2003 – 2004 ATTAINMENT OF PROPOSED WATER QUALITY OBJECTIVES FOR RUSSELL, HASCHEAK AND McDOUGALL CREEKS, AND TURBIDITY MONITORING ON LONE, BESTER, RENNIE AND AXEL CREEKS.

Prepared for:
Weyerhaeuser Canada Ltd. – Vavenby Division
and
B.C. Ministry of Environment, Lands and Parks

Prepared by:
Burke Phippen
BWP Consulting

April 21, 2004
# Table of Contents

Table of Contents.......................................................................................................................... i
List of Figures and Tables............................................................................................................... ii
1.0 Introduction............................................................................................................................. 1
2.0 Watershed Profiles................................................................................................................... 2
   2.1 Russell Creek .................................................................................................................. 2
   2.2 Hascheak Creek ............................................................................................................ 4
   2.3 McDougall Creek .......................................................................................................... 6
   2.4 Lone, Bester, Rennie and Axel creeks ......................................................................... 7
3.0 Methods................................................................................................................................... 7
   3.1 Discrete Sampling.......................................................................................................... 7
   3.2 Inventory Staff ............................................................................................................. 8
4.0 Proposed Water Quality Objectives ...................................................................................... 8
5.0 Discussion............................................................................................................................... 13
   5.1 Temperature ............................................................................................................... 13
   5.2 pH............................................................................................................................. 14
   5.3 Turbidity .................................................................................................................... 14
   5.4 Colour ......................................................................................................................... 14
   5.5 Total Suspended Solids and Total Dissolved Solids..................................................... 14
   5.4 Specific conductivity ................................................................................................. 15
   5.5 Nutrients..................................................................................................................... 15
   5.6 Fecal Coliforms ........................................................................................................ 16
   5.7 Turbidity values in Lone, Bester, Rennie and Axel creeks........................................ 17
6.0 Summary of Water Quality Objectives Attainment and CCME Water Quality Index
   Rankings................................................................................................................................. 18
   6.1 Russell Creek .............................................................................................................. 18
   6.2 Hascheak Creek ........................................................................................................ 18
   6.3 McDougall Creek ...................................................................................................... 19
7.0 Management Recommendations............................................................................................. 20
Literature Cited............................................................................................................................ 21
Figure 1. Points of diversion and sampling locations on Russell, Hascheak and McDougall creeks. ................................................................................................................................. 3

Table 1. Summary of water quality data collected at Site E223247, Russell Creek Upstream. ................................................................................................................................. 11
Table 2. Summary of water quality data collected at Site E223248, Russell Creek above Reservoir. ................................................................................................................................. 11
Table 3. Summary of water quality data collected at Site E223249, Hascheak Creek above Reservoir. ................................................................................................................................. 12
Table 4. Summary of water quality data collected at Site E223250, Hascheak Creek above Diversion. ................................................................................................................................. 12
Table 5. Summary of water quality data collected at Site E223252, McDougall Creek above Diversion. ................................................................................................................................. 13
Table 6. Summary of turbidity and temperature data collected at East Blackpool sites. 13
Table 8. 90th percentile values for bacteriological data collected at the five sampling sites. ................................................................................................................................. 17
1.0 **INTRODUCTION**

In 1996 the Ministry of Environment, Lands and Parks initiated water quality and water quantity monitoring projects on the Clearwater Community Watershed, located in the North Thompson, with the objectives of:

1. collecting background water quality and quantity data;
2. establishing water quality objectives to protect various existing water uses;
3. and monitoring for potential future impacts caused by logging activities.

The Clearwater Community Watershed consists of three sub-basins: Russell, Hascheak and McDougall creeks. Water from these three creeks is diverted into the Clearwater Reservoir, and supplies the community of Clearwater with approximately half of its total volume of drinking water (the remaining drinking water requirements are met by underground wells). In each of these watersheds, monitoring sites were established for the collection of water samples and staff gauges were installed to determine flow levels and generate discharge curves. In addition to these discrete sampling locations, an automated water quality monitoring station (measuring turbidity, specific conductivity, temperature and water level) was established on Russell Creek in November of 1997 in order to collect continuous water quality and hydrometric data, and calculate total discharge.

In June 1999, Weyerhaeuser Canada – Vavenby Division, with funding from Forest Renewal BC, began conducting water quality monitoring on four creeks (Lone, Bester, Rennie and Axel) located south-west of the Russell Creek watershed. Although these creeks are not designated community watersheds, there are a number of water licenses on both Axel and Lone creeks for domestic and irrigation use, and water is also diverted from both Bester and Rennie creeks for these purposes.

During the 1996-97 season, water quality monitoring was carried out by the Ministry of Environment in Kamloops. In 1997-98, the project was turned over to Weyerhaeuser Canada Limited, as they hold the timber harvesting rights to the Russell Creek watershed. Weyerhaeuser agreed to oversee the implementation of the monitoring contract for
Russell, Hascheak and McDougall Creeks. In 1998-99, the project was transferred to Slocan Forest Products – Vavenby Division, as they were the primary timber licensee in the Hascheak and McDougall watersheds. From 1999 to the present (2004), Weyerhaeuser Canada, Vavenby Division once again agreed to oversee the monitoring contract. This report provides a summary of the water quality monitoring completed by BWP Consulting for the period between April 1 2003 and March 31 2004, and compares results with water quality objectives proposed in the 2002 draft Water Quality Objectives (WQO) report (Phippen, 2002). It is important to note that these objectives are not yet formal Ministry of Water, Land and Air Protection policy as the acceptance process for forestry-related WQO reports is still under review. Funding for the water quality monitoring conducted in 2003-04 was provided by the Forest Investment Account (FIA).

