Hydrologic Assessment of the Kelly Creek Watershed

March 2013
1011.0041.01

Regional District of Kootenay Boundary

The Corporation of the Village of Fruitvale B.C.

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Glossary

BVWS	Beaver Valley Water Service
CBT	Columbia Basin Trust
EAA	Electoral Area A
ECA	Equivalent clear-cut area
Fruitvale	Village of Fruitvale
GIS	Geographic Information System
gpm	Gallons per minute
M3/s	Cubic meters per second
ML	Megalitres
MoE	Ministry of Environment
PCIC	Pacific Climate Impacts Consortium
RDCK	Regional District of Central Kootenay
RDKB	Regional District of Kootenay Boundary
WELLS	Water well database
WRA	Water Resources Atlas
WSAP	Water Smart Action Plan
~	Approximately

1.0 INTRODUCTION

Kelly Creek is the community watershed and primary source of supply for domestic water for the Village of Fruitvale (Fruitvale) and Electoral Area A (EAA). Beaver Valley Water Service (BVWS) is undertaking this hydrologic assessment of the watershed as part of future planning for its water system. Establishing a hydrologic profile and watershed condition is an essential step toward informed decision-making, investment planning, and development for BVWS. Results of the assessment speak to the sustainability of the Kelly Creek water supply and will help BVWS understand the need for and viability of options for developing sources of supply.

1.1 Project Scope

This report has been prepared for BVWS to assess the cumulative hydrologic impacts of current activities within the watershed.
Specific objectives of this assessment include the following:

- Establish the current hydrologic state of the watershed
- Assess the natural impacts occurring in the watershed
- Assess the anthropogenic risks which exist in the watershed
- Provide an overview of long term development trends in the watershed
- Examine the groundwater resources in the watershed and the viability as an additional source of supply
- Complete a data gap analysis
- Identify potential impact related to climate change

1.2 Geographic Area of Focus

The Kelly Creek Community Watershed is the primary water source for the Village of Fruitvale (Appendix E Map 1). Beaver Valley Water Service (BVWS) is responsible for delivering safe drinking water from both Kelly Creek and two groundwater wells to residents in Fruitvale and EAA RDKB. The BVWS is owned by the Regional District of Kootenay Boundary (RDKB) and is operated and maintained by Fruitvale. The majority of the watershed is private land within the Regional District of Central Kootenay (RDCK), whereas the water service area is located in the RDKB. The watershed is primarily private managed forestland that is subject to the *Private Managed Forest Land Act*. This hydrologic assessment is focused on the watershed from the BVWS intake upstream, and the groundwater sources in the watershed that may be available to the service.

1.3 Assessment Methodology

This hydrologic assessment was completed to be consistent with the requirements outlined in the Village of Fruitvale's RFP (Appendix A). The following tasks were competed:

Task 1: Background

Watershed overview

Relevant background information was reviewed regarding watershed geography, geology, biogeoclimatic zones, orthophoto review, and anthropogenic impacts. This information was used to understand past and current conditions of the watershed.

GIS Mapping and Equivalent Clear-cut Area Calculations
Using available GIS information, as well as relevant available forestry spatial information), the following mapping and calculations were completed for the watershed:

- The snow sensitive zone elevation was identified based on the H_{60} elevation[1] for the watershed.
- Current equivalent clear-cut areas were determined for the entire basin based on information available up to December 31, 2012.
- Watershed maps that included the existing cutblocks and roads, and applicable mountain pine beetle information.

Task 2: Field Assessment

A reconnaissance level field assessment was conducted to confirm the current conditions in the watershed and to identify potential hydrologic risks associated with natural and past and proposed anthropogenic sources. The field assessment included the following:

- confirm the current watershed conditions for the Kelly Creek watershed. This included an overview assessment of roads, channels, existing cutblocks, and any other known issues;
- identification of specific sites of concern (e.g. road crossings, surface erosion issues and impacted channels, etc.) and assigned a site number to these sites to accommodate further review;
- review of past and proposed development within the watershed that may have hydrologic or water quality concerns and assess the current and estimated future hydrologic and water quality conditions.

Task 3: Analysis

The results of tasks 1 and 2 were analyzed and a hydrologic condition rating determined. The watershed will be classified as “functioning”, “functioning at risk”, or “not functioning”. Based on the classification, recommendations are provided regarding:

- maintaining the condition of the watershed,
- opportunities to improve the watershed condition, and
- potential to restore watershed function where it was classified as not functioning.

Task 4: Draft Report

Prepare draft report summarizing the findings, provide an estimate of the current watershed condition and runoff, summarize groundwater resources and potential, and summarize the projections on possible impacts on future water supplies as a result of climate change (based on available analysis completed for the Columbia Basin Trust by the Pacific Climate Impacts Consortium and others).

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[1] The H_{60} elevation is a component of the hydrologic assessment that represents the elevation in the watershed above which is considered the snow sensitive zone. That is, the portion of the watershed that produces the spring runoff and is sensitive to changes in forest cover resulting from logging, forest health issues and wildfire.

2.0 BACKGROUND

Watershed Overview

Protecting the watershed has been a challenge for BVWS as most of the watershed land is private land. Under the land use and community planning strategy, BVWS's goals include continuing water source protection for the long-term, and continuing to support the RDCK's interest in the Kelly Creek watershed and associated groundwater opportunities in keeping with the BVWS's Water Smart Action Plan.

2.1 General Watershed Characteristics

The Kelly Creek watershed is located in the Selkirk Mountains and has a catchment area of approximately 2,392 ha above the BVWS's intake (Figure 1. Location Map). It is a 4^{th} order stream that is a tributary to Beaver Creek and originates on the ridge to the southeast of Fruitvale. The creek flows ~11km southwest where it joins Beaver Creek. Kelly Creek flows from the upland slopes of Mount Kelly, Stott Peak and several un-named ridges. Although there are two sub-basins in the upper watershed (Map 1), due to the small size of the watershed, for the purposes of this assessment it has been treated as a single unit. The watershed code is 300.029 assigned by the province when the watershed was designated as a community watershed on June 15, 1995. Elevations range from approximately 780m at the intake to 1,960m at the peak of Mount Kelly.

The annual runoff for the watershed upstream of the intake is represented by the data from the hydrometric station Kelly Creek at 850m Contour (Station # 08NE113) that was operated by Water Survey of Canada from 1971 – 1982. The annual minimum, maximum and mean hydrographs are provided in Figure 2. The peak runoff typically occurs during the latter half of May into early June and minimum flows during the December – February period but can also occur in the late August – September period during dry years. The monthly data for the period of record are provided in Appendix B.

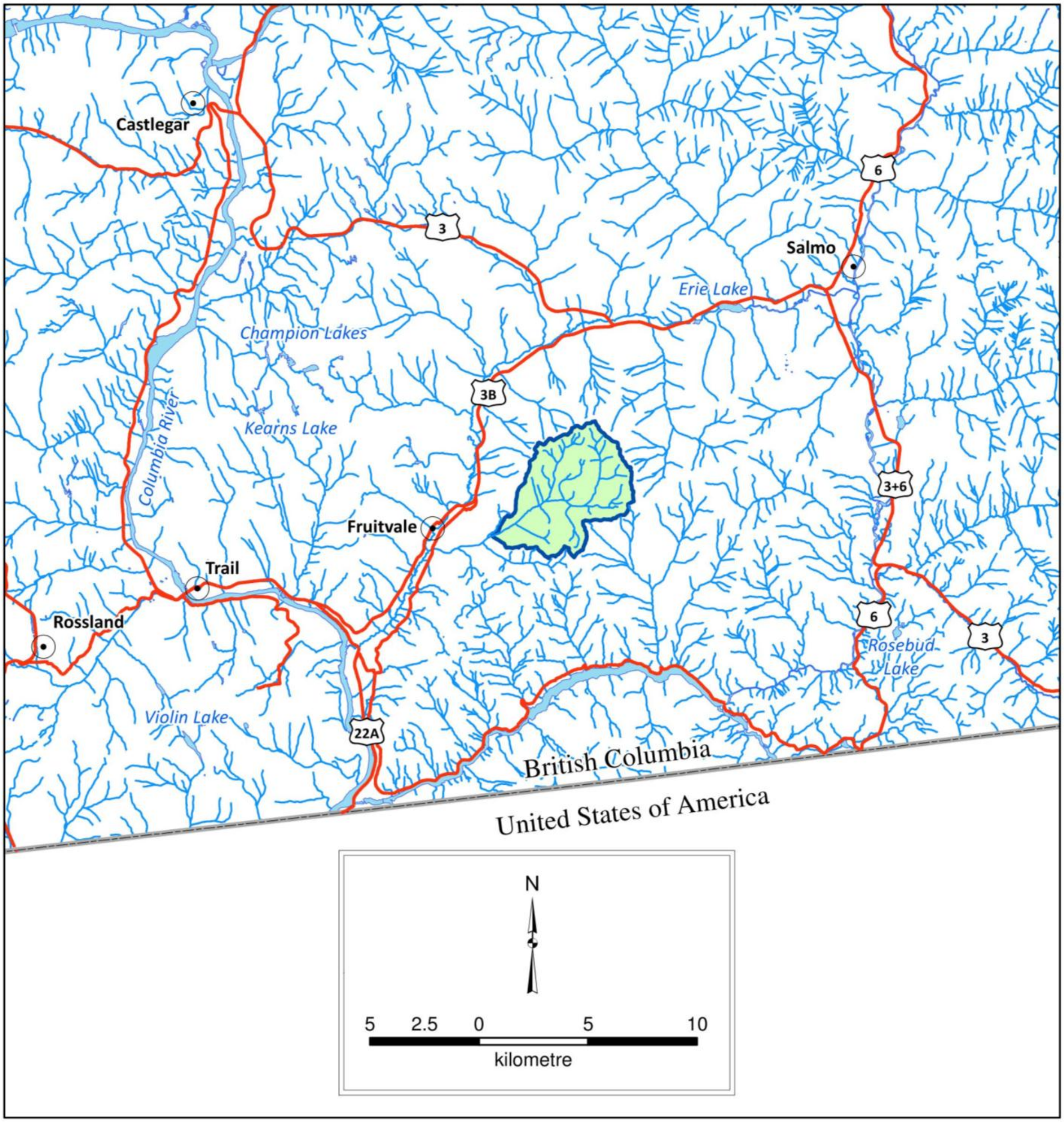
2.1.1 Land use

The private lands within the watershed are classified as managed forestland. The lands are owned by the Nelson family however forest management is the responsibility of the Kelly Creek Timber Co. Ltd. Atco Lumber Ltd. also holds a small portion of private forest land near the intake. Logging has occurred in the watershed since the 1940s. The block outlined by the heavy black line in the lower watershed on Map 1 is land owned by Atco Lumber Ltd. The balance of the watershed is private land managed by Kelly Creek Timber Co. Ltd. with the exception of two small areas of Crown land situated within the two Chart areas shown on Map 3.

2.1.2 Climate

Fruitvale is situated in the Columbia Mountains and Southern Rockies climate zone. Summers are typically warm with a mean temperature of approximately 19^{o}C and cool winters with mean temperatures of -5^{o}C. Annual rainfall is approximately 450mm and snowfall is approximately 180cm. There are two biogeoclimatic zones in the watershed, the Interior Cedar Hemlock in the lower elevations and the Engelmann Spruce Subalpine Fir in the upper elevations (Refer to Map 1).

Figure 1 - Location Map for Kelly Creek



2.1.3 Fish and Wildlife

Kelly Creek contains Rainbow trout captured in the lower reaches (Wildstone Resources, 1994). A fish barrier was assumed in the mid-watershed that prevents the upstream migration of fish and the stream was interpreted as non-fish bearing (Timberland Consultants, 2002). There is a diversity of wildlife in the watershed including mule and whitetail deer, elk, and black bears as well as various small mammals and birds.

2.1.4 Geology

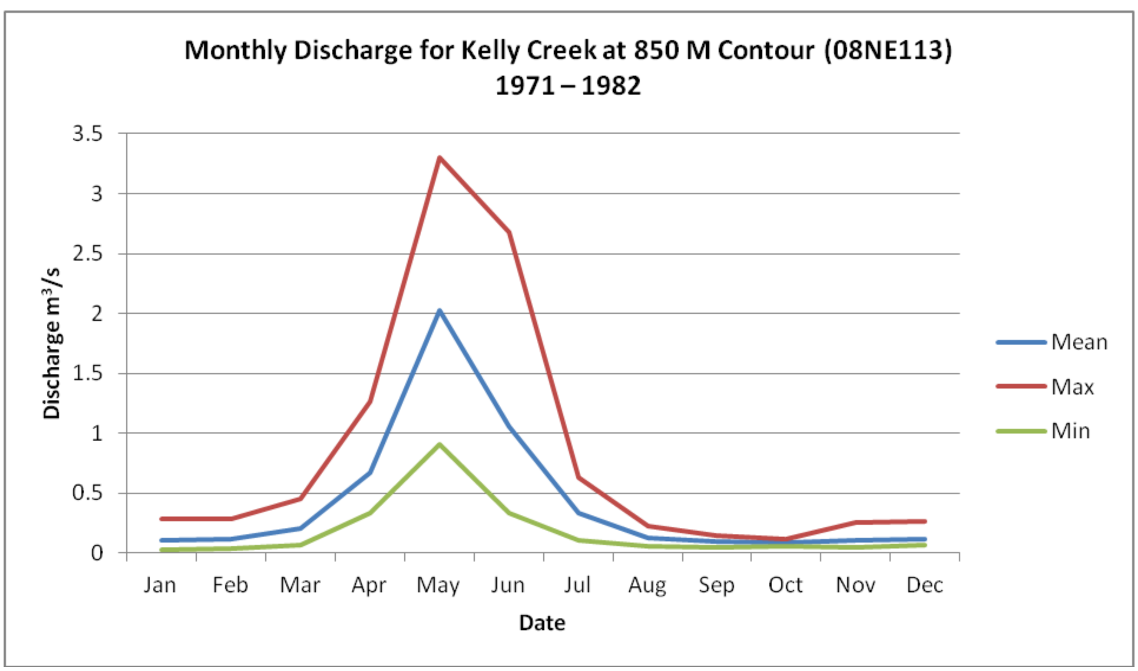
The watershed has been glaciated but the underlying bedrock is part of the Rossland Group and include the Elsie and Hall formations. Rock types include basalts and various sedimentary rocks such as mudstones and shales (Map 4). Soils are typically coarse textured colluvium in the upper watershed with basal tills in the mid watershed and glacio-fluvial deposits along the mainstem creek channel.

2.1.5 Watershed Hydrology

The watershed has snow-dominated hydrology with peak flows resulting from snow melt typically occurring from mid-May to early June. Hydrographs for the minimum, mean annual and maximum flows for the period 1971-1982 are provided in Figure 2. The peak flow of record at the Water Survey of Canada hydrometric station Kelly Creek at 850m Contour (08NE113) was 6.74m^3/s in 1972. The average peak flow during freshet is ~2 m^3/s. Low flows typically occur in the December-February period and are in the range of 0.02-0.03m^3/s. Low flows can also occur in the late summer and early fall and can be as low as 0.04 m^3/s.

For the purposes of this assessment the watershed has been divided into two parts, the upper 60% that is considered to be the snow sensitive zone and where the peak flows are generated and the lower 40% that is less sensitive to changes in forest cover that can impact peak flows and water yields. The H_{60} elevation is the 1,380m contour and is shown on Map1 as a heavy black contour line.

Figure 2: Kelly Creek maximum, minimum and mean annual hydrographs



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3.0 HYDROLOGIC CONDITION ASSESSMENT

3.1 Surface Water Assessment Methodology

The underlying methodology for the assessment of this watershed was based upon the assessment components (i.e. peak flows and hydrological recovery, sediment source survey, reconnaissance level channel assessment procedure and a riparian assessment) that are outlined in the Watershed Assessment Procedure, Guidebook (2001). Although the Forest and Ranges Practices Act has superseded the use of this guidebook this procedure is considered relevant for overview assessments of watersheds. The hydrologic hazards associated with forest development were evaluated using a risk assessment framework similar to Wise et al. (2004) and Forsite Consulting Ltd. and others (2007). Under this approach risk is defined as the product of consequence and hazard; however, since the resource value at stake is a domestic water intake, consequence was considered high for all hydrologic impacts. Risk ratings were assigned based on identified hazards and the likelihood of potential hazards causing impacts to water quality and quantity.

3.1.1 Natural Disturbances

Landslides

The natural disturbances in the watershed are limited. There were no natural landslides noted however there have been five lightning caused wildfires in the watershed ranging in size from ~30ha to several hundred hectares. Four of the five fires occurred in 1923 and one in 2007.

Wildlife

The watershed is used by a diversity of wildlife including deer, elk, bears, small mammals and birds. Wildlife can be carriers of various pathogenic organisms such as Giardia that can enter the water from fecal material. Fortunately, in this case, the watershed does not have lakes or wetlands that are habitats for beaver, muskrats and otter that are known carriers of Giardia. There was no data to indicate that Giardia had been detected in the water supply to date. The overall risks from wildlife are considered to be low.

3.1.2 Forest Development

Impacts of Timber Harvesting on Peak Flows

The watershed upstream of the intake is privately managed forestland. The only land use currently is timber harvesting which has occurred since to the 1940s. The majority of the watershed is managed by Kelly Creek Timber Co. Ltd. Discussions with the Woods Manager for Kelly Creek Timber indicated that the company had completed a number of assessments on its lands including updated equivalent clear-cut area (ECA) calculations, road assessments and stream channel assessments however this information was not made available. Atco Lumber Ltd. did supply GIS data and a summary of forest development on its lands. In the absence of similar data for the Kelly Creek Timber lands we used data that was available from the provincial databases as well as reviewing the most recent Google Earth® image dated September 25, 2009 and information collected during the fieldwork. The assembled data related to past forest development was adequate for the purposes of this assessment.

As indicated previously the watershed was divided into two parts, the snow sensitive zone in the upper watershed, and the less sensitive lower watershed. Research has determined that the source of the peak flows in the spring is the result of the melting snow in the upper 60% of the catchment. Changes in forest cover in this zone can have significant impacts on the magnitude of the peak flows and in turn can affect channel stability that will degrade water quality.

Timber harvesting in the snow sensitive zone will reduce the forest cover thereby allowing more snow to accumulate on the ground that will increase water yields. Water yields will also increase after logging due to the decrease in transpiration. It has been estimated that as much as 75% of the annual precipitation is consumed by either evaporation or transpiration by the forest vegetation (evapotranspiration).

The current equivalent clear-cut area is estimated to be ~17% (Refer to Appendix C -Watershed Report Card). The total area logged is estimated to be ~414ha. The cutblocks are shown on Map 1. The current ECA for the snow sensitive area is approximately 21% that is considered to have a low peak flow hazard.

The peak flow hazard rating was based upon the observed sensitivity and morphology of channels in the lower reaches of the watershed and the catchment area above the H_{60} line. The peak flow hazard rating also considered the results from other research such as Extension Note 67 (Schnorbus et al. 2004). Channel bank instability and channel morphologies are considered to be the most responsive to changes in peak flows that can affect water quality (Montgomery and MacDonald 2002).

Impacts of Timber Harvesting on Water Yield, Low flows and Timing of Flows

Detrimental changes to the components of streamflow such as water yield, low flows and timing of flows associated with the existing level of forest development are considered to have a low hazard for changes that could negatively affect downstream streamflows at the intake. In regards to water yield, Stednick (1996) showed that measureable water yield increases become detectable above harvest levels of 15% with variable results for increases in water yield for harvest levels (ECA levels) above 30% in snow dominated hydrologic regimes similar to the Kelly Creek watershed. Furthermore, decreases in water yield due to forest harvesting are not expected and do not typically occur in snow dominated hydrologic regimes (Stednick 1996, Scherer and Pike 2003). Furthermore, low flows are not expected to decrease due to forest development (Scherer and Pike 2003) since forest harvesting reduces interception losses and evapotranspiration during the summer growing season and increases water yields during the spring freshet when recharge of groundwater storage occurs. Based upon research changes in low flows have been shown to be undetectable subsequent to forest harvesting. A decrease in streamflow during the low flow period (summer/fall period) would be a much bigger concern at the intake since this could cause problems during higher periods of water demand. Detrimental effects on low flows associated with past forest harvesting are not expected.

In snowmelt dominated hydrologic regimes changes in the timing of streamflows typically occur in the spring on the rising limb of spring freshet peak flows (MacDonald and Stednick 2003). The timing of peak flows during the spring can be advanced as result of forest harvesting due to faster rate of snow melt and earlier melt of the snowpack (MacDonald and Stednick 2003, Scherer and Pike 2003). Based on a summary of research the date of advancement can range from 0 to 18 days with advances appearing to be highly variable (Scherer and Pike 2003). For the Kelly Creek watershed any change in the timing of peak flows is difficult to determine in absence of hydrometric data; however, given the ECA above the H_{60} line for the watershed there is a low hazard for potential advances in the timing of peak flows.

3.1.3 Forest Health

The biogeoclimatic zones in the watershed do not include significant stands of lodgepole pine. During the fieldwork it was noted that there is some lodgepole pine and some evidence of pine beetle damage but not extensive. There was little evidence of other forest health issues so the risks to the watershed are considered to be low.

3.1.4 Wildfire history

In addition to the five lightning caused fires there has been two human caused fires in the watershed, a 20ha burn in 1957 and a 0.7ha fire in 2008 (Map 5). The total burned area is less than 1,000ha. The largest fires occurred in 1923 and the burned areas have fully regenerated and are mature stands. The 2007 fire that was caused by lightning burned ~150ha on the south side of the watershed. The area was salvage logged following the fire and has been replanted. In the past 50 years there have been only two fires, one from natural causes and one by humans. This is a low number and suggests that the wildfire risk is low.

3.1.5 Mineral Development

There are six mineral claims registered in the provincial database within the Kelly Creek watershed. No active development was noted during the fieldwork so the current risk from mineral development is rated as low.

