

CITY OF KAMLOOPS SOURCE WATER PROTECTION PLAN

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PREPARED FOR
City of Kamloops - Public Works and Utilities
955 Concordia Way
Kamloops BC V2C 6V3

PREPARED BY
Tracy Thomas, Assistant Regional Manager, Fraser Basin Council
200A – 1383 McGill Road
Kamloops BC V2C 6K7

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1.0 Introduction

This Source Water Protection Plan has been prepared to support the City of Kamloops (City) Utility Services Division in meeting their Interior Health Authority (IHA) requirement to develop a strategy for protecting source water. This condition of the IHA water system operating permit, as stated under Section 8 of the Water Protection Act, is addressed in this plan for the City's River Street intake on the Lower South Thompson River and the proposed Yates Road emergency intake on the Lower North Thompson River. As a secondary benefit, this plan supports the City of Kamloops long term vision for social, environmental, and economic sustainability within the City and the Thompson Region as a whole. It does this by bringing to the forefront one of the most important components of the Sustainable Kamloops Plan, that being water.

The IHA has requested that the City develop a source water protection plan to identify areas and activities that could negatively affect the quality, quantity, and timing of flow of the drinking water sources on the lower South Thompson River downstream from the Thompson Nicola Regional District (TNRD) water intake in Pritchard through to the River Street intake, and on the lower North Thompson River downstream of the TNRD Black Pines water intake through to the proposed Yates Road emergency intake. By identifying critical areas and activities in both of the source water assessment areas, the City Utility Services Division can influence planning and measure impacts on their two systems drawing water from these rivers. Additionally, the source water protection plan will help reduce threats to water quality and provide an additional layer for drinking water protection.

To support this IHA requirement, this plan addresses four of the eight modules of the Ministry of Health's Comprehensive Drinking Water Source-to-Tap Assessment Guideline including:

- Module 1 – Source Delineation & Characterization
- Module 2 – Hazard Source Inventory
- Module 7 – Risk Assessment
- Module 8 – Actions to Improve Drinking Water Protection

This plan has been organized in such a way that each section corresponds to a drinking Water Source-to-Tap Assessment Guideline module (excluding modules 3, 4, 5, and 6). In each section, information specific to either the North Thompson or South Thompson watersheds will be appropriately distinguished by the applicable titles of "North Thompson" or "South Thompson". Likewise, information related to the assessment area of each watershed will be distinguished by the title of the "Lower North Thompson" or "Lower South Thompson".

During the development of this Source Water Protection Plan the following individuals formed an assessment team and made crucial decisions to guide this plan:

- Rob Fleming, Water Quality Specialist, Interior Health
- Michael Firlotte, Utility Services Manager, City of Kamloops
- Jen Fretz, Director of Public Works and Utilities, City of Kamloops
- Rob Smith, Utility Services Supervisor, City of Kamloops
- Marc Solomon, Environmental Services Coordinator, City of Kamloops
- Tracy Thomas, Assistant Regional Manager, Fraser Basin Council
- Mike Simpson, Regional Manager, Fraser Basin Council

2.0 Module 1 - Source Delineation & Characterization

2.1 Description and Delineation of the Watersheds

The Thompson River is the largest tributary of the Fraser River flowing through the southern interior of British Columbia (Wikipedia.org, 2013). The Thompson River has two main branches called the South Thompson River and the North Thompson River.

Lower South Thompson

Although the actual South Thompson River originates at the outlet of Little Shuswap Lake at the Village of Chase, the South Thompson Watershed in its entirety covers an area of approximately 17,460 km², and includes the areas surrounding the Shuswap Lakes, Adams Lake, Mara Lake, Mable Lake, and Sugar Lake.

After leaving the Little Shuswap Lake, the South Thompson River flows approximately 57 km southwest through a wide and moderately populated valley to Kamloops where it joins the North Thompson to form the Thompson River. The Trans-Canada Highway and the mainline of the Canadian Pacific Railway parallel the South Thompson River the entire distance.

Some of the key characteristics of the Lower South Thompson watershed can be summarized as follows:

- **Land ownership:**
Extensive private land exists in the watershed's assessment area. Crown land (much of which is tenured for agriculture, forestry, mining and other uses) and First Nations lands are also present in the assessment area.
- **Jurisdictions:**
All levels of government have jurisdiction within the Lower South Thompson watershed. The key federal agency involved is the Department of Fisheries and Oceans, and three First Nations communities (Tk'emlúps, Niskonlith, and Adams Lake) have interests in the area. Provincial agencies with the most pronounced involvement in this watershed range from the Ministry of Environment and the Ministry of Agriculture to the Ministry of Forests, Lands, and Natural Resource Operations, and the Ministry of Transportation. Finally, the entire Lower South Thompson watershed falls within the TNRD and includes the Village of Chase and the City of Kamloops.
- **Activities:**
Forest harvesting, agriculture (including grazing, winter feedlots, hay production, wineries and ginseng cultivation), mining, settlement, transportation (railway and highway) and recreation (both land and water-based) are all examples of human activities within the Lower South Thompson watershed. In addition, the area is heavily used by wildlife for habitation and frequently experiences erosion events due to high water, wind and silt bluffs slumping. A detailed orthographic map of the South Thompson Watershed is provided in Figure 2.1.

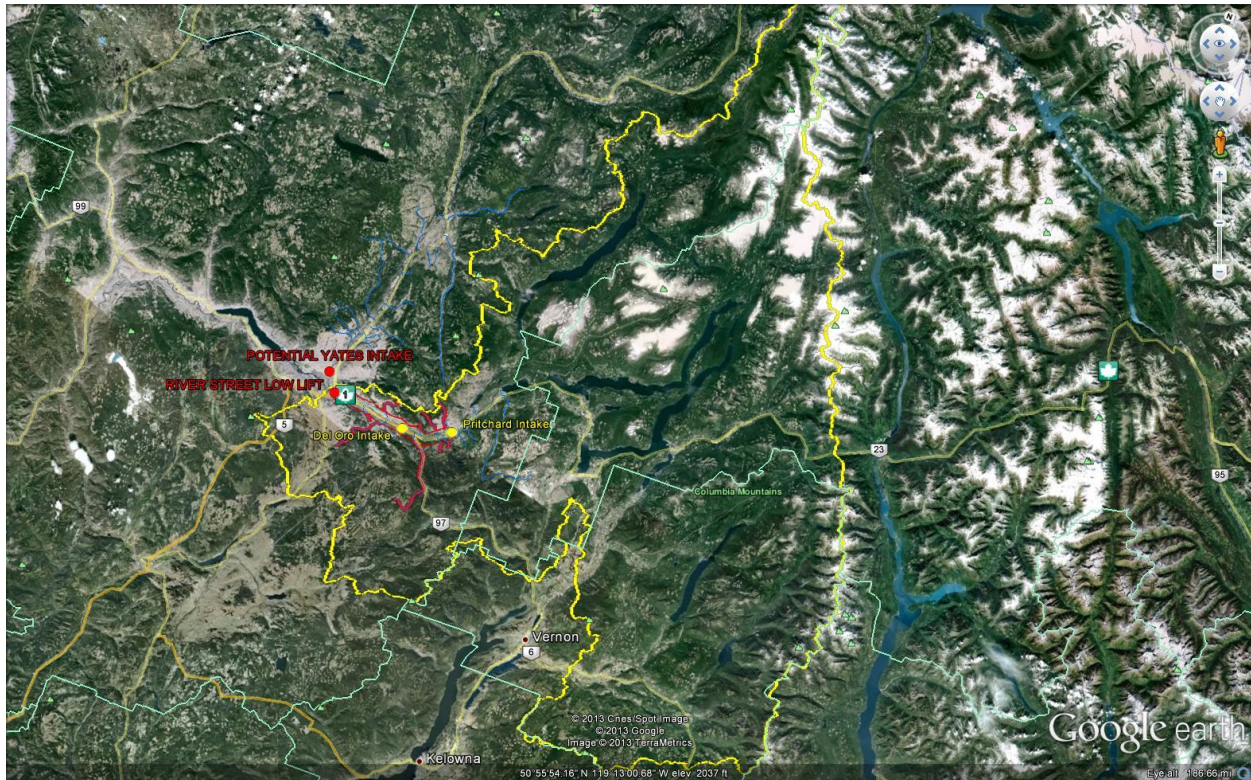


Figure 2.1: South Thompson Watershed Boundary

North Thompson

The North Thompson watershed covers an area of approximately 20,751 km² and includes East and North Barriere Lakes, Canim Lake, Mahood Lake, Clearwater, and Azure Lakes. The North Thompson River originates at the toe of the Thompson Glacier in the Cariboo Mountains, west of the community of Valemount and flows 300 km south towards Kamloops where it meets the South Thompson River. For most of its length; the North Thompson River is paralleled by Highway 5 and the CN Railway (both of which cross the river at several different locations). The North Thompson River passes by several small communities, the most notable of those being Blue River, Clearwater, and Barriere.

Some of the key characteristics of the Lower North Thompson watershed can be summarized as follows:

- **Land ownership:**
Extensive private land exists in the Lower North Thompson assessment area. Crown land (much of which is tenured for agriculture, forestry, mining, and other uses), Indian Reserve land, and First Nations asserted territories.
- **Jurisdictions:**
All orders of government have jurisdiction within the Lower North Thompson watershed. The key federal agency involved is Fisheries and Oceans Canada along with four First Nations communities (Simpson, Adams Lake, Whispering Pines, and Tk'emlúps). Provincial agencies with the most pronounced involvement in the watershed include the Ministry of Environment, Ministry of Agriculture, Ministry of Forests, Lands, and Natural Resource Operations, and the Ministry of Transportation and Infrastructure. The Lower North Thompson watershed falls within the TNRD and the towns of Barriere, Clearwater, Sun Peaks, and the City of Kamloops.

- **Activities:**
Activities in the North Thompson watershed include forest harvesting, agriculture (including grazing winter feedlots, hay production, and ginseng cultivation), mining, settlement, transportation (railway and highway), and recreation (both land and water-based). In addition, the area is heavily used by wildlife for habitation and frequently experiences erosion events due to high water levels eroding river banks. A detailed orthographic map of the North Thompson Watershed is provided in Figure 2.2.