2.0 WATERSHED PROFILES

2.1 RUSSELL CREEK
Russell Creek is located south of Clearwater, B.C. on the south side of the North Thompson River. It is designated a community watershed under the Forest Practices Code Section 41(8), and has provided drinking water for the community of Clearwater, B.C. since 1976. The drinking water license (#37465) held by the Clearwater Improvement District allows for the diversion of up to 200,000 gallons of water per day (331.9 dam$^3$/yr) all year from the combined flow of Russell and Hascheak Creeks.

The Russell Creek watershed is 18.822 km$^2$ in area and the stream itself is 49.72 km in length. It is bordered on the northeast by the Hascheak Creek watershed and by the McDougall Creek watershed to the southeast, and ranges in elevation from 1858 m on Foghorn Mountain to 512 m near the North Thompson River. It flows into Hascheak Creek a few meters downstream of the Clearwater reservoir (Figure 1). This drainage contains numerous biogeoclimatic zones including Interior Douglas-fir (IDF), Interior Cedar Hemlock (ICH), Montane Spruce (MS), and Engelmann Spruce-Subalpine Fir (ESSF). Historically, logging in this watershed has been mainly by selective logging by Slocan Forest Products and the Ministry of Forests. The current licensee is Weyerhaeuser Canada – Vavenby Division.
Figure 1. Points of diversion and sampling locations on Russell, Hascheak and McDougall creeks.
The current ECA in the Russell Creek watershed (as of the fall of 2000) is 10.2%. This is scheduled to increase to 11.9% by the fall of 2004. There are no landslides in this watershed, and the hazard for future slides occurring is low since most of the terrain is classified as stable. There are currently 18.14 km of existing roads within the watershed, with another 0.85 km of road construction proposed within the next four years. This will result in a road density of 1.07 km of road per square kilometer of watershed area, which is considered low. There are also 21 stream crossings, with no additional crossings proposed within the next four years, resulting in a density of 1.19 crossings per square kilometer of watershed area.

There are no active range tenures in the Russell Creek watershed, and although there is a mineral claim, there is no active mining. The watershed has been given a low fisheries priority (although there is a trout population in the stream), and has been determined to have a moderate capacity to sustain moose and deer populations. There has also been a trapping license (License Number 0338T001) issued for the Russell Creek watershed, but it is not known whether this license is active.

Water quality is currently sampled at two sites on Russell Creek. The upstream site is located just upstream of the bridge at 15 km on the East Blackpool (also called 1100) Forest Service Road (EMS site E223247), while the downstream site is located approximately 15 meters upstream of the Clearwater community reservoir (EMS site E223248).

2.2 Hascheak Creek

Hascheak Creek is also located south of the community of Clearwater on the south side of the Thompson River and is a designated community watershed under the Forest Practices Code Section 41(8). It is included in the same community water source license as Russell Creek (License 37465) which allows 200,000 gallons of water per day (331.9 dam$^3$/yr) to be diverted from these two streams. There are two other licenses held by the Clearwater Improvement District (#281962, and 270502). The first is for irrigation with a volume of 80 acre-feet per annum (98.7 dam$^3$/yr), and the second for domestic uses and flooding a skating rink at the Clearwater Ski Lodge (5000 gallons per day or 8.3
A final license (#3003316) is held by the Clearwater Ski Club for making snow (10 acre-feet per year, or 12.3 dam$^3$/yr).

The Hascheak Creek watershed is 6.061 km$^2$ in area and this first order stream is 12.12 km long. It is bordered by the Russell Creek watershed to the west and McDougall Creek to the east, and ranges in elevation from 1387 m at the top of the watershed to 512 m at the North Thompson River. This drainage also contains the IDF, ICH, MS, and ESSF biogeoclimatic zones.

Weyerhaeuser Canada – Vavenby Division has plans to increase the current ECA of 13.1% to a total of 24.2% by the fall of 2004. The road density will also increase significantly during that period, from the current 2.86 km/km$^2$ to a total of 4.07 km/km$^2$. Finally, the number of stream crossings will also increase by 2004, from the existing 2.81 km/km$^2$ to a density of 4.14 km/km$^2$. There are no landslides in this drainage and there is a low hazard rating for future slides.

Grazing in the watershed is confined to the Clearwater Ski Hill from May 15 to August 31. There are no fisheries priorities designated for this stream, and in terms of wildlife there is a moderate capability to sustain deer and moose populations. As with Russell Creek, both a trapping license and a mineral claim have been issued, but there is no active mining, and trapping activity is unknown.

The Historical Streamflow Summary of British Columbia shows that maximum discharges in Hascheak Creek usually occur in early- to mid- May, and minimums occur in early January. The mean annual discharge was 1,110 dam$^3$ between the years of 1970-1975.

Water quality is sampled at two sites in this watershed. The first sampling location is located upstream of the confluence of Hascheak Creek with the McDougall Creek diversion (EMS site E223250), and the second location is about 10 metres upstream from the Clearwater reservoir (EMS site E223249) (Fig. 1).
2.3 McDougall Creek

McDougall Creek is the third community watershed sampled in the Clearwater area. It is also located south of Clearwater on the south side of the Thompson River. It is the third creek affected under the Clearwater Improvements Districts’ water use license #37465 and 200,000 gallons per day (331.9 dam$^3$/yr) may be diverted from this creek to Hascheak Creek (Fig. 1). The total volume for this license is 400,000 gallons per day, consisting of 200,000 gallons from Hascheak and Russell creeks and 200,000 gallons from McDougall Creek.

