Mapping*

- Seven Sensitive Habitat Inventory Mapping (SHIM) projects have been funded through the WCQI program. The SHIM methodology is a standard for fish and aquatic habitat mapping in urban and rural watersheds. Data collected through SHIM can identify areas that may have water quality degradations, monitor for changes in habitat due to disturbance or pollution inputs, and identify sensitive habitats and habitat impairments for fish and wildlife along watercourses.

*Ecological Restoration*

- Other projects funded through WCQI grants that provide ecological benefits are a channel restoration at Joe Rich Creek and the development of a management plan for water levels on Ellison Lake to ensure minimum flows for fish are met in Middle Vernon Creek.

*Foreshore Inventory Mapping*

- In 2008, two Foreshore Inventory Mapping (FIM) projects were funded through the WCQI grants; one for northern Okanagan Lake and the other for Skaha Lake. These projects contribute data to a large regional initiative and enhance foreshore planning and development to incorporate ecologically sensitive areas.

*Mission Creek Water Use Plan*

- The Mission Creek Water Use Plan is determining instream flow requirements for fish. The Mission Creek watershed is the largest tributary in the Okanagan Basin and has very high water values for both fish and consumptive uses. The Water Use Plan will coordinate water management to benefit both users and fisheries requirements in light of population growth and climate change.

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# Appendix A:
## Eurasian Watermilfoil Treatment Maps for Okanagan Mainstem Lakes

These maps were created using information from the Okanagan Basin Water Board's Eurasian Watermilfoil treatment areas and include past and current treatment areas for rototilling (derooting) and harvesting. Ministry of Environment data on Sensitive Habitat Areas for Kokanee is also included. These maps are a new resource for the Okanagan Basin Water Board.


Treatment Location
Index Map
N
Westside Road
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
1
2
1
1
2
1
2
Legend
0 Non Treatment Maps
1 Treatment Maps
1:375,000

Treatment Locations for Kalamalka Lake
Legend
High Sensitivity Fish Habitat Buffer
Moderate Sensitivity Fish Habitat Buffer
Treatment Types
Derooted
Harvested
Previously Derooted
Previously Harvested
N
97
Kalamalka Lake
1:20,000

Treatment Locations for Kalamalka Lake
N
97
Legend
High Sensitivity Fish Habitat Buffer
Moderate Sensitivity Fish Habitat Buffer
Treatment Types
Derooted
Harvested
Previously Derooted
Previously Harvested
Kalamalka Lake
Oyama
1:20,000

Treatment Locations for Wood Lake
Legend
High Sensitivity Fish Habitat Buffer
Moderate Sensitivity Fish Habitat Buffer
Treatment Types
Derooted
Harvested
Previously Derooted
Previously Harvested
N
Kalamalka Lake
Oyama
97
Wood Lake
1:20,000


Treatment Locations for Okanagan Lake
Legend
High Sensitivity Fish Habitat Buffer
Moderate Sensitivity Fish Habitat Buffer
Treatment Types
Derooted
Harvested
Previously Derooted
Previously Harvested
N
Okanagan Lake
Westside Road
1:20,000

Treatment Locations for Okanagan Lake
Legend
High Sensitivity Fish Habitat Buffer
Moderate Sensitivity Fish Habitat Buffer
Treatment Types
Derooted
Harvested
Previously Derooted
Previously Harvested
N
Okanagan Lake
Westside Road
1:20,000


Treatment Locations for Okanagan Lake
Legend
High Sensitivity Fish Habitat Buffer
Moderate Sensitivity Fish Habitat Buffer
Treatment Types
Derooted
Harvested
Previously Derooted
Previously Harvested
Westside Road
N
Okanagan Lake
1:20,000

# Treatment Locations for Okanagan Lake


Treatment Locations for Okanagan Lake
N
Westside Road
Okanagan Lake
Kelowna
97
97
97
97
Lakeview Heights
Legend
High Sensitivity Fish Habitat Buffer
Moderate Sensitivity Fish Habitat Buffer
Treatment Types
Derooted
Harvested
Previously Derooted
Previously Harvested
1:20,000