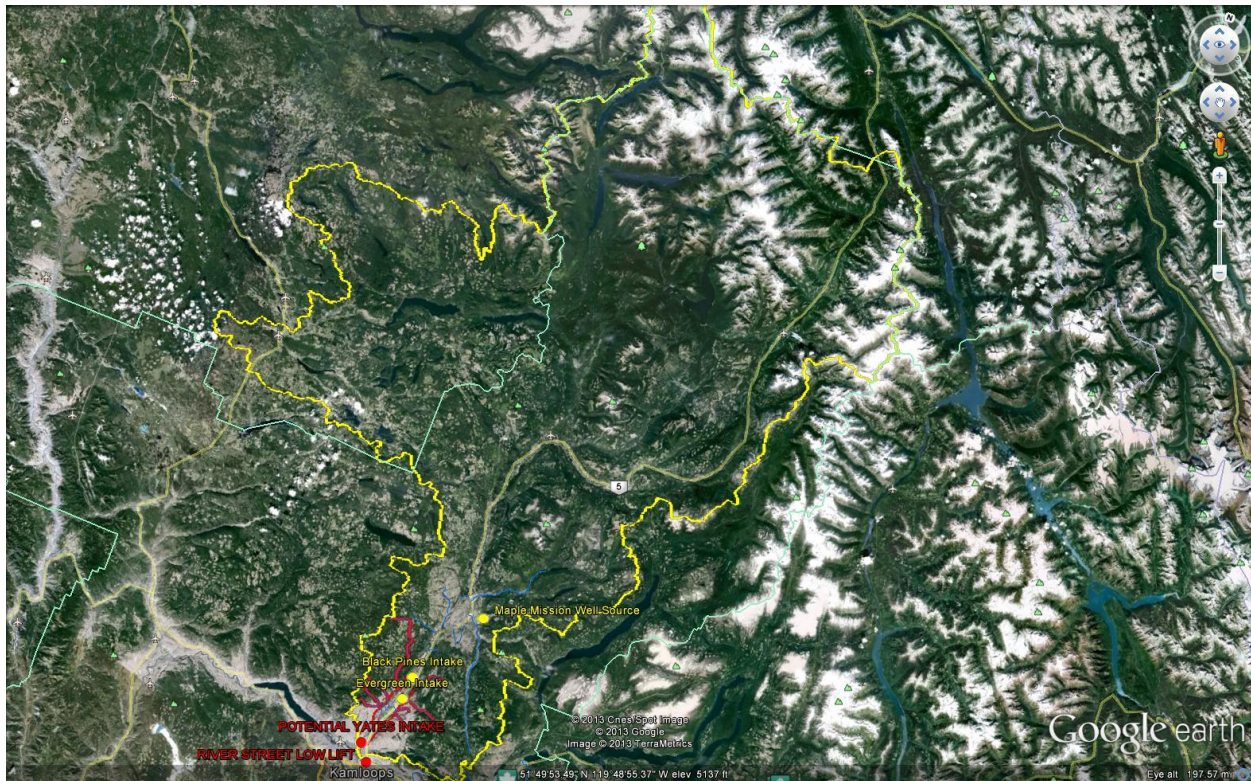


Figure 2.2: North Thompson Watershed Boundary

2.2 Description and Delineation of the Assessment Area

This source water protection plan delineates an assessment area located in both the lower portions of the North Thompson and South Thompson watersheds. A corridor approach was used for both assessment areas and includes a distance of 1500 m outwards from the edges of either side of the two main rivers, and 200 m outwards from the edges of all tributary rivers and creeks. These distances were determined by the assessment team to adequately capture the highest risk areas for potential contamination of the two watersheds. The combined total area of the two assessment areas is 284.8 km².

Lower South Thompson

The length of the Lower South Thompson assessment area runs east to west, beginning 100 m downstream of the TNRD water intake at Pritchard and ending 100 m past the Kamloops Centre for Water Quality River Street water intake. A detailed orthographic map of the Lower South Thompson Assessment Area is provided in Figure 2.3.



Figure 2.3: South Thompson Assessment Area Boundary

The Lower South Thompson assessment area is 155.91 km² in size and encompasses nine tributary creeks and rivers. The names and approximate horizontal distances of those creeks from the River Street water intake area can be found in Table 2.1.

Table 2.1: Horizontal Distances between the South Thompson River's Tributary Creeks and the River Street Water Intake

Tributary	Distance From The River Street South Thompson Water Intake (Km)
Juniper Creek	9.62
McGregor Creek	16.8
Campbell Creek	17.29
Monte Creek	26.04
Swain Creek	27.5
Dry Creek	33.05
Moulton Creek	33.33
Ned's Creek	35.05
Pemberton Creek	36.91

Lower North Thompson

The length of the Lower North Thompson assessment area runs north to south and begins 100 m downstream of the TNRD Black Pines water intake and ends 100 m past the City of Kamloops proposed Yates Road emergency intake. A detailed orthographic map of the Lower North Thompson assessment area is provided in Figure 2.4.

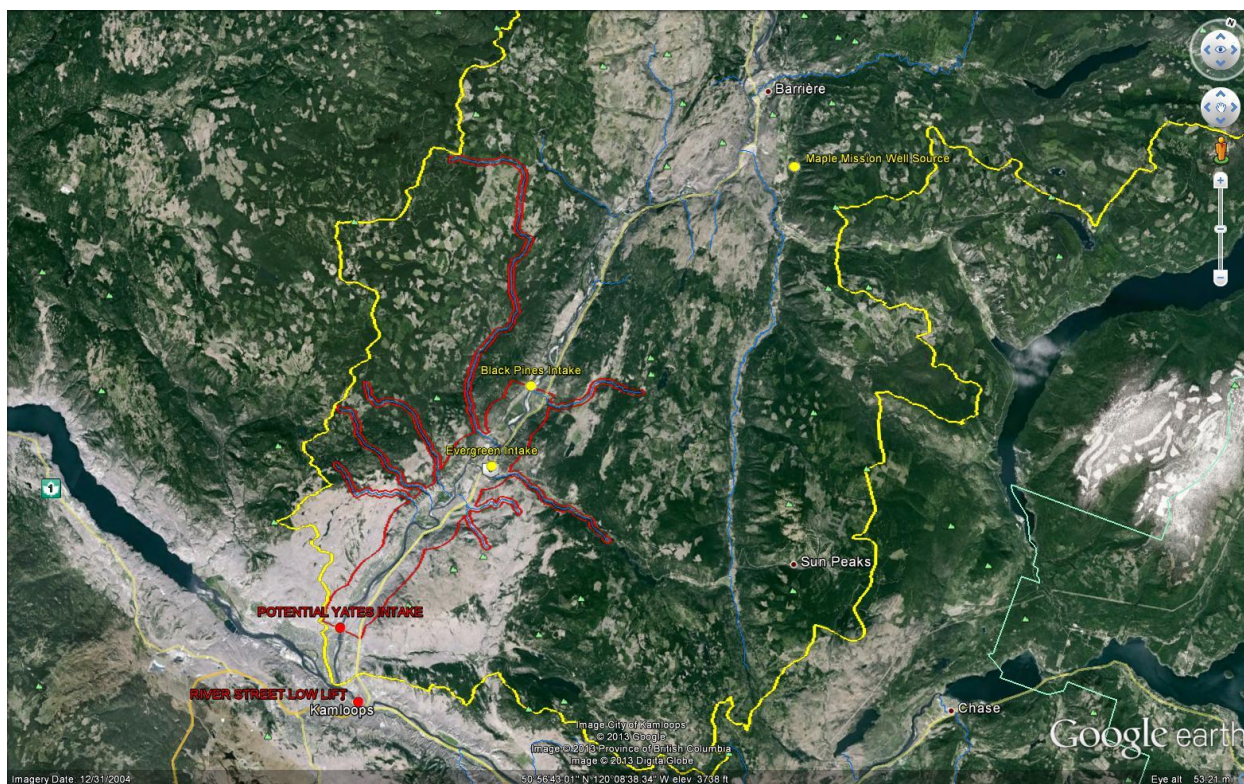


Figure 2.4: South Thompson Watershed Assessment Area Boundary

The Lower North Thompson assessment area is 128.89 km² and includes seven tributary streams. The names and approximate horizontal distances of those creeks from the proposed Yates Street water intake area can be found in Table 2.2.

Table 2.2: Horizontal Distances Between the North Thompson River's Tributary Creeks and the Proposed Yates Road Emergency Intake

Tributary	Distance From The Proposed Yates Street Lower North Thompson Water Intake (Km)
McQueen Creek	10.5
Dairy Creek	14.21
Lanes Creek	16.06
Robbins Creek	16.53
Heffley Creek	20.44
Jamieson Creek	22.8
Knouff Creek	28.48

Despite not falling within the assessment area, the Barriere River, located 63 km upstream of the proposed intake, and Louis Creek, located 58 km upstream of the proposed intake, are two of the larger tributary streams feeding into the North Thompson River; both sub-watersheds have extensive agriculture, forestry, landfill, and recreational activities occurring within them.

2.3 Stakeholders

The main stakeholders or parties with an interest in the water quality and quantity in the lower portion of the North and South Thompson watersheds are:

Lower South Thompson

- City of Kamloops
- Thompson-Nicola Regional District
- Tk'emlúps Indian Band
- Interior Heath Authority
- Fisheries and Oceans Canada
- Other Water Licensees
- Ministry of Environment
- Ministry of Forests, Lands, and Natural Resource Operations
- Ministry of Transportation and Infrastructure
- Ministry of Agriculture

Lower North Thompson

- City of Kamloops
- Thompson-Nicola Regional District
- Rayleigh Water Works
- Interior Heath Authority
- Fisheries and Oceans Canada
- Other Water Licensees
- Ministry of Environment
- Ministry of Forests, Lands, and Natural Resource Operations
- Ministry of Transportation and Infrastructure
- Ministry of Agriculture

2.4 Characterization of the Water Source Area

2.4.1 Biogeoclimatic Ecosystem Classification

Lower South Thompson

The South Thompson watershed is located within the Shuswap Highland of the Interior Plateau. Elevations range from approximately 337 m at the River Street water intake to over 2855 m in the mountains above the Seymour Arm of Shuswap Lake.

Within the South Thompson watershed there are seven distinct Biogeoclimatic Ecosystem Classification (BEC) zones. These BEC zones, their area (Km²), and the percentage of the total area they occupy in the watershed are listed in Table 2.3.

Table 2.3: South Thompson Watershed Biogeoclimatic Ecosystem Classification Breakdown

South Thompson Watershed		
Biogeoclimatic Ecosystem Classification Zone	Percentage	Area (Km ²)
Interior Cedar Hemlock - ICH	38.93%	6,797.67
Engelmann Spruce Sub-Alpine Fir - ESSF	28.31%	4,943.76
Interior Douglas Fir - IDF	24.59%	4,293.46
Montane Spruce - MS	4.59%	801.04
Interior Mountain-Heather Alpine - IMAun	1.41%	245.82
Bunchgrass - BG	1.13%	198.16
Ponderosa Pine - PP	1.03%	180.31
	100.00%	17,460.22

The Bunchgrass, Ponderosa Pine and Interior Douglas Fir BEC zones occupy the majority of the Lower South Thompson assessment area.

Lower North Thompson

The North Thompson watershed is located within the Shuswap Highland of the Interior Plateau. Elevations range from approximately 442 m at the proposed Yates Road emergency intake to over 3264 m in the northern end of the watershed.

There are nine distinct BEC zones in the North Thompson watershed. The BEC zones, their area (Km²), and the percentage of the total area they occupy in the watershed are listed in Table 2.4.

Table 2.4: North Thompson Watershed Biogeoclimatic Ecosystem Classification Breakdown

North Thompson Watershed		
Biogeoclimatic Ecosystem Classification Zone	Percentage	Area (Km ²)
Engelmann Spruce Sub-Alpine Fir - ESSF	38.18%	7,922.04
Interior Cedar Hemlock - ICH	27.03%	5,609.93
Sub-Boreal Spruce - SBS	12.78%	2,653.06
Interior Douglas Fir - IDF	12.06%	2,502.50
Interior Mountain-Heather Alpine - IMAun	4.75%	985.18
Montane Spruce - MS	3.57%	740.48
Ponderosa Pine - PP	0.64%	133.71
Bunchgrass - BG	0.49%	102.14
Sub-Boreal Pine-Spruce - SBPS	0.49%	102.61
	100.00%	20,751.65

The Bunchgrass, Ponderosa Pine and Interior Douglas Fir BEC zones occupy the majority of the Lower North Thompson assessment area.

