PROJECT REPORT

SAMMAMISH RIVER BRAZILIAN ELODEA REMOVAL

Prepared for
King County

Prepared by
Herrera Environmental Consultants, Inc.
Note:
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PROJECT REPORT

SAMMAMISH RIVER BRAZILIAN ELODEA REMOVAL

Prepared for
King County River and Floodplain Section
Water and Land Resources Division
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INTRODUCTION

Brazilian elodea (*Egeria densa*) is a non-native invasive aquatic plant with well established populations in Lake Sammamish, the Sammamish River, Lake Washington, and other waterbodies in Washington. It is considered a Class B weed by the Washington State Noxious Weed Control Board (indicating that distribution is limited to portions of the state). Brazilian elodea is designated for control in most water bodies of Washington but not in Lake Sammamish, the Sammamish River, and some other water bodies where it is well established.

In order to offset potential effects to salmonids derived from impacts of other projects, King County is coordinating the removal of Brazilian elodea from portions of the Sammamish River. This will be a multi-year study (Year 1 results are presented in this report) to evaluate the cost, efficiency, and effectiveness of control techniques for this invasive species. Prior to, during, and after weed removal operations, King County is monitoring hydrologic and water quality conditions within the river. The goal of the monitoring is to evaluate any effects on water quality, water level, or river flow as a result of invasive plant removal.

The project took place in a 1.5-mile stretch of the Sammamish River in unincorporated King County, Washington, between August 5, 2013, and August 14, 2013. The project began underneath the NE 145th Street Bridge and moved upstream (south) to the endpoint at NE 124th Street Bridge (Figure 1).

This report summarizes methods and results of Brazilian elodea removal, water level effects, and water quality effects. Background information, control methods, and best management practices for Brazilian elodea are available from King County (2010).
Figure 1.
Sammamish River Brazilian Elodea Removal Project Area Map. King County, Washington.
**Brazilian Elodea Removal**

**Methods**

Divers and snorkelers removed Brazilian elodea by pulling the plants out by the roots, or by first removing the shoots and then grubbing the roots. Brazilian elodea biomass was netted or placed on a small boat, and dragged to shore. Working from the shore, Washington Conservation Corps (WCC) crews took the Brazilian elodea biomass from the river to dump containers for eventual disposal at a compost facility. WCC crews also raked Brazilian elodea biomass that was reachable from the shore.

A support boat with a diver support team (rescue diver and dive supervisor) was on site at all times for the safety of the divers and snorkelers. Staff in the boat also scouted Brazilian elodea locations, and recorded daily progress on a GPS. All areas that were controlled had high density of infestations (over 75 percent of the river bed colonized). In many areas, Brazilian elodea spanned the entire channel.

Brazilian elodea removal procedures generally followed those described in the the project Health and Safety Plan (Herrera 2013). The Health and Safety Plan established safety protocols and emergency response procedures to address the identified physical and biological hazards of the project activities. Activity-specific attachments to this plan include a Waterborne Vessel Safety Plan, Site Specific Dive Plan, and Aquatic Invasive Species Protocols.

The anticipated project approach was to remove Brazilian elodea from 5.7 miles of the Sammamish River in a period of 8 days by starting at the NE 145th Street Bridge and working upstream to the downstream end of the Sammamish River Transition Zone located in Marymoor Park (Herrera 2013). Due to the abundance of Brazilian elodea throughout this river reach, it became apparent that removal rate was not fast enough to control the entire project area in 8 days. Therefore, removal activities occurred along segments of the river that were easily accessed between the NE 148th and NE 124th Street bridges.

**Results**

The following sections describe daily progress of Brazilian elodea removal on the Sammamish River, which is also summarized in Table 1. Figure 1 shows daily work areas. The weight of Brazilian elodea biomass removed was estimated to be 7,100 pounds for the 4-day period from August 5 to August 8, 11,860 pounds for August 12 and 13, and 2,580 pounds for the 1-day period on August 14, based on container tipping weight.

A total of 10.8 tons of Brazilian elodea was removed in 7 days from 3.4 acres, located in 0.5 river miles of a 1.5-mile reach between NE 124th Street and NE 148th Street. Average daily removal rates were equivalent to 1.5 tons/day, 0.5 acres/day, and 0.072 river miles/day (380 river feet/day). Applying this average removal rate over the 5.7-mile project area,
suggests that it require approximately 80 days to remove Brazilian elodea from the entire river reach between Marymoor Park and NE 148th Street using four divers, two snorkelers, and a shore disposal crew.

<table>
<thead>
<tr>
<th>Date</th>
<th>Plant Density</th>
<th>Method</th>
<th>Staffinga</th>
<th>Area Pulled (acres)</th>
<th>Linear Length Pulled (feet)</th>
<th>Tipping Weight (lbs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 5, 2013</td>
<td>High</td>
<td>Pulled roots and shoots from bank to bank, detailed root removal by divers.</td>
<td>4 Divers 4 Snorkelers</td>
<td>0.25</td>
<td>202</td>
<td>7,100</td>
</tr>
<tr>
<td>August 6, 2013</td>
<td>High</td>
<td>Pulled roots and shoots from bank to bank, detailed root removal by divers.</td>
<td>5 Divers 4 Snorkelers</td>
<td>0.34</td>
<td>232</td>
<td></td>
</tr>
<tr>
<td>August 7, 2013</td>
<td>High</td>
<td>Pulled primarily shoots from bank to bank. (4 Divers – mostly snorkeling) 1 Snorkeler</td>
<td></td>
<td>0.72</td>
<td>477</td>
<td></td>
</tr>
<tr>
<td>August 8, 2013</td>
<td>High</td>
<td>Pulled roots and shoots from bank to bank. General root removal by divers.</td>
<td>4 Divers 2 Snorkelers</td>
<td>0.81</td>
<td>602</td>
<td></td>
</tr>
<tr>
<td>August 12, 2013</td>
<td>High</td>
<td>Pulled roots and shoots from bank to bank</td>
<td>4 Divers 2 Snorkelers</td>
<td>0.41</td>
<td>314</td>
<td>11,860</td>
</tr>
<tr>
<td>August 13, 2013</td>
<td>High</td>
<td>Pulled roots and shoots from bank to bank</td>
<td>4 Divers 2 Snorkelers</td>
<td>0.41</td>
<td>325</td>
<td></td>
</tr>
<tr>
<td>August 14, 2013</td>
<td>High</td>
<td>Pulled roots and shoots primarily in river channel (two segments, upstream and downstream of August 13 work area)</td>
<td>4 Divers 2 Snorkelers</td>
<td>0.47</td>
<td>523</td>
<td>2,580</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>3.41</strong></td>
<td><strong>2,675</strong></td>
<td><strong>21,540</strong></td>
</tr>
</tbody>
</table>

a Dive team staffing includes a rescue diver (who assists with weed removal from the surface, geared up, with SCUBA gear ready to deploy) and a dive supervisor (who remains in the anchored boat and manages diver safety and in-water operations). Therefore a “4 Divers” team has two divers working in the water.