3.1.6 Grazing

There is no grazing in the watershed so the risk is low.

3.1.7 Utility Corridors

There is one BC Hydro power line right of way that crosses the watershed just upstream of the intake (Map 1). The right of way across the creek has been left undisturbed. There was no evidence that the clearing on the slopes away from the creek had caused any impacts on the water so the risk from the right of way is rated as low.

3.1.8 Recreation use

Although the watershed is private land and there are locked gates that restrict access there was evidence that off road vehicles do bypass the gates. There are also other roads into the upper watershed from adjacent drainages that allow recreation users access. During the fieldwork an individual on an ATV was encountered. The area appears to used mainly for hunting which is a low impact activity but can introduce pathogens from careless deposits of human waste. Regardless recreational use is considered a low risk in the watershed.

3.1.9 Climate Change

A more detailed summary on the potential impacts of climate change is provided in Section 5 of this report. The following provides a brief summary of the potential risks to the surface water supply. The Columbia Basin Trust engaged the Pacific Climate Impacts Consortium at the University of Victoria to undertake an assessment of climate trends in the Columbia basin in 2006. The study suggests that based on its assessment of a variety of Global Climate Model results that, as the climate changes, the following are likely effects on surface water sources:

- Average annual temperatures will increase
- Decreased summer precipitation, increased winter precipitation

- More rain, less snow in lower elevations
- Longer growing season
- Increased wildfire risk

The cumulative impacts of these changes will be an increased demand for water by the community during the summer as a result of hotter, drier days, and a decreased supply if the runoff from snow melt is reduced due to a smaller portion of the watershed receiving snow. For BVWS this will mean the potential for a more stressed supply with increasing conflicts as demands increase and supply diminishes.

3.2 Field Investigation

The following is a summary of the field inspections of the watershed and its sub-basins. Detailed information regarding the field inspections are included in Appendix D and referenced throughout the report.

3.2.1 Channel Stability/Disturbance

The riparian zone along the stream channels throughout the watershed remain in an undisturbed state. There are occasions when roads have been constructed near the riparian zone but the stands near the streams are undisturbed. There were 46 stream crossings identified from the available GIS data (Map 1). Not all crossings were examined during the fieldwork since a number of the older roads/trails were overgrown and no longer accessible other than on foot and there may be sites where the crossing has been removed.

The following list describes the assessed locations, as noted on Figure 3:

- The channel at location 6 was stable with a cobble/boulder substrate (Photo 6)[2]. It was noted that sediment from the road running surface and ditchlines was entering the creek at this location.
- At location 9 which is a major tributary entering the mainstem from the north, the channel upstream of the crossing was stable with a boulder/cobble substrate.
- Approximately 80m downstream of the crossing at Location 10 there had been a fillslope failure into the creek. The failure was not recent and the date is unknown. The debris from the slide, soil plus wood filled the creek channel but the water had cut a new channel though the debris (Photo 10). It did not appear that any remedial work had been done to remove the downed trees from the channel. The site was stable and there was no evidence of ongoing impacts to water quality.
- Location 11 was a smaller tributary flowing from the north and had a stable step-pool morphology with moss covered cobbles and abundant wood in the channel (Photo 11).
- Location 14 is the second major tributary flowing in from the north along the east boundary of the watershed (Photo 14). The channel has a boulder/cobble substrate and was stable.
- Location 16 is in the headwaters upstream of Location 14. The channel was dry. Upstream of the crossing the channel was stable with a boulder/cobble substrate. The

[2] All photo references indicate the photo at the referenced Location in the Field Work notes in Appendix D, e.g. Photo 6 is the photo for Location 6.

culvert had been overtopped and the road fill washed out likely by wood debris blocking the culvert (Photo 16a). Vehicles were able to cross the channel but were causing additional disturbance and sediment delivery.

- Location 19 was on a small tributary flowing in from the east. The channel is stable but the road culvert is almost completed blocked by wood debris and bed load (Photos 19 a&b).
- At Location 21 it was noted that the placement of the culvert had created a pool upstream that was full of fine sediment and organics (Photo 21). The material did not appear to be recent and the flow through the pool was clear. There is a road system that crosses three tributaries upstream and there is one cutblock in the upper watershed but the source of the sediment appears to be natural.
- Location 23 is on the main tributary flowing in from the south, below the 2007 wildfire. The channel upstream of the crossing was stable. The fire had not burned the riparian areas.
- Location 27 is located near the headwaters of the tributary flowing in from the south and the closest stream to the intake. The channels were stable (Photo 27). Overall the channels throughout the watershed are stable which is consistent with a stream with intact riparian zones and an ECA less than 20%.

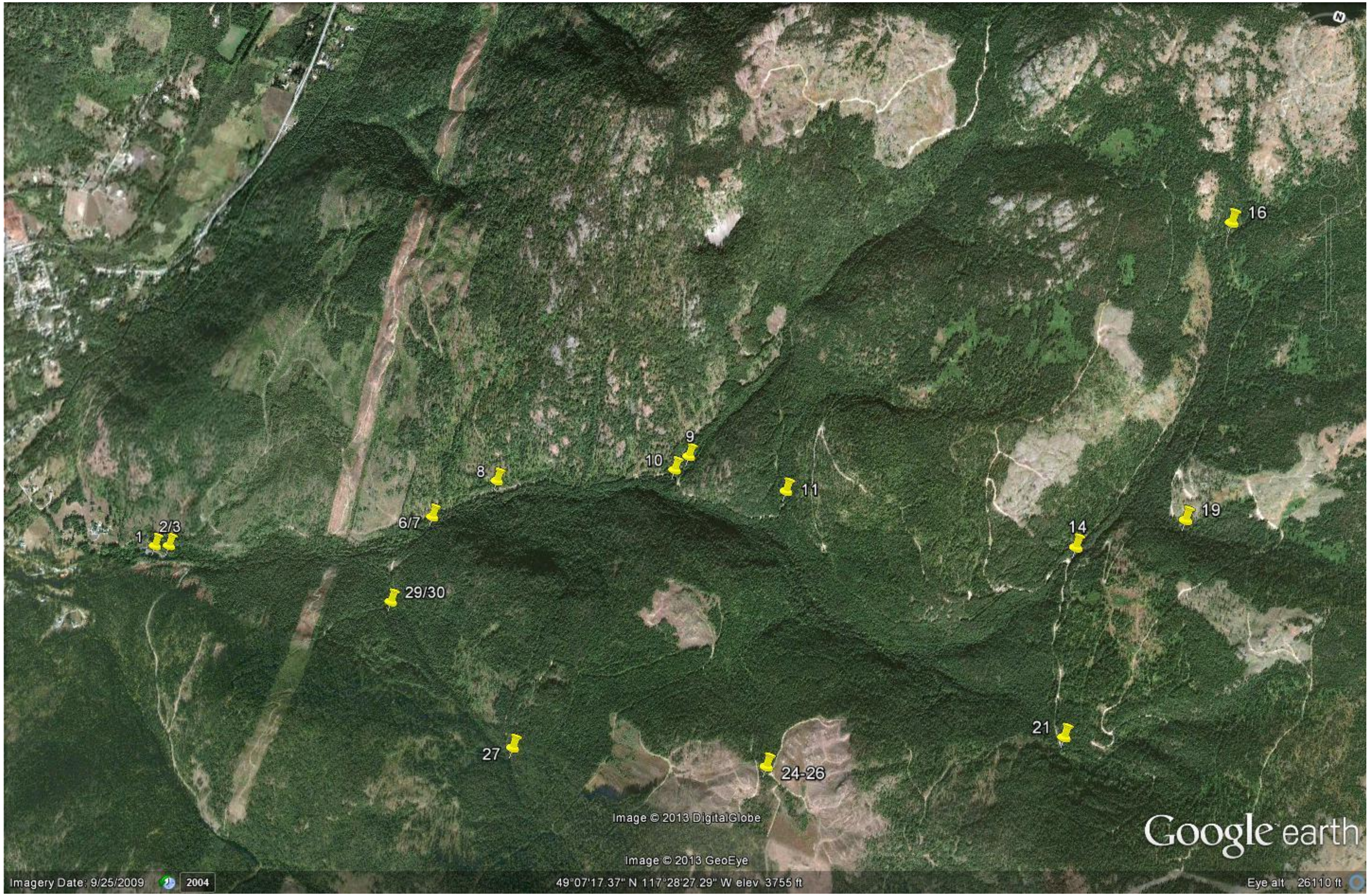
3.2.2 Mass Wasting

Due to the rolling terrain with limited steep slopes mass wasting is not a major concern in the watershed. There were no natural landslides noted in the watershed. There is one fillslope failure of the main access road into a tributary that terminated in the stream (Figure 3 – Location 10). Although the debris filled the channel the flow has established a new channel through the debris and the site is generally stable (Photo 10).

3.2.3 Surface Erosion

There is some sediment delivery off the road running surface in the proximity of stream crossings throughout the watershed. The one section of road that is of concern is located between Locations 6 and 8 on the north side of the mainstem. There is ongoing accumulated runoff down a sustained grade eroding the running surface (Photo 8). The sediment is entering the mainstem at the bridge (Photo 7). Since this crossing is within 1.5km of the intake, the water quality at the intake is affected.

Figure 3: Field Assessment Locations



3.3 Water Supply and Demand

3.3.1 Surface Water Quantity

The following four hydrometric stations have been operated, but have been discontinued, in the watershed by Water Survey of Canada; Kelly Creek near BVWS (Upper Station), 1940, Kelly Creek near Fruitvale (Lower Station) 1940-1942, Kelly Creek near Fruitvale 1946-1951 and Kelly Creek at 850m Contour for the period 1971-1982. Based on the data from the most recently operated station the mean annual runoff is approximately 0.416m^3/s. BVWS's average annual demand is 0.023m^3/s (18% of mean annual flow), however this is not a useful comparison since BVWS's demand varies significantly over the year. Table 3.1 presents the mean daily flow in the creek for each month and also the mean daily demand by month based on the results of BVWS's Water Smart Action Plan (CBT, November 2010). During normal years the data in Table 3.1 suggests that there should be adequate flow in the creek at the intake to meet the demand. It has been reported that during times of drought the low summer flows are not sufficient to meet the demand and during those times BVWS supplements its supply with water from wells. The objective of the Water Smart Action Plan is to reduce demand by 20% that will reduce the annual demand to ~580ML and provide an additional buffer during low creek flows.

Table 3:1 - Kelly Creek Supply and Demand (m3/s)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Daily Flow (m^3/s)	0.109	0.113	0.206	0.673	2.03	1.06	0.33	0.124	0.094	0.085	0.111	0.114
Mean Daily Demand (m^3/s)	0.0157	0.0164	0.0158	0.0176	0.0235	0.0314	0.0434	0.0349	0.0246	0.0167	0.0155	0.0161
Demand as % of Flow	14	15	8	3	1	3	13	28	26	20	14	14

Table 3.2 illustrates the current demand as a function of the minimum daily stream flows as reported in the Water Smart Action Plan. It is evident that the demand is a significant amount of the flow in the months of August and January.

Table 3:2 - Minimum Flows in Kelly Creek and Mean Daily Demand (m3/s)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min Daily Flow (m^3/s)	0.030	0.041	0.063	0.337	0.906	0.338	0.109	0.059	0.049	0.056	0.049	0.063
Daily Demand (m^3/s)	0.016	0.016	0.016	0.018	0.024	0.031	0.043	0.035	0.025	0.017	0.016	0.016
Demand as % of Flow	52	40	25	5	3	9	40	59	51	30	32	26

3.3.2 Surface Water Quality

The Interior Health Authority regulates the drinking water quality for water delivered by the BVWS through the administration of the *Drinking Water Protection Act* (http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/00_01009_01) and the Drinking Water Protection Regulation (http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/200_2003). The federal government provides guidance for drinking water quality through the Guidelines for Canadian Drinking Water Quality (http://www.hc-sc.gc.ca/ewh-semt/water-eau/drink-potab/guide/index-eng.php) however these are guidelines only, for the information of water suppliers and are not standards or requirements. It is important to understand that the provincial Act and Regulations address treated water, not raw water quality.

A search of the provincial databases including the Interior Health Authority did not result in any evidence of issues or concerns by the regulators regarding either raw water or treated water. That being said, it is understood that Kelly Creek has a history of elevated turbidity during spring freshet and following intense summer rainstorms that is typical for surface water supplies. During periods of high turbidity the BVWS switches the supply from surface water to groundwater in order to continue delivery of safe drinking water to the community. It is likely that part of the turbidity issues are related to sediment delivery from the road network in the watershed, in particular the section near the first crossing. The debris from the landslide near Location 10 may be adding to the sediment load during high flows. Raw water quality for Kelly Creek at the intake was not available.

Over the long-term the raw water quality should not deteriorate since the forest development by Kelly Creek Timber appears to be planned and implemented with the recognition that watershed is also the source of water for the BVWS area. In fact, it may be possible for Kelly Creek Timber to address some of the road issues and the slope failure that could reduce some of the anthropogenic sediment sources. This will be addressed in the Recommendations section of this report.

3.3.3 Infrastructure vulnerability

BVWS has developed an off-stream intake pond that supplies water to its water treatment plant where water is filtered through a series of sand filters before chlorination (Photo 1). The intake on the creek is a below the bed gallery that allows debris, coarse sediment and high flows to pass downstream (Photo 3). The intake is situated immediately downstream of a section of bedrock channel that adds additional protection to the instream works. The intake and off stream pond were constructed in the 1980's. The water treatment plant was built in the 1990's. This design is considered to have a low vulnerability to damage during peak flows that bypass the intake pond.

3.3.4 Supply vulnerability

Unfortunately there are no lakes in the watershed and no feasible sites for creating storage upstream of the intake. Therefore BVWS is vulnerable to drought conditions that may reduce streamflows to volumes less than the demand. There are 34 water licences registered on the creek. The Regional District of Kootenay Boundary holds two of the licences, C63883 for 331,865 cubic meters per year (331.865 ML/yr) with a priority date of December 17, 1946 and number 18 in priority, and C63887 for 597,356 cubic meters per year (597.356 ML/yr) with a priority date of December 30, 1985 that is number 33 in priority. BVWS's total licenced volume of 929,221 cubic meters (929ML) exceeds the current demand of approximately 727,000 cubic meters (727ML) by ~28% so Fruitvale is well within its licenced volume.

Domestic licenses other than BVWS's account for 6.97ML/yr or ~0.7% of the licenced volume. During periods of low there are five priority domestic licences before BVWS's 1946 licence with a combined demand of 0.000006m^3/s that would have priority over the BVWS's licences. Minimum flows in August are approximately 0.059 m^3/s (Table 3.2). Fruitvale's 1946 water licence allows for the diversion of ~0.01m^3/s which would leave 0.049m^3/s of flow that is well in excess of the demand of 0.000006m^3/s required to supply all the priority domestic licences.

BVWS's 1985 water licence that is priority 33 has 11 priority domestic water licences ahead of it with a total demand of ~0.0005 m^3/s. During periods of drought, in August, as noted above, after diverting the water for its 1946 licence and allowing for all the other priority domestic licences, there would still be ~0.048m^3/s of flow. The 1985 licence allows for the diversion of less than 0.02m^3/s which would still leave ~0.028m^3/s of residual flow. In summary, during periods of drought, even allowing for all the priority domestic licences (not irrigation licences) there should be sufficient flow in the stream to meet BVWS's demand.

Fortunately BVWS has two wells that are used to supplement the supply during periods of low stream flow. Currently BVWS has approximately 4,900 cubic meters (4.9ML) of storage in its system that would meet its normal daily demand in August of ~3,000 cubic meters (3ML) per day for approximately a day and a half without any supplementary water from the wells.

The results in Table 3.2 indicate that during periods of estimated minimum flows in the creek, BVWS's demand could reach 60% of the daily stream flow in August and approximately 50% of the January flows. The priority domestic licences account for a minimal volume. Recognizing that the available data is not current and that there is a history of BVWS supplementing the creek supply with groundwater, even though the available data suggests that there should be adequate water in the creek, the surface water supply is considered to have a high vulnerability.

3.4 Risk Assessment

The risk assessment considers the hazards to drinking water quality identified in section 3.3, along with the consequence to drinking water should a contaminant or combination of contaminants reach the intake. The risk ranking is the basis for the determination of the overall hydrologic risk in the watershed. This risk assessment is consistent with the principles outlined in the *Comprehensive Drinking Water Source to Tap Assessment Guidelines*. In evaluating the risks, consideration is given to the opportunities to buffer the intake from upstream impacts. Buffers could include upstream lakes or reservoirs, and the presence of low gradient reaches upstream where contaminants could settle out. Intakes may be rated as buffered, partially buffered, or not buffered depending upon the watershed characteristics. In the case of the Kelly Creek watershed since there are no lakes or reservoirs, or low gradient reaches upstream of the intake, the intake is rated as unbuffered which means it is vulnerable to changes in water quality.

3.4.1 Defining Risk

The risk assessment model used in this hydrologic assessment is similar to the one outlined in the *Comprehensive Drinking Water Source-To-Tap Assessment Guideline*, with some simplifying modifications, and is summarized in the sections that follow and in the following simple equation:

RISK = Likelihood of Hazard occurring x Consequence to the water supply if impacted by the Hazard

It is important that the terms used in the risk assessment are clearly understood. The following sections define risk hazard, consequence, and likelihood.

Hazard

A hazard is an event, condition, action or inaction that may pose a threat to human health or a sustainable supply of water.

Consequence
A consequence is defined as the nature and degree of impacts if a hazard does occur (Table 3.3).

Table 3:3 - Qualitative Measures of Consequence

Descriptor	Description
Minor	Minor impact to small population, none to mild illness possible, little or manageable operation disruption, little or no increase in operating cost
Moderate	Minor impact for larger population, mild to moderate illness probable, significant modification to normal operation but manageable, operating costs increase, increased monitoring
Major	Major impact for small population, severe illness probable, systems significantly compromised and abnormal operation if at all, high-level monitoring required

Note: the "Insignificant" and "Catastrophic" levels of consequence were removed from the Guideline table for simplicity.

Likelihood
Likelihood is an estimate of the probability that a hazard, a harmful event, condition, action or inaction would occur over a defined period of time, and the negative impacts that could result (Table 3.4).

Table 3:4 - Qualitative Measures of Likelihood Table

Descriptor	Description	Probability of Occurrence in next 10 years
Likely	Will probably occur in most circumstances	71-90%
Possible	Will probably occur at some time	31-70%
Unlikely	Could occur at some time	10-30%

3.4.2 Characterizing Risk
Risk is the combination of the likelihood that a hazard will occur and cause harm, and the extent and degree of that harm (consequence) (Table 3.5).

Table 3:5 - Qualitative Risk Analysis Matrix Table

Likelihood	Consequences		
	Minor	Moderate	Major
Likely	Moderate	High	High
Possible	Low	Moderate	High
Unlikely	Low	Low	Moderate

3.4.3 Hazards in Kelly Creek Watershed
The hazards in Kelly Creek were defined in the following three categories, physical, biological, and chemical.

Physical Hazards
Sediment - Suspended sediment/turbidity is not directly harmful but can compromise the disinfection process and therefore the consequence from all sources is assumed to be at least moderate. Water is diverted from the creek into an intake pond where settling action can reduce

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the consequence from sediment and turbidity introduced upstream to water quality at the intake but remain rated as a moderate consequence.

Sediment from natural sources such channel erosion will continue to occur especially during periods of high flow. Only one landslide was identified that may still contribute some sediment occasionally. The risk of new landslides is considered to be low.

Sediment from human activities has been identified throughout the watershed however overall it is limited. Ongoing attention to roads is recommended. Roads not required for active logging use should be deactivated (temporary or permanent). A watershed access plan would help determine appropriate levels of deactivation for existing roads as well as future roads. It was noted during the field assessments that there are access control gates on some of the roads. They were all closed and locked at the time.

Stream flow- High peak flows during freshet can degrade water quality as a result of increased sediment loads. The equivalent clear-cut area is ~20% that is considered to present a low hazard to affecting flows. The intake design allows for most coarse sediment and debris to pass the intake and the intake pond is located off-stream. The likelihood of increased peak flows impacting the supply is rated as low.

Wildfire - The consequence from a wildfire in the watershed is low. There have only been two wildfires in the watershed over the past 50 years that burned less than 150 ha (6% of the watershed). Wildfires remain a concern, although the overall risk of a wildfire is low, the consequences from a large wildfire would be high.

Climate change - Over the longer term possibly 50 years and beyond, if the precipitation and temperature patterns change as suggested by the PCIC research, runoff may decline as a result of less snow and warmer temperatures. Lower water yields would mean less supply however based on the current and projected demand and the robust supply, and on a time horizon of 10 years, the likelihood of these changes having detectable impacts on the water quantity is rated as unlikely.

Biological Hazards

Bacteria, protozoa and viruses - The presence of bacteria, protozoa and viruses is a concern to drinking water safety since small concentrations of these contaminants in drinking water could lead to impaired human health. The consequence of bacteria, protozoa and viruses being present in treated drinking water would be high however the likelihood of this occurring is low as long as the water treatment plant is functioning as designed.

Fecal Coliform/E.coli - Wildlife and humans are potential pathogen sources in the watershed. Wildlife movement in the watershed is unknown but it is likely that during the course of a year most of the stream crossings are used by wildlife. Even though the watershed is private land it is frequented by people for recreational/hunting purposes. Pathogens entering the stream network from animal and human waste is likely.

Chemical Hazards

Total organic carbon and hydrocarbons - Chemical hazards to drinking water, total organic carbon and hydrocarbons, are considered a minor consequence. The presence of total organic carbon is an indicator of organic compounds that could contribute to the formation of trihalomethane compounds following chlorination. Small volumes of hydrocarbons from fuel spills can contaminate large volumes of water. The contaminants are typically less dense than water and affect the surface water only. Hydrocarbon compounds associated with petro-chemical spills are also volatile and can evaporate quickly depending on water and air temperatures. The amount of total organic carbon in the raw water is not known but based on the field assessment the level is likely low. A petroleum spill is possible but due to the limited industrial activity and controlled access, a significant spill is unlikely and the likelihood of a spill occurring that would affect the water at the intake is considered unlikely.