2.4.2 Forest Cover / Forest Beetle Infestation

Both the North and South Thompson Watersheds have extensive grassland and forest cover. The forest cover within the three dominant BEC zones of both watersheds comprise a variety of merchantable tree species including Douglas fir, lodgepole pine, cedar, Engelmann spruce, white spruce, white pine, larch, hemlock, aspen, and sub alpine fir. All of these species are highly valued by the regional lumber industry and as such, forest harvesting is extensive within these watersheds.

Both the North and South Thompson Watersheds have been impacted significantly by forest beetle infestations, specifically the mountain pine beetle infestation. Since 2003, the forest harvesting annual allowable cut (AAC) within the Okanagan and Kamloops Timber Supply Areas have increased significantly in order to address the salvage of timber damaged by fire and the various forest beetle infestations. Within the Kamloops Timber Supply Area alone, the AAC went from 2.68 million cubic metres in 2003 to 4 million cubic metres between 2004 and 2011 (MFLNRO, 2013). Although the AAC was lowered to 2.51 cubic metres in 2012, the increased forest harvesting and forest road development that has taken place in this area has increased the likelihood of the source water quality and quantity. These impacts include increased erosion and sedimentation loads, increased snow packs, and increased melting rates.

Forests in the Lower North and Lower South Thompson watersheds that have been impacted by the forest beetle infestation, and have not been harvested, are also changing the water quantity and quality in the two watersheds.

In comparison to a healthy living forest, those forests that have been impacted by a forest beetle infestation tend to allow a greater level of precipitation penetration through the forest canopy onto the forest floor. That increased precipitation onto the forest floor can result in higher levels of ground disturbance and faster forest soil saturation. Once the forest soils are saturated, the level of surface run-off and soil erosion increases altering the water quantity and quality entering the tributary creeks and the main river channels of the South and North Thompson Rivers.

In addition, forests in the North and South Thompson Watersheds that have high forest beetle tree mortality levels have less water absorption and transpiration levels. This results in increased spring and total annual stream flow volumes, earlier onset of snowmelt, and a more rapid stream flow response to storms.

2.4.3 Wildfire

Both the Lower North and South Thompson watersheds fall within the Kamloops Fire Region which is the most active region in the province for wildfires. In 2012 there were 460 human-caused and naturally occurring fires in the Kamloops Fire Region. The most notable wildfire to occur in the North Thompson watershed was the McClure fire in 2003 which resulted in the loss or damage to 72 homes and nine businesses in the small communities of McClure, Barriere, and Louis Creek. The fire reached a final size of 26,420 hectares and resulted in increased erosion events throughout the area (Wildfire Management Branch, 2013). One of the worst fires in the South Thompson watershed occurred in Salmon Arm area in 1998 and damaged over 6,000 hectares, caused the evacuation of approximately 7,000 people, destroyed 40 buildings, and cost over \$10 million to extinguish (Wildfire Management Branch, 2013).

Since the North and South Thompson watersheds are prone to frequent wildfire events, the Provincial Air Tanker Centre and Kamloops Fire Centre are both located at the Kamloops airport allowing for a

quick response time to wildfires. Normally two - four air tankers, two - four helicopters, six initial attack crews with three people each, and one Sustained Action crew with twenty people are stationed at the airport (Wildfire Management Branch, 2013).

The wildfires that have occurred in the two watersheds in the past have affected the source water quantity and quality to varying degrees depending on the severity and size of the wildfire. Some of the effects range from increased stream flow and stream bank erosion, earlier and larger peak flows, deeper snow packs that melt earlier, increased water temperature where riparian shade has been reduced, increased soil water repellency resulting in overland flow instead of infiltration and increased erosion and sedimentation into the water source (Forrex, 2003). Large and intense wildfires that may occur in the future could impact the source water quality and quantity in both watersheds for several years following the fire unless proper steps are taken to mitigate these effects.

2.4.4 Wildlife

Both the South and North Thompson watersheds have large populations of wildlife including a variety of ungulates, carnivores, birds, reptiles, and fish.

Lower South Thompson

In the Lower South Thompson assessment area, the most notable ungulate species are mule deer, California bighorn sheep, white-tailed deer, moose, and a small herd of elk near the Pritchard area. The extensive Douglas fir forest stands and grasslands in the area provide ideal winter habitat for both the mule deer and the California bighorn sheep populations.

As a result of the dryer climate in the South Thompson, the ungulate populations are frequently drawn to the South Thompson River and its many tributary streams for their drinking water. Those same animals can contribute to the overall *Escherichia coli* (*E. coli*) levels of the source water as a result of them directly defecating into the water, or their feces being deposited adjacent to the water source and then leaching into the water. In addition to the feces impact, ungulates occasionally die in the river either by natural causes or by drowning. The presence of those carcasses in the source water can increase the overall pathogen levels further reducing water quality.

Common carnivores in the South Thompson include black bears, coyotes, bobcat, wolves, badger, and cougars. The most notable reptile species in the South Thompson include western yellow bellied racer, spadefoot toad, rubber boa, and western rattlesnake. The overall impact of these species populations on the source water quality is believed to be minimal.

Due to its calm waters, the South Thompson River provides excellent foraging habitat for wintering waterfowl, while riparian vegetation along its banks, primarily black cottonwoods and ponderosa pines, provide habitat for various breeding birds (IBA Canada, 2012). The river is known to provide habitat for large numbers of Canadian geese, bald eagles, osprey, Lewis woodpecker, trumpeter swans, and on occasion tundra swans. Feces from these overwintering birds may impact the source water quality seasonally as the water levels rise and pick up the feces from the beaches along the river, or when the birds defecate directly into the water.

The South Thompson River has historically been known for its prime fish habitat particularly for supporting the Adams River sockeye run each summer and fall, and many native species including

steelhead, rainbow trout, and Rocky Mountain Whitefish year-round. In 2012 an estimated 3.9 million sockeye salmon travelled up the South Thompson River to spawn in the Adams River (Wikipedia.org, 2013). Such a large number of salmon may result in a change in the seasonal water quality due to the increased nutrient loading in the source water resulting from the spawning activities and the large number of dead salmon carcasses floating downstream after the spawning event.

Lower North Thompson

In the Lower North Thompson, the most notable ungulate species are mule deer, white-tailed deer, and moose. The Douglas fir stands in the North Thompson River area provide ideal winter habitat for mule deer resulting in higher animal numbers. As with the South Thompson, the ungulate populations can contribute to the overall *E. coli* levels of the source water as a result of the animals directly defecating into the water, or the feces being deposited adjacent to the water source and then leaching into the water. In addition to the feces impact, ungulates occasionally die in the river either by natural causes or by drowning. The presence of those carcasses in the source water can increase the overall pathogen levels further reducing water quality.

Common carnivores in the South Thompson include black bears, coyotes, bobcat, wolves, cougars, and grizzly bears. The most notable reptile species in the North Thompson tend to be found in the southern most end of the watershed and include garter snake, spadefoot toad, rubber boa, and western rattlesnake. The overall impact of these species on the source water quality is believed to be minimal.

Unlike the South Thompson River, the North Thompson River tends to provide less desirable habitat to wintering waterfowl due to its higher flow and colder temperatures. Eagles and osprey are however commonly found along the river (IBA Canada, 2012). The overall impact on the source water quality is believed to be less than that of the South Thompson due to the lower bird population.

The North Thompson River also provides prime fish habitat and contains several salmon species and many native species including Dolly Varden, rainbow trout, and Rocky Mountain whitefish (Wikipedia.org, 2013). The annual salmon spawning event that occurs in the North Thompson River and tributary streams are traditionally lower than that of the South Thompson River. Despite the smaller run, the salmon can still increase the nutrient loading of the source water impacting the water quality seasonally.

2.4.5 Soils, Terrain Stability and Sedimentation

The soil and terrain stability in the North and South Thompson watersheds are heavily influenced by the glacial processes that occurred several thousand years ago and play a large role in the sedimentation levels and overall water quality of the source waters that we see today.

Both the North and South Thompson River headwaters drain the Columbia Mountains and its many glaciers resulting in their waters being muddied by glacial silt. By the time the two rivers reach the two intake locations in Kamloops, the water in the North Thompson River is noticeably more turbid with higher levels of silt than the South Thompson River.

Lower South Thompson

The headwater streams of the South Thompson River all flow into the Shuswap Lake system which has the benefit of settling out the particulate matter into the large lakes. The South Thompson River

then flows out of Little Shuswap Lake as clear as the lake water itself. Downstream of Little Shuswap Lake, turbidity levels of the Lower South Thompson River can once again increase as a result of sources of sedimentation potentially coming from silt bench erosion, riverbank erosion or Chase Creek.

Despite not falling within the assessment area, Chase Creek, which is the largest tributary creek of the South Thompson River, has traditionally been the leading source of sedimentation and resulting high turbidity levels in the lower part of the South Thompson River. The Chase Creek watershed is located 57 km upstream from the River Street water intake, and frequently experiences landslides due to unstable parent materials, heavy precipitation events, and the creek undercutting of steep slopes. In 1996/1997, 22 landslides occurred in the Upper Chase Creek watershed. Although most of the landslides were determined to have been a result of natural occurrences, it was noted that forestry clear-cutting and road building activities in the watershed likely contributed to the overall magnitude and impact of many of those landslides (Grainger, 1997). Soil runoff and bank erosion due to agriculture practices in the watershed, and livestock entering the creek have also likely contributed to the overall sedimentation levels in Chase Creek resulting in increased turbidity in the South Thompson River.

Additional turbidity in the South Thompson River can come from events in the assessment area. The Lower South Thompson was once the bottom of a glacial lake formed when a glacier in the North Thompson Valley protruded out blocking the South Thompson River from draining. That blockage resulted in the annual settling of silt and clay on the bottom of the glacial lake forming what is today seen in the layered terraced benches throughout the South Thompson valley bottom. The parent material within these benches consists of glacio-lacustrine silts which are highly susceptible to water erosion (Yee Lum, 1979). Throughout the assessment area signs of piping, sink holes, shallow slab failures, and block failures are evident in the benches; the colluvium parent material at the bottom of these steep benches are the direct result of the glacio-lacustrine silt parent material failing and moving down slope due to gravitational forces. The glacio-lacustrine silts are most susceptible to erosion and failure during periods of heavy precipitation and the spring freshet and have a higher likelihood of being transported into the source water increasing the sedimentation load during those times. Likewise, the South Thompson River banks are also highly susceptible to erosion during periods of high water and can also add sedimentation, increasing the overall turbidity levels of the source water.

The soil types in the Lower South Thompson assessment area that were influenced in their formation by the aforementioned parent materials are a mixture of Brown Chernozemic, Brunisolic, and Luvisolic soils. All of these soils are considered to be well drained to moderately well drained (Agriculture and Agri-Food Canada, 2013).

Lower North Thompson

Unlike the South Thompson River, the majority of the North Thompson River does not flow through large lakes preventing the mud and silt eroded from mountain glaciers from settling out of the water. As a result most of this material is transported all the way downstream to Kamloops where the greyish appearance of the water is still very noticeable.