The McDougall Creek watershed is bordered on the west by the Russell and Hascheak creek watersheds, and to the east by the Upper Joseph Creek watershed. This drainage is 17.263 km$^2$ in size, and McDougall Creek is a 3rd order stream 20.1 km in length. The watershed ranges from 2,017 m to 826 m in elevation. The biogeoclimatic zones in this watershed are ICH, MS, and ESSF.

In the 1980s some timber harvesting was conducted near the headwaters, but there has been little logging activity in the recent past. The current ECA in the McDougall Creek watershed is 13.4%, and this is scheduled to increase to 17.3% by the fall of 2004. There are currently 19.94 km of existing road within the watershed, and this will increase by 3.39 km by the fall of 2004. The resulting road density will be 1.46 km/km$^2$. The number of stream crossings will increase from 10 to 11 by 2004, with a resulting density of 0.69 km/km$^2$. As with Hascheak and Russell Creek, there have been no landslides in the McDougall watershed and the hazard rating for future slides is low.

The presence of both Rainbow and Bull trout have been observed at the mouth of McDougall Creek, but it has not been given any fisheries priority. Again there is a mineral claim without any active mining, and a trapper’s license. In terms of recreational value, the McDougall Creek road system is utilized by the Snow Drifters snowmobile club as an access to Foghorn Mountain.
McDougall Creek is sampled in one location (EMS site E223252), approximately 15 meters upstream of the diversion into Hascheak Creek (Fig. 1).

2.4 LONE, BESTER, RENNIE AND AXEL CREEKS
These four creeks are tributaries to the North Thompson River, and drain off the slopes south-west of the Russell Creek watershed. All four are relatively small in size, with relatively low but consistent year-round flows. The exception to this is Bester Creek, which has sub-surface flows between about mid-July and April of recent years.

3.0 METHODS
Discrete samples were collected at the various sites four times in June, twice in July, once in August and September (due to restricted access resulting from forest fires in the area), twice in October, monthly in November through February and bimonthly once again in March of 2004.

3.1 DISCRETE SAMPLING
Discrete sampling was conducted according to the schedule outlined in Section 3.0. Exceptions to this were at the Russell Creek site above the reservoir and the Hascheak Creek site above the McDougal diversion, where extreme low flows during the late summer occasionally made representative sampling impossible. In addition, Bester Creek had sub-surface flows for the duration of the study this year and therefore was not sampled.

Discrete water sampling involved the collection of water samples in each of three different water bottles. First, a pre-labeled plastic 1 liter bottle was filled to provide enough sample for turbidity, phosphorus, pH, specific conductivity, total dissolved solids, total suspended solids and colour. Next, a pre-labeled 500-mL acid preserved “nitrogen bottle” was filled with stream water to be tested for nitrate and nitrite. Finally, one sterile 500-mL coliform bottles were filled with sample to be analyzed for fecal coliforms and E. coli. All discrete samples were collected using methods described in Cavenagh et al. (1994). All samples were immediately placed on ice and kept cool during transport. Coliform samples were shipped to Cantest Laboratories Ltd and analyzed the next day.
while the remaining samples were delivered to the EcoTech Laboratory in Kamloops, B.C. either the day of or the day after they were collected.

Discrete samples were collected from Lone, Rennie and Axel creeks in a 500-mL plastic bottle and shipped to EcoTech for turbidity analysis only.

3.2 Inventory Staff

The majority of sampling, hand-held monitoring and maintenance of the automated station was conducted by Burke Phippen, RPBio., Senior Biologist of BWP Consulting in Kamloops. On occasion (especially during the winter on snowmobile trips, for safety reasons) he was accompanied by Cheryl Phippen, B.Sc. and/or Neil Horvath (Technical diploma, Forestry and Fish and Wildlife) who assisted in sampling and maintenance. All staff were trained in Resource Inventory Commission (RIC) sample collection methodology, as well as automated water quality station maintenance.

4.0 Proposed Water Quality Objectives

The following objectives have been proposed for each watershed. Water quality monitoring data collected as part of the 2003-04 water quality monitoring program for the various community watershed sites is summarized in tables 1 through 5, while turbidity data for the East Blackpool sites are provided in Table 6.

**Russell Creek**

Fecal coliforms

*The objective is that the 90th percentile of a minimum of five samples collected in a 30-day period at the lower Russell Creek site should not exceed 5 CFU/100 mL.*

*E. coli*

*The objective is that the 90th percentile of a minimum of five samples collected in a 30-day period at the lower Russell Creek site should not exceed 5 CFU/100 mL.*
Turbidity

The objective is that the maximum turbidity value measured at the lower Russell Creek site above the reservoir should not exceed 5 NTU and the mean of a minimum of five samples collected in a 30-day period should not exceed 2 NTU during the turbid flow period (between April and July). During the clear flow period, the maximum turbidity should not exceed 2 NTU, and the mean of a minimum of 5 samples collected in a 30-day period should not exceed 1 NTU during the remainder of the year (August through March). Elevated turbidity levels associated with rainfall during the clear flow period should be assessed according to the objective for the turbid flow period (mean \( \leq 2 \) NTU, max \( \leq 5 \) NTU).