Treatment Locations for Okanagan Lake

Treatment Locations for Okanagan Lake
N
97
Okanagan Lake
Legend
High Sensitivity Fish Habitat Buffer
Moderate Sensitivity Fish Habitat Buffer
Treatment Types
Derooted
Harvested
Previously Derooted
Previously Harvested
1:20,000


Treatment Locations for
Okanagan Lake
N
Peachland
97
Okanagan Lake
Lake
Legend
High Sensitivity Fish Habitat Buffer
Moderate Sensitivity Fish Habitat Buffer
Treatment Types
Derooted
Harvested
Previously Derooted
Previously Harvested
1:20,000


Treatment Locations for Okanagan Lake
N
Okanagan Lake
Lake
Greata
97
Legend
High Sensitivity Fish Habitat Buffer
Moderate Sensitivity Fish Habitat Buffer
Treatment Types
Derooted
Harvested
Previously Derooted
Previously Harvested
1:20,000


Treatment Locations for Okanagan Lake
Legend
High Sensitivity Fish Habitat Buffer
Moderate Sensitivity Fish Habitat Buffer
Treatment Types
Derooted
Harvested
Previously Derooted
Previously Harvested
N
Okanagan Lake
97
Summerland
1:20,000


Treatment Locations for
Okanagan Lake
N
Okanagan Lake
97
Legend
High Sensitivity Fish Habitat Buffer
Moderate Sensitivity Fish Habitat Buffer
Treatment Types
Derooted
Harvested
Previously Derooted
Previously Harvested
1:20,000

Treatment Locations for Skaha Lake
N
97
Skaha Lake
Kaleden
Legend
High Sensitivity Fish Habitat Buffer
Moderate Sensitivity Fish Habitat Buffer
Treatment Types
Derooted
Harvested
Previously Derooted
Previously Harvested
1:20,000


Treatment Locations for Skaha Lake
N
Kaleden
Skaha Lake
Lake
Lake
Lake
97
Okanagan Falls
Legend
High Sensitivity Fish Habitat Buffer
Moderate Sensitivity Fish Habitat Buffer
Treatment Types
Derooted
Harvested
Previously Derooted
Previously Harvested
1:20,000


Treatment Locations for
Osoyoos Lake
N
97
3
Osoyoos Lake
Legend
High Sensitivity Fish Habitat Buffer
Moderate Sensitivity Fish Habitat Buffer
Treatment Types
Derooted
Harvested
Previously Derooted
Previously Harvested
1:20,000

Treatment Locations for
Osoyoos Lake
N
Osoyoos Lake
Osoyoos
97
3
Lake
Legend
High Sensitivity Fish Habitat Buffer
Moderate Sensitivity Fish Habitat Buffer
Treatment Types
Derooted
Harvested
Previously Derooted
Previously Harvested
97
1:20,000

# Appendix B:
## OBWB Eurasian Watermilfoil Control Program
## Turbidity Sampling, Spring 2007

# Eurasian Watermilfoil Control Program

# Turbidity Sampling, Spring 2007

Okanagan Basin Water Board
Genevieve Dunbar, BSc.
Water Stewardship Coordinator

# Table of Contents

# Review of Aquatic Weed Control Program and Report on Turbidity Sampling for Eurasian Watermilfoil Removal Operations, Spring 2007
# Okanagan Basin Water Board

## 1.0 Introduction

History

Eurasian watermilfoil (*Myriophyllum spicatum*) was first identified in Okanagan Lake in 1970 in the Vernon area. In four years the plant was well established in all the main lakes of the Okanagan. The plant forms thick stands of underwater stems and dense mats of vegetation on the water's surface. The fibrous root masses can produce hundreds of stems per square meter. Once established, eradication is almost impossible.