The Lower North Thompson watershed was previously covered by a glacier resulting in a fluvial glacial parent material deposition of gravel, sand and silt throughout the valley. Surrounding the River are undulating and rolling terrain with minimal slumping and landslides to note in comparison

to the Lower South Thompson assessment area. As the North Thompson River meanders through the assessment area it erodes specific areas of the riverbanks where the River has a dramatic change in direction. The key riverbanks being eroded are east of the Rayleigh Water Works intake, north of Dairy Road in Westsyde, and north of Station Road in Heffley Creek. These areas typically have the greatest erosion and sedimentation loading into the North Thompson River during the high river flow months of June and July, but may also be eroded during periods of heavy precipitation.

Sources of Manganese leachate have also been traced in the TNRD Black Pine intake samples and has been identified as leaching from a nearby natural source upstream of the intake on the west side of the North Thompson River. The impact of this Manganese leachate is not expected to have an impact on the proposed Yates Road emergency intake as it does on the TNRD Black Pines water intake. The impact of the Manganese leachate on an intake system can include the growth of unwanted bacteria that can form a slimy coating in water pipes, and the forming of deposits within pipes that can break off as black particles giving the water an unpleasant appearance and taste.

The soils types in the Lower North Thompson assessment area influenced by fluvial glacial parent material are a mixture of Eutric Brunisol, Dark Brown Chernozemic and Gray Luvisol soils. All of these soils are considered to be very rapid and rapid in their drainage capabilities. (Agriculture and Agri-Food Canada, 2013).

2.4.6 Total Impervious Cover

Due to limited GIS capabilities, an accurate estimation of the total impervious covers for both the North and South Thompson assessment areas is difficult to provide. What can be noted is that the total impervious cover for the North Thompson is significantly lower than the South Thompson due to its limited development of residential areas and roads.

As the population in the two assessment areas continue to grow so will the amount of impervious cover. This will likely increase the amount of surface runoff into the North and South Thompson Rivers, therefore increasing the likelihood of surface contaminants entering the two source waters.

2.4.7 Climate

Lower South Thompson

The Lower South Thompson watershed is located in a very dry region of the province. The temperature and precipitation data for the Lower South Thompson between 1971 and 2000 was recorded by Environment Canada's Kamloops Airport weather station and has been summarized in Table 2.5 below. The average annual precipitation is approximately 279 mm with about 218 mm of rain and 75.5 cm of moisture as snowfall. The average annual temperature is about 8.9°C with an average peak of 21°C occurring in July and the minimum average of -4.2°C occurring in January. The maximum average snowfall of 26.1 cm occurs in December.

Table 2.5: Lower South Thompson Canadian Climate Normals for the Kamloops Airport Station, 1971 to 2000

1971-2000 South Thompson Temperature Data - Kamloops Airport Station												
Temperature Degrees Celsius	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	-4.2	-0.4	4.8	9.7	14.4	18.1	21	20.5	15.3	8.5	1.8	-3
Maximum	-0.8	3.6	10.5	16.5	21.3	24.8	28.3	27.8	22	13.7	5.2	0.1
Minimum	-7.6	-4.4	-0.9	2.9	7.5	11.3	13.7	13.2	8.5	3.2	-1.7	-6.1
Environment Canada, 2012												
1971-2000 South Thompson Precipitation Data - Kamloops Airport Station												
Precipitation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	5.4	5.4	8.6	14.4	24.4	35.2	29.5	29.1	28	15.8	13.7	8.3
Snowfall (cm)	21.8	11.3	3.5	0.3	0	0	0	0	0	0.3	12.2	26.1
Precipitation (mm)	22.9	14.4	11.7	14.6	24.4	35.2	29.5	29.1	28	16.2	24.1	28.9

Lower North Thompson

The Lower North Thompson is located in a region of the province that has a mixture of very dry and very moist areas. The temperature and precipitation data for the Lower North Thompson from 1971 to 2000 was recorded by Environment Canada's Barriere weather station and has been summarized in Table 2.6. The average annual precipitation is approximately 486 mm with about 365 mm of rain and 121 cm as snowfall. The average annual temperature is about 6.9°C with an average peak of 19°C occurring in July and the minimum average of -6.5°C occurring in January. The maximum average snowfall of 39.9 cm occurs in December.

Table 2.6: Lower North Thompson Canadian Climate Normals for the Barriere Station, 1971 to 2000

1971-2000 North Thompson Temperature Data - Barriere Station												
Temperature Degrees Celsius	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	-6.5	-2.6	3	8.1	12.7	16.5	19	18.4	13.2	6.5	-0.2	-5.1
Maximum	-2.7	2.2	9.6	15.9	20.7	24.4	27.9	27.1	21.3	12.3	3.2	-1.9
Minimum	-10.2	-7.3	-3.7	0.2	4.7	8.5	10.1	9.6	5.1	0.6	-3.6	-8.2
Environment Canada, 2012												
1971-2000 North Thompson Precipitation Data - Barriere Station												
Precipitation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	11.3	12.1	20.4	26.1	41.6	51.8	47.6	45.8	33.4	34.8	28.8	11.6
Snowfall (cm)	33.3	19.6	4.9	0.6	0.1	0	0	0	0	1.7	21	39.9
Precipitation (mm)	44.6	31.7	25.3	26.7	41.7	51.8	47.6	45.8	33.4	36.5	49.7	51.5

Environment Canada, 2012

2.4.8 Climate Change

Over the last 100 years, the climate has changed in both the South and North Thompson watersheds and evidence of this change has been seen in various natural phenomena. Some of these natural phenomena that have changes include: the increased intensity of storms resulting in more precipitation occurring in shorter periods of time which challenge storm water systems in urban areas and natural stream channels eroding banks causing more pollution runoff and sedimentation in the source water; the increased mountain pine beetle infestation resulting from higher winter temperatures allowing for greater survival of mountain pine beetle and thus more damage to pine

forests throughout the two watersheds; and the increased forest fire activity as a result of hotter and drier summers, as well as the impact of the pine beetle infestation.

If these changes persist, climate change could result in changes to the characteristics of the two watersheds. This could include ecological changes, change in precipitation patterns, increased risk of flooding, increased risk of wildfires, and potential water scarcity. As a result of continued climate change, the impact on the overall source water quality and quantity could be significant and should be monitored into the future.

2.4.9 Water Quantity

The City of Kamloops currently holds nine water-work, water licenses on South Thompson River and six on the North Thompson River totaling over 43 million m³/year in water use allowances. On a typical summer day the River Street Kamloops Centre for Water Quality supplies an average of 120,000 m³/d (120 million litres/d) of water to its residents and visitors, with a maximum capacity of 160,000 m³/d (160 million litres/d). The proposed Yates Road emergency intake will initially be built to provide a back-up supply of 45,000 m³/day (45 million litres/d), with a long term goal of raising that capacity up to 60,000 m³/d (72.5 million litres/d).

As the North and South Thompson Rivers are two of BC's largest rivers and have a combined total annual water daily discharge of approximately 293,000 m³/second, a water shortage is currently not a high risk during any time of the year for either the River Street intake or the proposed Yates Road emergency intake.

The lowest water discharge months for both rivers are typically between January and March and, although not considered to be a risk, the River Street intake and the proposed Yates Road emergency intake were both designed to be strategically placed below the 100 year minimum flow level, further reducing the risk of a water shortage. However, with the threat of a changing climate in the region, a water shortage should not be ruled out in the future and should be monitored.

The main water quantity concern that the two intakes have relate to high water levels, particularly during flooding events. Each year Kamloops and other upstream communities are faced with the threat of flooding from the North and South Thompson Rivers. The flood potential in any given year depends on the snow pack level within watersheds and warm spring weather.

Typically the months of June and July have the highest risk for high water and flooding events, and the risks associated with these events relate to the contaminants that can be drawn into the source water throughout the watershed. These include various physical, biological and chemical contaminants that are typically above and away from the source water such as bacteria from flooded septic fields, sedimentation from eroded banks, and even fertilizers from flooded farmland.

Lower South Thompson

The Lower South Thompson River's hydrometric station is located at 50° 45' 54" N and 119° 44' 25" W downstream of the Village of Chase (08LE031). The station has been in operation since 1911 and monitors a drainage area of 15,800 Km². The mean flow of the South Thompson is 292 m³/second (1911-2011) and is modulated due to upstream lake storage. The total discharge average between 2000 and 2011 was 9,010,000 dam³/yr. Highlights of some of the key discharge measurements recorded by the monitoring station since 1911 are listed in Table 2.7.

Table 2.7: South Thompson River at Chase (08LE031) - Continuous Measurement from 1911-2011

South Thompson River Measurements	Monthly Discharge M3/S	Month
1911-2011 Mean Discharge	292	n/a
1911-2011 Maximum Mean Discharge	452	n/a
1911-2011 Minimum Mean Discharge	171	n/a
1911-2011 Monthly Maximum Discharge	1410	June
1911-2011 Monthly Minimum Discharge	45.8	March
2011 Overall Mean Discharge	319	n/a
2006 Overall Mean Discharge (5 year comparison)	286	n/a
2001 Overall Mean Discharge (10 year comparison)	256	n/a
1996 Overall Mean Discharge (15 year comparison)	353	n/a
1915 Overall Mean Discharge (first year of continuous measurement)	280	n/a

Environment Canada, 2012

Lower North Thompson

The Lower North Thompson River's hydrometric station is located at 51° 2' 29" N and 120° 14' 28" W in the community of McClure (08LB064). The station has been in operation since 1958 and monitors a drainage area of 19,600 Km². The mean flow of the South Thompson is 427 m³/second (1958-2011) and the total discharge average between 2000 and 2011 was 12,925,000 dam³/yr. Unlike the South Thompson River, the North Thompson is a free flowing river and is greatly affected by heavy rains and sudden snow melt. Highlights of some of the key discharge measurements recorded by the monitoring station since 1958 are listed in Table 2.8.

Table 2.8: North Thompson River at McClure (08LB064) - Continuous Measurement from 1958-2011

North Thompson River At McClure Measurements	Monthly Discharge M3/S	Month
1958-2011 Mean Discharge	427	n/a
1958-2011 Maximum Mean Discharge	587	n/a
1958-2011 Minimum Mean Discharge	311	n/a
1958-2011 Monthly Maximum Discharge	1990	June
1958-2011 Monthly Minimum Discharge	49.4	January
2011 Overall Mean Discharge	484	n/a
2006 Overall Mean Discharge (5 year comparison)	375	n/a
2001 Overall Mean Discharge (10 year comparison)	381	n/a
1996 Overall Mean Discharge (15 year comparison)	474	n/a
1959 Overall Mean Discharge (first year of continuous measurement)	475	n/a

Environment Canada, 2012

2.4.10 Water Quality

Prior to the commissioning of the River Street Kamloops Centre for Water Quality in 2005, the City used only a 3 mm fine screen to remove debris and chlorine to kill pathogens. This older system often failed to meet the Canadian drinking Water Quality Guidelines (one nephelometric turbidity unit (NTU)) during the spring freshet on the South Thompson River, when waters would muddy and

occasionally resulted in turbidity levels up to 500 NTU. This often resulted in the Interior Health Authority issuing a boil water advisory alerting residents to boil their drinking water to ensure adequate water safety.