3.5 Risks to Drinking Water Quality and Quantity

Table 3.6 provides a summary of the hydrologic risks related to the Kelly Creek supply.

Table 3:6 - Hydrologic risk summary for Kelly Creek supply.

Category	Hazard	Likelihood	Consequence	Risk
Physical				
Landslides	Sediment	unlikely	moderate	**low**
Forest development	Increased peak flows	possible	moderate	**moderate**
Forest development	Low flows	unlikely	high	**moderate**
Forest development	Timing of runoff	unlikely	low	**low**
Forest development	Water yield	unlikely	moderate	**low**
Forest health	Water yield	unlikely	moderate	**low**
Wildfire	Water yield	possible	low	**low**
Climate Change	Water yield	likely	Moderate	**high**
Priority water licences	Water supply	unlikely	High	**moderate**
Biological				
Wildfire	Water quality	possible	low	**low**
Mineral development	Water quality	possible	moderate	**moderate**
Grazing	Water quality	unlikely	moderate	**low**
Utility Corridors	Water quality	unlikely	low	**low**
Recreation use	Water quality	possible	moderate	**moderate**
Chemical				
Total organic carbon	Water quality	possible	moderate	**moderate**
Hydrocarbons	Water quality	unlikely	moderate	**moderate**

4.0 GROUNDWATER

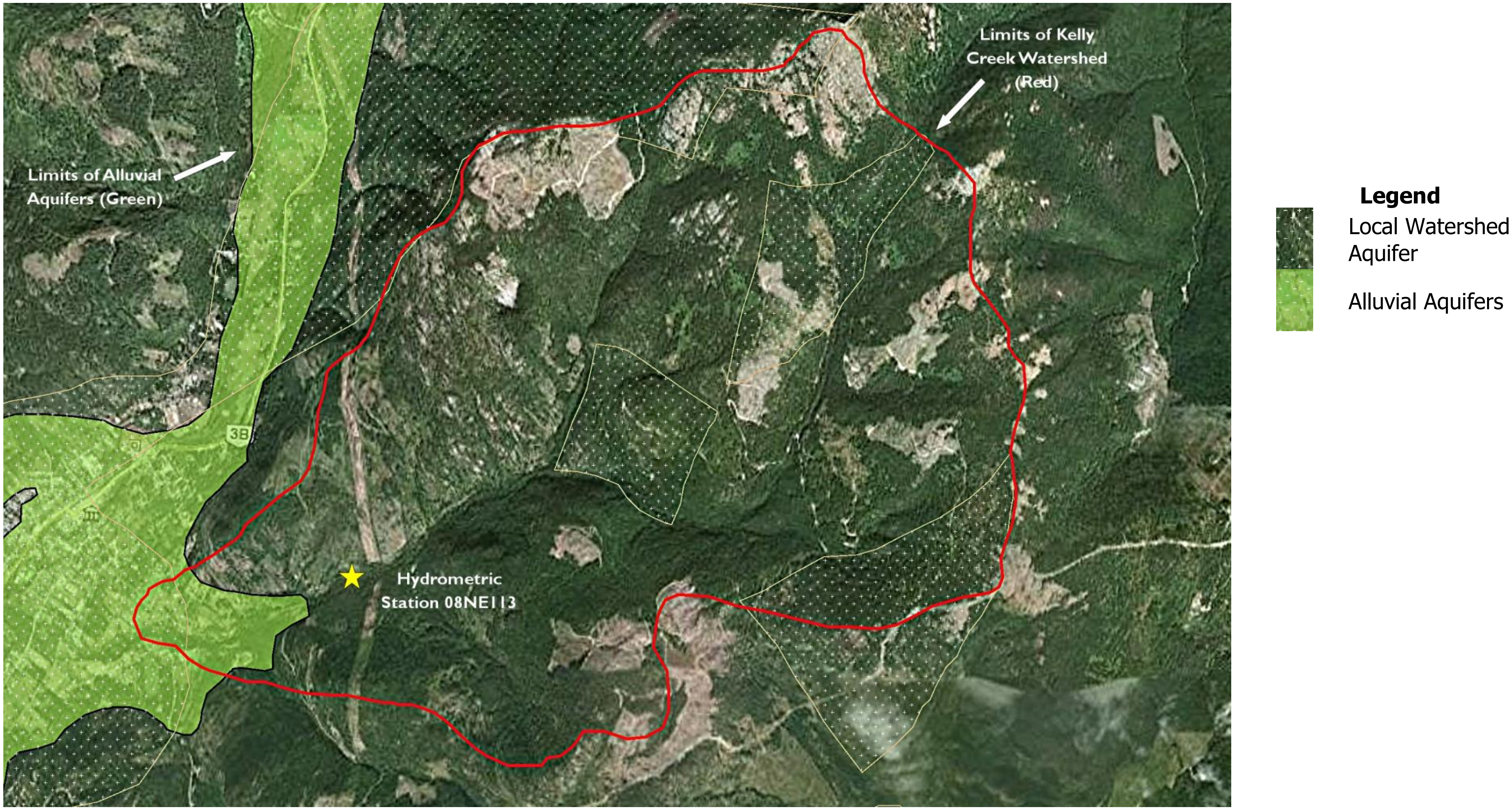
The Kelly Creek watershed is a mountainous watershed covering an area of approximately 29km^2, located in the upland area to the east of Fruitvale & EAA RDKB. The watershed is a sub-catchment to the much larger Beaver Creek watershed, which is approximately 190km^2. The Kelly Creek watershed extends approximately 11km to the north east of Fruitvale and the two watersheds confluence within the community (Figure 4). The elevation of the top end of the catchment reaches 1,850 meters above sea level (m asl) whereas the confluence with Beaver Valley at the lower end of the watershed occurs at approximately 580m asl. The mean first order surface gradient of the watershed is therefore 0.14, which is relatively steep. This infers that groundwater flow within the catchment is driven predominantly by topography (gravity).

The BVWS area contains both unconsolidated and bedrock aquifer types. Unconsolidated aquifers typically consist of various mixtures of sand, gravel, cobbles, silt, and/or clay sediments and this type of aquifer exists underneath the community in the lowest elevation portion base of Beaver Valley. Groundwater within unconsolidated aquifers exists in the pore space between the sediment grains and can migrate through the aquifer because the pores are connected.

Bedrock aquifers dominate the highland areas surrounding BVWS, but may also be present beneath unconsolidated deposits in lower elevation areas. Groundwater in bedrock aquifers resides in the rock fractures and may migrate through the aquifer where the fractures are connected. However, groundwater migration through fractured bedrock may be significantly limited if the fracture zones are isolated (not connected to other fractures). Approximately 95 percent of the Kelly Creek Catchment is dominated by bedrock, in some cases overlain with a relatively thin (less than 2 m thick) veneer of alluvium. The dominant bedrock type underlying the watershed is the Elise Formation, which is part of the Rossland Group and characterized as a Lower Jurassic period basalt. The less dominant rock type in the basin is the Hall Formation, which is characterized as fine clastic sedimentary rock (argillite and siltstone).

Information available from the Ministry of Environment (MoE) water well database (WELLS), and the on-line graphical interface, the Water Resources Atlas (WRA), was reviewed for the area. The WRA also provides topographical, geological and surface water information, as well as the extent of aquifers mapped using the MoE Aquifer Classification System (Kreye et al, 1998). The WRA indicates there are aquifers along the flanks of Beaver Valley, to the northeast, northwest and southeast of the point of confluence between Kelly Creek and Beaver Creek. These include Aquifer 494 (IIB), Aquifer 495 (IIB) and Aquifer 486 (IIB). There are an insufficient number of wells completed in the alluvium along Beaver Creek to warrant classification under the aquifer classification system. However, there are several wells completed in the alluvium located immediately north of the junction of Bluebird Road and Scout Road. The wells range from 50ft to 75ft and are capable of yielding as much as 18.9L/s (300USgpm), depending on the saturated thickness and grain size distribution of aquifer materials encountered. Wells operated by the Beaver Valley Improvement District and the Village of Fruitvale are completed in the alluvium.

Figure 4: Aquifers in and around the Kelly Creek watershed



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There are no known water wells and no aquifer located within the Kelly Creek Watershed. However, there are some relatively shallow bedrock wells and springs present at the extreme lower end of the catchment, in the area where the geology transitions from bedrock to alluvium, generally in the area of Greenhouse Road along the north flank of Kelly Creek and in the area of Old Mill, Webster and Nine Mile roads to the south of the Creek. Similar to the base of the main valley, there are an insufficient number of wells for these areas to be characterized as aquifers under the classification system. Wells in bedrock in the Fruitvale area are capable of producing a maximum of 1.6L/s (25 USgpm) and on average less than 0.3L/s (5 USgpm).

Precipitation falling within the watershed will generally partition to surface water runoff (i.e., creek discharge), evaporation, transpiration by plants, and recharge to groundwater. A basic water balance approach to estimating recharge requires knowledge of precipitation rates, catchment areas, surface water run-off volumes, and evapotranspiration rates. Groundwater discharge provides the base flow to streams and creeks and may be the only source of flow during the drier (and coldest) periods of the year.

Based on information available from the interactive on-line Climate-BC Map, the total precipitation in the Kelly Creek watershed is in the order of 1,050mm/yr, whereas the estimated evapotranspiration is in the order of 650mm/yr, or roughly 62 percent. Recharge to groundwater occurs predominantly during spring snowmelt (April to June) and during the months where precipitation exceeds evapotranspiration, from November through February.

Historical surface water flow in Kelly Creek is available at four locations and was used to estimate mean annual runoff. Based on the data from the hydrometric station Kelly Creek at 850m Contour (08NE113), the mean annual flow in the creek above the dam is on the order of 13,119ML. The stream flow represents roughly 42 percent of the total precipitation falling in the catchment, indicating that evapotranspiration losses account for roughly 58 percent of the water balance. This value is consistent with the evapotranspiration estimated using the value from the Climate BC Map. For comparative purposes, another similarly detailed study completed in the Kootenay Region derived an estimate for evapotranspiration in the range of 48 to 66 percent (Klohn-Crippen, 2005).

The base flow in the creek has been estimated to be on the order of 1,700ML or roughly 13 percent of the mean annual streamflow. In other terms, the base flow is equivalent to roughly 5.5 percent of the annual precipitation in the catchment. This is consistent with other studies in British Columbia which have estimated groundwater recharge to bedrock using base flow recession methods to range between 4 and 10 percent of mean annual precipitation (Golder et al, 2008/2009). Base flow is derived from the sum of deep subsurface flow plus delayed shallow subsurface flow. In theory, base flow represents the volume of flow required to sustain the groundwater levels (and flow) in the aquifers in the catchment and hence, the annual groundwater recharge.

Therefore, represented as a flow rate, the total volume for groundwater recharge in the upper part of the catchment is equivalent to 55L/s (870USgpm). In the absence of information regarding groundwater levels within the bedrock, it is difficult to determine if the estimated base flow is comprised primarily of the shallow (localized) flow, versus deep-seated (regional) flow. Hydrometric flow data for additional stations at more locations along the Creek and for the same period of record would assist with a more detailed assessment. Therefore, an estimate of well yield for the bedrock can only be based on information available from the limited number of wells logs available from the WRA for the lowest elevation portion of the Catchment.

Table 7 presents a summary of information for the 30 wells known to exist in the Fruitvale area. Information for 9 of the wells completed in bedrock within the lower portion of Kelly Creek indicates the average depth for a well in bedrock is 61m (200ft) and the average yield is 0.3L/s (5USgpm).

In summary, the groundwater development potential within the Kelly Creek Catchment is limited within the lower portion of the catchment to wells capable of providing on the order of 0.3L/s (5USgpm).

Table 4:1 - Groundwater well summary for wells within the Fruitvale area

Well Tag No	Water Depth (ft)	Yield Value (gpm)	Depth Well Drilled (ft)	Diameter	Bedrock Depth (ft)	Aquifer Lithology Code	Date Drilled	Date Drilled	Elevation	Ground Water Flag	Owner	Well ID Plate No.	Well Use Name
000000093184		10	354		46	BED	24-Sep-07	23-Sep-07	2192	N	WEATHERFORD	19698	Private Domestic
000000095279	30	7	195		8	BED	20-Jul-09	20-Jul-09	2354	N	SAMULAK	28764	Private Domestic
000000053839		4	200	6.0	7	BED		31-Jul-84	0		DAVE BORTNICK		Private Domestic
000000085838		1	595	6	93	BED	21-Jun-06	19-Jun-06	2092	N	BISARO	11892	Private Domestic
000000031296	250	0.5	600	0.0	120	BED		20-Sep-74	0		STEINEMAN W		Unknown Well Use
000000093181		2	456		105	BED	23-Sep-07	19-Sep-07	2139	N	STEINEMANN	19697	Private Domestic
000000093182		25	380		200	BED	27-Sep-07	24-Sep-07	2696	N	NELSON	19699	Private Domestic
000000099587		10	295		15	BED	23-May-05	23-May-05		N	ROTHWELL		Private Domestic
000000099636	30	3	235		7	BED	17-Jun-02	17-Jun-02		N	MONCRIEFF		Private Domestic
000000099741	40	15	116			BED	13-Nov-01	13-Nov-01		N	LAROCQUE		Private Domestic
000000040860	100	3	375	6.0	50	BED		22-Oct-78	0		BILL HOPPER		Unknown Well Use
000000048991		15	160	0.0	55	BED		31-Aug-81	0	N	DAVE HENKE		Private Domestic
000000039942	150	2	370	6.0	30	BED		23-Jun-78	0		LES STAATS		Unknown Well Use
000000040856	40	3	150	6.0	73	BED		19-Oct-78	0		TERRY COOMBS		Unknown Well Use
000000102927	10	3	396			BED	26-Oct-10	26-Oct-10	2680	N	LAFRENIERE	28886	Private Domestic
000000051462			34	0.0	32	UNC		31-Dec-82	0		BEAVER FALLS WATERWKS		Unknown Well Use
000000025275	9	300	58	6.0		UNC		18-Aug-71	0		BEAVER FALLS WATERWKS		Unknown Well Use
000000101668	25		76			UNC	25-May-05	25-May-05		N	BEAVER FALLS WATERWKS		Water Supply System
000000018231	9	200	49.6	10.0	49	UNC		30-Sep-63	0		VILLAGE OF FRUITVALE		Other
000000051463			20	0.0	16	UNC		31-Dec-82	0		BEAVERFALLS WATERWKS		Unknown Well Use
000000052396	4	150	214	8.0		UNC		30-Jun-83	0		BEAVER FALLS WATER		Unknown Well Use
000000027582	6	250	68	10.0		UNC		30-Jan-73	0		BEAVER FALLS WATER		Unknown Well Use
000000066087	16	5	35	6.0		UNK		24-Oct-88	0	N	BROWN JEFFREY D		Private Domestic
000000086316	100	10	319		25	UNK	10-Oct-06	9-Oct-06	2614	N	MUISE	17110	
000000088326		10	97		10	UNK	16-Jul-07	16-Jul-07	2252	N	COFFIN & MCKENZIE	19664	Private Domestic
000000074709			118	0.0		UNK		5-Apr-90	0	N	JOHN M WILSON		Private Domestic
000000074711	40	25	118	6.0	30	UNK		12-Oct-89	0		RICHARD HIGGINS		Private Domestic
000000091110	113	5	260		105	UNK	8-Nov-05	8-Nov-05		N	KNIGHT		Private Domestic
000000086188	38	4	258		30	UNK	14-Dec-06	12-Dec-06		N	MUISE	17683	Private Domestic
000000103659		3	496		42	UNK	27-Sep-09	22-Sep-09	1950	N	MORRISON	28724	Private Domestic
Geo Mean	31.1	8.9	171.0		35.0								
Max	250.0	300.0	600.0		200.0								
Min	4.0	0.5	20.0		7.0								

5.0 CLIMATE CHANGE AND LONG TERM TRENDS

In 2006 the Columbia Basin Trust (CBT) engaged the Pacific Climate Impacts Consortium at the University of Victoria to undertake a preliminary assessment of climate trends in the Columbia basin. The CBT released the report A Preliminary Assessment of Climate Trends, Variability in Change in the Canadian Portion of the Columbia Basin From Dialogue to Action (September 2006). The following is an excerpt from the report that summarizes its findings related to the water resources:

A changing climate will have impacts on the Basin environment, creating changes in watersheds and ecosystems. This section…. explores the impacts on human economic and social systems in our communities that may occur directly as a result of climate changes and as a result of climate-related changes to the natural environment.

Increases in Water Temperatures
Water temperature is one of the main regulating factors of aquatic ecosystems. Rising summer air temperatures are expected to increase water temperatures in streams and lakes in the Basin. The projected changes in glacial runoff described above may reduce cold water inputs to Basin watersheds and contribute to increased water temperatures.

Different species will respond differently to warming temperatures. For temperature-sensitive species, increases in water temperature could result in increased disease, an increased requirement for energy expenditure, altered growth, thermal barriers to migration and reduced reproductive success. Some species, including salmonids like bull trout, will likely be negatively impacted and displaced in locations where they are currently close to their tolerated temperature ranges. Conversely, in locations where water temperatures are currently below-optimal for fish, increased water temperatures may promote fish growth and survival. Warmer water temperatures may also lead to changes in water quality.

Earlier Spring Peak Flows, Decrease in Late Summer Flows and More Rapid Runoff
The seasonal flow patterns of Basin rivers and streams have changed. While most of the stream systems in the Basin have historically been snow-dominated, some streams in low-elevation watersheds are shifting toward being hybrid or rain-dominated as the climate changes.

A study of the Columbia River Basin found that the spring peak flow occurred 20 days earlier between 1984 and 1995 than between 1970 and 1983. Another study of flows in the Columbia River at the Canada-U.S. border from 1970 to 2000 found a decreasing trend in maximum annual flows, with an approximate 25% reduction over that period. It also found that maximum flows during this period occasionally occurred in winter rather than summer, potentially associated with major winter melting episodes. However, due to the operation of dams in the Basin affecting the timing of storage and release of water these findings cannot directly be attributed to a changing climate.

A study projecting future stream flows for the Canadian Columbia Basin indicated that the median total annual flow for the Columbia River will increase by 10% by the 2050s, with increases ranging between 3% and 19% depending on the location. Projected seasonal changes include: an earlier onset of spring melt; substantially higher flows during spring and early summer, with peak flows shifting one month earlier (from July to June); lower late summer and early fall flows; and, an increase in monthly flows during late fall and winter. Another study found slightly different shifts, projecting earlier spring peak flows and reduced runoff volumes in the Columbia River from April to September by the 2040s.

Changes in stream flow are expected to impact the timing and quantity of water available and the quality of that water. Higher peak flows may result in increased water turbidity and lower flows may result in higher water temperatures. This is expected to impact aquatic ecosystems, as well as individual aquatic species. The study that projected reduced runoff volumes in the Columbia River by 2045 from April to September suggested that the reductions will be large enough to cause negative impacts on fish. As well, the expected increase in winter flows may affect fish species. For example, eggs of fall- and winter-spawning fish, like bull trout, may suffer higher levels of mortality during increased winter flows in rain-dominated and hybrid regimes.

Increase in Rain-on-snow and Rain-on-frozen-ground Events

The projected warming and increases in winter precipitation falling as rain could result in an increase in *rain-on-snow and rain-on-frozen-ground events in the Basin. Rain-on-snow and rain-on-frozen-ground events cause more runoff than rain falling on soil because the soil is less permeable when it is frozen, plus rain can cause a partial melt of the snow or ice. As a result, these types of events can result in landslides, mass-wasting of hill slopes, damage to riverbanks and downstream flooding.*

Shifts in Timing and Scale of Flooding

More frequent intense rainstorms, increased glacier melt, rain-on-frozen ground, rain-on-snow and higher winter peak flows may increase the risk of flooding, with more events occurring in late winter/early spring than in the past. Studies on specific expectations for flooding have not yet been undertaken in the Basin. However, projected increases in stream flow suggest a need for flood control and response requirements to be be reviewed and updated as needed.

Flooding was identified as a major concern in the communities of Elkford, Kimberley and Castlegar through community-planning processes. Discussions in these communities highlighted concerns regarding the potential for flooding of buildings, lands and infrastructure (such as sewer lagoons), the potential for damage to bridge integrity and the capacity of culverts and stormwater systems to handle peak flows.

More Frequent and Intense Droughts

The combination of lower winter snowpacks at lower elevations, less summer rainfall and warmer summer temperatures with more hot days and longer warm spells may cause lower summer soil moisture levels, creating more frequent and intense drought conditions. Even if rainfall doesn't decline in summer, higher summer temperatures will cause more evaporation from land and water bodies, as well as transpiration through plants, which could lead to the occurrence of drought conditions more often, and potentially more severe droughts than in the past. In the Cranbrook area, one study projected that the climatic moisture deficit—the amount by which the monthly the monthly precipitation is less than the monthly evaporative demand—will become 30% to 60% larger by the 2080s.

Changes in Diseases and Pathogens

Climate change is expected to result in an increase in diseases spread by water, animals, insects and air. Increases in temperature and increases in precipitation in some seasons and locations, as well as a decrease in cold temperatures or the lengths of periods of colder temperatures, could contribute to the increase or prolonged transmission cycle of certain diseases, such as influenza, food-borne gastroenteritis and waterborne diseases. These changes in climate could also result in an expansion in the ranges of disease-causing agents such as mosquitoes, ticks, rodents, and fungi like Cryptococcus gatti, with a resultant expansion in related diseases such as Lyme disease, hantavirus and West Nile virus. Originally found in the tropics, Cryptococcus gatti can now be found in Washington, Idaho and Vancouver Island.