With problem levels of Eurasian watermilfoil (EWM) infestation in the Okanagan lakes system the BC Ministry of Environment, in partnership with the Okanagan Basin Water Board began operating the control program in 1976. As a result of successful efforts for the last 30 years, Eurasian watermilfoil is managed to acceptable levels with no new infestations occurring. Currently there is a limited summer harvesting program and a more extensive winter rototilling of the root systems in shallow areas of Okanagan, Wood, Kalamalka and Osoyoos Lakes.

Treatment Method

The method of rototilling roots from the lake bottom in shallow areas creates turbidity in the water column, which can affect aquatic organisms. Generally 100% removal of EWM roots is not achieved in one treatment, though repeat annual applications can reduce the weed density to a very low level. Effectiveness is dependent on the type of lake bottom substrate, obstacles in treatment sites such as wharves and pilings, debris (usually large boat anchors), water intakes, sewer outfalls and in a few cases, sewer mains and collectors. Areas which cannot be rototilled usually cause increased rate of infestation.

The rototilling machine operates in shallow sites (less than 4 or 5 meters depth) in Kalamalka, Wood, Okanagan and Osoyoos Lakes. Often the machine moves perpendicular to shore, traveling from close to the shoreline (1 metre water depth) and moving out into the lake until the maximum depth for the rototiller arm is reached at about 4.5 meters. For purposes of this report, travel in this manner is referred to as a 'pass' of the rototiller. The machine will also operate parallel to shore, depending on characteristics of the bottom sediment, wind speed and direction, and weather patterns. In data gathering for this report, the rototiller moved only in a perpendicular fashion during sampling sessions.

## 2.0 Turbidity Sampling

In April 2007, staff of the Okanagan Basin Water Board conducted a sampling program for turbidity in rototiller treatment areas on both Okanagan Lake near Kelowna and at the south end of Wood Lake. The objective of this sampling was to characterize turbidity in the treatment zone while the machine was operating.

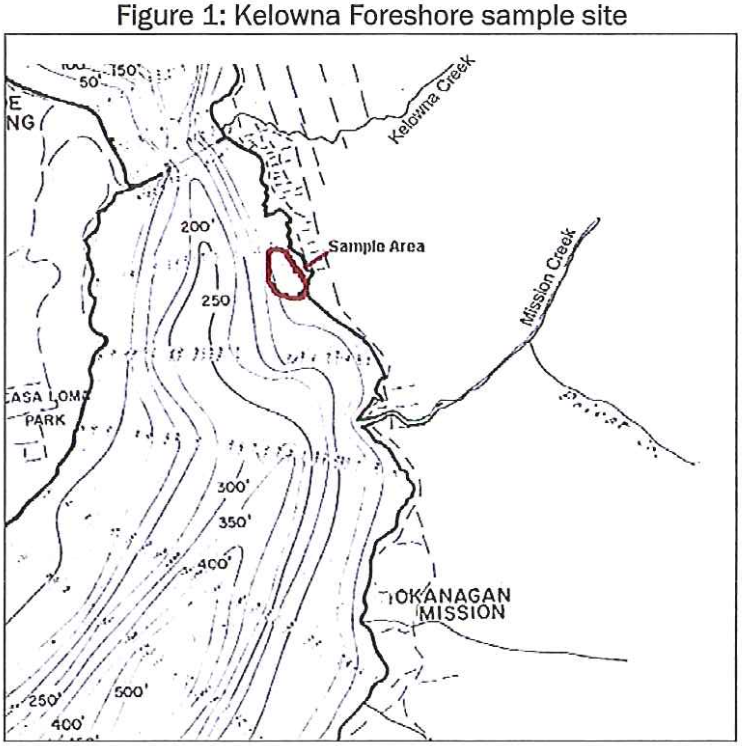
Methods:
Turbidity sampling took place at two different locations; Okanagan Lake and Wood Lake. Both sample locations were shallow sites with a high proportion of sandy sediment (Ian Horner, personal communication); though Wood Lake did exhibit small patches of finer, silt like sediment.