**August 5**

Herrera and WCC met at the NE 145th Street Bridge and Sammamish River Trail Access parking lot. Herrera led a project planning meeting and safety briefing. Herrera mobilized diver and snorkeler gear, boat, and weed removal tools to the put-in location under the NE 145th Street Bridge. A preliminary survey of the infestation extent was performed by boat. It was found that there was an overall high density of Brazilian elodea, with some smaller populations of native elodea (*Elodea canadensis*) and giant burred (*Sparganium eurycarpum*), which were left intact, except when intermixed with dense Brazilian elodea.
Two divers working in the water (plus two support divers, see table note above) and four snorkelers removed and bagged the roots and shoots of the Brazilian elodea. The divers were in the water for 3.25 hours. The Brazilian elodea biomass was brought to shore, where WCC crews pulled it from the river and took it to an off-site dump location. It was found that there was a very high density of Brazilian elodea and the root mats were often layered, with sediment accumulation between the root layers.

Removal took place from bank to bank. A total of 0.25 acres over 202 linear feet were covered. Limits of removal were mapped with GPS.

**August 6**

Herrera and WCC met at the NE 145th Street Bridge and Sammamish River Trail Access parking lot. Herrera led a safety briefing. Herrera mobilized diver and snorkeler gear, boat, and weed removal tools to the put-in location under the NE 145th Street Bridge. The boat was sent upstream to look for Brazilian elodea populations that the WCC crews could rake from shore. Brazilian elodea removal continued where crews had ended on August 5 and moved upstream.

Three divers working in the water and four snorkelers removed and bagged the roots and shoots of the Brazilian elodea. Two safety divers remained in the boat. The divers were in the water for 3.75 hours.

Removal took place from bank to bank. Limits of removal were marked with GPS. A total of 0.34 acres over 232 linear feet were covered.

**August 7**

Herrera and WCC met at the NE 145th Street Bridge and Sammamish River Trail Access parking lot. Herrera led a safety briefing. Herrera mobilized diver and snorkeler gear, boat, and weed removal tools to the put-in location under the NE 145th Street Bridge. The Brazilian elodea removal began where WCC crews were able to rake from shore, upstream of where the crews had ended the previous day.

Two divers working in the water and one snorkeler removed and bagged the roots and shoots of the Brazilian elodea. Two safety divers remained in the boat. The divers were in the water for 2.0 hours. WCC crews also raked Brazilian elodea shoots from the shore and from a boat. The divers, snorkeler, and WCC crews primarily focused on the removal of shoots this day.

Removal took place from bank to bank. Limits of removal were marked with GPS. A total of 0.72 acres over 477 linear feet were covered.

**August 8**

Herrera and WCC met at the NE 145th Street Bridge and Sammamish River Trail Access parking lot. Herrera led a safety briefing. Herrera mobilized diver and snorkeler gear, boat, and weed removal tools to the put-in location under the NE 145th Street Bridge. Brazilian elodea removal continued where crews had ended on August 7 and moved upstream.
Two divers in the water and two snorkelers removed and bagged the roots and shoots of the Brazilian elodea. Two safety divers remained in the boat. The divers were in the water for 4.5 hours.

Removal took place from bank to bank. Limits of removal were marked with GPS. A total of 0.81 acres over 602 linear feet were covered.

**August 12**

Herrera and WCC met at the NE 124th Street Bridge Pump Station. Herrera led a safety briefing. Herrera mobilized diver and snorkeler gear, boat, and weed removal tools to the put-in location under the NE 124th Street Bridge. Brazilian elodea removal began at the NE 124th Street Bridge and continued downstream.

Two divers in the water and two snorkelers removed and bagged the roots and shoots of the Brazilian elodea. Two safety divers remained in the boat. The divers were in the water for 4.25 hours.

Removal took place from bank to bank. Limits of removal were marked with GPS. A total of 0.41 acres over 314 linear feet were covered.

**August 13**

Herrera and WCC met at the NE 124th Street Bridge Pump Station. Herrera led a safety briefing. Herrera mobilized diver and snorkeler gear, boat, and weed removal tools to the put-in location under the NE 124th Street Bridge. Brazilian elodea removal continued where crews had ended on August 12 and moved downstream.

Two divers in the water and two snorkelers removed and bagged the roots and shoots of the Brazilian elodea. Two safety divers remained in the boat. The divers were in the water for 3.5 hours.

Removal took place from bank to bank. Limits of removal were marked with GPS. A total of 0.41 acres over 325 linear feet were covered.

**August 14**

Herrera and WCC met at the NE 124th Street Bridge Pump Station. Herrera led a safety briefing. Herrera mobilized diver and snorkeler gear, boat, and weed removal tools to the put-in point location under the NE 124th Street Bridge. Brazilian elodea removal was conducted in two segments, one upstream and one downstream of the August 13 work area.

Two divers in the water and two snorkelers removed and bagged the roots and shoots of the Brazilian elodea. Two safety divers remained in the boat. The divers were in the water for 3.5 hours.

Removal took place primarily within the central portion of the channel (approximately 75 percent of the bank to bank width) to focus efforts where any hydrologic change could be detected by King County monitoring. Removal took place primarily in the channel. Limits of removal were marked with GPS. A total of 0.47 acres over 523 linear feet were covered.
WATER LEVEL EFFECTS

Dense stands of Brazilian elodea have recently developed in Lake Sammamish and the Sammamish River. Observations of this aquatic invasive plant was first documented in 2003 for the lake and in 2009 for the river (Washington Department of Ecology Aquatic Plant Monitoring website). Currently, Brazilian elodea grows on most of the river bottom from the lake to the downstream extent of the control project at NE 148th Street, where plant density in the river is generally highest closer to the lake. Like other submersed aquatic plants in the river, Brazilian elodea begins growing from overwintered roots in the spring, reaches maximum density in late summer (August to September), and its shoots die-off when water temperature and light decrease during the fall season. Thus, potential effects of Brazilian elodea on river water levels increase during the spring and summer growth periods, and decrease during the fall die-off period.

The primary effect of Brazilian elodea on river water levels is the dense shoot and leaf biomass that obstructs flow, essentially raising the effective river bottom and increasing the channel roughness. Native submersed aquatic plants in the river generally do not attain enough density and biomass to appreciably affect river water levels, and are generally only present near the river banks because they are not strong enough to withstand strong currents near the center of the river channel.

A secondary effect of the dense Brazilian elodea biomass on river water levels is the accumulation of sediment from reduced river currents within the dense plant stands. This effect was apparent by the plant growth and sediment accumulation patterns observed during the removal project. For example, plants were commonly growing on elevated sand bars located in faster currents near the center of the channel and their roots appeared to be buried in over 6 inches of sediment. In addition, overwintered plant roots likely stabilize sediments and reduce sediment erosion during high winter flows. Thus, the plant roots and accumulated sediment remaining in the river following the fall die-off period likely affect river water levels during the winter.

Shoreline residents of Lake Sammamish have observed higher water levels in the lake since the establishment of Brazilian elodea, and it has been suggested that this apparent lake level increase may be due to reduced lake outflow from establishment of dense Brazilian elodea in the Sammamish River. To address these and other concerns, effects of the 2013 Brazilian elodea removal on water levels of the Sammamish River were evaluated. This water level effect evaluation was limited to effects on the river and does not address how Brazilian elodea may have affected lake water levels.