Increase in the Frequency and Severity of Wildfires

In BC, the amount of area burned by biogeoclimatic zone has declined over the past century, as has the annual area burned in the West Kootenay. However, the wildfire season in BC has been increasing in length by one to two days a year since at least 1980, and the annual area burned in the West Kootenay increased slightly in the last decade of the twentieth century (but remained less than the annual area burned in the early part of the century). Studies in the U.S. and Canada have also noted increases in area burned since the 1980s, and have suggested that this may be linked to climate change.

Wildfire frequency and severity is expected to increase due to increases in summer temperature, very hot days, longer warm spells, reduced summer precipitation, fuel accumulation, extended droughts and pest outbreaks. There is considerable variability and uncertainty in models used to predict future wildfire activity. One projection for BC suggests an increase in the seasonal fire severity rating and an increase in fire season length of one to two weeks by 2045. Fire starts in BC have been projected to increase by 21% to 190% by 2100, with regional variation. Modelling for the West Kootenay projects a dramatic increase in average annual area burned by the 2050s: by at least four times in the south and five times in the north.

Wildfires are part of the natural process of forest renewal in Basin forest ecosystems. However, they can be major disturbances and could permanently alter ecosystems depending on the frequency and severity of fire events. After a wildfire in a dry, low-elevation forest, conditions may become unsuitable for tree regeneration, creating opportunities for invasive species, grasses and shrubs to colonize or re-colonize a previously forested area. Over time, these conditions may result in an increase in grasslands and shrub-dominated ecosystems in the Basin. While wildfire is generally a desirable part of grassland regeneration, very intense and large fires that result in the total destruction of vegetation and significant soil damage could damage grassland ecosystems and result in extirpations of important grassland species. Conditions after these events could favour invasive species.

Wildfires also affect air quality and change water flows. After a very hot fire, soils often absorb and hold less water, resulting in increased runoff that can cause erosion, landslides, flooding and damage to aquatic ecosystems, especially in steeper areas. One study in Keremeos showed that soils remained more than 50% strongly water repellent two years after a fire.

Risks to Biodiversity and Increases in Pests

…… Climate changes are expected to favour non-native and invasive plant species, insects and disease pests, which will cause them to further establish themselves in disrupted ecosystems, as has already been seen with mountain pine beetle and spruce budworm in parts of the Basin. Extreme temperatures and increases in climate variability may have greater impacts on the abilities of species to adapt than increases in mean temperatures. Climate-change-related disturbances—such as wildfire, flooding and high-intensity rainfall—will also affect ecosystems.

In summary, the results of the research commissioned by the CBT into climate change suggests that there will be negative impacts on the water resources both surface and groundwater that may impact the water supplies for BVWS over the long-term. Proactive initiatives by the community such as the Water Smart Action Plan (November 2010) and this hydrologic assessment of the Kelly Creek and groundwater resources will assist in developing plans to reduce demands and increase supplies that will reduce future risks.

6.0 DATA GAP ANALYSIS

According to Kelly Creek Timber the company has undertaken a number of watershed assessments and has completed recent analysis of the past harvesting to determine a current equivalent clear-cut area. The results of the assessments undertaken by the company would have been useful in this assessment however this information was not made available. This represents a gap in the data available that would have been "nice to have" but was not considered critical to the project since the review team was permitted to access the watershed by Kelly Creek Timber and was able to assess the actual watershed conditions.

Raw water quality data was not available. A search of the provincial databases did not result in any reports or data specific to the watershed. Atco Lumber was contacted and supplied all pertinent information that it had in its files on the watershed for the area within it operates however this is a very limited area. It is likely that Kelly Creek Timber has reports and data that would have been of value to the assessment if the information were made available. This source of data and information remains a gap.

Current water quantity data e.g. hydrometric data is not available since the Water Survey of Canada station Kelly Creek at 850m Contour was discontinued in 1982. It has been determined through studies of other streams in the interior of BC by Environment Canada and others that water yields in the latter part of the last century, i.e. 1980 and later, were lower than for the period 1950-1980. This is likely a result of a changing climate. Since the only available stream flow data for this assessment was for the period 1971-1982, it may be that the data over-estimates the actual runoff. Accurate current stream flow data is a gap.

There was very limited soil data available. This data is helpful in assessing the potential for erosion in the watershed. Similarly there was no detailed channel assessment data made available that would have been useful in determining the potential risk of channel instability on water quality at the intake. There may have been channel assessment work completed for Kelly Creek Timber but this is not known. Comprehensive data on soils and channels is a gap but was addressed through discussions with Fruitvale staff on sediment issues at the intake and through field observations.

7.0 CONCLUSIONS

The hydrologic condition of the Kelly Creek watershed is considered to be good. In terms of watershed function it is in a "functioning" condition. The hydrologic assessments of the Kelly Creek water supply and also the groundwater resources available to the community concluded the following:

7.1 Raw Water Quality

The raw water quality in Kelly Creek is generally good. There are occasions during the spring freshet and rainstorms when the turbidity increases but this is typical of surface water sources in the interior of BC.

There are two point sources of sediment to the creek that may be impacting the water quality at the intake and a non-point source. The two point sources are the section of road immediately upstream of the first road crossing (Location 6) above the intake that are accumulating runoff and delivering sediment into the creek at the bridge. The second is the landslide at Location 10 that terminates in the creek and may be impacting water quality during high flows. The non-point source is the road system, specifically those sections of road near stream crossings where it was noted that runoff from the road can deliver fine sediments to the creek.

No records were found indicating any issues from the Interior Health Authority regarding raw water quality in Kelly Creek.

There were no significant issues related to groundwater quality noted in the review of the available data on file.

Climate change has the potential to impact surface water quality as a result of increased water temperature that promotes aquatic growth, impacts of rapid runoff on channel stability and surface erosion, increased risks of wildfires, increased risks of the introduction of pathogens into the water supply, and increased risks of forest health issues affecting the forests in the watershed.

Water quality data gaps include a lack of current hydrometric data, raw water quality data, soils information, groundwater quality data, and channel condition information.

7.2 Water Quantity

The assessment of the current surface water quantity in Kelly Creek suggests that under normal flow conditions there is sufficient water to meet the demand of all the active licences. During periods of drought (although the available data suggests that there should be enough water during periods of low flow and high demand to meet both Fruitvale's demands plus those with priority domestic licences) it is reported that Beaver Valley Water Service supplements its supply by using groundwater.

Based on the available hydrometric data the normal total runoff in Kelly Creek is ~13,100 ML. The two water licences held by the Regional District of Kootenay Boundary on Kelly Creek that are used by the Beaver Valley Water Service total 929 ML and account for ~99% of the licenced

URBAN systems

domestic volume. The irrigation licences total ~124ML or 13% of the RDKB licences. The total water licenced in the watershed is ~936 ML for domestic use and ~124 ML for irrigation (April – September). The combined demand is ~8% of the total runoff however it is the demand during low flows that is the appropriate indicator of the supply and demand balance. The analysis of the water balance in August which represents low stream flows and high demand suggests that during normal periods of runoff, the total demand (domestic + irrigation) is in the range of 35-40% of the available flow. However during periods of drought it is reported that the Beaver Valley Water Service supplements the supply with groundwater. This would indicate that during periods of drought, the current surface water supply is not sufficient to meet the current demand.

It was also understood that one of the purposes of this assessment is to assist BVWS in determining how it might increase its water supply to meet future demand as the community grows. Based on the assessment of the watershed upstream of the intake, there were no feasible locations to develop storage reservoirs, as there are no lakes or wetlands. An option may be to develop additional storage for treated water in a closed reservoir downstream of the treatment plant that could supplement the existing 4.9ML of storage.

The groundwater assessment indicated that there are limited opportunities to develop groundwater within the Kelly Creek catchment. There are no known aquifers or wells within the Kelly Creek catchment. It is estimated that if a well was drilled it might produce in the range of 5USgpm.

A fish assessment was completed in the Beaver Creek watershed including Kelly Creek in 2002 for Atco Lumber - Reconnaissance (1:20,000) Fish and Fish Habitat Inventory of the Beaver Creek Study Area WSC: 300-619500 (Timberland Consultants, February 2002). It determined that there was a fish barrier upstream of the intake and classed the stream as non-fish bearing although noted that it had good habitat. No information was provided on required flows for fish, however the BC Instream Flow Guidelines for Fish recommends that for “fishless” streams that the minimum instream flow should be the median flow for the low flow months. For Kelly Creek this would suggest an instream flow of slightly less than 0.030m^3/s (the mean flow in January). Fruitvale’s highest summer demand is ~0.043m^3/s when the runoff is between 0.12 and 0.33m^3/s. This would suggest under normal runoff conditions that there should be sufficient residual flow to achieve this threshold.

7.3 Climate Change

The climate assessment completed by the Pacific Climate Impacts Consortium for the Columbia basin for the Columbia Basin Trust suggests significant impacts on the water resources that may affect water supply for BVWS. The study suggests that demand will increase while supply may decline and that water quality could be degraded as a result of more rapid runoff, increased risk of wildfires and increased forest health issues that may affect the basin hydrology.

8.0 RECOMMENDATIONS

The following recommendations are provided regarding:

8.1 Water Quality

- Collaborate with Kelly Creek Timber to:
- Improve the drainage works on the section of road immediately upstream of the first bridge by installing additional crossdrains or waterbars to reduce the sediment delivery off the running surface into the creek;
- Restore the creek channel near Location 10 by removing the landslide debris in the creek;
- Implement temporary deactivation on roads near stream crossings to reduce the sediment delivery to the creek during spring runoff and during rainstorms;
- Improve access control to further restrict motor vehicles from entering the watershed.
- Implement a raw water quality monitoring program at the intake.

8.2 Water Quantity

- Reactivate the hydrometric station Kelly Creek at 850m Contour either through agreement with Water Survey of Canada or through a contractor. It may be practical to include water quality monitoring at this site as well.
- Investigate the most cost effective means of developing additional water supply, by either increasing the treated water storage within the system or additional groundwater sources to supplement flows during periods of low flow in the creek.
- Continue to reduce overall water demand in the community as recommended in the Water Smart Action Plan specifically outdoor water use that is the most significant demand for water. A significant component in any water conservation plan is through the installation of water meters and an effective pricing policy.

8.3 Climate Change

- The current research provides compelling evidence that as the climate changes there will be detrimental impacts on the water supplies. Although these changes will likely occur gradually of the next 50 years, there is little reason to doubt that they will occur. There will most likely be reduced surface runoff as well as increased recharge of the aquifers that will affect the productivity of the wells. There will be increased demand due to higher summer temperatures and a longer growing season. The proactive actions by the community of increasing supply opportunities and controlling demands as recommended in the previous section may effectively reduce the climate change impacts. Also collecting water quantity and quality data so that it is possible to determine supply and quality trends over time is important.

Sincerely,

URBAN SYSTEMS LTD.

ORIGINAL SIGNED BY

Don Dobson, P.Eng.
Senior Water Engineer

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Appendix A

Request for Proposal

Hydrologic Assessment of the Kelly Creek Watershed
For
Beaver Valley Water Service

Request for Proposal

Hydrologic Assessment of the Kelly Creek Watershed

for Beaver Valley Water Service

Request for Proposal
Hydrologic Assessment of the Kelly Creek Watershed

General Instructions to Proponents

1. Closing Date for Responses:

   Friday, August 31, 2012 at 4:00 p.m. (PDT).
   It is the sole responsibility of the Proponent to ensure that the Proposal is received on time. If the Proponent is submitting hard copies of their Proposal then please send 2 copies to the contact in Section 2 following. If the Proponent is submitting an electronic copy of their Proposal, then please send a copy to the email contact address in Section 2 following. Proposals received after the closing date and time will be considered disqualified and will be returned to the Proponent.

2. Beaver Valley Water Service/Village of Fruitvale Contact:

   Lila Cresswell, Chief Administrative Officer
   Village of Fruitvale / Beaver Valley Water Service (BVWS)
   Post Office Box 370
   1947 Beaver Street
   Fruitvale, BC V0G 1L0
   Telephone: (250) 367-7551
   Email: @village.fruitvale.bc.

3. Request for Proposal Composition:

   Section I: Administrative Section
   Section II: Hydrologic Assessment of the Kelly Creek Watershed: RFP Requirements

   *Proponents are advised to read and respond appropriately to both sections of this Request for Proposal. An incomplete Proposal may be rejected.

4. Review and Interpretation of Proposals:

   Each Proponent will be solely responsible for examining all the RFP documents, including any issues during the RFP period and for independently informing itself with respect to any and all information contained therein, and any and all conditions that may in any way affect the Proposal, before the Proposal is submitted.

   Each Proponent will review all RFP documents and will promptly report and request clarification of any discrepancy, deficiency, ambiguity, error, inconsistency or omission contained therein. Any such request must be submitted to the BVWS representative in writing, electronically or otherwise, no later than 2:00 PM, five (5) business days before the closing date. Where such requests result in a change or a clarification to the requirements of the RFP, the BVWS will prepare and issue an Addendum to this RFP.

5. Addendum:

   Written addenda issued by the BVWS will be the only mean of varying, clarifying or otherwise changing any of the information contained in this RFP. The BVWS reserves the right to issue Addenda up to the RFP closing date and time. The date set for submitting Proposals may be changed if, in the BVWS's opinion, more time is necessary to enable Proponents to revise their Proposals. Addenda will state any changes to the RFP closing date and time. Please use the above project name in all correspondence.

Request for Proposal
Hydrologic Assessment of the Kelly Creek Watershed

Section I: Administrative Section

1.0 Introduction

1.1 *Terminology*
Throughout this Request for Proposal (RFP), terminology is used as follows:

"Must" and "Required" – A standard or specification that must be met or agreed to; Proposals should indicate ability to comply.

"Should" – A requirement having a significant degree of importance to the objectives of the Request for Proposal.

Purpose

The Beaver Valley Water Service, hereinafter referred to as "BVWS", is soliciting submissions from qualified consultants to undertake the development of a **Hydrologic Assessment of the Kelly Creek Watershed**. The full scope of the work is outlined in Section II: Hydrologic Assessment of the Kelly Creek Watershed: RFP Requirements.

Proponents are hereby advised that the BVWS has authorized funding for the work, however the BVWS reserves the right to delete, alter, or expand all or part of the work outlined in Section II: Hydrologic Assessment of the Kelly Creek Watershed: RFP Requirements Prior to the award of a contract.

1.2 *Timing*
The work to be undertaken by the successful Proponent will commence immediately upon the awarding of this contract. The anticipated date of completion of work is **November 30, 2012.**

2.0 Proposal Preparation and Submission

2.1 *Proponent Expenses*
All Proponents shall be solely liable for all costs incurred in the preparation of Proposals in response to this RFP. The BVWS shall not be held accountable for any such costs, however incurred.

2.2 *Additional Inquiries*
All inquiries must be directed to the contact as shown in the General Instructions for Proponents. Inquiries should not be directed to any other person, including elected officials of the BVWS or Village of Fruitvale.

2.3 *Closing Date and Acceptable Submission Formats*
A set of two (2) copies in an 8 ½ inch x 11 inch format and suitable for black and white photocopying, must be received at the location and time specified in the General Instructions to Proponents. Proposals submitted by mail, should be clearly marked with the name and address of the Proponent and have the title **Hydrologic Assessment of the Kelly Creek Watershed** on the envelope. All envelopes must be sealed and marked 'Confidential'. The Proposal submitted by each Proponent will be signed by an Authorized Representative of the Proponent.

Proposals may be submitted via email (preferred) in 'Adobe Acrobat' PDF file format, preferably using the most recent software version. E-mailed Proposals must be received as per the identified closing date and time. It is the sole responsibility of the Proponent to confirm with the BVWS contact that the Proposal has been received. The BVWS does not accept any liability for any claim, demand, or other action should an email submission not be received or for any other reason. Complete Proposals and/or amendments thereto will not be accepted by facsimile (fax).

2.4 *Format*
Proposals must be in the general format as detailed in Section II: Hydrologic Assessment of the Kelly Creek Watershed: RFP Requirements. Additional written material, including maps, diagrams, or GAANT charts may be submitted. If submitted, the material must accompany each copy of the Proposal and be clearly identified as forming part of the Proposal.

3.0 Selection Criteria and Procedures

3.1 *Mandatory Requirements*
This Request for Proposal contains mandatory requirements. Proposals not meeting or containing the following mandatory requirements will be rejected without further consideration:

a. Submissions must be received before the closing time and date as stated in the General Instructions to Proponents;
b. A description of the methodology the Consultant intends to use to accomplish the tasks outlined in Section II,4.0 Scope of Work;
c. The Consultant's familiarity and/or understanding of the Kootenay region and/or British Columbia;
d. Example(s) of watershed assessments or source protection work completed by the Consultant;
e. Submissions must include project management and leadership details, delivery and schedule, relevant experience and the contractor's price proposal;
f. The Proposal should clearly show the complete company name, nearest location to the BVWS, and name and telephone number of the primary contact person;
g. The Proposal should include a statement of previous experience, which will include experience in the completion of similar projects (at least three and no more than 10) for other organizations for which the company and/or team members have provided similar services, as well as two references (name, position, organization, telephone and email address);
h. The Proposal should identify any other person or contracted service to be assigned to this project, include any affiliates or sub-consultant(s) and a statement of their responsibilities, experience and expected involvement;
i. The Proposal must include a price breakdown for each task including hourly/daily rates, direct expenses, and sub-contracts (if applicable), internal costs (e.g., computer usage charges), travel costs, and any other applicable costs either direct or overhead (meaning included in the hourly rate);
j. All prices must be quoted in Canadian currency, exclusive of all taxes;
k. Proposals must include a Payment Schedule based on the deliverables to be achieved and a budget for each deliverable to demonstrate that the payment for the milestone is commensurate with its anticipated cost; and
l. Submissions must include one (1) copy of the Acknowledgement of Terms (Section I, Part 6.0) signed by an Authorized Signatory for the Proponent.

3.2 *Evaluation Criteria and Process*
Proponents must demonstrate in their Proposal that they have a clear understanding of this Request for Proposal. Proponents need to articulate their intentions, expectations, and indicate how

they will fulfill the requirements of the Request for Proposal (see Section I, Parts 2.0 and 3.0 and Section II). Proposals will be evaluated on the following:

- Proposed methodology;
- Relevant experience;
- Consultant's understanding of the context, issues, and ultimate objectives of the project;
- Clarity and presentation;
- Project management and leadership / personnel;
- Product delivery and schedule; and
- Contractor's price proposal.

Each Proponent will be informed of the results of the evaluation once a decision has been made. The successful Proposal will be used to negotiate a final contract, and will become an integral part of that contract. The BVWS reserves the right to require additional terms and conditions in any final contract to be negotiated with the successful Proponent.

The BVWS is looking for a Proposal offering the best overall value. The lowest cost submission or any Proposal may not necessarily be accepted.

3.3 *Negotiation*

If a final contract cannot be negotiated with any given Proponent, the BVWS may terminate negotiations with that Proponent and negotiate a final contract with another Proponent.

4.0 Terms and Conditions

4.1 *Acceptance of Proposals*

The BVWS reserves the right:

- to conduct post-selection meetings in order to correct, change or adapt Proposals to the wishes of the BVWS;
- to reject any or all Proposals, or any part thereof;
- to accept the Proposal that is in the best interest of the BVWS;
- to negotiate the terms of any Proposal; and
- to select a Proponent based on a combination of relevant experience, expertise, cost, schedule, and completeness and clarity of submission.

The BVWS will not necessarily select a submission based solely on lowest cost. All else being equal the BVWS reserves the right to use a local consultant in the first instance.

Upon the award of this assignment, a Professional Services Agreement between BVWS and the selected consultant will be executed. The Request for Proposal, Proponent's Proposal and any additional negotiated amendments thereafter as authorized by the Chief Administrative Officer in writing will be included in the Professional Services Agreement.

4.2 *Insurance Coverage*

As a component of the Request for Proposal submission, the Proponent must include proof of the Company's insurance protection, specifically one copy (1) per submission package of:

- Commercial General Liability – not less than $1,000,000 per occurrence
- Vehicle Third Party Liability – not less than $1,000,000 per occurrence
- Error & Omissions Insurance – not less than $500,000 per occurrence

The Proponent must continuously hold for the term of the Contract, the minimum insurance coverage stated.

The Proponent must comply with all applicable laws and bylaws within the jurisdiction of the work. The Proponent must further comply with all conditions and safety regulations of the *Workers' Compensation Act* of British Columbia and must be in good standing during the term of any Contract entered into from this process.

4.3 *Conflict of Interest*

By submitting a Proposal, the Proponent warrants that neither it nor any of its officers, directors, employees or subcontractors has any financial or personal relationship or affiliation with any elected official or employee of the BVWS/Village of Fruitvale or their immediate families which might in any way be seen or perceived (in the BVWS's sole and unfettered discretion) to create a conflict of interest.

4.4 *Security*

The BVWS reserves the right to request security on the successful consultant. The BVWS may request a performance and/or labour/material bond or alternative approved security if deemed necessary by the Chief Administrative Officer. The security will be held until contract completion.

4.5 *Contractor Obligations and Responsibilities*

Unless specifically outlined in the Proposal, the services or any part thereof may not be sub-contracted, transferred or assigned to another firm, person or company without the prior written authorization of the BVWS.

The originals of all surveys, drawings, maps, specifications, reports and any other documentation produced by the Consultant for the BVWS during the course of this assignment shall upon completion of this assignment become the property of the BVWS. This information shall also be provided in electronic format.

The Proponent may be required to sign non-disclosure, confidentiality or other documents which the BVWS provides when using BVWS information.

The applicant must prepare the Request for Proposal application, and conduct any work undertaken for the BVWS, on legally licensed software packages and legally obtained data and information. The BVWS will not be held liable for the violation of copyright law in the execution of this assignment. The Consultant must include the following endorsement in their proposal:

> *"We <u>(name of consultant)</u> do hereby confirm that all computer software used by the Consultant in the execution of this assignment is directly licensed to the Consultant and the Sub-consultants."*

It is the responsibility of the Proponent to ensure that the terms and conditions contained herein are fully understood and to obtain any further information required for the development of a Proposal at their own initiative. The BVWS reserves the right to share, with all Proponents, all questions and answers related to this Request for Proposal.