True Colour

The objective is that colour levels should not exceed 15 TCU during the clear flow period (August through March), and should not exceed 20 TCU during the turbid flow period at the lower site on Russell Creek.

Hascheak Creek

Fecal coliforms

The objective for fecal coliforms in Hascheak Creek is that the 90\(^{th}\) percentile of a minimum of five samples collected within a 30-day period should not exceed 10 CFU/100 mL in Hascheak Creek above the reservoir.

E. coli

The objective for E. coli in Hascheak Creek is that the 90\(^{th}\) percentile of a minimum of five samples collected within a 30-day period should not exceed 10 CFU/100 mL in Hascheak Creek above the reservoir.

Turbidity

The mean of a minimum of five samples collected at the lower Hascheak Creek site during the turbid-flow period (between April and July) shall not exceed 2.0 NTU and the maximum turbidity should not exceed 16 NTU. During the clear flow period
(between August and March), the maximum turbidity should not exceed 6 NTU, and the mean of a minimum of five samples collected in a 30-day period should not exceed 1 NTU.

True Colour

*The objective is that true colour values measured in Hascheak Creek above the reservoir should not exceed 15 TCU at any time of the year.*

Total Suspended Solids

*The objective states that total suspended solids concentrations should not increase more than 10 mg/L above concentrations at the upper site for a duration of 24 hours, and average concentrations over 30 days should not increase more than 5 mg/L during this period (based on a minimum of five samples collected in 30-days).*

**McDougall Creek**

Fecal coliforms

*The objective is that the 90th percentile of a minimum of five samples collected within a 30-day period should not exceed 10 CFU/100 mL.*

*E. coli*

*The objective is that the 90th percentile of a minimum of five samples collected within a 30-day period should not exceed 10 CFU/100 mL.*

Turbidity

*The objective is that the maximum turbidity measured during the clear flow period should not exceed 3 NTU and the average turbidity of a minimum of five samples collected within a 30-day period should not exceed 1 NTU during the clear flow period (August to March). During the turbid-flow period (April to July), the maximum turbidity value should not exceed 12 NTU and the average of a minimum of five samples collected in a 30-day period should not exceed 2 NTU.*
True Colour

*The objective is that true colour values measured in McDougall Creek should not exceed 20 TCU during the turbid-flow period, and should not exceed 15 NTU during the clear-flow period.*

**Table 1. Summary of water quality data collected at Site E223247, Russell Creek Upstream.**

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average</th>
<th>Std Dev</th>
<th>No. of Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (pH units)</td>
<td>7.39</td>
<td>7.97</td>
<td>7.71</td>
<td>0.16</td>
<td>16</td>
</tr>
<tr>
<td>Colour (TCU)</td>
<td>&lt;5</td>
<td>30</td>
<td>8.1</td>
<td>6.9</td>
<td>16</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>&lt;0.2</td>
<td>0.5</td>
<td>0.2</td>
<td>0.1</td>
<td>16</td>
</tr>
<tr>
<td>Conductivity (µs/cm)</td>
<td>80</td>
<td>184</td>
<td>145.3</td>
<td>36.5</td>
<td>16</td>
</tr>
<tr>
<td>Total Suspended Solids (mg/L)</td>
<td>&lt;1</td>
<td>7</td>
<td>2.3</td>
<td>1.7</td>
<td>16</td>
</tr>
<tr>
<td>Total Dissolved Solids (mg/L)</td>
<td>64</td>
<td>140</td>
<td>105.1</td>
<td>19.9</td>
<td>16</td>
</tr>
<tr>
<td>Nitrate (mg/L)</td>
<td>&lt;0.003</td>
<td>0.114</td>
<td>0.041</td>
<td>0.043</td>
<td>16</td>
</tr>
<tr>
<td>Nitrite (mg/L)</td>
<td>&lt;0.003</td>
<td>&lt;0.003</td>
<td>&lt;0.003</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>Total Phosphate (mg/L)</td>
<td>&lt;0.003</td>
<td>0.018</td>
<td>0.005</td>
<td>0.004</td>
<td>16</td>
</tr>
<tr>
<td>Fecal Coliform (CFU/100mL)</td>
<td>&lt;1</td>
<td>141</td>
<td>10.6</td>
<td>34.8</td>
<td>16</td>
</tr>
<tr>
<td><em>E. coli</em> (CFU/100mL)</td>
<td>&lt;1</td>
<td>95</td>
<td>7.5</td>
<td>23.4</td>
<td>16</td>
</tr>
<tr>
<td>Field Temperature</td>
<td>5.6</td>
<td>13.9</td>
<td>9.1</td>
<td>2.8</td>
<td>7</td>
</tr>
</tbody>
</table>