The City now uses a state-of-the-art treatment plant that employs an advanced membrane technology system built to filter out all particles in the South Thompson River source water larger than four, one hundred millionths of a millimeter, including water-borne disease-causing pathogens such as *Cryptosporidium* and *Giardia*. The new system has three phases including a flocculation phase to reduce the physical contaminants such as organics in the water, a membrane filtration phase to remove biological contaminants and small amounts of chemical contaminants from the water, and a sodium hypochlorite injection phase to further ensure full disinfecting of the water prior to leaving the plant.

In addition to having a modern treatment plant, the City has taken a number of steps to safeguard the quality of water supplied by the River Street intake including:

- Maintenance of an appropriate disinfection residual in the water throughout the distribution system;
- Completion of cleaning of the distribution system through a uni-directional flushing program; and
- Ongoing program of cross-connection control to protect the system from the introduction of unwanted substances.

Efforts have also been directed toward understanding and managing the Lower South Thompson watershed. These efforts have included working in partnership with various agencies on initiatives including stream bank preservation and restoration, riparian area protection, and long-term planning.

Despite these initiatives and efforts, the River Street Intake is still at risk of contamination in the event of a major chemical spill into the South Thompson River. Based upon the results of a previous Lower South Thompson River Risk Assessment Overview (Urban Systems, 2007) and a subsequent study completed by the City of Kamloops, the risk level for the River Street water intake has been rated at moderate to high.

As a result of that risk the City of Kamloops is working towards the construction of an emergency intake treatment plant on the North Thompson River at the Yates Road location. This proposed Yates Road intake will be a simple fine screen and chlorine injection treatment facility designed only to meet the short term water needs of the City during an emergency shutdown of the River Street Intake.

* Note: The Guidelines for Canadian Drinking Water Quality have been listed in Table 2.9. When comparing these guidelines to the Lower South Thompson River and Lower North Thompson River water quality data in Tables 2.10 and 2.11, note that the data in those tables are for the raw water quality entering the intake and not treated water quality leaving the treatment plants.

***Table 2.9: Guidelines for Canadian Drinking Water Quality – Summary**

Parameter	Guideline At Exit Of Municipal Treatment Plant
TDS	Aesthetic Objectives (AO) ≤ 500 mg/L
Turbidity	< 0.1 Nephelometric Turbidity Units (NTU)
Raw Total Coliform	90% of samples taken should not exceed 10 Colony-forming Units (CFU)/100 ml
Raw <i>E. Coli</i>	90% of samples taken should not exceed 10 Colony-forming Units (CFU)/100 ml
pH	6.5 – 8.5 pH
Temperature	No guideline available

Health Canada, 2013

Lower South Thompson

The Lower South Thompson raw water quality levels regularly monitored at the Rivers Street's Kamloops Centre for Water Quality have been listed in Table 2.10 for the years 2012 and 2007.

Table 2.10: South Thompson Raw Water Quality 2007 & 2012

South Thompson Raw Water Quality						
2012	pH	TDS	Turbidity	Temp	Raw Total Coliform	Raw <i>E. Coli</i>
Min	7.38	31.50	0.51	1.60	ND	ND
Max	8.08	39.70	38.80	22.40	200.50	42.90
Avg	7.76	35.64	2.61	10.41	46.49	4.17
# of Samples	366	366	366	366	366	366
2007	pH	TDS	Turbidity	Temp	Raw Total Coliform	Raw <i>E. Coli</i>
Min	7.65	30.30	0.46	1.20	<1	<1
Max	8.02	39.30	6.71	20.50	>200.5	165.20
Avg	7.78	34.01	2.06	9.96	69.63	8.13
# of Samples	365	365	365	365	365	365

Lower North Thompson

The Lower North Thompson raw water quality levels regularly monitored at the TNRD's Black Pines and Evergreen intakes have been listed in Table 2.11 for the years 2012 and 2008.

Table 2.11: North Thompson Raw Water Quality 2008 & 2012

North Thompson Raw Water Quality						
2012	pH	TDS	Turbidity	Temp	Raw Total Coliform	Raw <i>E. Coli</i>
Min	7.37	35	0.05	4.9	0	0
Max	8.46	691	15.9	24	TNTC	TNTC
Avg.	7.84	363	2.62	11.6	10.87	6.24
# of Samples	99	2	99	99	99	99
2008	pH	TDS	Turbidity	Temp	Raw Total Coliform	Raw <i>E. Coli</i>
Min	7.36	61	0.05	4.5	0	0
Max	8.85	862	6.53	18.8	TNTC	TNTC
Avg.	7.9	467.17	0.93	11.28	2.11	2.03
# of Samples	103	6	103	103	103	103

2.5 Integrity and Vulnerability of the Intakes

Lower South Thompson

- Intake location: 1300 River Street
- Intake depth: 45' or 13 m
- Accessibility for inspection and cleaning: Trash screens and intake port gates are inspected and cleaned by contracted divers annually. The fish screens on the intake are a “travelling” type, and are inspected and cleaned at the main floor level of the intake structure several times throughout the year.
- Water circulation patterns: Based on staff observations, due to the location of the intake ports in the river, there is no circulation of the water at the entrance to the intake. The river flow across the surface of the intake port is continuous which is good.
- Bank stability and potential for localized flooding: The intake site has a gently sloping bank with thick vegetation, and there are no current erosion issues to note. There is however, minor erosion on the discharge channel from the Kamloops Centre for Water Quality and this is currently being monitored.
- Bottom sediment build-up and siltation: There is very minor sediment build up in the well of the intake. There are primary trash gates on the outside of the intake ports with secondary “travelling” screens in the well for controlling most of the debris into the pumps.
- Protection from other uses: The concrete intake structure is large and robust enough to not be damaged by possible impact by vessels that are small enough to navigate the South Thompson River.
- Potential for ice formation: In very cold winters with a strong wind, the potential is there for frazzle ice to develop on the intake. This has been experienced this only once in the history of the River Street intake’s operation.
- Protection from animals and vandalism: The perimeter is fenced with a six foot fence with barb wire on top. Access to the intake is through a locked and coded gate. The City has a pest control company look after any internal rodent control at the intake.

Lower North Thompson

- Yates Road emergency intake location: The City is currently working towards the establishment of an emergency/alternate water supply from the North Thompson River and the construction of this intake is dependent upon final approval and funding from Council.
- The Yates Road site will be located on a small gravel cul-de-sac at the terminus of Yates Road east of Westsyde Road in an urban residential area. This site is located on the west bank of the North Thompson River, 800 m upstream from the Halston Avenue Bridge.
- Intake depth: The depth of the intake will be determined at the time of construction. At a minimum, it will be set below the 100-year minimum flow levels of the North Thompson River.
- Bank stability and potential for localized flooding: The west bank and the channel banks at the proposed Yates Road location has been identified as having high stability with minimal disturbance over the past 40 years.
- Protection of the intake: The vulnerabilities and measures taken for the Yates Road emergency intake will be similar to those of the River Street intake and will be documented further in future reviews of this plan pending the final construction of the water intake.

2.6 Summary

The water source natural hazards and vulnerabilities identified in Module 1 for both the South Thompson and North Thompson watersheds have been summarized in Table 2.12.

Table 2.12 Water Source Natural Hazard/Vulnerability Identification

Hazard No.	Hazardous Event/Drinking Water Hazard	Hazard Cause		Hazard Type			Possible Effects	Existing Preventative Measures	Associated Barrier(s)
		Natural	Human	Biological	Chemical	Physical			
1-1	High water, flooding and bank erosion	x		x	x	x	Increased peak flows due to a changing climate, or seasonal rapid snow melt can result in an increase in sediment, chemical and material transport from the flooded areas.	Membrane filtration at the River Street intake, chlorine disinfection with adequate contact time.	Source water protection, water treatment.
1-2	Presence of birds, salmon, and other wildlife in watershed (feces and mortality)	x		x		x	Wildlife are hosts for pathogenic bacteria (Escherichia coli) and protozoa (Giardia, Cryptosporidium) and can result in water quality issues. Mass nutrient loading due to millions of salmon spawning and then dying can result in seasonal water quality issues.	Membrane filtration at the River Street intake, chlorine disinfection with adequate contact time.	Source water protection, water treatment.
1-3	Slope failure/debris flows.	x		x		x	May result in higher turbidity and colour parameters due to channel displacement and erosion in floodplain, sediment and nutrient into source watercourses.	Membrane filtration at the River Street intake, chlorine disinfection with adequate contact time, and continuous monitoring of turbidity in the raw water.	Source water protection, water treatment.
1-4	Wildfire	x	x		x	x	As a result of a changing climate and increased levels of forest pests such as mountain pine beetle, there is an increasing risk of wildfire. The reduction in tree and ground cover after a fire may lead to the destabilization of soils resulting in erosion and increased turbidity. The increased turbidity can reduce the effectiveness of chlorination or UV disinfection. Organic matter/ash dispersal will also occur. Fire retardant dispersal on the fire may result in degraded water quality due to the release of nutrients/chemicals.	Active wildfire monitoring and fighting from Kamloops Fire Centre. Turbidity monitoring at treatment plants as well as a membrane filtration at the River Street intake, and	

Hazard No.	Hazardous Event/Drinking Water Hazard	Hazard Cause		Hazard Type			Possible Effects	Existing Preventative Measures	Associated Barrier(s)
		Natural	Human	Biological	Chemical	Physical			
								chlorine disinfection with adequate contact time.	
1-5	High turbidity levels during spring freshet primarily due to natural stream processes.	x		x	x	x	High turbidity indicates the presence of suspended particulate matter, such as sediment, organic material and microorganisms. Unless filtered, particulate matter can reduce the effectiveness of disinfection, potentially causing illness if pathogens are present.	Membrane filtration at the River Street intake, chlorine disinfection with adequate contact time, and continuous monitoring of turbidity in the raw water.	Wildfires likely to be actioned quickly. Water treatment.
1-6	Manganese leachate	x			x	x	Water with a high concentration of manganese can increase the growth of unwanted bacteria that form a slimy coating in water pipes, it may cause staining of plumbing fixtures or laundry, or form deposits within pipes and break off as black particles that give water an unpleasant appearance and taste.	Membrane filtration at the River Street intake, chlorine disinfection with adequate contact time.	Source water protection, water treatment.

Hazard No.	Hazardous Event/Drinking Water Hazard	Hazard Cause		Hazard Type			Possible Effects	Existing Preventative Measures	Associated Barrier(s)
		Natural	Human	Biological	Chemical	Physical			
1-7	Forest beetle infestation	x				x	Due to the thinning of the forest canopy there is an increase in precipitation reaching the forest floor and flowing from hill slopes. Increased spring and total annual stream flow volumes, earlier onset of snowmelt, and a more rapid stream flow response to storms.	Membrane filtration at the River Street intake, chlorine disinfection with adequate contact time.	Source water protection, water treatment.

3.0 Module 2 – Hazard Source Inventory

3.1 Purpose

The purpose of conducting a hazard source inventory is to gain a better understanding of contamination sources that occur within the Lower North Thompson and Lower South Thompson assessment areas as described in Module 1. Present contaminants along with consideration for past and potential or future contamination are considered so that resources can be applied and plans can be prepared for those areas or issues posing the greatest risk(s) to drinking water in Kamloops.