The turbidity sampling program relied on a YSI 6820 Multi Parameter Meter. Specifications for the meter can be found in Appendix A. A 6.5 m twin engine aluminum workboat was used as the working vessel. A handheld Garmin eTrex GPS unit (specifications can be found in Appendix B) was used to take UTM coordinates of every sample point and to determine distances between sample points when necessary.

In order to take accurate background turbidity samples, the rototiller did not begin operation until background turbidity levels were taken in the treatment area on April 17 where sampling along the Kelowna Foreshore occurred the first time, and on April 19, where sampling was conducted at the South end of Wood Lake. On April 27, the rototiller machine was already operating by the time the boat was launched to re-sample at the Kelowna foreshore location, preventing a background reading.

Okanagan Lake – "Kelowna Foreshore"
The sample area on Okanagan Lake was at the Kelowna Foreshore, located south of Kelowna Creek's outflow into the lake and north, northeast of the El Dorado Hotel and Marina, where there is a long, shallow, sandy ledge (max depth = 5 m) that stretches approximately 200 meters from shore before an abrupt drop off occurs and the depth increases to approximately 15 meters (Figure 1).

Figure 1: Kelowna Foreshore sample site




The April 17, 2007 sample date at this location was very windy, and it was difficult to position the boat to take in situ samples. Sampling on April 27 provided a calm day with virtually no wind.

Sample methods at this location consisted of three methods.

Method 1: The boat was positioned so that at the midpoint of a rototiller pass the boat could quickly move in behind and scoop a 5 gallon pail of water from the surface. The turbidity was taken immediately and then 5 minutes after the bucket had sat undisturbed and allowed to settle.

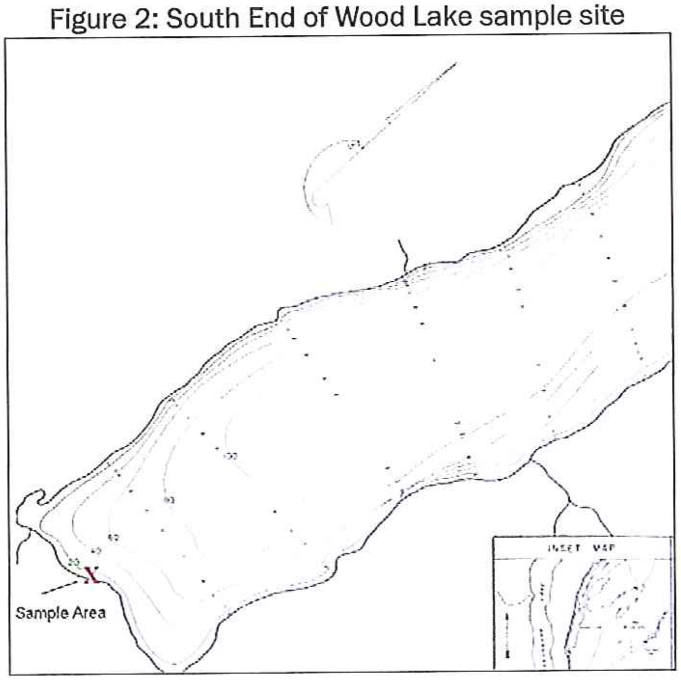
Method 2: The boat was taken to the deepest point of the rototiller work area. Immediately after the rototiller machine completed the deepest area of rototilling, the meter was lowered into the water and a profile of turbidity with depth was taken; usually 4 to 5 meters deep.

Method 3: Using the Garmin eTrex GPS unit we approximated the mid point of the treatment site for the day and marked it as a point. The boat then traveled out from that point by 50 m and 100 m, parallel to the shoreline on either side of the mid-point and turbidity was measured, in situ, at the surface (0.5 m).