**Table 2. Summary of water quality data collected at Site E223248, Russell Creek above Reservoir.**

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average</th>
<th>Std Dev</th>
<th>No. of Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (pH units)</td>
<td>7.69</td>
<td>8.13</td>
<td>7.85</td>
<td>0.10</td>
<td>13</td>
</tr>
<tr>
<td>Colour (TCU)</td>
<td>&lt;5</td>
<td>25</td>
<td>7.6</td>
<td>5.7</td>
<td>13</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>&lt;0.2</td>
<td>0.5</td>
<td>0.2</td>
<td>0.1</td>
<td>13</td>
</tr>
<tr>
<td>Conductivity (µs/cm)</td>
<td>98</td>
<td>348</td>
<td>197.3</td>
<td>76.0</td>
<td>13</td>
</tr>
<tr>
<td>Total Suspended Solids (mg/L)</td>
<td>&lt;1</td>
<td>5</td>
<td>1.5</td>
<td>1.1</td>
<td>13</td>
</tr>
<tr>
<td>Total Dissolved Solids (mg/L)</td>
<td>81</td>
<td>237</td>
<td>142.5</td>
<td>45.7</td>
<td>13</td>
</tr>
<tr>
<td>Nitrate (mg/L)</td>
<td>&lt;0.003</td>
<td>0.381</td>
<td>0.182</td>
<td>0.153</td>
<td>13</td>
</tr>
<tr>
<td>Nitrite (mg/L)</td>
<td>&lt;0.003</td>
<td>&lt;0.003</td>
<td>&lt;0.003</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Total Phosphate (mg/L)</td>
<td>&lt;0.003</td>
<td>0.044</td>
<td>0.006</td>
<td>0.011</td>
<td>13</td>
</tr>
<tr>
<td>Fecal Coliform (CFU/100mL)</td>
<td>&lt;1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td><em>E. coli</em> (CFU/100mL)</td>
<td>&lt;1</td>
<td>1</td>
<td>&lt;1</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Field Temperature</td>
<td>9.1</td>
<td>13.6</td>
<td>11.8</td>
<td>1.8</td>
<td>6</td>
</tr>
</tbody>
</table>
Table 3. Summary of water quality data collected at Site E223249, Hascheak Creek above Reservoir.

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average</th>
<th>Std Dev</th>
<th>No. of Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (pH units)</td>
<td>8.03</td>
<td>8.36</td>
<td>8.19</td>
<td>0.09</td>
<td>16</td>
</tr>
<tr>
<td>Colour (TCU)</td>
<td>&lt;5</td>
<td>&lt;5</td>
<td>&lt;5</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>0.2</td>
<td>0.4</td>
<td>0.2</td>
<td>0.1</td>
<td>16</td>
</tr>
<tr>
<td>Conductivity (µs/cm)</td>
<td>301</td>
<td>361</td>
<td>321.6</td>
<td>15.3</td>
<td>16</td>
</tr>
<tr>
<td>Total Suspended Solids (mg/L)</td>
<td>&lt;1</td>
<td>3</td>
<td>1.6</td>
<td>0.9</td>
<td>16</td>
</tr>
<tr>
<td>Total Dissolved Solids (mg/L)</td>
<td>201</td>
<td>246</td>
<td>222.4</td>
<td>12.3</td>
<td>16</td>
</tr>
<tr>
<td>Nitrate (mg/L)</td>
<td>&lt;0.003</td>
<td>0.084</td>
<td>0.037</td>
<td>0.031</td>
<td>16</td>
</tr>
<tr>
<td>Nitrite (mg/L)</td>
<td>&lt;0.003</td>
<td>&lt;0.003</td>
<td>&lt;0.003</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>Total Phosphate (mg/L)</td>
<td>&lt;0.003</td>
<td>0.081</td>
<td>0.015</td>
<td>0.023</td>
<td>16</td>
</tr>
<tr>
<td>Fecal Coliform (CFU/100mL)</td>
<td>&lt;1</td>
<td>33</td>
<td>3.1</td>
<td>8.0</td>
<td>16</td>
</tr>
<tr>
<td>E. coli (CFU/100mL)</td>
<td>&lt;1</td>
<td>27</td>
<td>2.7</td>
<td>6.5</td>
<td>16</td>
</tr>
<tr>
<td>Field Temperature</td>
<td>9.3</td>
<td>13.3</td>
<td>10.9</td>
<td>1.5</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 4. Summary of water quality data collected at Site E223250, Hascheak Creek above Diversion.

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average</th>
<th>Std Dev</th>
<th>No. of Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (pH units)</td>
<td>7.87</td>
<td>8.18</td>
<td>8.05</td>
<td>0.10</td>
<td>14</td>
</tr>
<tr>
<td>Colour (TCU)</td>
<td>&lt;5</td>
<td>&lt;5</td>
<td>&lt;5</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>&lt;0.2</td>
<td>0.8</td>
<td>0.2</td>
<td>0.2</td>
<td>14</td>
</tr>
<tr>
<td>Conductivity (µs/cm)</td>
<td>316</td>
<td>425</td>
<td>377.6</td>
<td>39.1</td>
<td>14</td>
</tr>
<tr>
<td>Total Suspended Solids (mg/L)</td>
<td>&lt;1</td>
<td>6</td>
<td>1.6</td>
<td>1.4</td>
<td>14</td>
</tr>
<tr>
<td>Total Dissolved Solids (mg/L)</td>
<td>209</td>
<td>274</td>
<td>250.1</td>
<td>22.7</td>
<td>14</td>
</tr>
<tr>
<td>Nitrate (mg/L)</td>
<td>&lt;0.003</td>
<td>0.041</td>
<td>0.012</td>
<td>0.013</td>
<td>14</td>
</tr>
<tr>
<td>Nitrite (mg/L)</td>
<td>&lt;0.003</td>
<td>&lt;0.003</td>
<td>&lt;0.003</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>Total Phosphate (mg/L)</td>
<td>&lt;0.003</td>
<td>0.012</td>
<td>0.004</td>
<td>0.003</td>
<td>14</td>
</tr>
<tr>
<td>Fecal Coliform (CFU/100mL)</td>
<td>&lt;1</td>
<td>22</td>
<td>2.3</td>
<td>5.7</td>
<td>14</td>
</tr>
<tr>
<td>E. coli (CFU/100mL)</td>
<td>&lt;1</td>
<td>21</td>
<td>2.2</td>
<td>5.4</td>
<td>14</td>
</tr>
<tr>
<td>Field Temperature</td>
<td>6.5</td>
<td>12.7</td>
<td>8.8</td>
<td>2.2</td>
<td>6</td>
</tr>
</tbody>
</table>
Table 5. Summary of water quality data collected at Site E223252, McDougall Creek above Diversion.