Methods

Effects of the 2013 Brazilian elodea removal on water levels of the Sammamish River were evaluated using river gauging data for the following four sites listed from downstream to upstream (Figure 2):
Figure 2. Sammamish River Monitoring Locations and 2013 Brazilian Elodea Removal Areas.

Legend
- Water level gauge
- Water quality site
- Removal area
- City limit

Citation: USDA, Aerial (2011); King County GIS Center (2013)
• **124th Street (downstream) gauge** located at the upstream side of the NE 124th Street Bridge crossing at RM 4.9 of the Sammamish River. This gauge was installed on July 16, 2012, for this project, and river flow has not been measured at this gauge to develop a rating curve for calculating corresponding river flow rates. Water level data in 15-minute intervals were provided by King County for this evaluation (David Funke, personal communication).

• **116th Street (midstream) gauge** located at the upstream side of the NE 116th Street Bridge crossing at RM 4.3 of the Sammamish River. Water level data have been collected by King County and the US Geological Survey (USGS) at this gauge (King County gauge 51T and USGS gauge 12125200) since it was installed in 2005. Water level data in 15-minute intervals were provided by King County for this evaluation (David Funke, personal communication). Average daily water level and flow data for this gauge were obtained from the King County Hydrologic Information Center. River stage records were converted to water level by subtracting 15.00 feet to match the magnitude of water levels measured at the NE 124th Street and NE 90th Street gauges.

• **90th Street (upstream) gauge** located at the upstream side of the NE 90th Street Bridge crossing at RM 2.7 of the Sammamish River. This gauge was installed on July 16, 2012, for this project and river flow has not been measured at this gauge to develop a rating curve for calculating corresponding river flow rates. Water level data at 15-minute intervals were provided by King County for this evaluation (David Funke, personal communication).

• **Marymoor (headwater) gauge** located adjacent to NE 51st Street at a weir in Marymoor Park at RM 0.6 of the Sammamish River (upstream of Bear Creek and Highway 520). Water level data have been collected by King County at this gauge (site 51M) since it was installed in 1995. Average daily water level and flow data for this gauge were obtained from the King County Hydrologic Information Center. River stage records were converted to water level by subtracting 27.50 feet to match the magnitude of water levels measured at the NE 124th Street and NE 90th Street gauges.

Water levels are equivalent to water depths at the pressure transducer and were not converted to elevation based on the pressure transducer elevation. Water level data received from King County were not reviewed or edited for data quality.

King County also provided flow data for another gauge on the Sammamish River at Highway 520 above Bear Creek and for a gauge located near the mouth of Bear Creek. In addition, precipitation data for a King County rain gauge located in Marymoor Park were obtained from the King County Hydrologic Information Center (http://green.kingcounty.gov/WLR/Waterres/hydrology/default.aspx). Water level data for a removal period (August 4-15, 2013, including a day before and after removal activities) were compared among the gauges in relation to the removal area located downstream of the gauges. In addition, water level data for a control period (August 4-15, 2012) were compared among the gauges to account for temporal differences in the data when there were no removal
activities. Finally, water level and flow data were compared to examine for potential shifts in rating curves due to sediment accumulation.

**Results**

Water levels at the NE 124th Street, NE 116th Street, and NE 90th Street gauges are presented for the period of record in Figure 3. Water levels were very similar at the three gauges, ranging from a low of approximately 1.5 feet at the end of summer (September 2012 and August 2013) and increasing rapidly during storm events. Figure 3 also presents total river flow calculated as the sum of flow at the river gauge below Bear Creek and the stream gauge on Bear Creek. River flow follows the water level pattern, ranging from less than 50 cubic feet per second (cfs) at the end of summer to over 900 cfs during large winter storms. As noted above, water level data presented in this report are equivalent to water depth at the pressure transducer location and do not represent water surface elevation or average water depth across the river channel. Water levels at the NE 124th Street, NE 116th Street, NE 90th Street, and Marymoor gauges are presented in Figure 4 for the 2012 control period and in Figure 5 for the 2013 removal period. Water levels steadily declined at all gauges during the dry control period, but the decline was much greater at the two downstream gauges (NE 124th Street and NE 116th Street) than the two upstream gauges (NE 90th Street and Marymoor). A similar pattern was observed during the 2013 removal period except for a slight increase in water levels downstream of the Marymoor gauge on the weekend between removal activities. This water level increase may have been due to the small amount of rainfall (0.09 inches) that occurred during the weekend. However, river flow increased only 2.8 percent during this period, and water levels also increased at these downstream gauges and not at the Marymoor gauge over several days in August 2012 when no precipitation was recorded (see Figure 4). Thus, the increase in water levels at the downstream gauges may have been due to factors other than precipitation, which may include obstruction of river flow by plant fragments or other debris, or withdrawal of river water for irrigation.

The greatest water level decline occurred at the two downstream gauges (NE 124th Street and NE 116th Street) when the largest amount of Brazilian elodea was removed from below the NE 124th Street gauge on August 12 and 12, 2013 (see Figure 5). These results suggest that the plant removal may have lowered water levels at the downstream gauges (NE 124th Street and NE 116th Street), but not at the upstream gauges (NE 90th Street and Marymoor).

Hydrologic and removal data are summarized in Table 2. Daily mean water levels are compared for each gauge for start (August 4) and end (August 15) of the 2012 control and 2013 removal periods, and the water level change is calculated from start to end of each period. Water levels decreased during each period at all gauges except for a small (0.06 feet) increase at the NE 90th Street gauge during the 2013 control period. The water level decrease was greater in the 2012 control period than the 2013 removal period, likely due to the 0.18 inches of rain during the removal period versus no rain during the control period. The water level decrease was generally greater progressing downstream from the Marymoor gauge (-0.07 feet change for the control period and -0.04 feet change for the removal period) to the NE 124th Street gauge (change of -0.29 feet for the control period and -0.32 feet for the removal period).
Figure 3. Sammamish River Water Levels and Flow from July 2012 to September 2013.
Figure 4. Sammamish River Water Levels in August 2012 (Control).
Figure 5. Sammamish River Water Levels in August 2013 (Removal).
Table 2. Summary of Hydrologic and Brazilian Elodea Removal Data for the Sammamish River in 2012 and 2013.