4.6 *Disclaimers and Limitations of Liability*

The BVWS, its employees, agents and consultants expressly disclaim any and all liability for representations, warranties expressed or implied or contained herein, or for omissions from this Request for Proposal package, or any written or oral information transmitted or made available at any time to a Proponent by or on behalf of the BVWS.

While the BVWS has used considerable effort to ensure an accurate representation of information in this Request for Proposal, it should be noted that the information is not guaranteed to be accurate nor necessarily comprehensive or exhaustive. All Proponents are advised to conduct their own investigations into the material facts affecting the Contract.

The successful Proponent (Consultant) and any Sub-consultants shall at all times indemnify and save harmless the BVWS and or any of its officers, employees or agents from and against all claims and demands, loss, costs, damages, actions, suits, fees, or other proceedings by whomsoever made, brought or prosecuted, in any manner based upon, occasioned by or attributable to the execution of this assignment, or any action taken or things done or maintained by virtue of this assignment or the exercise in any manner of rights except claims for damage resulting from the negligence of any officer, servant or agent of the BVWS while acting within the scope of their duties of employment.

Neither acceptance of a Proposal, nor execution of a final Contract shall constitute approval of any activity or development contemplated in any Proposal that requires any approval, permit or license pursuant to any Federal, Provincial or Local Government statute, regulation or bylaw. The BVWS shall not be obligated in any manner to any Proponent whatsoever until a final Contract has been duly executed relating to an approved Proposal. The BVWS reserves the right to modify the terms of the Request for Proposal at any time in its sole discretion.

5.0 Confidentiality and Security

This document, or any portion thereof, may not be used for any purpose other than the submission of Proposals. Information pertaining to the BVWS obtained by the Proponent as a result of participation in this project is confidential and must not be disclosed without written authorization from the BVWS.

All submitted proposals, after the closure date of the Request for Proposal, become the property of the BVWS. The BVWS is, subject to the disclosure provisions of the *Freedom of Information and Protection of Privacy Act* (FIPPA). Proponents who wish to ensure particular parts of their Proposals are protected from disclosure under the FIPP Act should specifically identify any information or records provided with their Proposals that constitute:

a. trade secrets,
b. that are supplied in confidence, and
c. the release of which could significantly harm their competitive position.

Information that does not meet all three of the foregoing categories may be subject to disclosure to third parties under the FIPPA. Please refer to the *Freedom of Information and Protection of Privacy Act* for further information.

Any information acquired about the BVWS by a Proponent during this RFP process must not be disclosed unless authorized in writing by the BVWS, and this obligation will survive the termination of this RFP process.

6.0 Acknowledgement of Terms

In consideration of the BVWS allowing the undersigned Proponent to submit a Proposal for this Request for Proposal, the undersigned Proponent:

a. acknowledges that the BVWS reserves the right to arbitrarily accept or reject any or all Proposals and to waive irregularities at its own discretion;

b. acknowledges that the BVWS reserves the right to arbitrarily reject any Proposals submitted by a Proponent that has a disputed account against or due to the BVWS or against whom the BVWS has a disputed account;
c. acknowledges that the BVWS reserves the right to negotiate terms and conditions with the successful Proponent;
d. acknowledges that the lowest price Proposal or any Proposal will not necessarily be accepted; and
e. releases and forever discharges the BVWS of and from any and all manners of actions, causes of actions, suits, debts, dues, accounts, bonds, covenants, contracts, claims, damages, costs, losses or injuries, whether known or unknown, heretofore arisen or hereafter arising, of any nature or kind whatsoever, which as against the BVWS, the Proponent, has or hereafter can, shall or may have, in any way resulting from this Request for Proposal process, including but not limited to the process for selection of the successful Proposal or a decision to reject any or all Proposals.

Dated on August 31, 2012

Don Dobson
Name (please print)

Authorized Signature

Senior Water Engineer
Title / Position

Urban Systems Ltd.
Company

Request for Proposal
Hydrologic Assessment of the Kelly Creek Watershed

Section II:
Hydrologic Assessment of the Kelly Creek Watershed: RFP Requirements

1.0 INTRODUCTION:

The Beaver Valley Water Service (BVWS) is currently undertaking the assessment of the Kelly Creek Watershed as part of the future planning for the water system, with the support of the Columbia Basin Trust Water Smart Program. Significant work has been undertaken previously to identify water usage, conservation opportunities and potential future area requirements. The BVWS is issuing this Request for Proposals to identify a consultant who is interested and qualified to carry out a hydrologic assessment of the Kelly Creek Watershed for the purposes of establishing a watershed profile specifically focusing on water quality and quantity.

2.0 BACKGROUND:

To date, planning for future service requirements and upgrades has been carried out without benefit of a comprehensive hydrology study of the watershed. The BVWS also operates two wells in addition to the water treatment plant utilizing surface water from Kelly Creek. Prior to planning for or identifying a location for future well source, it was deemed advisable to complete a hydrologic study of the Kelly Creek Watershed to determine the current watershed condition and identify data gaps. It is essential that a baseline of particular variables such as water quality, water quantity, land use, biological indicators and potential pressures are established in order to allow for monitoring and comparisons in the years to come.

Areas of concern include;

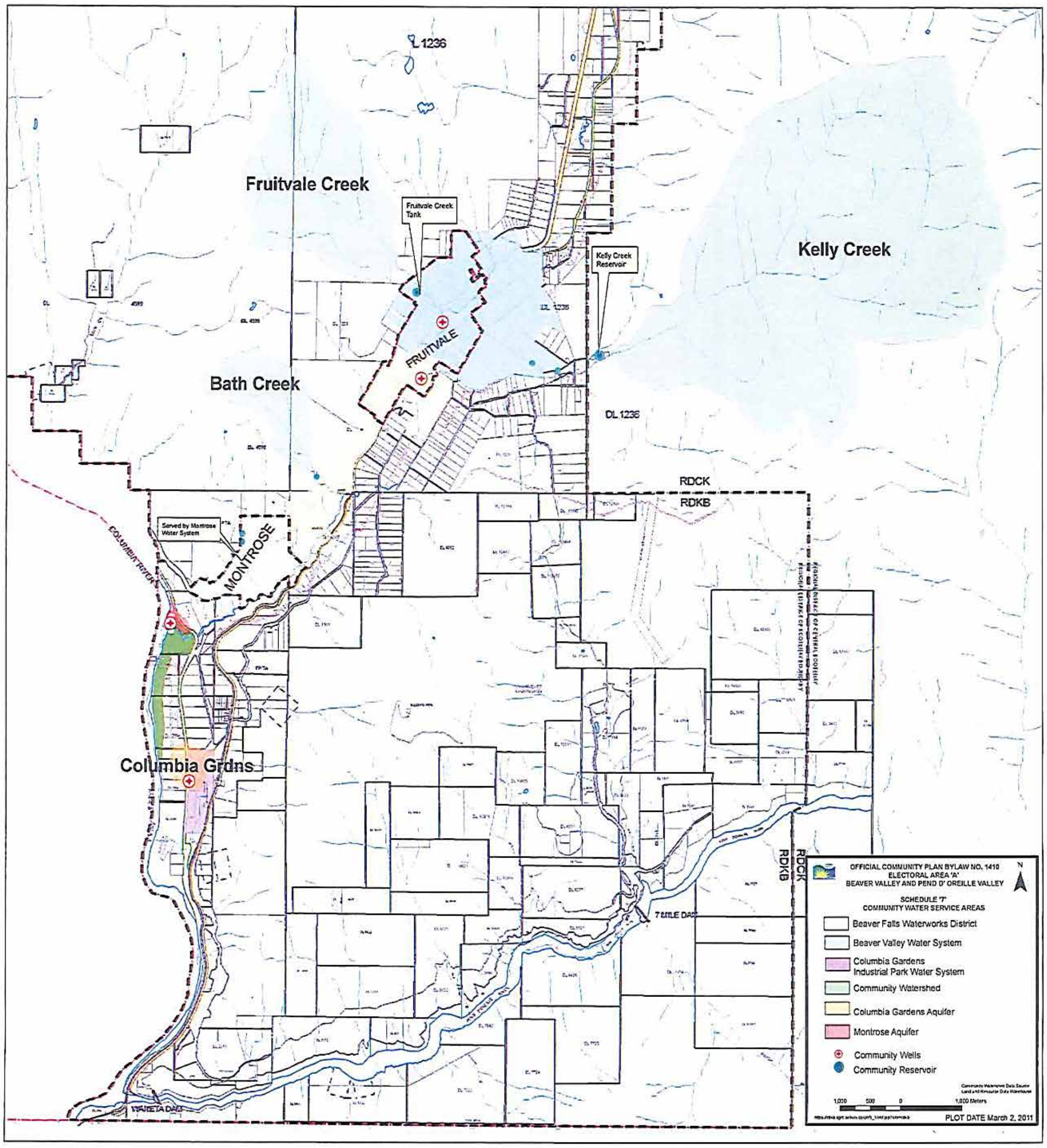
- Impacts of forestry operations
- Impacts of unauthorized recreational use
- Water quality concerns
    - o Human health (drinking water)
    - o Ecosystem health
- Fishery habitat

3.0 STUDY AREA:

The Kelly Creek Watershed is primarily private land under forestry operation. Although it is the primary water source for Beaver Valley, the actual watershed is located within the Central Kootenay Regional District and therefore not subject to any land use controls within the scope of the local government in charge of the water system

Please refer to **Figure 1** following for a map of the Kelly Creek Watershed.

Figure 1: Kelly Creek Watershed Map



4.0 SCOPE OF WORK:

The objective of the **Hydrologic Assessment of the Kelly Creek Watershed** is to provide a detailed report on the current watershed profile specifically focusing on water quality and quantity. The data will be compiled from various sources, including existing studies and reports, local sources, and provincial and federal agencies. The goal is to establish a baseline on the current status of the watershed which will provide a strong scientific base which will guide the decisions being made for future water system planning.

It is recommended that the applicant provide a cost breakdown based upon core deliverables and additional options for the BVWS to consider. This scope of work may be refined by BVWS as the assessment progresses, however, using available data sources, the report should contain at a minimum:

Watershed Physical Description:
An overview description of the watershed including: land use, climate, ecology, bedrock geology, surficial geology, regional hydrogeology, watershed hydrology, soils, natural sub-regions and identified sub watersheds.

Water Quality

- Examine existing studies conducted by provincial, federal and local agencies of the degree to which established water quality standards are being met in the plan area.
- Examine any existing provincial, federal and local agencies studies that outline any causes of any water quality problems or violations in the plan area including an examination of information regarding land uses, pollutants, point and non- point sources of pollution.
- Identify anthropogenic (human) and intrinsic (natural) activities & influences that negatively impact water quality and complete a risk assessment to prioritize which activities pose the greatest threat.
- Examine the impacts of the major land uses occurring in the plan area, including urban and rural development, agriculture and forestry.
- Examine the potential impacts resulting from Climate Change
- Identify any gaps in knowledge regarding water quality.

Water Quantity

- Provide an estimate of the surface and groundwater present in the plan area (maps identified in provincial ministries' databases).
- Provide an estimate of the water within the watershed that is allocated under a water license or any other form of water right.
- Provide an estimate of the surface and groundwater actually being used in the watershed (Allotment vs. how much is being consumed).
- Review Data and Research that identifies minimum thresholds required for in stream flows to maintain the aquatic environment for fish and fish habitat; determine data gaps.
- Identify large water extractors and identify possible risks, if any, of over extraction.
- Identify land uses or practices that impact quantity or quality of water or pose a high risk to introducing contaminates.
- Explore seasonal and yearly variations in water quantity within the watershed; identify long term trends for water availability and potential impacts resulting from Climate Change.

5.0 DELIVERABLES:

Deliverables for this project shall include:

- A **Hydrologic Assessment of the Kelly Creek Watershed** which includes detailed data and mapping addressing each of the subject areas identified in the scope of work, a data gap analysis; identifying areas where more information is needed, and an overview of long-term trends in water quality and quantity within the watershed.
- GIS databases and mapping associated with the relevant subject areas identified under the scope of work, subject to the availability of that data (e.g. Biogeoclimatic Zone & Bedrock Geology Information, location of recharge areas, locations of areas vulnerable to flooding, locations of water licenses, Forestry Boundaries and Forestry Information, Mineral Resources, etc.)
- Regular meetings with the Chief Administrative Officer regarding the progress of the project.
- Presentation of a final draft to the Beaver Valley Water System Committee.
- Final report, as described above, presented as the "Hydrologic Assessment of the Kelly Creek Watershed".

6.0 TIMING

The assessment will commence upon the awarding of the Contract with a projected completion date of **November 30, 2012.**

Appendix B

Hydrometric Data
For
Kelly Creek at 850m Contour
(WSC sta # 08NE113)

ID	Year	Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
08NE113	1971	1				0.125	1.83	1.37	0.535	0.227	0.144	0.119	0.085	0.093
08NE113	1971	2				0.136	2.44	1.31	0.513	0.21	0.136	0.113	0.085	0.091
08NE113	1971	3				0.147	3.23	1.25	0.49	0.201	0.13	0.11	0.082	0.091
08NE113	1971	4				0.207	3.43	1.25	0.538	0.195	0.125	0.108	0.079	0.088
08NE113	1971	5				0.283	3.68	1.25	0.6	0.184	0.119	0.102	0.076	0.085
08NE113	1971	6				0.405	3.4	1.25	0.564	0.164	0.241	0.099	0.074	0.082
08NE113	1971	7				0.583	3.11	1.17	0.527	0.153	0.207	0.096	0.071	0.079
08NE113	1971	8				0.64	3.2	1.1	0.507	0.142	0.147	0.093	0.079	0.076
08NE113	1971	9				0.708	3.28	1.07	0.49	0.13	0.119	0.091	0.099	0.074
08NE113	1971	10				0.784	3.4	1.05	0.68	0.127	0.113	0.088	0.13	0.071
08NE113	1971	11				0.784	4.39	1.16	0.966	0.125	0.105	0.085	0.147	0.068
08NE113	1971	12				0.784	5.15	1.18	0.878	0.113	0.096	0.082	0.153	0.065
08NE113	1971	13				0.784	6.2	1.19	0.81	0.102	0.088	0.076	0.156	0.062
08NE113	1971	14				0.784	4.36	1.19	0.765	0.093	0.082	0.071	0.153	0.062
08NE113	1971	15				0.733	3.17	0.886	0.725	0.093	0.076	0.068	0.142	0.059
08NE113	1971	16				0.688	2.21	0.852	0.68	0.093	0.076	0.062	0.13	0.057
08NE113	1971	17				0.651	1.59	0.821	0.64	0.093	0.076	0.062	0.127	0.057
08NE113	1971	18				0.651	1.48	0.79	0.609	0.085	0.076	0.062	0.125	0.057
08NE113	1971	19				0.708	1.4	0.748	0.58	0.076	0.082	0.105	0.122	0.057
08NE113	1971	20				1.05	1.36	0.714	0.561	0.068	0.088	0.113	0.119	0.057
08NE113	1971	21				1.59	1.42	0.682	0.535	0.062	0.085	0.122	0.119	0.057
08NE113	1971	22				1.63	1.53	0.648	0.51	0.071	0.082	0.13	0.125	0.057
08NE113	1971	23				1.67	1.7	0.617	0.453	0.082	0.079	0.139	0.13	0.065
08NE113	1971	24				1.71	1.93	0.682	0.405	0.074	0.076	0.127	0.122	0.076
08NE113	1971	25				1.77	2.21	0.748	0.382	0.065	0.082	0.119	0.113	0.074
08NE113	1971	26			0.085	1.39	2.22	0.699	0.357	0.057	0.088	0.11	0.105	0.071
08NE113	1971	27			0.088	1.26	1.95	0.654	0.343	0.051	0.091	0.105	0.099	0.071
08NE113	1971	28			0.091	1.15	1.7	0.617	0.326	0.048	0.113	0.099	0.099	0.068
08NE113	1971	29			0.096	1.13	1.63	0.583	0.294	0.048	0.156	0.093	0.096	0.065
08NE113	1971	30			0.105	1.13	1.53	0.564	0.272	0.045	0.136	0.091	0.093	0.065
08NE113	1971	31			0.113		1.45		0.249	0.108		0.088		0.062

ID	Year	Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
08NE113	1972	1	0.062	0.068	0.13	0.589	0.779	2.66	0.419	0.164	0.074	0.125	0.065	0.071
08NE113	1972	2	0.059	0.065	0.125	0.654	0.861	1.85	0.405	0.156	0.071	0.116	0.071	0.068
08NE113	1972	3	0.057	0.062	0.125	0.719	0.946	1.63	0.388	0.15	0.068	0.108	0.074	0.068
08NE113	1972	4	0.054	0.059	0.125	0.782	1.27	1.42	0.374	0.147	0.068	0.096	0.088	0.065
08NE113	1972	5	0.057	0.057	0.125	0.847	1.58	1.31	0.348	0.142	0.065	0.088	0.093	0.065
08NE113	1972	6	0.057	0.057	0.125	0.912	1.9	1.2	0.32	0.133	0.068	0.088	0.099	0.062
08NE113	1972	7	0.057	0.057	0.125	0.85	1.83	1.09	0.328	0.125	0.068	0.085	0.099	0.062
08NE113	1972	8	0.057	0.057	0.125	0.787	1.75	0.983	0.337	0.119	0.071	0.082	0.096	0.062
08NE113	1972	9	0.057	0.057	0.142	0.725	1.83	0.983	0.326	0.11	0.071	0.082	0.096	0.059
08NE113	1972	10	0.057	0.057	0.227	0.688	1.9	0.983	0.311	0.108	0.074	0.079	0.093	0.059
08NE113	1972	11	0.054	0.057	0.32	0.651	2.69	0.949	0.337	0.105	0.068	0.076	0.091	0.057
08NE113	1972	12	0.054	0.057	0.413	0.631	3.48	0.915	0.365	0.102	0.059	0.076	0.091	0.057
08NE113	1972	13	0.054	0.057	0.504	0.609	4.28	0.881	0.391	0.099	0.062	0.074	0.088	0.054
08NE113	1972	14	0.051	0.057	0.597	0.589	4.53	0.784	0.351	0.096	0.062	0.071	0.085	0.054
08NE113	1972	15	0.051	0.057	0.566	0.572	3.96	0.688	0.311	0.108	0.065	0.071	0.082	0.057
08NE113	1972	16	0.051	0.057	0.595	0.555	3.45	0.648	0.306	0.119	0.065	0.068	0.082	0.057
08NE113	1972	17	0.059	0.054	0.651	0.535	3.51	0.606	0.303	0.116	0.079	0.068	0.079	0.059
08NE113	1972	18	0.068	0.054	0.657	0.518	3.57	0.566	0.297	0.11	0.093	0.065	0.079	0.062
08NE113	1972	19	0.076	0.057	0.663	0.518	3.62	0.53	0.278	0.108	0.108	0.065	0.076	0.062
08NE113	1972	20	0.082	0.057	0.671	0.518	4.67	0.49	0.258	0.116	0.156	0.068	0.076	0.065
08NE113	1972	21	0.091	0.051	0.677	0.518	5.69	0.518	0.252	0.122	0.204	0.068	0.076	0.079
08NE113	1972	22	0.099	0.051	0.682	0.518	6.74	0.544	0.244	0.13	0.204	0.068	0.076	0.093
08NE113	1972	23	0.102	0.051	0.671	0.524	5.32	0.572	0.238	0.11	0.204	0.065	0.074	0.105
08NE113	1972	24	0.096	0.051	0.663	0.53	3.91	0.575	0.229	0.212	0.173	0.062	0.074	0.119
08NE113	1972	25	0.093	0.051	0.651	0.535	2.5	0.58	0.224	0.156	0.142	0.059	0.074	0.125
08NE113	1972	26	0.088	0.051	0.629	0.592	3.77	0.583	0.21	0.096	0.11	0.062	0.074	0.125
08NE113	1972	27	0.085	0.079	0.606	0.648	5.04	0.547	0.193	0.096	0.099	0.062	0.074	0.116
08NE113	1972	28	0.082	0.125	0.583	0.705	4.79	0.507	0.187	0.093	0.088	0.065	0.074	0.11
08NE113	1972	29	0.076	0.136	0.561	0.699	4.53	0.47	0.184	0.088	0.099	0.065	0.074	0.102
08NE113	1972	30	0.074		0.569	0.694	4.28	0.445	0.178	0.079	0.113	0.065	0.074	0.096
08NE113	1972	31	0.071		0.58		3.45		0.173	0.076		0.065		0.088