Wood Lake – South End

The sample area on Wood Lake was located at the south end of the lake, again in a shallow area (Figure 2). The sample area at this location displayed a more noticeable grade along the lake bottom and did not consist of a large shallow shelf. Sample methods at this location involved scooping surface water with the 5 gallon pail as described in Method 1. A distance sample as described in Method 3 was initiated but the meter malfunctioned before any samples were collected.

Figure 2: South End of Wood Lake sample site



Results and Observations:

Results for turbidity sampling via the bucket scooping method are provided in the table below.

Table 1: Method 1 results, turbidity settling in 5 gallon pail

| Site name/method | Timing | Turbidity | % decrease through settling |
|---|---|---|---|
| **Wood Lake –South End** | | | |
| Bucket #1 | 0 mins<br>5 mins | 6.3<br>4.4 | 30.16 |
| Bucket #2 | 0 mins<br>5 mins | 16.9<br>8.6 | 49.11 |
| Bucket #3 | 0 mins<br>5 mins | 20.9<br>10.8 | 48.33 |
| Bucket #4 | 0 mins<br>5 mins | 10.2<br>4.4 | 56.86 |
| **Kelowna Foreshore** | | | |
| Bucket #1 | 0 mins<br>5 mins | 24.2<br>5.6 | 76.86 |
| Bucket #2 | 0 mins<br>5 mins | 11.2<br>8.9 | 20.54 |
| Bucket #3 | 0 mins<br>5 mins | 3<br>1.2 | 60.00 |
| Bucket #4 | 0 mins<br>5 mins | 11.4<br>3.2 | 71.93 |

This table shows that while turbidity values varied in both initial readings and total change during the 5 minute settling time, they always decreased. As sediment compaction and composition varies over the treatment area, initial turbidity readings will vary with the type of sediment disturbed by the rototiller arms, churned to the surface and scooped with the pail. In general, it can be said that there is greater decreases in turbidity, and therefore greater sediment settling in the samples taken at the Kelowna foreshore location than at the south end of Wood Lake.

Figure 3: Turbidity with depth at deep spot of working area

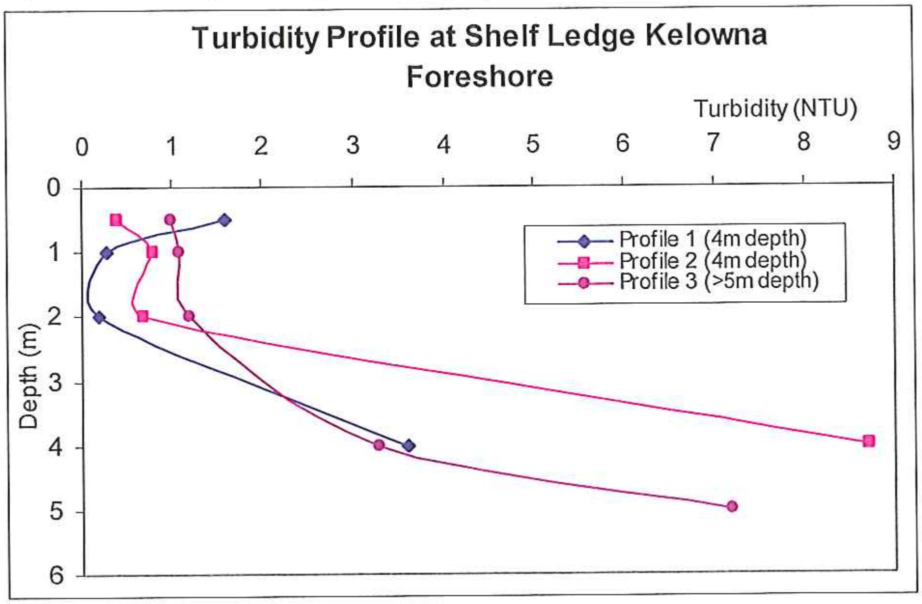



Figure 3 shows the turbidity profile taken at the deep edge (5 m depth) of the rototiller work area when sampling at the Kelowna Foreshore, April 27. It can be seen that the surface samples have minimal turbidity (ranging from 0.4 to 1.6 NTU) while lower depths close to the bottom show a marked increase in turbidity, jumping to as much as 8.7 NTU in one sample.