<table>
<thead>
<tr>
<th>Study Period</th>
<th>2012 Control Period</th>
<th>2013 Removal Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start Date</td>
<td>8/4/2012</td>
<td>8/4/2013</td>
</tr>
<tr>
<td>End Date</td>
<td>8/15/2012</td>
<td>8/15/2013</td>
</tr>
<tr>
<td>Brazilian Elodea Removal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wet mass removed (tons)</td>
<td>–</td>
<td>10.8</td>
</tr>
<tr>
<td>River area removed (acres)</td>
<td>–</td>
<td>3.4</td>
</tr>
<tr>
<td>River length removed (miles)</td>
<td>–</td>
<td>0.51</td>
</tr>
<tr>
<td>Precipitation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total amount (inches)</td>
<td>0.00</td>
<td>0.18</td>
</tr>
<tr>
<td>Number of Days &gt; 0.05 inches</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Marymoor Level (Headwater)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start Water Level (feet)</td>
<td>2.10</td>
<td>1.93</td>
</tr>
<tr>
<td>End Water Level (feet)</td>
<td>2.03</td>
<td>1.89</td>
</tr>
<tr>
<td>Water Level Change (feet)</td>
<td>-0.07</td>
<td>-0.04</td>
</tr>
<tr>
<td>90th Street Level (Upstream)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start Water Level (feet)</td>
<td>2.05</td>
<td>1.82</td>
</tr>
<tr>
<td>End Water Level (feet)</td>
<td>1.88</td>
<td>1.88</td>
</tr>
<tr>
<td>Water Level Change (feet)</td>
<td>-0.17</td>
<td>0.06</td>
</tr>
<tr>
<td>116th Street Level (Midstream)</td>
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</tr>
<tr>
<td>Start Water Level (feet)</td>
<td>1.88</td>
<td>1.84</td>
</tr>
<tr>
<td>End Water Level (feet)</td>
<td>1.61</td>
<td>1.61</td>
</tr>
<tr>
<td>Water Level Change (feet)</td>
<td>-0.27</td>
<td>-0.22</td>
</tr>
<tr>
<td>124th Street Level (Downstream)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start Water Level (feet)</td>
<td>1.97</td>
<td>1.91</td>
</tr>
<tr>
<td>End Water Level (feet)</td>
<td>1.68</td>
<td>1.59</td>
</tr>
<tr>
<td>Water Level Change (feet)</td>
<td>-0.29</td>
<td>-0.32</td>
</tr>
<tr>
<td>Difference in Water Level Change</td>
<td></td>
<td></td>
</tr>
<tr>
<td>116th - 90th Level Change (feet)</td>
<td>-0.10</td>
<td>-0.28</td>
</tr>
<tr>
<td>124th - 90th Level Change (feet)</td>
<td>-0.12</td>
<td>-0.38</td>
</tr>
<tr>
<td>Removal Effect on Water Level(^a)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>116th Street(^b)</td>
<td>–</td>
<td>-0.19</td>
</tr>
<tr>
<td>124th Street(^b)</td>
<td>–</td>
<td>-0.26</td>
</tr>
</tbody>
</table>

\(^a\) Assumes no effect of removal at NE 90th Street

\(^b\) Effect = 2013 - 2012 differences in water level change
As shown in Figure 5 and noted above, no effects of the Brazilian elodea removal were apparent at the NE 90th Street gauge. Therefore, water level changes at the NE 90th Street gauge were subtracted from the NE 116th Street and NE 124th Street gauge changes to account for upstream changes in water level that were not affected by the Brazilian elodea removal. This resulted in an upstream-corrected water level decrease of 0.38 feet at the NE 124th Street gauge and 0.28 feet at the NE 116th Street gauge (see Table 3). To account for the greater decrease in water levels at the downstream gauges (NE 124th Street and NE 116th Street) than the upstream gauge at NE 90th Street, the upstream-corrected change was reduced by subtracting the upstream-corrected water level for the control period from the upstream-corrected water level for the removal period. This resulted in an overall removal effect of decreasing river water level by 0.26 feet at NE 124th Street and 0.19 feet at NE 116th Street.

<table>
<thead>
<tr>
<th>Date</th>
<th>NE 124th Street Level (ft)</th>
<th>NE 116th Street Level (ft)</th>
<th>NE 116th Street Flow (cfs)</th>
<th>NE 90th Street Level (ft)</th>
<th>Marymoor Level (ft)</th>
<th>Marymoor Flow (cfs)</th>
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</thead>
<tbody>
<tr>
<td>August 5-15, 2012</td>
<td>1.84</td>
<td>1.76</td>
<td>79.2</td>
<td>1.98</td>
<td>2.07</td>
<td>43.0</td>
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<tr>
<td>August 5-15, 2013</td>
<td>1.74</td>
<td>1.70</td>
<td>51.1</td>
<td>1.79</td>
<td>1.91</td>
<td>30.3</td>
</tr>
<tr>
<td>Difference</td>
<td>-0.09</td>
<td>-0.06</td>
<td>-28.1</td>
<td>-0.18</td>
<td>-0.16</td>
<td>-12.8</td>
</tr>
</tbody>
</table>

In summary, this water level effects evaluation indicates that removal of 10.8 tons of Brazilian elodea from 3.4 acres, located in 0.5 river miles of a 1.5-mile reach downstream of NE 124th Street, decreased the water level by 0.26 feet at the upper boundary of the removal area in August 2013. A water level decrease of 0.19 feet was estimated to occur 0.6 miles upstream of the removal area at NE 116th Street, and no water level effects were observed 2.2 miles upstream of the removal area at NE 90th Street.
**Water Quality Effects**

Dense growth of invasive aquatic plants such as Brazilian elodea have been shown to alter water chemistry (e.g., dissolved oxygen, pH, and nutrients) in lakes and rivers (Welch and Jacoby 2004). During the summer growth period, plant photosynthesis increases dissolved oxygen and pH during the day, and plant respiration decreases dissolved oxygen and pH during the night. Diel fluctuations in dissolved oxygen and pH have been observed during the summer in the Sammamish River, and were attributed to photosynthesis and respiration of submerged plants and attached algae throughout the river (King County 2005). In addition, plant decay during the late fall/winter senescence period decreases dissolved oxygen and pH.

Rooted submersed plants such as Brazilian elodea primarily obtain their nutrients from sediment and typically release very little nutrients to the surrounding water via excretion during the summer growth period. However, dense submersed plant beds may contribute substantially to internal nutrient loading through decay, and release of plant nutrients to the surrounding water is most pronounced during the winter senescence period (Welch and Jacoby 2004).

Effects of aquatic plants on water temperature have not been well studied. Elevated water temperatures have been observed within dense submersed plant beds in lakes, apparently due to reduced water circulation. Submersed aquatic plants provide a very limited shading effect because infrared light is able to warm the water column.

**Methods**

King County monitored water temperature and dissolved oxygen in the Sammamish River from July through September of 2012 and 2013 for the Brazilian elodea removal project. In addition, King County routinely monitors water temperature and dissolved oxygen at one location in Lake Sammamish. Effects of the 2013 Brazilian elodea removal on water temperature and dissolved oxygen in the Sammamish River were evaluated using continuous water quality monitoring data for the following four sites listed from downstream to upstream (Figure 2):

- **NE 124th Street (downstream) station** located at the upstream side of the NE 124th Street bridge crossing at RM 4.9 of the Sammamish River. A YSI water quality meter was installed at this location on July 3, 2012, by laying the probe on the river bed within moderately dense plant growth until it was removed on September 27, 2012. A YSI water quality meter was installed at this location on July 2, 2013, by anchoring the probe off of the river bed within moderately dense plant growth until it was removed on September 23, 2013. Temperature and dissolved oxygen data in 15-minute intervals were provided by King County for this evaluation (Christopher Barnes, personal communication).

- **NE 90th Street (upstream) station** located at the upstream side of the NE 90th Street bridge crossing at RM 2.7 of the Sammamish River. A YSI water quality meter was
installed at this location on July 3, 2012, by laying the probe on the river bed within dense plant growth until it was removed on September 27, 2012. A YSI water quality meter was not installed at this station in 2013. Temperature and dissolved oxygen data in 15-minute intervals were provided by King County for this evaluation (Christopher Barnes, personal communication).