ID	Year	Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
08NE113	1973	1	0.091	0.068	0.096	0.218	0.833	1.16	0.255	0.071	0.068	0.054	0.088	0.195
08NE113	1973	2	0.088	0.068	0.102	0.224	0.929	1.07	0.249	0.068	0.065	0.054	0.085	0.193
08NE113	1973	3	0.082	0.068	0.11	0.232	1.03	0.974	0.241	0.068	0.059	0.054	0.082	0.193
08NE113	1973	4	0.079	0.068	0.113	0.238	1.12	0.881	0.235	0.065	0.054	0.054	0.079	0.195
08NE113	1973	5	0.079	0.068	0.116	0.244	1.22	0.852	0.227	0.065	0.051	0.057	0.076	0.201
08NE113	1973	6	0.076	0.068	0.116	0.246	1.54	0.821	0.221	0.065	0.045	0.057	0.074	0.204
08NE113	1973	7	0.076	0.068	0.119	0.249	1.68	0.793	0.212	0.062	0.045	0.059	0.105	0.207
08NE113	1973	8	0.074	0.065	0.122	0.249	1.54	0.765	0.198	0.062	0.045	0.059	0.133	0.201
08NE113	1973	9	0.074	0.065	0.125	0.252	1.39	0.733	0.19	0.062	0.045	0.062	0.164	0.195
08NE113	1973	10	0.076	0.065	0.125	0.306	1.25	0.705	0.178	0.059	0.045	0.065	0.195	0.19
08NE113	1973	11	0.079	0.062	0.127	0.36	1.42	0.668	0.17	0.059	0.042	0.065	0.227	0.181
08NE113	1973	12	0.085	0.062	0.13	0.413	1.58	0.634	0.161	0.057	0.042	0.068	0.255	0.176
08NE113	1973	13	0.091	0.062	0.127	0.467	1.74	0.597	0.156	0.057	0.042	0.068	0.286	0.17
08NE113	1973	14	0.093	0.059	0.122	0.521	1.9	0.575	0.147	0.054	0.042	0.068	0.263	0.164
08NE113	1973	15	0.091	0.059	0.119	0.501	2.64	0.552	0.139	0.054	0.042	0.071	0.244	0.187
08NE113	1973	16	0.088	0.059	0.122	0.481	3.37	0.53	0.13	0.054	0.057	0.071	0.221	0.207
08NE113	1973	17	0.082	0.059	0.125	0.459	4.11	0.507	0.122	0.054	0.068	0.074	0.198	0.229
08NE113	1973	18	0.079	0.059	0.125	0.439	4.84	0.484	0.113	0.054	0.082	0.074	0.193	0.249
08NE113	1973	19	0.079	0.059	0.127	0.419	4.02	0.45	0.11	0.051	0.093	0.074	0.184	0.235
08NE113	1973	20	0.076	0.059	0.13	0.453	3.23	0.419	0.108	0.051	0.082	0.076	0.178	0.227
08NE113	1973	21	0.076	0.059	0.142	0.49	2.41	0.385	0.108	0.051	0.071	0.076	0.173	0.221
08NE113	1973	22	0.074	0.059	0.15	0.524	1.6	0.385	0.105	0.051	0.059	0.079	0.164	0.212
08NE113	1973	23	0.074	0.059	0.161	0.558	2.11	0.385	0.102	0.054	0.059	0.079	0.159	0.207
08NE113	1973	24	0.074	0.059	0.167	0.597	2.61	0.371	0.099	0.054	0.057	0.082	0.153	0.204
08NE113	1973	25	0.071	0.068	0.173	0.634	3.11	0.354	0.096	0.054	0.057	0.082	0.164	0.198
08NE113	1973	26	0.071	0.074	0.181	0.674	2.8	0.34	0.093	0.057	0.054	0.085	0.176	0.195
08NE113	1973	27	0.071	0.082	0.187	0.705	2.49	0.323	0.091	0.059	0.054	0.085	0.187	0.19
08NE113	1973	28	0.071	0.088	0.193	0.736	2.18	0.306	0.085	0.065	0.051	0.088	0.198	0.187
08NE113	1973	29	0.071		0.198	0.77	1.87	0.286	0.082	0.068	0.051	0.088	0.198	0.184
08NE113	1973	30	0.068		0.207	0.801	1.56	0.263	0.079	0.071	0.051	0.091	0.195	0.178
08NE113	1973	31	0.068		0.212		1.25		0.074	0.074		0.091		0.176

ID	Year	Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
08NE113	1974	1	0.176	0.272	0.144	0.436	2.14	3.82	0.643	0.212	0.088	0.071	0.071	0.093
08NE113	1974	2	0.173	0.266	0.142	0.442	1.97	3.88	0.592	0.201	0.088	0.071	0.071	0.096
08NE113	1974	3	0.173	0.258	0.139	0.45	1.8	3.91	0.538	0.193	0.088	0.074	0.071	0.096
08NE113	1974	4	0.173	0.249	0.139	0.456	2.31	3.96	0.518	0.181	0.085	0.074	0.071	0.099
08NE113	1974	5	0.17	0.241	0.136	0.462	2.82	3.71	0.496	0.173	0.085	0.074	0.074	0.096
08NE113	1974	6	0.17	0.229	0.133	0.47	3.23	3.43	0.476	0.164	0.085	0.074	0.074	0.091
08NE113	1974	7	0.167	0.221	0.13	0.476	3.65	3.45	0.476	0.156	0.085	0.074	0.076	0.088
08NE113	1974	8	0.167	0.212	0.13	0.532	4.08	3.51	0.476	0.153	0.085	0.074	0.076	0.088
08NE113	1974	9	0.167	0.21	0.127	0.589	3.4	3.54	0.6	0.153	0.088	0.071	0.079	0.088
08NE113	1974	10	0.164	0.207	0.127	0.646	2.72	3.96	0.722	0.15	0.088	0.071	0.079	0.088
08NE113	1974	11	0.164	0.204	0.127	0.702	2.04	4.39	0.847	0.153	0.091	0.071	0.076	0.088
08NE113	1974	12	0.161	0.198	0.127	0.759	1.87	4.16	0.759	0.156	0.088	0.071	0.076	0.085
08NE113	1974	13	0.161	0.195	0.127	0.818	1.69	3.94	0.668	0.159	0.088	0.071	0.074	0.085
08NE113	1974	14	0.167	0.193	0.127	0.875	1.53	3.71	0.637	0.161	0.085	0.071	0.074	0.082
08NE113	1974	15	0.193	0.193	0.139	0.932	1.37	3.54	0.606	0.153	0.085	0.071	0.074	0.082
08NE113	1974	16	0.241	0.193	0.15	0.988	1.21	3.34	0.575	0.147	0.085	0.071	0.071	0.079
08NE113	1974	17	0.538	0.193	0.164	1.04	1.05	3.17	0.549	0.139	0.082	0.071	0.113	0.079
08NE113	1974	18	0.481	0.193	0.176	1.1	1.05	2.63	0.524	0.13	0.082	0.071	0.159	0.079
08NE113	1974	19	0.428	0.187	0.187	1.12	1.06	2.14	0.498	0.127	0.079	0.071	0.201	0.079
08NE113	1974	20	0.371	0.181	0.187	1.13	1.06	1.64	0.473	0.125	0.076	0.071	0.244	0.079
08NE113	1974	21	0.36	0.176	0.184	1.15	1.21	1.52	0.447	0.122	0.074	0.071	0.215	0.079
08NE113	1974	22	0.351	0.173	0.184	1.16	1.36	1.4	0.422	0.116	0.074	0.074	0.184	0.079
08NE113	1974	23	0.34	0.167	0.181	1.19	1.5	1.27	0.391	0.113	0.074	0.074	0.156	0.076
08NE113	1974	24	0.328	0.161	0.215	1.21	2.66	1.18	0.36	0.108	0.074	0.074	0.142	0.076
08NE113	1974	25	0.317	0.156	0.249	1.4	3.82	1.09	0.328	0.105	0.074	0.074	0.127	0.076
08NE113	1974	26	0.309	0.153	0.283	1.58	3.82	1	0.297	0.102	0.071	0.074	0.11	0.076
08NE113	1974	27	0.297	0.15	0.32	1.77	3.79	0.909	0.28	0.099	0.071	0.074	0.096	0.074
08NE113	1974	28	0.292	0.147	0.354	1.86	3.54	0.838	0.261	0.096	0.071	0.074	0.093	0.074
08NE113	1974	29	0.286		0.388	1.96	3.28	0.767	0.244	0.093	0.071	0.074	0.093	0.074
08NE113	1974	30	0.283		0.422	2.05	3.03	0.697	0.232	0.091	0.071	0.071	0.091	0.074
08NE113	1974	31	0.278		0.428		3.43		0.224	0.091		0.071		0.071

ID	Year	Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
08NE113	1975	1	0.071	0.054	0.079	0.088	0.784	3.68	0.549	0.804	0.201	0.079	0.3	0.221
08NE113	1975	2	0.068	0.054	0.085	0.088	0.804	3.82	0.416	0.728	0.19	0.082	0.3	0.246
08NE113	1975	3	0.068	0.054	0.093	0.088	0.824	3.96	0.408	0.648	0.176	0.085	0.297	0.272
08NE113	1975	4	0.068	0.054	0.091	0.088	0.844	3.62	0.396	0.416	0.164	0.085	0.297	0.306
08NE113	1975	5	0.068	0.054	0.088	0.088	0.864	3.26	0.382	0.181	0.15	0.085	0.294	0.345
08NE113	1975	6	0.065	0.051	0.091	0.088	0.883	3.11	0.368	0.167	0.15	0.105	0.278	0.334
08NE113	1975	7	0.062	0.054	0.091	0.088	0.983	2.97	0.413	0.15	0.15	0.125	0.258	0.289
08NE113	1975	8	0.059	0.057	0.091	0.088	1.08	2.35	0.459	0.144	0.147	0.136	0.241	0.3
08NE113	1975	9	0.059	0.059	0.088	0.091	1.22	1.72	0.796	0.136	0.144	0.144	0.221	0.317
08NE113	1975	10	0.059	0.059	0.088	0.093	1.36	1.59	1.13	0.13	0.139	0.144	0.21	0.311
08NE113	1975	11	0.059	0.059	0.088	0.142	1.75	1.46	1.42	0.125	0.13	0.144	0.198	0.306
08NE113	1975	12	0.059	0.059	0.088	0.187	2.14	1.44	1.72	0.11	0.127	0.119	0.187	0.289
08NE113	1975	13	0.057	0.059	0.088	0.235	2.3	1.42	1.2	0.096	0.125	0.091	0.221	0.28
08NE113	1975	14	0.057	0.059	0.088	0.28	2.47	1.25	0.677	0.096	0.119	0.088	0.255	0.278
08NE113	1975	15	0.054	0.071	0.088	0.328	3	1.09	0.663	0.093	0.113	0.085	0.289	0.272
08NE113	1975	16	0.054	0.071	0.091	0.368	3.54	1.15	0.527	0.15	0.119	0.085	0.323	0.263
08NE113	1975	17	0.054	0.071	0.091	0.408	1.4	1.21	0.515	0.161	0.116	0.082	0.311	0.252
08NE113	1975	18	0.054	0.074	0.091	0.411	1.23	1.08	0.501	0.17	0.113	0.079	0.3	0.246
08NE113	1975	19	0.054	0.074	0.088	0.413	1.38	0.946	0.445	0.156	0.113	0.074	0.292	0.241
08NE113	1975	20	0.054	0.071	0.088	0.419	1.52	0.883	0.388	0.139	0.11	0.085	0.28	0.238
08NE113	1975	21	0.054	0.068	0.088	0.422	1.58	0.818	0.36	0.195	0.108	0.096	0.269	0.235
08NE113	1975	22	0.054	0.068	0.088	0.425	1.64	0.748	0.331	0.249	0.105	0.093	0.258	0.232
08NE113	1975	23	0.054	0.071	0.088	0.513	1.83	0.677	0.416	0.244	0.102	0.088	0.249	0.232
08NE113	1975	24	0.054	0.071	0.088	0.6	2.02	0.756	0.501	0.235	0.099	0.091	0.241	0.229
08NE113	1975	25	0.054	0.071	0.091	0.623	1.93	0.833	0.464	0.198	0.096	0.093	0.232	0.227
08NE113	1975	26	0.054	0.071	0.091	0.643	1.85	0.756	0.428	0.161	0.093	0.099	0.227	0.224
08NE113	1975	27	0.054	0.071	0.091	0.665	1.82	0.677	0.595	0.156	0.088	0.105	0.221	0.221
08NE113	1975	28	0.054	0.071	0.088	0.685	1.8	0.663	0.759	0.15	0.085	0.099	0.212	0.215
08NE113	1975	29	0.054		0.088	0.708	2.56	0.648	0.736	0.164	0.079	0.201	0.207	0.212
08NE113	1975	30	0.054		0.088	0.748	3.31	0.6	0.714	0.176	0.079	0.303	0.204	0.21
08NE113	1975	31	0.054		0.088		3.51		0.759	0.19		0.303		0.207

ID	Year	Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
08NE113	1976	1	0.207	0.153	0.113	0.127	1.06	1.49	0.481	0.116	0.167	0.102	0.105	0.076
08NE113	1976	2	0.204	0.153	0.11	0.13	1.25	1.34	0.481	0.167	0.153	0.136	0.108	0.074
08NE113	1976	3	0.201	0.153	0.108	0.133	1.53	1.4	0.459	0.215	0.147	0.167	0.11	0.068
08NE113	1976	4	0.198	0.153	0.108	0.21	1.8	1.47	0.433	0.221	0.139	0.153	0.102	0.065
08NE113	1976	5	0.193	0.156	0.105	0.289	2.6	1.4	0.379	0.224	0.181	0.139	0.096	0.065
08NE113	1976	6	0.19	0.156	0.105	0.365	3.4	1.34	0.326	0.241	0.224	0.116	0.088	0.065
08NE113	1976	7	0.187	0.159	0.108	0.589	3.48	1.33	0.326	0.258	0.204	0.093	0.088	0.065
08NE113	1976	8	0.184	0.159	0.11	0.81	3.54	1.32	0.326	0.255	0.181	0.085	0.088	0.065
08NE113	1976	9	0.178	0.156	0.11	0.81	3.88	1.31	0.311	0.249	0.181	0.076	0.088	0.065
08NE113	1976	10	0.173	0.156	0.113	0.81	4.22	1.3	0.294	0.229	0.181	0.096	0.088	0.065
08NE113	1976	11	0.167	0.153	0.11	0.83	3.91	1.29	0.292	0.207	0.173	0.116	0.088	0.065
08NE113	1976	12	0.164	0.15	0.108	0.85	3.99	1.29	0.286	0.207	0.161	0.133	0.088	0.062
08NE113	1976	13	0.161	0.15	0.105	0.875	4.08	1.27	0.286	0.207	0.161	0.153	0.068	0.062
08NE113	1976	14	0.159	0.147	0.105	0.9	3.51	1.27	0.286	0.195	0.161	0.139	0.079	0.062
08NE113	1976	15	0.164	0.144	0.105	0.895	2.94	1.26	0.278	0.181	0.147	0.125	0.091	0.062
08NE113	1976	16	0.17	0.142	0.105	0.889	2.74	1.19	0.266	0.207	0.13	0.119	0.099	0.065
08NE113	1976	17	0.173	0.142	0.105	0.824	2.54	1.13	0.249	0.232	0.13	0.113	0.11	0.065
08NE113	1976	18	0.167	0.139	0.105	0.759	2.45	1.07	0.232	0.241	0.13	0.108	0.102	0.065
08NE113	1976	19	0.161	0.136	0.108	0.731	2.35	1.01	0.229	0.249	0.136	0.102	0.096	0.065
08NE113	1976	20	0.153	0.133	0.108	0.699	2.26	0.951	0.224	0.241	0.139	0.093	0.088	0.065
08NE113	1976	21	0.147	0.125	0.113	0.654	2.16	1.01	0.212	0.232	0.144	0.088	0.088	0.062
08NE113	1976	22	0.15	0.125	0.116	0.609	2.21	1.06	0.198	0.221	0.139	0.082	0.085	0.062
08NE113	1976	23	0.15	0.125	0.122	0.614	2.26	1.03	0.19	0.207	0.136	0.076	0.085	0.062
08NE113	1976	24	0.153	0.125	0.125	0.617	2.09	0.988	0.181	0.195	0.13	0.093	0.085	0.062
08NE113	1976	25	0.156	0.125	0.125	0.614	1.91	0.906	0.181	0.181	0.125	0.11	0.082	0.062
08NE113	1976	26	0.156	0.122	0.122	0.609	1.84	0.824	0.181	0.238	0.119	0.102	0.082	0.062
08NE113	1976	27	0.159	0.119	0.122	0.691	1.77	0.694	0.167	0.294	0.11	0.093	0.079	0.062
08NE113	1976	28	0.159	0.116	0.122	0.773	1.85	0.564	0.153	0.255	0.11	0.096	0.079	0.062
08NE113	1976	29	0.156	0.113	0.125	0.824	1.94	0.524	0.167	0.215	0.11	0.099	0.079	0.062
08NE113	1976	30	0.156		0.125	0.875	1.79	0.481	0.181	0.198	0.108	0.102	0.076	0.062
08NE113	1976	31	0.153		0.125		1.64		0.15	0.181		0.102		0.059

ID	Year	Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
08NE113	1977	1	0.057	0.034	0.051	0.057	1.41	0.532	0.161	0.059	0.054	0.059	0.079	0.082
08NE113	1977	2	0.051	0.034	0.051	0.074	1.62	0.513	0.15	0.057	0.051	0.062	0.085	0.082
08NE113	1977	3	0.045	0.034	0.051	0.093	1.53	0.493	0.144	0.057	0.054	0.062	0.091	0.082
08NE113	1977	4	0.042	0.034	0.054	0.11	1.12	0.493	0.136	0.059	0.054	0.065	0.088	0.082
08NE113	1977	5	0.034	0.034	0.057	0.139	1.1	0.493	0.136	0.059	0.059	0.065	0.085	0.082
08NE113	1977	6	0.034	0.037	0.057	0.167	1.09	0.479	0.136	0.054	0.054	0.068	0.085	0.079
08NE113	1977	7	0.034	0.037	0.057	0.232	1.07	0.467	0.13	0.054	0.054	0.068	0.082	0.082
08NE113	1977	8	0.034	0.037	0.057	0.294	1.06	0.453	0.125	0.054	0.059	0.068	0.082	0.082
08NE113	1977	9	0.034	0.034	0.057	0.294	1.04	0.439	0.122	0.051	0.054	0.068	0.079	0.082
08NE113	1977	10	0.034	0.034	0.059	0.294	0.988	0.425	0.119	0.048	0.051	0.068	0.079	0.079
08NE113	1977	11	0.034	0.037	0.062	0.294	0.937	0.413	0.127	0.048	0.048	0.071	0.076	0.082
08NE113	1977	12	0.034	0.034	0.065	0.32	0.872	0.399	0.136	0.048	0.048	0.071	0.076	0.082
08NE113	1977	13	0.034	0.04	0.065	0.345	0.807	0.385	0.13	0.045	0.045	0.071	0.076	0.088
08NE113	1977	14	0.034	0.045	0.065	0.334	0.779	0.377	0.125	0.048	0.042	0.071	0.079	0.091
08NE113	1977	15	0.034	0.045	0.065	0.326	0.748	0.371	0.125	0.045	0.059	0.071	0.082	0.102
08NE113	1977	16	0.034	0.042	0.065	0.323	0.801	0.362	0.125	0.045	0.054	0.071	0.082	0.113
08NE113	1977	17	0.034	0.042	0.065	0.323	0.852	0.311	0.113	0.045	0.054	0.071	0.079	0.105
08NE113	1977	18	0.045	0.042	0.065	0.326	0.906	0.258	0.105	0.042	0.071	0.068	0.076	0.099
08NE113	1977	19	0.065	0.042	0.065	0.323	0.841	0.249	0.093	0.042	0.071	0.068	0.076	0.096
08NE113	1977	20	0.048	0.04	0.065	0.326	0.776	0.238	0.082	0.042	0.079	0.068	0.074	0.093
08NE113	1977	21	0.04	0.037	0.068	0.328	0.776	0.235	0.082	0.042	0.076	0.068	0.062	0.091
08NE113	1977	22	0.04	0.042	0.068	0.334	0.776	0.229	0.079	0.04	0.099	0.071	0.057	0.088
08NE113	1977	23	0.037	0.045	0.068	0.337	0.776	0.215	0.082	0.04	0.071	0.071	0.062	0.085
08NE113	1977	24	0.034	0.051	0.071	0.345	0.776	0.198	0.085	0.125	0.065	0.074	0.068	0.082
08NE113	1977	25	0.037	0.048	0.071	1.62	0.762	0.198	0.091	0.136	0.062	0.076	0.074	0.082
08NE113	1977	26	0.042	0.048	0.074	1.58	0.748	0.198	0.093	0.15	0.059	0.074	0.076	0.088
08NE113	1977	27	0.037	0.048	0.071	1.55	0.711	0.187	0.076	0.091	0.059	0.071	0.079	0.093
08NE113	1977	28	0.037	0.048	0.065	1.28	0.674	0.173	0.071	0.076	0.057	0.071	0.079	0.096
08NE113	1977	29	0.034		0.062	1.01	0.623	0.173	0.068	0.071	0.059	0.071	0.079	0.091
08NE113	1977	30	0.034		0.057	1.21	0.572	0.173	0.065	0.059	0.062	0.074	0.082	0.091
08NE113	1977	31	0.034		0.057		0.552		0.059	0.054		0.076		0.091