The rototiller machine moves quickly through a treatment area and stirs up sediment on a continual basis which makes it difficult to get instantaneous turbidity readings – they change every few seconds due to water and sediment movement in the treatment zone. On occasion when the meter was lowered into the water directly behind the rototiller, and left to fluctuate with water and sediment movement, readings varied from very little, at 2 to 3 NTU to a spike of over 200 NTU. The most common reading during this period of fluctuation was in the range of 17 to 22 NTU.

In conducting the shallow in-situ sample directly behind the rototiller, it was observed that there are often clumps of sediment passing by the meter when it is in the water column, hovering close to the bottom (total depth 1 to 2 m in most cases). Clumps of sediment interfere with the sensor and cause it to go into an automatic cleaning mode, which uses a brush to wipe the clumped sediment off the sensor tip. Both clumps of sediment and the bristles of the brush directly against the sensor will cause it to display high turbidity 'values'. With the meter in the water it is hard to determine if the high readings are due to the cleaning brush covering the sensor or are accurate turbidity readings. The YSI must be lifted out of the water and visually inspected to determine if the cleaning brush is in operation. For this reason, turbidity values should be judged as conservative.

In Method 3 where the mid point of the treatment area for the day was approximated, samples were taken perpendicular from the working path of the machine (and parallel to shore) – at distances of 50 and 100 metres using the handheld GPS unit (accuracy at the time = 5 metres). At the Kelowna Foreshore location on April 27, the samples for 50 metres on either side of 'centre' were 1.5 and 4.0 NTU respectively. The samples for 100 metres away on either side of 'centre' were 1.6 and 1.7 NTU respectively. These readings are in the normal range for a shallow foreshore area if the rototiller machine were not working in the area; as background levels (Dennis Einarson, personal communication).

On the initial sampling trip at the Kelowna foreshore site on April 17, the wind was moderate in the southwest direction, making sampling difficult and causing sediment disturbed from the rototiller to move with prevailing currents. Generally it was observed that the wind was causing the sediment plume to travel north-northeast and in toward shore. This could be observed visually. GPS readings at the edge of this turbidity plume were taken after the machine had been working for a couple of hours, and are awaiting input into a GIS system for mapping. Due to difficulties with the equipment, determining the edge of the sediment plume was done visually, so there are likely to be discrepancies.

Discussion on Sampling:
From general observation and sampling it appears there are a few constants;

- the sediment settles from the water in relatively high proportions in a short amount of time
- when the rototiller is working in deeper water (4 to 5 m) the water column is more turbid at the bottom than close to the surface
- when there are prevailing winds the sediment is transported in the water column according to wind direction and current.

There are a couple of possibilities in examining the 5 m profile results; that the water does not become as mixed at the deepest point of rototilling, thus the absence of a more uniform distribution of turbidity values, or that the majority of the sediment has begun to settle by the time the profile was taken to the bottom.

Most of the sediment in the sampling areas we chose for the program was composed of a high sand fraction (determined visually). Sand is a larger and heavier particle than silt or clay, which causes it to settle out of the water column faster than other particles and results in lower turbidity values.

The rototiller moves quite fast in the treatment area, perpendicular to shore in this case, and can cover one 'pass' of shallowest to deepest parts of the treatment area in under a minute depending on a few factors such as sediment type, weather, and wind. The rototiller moves along the same path for a few 'passes', so the sampling boat needs to be out of the path of the machine in a short amount of time. This poses challenges when sampling for turbidity as the machine comes along faster than an in situ sample can occur. In addition, the water column is still mixing, resulting in uneven distribution of sediment in the water column, and therefore uneven turbidity readings.