- **Marymoor (headwater) station** located immediately upstream of NE Marymoor Way at RM 1.0 of the Sammamish River (upstream of Bear Creek and Highway 520, and 0.4 miles downstream of the Marymoor gauge shown in Figure 2). A YSI water quality meter was installed at this location on July 3, 2012, by laying the probe on the river bed within dense plant growth until it was removed on September 27, 2012. However, the probe became exposed to air due to a drop in water level on approximately August 21, 2012, and data collected from then to September 27, 2012, were rejected. A YSI water quality meter was installed at this location on July 2, 2013, by anchoring the probe off of the river bed within dense plant growth until it was removed on September 23, 2013. Temperature and dissolved oxygen data in 15-minute intervals were provided by King County for this evaluation (Christopher Barnes, personal communication).

- **Lake Sammamish (lake) station** located at a monitoring buoy near the center of Lake Sammamish (not shown in Figure 2). A YSI meter moves vertically through the water column collecting data in approximately 2-hour intervals at each 1-meter depth interval (Christopher Barnes, personal communication). Data collected at 1- and 2-meter depths from July through September 2013 were used for this water quality effects analysis.

Water quality data collected in 2012 and 2013 were evaluated to identify potential effects of Brazilian elodea growth in the Sammamish River on temperature and DO. Because the 2013 removal occurred at and below the lower most water quality monitoring station on the river, direct effects of the removal would not be expected to reflect in water quality data.

Water quality data were not collected downstream of the removal area at NE 148th Street because a limited number of water quality meters were available and it was thought that removal would occur upstream of the NE 124th Street station. The monitoring plan submitted with the Joint Aquatic Resources Permit (King County 2013) proposed a different study design that included deployment of two meters located within and outside of one large Brazilian elodea patch for a few days to evaluate localized water quality effects of dense Brazilian elodea growth (Appendix B). The implemented approach of using one meter located at two or three river stations for the entire summer is useful for evaluating overall effects of Brazilian elodea on water quality as the river flows through 3.9 miles of moderate to dense growth of Brazilian elodea.

**Results**

**Water Temperature**

Water quality criteria for temperature are based on the 7-day average of the daily maximum temperatures (7-DADMax) (WAC 173-201A). The temperature criterion for the Sammamish River and Lake Sammamish (Core Summer Salmonid Habitat) is for the 7-DADMax not to
The 7-DADMax was calculated for each water quality monitoring station, and daily values are presented in Figure 6 for 2012 and Figure 7 for 2013. Differences in the 7-DADMax from upstream to downstream stations were calculated and are included in Figures 6 and 7.

The temperature criterion (16°C) was exceeded at all lake and river stations on all days of both summer study periods. The maximum 7-DADMax in the Sammamish River (24°C) occurred at Marymoor in August 2012 and 2013.

In 2012, the 7-DADMax decreased up to 3°C downstream from Marymoor to NE 90th Street, but no appreciable change was observed from NE 90th Street to NE 124th Street (see Figure 6). In 2013, the 7-DADMax decreased up to 2°C downstream from the lake to Marymoor and up to 3°C from Marymoor to NE 124th Street (see Figure 7).

The observed temperature decrease from the lake to Marymoor may have been due to upwelling of ground water in the river headwaters. The observed temperature decrease from Marymoor to 90th Street in 2012 and to NE 124th Street in 2013 was likely due to the inflow of cooler waters from Bear Creek. Bear Creek flow comprised between 35 and 80 percent of the Sammamish River flow during the 2013 summer study period. The similar maximum temperatures at NE 90th Street and NE 124th Street in 2013 suggests there were no effects from either groundwater inflow or Brazilian elodea between these river stations. Removal of Brazilian elodea in the vicinity of the 124th Street station in August 2013 had no apparent effect on river temperature (see Figure 7). These results suggest that Brazilian elodea removal from the Sammamish River would not affect water temperature.

**Dissolved Oxygen**

Water quality criteria for dissolved oxygen based on the 1-day minimum concentration of dissolved oxygen (WAC 173-201A). The dissolved oxygen (DO) criterion for the Sammamish River and Lake Sammamish (Core Summer Salmonid Habitat) is for the 1-day minimum not to exceed 9.5 mg/L. The 1-day minimum DO concentration was calculated for each water quality monitoring station, and daily values are presented in Figure 8 for 2012 and Figure 9 for 2013. Differences in the minimum DO concentrations from upstream to downstream stations were calculated and are included in Figures 8 and 9. In addition, daily minimum DO values for percent saturation of dissolved oxygen are presented in Figure 10 for 2013.

The dissolved oxygen criterion (9.5 mg/L) was not met at any river station on any day of either summer study period, but was generally within 0.5 mg/L of the criterion in Lake Sammamish for the entire summer period in 2013.

Minimum DO concentrations in the river generally decreased as the summer progressed. A dramatic decrease and highly variable DO concentrations were observed in 2012, apparently due to the accumulation of sediment on the meter probes resting on the river bottom, as noted by monitoring staff (Christopher Barnes, personal communication). However, DO concentrations were relatively stable during the first week of monitoring in 2012. During this first week, minimum DO concentrations decreased approximately 1 mg/L from Marymoor to NE 90th Street and 1 mg/L from NE 90th Street to NE 124th Street. While the decrease downstream of Marymoor may have been due to Bear Creek inflow, the decrease observed
Figure 6. Comparison of 7-DADMmax Temperature in the Sammamish River at Marymoor Park (MP), NE 90th Street, and NE 124th Street Stations, July-September 2012.
Figure 7. Comparison of 7-DADMax Temperature in Lake Sammamish to the Sammamish River at Marymoor Park (MP) and NE 124th Street Stations, July-September 2013.
Figure 8. Comparison of 1-day Minimum Dissolved Oxygen in the Sammamish River at Marymoor Park (MP), NE 90th Street, and NE 124th Street Stations, July-September 2012.
Figure 9. Comparison of 1-day Minimum Dissolved Oxygen in Lake Sammamish to the Sammamish River at Marymoor Park (MP) and NE 124th Street Stations, July-September 2013.
Figure 10. Comparison of 1-day Minimum Dissolved Oxygen Saturation in Lake Sammamish to the Sammamish River at Marymoor Park (MP) and NE 124th Street Stations, July-September 2013.
downstream of NE 90th Street suggests may have been due to aquatic plant respiration/decay or sediment oxygen demand.

In 2013, DO concentrations decreased up to 5 mg/L from the lake to the river at Marymoor, but generally did not vary more than 1.5 mg/L between Marymoor and NE 124th Street. During Brazilian elodea removal in August 2013, minimum DO concentrations decreased approximately 1 mg/L from Marymoor to NE 124th Street. Removal of Brazilian elodea in the vicinity of the NE 124th Street station in August 2013 had no apparent effect on river DO (see Figure 9).