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08NE113	1978	1	0.088	0.071	0.076	1.14	2.97	2.15	0.524	0.096	0.102	0.15	0.099	0.062
08NE113	1978	2	0.085	0.071	0.079	1.06	2.27	2.46	0.544	0.105	0.102	0.147	0.11	0.062
08NE113	1978	3	0.082	0.071	0.079	0.971	1.97	2.78	0.561	0.102	0.102	0.144	0.133	0.065
08NE113	1978	4	0.082	0.071	0.079	0.889	1.67	3.09	0.578	0.099	0.102	0.139	0.153	0.065
08NE113	1978	5	0.082	0.074	0.076	0.807	1.37	2.75	0.541	0.102	0.105	0.136	0.127	0.065
08NE113	1978	6	0.082	0.082	0.076	0.725	1.07	2.42	0.501	0.105	0.105	0.13	0.11	0.065
08NE113	1978	7	0.079	0.091	0.079	0.719	1.08	2.08	0.439	0.099	0.105	0.122	0.102	0.065
08NE113	1978	8	0.079	0.085	0.085	0.714	1.09	1.92	0.374	0.093	0.142	0.11	0.102	0.065
08NE113	1978	9	0.079	0.079	0.088	0.708	1.33	1.77	0.402	0.091	0.181	0.108	0.096	0.065
08NE113	1978	10	0.082	0.074	0.091	0.694	1.57	1.61	0.428	0.085	0.218	0.102	0.085	0.062
08NE113	1978	11	0.079	0.071	0.091	0.711	1.37	1.49	0.377	0.065	0.159	0.099	0.079	0.065
08NE113	1978	12	0.079	0.068	0.093	0.725	1.17	1.37	0.326	0.045	0.164	0.099	0.076	0.065
08NE113	1978	13	0.079	0.065	0.093	0.705	1.25	1.25	0.235	0.079	0.173	0.099	0.074	0.065
08NE113	1978	14	0.079	0.065	0.093	0.685	1.33	1.13	0.286	0.11	0.178	0.099	0.074	0.065
08NE113	1978	15	0.076	0.068	0.093	0.665	2.25	1.09	0.272	0.144	0.161	0.099	0.074	0.065
08NE113	1978	16	0.079	0.068	0.093	0.654	3.17	1.04	0.258	0.142	0.147	0.099	0.074	0.062
08NE113	1978	17	0.079	0.068	0.096	0.646	3.11	1	0.244	0.142	0.13	0.099	0.076	0.062
08NE113	1978	18	0.076	0.068	0.096	0.634	3.06	0.946	0.224	0.139	0.113	0.099	0.071	0.062
08NE113	1978	19	0.076	0.068	0.099	0.646	3	0.889	0.207	0.139	0.125	0.093	0.071	0.062
08NE113	1978	20	0.074	0.071	0.181	0.654	2.97	0.833	0.187	0.142	0.133	0.088	0.071	0.059
08NE113	1978	21	0.074	0.071	0.261	0.665	2.55	0.776	0.173	0.142	0.144	0.088	0.071	0.059
08NE113	1978	22	0.074	0.074	0.343	0.674	2.12	0.736	0.159	0.144	0.153	0.088	0.071	0.059
08NE113	1978	23	0.074	0.082	0.422	0.685	1.82	0.697	0.173	0.144	0.147	0.088	0.068	0.062
08NE113	1978	24	0.074	0.082	0.504	0.694	1.52	0.657	0.187	0.142	0.144	0.088	0.065	0.062
08NE113	1978	25	0.074	0.082	0.583	0.864	1.44	0.617	0.198	0.139	0.139	0.088	0.065	0.062
08NE113	1978	26	0.074	0.079	0.665	1.04	1.36	0.578	0.212	0.133	0.153	0.088	0.062	0.062
08NE113	1978	27	0.074	0.076	0.878	1.21	1.28	0.549	0.227	0.125	0.164	0.085	0.062	0.062
08NE113	1978	28	0.074	0.076	1.09	1.85	1.36	0.518	0.19	0.113	0.161	0.082	0.062	0.059
08NE113	1978	29	0.071		1.2	2.5	1.45	0.49	0.153	0.099	0.159	0.082	0.062	0.057
08NE113	1978	30	0.071		1.3	3.14	1.53	0.507	0.119	0.099	0.156	0.079	0.062	0.054
08NE113	1978	31	0.071		1.22		1.84		0.085	0.099		0.091		0.051

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08NE113	1979	1	0.051	0.042	0.071	0.119	1.87	0.975	0.205	0.069	0.065	0.042	0.048	0.057
08NE113	1979	2	0.048	0.045	0.076	0.119	2.14	0.943	0.221	0.069	0.079	0.037	0.057	0.059
08NE113	1979	3	0.045	0.048	0.079	0.116	2.4	0.913	0.238	0.063	0.093	0.037	0.054	0.059
08NE113	1979	4	0.04	0.048	0.091	0.109	1.67	0.858	0.23	0.057	0.076	0.037	0.048	0.062
08NE113	1979	5	0.031	0.048	0.099	0.105	2.38	0.804	0.221	0.056	0.068	0.04	0.042	0.059
08NE113	1979	6	0.028	0.051	0.102	0.099	2.1	0.77	0.209	0.055	0.059	0.04	0.045	0.057
08NE113	1979	7	0.028	0.051	0.084	0.108	1.87	0.734	0.197	0.053	0.054	0.04	0.048	0.054
08NE113	1979	8	0.027	0.051	0.079	0.114	1.64	0.711	0.185	0.051	0.054	0.04	0.051	0.065
08NE113	1979	9	0.026	0.051	0.071	0.122	1.55	0.686	0.172	0.05	0.054	0.04	0.048	0.076
08NE113	1979	10	0.025	0.054	0.068	0.131	1.46	0.657	0.158	0.049	0.054	0.037	0.048	0.048
08NE113	1979	11	0.025	0.054	0.062	0.139	1.5	0.626	0.144	0.049	0.054	0.037	0.048	0.045
08NE113	1979	12	0.024	0.057	0.068	0.145	1.53	0.578	0.138	0.049	0.051	0.037	0.048	0.042
08NE113	1979	13	0.024	0.059	0.071	0.144	1.53	0.528	0.132	0.051	0.048	0.04	0.051	0.045
08NE113	1979	14	0.024	0.062	0.079	0.145	1.53	0.504	0.132	0.053	0.045	0.042	0.048	0.057
08NE113	1979	15	0.024	0.062	0.088	0.184	1.53	0.477	0.132	0.054	0.042	0.045	0.048	0.054
08NE113	1979	16	0.023	0.062	0.096	0.227	1.53	0.433	0.123	0.055	0.042	0.045	0.051	0.071
08NE113	1979	17	0.023	0.059	0.105	0.266	1.57	0.385	0.114	0.065	0.042	0.048	0.057	0.108
08NE113	1979	18	0.023	0.059	0.113	0.306	1.61	0.385	0.108	0.062	0.042	0.048	0.051	0.13
08NE113	1979	19	0.023	0.059	0.122	0.303	1.64	0.385	0.102	0.059	0.042	0.045	0.048	0.136
08NE113	1979	20	0.024	0.059	0.13	0.297	1.67	0.365	0.095	0.059	0.04	0.042	0.045	0.127
08NE113	1979	21	0.024	0.057	0.138	0.297	1.64	0.342	0.088	0.057	0.037	0.057	0.045	0.127
08NE113	1979	22	0.025	0.057	0.139	0.297	1.61	0.326	0.082	0.057	0.034	0.065	0.042	0.125
08NE113	1979	23	0.025	0.057	0.138	0.391	1.59	0.306	0.076	0.054	0.037	0.127	0.042	0.125
08NE113	1979	24	0.026	0.057	0.147	0.487	1.56	0.289	0.076	0.054	0.04	0.105	0.045	0.108
08NE113	1979	25	0.028	0.057	0.152	0.58	1.53	0.27	0.076	0.099	0.04	0.099	0.048	0.093
08NE113	1979	26	0.031	0.059	0.142	0.674	1.51	0.251	0.072	0.076	0.037	0.099	0.051	0.085
08NE113	1979	27	0.034	0.062	0.131	0.77	1.48	0.233	0.069	0.065	0.034	0.102	0.051	0.079
08NE113	1979	28	0.037	0.068	0.136	0.864	1.46	0.215	0.069	0.059	0.034	0.082	0.051	0.076
08NE113	1979	29	0.037		0.138	1.24	1.24	0.197	0.069	0.057	0.037	0.065	0.054	0.074
08NE113	1979	30	0.04		0.13	1.61	1.38	0.201	0.069	0.054	0.04	0.054	0.054	0.074
08NE113	1979	31	0.042		0.119		1.18		0.069	0.059		0.051		0.071

ID	Year	Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
08NE113	1980	1	0.071	0.051	0.391	0.156	3.91	0.539	0.211	0.071	0.069	0.048	0.096	0.088
08NE113	1980	2	0.071	0.051	0.34	0.159	3.37	0.555	0.204	0.069	0.119	0.048	0.133	0.088
08NE113	1980	3	0.068	0.054	0.292	0.164	2.75	0.57	0.197	0.071	0.168	0.045	0.122	0.109
08NE113	1980	4	0.068	0.051	0.272	0.176	2.13	0.547	0.19	0.074	0.133	0.045	0.112	0.13
08NE113	1980	5	0.068	0.051	0.258	0.187	2.45	0.524	0.183	0.076	0.1	0.042	0.105	0.122
08NE113	1980	6	0.062	0.048	0.238	0.198	2.77	0.501	0.176	0.079	0.093	0.042	0.094	0.114
08NE113	1980	7	0.059	0.048	0.218	0.207	2.66	0.478	0.168	0.071	0.089	0.04	0.118	0.106
08NE113	1980	8	0.059	0.048	0.201	0.218	2.55	0.459	0.161	0.064	0.085	0.04	0.142	0.099
08NE113	1980	9	0.059	0.048	0.198	0.227	2.46	0.437	0.154	0.062	0.079	0.04	0.133	0.091
08NE113	1980	10	0.057	0.048	0.195	0.232	2.38	0.425	0.17	0.059	0.074	0.04	0.124	0.083
08NE113	1980	11	0.057	0.048	0.193	0.238	2.11	0.415	0.183	0.065	0.069	0.037	0.112	0.082
08NE113	1980	12	0.057	0.048	0.187	0.283	1.85	0.405	0.176	0.069	0.071	0.059	0.1	0.081
08NE113	1980	13	0.057	0.048	0.178	0.382	1.61	0.394	0.168	0.059	0.074	0.079	0.094	0.08
08NE113	1980	14	0.057	0.048	0.173	0.51	1.36	0.385	0.198	0.051	0.068	0.071	0.088	0.089
08NE113	1980	15	0.057	0.048	0.17	0.68	1.31	0.377	0.225	0.051	0.059	0.064	0.087	0.097
08NE113	1980	16	0.057	0.048	0.164	0.821	1.26	0.368	0.198	0.048	0.059	0.057	0.086	0.106
08NE113	1980	17	0.057	0.054	0.161	0.963	1.14	0.361	0.168	0.167	0.059	0.048	0.09	0.1
08NE113	1980	18	0.057	0.059	0.159	1.09	1.01	0.337	0.164	0.284	0.057	0.048	0.094	0.094
08NE113	1980	19	0.057	0.071	0.159	1.11	0.898	0.312	0.161	0.198	0.054	0.045	0.094	0.088
08NE113	1980	20	0.057	0.076	0.159	1.26	0.784	0.303	0.15	0.112	0.059	0.079	0.094	0.09
08NE113	1980	21	0.057	0.071	0.156	1.44	0.807	0.293	0.14	0.099	0.064	0.112	0.107	0.091
08NE113	1980	22	0.057	0.068	0.156	1.64	0.83	0.289	0.133	0.084	0.062	0.085	0.121	0.093
08NE113	1980	23	0.054	0.062	0.161	1.93	0.725	0.284	0.126	0.076	0.059	0.059	0.102	0.093
08NE113	1980	24	0.054	0.059	0.164	2.27	0.621	0.266	0.116	0.069	0.054	0.068	0.083	0.153
08NE113	1980	25	0.054	0.113	0.167	2.63	0.595	0.246	0.105	0.065	0.051	0.079	0.089	0.255
08NE113	1980	26	0.051	0.181	0.17	2.8	0.57	0.244	0.096	0.059	0.051	0.068	0.094	0.396
08NE113	1980	27	0.051	0.263	0.17	3.06	0.564	0.239	0.089	0.071	0.048	0.059	0.091	0.62
08NE113	1980	28	0.051	0.374	0.167	3.37	0.554	0.244	0.088	0.084	0.051	0.054	0.088	0.453
08NE113	1980	29	0.051	0.504	0.161	4.81	0.538	0.246	0.084	0.076	0.051	0.051	0.088	0.326
08NE113	1980	30	0.051		0.161	4.47	0.524	0.229	0.079	0.069	0.051	0.054	0.088	0.246
08NE113	1980	31	0.051		0.159		0.532		0.074	0.068		0.059		0.198

ID	Year	Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
08NE113	1981	1	0.425	0.283	0.311	0.411	1.78	1.43	0.691	0.262	0.104	0.081	0.116	0.09
08NE113	1981	2	0.394	0.275	0.306	0.408	2.13	1.39	0.614	0.237	0.101	0.083	0.129	0.088
08NE113	1981	3	0.362	0.265	0.302	0.404	1.85	1.36	0.537	0.232	0.097	0.085	0.122	0.087
08NE113	1981	4	0.334	0.266	0.3	0.394	1.57	1.21	0.513	0.228	0.101	0.081	0.116	0.085
08NE113	1981	5	0.312	0.266	0.297	0.382	1.47	1.07	0.485	0.219	0.104	0.076	0.107	0.087
08NE113	1981	6	0.306	0.265	0.293	0.372	1.36	1.03	0.6	0.211	0.094	0.116	0.097	0.088
08NE113	1981	7	0.297	0.249	0.289	0.365	1.23	0.988	0.714	0.197	0.085	0.154	0.091	0.09
08NE113	1981	8	0.292	0.232	0.286	0.357	1.09	1.21	0.691	0.183	0.083	0.161	0.085	0.091
08NE113	1981	9	0.284	0.215	0.284	0.351	1.22	1.43	0.668	0.179	0.081	0.168	0.085	0.108
08NE113	1981	10	0.275	0.197	0.286	0.34	1.35	1.46	0.612	0.176	0.079	0.136	0.085	0.124
08NE113	1981	11	0.263	0.207	0.289	0.328	1.39	1.5	0.554	0.165	0.076	0.104	0.089	0.141
08NE113	1981	12	0.252	0.218	0.293	0.317	1.42	1.45	0.538	0.154	0.074	0.094	0.093	0.133
08NE113	1981	13	0.244	0.229	0.309	0.306	1.65	1.39	0.519	0.148	0.072	0.085	0.097	0.125
08NE113	1981	14	0.232	0.239	0.326	0.293	1.57	1.46	0.53	0.141	0.07	0.083	0.101	0.118
08NE113	1981	15	0.229	0.261	0.34	0.306	1.86	1.53	0.537	0.138	0.068	0.081	0.104	0.11
08NE113	1981	16	0.229	0.28	0.357	0.321	2.14	1.46	0.513	0.135	0.066	0.079	0.107	0.108
08NE113	1981	17	0.227	0.302	0.372	0.36	2.1	1.39	0.485	0.132	0.064	0.076	0.11	0.106
08NE113	1981	18	0.225	0.328	0.368	0.396	2.05	1.43	0.467	0.129	0.07	0.074	0.108	0.104
08NE113	1981	19	0.218	0.357	0.365	0.433	2.14	1.46	0.453	0.132	0.076	0.072	0.106	0.101
08NE113	1981	20	0.212	0.383	0.361	0.47	2.22	1.41	0.437	0.135	0.09	0.07	0.104	0.097
08NE113	1981	21	0.204	0.371	0.365	0.509	2.27	1.36	0.423	0.122	0.104	0.068	0.112	0.094
08NE113	1981	22	0.235	0.357	0.368	0.858	2.31	1.34	0.396	0.11	0.09	0.068	0.12	0.091
08NE113	1981	23	0.266	0.343	0.368	1.21	2.2	1.33	0.369	0.107	0.076	0.068	0.129	0.091
08NE113	1981	24	0.3	0.33	0.372	1.56	2.1	1.17	0.362	0.104	0.074	0.068	0.117	0.091
08NE113	1981	25	0.33	0.328	0.377	1.37	2.14	1.02	0.355	0.101	0.072	0.068	0.105	0.091
08NE113	1981	26	0.326	0.326	0.379	1.18	2.18	0.923	0.348	0.097	0.072	0.072	0.093	0.091
08NE113	1981	27	0.317	0.321	0.383	0.987	1.99	0.827	0.343	0.094	0.072	0.076	0.081	0.089
08NE113	1981	28	0.312	0.317	0.391	1.31	1.8	0.77	0.32	0.091	0.076	0.096	0.084	0.087
08NE113	1981	29	0.306		0.399	1.64	1.69	0.714	0.295	0.097	0.081	0.116	0.088	0.085
08NE113	1981	30	0.3		0.408	1.44	1.57	0.702	0.292	0.104	0.081	0.11	0.091	0.085
08NE113	1981	31	0.293		0.415		1.5		0.285	0.104		0.104		0.082

ID	Year	Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
08NE113	1982	1	0.085	0.076	0.258	0.246	1.16	1.7	0.564	0.191	0.102	0.105	0.108	0.101
08NE113	1982	2	0.085	0.076	0.266	0.237	1.23	1.74	0.607	0.184	0.097	0.105	0.106	0.114
08NE113	1982	3	0.082	0.076	0.261	0.232	1.29	1.79	0.597	0.181	0.094	0.105	0.105	0.126
08NE113	1982	4	0.082	0.076	0.252	0.227	1.36	1.83	0.589	0.178	0.094	0.099	0.105	0.162
08NE113	1982	5	0.081	0.076	0.247	0.224	1.31	1.76	0.58	0.168	0.094	0.094	0.105	0.198
08NE113	1982	6	0.079	0.076	0.244	0.218	1.26	1.68	0.57	0.158	0.097	0.106	0.105	0.234
08NE113	1982	7	0.079	0.076	0.244	0.215	1.21	1.6	0.544	0.155	0.101	0.118	0.112	0.269
08NE113	1982	8	0.076	0.076	0.241	0.212	1.23	1.52	0.515	0.152	0.097	0.111	0.119	0.221
08NE113	1982	9	0.076	0.076	0.237	0.211	1.25	1.49	0.489	0.168	0.094	0.105	0.126	0.174
08NE113	1982	10	0.076	0.074	0.227	0.275	1.27	1.46	0.479	0.184	0.106	0.103	0.119	0.126
08NE113	1982	11	0.074	0.068	0.244	0.34	1.29	1.44	0.467	0.184	0.118	0.101	0.111	0.122
08NE113	1982	12	0.072	0.064	0.257	0.402	1.46	1.42	0.456	0.171	0.122	0.101	0.104	0.118
08NE113	1982	13	0.074	0.11	0.258	0.468	1.62	1.4	0.441	0.22	0.126	0.101	0.096	0.113
08NE113	1982	14	0.074	0.156	0.258	0.456	1.79	1.38	0.453	0.269	0.118	0.097	0.096	0.109
08NE113	1982	15	0.074	0.201	0.258	0.447	1.91	1.36	0.462	0.22	0.109	0.094	0.096	0.113
08NE113	1982	16	0.072	0.247	0.257	0.437	2.02	1.22	0.473	0.173	0.103	0.097	0.096	0.118
08NE113	1982	17	0.074	0.235	0.249	0.419	2.14	1.09	0.45	0.158	0.096	0.101	0.099	0.122
08NE113	1982	18	0.074	0.224	0.244	0.402	3.67	0.949	0.43	0.145	0.095	0.096	0.102	0.12
08NE113	1982	19	0.072	0.212	0.237	0.385	3.2	0.864	0.408	0.138	0.094	0.091	0.105	0.118
08NE113	1982	20	0.074	0.232	0.232	0.369	2.72	0.779	0.387	0.13	0.091	0.091	0.105	0.116
08NE113	1982	21	0.074	0.252	0.227	0.425	2.25	0.691	0.362	0.13	0.089	0.091	0.102	0.113
08NE113	1982	22	0.072	0.275	0.224	0.481	2.43	0.607	0.337	0.13	0.09	0.096	0.099	0.11
08NE113	1982	23	0.076	0.295	0.218	0.537	2.61	0.566	0.31	0.124	0.091	0.101	0.096	0.107
08NE113	1982	24	0.079	0.275	0.227	0.597	2.78	0.53	0.294	0.118	0.096	0.101	0.091	0.105
08NE113	1982	25	0.082	0.258	0.238	0.66	2.96	0.489	0.279	0.113	0.101	0.101	0.085	0.104
08NE113	1982	26	0.085	0.237	0.247	0.719	2.6	0.484	0.265	0.109	0.113	0.105	0.079	0.103
08NE113	1982	27	0.085	0.244	0.252	0.782	2.24	0.481	0.251	0.105	0.126	0.109	0.082	0.102
08NE113	1982	28	0.082	0.252	0.258	0.886	1.88	0.479	0.232	0.101	0.122	0.116	0.085	0.101
08NE113	1982	29	0.081		0.261	0.994	1.83	0.473	0.213	0.101	0.118	0.122	0.085	0.101
08NE113	1982	30	0.079		0.266	1.1	1.79	0.518	0.205	0.101	0.111	0.116	0.089	0.101
08NE113	1982	31	0.079		0.258		1.74		0.197	0.101		0.109		0.101

Appendix C

Watershed Report Card
For
Kelly Creek

URBAN systems

*Watershed Report Card for Kelly Creek 2012**

Basin	*Gross Area (ha)*	*Total Harvested Area Ha %*	*ECA ha %*	*ECA below Snowline ha %*	*Area Above Snowline ha*	*ECA Above Snowline ha %*
Kelly Creek	2,391.9	414.4 17.3	410.6 17.2	105.1 11.3	1,460.5	305.5 20.9

** Includes all known blocks cut or proposed to be cut before end 2012*

Appendix D

Field Work Summary and Photographs

Field Work Date:	October 17, 2012
Client:	Beaver Valley Water Service
File:	1011.0041.01
Prepared By:	Michelle Cook

General Field Notes

The Kelly Creek watershed is considered to be in good a good hydrologic condition

1 Location	
BVWS Intake Pond	
GPS	
49° 6'25.09"N 117°30'49.46"W	
Notes	
Intake reservoir is in good condition.	
2 Location	
Kelly Creek Intake structure, with gates and security fence	
GPS	
49° 6'25.99"N 117°30'45.41"W	
Notes	
Site security	

URBAN systems

3	Location
Kelly Creek Intake	
GPS	
49° 6'25.99"N 117°30'45.41"W	
Notes	
During the field investigation (October 2012) all creek flow was being diverted into the intake pond (Photo 1) through the screen.	

4	Location
Public signage and locked gate	
GPS	
49° 6'24.42"N 117°30'46.73"W	
Notes	
The gate only blocks access to the watershed during the day when it is swung across the road and there are people working at the intake and treatment facility.	

5	Location
Watershed access gate, locked – path around when gate is locked	
GPS	
49° 6'24.42"N 117°30'46.73"W	
Notes	
Unauthorized access past locked gate into watershed that 4x4 trucks and ATVs use frequently. Cement barricades, placed to block access, have been displaced.	