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average</th>
<th>Std Dev</th>
<th>No. of Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (pH units)</td>
<td>7.84</td>
<td>8.29</td>
<td>8.02</td>
<td>0.12</td>
<td>16</td>
</tr>
<tr>
<td>Colour (TCU)</td>
<td>&lt;5</td>
<td>25</td>
<td>8.1</td>
<td>6.0</td>
<td>16</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>&lt;0.2</td>
<td>1</td>
<td>0.3</td>
<td>0.2</td>
<td>16</td>
</tr>
<tr>
<td>Conductivity (µs/cm)</td>
<td>89</td>
<td>250</td>
<td>184.8</td>
<td>55.9</td>
<td>16</td>
</tr>
<tr>
<td>Total Suspended Solids (mg/L)</td>
<td>&lt;1</td>
<td>8</td>
<td>2.1</td>
<td>2.4</td>
<td>16</td>
</tr>
<tr>
<td>Total Dissolved Solids (mg/L)</td>
<td>73</td>
<td>178</td>
<td>140.1</td>
<td>36.2</td>
<td>16</td>
</tr>
<tr>
<td>Nitrate (mg/L)</td>
<td>&lt;0.003</td>
<td>0.208</td>
<td>0.076</td>
<td>0.079</td>
<td>16</td>
</tr>
<tr>
<td>Nitrite (mg/L)</td>
<td>&lt;0.003</td>
<td>&lt;0.003</td>
<td>&lt;0.003</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>Total Phosphate (mg/L)</td>
<td>&lt;0.003</td>
<td>0.011</td>
<td>0.004</td>
<td>0.002</td>
<td>16</td>
</tr>
<tr>
<td>Fecal Coliform (CFU/100mL)</td>
<td>&lt;1</td>
<td>23</td>
<td>2.3</td>
<td>5.5</td>
<td>16</td>
</tr>
<tr>
<td>E. coli (CFU/100mL)</td>
<td>&lt;1</td>
<td>18</td>
<td>2.2</td>
<td>4.4</td>
<td>16</td>
</tr>
<tr>
<td>Field Temperature</td>
<td>6.3</td>
<td>13.2</td>
<td>10.0</td>
<td>2.4</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 6. Summary of turbidity and temperature data collected at East Blackpool sites.

<table>
<thead>
<tr>
<th></th>
<th>Axel Creek</th>
<th>Lone Creek</th>
<th>Bester Creek</th>
<th>Rennie Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbidity (NTU)</td>
<td>Minimum</td>
<td>Maximum</td>
<td>Average</td>
<td>Std Dev</td>
</tr>
<tr>
<td></td>
<td>&lt;0.2</td>
<td>0.27</td>
<td>0.19</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td>6.4</td>
<td>14.1</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
<td>Average</td>
<td>Std Dev</td>
</tr>
<tr>
<td></td>
<td>&lt;0.2</td>
<td>0.2</td>
<td>&lt;0.2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>6.2</td>
<td>12.1</td>
<td>10.1</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
<td>Average</td>
<td>Std Dev</td>
</tr>
<tr>
<td></td>
<td>&lt;0.2</td>
<td>0</td>
<td>0</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>6.2</td>
<td>1.6</td>
<td>0</td>
<td>2.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
<td>Average</td>
<td>Std Dev</td>
</tr>
<tr>
<td></td>
<td>&lt;0.2</td>
<td>0</td>
<td>0</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>6.2</td>
<td>1.6</td>
<td>0</td>
<td>2.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.0 DISCUSSION

5.1 Temperature

As would be expected, water temperatures increased through the early spring, reached their maximum in July, and then began to decrease again through the fall and into the winter. Maximum temperatures were similar at all of the sites, with the maximum temperature of 13.9°C occurring on July 31 at the upper Russell Creek site, and the lowest maximum temperature occurring in Hascheak Creek above the McDougall Creek diversion site with a maximum of only 12.7°C, also on July 31. Temperatures for all creeks decreased to near 0°C by December. All values remained below the maximum water quality guideline of 15°C, established for drinking water for esthetic purposes (Nagpal et al. 1995), and no objectives were proposed for temperature in any of the creeks.
5.2 pH
The pH for all streams measured was consistently neutral to slightly basic, with mean values ranging from 7.71 at the Russell Creek upstream site to 8.19 pH units at the Hascheak Creek site upstream from the reservoir. No clear seasonal trend was evident for pH values in any of the watersheds, and no objective has been proposed for pH in any of the watersheds.

5.3 Turbidity
Turbidity values were at or below the detectable limit (< 0.2 NTU) for the majority of the samples collected at each of the sites. Maximum turbidity levels ranged from 0.4 NTU in Hascheak Creek above the reservoir to 1 NTU in McDougal Creek above the diversion. However, as sampling did not begin until June, the early part of freshet was missed and therefore higher turbidity values may have occurred earlier in the year. However, none of the turbidity values collected at these sites exceeded the proposed turbidity objectives.