DO saturation ranged from 100 to 120 percent at the surface of Lake Sammamish during the summer of 2013 (see Figure 10), and this super-saturation of DO was likely due to oxygen production by phytoplankton photosynthesis in the lake surface waters. DO saturation was much lower in the Sammamish River, generally ranging from 60 to 80 percent. DO saturation decreased about 15 percent downstream from Marymoor to NE 124th Street in early July and again in September, but increased about 10 percent downstream in August. Considering the relatively consistent difference in maximum water temperatures between river stations and the lack of rainfall in August 2013, the downstream decrease in DO saturation in August 2013 suggests a possible input of DO from Bear Creek.

These results suggest that decay of Brazilian elodea in the Sammamish River did not decrease the minimum DO concentration during the summer, and its removal would not increase the minimum DO concentration in the river during the summer. However, river DO concentrations may have decreased during plant senescence, which would have occurred after DO monitoring was terminated in September. Therefore, it is recommended that dissolved oxygen monitoring be continued into December to evaluate the potential effects of plant senescence on river DO.
CONCLUSIONS

Brazilian Elodea Removal

Brazilian elodea was removed from the Sammamish River over a period of 7 days from August 5-14, 2013. Herrera divers and snorkelers removed Brazilian elodea by pulling the plants out by the roots, or by first removing the shoots and then grubbing the roots. Brazilian elodea biomass was netted or placed on a small boat, and dragged to shore. Working from the shore, Washington Conservation Corps (WCC) crews took the Brazilian elodea biomass from the river to dump containers. WCC crews also raked Brazilian elodea biomass that was reachable from the shore.

A total of 10.8 tons of Brazilian elodea was removed in 7 days from 3.4 acres, located in 0.5 river miles of a 1.5-mile reach between NE 124th Street and NE 148th Street. Average daily removal rates were equivalent to 1.5 tons/day, 0.5 acres/day, and 0.072 river miles/day (380 river feet/day). Applying this average removal rate over the 5.7-mile project area, suggests that it require approximately 80 days to remove Brazilian elodea from the entire river reach between the wier in Marymoor Park and NE 148th Street using four divers, two snorkelers, and a shore disposal crew.

Water Level Effects

The primary effect of Brazilian elodea on river water levels is the dense shoot and leaf biomass that obstructs flow, essentially raising the effective river bottom and increasing the channel roughness. Native submersed aquatic plants in the river generally do not attain enough density and biomass to appreciably affect river water levels, and are generally only present near the river banks because they are not strong enough to withstand strong currents near the center of the river channel.

A secondary effect of the dense Brazilian elodea biomass on river water levels is the accumulation of sediment from reduced river currents within the dense plant stands. This effect was apparent by the plant growth and sediment accumulation patterns observed during the removal project. For example, plants were commonly growing on elevated sand bars located in faster currents near the center of the channel and their roots appeared to be buried in over 6 inches of sediment. In addition, overwintered plant roots likely stabilize sediments and reduce sediment erosion during high winter flows. Thus, the plant roots and accumulated sediment remaining in the river following the fall die-off period likely affect river water levels during the winter.

Effects of the 2013 Brazilian elodea removal on water levels of the Sammamish River were evaluated using river gauging data for the following four sites listed from upstream to downstream: Marymoor Park, NE 90th Street, NE 116th Street, and NE 124th Street. Water level data for a removal period (August 4-15, 2013, including a day before and after removal activities) were compared among the gauges in relation to the removal area located
downstream of the gauges. In addition, water level data for a control period (August 4-15, 2012) were compared among the gauges to account for temporal differences in the data when there were no removal activities. Finally, water level and flow data were compared to examine for potential shifts in rating curves due to sediment accumulation.

Water levels steadily declined at all gauges during the dry control period, but the decline was much greater at the two downstream gauges (NE 124th Street and NE 116th Street) than the two upstream gauges (NE 90th Street and Marymoor). A similar pattern was observed during the 2013 removal period except for a slight increase in water levels downstream of the Marymoor gauge on the weekend between removal activities. This water level increase may have been due to the small amount of rainfall (0.09 inches) that occurred during the weekend. However, river flow increased only 2.8 percent during this period, and water levels also increased at these downstream gauges and not at the Marymoor gauge over several days in August 2012 when no precipitation was recorded (see Figure 4). Thus, the increase in water levels at the downstream gauges may have been due to factors other than precipitation, which may include obstruction of river flow by plant fragments or other debris, or withdrawal of river water for irrigation.

Daily mean water levels were compared for each gauge for start (August 4) and end (August 15) of the 2012 control and 2013 removal periods, and the water level change was calculated from start to end of each period. Because no water level effects of the Brazilian elodea removal were apparent at the NE 90th Street gauge, water level changes at the 90th Street gauge were subtracted from the NE 116th Street and NE 124th Street gauge changes to account for upstream changes in water level that were not affected by the Brazilian elodea removal. To account for the greater decrease in water levels at the downstream gauges (NE 124th Street and NE 116th Street) than the upstream gauge at NE 90th Street, the upstream-corrected change was reduced by subtracting the upstream-corrected water level for the control period from the upstream-corrected water level for the removal period.

The water level effects evaluation showed that removal of 10.8 tons of Brazilian elodea from 3.4 acres, located in 0.5 river miles of a 1.5-mile reach downstream of NE 124th Street, decreased the water level by 0.26 feet at the upper boundary of the removal area at NE 124th Street in August 2013. A water level decrease of 0.19 feet was estimated to occur 0.6 miles upstream of the removal area at NE 116th Street, and no water level effects were observed 2.2 miles upstream of the removal area at NE 90th Street.

**Water Quality Effects**

Dense growth of invasive aquatic plants such as Brazilian elodea have been shown to alter water chemistry (e.g., dissolved oxygen, pH, and nutrients) in lakes and rivers. Diel fluctuations in dissolved oxygen and pH have been observed during the summer in the Sammamish River, and were attributed to photosynthesis and respiration of submerged plants and attached algae throughout the river.

King County monitored water temperature and dissolved oxygen in the Sammamish River from July through September of 2012 and 2013 for the Brazilian elodea removal project at the following three sites listed from upstream to downstream: Marymoor Park, NE 90th Street...
Water quality data collected in 2012 and 2013 were evaluated to identify potential effects of Brazilian elodea growth in the Sammamish River on temperature and DO. Because the 2013 removal occurred at and below the lower most water quality monitoring station on the river, direct effects of the removal would not be expected to reflect in water quality data. Water quality data were not collected downstream of the removal area at NE 148th Street because a limited number of water quality meters were available and it was thought that removal would occur upstream of the NE 124th Street station. Therefore, the collected data were used to evaluate overall effects of Brazilian elodea on water quality as the river flows through 3.9 miles of moderate to dense growth of Brazilian elodea.

Water temperature decreased from the lake to Marymoor Park, possibly due to upwelling of ground water in the river headwaters. Water temperature decreased from Marymoor Park to NE 90th Street in 2012 and to NE 124th Street in 2013, likely due to the inflow of cooler waters from Bear Creek. Maximum temperatures were similar at NE 90th Street and NE 124th Street in 2013, which suggests there were no effects from either groundwater inflow or Brazilian elodea between these river stations. Removal of Brazilian elodea in the vicinity of the NE 124th Street station in August 2013 had no apparent effect on river temperature. These results suggest that Brazilian elodea removal from the Sammamish River would not affect water temperature.