6	Location
Kelly Creek stream crossing	
GPS	
49° 6'47.79"N 117°29'32.10"W	
Notes	
Stable channel	

7	Location
Kelly Creek stream crossing	
GPS	
49° 6'47.79"N 117°29'32.10"W	
Notes	
Bridge in good condition	

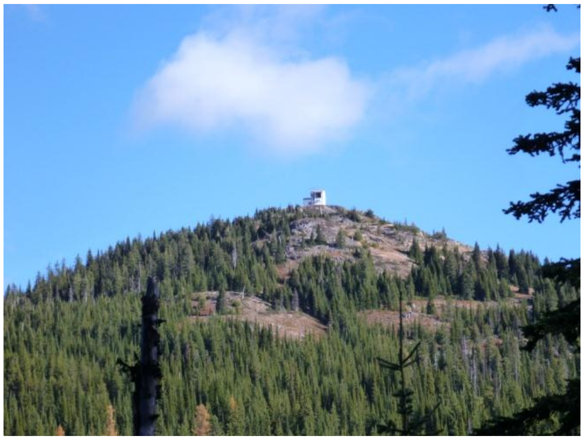
8	Location
Runoff and erosion present on steep road after the first stream crossing	
GPS	
49° 6'58.26"N 117°29'17.07"W	
Notes	
Sediment delivery from the road enters the creek at the bridge	

9	**Location**	
Creek 1		
GPS		
49° 7'14.02"N 117°28'26.03"W		
Notes		
Stable channel		
10	**Location**	
Landslide from cause by main FSR		
GPS		
49° 7'10.81"N 117°28'28.68"W		
Notes		
Wood debris and soil terminates in channel. Creek has cut a channel through the debris		
11	**Location**	
Creek 2		
GPS		
49° 7'13.41"N 117°27'56.82"W		
Notes		
Stable channel		

13	Location
	Blue stain fungus in dead lodgepole pine
	GPS
	Notes
	Blue stain fungus that kills mature lodgepole pine trees that are attacked by mountain pine beetle

14	Location
	Creek 3
	GPS
	49° 7'19.74"N 117°26'38.01"W
	Notes
	Stable channel

15	Location
	Structure on top of Kelly Mtn.
	GPS
	Notes



16 Location	 
Creek 4, road crossing	
GPS	
49° 8'21.63"N 117°26'27.71"W	
Notes	
Culvert blocked by debris causing flow to overtop and wash out the crossing	
17 Location	
View of south high elevation cut block and 2007 fire location	
GPS	
49° 7'36.59"N 117°26'15.71"W	
Notes	
Brown trees in foreground are larch as needles change in the fall.	

18 Location	
View of mid-elevation cut block in the centre of the watershed	
GPS	
49° 7'36.59"N 117°26'15.71"W	
Notes	
Stable block and roads	

19 Location	
Creek 5 – road culvert almost buried	 
GPS	
49° 7'30.13"N 117°26'13.78"W	
Notes	
Stable channel. Second photo indicates debris blocking culvert	

21	**Location**	
Creek 6 – pooling on upstream side of road, perched culvert		
GPS		
49° 6'47.20"N 117°26'26.06"W		
Notes		
Fine organic sediment in pond upstream of culvert. Source of material is from natural sources		
22	**Location**	
View of south high elevation cut block		
GPS		
49° 6'33.62"N 117°26'52.54"W		
Notes		
2007 wildfire		
23	**Location**	
Creek 7 culverts		
GPS		
49° 6'25.59"N 117°27'39.55"W		
Notes		
Stable channel		

24	Location
High elevation south cut block	
GPS	
49° 6'12.55"N 117°27'46.63"W	
Notes	

25	Location
Creek 8 – showing riparian area	
GPS	
49° 6'12.55"N 117°27'46.63"W	
Notes	
2007 wildfire did not burn the riparian area along the creek	

26	Location
Westward view of the watershed towards Fruitvale	
GPS	
49° 6'12.55"N 117°27'46.63"W	
Notes	

URBAN systems

27 Location	
Creek 9 upper reach	
GPS	
49° 6'13.20"N 117°28'47.29"W	
Notes	
Small, stable, headwater channel	
28 Location	
Northward view of the watershed	
GPS	
49° 6'12.51"N 117°29'6.48"W	
Notes	

29	Location
Creek 9 – lower reach fan	
GPS	
49° 6'30.14"N 117°29'35.26"W	
Notes	

30	Location
Road erosion	
GPS	
49° 6'29.93"N 117°29'38.45"W	
Notes	

31	**Location**	
Intake pond spillway		
GPS		
49° 6'25.09"N 117°30'49.46"W		
Notes		
32	**Location**	
Kelly Creek south of intake		
GPS		
49° 6'16.43"N 117°31'7.94"W		
Notes		
Channel downstream of intake pond spillway		

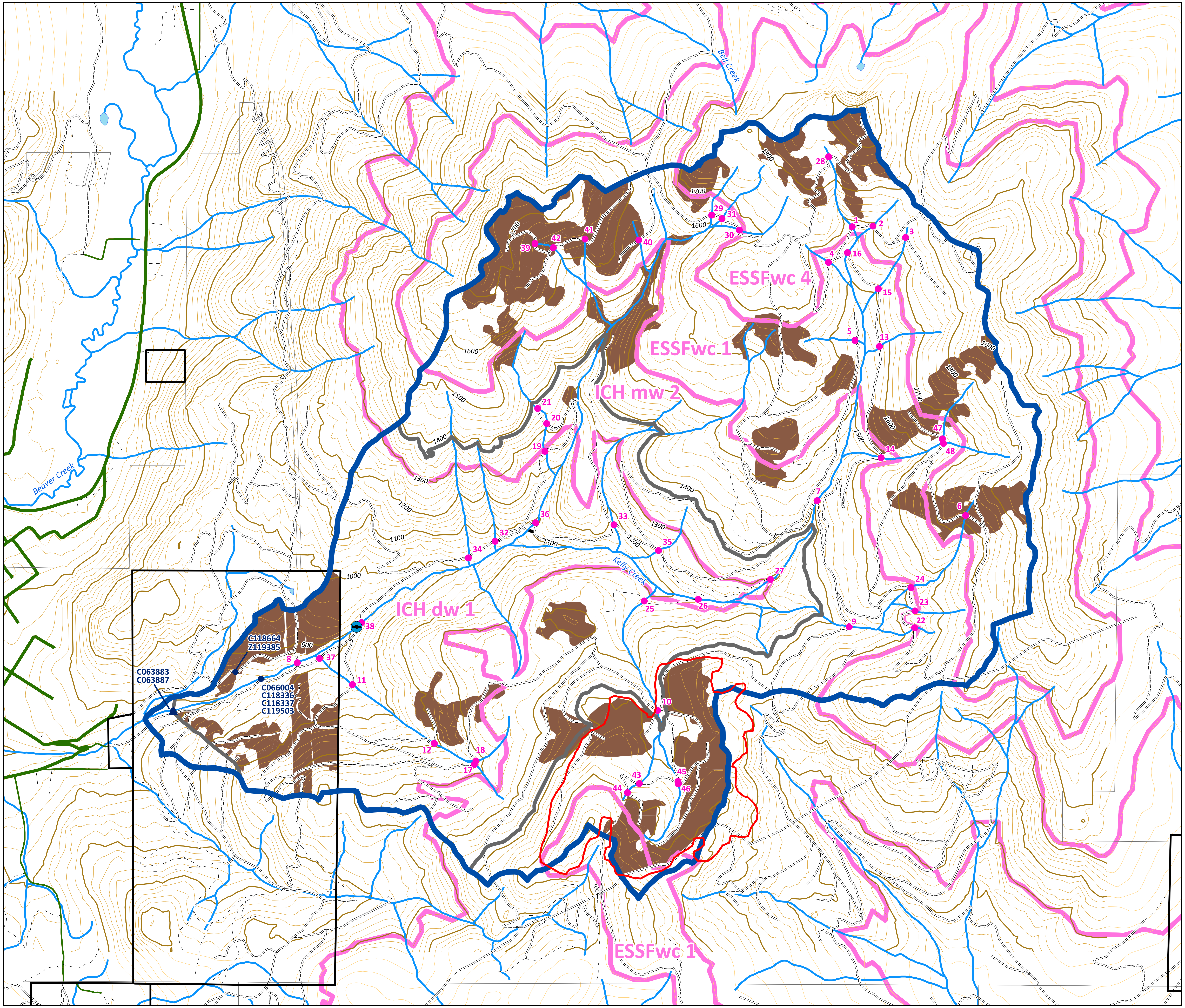
URBAN SYSTEMS LTD.

Michelle Cook
Water Resource Planner

/MC

Appendix E

Maps



Regional District of Kootenay Boundary

Fruitvale

Kelly Creek Community Watershed Current Condition Map 2012

MAP 1

Legend

Boundaries
- Watershed
- H_{60}
- Private Land
- ATCO Private Lands

Wild Fire Boundary
- 2007

Water
- Lake
- Stream
- Intake
- 47 Stream Crossing
- Fish Observed
- Water Licence

Forest Cover
- Logged
- Landslide

Roads
- Paved
- Loose
- Rough

Contours
- Index (100m)
- Intermediate (20m)
- 40m

N E S W

Projection: UTM Zone 11
Datum: NAD 83
Scale: 1:20,000

0 300 600 1,200 1,800
metre

URBAN systems

Map produced for:
Urban Systems Ltd.
304-1353 Ellis Street, Kelowna, BC V1Y 1Z9

FPS Drafting & Geomatics Ltd.

Map Prepared by:
FPS Drafting & Geomatics Ltd.
2784 Paris Street, Penticton, BC, V2A 8G2

Source
Atco Wood Products Ltd.
Land Resource Data Warehouse
National Resource Canada

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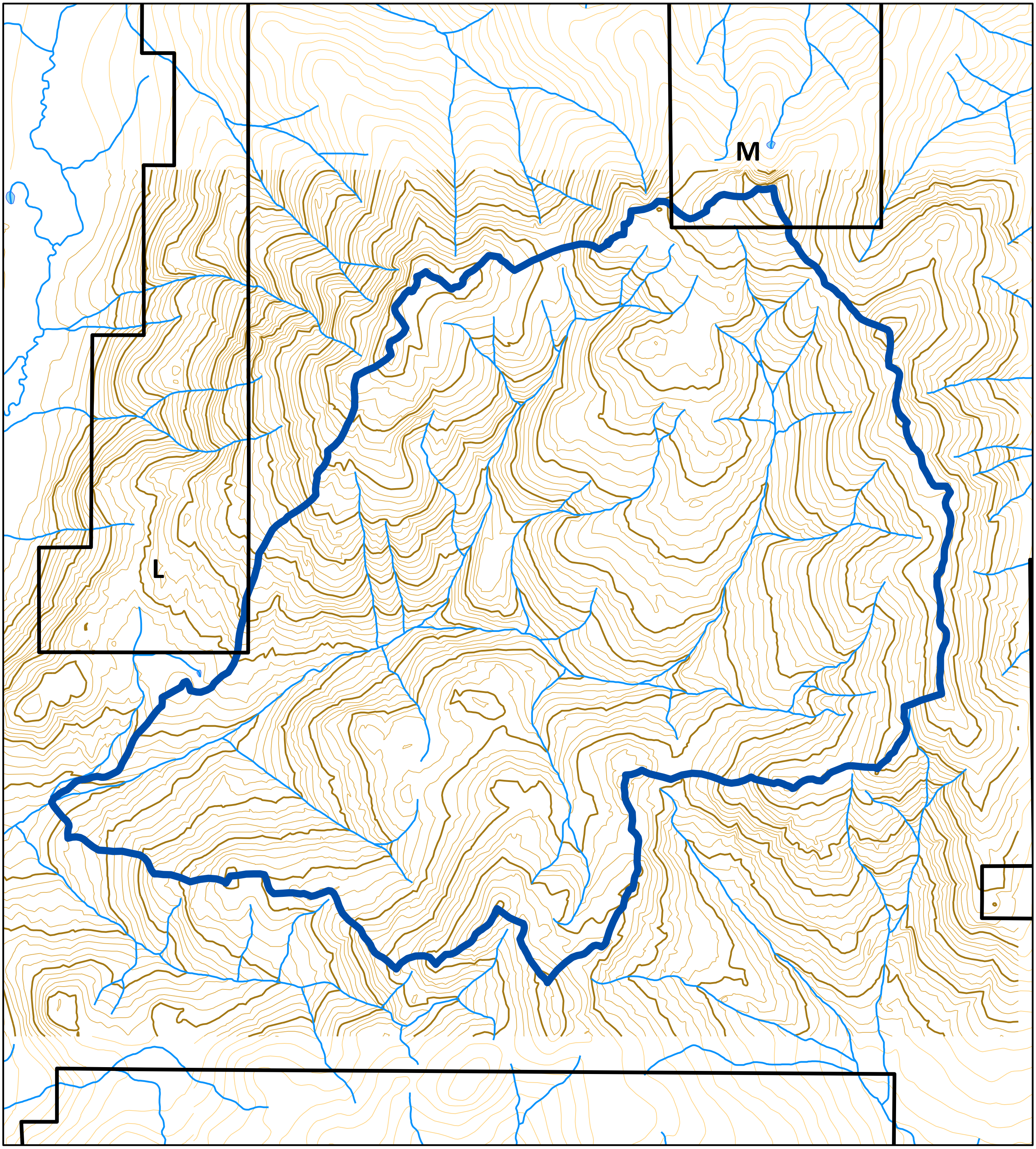
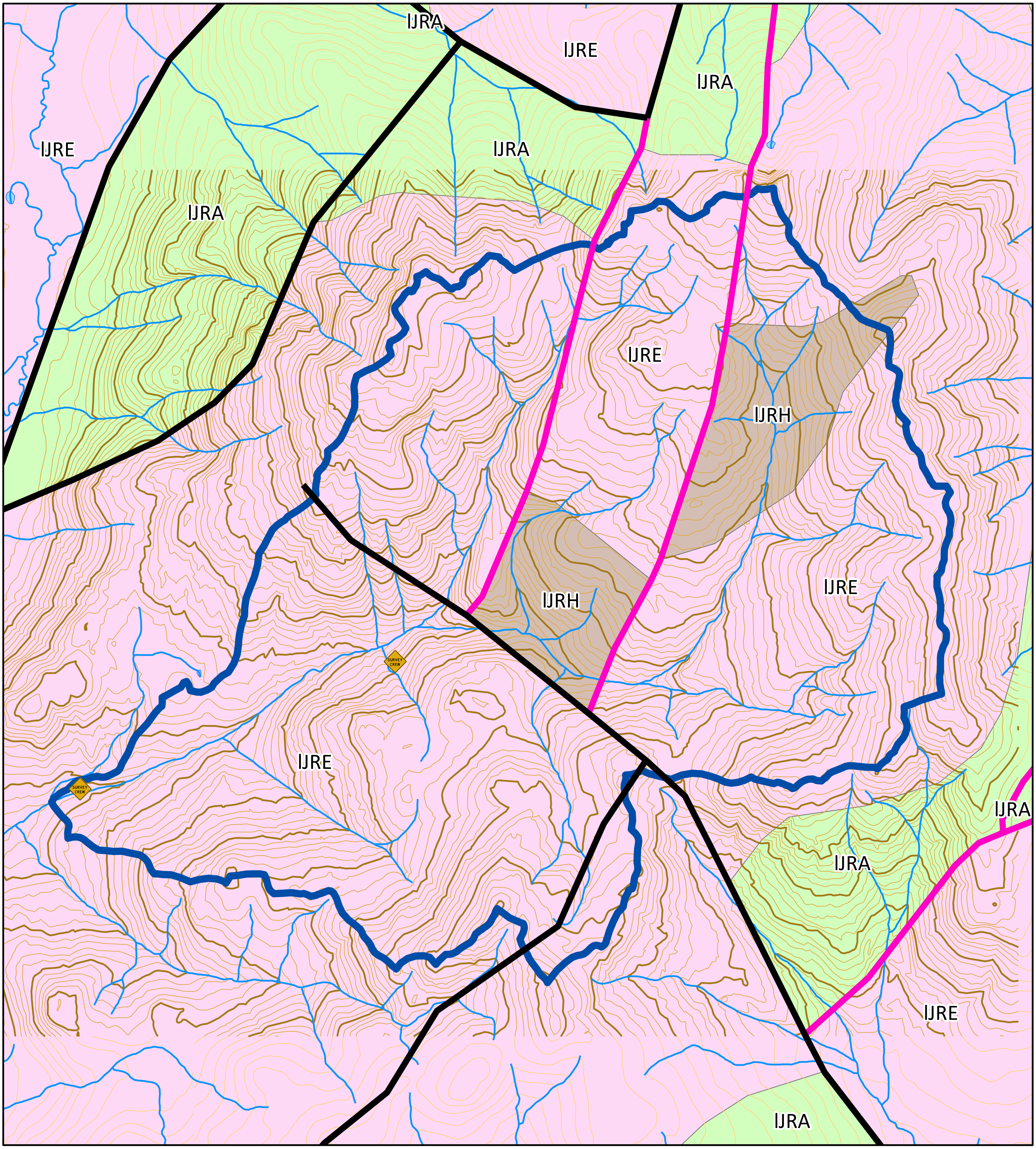


Kelly Creek Watershed
Stream
Index Contour (100m)
Intermediate Contour(20m)
40m Contour
Charts

Map 2

Kelly Creek
Community Watershed
Geology Map 2012

Source
Land Resource Data Warehouse
National Resource Canada



Regional District of Kootenay Boundary

Map 3

Kelly Creek
Community Watershed
Geology Map 2012

- Kelly Creek Watershed
- Stream
- Index Contour (100m)
- Intermediate Contour(20m)
- 40m Contour
- Thrust Fault
- Normal Fault
- Geological Survey

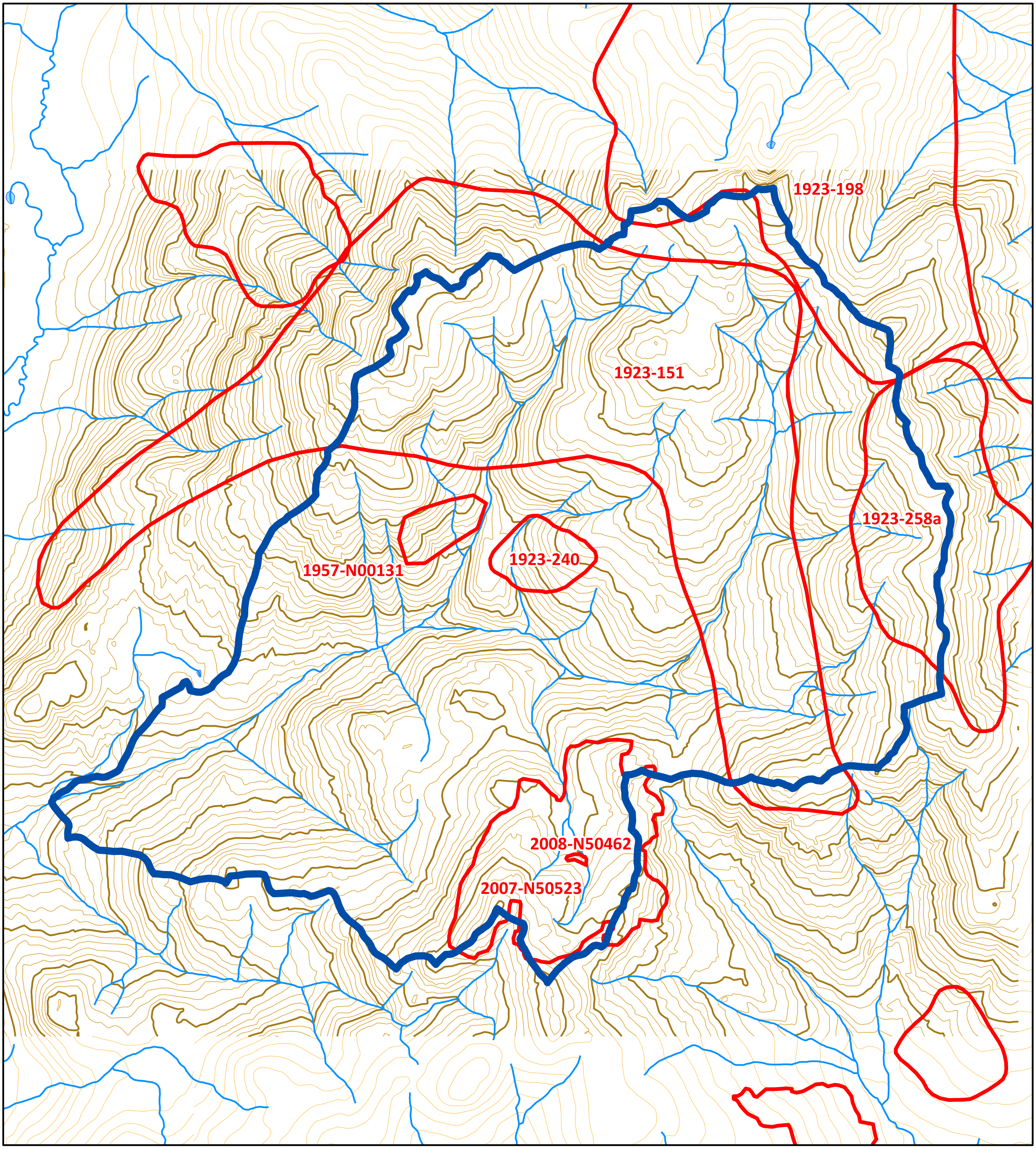
URBAN systems

FPS Drafting & Geomatics Ltd.

0 200 400 800 1,200 1,600

metre

Source
Land Resource Data Warehouse
National Resource Canada



Kelly Creek Watershed
Stream
Index Contour (100m)
Intermediate Contour(20m)
40m Contour

Regional District of Kootenay Boundary

Map 4
Kelly Creek
Community Watershed
Geology Map 2012

URBAN systems
FPS Drafting & Geomatics Ltd.

0 200 400 800 1,200 1,600
metre

Source
Land Resource Data Warehouse
National Resource Canada