5.4 Colour
The true colour of the water was generally low, with average values ranging from <5 TCU in Hascheak Creek both above the diversion and above the reservoir, to 8.1 TCU in both McDougall Creek above the diversion and at the Russell Creek upstream site. While the majority of values at all of the sites were below detectable limits (<5 TCU), there were a few elevated values that occurred during the spring freshet. An objective of 15 TCU was proposed for maximum true colour values at both Hascheak Creek above the reservoir and McDougall Creek above the diversion, and an objective of a maximum of 20 TCU during the turbid-flow period (from April to July) was proposed for Russell Creek above the reservoir. The objective was exceeded in McDougall Creek, with a maximum value of 25 TCU, as well as in Russell Creek above the reservoir, with a maximum true colour value of 25 TCU. Maximum true colour values occurred at all sites on June 11, 2003.

5.5 Total Suspended Solids and Total Dissolved Solids
Total suspended solids (non-filterable residue, or NFR) were generally below the detectable limit (< 1 mg/L) at all of the sites. During the spring freshet, maximum values
ranged from 3 mg/L in Hascheak Creek above the reservoir to 8 mg/L at McDougal Creek above the diversion. The maximum value measured at the Hascheak Creek site above the reservoir was considerably lower than the maximum value measure in 2002-03 (198 mg/L). However, the maximum value measured in 2002-03 occurred on May 21, 2002, about two weeks earlier than the earliest sample collected in 2003. Therefore, higher suspended solids concentrations may have occurred earlier in the freshet and simply not have been measured. Based on the available data, the objective for total suspended solids in Hascheak Creek above the reservoir was not exceeded.

Total dissolved solids (filterable residue, FR) values varied considerably between sites, ranging from a mean of 105 mg/L at the Russell Creek upstream site to 250 mg/L at the Hascheak Creek upstream from the diversion site. Trends in total dissolved solids were generally opposite those of total suspended solids, with higher values occurring during the late fall and early spring and lower values during the spring freshet. This is due primarily to the dilution of the dissolved solids by the melting snow. All values are well below the aesthetic drinking water guideline of 500 mg/L (Nagpal et al. 1995).

5.4 Specific conductivity
Specific conductivity levels at the different sites tended to vary in a direct proportions to their concentrations of total dissolved solids. Mean values at the sites ranged from 145 \( \mu \text{S/cm} \) at the Russell Creek upstream site to 378 \( \mu \text{S/cm} \) in Hascheak Creek upstream from the diversion site. The minimum value recorded at the Russell Creek upstream site was 80 \( \mu \text{S/cm} \), while the maximum value measured at the Hascheak Creek site upstream from the diversion was 425 \( \mu \text{S/cm} \). All values are well below the drinking water guideline of 700 \( \mu \text{S/cm} \) (Nagpal et al. 1995), and no objective was proposed for specific conductivity in these watersheds.

5.5 Nutrients
Nitrogen (measured as both nitrate and nitrite) and phosphorus levels were generally low in each of the watersheds sampled. Nitrite levels were invariably below the detection limit of 0.003 mg/L at all five of the monitoring sites. Nitrogen levels in the form of
Nitrate were highest in the mid-summer to late fall period, as biological activity tended to decrease and decomposition of organic material resulted in the release of nitrogen wastes. Maximum nitrate concentrations ranged from 0.041 mg/L in Hascheak Creek above the diversion to a maximum of 0.381 mg/L at the Russell Creek site upstream from the reservoir. Phosphorus concentrations measured as total phosphate were also low, below the detectable limit of 0.003 mg/L the majority of the time at all sites. The highest total phosphate concentrations measured at any of the sites were 0.084 mg/L at the Hascheak Creek reservoir site and 0.044 mg/L at the Russell Creek reservoir site. Nitrate and nitrite values were well below their respective drinking water guidelines of 10 mg/L and 1 mg/L (Nagpal et al. 1995) and no objective has been proposed for nitrogen concentrations in these watersheds. There is no guideline for phosphorus concentrations in streams, and no objective has been proposed for these watersheds.

5.6 Fecal Coliforms
Concentrations of fecal coliforms within the water column of a stream is extremely variable. The presence or absence of a minute fragment of fecal material from any warm-blooded animal can result in extremely high coliform concentrations being reported for that sample. For this reason, the 90th percentile of coliform data is used to determine compliance with the drinking water guideline. This would tend to exclude the occasional sample that might contain fecal coliforms not representative of the average values. For this reason, Table 17 is included below to provide the 90th percentile values for fecal coliform concentrations measured at the various sampling locations over the course of the year. To determine compliance with the guideline, a minimum of five samples are required within a 30-day period, and for this reason, the 90th percentile for the five samples collected between June 3 and July 8 is also included in Table 17.

A chlorination station located below the Clearwater reservoir disinfects the raw water prior to consumption. Therefore, the drinking water guideline for both fecal coliforms and E. coli is ≤ 10 CFU/100 mL in the raw water. The 90th percentiles for fecal coliforms ranged from 1 CFU/100 mL at McDougall Creek and at Hascheak Creek above the diversion to 5 CFU/100 mL at the upper Russell Creek site. The 90th percentile values
for *E. coli* for the annual data were almost identical to those for fecal coliforms, with values ranging from 1 CFU/100 mL at McDougall Creek and at Hascheak Creek above the diversion to 5 CFU/100 mL at the upper Russell Creek site. All of the sites had 90th percentile values below the drinking water guideline, as well as below the objectives of a 90th percentile of 5 CFU/100 mL proposed for the lower site on Russell Creek and the proposed objective of a 90th percentile of 10 CFU/100 mL for Hascheak Creek above the reservoir and the McDougall Creek site. When 90th percentiles were calculated on the five samples in 30-days necessary for determining guideline compliance, all values were below the guideline levels (see Table 8).