Minimum dissolved oxygen (DO) concentrations in the river generally decreased as the summer progressed. A dramatic decrease and highly variable DO concentrations were observed in 2012, apparently due to the accumulation of sediment on the meter probes resting on the river bottom. However, DO concentrations were relatively stable during the first week of monitoring in 2012. During this first week, minimum DO concentrations decreased approximately 1 mg/L from Marymoor to NE 90th Street and 1 mg/L from NE 90th Street to NE 124th Street. While the decrease downstream of Marymoor may have been due to Bear Creek inflow, the decrease observed downstream of NE 90th Street suggests may have been due to aquatic plant respiration/decay or sediment oxygen demand.

In 2013, DO concentrations decreased up to 5 mg/L from the lake to the river at Marymoor, but generally did not vary more than 1.5 mg/L between Marymoor and NE 124th Street. During Brazilian elodea removal in August 2013, minimum DO concentrations decreased approximately 1 mg/L from Marymoor to NE 124th Street. Removal of Brazilian elodea in the vicinity of the NE 124th Street station in August 2013 had no apparent effect on river temperature (see Figure 9).

The study results suggest that decay of Brazilian elodea in the Sammamish River did not decrease the minimum DO concentration during the summer and, therefore, its removal would not increase the minimum DO concentration in the river during the summer. However, river DO concentrations may have decreased during plant senescence, which would have occurred after DO monitoring was terminated in September. DO monitoring would need to be conducted downstream of a large removal area to adequately evaluate immediate effects of the removal on river DO, and monitoring would need to be continued into December to evaluate the potential effects of plant senescence on river DO.
**Recommendations**

If Brazilian elodea is removed in the future to potentially reduce Sammamish River water levels and/or increase minimum dissolved oxygen concentrations, then removal procedures should be modified to increase removal efficiency and effectiveness. Future removal procedures should be based on lessons learned from the Chehalis River Brazilian Elodea Removal Project (Thurston County 2013).

The Chehalis River project began with diver hand removal in 1999 and changed to diver suction dredging in 2004 due to the extensive amount of plants and the relatively poor effectiveness of diver hand removal. Effectiveness of diver suction dredging dramatically improved in 2005 and subsequent regrowth was substantially reduced when the method was modified to include removal of roots below the point of the double node, which is the root crown of previous year growth located below the root crown of the current year growth. Brazilian elodea removal amounts peaked at 53 tons from 9.4 acres in 2007 and declined each following year to a low of 0.4 tons from approximately 2.8 acres in 2012. Due to the success of the modified diver suction dredging method, only diver hand removal has been necessary to remove Brazilian elodea from 34 river miles in 2011 through 2013 (Thurston County 2013).

Diver suction dredging is more efficient than hand removal in dense plant areas because divers or snorkelers do not spend time transporting plant material to a boat or shore. For example, daily removal rates estimated for the Chehalis River project increased from 100 pounds/day using hand removal, to 1,000 pounds/day using a small (2-inch) suction dredge, and to 4,000 pounds/day using a large (4-inch) suction dredge (Rick Johnson, Thurston County Noxious Weed Control Coordinator, personal communication).

Diver suction dredging of the Sammamish River should progress at a faster rate with fewer staff than was achieved using diver hand removal in 2013. Removal rates would vary directly with the size of suction dredge and efficiency of material transport. Using four divers and a three-person shore crew, it is estimated that approximately 20 to 40 days (4 to 8 weeks) would be required to remove Brazilian elodea from the entire 5.7-mile river reach between the weir in Marymoor Park and NE 148th Street. Removal would likely be needed once every few years to meet water level and quality objectives based on the anticipated increase in Brazilian elodea density from upstream plant introduction and existing plant regrowth.

Methods for transporting plant material from the dredging barge to a hauling container on shore should be investigated to further increase efficiency of diver suction dredging of Brazilian elodea in the Sammamish River. Use of a shore crane would greatly increase the efficiency of material transport, as was achieved for the Chehalis River project (Rick Johnson, Thurston County Noxious Weed Control Coordinator, personal communication).

A removal plan should be prepared that specifies detailed procedures for Brazilian elodea removal and disposal, and for water level and water quality impacts assessment. Quantitative aquatic plant mapping should be conducted in the removal area before and after each
removal season. Spatial coverage of each plant species and the relative plant density should be accurately mapped.

Water level and water quality monitoring methods should be modified to generally follow those originally proposed for the pilot project and submitted with the project permit (see Appendix B). The pilot project experimental design is based on a before-after analysis of control (no removal) and impact (removal) sites:

- Water level monitoring was to be conducted year-round at five impact sites in Marymoor Park (between the lake outlet and Bear Creek) and four downstream control sites (between 1 and 2 miles downstream of NE 145th Street).
- Therimster chains were proposed to measure water temperature year-round at two depths (bottom and mid-depth) at three locations in high density plants and three locations in low density plants.
- Dissolved oxygen sondes were to be deployed for a few days at one location within a large plant patch and at one location outside a large plant patch.

It is recommended that monitoring procedures proposed for the pilot project be modified to include:

- Water level and water quality monitoring for one calendar year before removal through December of the removal year
- Water level monitoring using one pressure transducer at each of five impact sites located between the lake and NE 148th Street (e.g., lake outlet upstream of the wier in Marymoor Park, between the wier and Bear Creek, NE 90th Street, NE 116th Street, and NE 148th Street) and at two control sites located between 1 and 2 miles downstream of NE 145th Street
- Water quality monitoring of temperature and dissolved oxygen using two multi-meter sondes (positioned approximately 1 foot above the river bottom near the center of dense plant growth and near the center of an adjacent area with no plant growth) at each of three impact sites (e.g., NE 90th Street, NE 116th Street, and NE 148th Street) and one control site located between 1 and 2 miles downstream of NE 145th Street.
REFERENCES


King County. 2013. Washington State Joint Aquatic Resources Permit Application (JARPA) Form, Sammamish River Transition Zone Reed Canarygrass and Sediment Maintenance. King County Department of Natural Resources and Parks, Water and Land Resources Division, Science Section, Seattle, Washington. Submitted to the Washington State Department of Ecology on July 8, 2013.


APPENDIX A

Photographic Documentation
# Sammamish River Brazilian Elodea Removal Photographic Log

<table>
<thead>
<tr>
<th>Photo Number</th>
<th>Photo Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Condition near the NE 145th St. Bridge showing Brazilian elodea growing intermixed with giant burred.</td>
</tr>
<tr>
<td>2</td>
<td>Underwater view of river substrate following initial removal. Shown are root fragments to be cleaned out by divers.</td>
</tr>
<tr>
<td>3</td>
<td>Conditions in August 7 removal location (mid-point between NE 145th and 124th St. bridges). Shown is dense Brazilian elodea in channel and along banks.</td>
</tr>
<tr>
<td>4</td>
<td>Post-removal conditions on August 7. Shown is a cleared channel and banks, with native Elodea retained along left (west) bank.</td>
</tr>
<tr>
<td>5</td>
<td>Container filling with elodea (again) by noon on August 13.</td>
</tr>
<tr>
<td>6</td>
<td>Post-removal on August 14 showing prioritized clearing of channel.</td>
</tr>
<tr>
<td>7</td>
<td>Boats filled with Brazilian elodea on August 14. NE 124th Street Bridge is evident in background.</td>
</tr>
<tr>
<td>8</td>
<td>View downstream from NE 124th Street Bridge showing removal of elodea from center of channel on August 14.</td>
</tr>
</tbody>
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APPENDIX B

King County Water Monitoring Plan for the Sammamish River
Problem
Brazilian elodea is an invasive aquatic weed that appears to be rapidly colonizing the upper reaches of the Sammamish River. The weed is known to impede river flow, induce sedimentation, create fish passage barriers, and create water quality problems such as reduced dissolved oxygen and increased water temperatures. Developing a strategy for managing Brazilian elodea has become a priority for King County due to the potential that it may be involved in a trend of increasing water surface elevations on Lake Sammamish and the possibility that it could exacerbate a known thermal barrier issue to salmon migration up the Sammamish River. Because there is a substantial elodea infestation in Lake Sammamish the goal of an elodea maintenance program would be control rather than eradication.