3.2 Methodology

This inventory is consistent with Module 2 of the Comprehensive drinking Water Source-To-Tap Assessment Guideline. The inventory includes current contaminants and where possible, past and future (five years). Historical land use could cause water contamination for example; a closed landfill may begin to leach into the ground over time. The future aspect is included as this plan is a living document and will be updated in five years. Future changes are taken into account as a change in land use may contaminate water and the physical development of land may cause increased sedimentation and possibly an increase in overland flow as a greater area is paved or built over.

Contamination data and information were collected using existing sources from the City of Kamloops (hereafter referred to as “the City”), peer reviewed articles, industrial reports, Provincial Government websites and maps, and Google Earth was used for orthographic photos. Google Earth was also used to investigate sites where field/site visits were not possible due to funding and time restraints. Given that Google Earth images are not up to date, it is possible that there have been changes to sites that may not be captured in this inventory. Additional mapping expertise was also provided by the City. Past contamination data may be missed because a field assessment was not completed and because some data can only be obtained through personal communication, of which is not always possible.

Types of contamination were divided into the following three categories (Table 3.1):

1. Line Source - all contamination related to linear development for example, highways and pipelines
2. Point Source – all contamination coming from a known location for example, an effluent drainage pipe into the water source
3. Non-point Source – includes contamination from many different sources where no one source has a specific point of entry into the water source for example, runoff from streets.

Each of the contamination sources in the Lower North Thompson and Lower South Thompson assessment areas was ranked by the City of Kamloops technical team as low, moderate or high risk. Rankings were based on the source being surface water and the capacity of the Kamloops Water Treatment plant to effectively remove various contaminants types; the rankings are shown in Table 3.1.

Commercial and industrial enterprises that were ranked by the City as “high” or “moderate” contamination risk were given a personal interview survey. The surveys were conducted in person so that each site could be assessed and so that backflow prevention valves could also be checked. In addition, businesses often change in nature or duration prior to the business license being updated; many businesses in the assessment areas had closed, moved or changed since their business license had been issued.

Table 3.1: Category, type and rank of source water contaminants for the Kamloops Source Water Protection Plan

Category	Source Type	Contaminant Source	Rank
Line Source	linear development	pipelines	HIGH
	linear development	highway spills/accidents, road salt applications, road de-icing operations	HIGH
	linear development	railroad tracks and yards	HIGH
	linear development	highways/roads runoff	HIGH
	linear development	sewer lines	HIGH
Non-Point Source	commercial/industrial	aircraft crashes/fuel discharge	HIGH
	commercial/industrial	petroleum production, storage, service stations	HIGH
	natural	flooding	HIGH
	natural	forest fires	HIGH
	natural	landslides and other sources of sedimentation	HIGH
	residential	storm-water drains/basins, urban runoff	HIGH
	residential	septic systems	HIGH
	agriculture	manure storage/spreading/feedlots	MODERATE
	agriculture/commercial/industrial/residential	fertilizer, pesticide storage (golf courses, farms etc.)	MODERATE
	agriculture/industrial	timber harvesting, road building/calclification of dirt road surfaces	MODERATE
	agriculture/natural	animal carcasses in or near water salmon/wildlife	MODERATE
	agriculture/natural	animals in water, domestic/wild	MODERATE
	commercial	marinas, boat operation/maintenance/black/grey water discharge	MODERATE
	commercial/industrial	new developments/construction	MODERATE
Point Source	industrial/residential	effluent discharge sites	HIGH
	commercial/industrial	municipal landfills, transfer stations, eco-depots, recycling reduction facilities	MODERATE
	industrial	mining and mine drainage	MODERATE
	industrial/linear development	road salt storage/snow storage/material stockpile sites	MODERATE
	natural	manganese leachate (black pines area)	MODERATE

3.3 Assessment Area Activities

This section describes the broad source water contamination categories in both the Lower North and South Thompson assessment areas. Google Earth was used to determine the assessment area activities; the orthographic photos are several years out of date and there has been substantial development in recent years.

3.3.1 Agriculture & Range

For the purpose of this inventory, range practices (ranching practices) are considered part of agriculture. Ranching is the dominant form of agriculture across both the North and South Thompson watersheds. According to the 2013 *Kamloops Agriculture Plan Backgrounder*, agriculture practices in both assessment areas are largely comprised of forage crop production and grazing pastures to support cow-calf operations. Outlying grasslands and forested lands provide forage for the ranching industry as well. Rangeland is generally comprised of grasslands and forested areas in the Bunchgrass, Ponderosa Pine, and Interior Douglas Fir Biogeoclimatic (BEC) Zones. Cultivated crops in the assessment areas include forage crops, vegetables, berries, nuts, fruit and Christmas trees. There are also a lesser number of lamb, mutton, bison, turkey, chicken/egg, and bee keeping operations. In addition, the *Kamloops Agriculture Plan Backgrounder* shows that a large proportion of agricultural land is used for equine (horse) operations.

Potential water contamination threats from range practices include the following:

- Increased runoff/overland/sedimentation flow due to overgrazing and compaction of soils on rangelands and grazing pastures
- Degradation of riparian vegetation
- Nutrient inputs to water source (cattle directly entering streams)

Potential water contamination threats from crop production include the following:

- Nutrient runoff from manure and improper manure storage or spreading
- Improper storage of fertilizer (nutrients), pesticide, and herbicide
- Application/improper application and runoff of fertilizer, pesticide, and herbicide
- Dust/sedimentation
- Degradation of riparian vegetation
- Improper carcass disposal/mortality composting
- Sloughing of soils (adjacent to river) due the combination of irrigation and removal of riparian vegetation

Lower North Thompson

Rangeland is utilized throughout the North Thompson assessment area except where there is residential/business development and where cultivated crops are grown. Cattle are grazed adjacent to the east side of the Yellow Head Highway and around/near the tributaries for the length of the assessment area. On both sides of the North Thompson River, there is rangeland around the assessment area tributaries.

There are agricultural operations on the east and west sides of the North Thompson River starting south of the intersection of Kerindale and Westsyde Roads and continuing north to the Thompson Nicola Regional District (TNRD) water intake at Black Pines; there are also some operations along Seven-O Creek, Robbins Creek, and Knouff Creek. These operations primarily consist of forage, tree, and vegetable crops and beef and equine operations. The exact type of operation on a given site and area of land used is unknown as a field investigation was not conducted. See Appendix A for a map of the Lower North Thompson agriculture areas.

Lower South Thompson

Rangeland in the Lower South Thompson assessment area is generally located around the tributaries on the north and south sides of the River. Agriculture operations are located along the north and south shores of the South Thompson River and around Campbell, Monte, Neds, McGregor, and Pemberton Creeks. These operations primarily consist of forage, tree, and vegetable crops and beef or equine operations. The exact type of operation and area of land used is unknown as a field investigation was not conducted. See Appendix B for a map of the Lower South Thompson agricultural areas.

3.3.2 Recreation

Many types of recreation take place across both the Lower North and South Thompson assessment areas. Because recreation is not specific or limited to certain areas, there is no associated map. Types of recreation that could contaminate source water include but are not limited to the following:

- Motorized and non-motorized boating (including concentrated boating around the River Street intake)
- Swimming/floating (both pets and people)
- All-terrain vehicle (ATV) use on and off trails
- Hiking and biking along trails
- Camping adjacent to source water
- Shoreline modification, including the removal of riparian vegetation

Source water contamination caused by recreation includes:

- Black and grey water from boats
- Poor waste management and water use practices adjacent to source water
- Fuel and other mechanical fluids leaked into water
- Increased sedimentation due to ATV/bike use
- Pets and pet waste
- Soil compaction and resulting increased overland flow
- Application/runoff and storage of fertilizer/herbicide/pesticide used on parks

3.3.3 Residential Development

There is substantial residential development in both the Lower North and South Thompson assessment areas. There are also many properties within the assessment areas that are either in the early stages of development or for sale; it appears that development in both areas will be ongoing in the next five years. Contamination from residential development is non-point source pollution consisting of a mixture of chemicals that are used in homes or on lawns and gardens. It is problematic because it is difficult to discern the origin of any specific contaminant. This mixture of chemical and biological waste is washed down storm drains with rainwater and drained directly into the source water through drainage outlets. In addition to storm drain run-off, there is also biological waste associated with septic systems that are improperly installed or maintained that may leach into surface water, especially during flood events.

For the purpose of this inventory, contaminants from residential development include the following:

- Runoff from roads/driveways including house hold chemicals, fertilizer/pesticide/other gardening chemicals, pet waste, automobile fluids/fuel, sediment
- Swimming pool chemicals, storage, use, disposal (down storm drains)
- Prescription medication and other chemicals (paint/paint thinner) dumped down drains/storm drains
- Leaching from improperly maintained septic fields/tanks adjacent to source water
- Application/storage of road salt/de-icing chemicals

Lower North Thompson

In the Lower North Thompson assessment area there is substantial residential development. This area includes housing, schools and approximately 15 storm drain outlets on the west side of the river. Appendix C shows the section of the assessment area where there is a high concentration of residential development.

Lower South Thompson

In the South Thompson assessment area there is substantial residential development and more than 30 storm drainage outlets on the south side of the River. Residential development on the north side of the River includes part of the Sun Rivers Community and larger rural properties continuing east along the entirety of the assessment area. The Sun Rivers development is tied into the City septic services whereas the rural properties are on septic systems. There are no maps available regarding storm drains on the north side of the South Thompson River, a field inventory will need to be completed to determine if there are storm drain outflows. Appendix D shows the area in the Lower South Thompson assessment area where there is a high concentration of residential development.

3.3.4 Linear Development

For the purpose of this inventory, linear development includes all line shaped development. Appendix E shows a large scale map of the linear development in the Lower North Thompson assessment area where there is substantial development. Appendix F shows a large scale map of the linear development in the Lower South Thompson assessment area where there is substantial development. Much of the linear development in both assessment areas is proximal to the North and South Thompson Rivers. In some cases there are roads and or railroads that are within 20 m of the water. Linear development in the assessment areas includes:

- Railroads/yards
- Highways
- Fuel, hydro, communications lines
- Sewage and drainage lines

Possible source water contamination associated with linear development includes:

- Heavy metals leaching into soils (railroads/yards)
- Application/storage/runoff of road salt/de-icing chemicals
- Leaching of sewage
- Air pollution
- Vehicle/train accidents
- Road runoff
- Sediment
- Application of pesticide (herbicide) for brush and invasive plants

3.3.5 Nature

There are several natural causes of water contamination; Module 1 provides a detailed description of the natural causes of contamination in the Lower North and South assessment areas. Natural sources of water contamination in the assessment areas include:

- Flooding due to spring freshet/extreme weather events (climate change), modified landscapes (harvested/burned forest cover, road building/drainage developments, soil damage including compaction, erosion, and hydrophobicity)
- Forest fires
- Mountain pine beetle infestation
- Sedimentation (landslides i.e. Chase Creek)
- Erosion and deposition of river banks
- Dead salmon/wildlife in water
- Migratory birds on shores and in water
- Influence of lands outside the assessment areas
- Contaminated groundwater

Flooding is a major cause of water contamination and is directly related to several factors aside from heavy precipitation events including forestry, land use, and climate change. Flooding is also directly related to the activities and land use across the entire watershed. The North and South Thompson watersheds are subject to frequent forest fires and have had devastating mountain pine beetle infestations. The resulting loss of forest cover and function continues to affect the hydrologic cycle long after a fire or infestation has taken place. Appendix G shows a large scale map of the floodplains in the more heavily developed areas of the Lower North Thompson assessment area and Appendix H shows a smaller scale map that includes the McClure forest fire boundary and mountain pine beetle affected areas. Appendix I shows a large scale map of the floodplains in the Lower South Thompson assessment area.