### Table 7. 90th percentile values for bacteriological data collected at the five sampling sites.

<table>
<thead>
<tr>
<th>Sampling Location</th>
<th>Fecal coliform (CFU/100 mL)</th>
<th><em>E. coli</em> (CFU/100 mL)</th>
<th>Fecal coliform (CFU/100 mL)</th>
<th><em>E. coli</em> (CFU/100 mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russell Creek Upstream</td>
<td>5</td>
<td>5</td>
<td>4.2</td>
<td>4.6</td>
</tr>
<tr>
<td>Russell Creek Upstream of Reservoir</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Hascheak Creek Upstream of Reservoir</td>
<td>2.5</td>
<td>2.5</td>
<td>2.6</td>
<td>2.2</td>
</tr>
<tr>
<td>Hascheak Creek Upstream of Diversion</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>McDougall Creek Upstream of Diversion</td>
<td>1.5</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

#### 5.7 Turbidity values in Lone, Bester, Rennie and Axel creeks

Turbidity values in Lone, Rennie and Axel creeks were consistently below the health advisory guideline of 1.0 NTU, with averages of 0.27 NTU, < 0.2 NTU, and 0.2 NTU, respectively. Maximum values at the sites ranged from 0.2 NTU in Lone Creek to 0.9 NTU in Axel Creek. As short-lived elevated turbidity levels have been observed in previous years for both Axel and Rennie creeks, and considering that sampling did not begin until well into spring freshet, it is possible that maximum turbidity levels were not captured during this years monitoring program. However, the lack of elevated values throughout the remainder of the monitoring program suggest that turbidity is not a concern in these watersheds.
6.0 SUMMARY OF WATER QUALITY OBJECTIVES ATTAINMENT AND CCME WATER QUALITY INDEX RANKINGS

Water quality objectives attainment is summarized for each watershed below. In addition, the Canadian Council of Ministers of the Environment (CCME) Water Quality Index is calculated for each watershed, and the watershed ranking is given (CCME, 2003). A summary of these calculations is given in Table 9.

6.1 RUSSELL CREEK

The following objectives for Russell Creek above the reservoir were met during the 2003-04 monitoring season:

- fecal coliforms (a maximum 90th percentile of 5 CFU/100 mL)
- *E. coli* (a maximum 90th percentile of 5 CFU/100 mL)
- maximum turbidity value during clear-flow period (2 NTU)
- maximum turbidity value during turbid-flow period (5 NTU)
- average turbidity during turbid-flow period (2 NTU)
- average turbidity during clear-flow period (1 NTU)
- maximum colour during clear-flow period (15 TCU)

The following objectives were exceeded in Russell Creek during the 2003-04 monitoring season:

- maximum colour during turbid-flow period (25 TCU versus objective of 20 TCU)

6.2 HASCEAK CREEK

The following objectives for Hascheak Creek above the reservoir were met during the 2003-04 monitoring season:

- fecal coliforms (a maximum 90th percentile of 10 CFU/100 mL)
- *E. coli* (a maximum 90th percentile of 10 CFU/100 mL)
- maximum turbidity value during clear-flow period (6 NTU)
- average turbidity during clear-flow period (1 NTU)
- maximum turbidity value during turbid-flow period (16 NTU)
- average turbidity value during turbid-flow period (2 NTU objective)
- total suspended solids increase (maximum increase 10 mg/L)
- total suspended solids increase (average increase 5 mg/L)
o maximum true colour value (15 TCU)

No objectives were exceeded in Hascheak Creek above the reservoir during the 2003-04 monitoring season:

### 6.3 McDougall Creek

The following objectives for McDougall Creek above the diversion were met during the 2003-04 monitoring season:

- fecal coliforms (a maximum 90\textsuperscript{th} percentile of 10 CFU/100 mL)
- maximum turbidity value during turbid-flow period (12 NTU)
- average turbidity during turbid-flow period (2 NTU)
- maximum turbidity value during clear-flow period (3 NTU)
- average turbidity during clear-flow period (1 NTU)

The following objective was exceeded in McDougall Creek above the diversion during the 2003-04 monitoring season:

- maximum true colour value (25 TCU versus objective of 15 TCU)
7.0 MANAGEMENT RECOMMENDATIONS

It is recommended that water quality monitoring for the parameters discussed in this report (fecal coliforms and *E. coli*, true colour, nutrients (nitrogen and phosphorus), pH, filterable and non-filterable residue, specific conductivity, temperature and turbidity) continue to be monitored during both the clear-flow and turbid-flow periods. In order to accurately assess objectives compliance of parameters such as fecal coliforms or non-filterable residue, we recommend a minimum of five samples be collected during a period of not more than 30-days, both during freshet (between mid-May and late June) and during fall low-flows (early September to late October).
LITERATURE CITED


Phippen, B.W. and C.M. Horvath. 1999 Draft. A Summary of Background Information Required for the Development of Water Quality Objectives on Russell Creek, Hascheak Creek, McDougall Creek, White River, North Blue River and Mileage Creek. BWP Consulting. Kamloops, B.C.