Proposal
King County proposes to conduct an experiment to test the efficacy of Brazilian elodea removal for reducing Sammamish Lake surface water elevation during high to moderate flows as well as improving water quality along the Sammamish River.

Experiment Design
The experiment is a before-after design to include collection of data on flood and water quality parameters in an experimental reach before and after physical removal of Brazilian elodea. The purpose of the study is to gather empirical information on the effectiveness of elodea control for improving flood conveyance and water quality. The experiment will be completed between spring 2012 and spring 2014.

Activities
1. Experiment Establishment

   A. Map Elodea Patches in Treatment Area. King County Noxious Weeds staff have collected linear data on the presence and percent cover of elodea along the Sammamish River (Fig 1). These maps identify where large patches of elodea are found, but do not provide information on the areal extent of the patches. This mapping activity includes field survey and GIS polygon development for all large patches of elodea, large defined as those blocking more than 25% of the cross-sectional channel area in the treatment reach. The treatment reach is defined as the 5.7 miles from the Sammamish River weir in the transition zone near the outlet of Lake Sammamish to the 145th Street Bridge crossing. Elodea patch mapping will occur in June and July 2013 after significant growth of elodea patches.

   B. Identify Sites and Deploy Pressure Transducers and Thermistor Chains.

      i. Submersible Pressure Transducers
      Submersible pressure transducers will be deployed in order to detect changes in water depth at a variety of river flows before and after Brazilian elodea removal. The information collected from the transducers will be used to determine whether or not the effect of the removal of the largest patches of elodea in the experimental reach propagates a water surface elevation affect upstream as far as Lake Sammamish. Transducers will be deployed in winter 2012. Transducer locations will be surveyed to determine depth of placement and to aid in relocation.
1. Experimental Reach
Five continuous logging submersible pressure transducers will be deployed between the Lake Sammamish outlet and the confluence of the Sammamish River and Bear Creek.

2. Control Reach
Four continuous logging submersible pressure transducer devices will be deployed between one and two miles downstream of the 145th St. bridge crossing. Two will be deployed immediately upstream of sites with known elodea infestations and two at sites known to be free of elodea. These transducers will serve as a control to help analysts better understand if the scale of any changes in depth observed in the experimental reach are related to reduction in a backwater effect due to elodea removal or if they are related to river system-wide hydrologic changes in the seasons of measurement.

ii. Thermistor Chains
Thermistor chains, capable of taking continuous measurement of temperature at the stream bed and mid-water column will be deployed in order to detect changes in diurnal water temperature before and after Brazilian elodea removal. The information collected from the thermistors will be used to determine whether or not elodea is contributing to water quality problems that affect migrating and resident fish in the Sammamish River.

1. Experimental Reach

Year-Round Data Collection Devices
Six thermistor chains will be placed in the experimental reach in spring 2012 in order track seasonal changes of water temperature. Three thermistor chains will be placed outside of elodea patches in two different reach types classified by low and high areas of Brazilian elodea infestation:

- Low level infestation site: between Bear Creek and NE 90th St.
- High level infestation site: between NE 124th St. and NE 145th St.

Pre/Post Removal Data Collection Devices
Following elodea patch mapping in July 2012, six additional thermistor chains will be deployed for a short period of time to measure the direct effect of elodea removal on water temperature. Three devices will be placed within elodea patches in the low and three in the high areas of infestation as defined above.

C. Dissolved Oxygen Sondes
Aquatic weed infestations have been observed to create dissolved oxygen problems in low flow, deep water stream environments. The experimental team assumes there is enough flow through and around patches of elodea in the shallow water of Lake Sammamish that dissolved oxygen is not an issue, so a full experiment to measure a potential DO problem...
will not be deployed. Instead, two DO sondes will be deployed to measure diurnal DO for a few days within and outside of one large elodea patches to confirm that this water quality parameter is not affected by the weeds.

2. **Data Collection**
   
   A. **Transducer Data.** Pressure transducer data will be downloaded to a field laptop and imported onto a King County server monthly. During data collection events stage and flow will be measured at gauges on Lake Sammamish and in the Sammamish River in the project area.
   
   B. **Thermistor Chain Data.** Thermistor chain data will be downloaded to a field laptop and imported to a King County server monthly.

3. **Elodea Removal**
   
   A snorkel dive crew will remove identified patches of elodea within the 5.7 mile treatment reach. Treatment will occur no later than August 12th, 2013. The diver crew will prioritize removal sites under the supervision of the project manager based on the likelihood of a patch affecting lake elevations. The prioritization of patch removal will be to start with the largest patches of elodea, particularly those that span the entire channel, moving to the smallest patches of elodea. Patch removal will start at the downstream end of the experimental reach at NE 145th St. moving towards Lake Sammamish.

4. **Re-growth Rate Data Collection**
   
   All patches identified in 1A will be remapped in July 2014 to determine the efficacy of the dredge diver removal process and help understand the long term maintenance necessary to control elodea on the Sammamish River.

Analysis

5. **Modeling**
   
   A sensitivity analysis was conducted in spring 2011 using an NHC model to estimate the potential for elodea removal to affect Lake Sammamish water surface elevation. The sensitivity analysis suggested that removal of large patches of elodea could reduce water surface elevations during spring flows by up to 6 inches.

6. **Pressure Transducer Data**
   
   Depth of water in treatment and control reaches will be compared pre- and post-elodea removal and discussed in the context of seasonal variability.

7. **Gauge Data**
   
   Lake and River water surface elevations will be compared pre and post elodea removal and evaluated in the context of seasonal variability and pressure transducer data analysis results. This data will also be evaluated in the context of the results of the Modeling exercise above to determine if the model accurately predicted potential changes in water surface elevations.

8. **Habitat Data**
   
   Temperature data pre and post elodea removal will be compared between treatment and control reaches and considered in the context of existing literature identifying water quality
issues for migrating and resident fish in the Sammamish River. Dissolved oxygen data in and outside of elodea patches will be compared.

9. Reporting
A final written report to include the experimental design, methods, data, maps, analysis and conclusions will be generated. The report will be delivered in the format of two CDs and two hard copies. All data will be provided in readily accessible electronic formats to include MS Excel spreadsheets and an ArcGIS Geodatabase.
## 2012 Sammamish River Brazilian Elodea Removal Experiment Budget

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<th>Task</th>
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