Another natural source of contamination is via groundwater through recharge areas in the North and South Thompson Rivers. If there is a source of contamination in the groundwater proximal to the recharge area, source water contamination could result. There are many ways in which ground water can be contaminated; one example is via contaminated wells. A Groundwater Protection Officer from the BC Ministry of Forests Lands and Natural Resource Operations (MFLNRO) explained that there are many wells in both of the assessment areas however, only wells that are drilled (not dug) need to be reported to the provincial government; there are likely many wells that are not included in the provincial record. There are often cases where wells are not dug following provincial guidelines resulting in contamination for example, being developed too close to septic fields, feedlots or other sources of biological waste; there are also examples of wells being used for waste disposal, also resulting in contamination. Figures 3.1 and 3.2 are maps from the BC Water Resources Atlas and they show the known wells in the general vicinity of the Lower North and South Thompson assessment areas respectively.

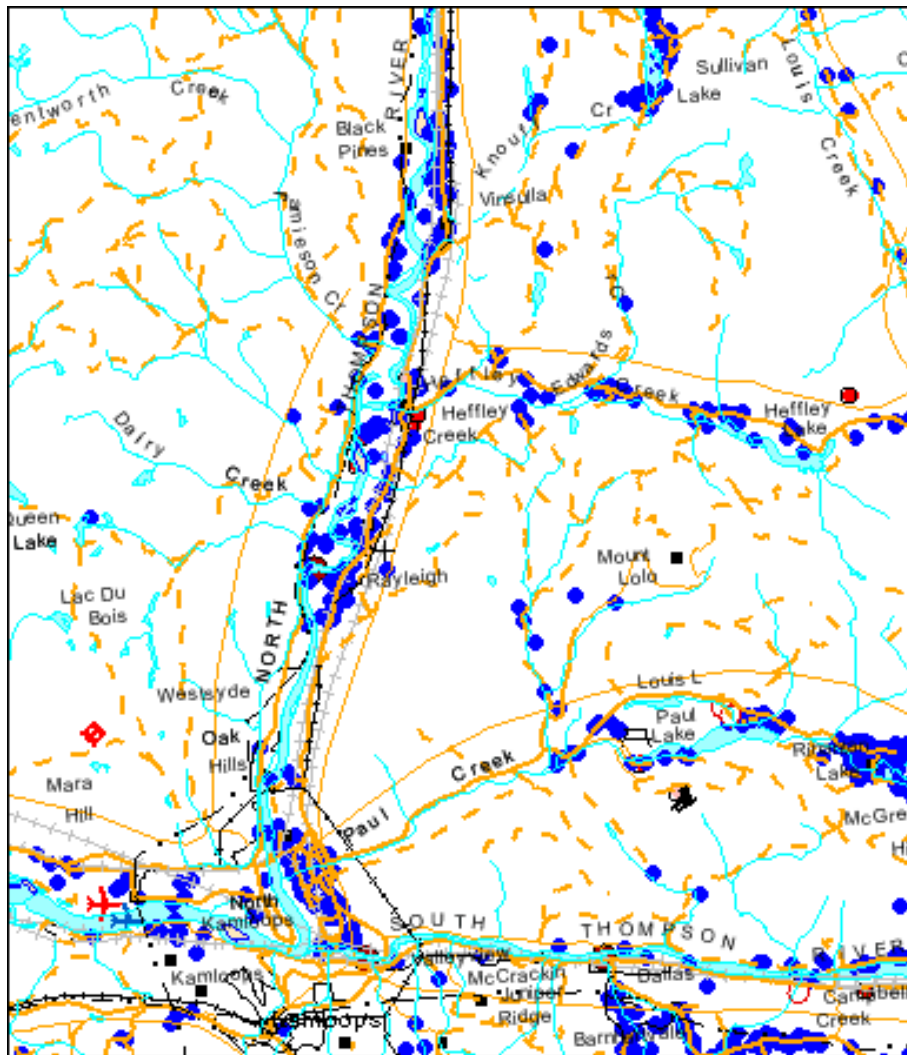


Figure 3.1: Map showing wells (blue dots) in the general vicinity of the Lower North Thompson assessment area

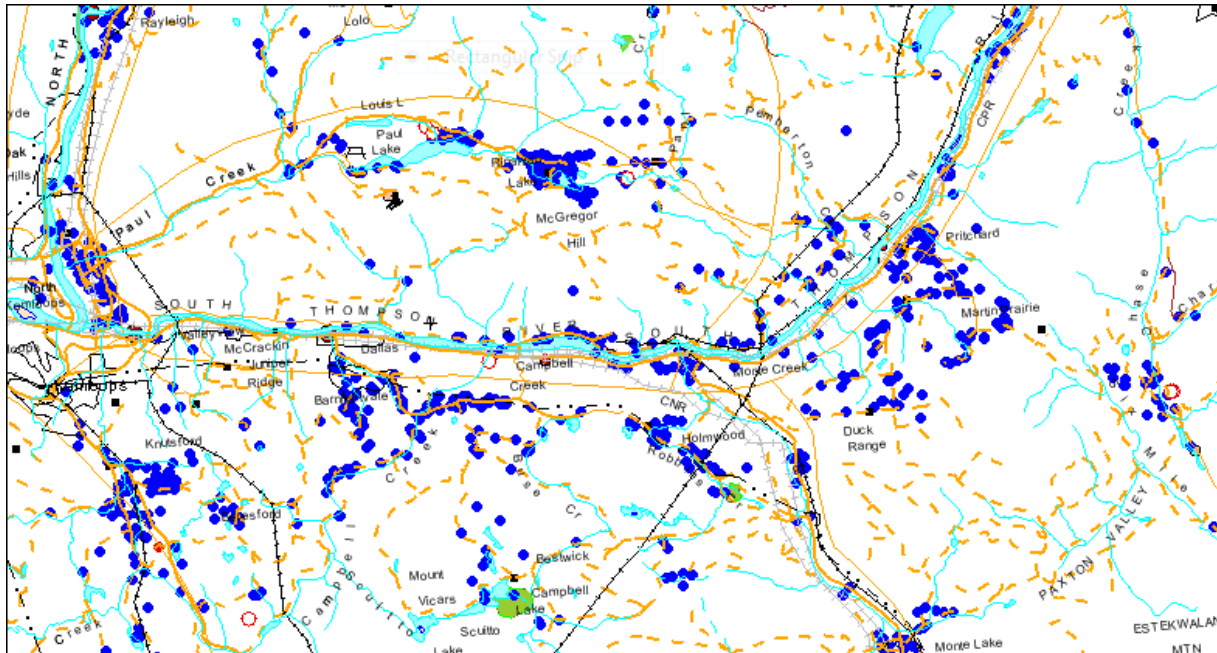


Figure 3.2: Map showing wells (blue dots) in the general vicinity of the Lower South Thompson assessment area

3.3.6 Commerce & Industry

The City of Kamloops provided a list of all businesses and industries within the Lower North and South Thompson assessment areas operating with a business license. Businesses were ranked based on the type of business and the risk (low, moderate, high) of source water contamination associated with respective business operations for example, gas stations received a “high risk” ranking and seniors’ homes received a “low risk” ranking. It is important to note that there is air traffic over the assessment areas due to the proximity of the Kamloops Airport and Kamloops Fire Center. The Airport is not within an assessment area therefore it is not included however; water contamination as a result of air traffic could cause water contamination for example, air pollution, dropping fuel, and aircraft accidents.

A personal interview survey was conducted for all businesses and industries that were ranked as moderate or high risk for source water contamination within the assessment areas. The survey was designed to get a clear picture of the actual contaminants present on each site, safety planning and procedures, and any water contamination prevention programs in place above and beyond respective industry standards. Personal interviews also provided a peripheral opportunity to raise awareness of source water contamination and to learn the history and future for each of the sites.

Source water contamination as a result of industry and commerce can occur in a multitude of ways respective of the type of industry or business. Below are some examples of contamination that may be caused by business/industry:

- Leaching of hydrocarbons through ground water or overland flow – gas/service stations

- Leaching of a multitude of chemicals through ground water or overland flow from landfills, eco-depots, local dump spots
- Point source deposition of effluent into or near water source
- Air pollution from air emissions
- Improperly stored toxic waste
- Improperly stored fuel/leaking vehicles
- Increased overland flow of water (over site/paved areas) into storm drains or directly into the water source

Lower North Thompson

Commerce in the North Thompson assessment area is generally conducted on or around Westsyde Road as far as the *Dunes at Kamloops* golf course, south of Karindale Road. On the east side of the river there are only a few businesses and industrial sites. Industry in the North Thompson assessment areas includes forestry (logging), fabricating and manufacturing products such as dimensional lumber and cabinetry. See Table 3.2 below for a list of high or moderately ranked businesses and industries in the North Thompson assessment area.

Table 3.2: Businesses surveyed in the Lower North Thompson assessment area

Business Address	Lower North Thompson Business Name	Business License Description	Risk	Survey
		fuel bar	HIGH	COMPLETE
		fuel bar	HIGH	COMPLETE
		gasoline fuel bar	HIGH	COMPLETE
		gasoline fuel bar	HIGH	COMPLETE
		veneer & plywood mill	HIGH	COMPLETE
		hardware store	MODERATE	COMPLETE
		trucking sand & gravel products	MODERATE	COMPLETE
		vehicle repair shop	MODERATE	COMPLETE
		fabricating- doors/mouldings	MODERATE	COMPLETE
		golf course / pro shop	MODERATE	COMPLETE

Lower South Thompson

Extensive commerce and industry is conducted along Highway 1 and Valleyview Drive, across most of the South Thompson assessment area. Industries include forestry, mining, fabricating, and manufacturing. See Table 3.3 below for a list of high or moderately ranked businesses and industries in the South Thompson assessment area.