Depending on wind, waves and current at the time, the area around a portion of the treatment zone stays well mixed during operation of the machine, even in areas where the rototiller has moved past.

It was found that on many occasions the turbidity meter would spike to a very high reading (between 100 and 300 NTU) when the sensor was placed in the water (using the continuous read option on the YSI). These would be instantaneous readings as within a matter of seconds the turbidity value on the display would drop again. It is believed that the turbidity is 'spiking' in this manner due to clumps of sediment/plant material passing by the meter when it is in shallow water (total depth 1 to 2 m in most cases) and this can cause the meter to misread and to spend time in automatic cleaning mode for the probe. These clumps will likely fall directly to the bottom, though there is potential for them to break apart in the water column and contribute to overall turbidity.

Conclusion:
Through this sampling effort it can be seen that in areas with a high sand fraction the sediment settles out of solution in a high proportion over a short amount of time as determined by scooping turbid water with a pail. While sampling at the deepest point of rototiller operation it was observed that the

water just above the bottom is more turbid than the rest of the water column – which can either indicate the sediment has settled from the upper portion of the water column or there isn't much mixing in water 4 to 5 meters deep during rototiller operation. Also observed were highly fluctuating turbidity values in the surface water of shallow areas when the meter was held in one location after the rototiller had passed by, likely due to the swirling of water and sediment caused by the machine.

From sampling results, it also appears that the turbidity does not remain high when traveling away from the machine; approximate background turbidity levels were achieved in only 50 to 100 m distance from operating area, taken while the rototiller was still working.

The Okanagan Basin Water Board is committed to continuing Eurasian watermilfoil removal operations in an ecologically sound manner and will contribute the information gathered in this sampling effort to the best management practices for operation of rototillers and harvesters on lakes in the Okanagan.

# Appendix C:
## Copy of Table 6.1 – Summary of the Regional and Provincial Benefits of the Okanagan Valley Eurasian Watermilfoil Control Program

Table excerpted from "Evaluation of the Socio-Economic Benefits of the Okanagan Valley Eurasian Watermilfoil Control Program" by Ference Weickler & Company Management Consultants, December 1991.

## Table 6.1

## SUMMARY OF THE REGIONAL AND PROVINCIAL BENEFITS OF THE OKANAGAN VALLEY EURASIAN WATER MILFOIL CONTROL PROGRAM

| | Regional Benefits | Provincial Benefits |
|---|---|---|
| **Tourism Operators:** | | |
| Impact on Revenues by Sector ($000) (1): | | |
| Transportation | $ 19,120 | $ 8,990 |
| Restaurants | 17,760 | 8,350 |
| Accommodation | 17,510 | 8,230 |
| Shopping | 15,220 | 7,150 |
| Other | 15,380 | 7,230 |
| Total | $ 84,990 | $ 39,950 |
| **Lakeshore Residents:** | | |
| Impact on Real Estate Values ($000) (2) | $ 133,000 | - |
| **General Public:** | | |
| Impact on Real Estate Values ($000) (3) | $ 227,000 | - |
| Impact on Employment | 1,700 Jobs | 800 Jobs |
| **Provincial Government:** | | |
| Impact on Revenues by Category ($000): | | |
| Sales Tax | - | $ 2,500 |
| Room Tax | - | 130 |
| Corporate Income Tax | - | 360 |
| Total | - | $ 2,990 |
| **Total Impact ($000)** | Over $ 450,000 | Over $ 40,000 |

Notes:

(1) Breakdown between sectors based on data from Visitor'89 and Resident Travel Survey (See Section A in Chapter IV for more details).

(2) Lakeshore residents are defined as those living on privately owned developed lakefront lots, as opposed to privately owned undeveloped lots. We have estimated in Section A that there are about 4,396 such lots which can be valued at about $1.33 billion, including $0.75 billion for land and $0.58 billion for improvements (See Section A in Chapter IV for more details).

(3) Defined as total impact on real estate values ($360 million) minus the impact on real estate values for lakeshore residents.