Table 3.3: Businesses surveyed in the Lower South Thompson assessment area

[illegible]

Table 3.4: Lower North and South Thompson assessment area contaminant inventory summary

Survey ID/Hazard Number	Assessment Area	Rank	Contaminant Source (Type And Description)	Location	Approximate Distance To The River	Potential/Known Contaminants Of Concern	Contaminant Transport Mechanism
1	North Thompson (NT)	M	gravel pit operation		560	diesel 4300 L, sand and gravel mined from site(several VERY lg. piles), dozen pieces of HD equip/trucks	overland flow
2	NT	H	self-serve gas bar, carwash		170	regular gasoline 52,000 L, premium gasoline 23,000 L, diesel 23,000L, carwash soap/wax/degreaser 60 L, new oil 12 L, coolant 24 L, windshield wash 200 L, propane 480 lbs	overland flow
3	NT	H	glues/stains/paints for cabinetry		260	wood paint 1000 L, varnish 1000 L, glue(PVA) 200 L, sawdust 20 m3	overland flow
4	NT	M	paint/varnish/stain, ice melt, road salt, concrete mix, fertilizers		395	paints(all) 1500 L, varsol 60 L, Driveway sealer 280 L, fertilizers 1500 L, road salt 1000 L, extreme ice melt 2000 L, concrete mix 1000 L, automotive fluids 75 L, insecticides 500 L, misc. household cleaners 1500 L, rat killer(warfarin) 4 L, propane 120 lbs	overland flow
5	NT	H	service shop		520	new oil 144 L, used oil 1500 L, used oil filters 170 L, gasoline 20 L, grease 12 L, coolant 20 L, used coolant 40 L, solvent 20 L, assorted auto fluids 20 L oxygen/acetylene 240 lbs	overland flow
6	NT	H	self-serve gas bar		355	regular gasoline 40,000 L , premium gasoline 24,000, bulk propane 7500 L, new oil 48 L, misc. auto fluids 24 L, coolant 12 L	overland flow
7	NT	H	self-serve gas bar		270	regular gasoline 17,000 L, premium gasoline 17,000 L, diesel 16,000 L, propane 7.5 m3, new oil 120 L, coolant 16 L, windshield wash 16 L, assorted auto fluids 20 L,	overland flow
8	NT	H	self-serve gas bar		810	regular gasoline 22,728 L, premium gasoline 72,730 L, diesel 22,728 L, new oil 150 L, coolant 24 L, windshield wash 400 L, assorted auto fluids 40 L, propane 480 lbs	overland flow
9	NT	H	veneer and plywood plant		30	resin 128,944 L, mixed glue 60,117 L, diesel 5700 L, gasoline 5700 L, marking paint 5000 L, solvents 75 L, hydraulic /gearbox/thermal oils 7600 L, glycol 3800 L, used oils 7600 L, large wood chip pile 1200 m3	overland flow
10	NT	M	golf course & restaurant/banquet hall		0	3m3 liquid fertilizer, some sand, 500 gallons diesel, 500 gallons gas	overland flow
11	NT	H	Trans Mountain pipeline		no field observation	corrosive fluids, hydrocarbons	soil diffusion, overland flow
1	South Thompson (ST)	H	wood work/store fixtures		45 m	gun wash/paint/stain	overland flow
2	ST	M	gardening supplies		120 m	fertilizer, pesticide, fungicide	overland flow
3	ST	M	multi recycling facility		0 m	up to 500 Gallons of fuel (some is in vehicles/fork lift etc.)	overland flow
4	ST	M	retreading medium truck tires		2 m	propane, solvent, black cement (solvent + rubber)	overland flow

Survey ID/Hazard Number	Assessment Area	Rank	Contaminant Source (Type And Description)	Location	Approximate Distance To The River	Potential/Known Contaminants Of Concern	Contaminant Transport Mechanism
5	ST	H	heavy duty auto mechanic shop		2 m	propane, solvent, used oil, new oil, diesel exhaust fluid	overland flow
6	ST	M	retreading mining truck tires		2 m	propane, solvent, used oil, new oil, "tire life"	overland flow
7	ST	H	heavy duty equipment dealership(sell, fix, repair)		25 m	diesel 10,000L, used oil 1000 L, coolant 10,000 L, oil 100 L, solvent 100 L	overland flow
8	ST	M	manufacturing of hydraulic hoses		140 m	coils of hose	overland flow
9	ST	H	retail outlet motorbike sales and service		135 m	fuel 53 L, used oil 1000L, oil 50 L	overland flow
10	ST	M	industrial contractor for pulp mill upgrades and heavy construction		40 m	170 L used oil, glue, propane, gas diesel, grout ,solvent	overland flow
11	ST	H	manufacture highway petroleum tanks		40 m	oxygen/acetylene tanks, cars on site	overland flow
12	ST	H	new and used farm and industrial equipment sales and service		288 m	diesel 190 L, gas 190 L, used oil 38 L, oil/lube retail sales 15 L.	overland flow
13	ST	M	heavy duty equipment sales, mostly parts		390 m	engine oil 340 L, hydraulic oil 340L, used oil 20 L.	overland flow
14	ST	M	testing labs for mining/minerals industry		257 m	nitric acid 75 L, hydrochloric acid 75 L ,perchloric acid 2.5 L, hydrofluoric acid 2.5 L, methyl hydrate 5 L, lead oxide(granular)) 0.5 m3, liquid argon 3 m3, propane bottles 90 lb	overland flow
15	ST	H	heavy Duty Diesel Engine Sales & Service		260 m	new oil 1000 L, used oil 500 L, coolant, 200 L, diesel 1000 L, paint 170 L, Attax 170 L, liquid nitrogen 170 L, gun wash 380 L, varsol solvent 170 L, sludge from distilled water 170 L, misc. top up fluids 75 L	overland flow
16	ST	M	bulk propane sales		260 m	propane 567,811 L, paint 58 L , gun wash and solvents 38 L, oxygen/acetylene/mig gases 120 lbs	overland flow
17	ST	H	gasoline station & heavy duty truck service		255 m	premium gas 75,708 L, 75,708 L, diesel 75,708 L, new oil 170 L, used oil 750 L, misc. automobile fluids 38 L	overland flow
18	ST	M	used battery recycling, warehouse and battery wholesale		243 m	sulphuric acid and lead acid 50,000 lbs	overland flow
19	ST	M	distribution of bulk cement powder to		315 m	cement powder contents 400 ton , small jerry cans of gasoline 38 L	overland flow

Survey ID/Hazard Number	Assessment Area	Rank	Contaminant Source (Type And Description)	Location	Approximate Distance To The River	Potential/Known Contaminants Of Concern	Contaminant Transport Mechanism
			other distribution plants				
20	ST	M	tire retread plant,, shipping & receiving, administration bldg..		10 m	gasoline 20 L, diesel 20 L, propane 1900 L, A-tech tire paint 38 L, TireLife 4000 L	overland flow
21	ST	M	small energy company, research & development - testing facility of wood waste to syngas		27 m	diesel 750 L, oxygen/acetylene tanks 100 lbs, sawdust chips (biomass)30 m3	overland flow
22	ST	M	veneer & panel (plywood) manufacturing		406 m	hydraulic oil 5000 L, thermal oil 2700 L, gear/lube oil 200 L, solvents 30 L, propane 200 lbs, Biobasics (pitch cleaner) 200 L, phenol formaldehyde 90,400 lbs, flour/corn/soda ash 10,000 lbs, water based ink 200 L, diesel 100L, compressor oil 120 L, used oils 700 L, used oil filters 170 L, drum, coolant 20 L, water base paint 20 L, oil base paint 10 L.	overland flow
23	ST	H	manufacturing of steel grinding balls		125 m	pond midscale(iron oxide) 3200 m3, hydraulic oil 2000 L, gear oil 4500 L, misting oil 170 L, diesel 250 L, gasoline 100 L, Slapshot solvent 170 L, varsol 40 L, auto transmission fluid 380 L, motor oil 40 L, bug-be-gone(biocircle) 75 L, propane 180 lbs, paint 75 L, Candry (absorbent) 1000 L	overland flow
24	ST	M	steel fabrication, repair of mining equipment, machine and welding shop		27 m	paint primer for metal 455 L, paint thinner 38 L, propane 360 lbs, oxygen/acetylene gas 16 m3, arcal gas 1 m3, hydrogen gas 7.5 m3, cutting fluid 75 L, xylene 170 L, DEF 100 L	overland flow
25	ST	M	bulk water hauling service		100 m	new oil 50 L, diesel 20 L, misc. auto fluids 20 L	overland flow
26	ST	M	wholesaler of meats		165 m	packaged meats 40 m3, paints 20 L, gas 20 L, industrial cleaners 8 L	overland flow
27	ST	H	fuel sales - larger truck stop		35 m	gasoline 245,000 L, diesel 155,000 L, propane 3000 L, new oil 50 L, misc. auto fluids 24 L	overland flow
28	ST	M	log debarking & chipping		160 m	propane 30 lb, lube oil 20 L, grease tubes 20 L	overland flow
29	ST	M	trucking transportation services		130 m	varsol solvent 170 L, engine oil 170 L, DEF 1000 L, propane 240 lbs, grease tubes 20 L	overland flow
30	ST	M	garden centre		2050 m	diesel 38 L, gasoline 20 L, kelp and corn gluten fertilizers only 1 m3, assorted bugs sprays 20 L	overland flow
31	ST	M	Barnhartvale landfill & recycling		1400 m	diesel 1900 L, used household paint 4 m3, car batteries 1.5 m3, propane 1 m3, regular garbage ?? Vehicle tires, metal piles	overland flow
32	ST	M	Gravel pit operation		1500 m	diesel 2300 L, hydraulic oil 20 L, duron oil 20 L, antifreeze 32 L, grease tubes 4 L	overland flow

Survey ID/Hazard Number	Assessment Area	Rank	Contaminant Source (Type And Description)	Location	Approximate Distance To The River	Potential/Known Contaminants Of Concern	Contaminant Transport Mechanism
33	ST	H	machine shop & repairs, manufactures pump sleeves, general welding/fabrication, mining truck repairs		0 m	used grit (silica) 6 m3, engine oil 20 L, coolant 20 L, solvent 4 L, paint 20 L, propane 120 lb, oxygen/acetylene 240 lbs, liquid petroleum gas 240 lbs, arcal gas 120 lbs, liquid oxygen gas 330 lbs, map gas 330 lbs	overland flow
34	ST	M	welding & fabricating - manufactures components for HD equipment		400 m	paint 25 gal, xylene 5 gal, toluene 5 gal, silicone tubes 1 gal, hydraulic oil 5 gal, gasoline 10 gal, diesel 2 gal, solvent 1 gal, coolant 5 gal, oxygen/acetylene 300 lbs, arcal gas 60 lbs, map gas 60 lbs	overland flow
35	ST	H	industrial truck repair shop, concrete truck pump repairs		410 m	new oil 5700 L, used oil 570 L, solvent 75 L, propane 750 L, coolant 170 L, degreaser 40 L, carwash soap(biodegradable) 20 L	overland flow
36	ST	H	HD truck body shop & repair		410 m	paint 4 L, gun-wash 20 L, resin 20 L, used oil 170 L, used antifreeze 170 L, propane 90 lbs, auto body fill 20 L, short strand fiberglass 20 L	overland flow
37	ST	M	wholesale meat sales- small quantity		180 m	packaged beef and pork in freezer 4 m3, propane tank 1900 L	overland flow
38	ST	H	self-serve gas bar, carwash, convenience store		145 m	gasoline 135,000 L, diesel 25,000 L, antifreeze 64 L, windshield wash 320 L, top up auto fluids 75 L, carwash chemicals (biodegradable soap, wax, degreaser) 300 L	overland flow
39	ST	H	new & used vehicle sales and service		245 m	New oil 3000 L, used oil 1900 L, coolant 1900 L, used coolant 500 L, solvent 40 L, carwash soaps 20 L, misc. auto fluids 75 L	overland flow
40	ST	H	new & used vehicle sales and service		245 m	new oil 12,000 L, DEF 12,000 L, antifreeze 4,100 L, windshield fluid 34,300 L, car undercoat sealant 540 L, refrigerant 500 lbs, used oil 3800 L, solvent 75 L, gasoline 340 L, diesel 500 L, car soap 830 L, degreaser 500 L, oxygen/acetylene 480 lbs, argon gas 60 lbs, nitrogen 60 lbs	overland flow
41	ST	H	new & used vehicle sales and service		250 m	New oil 1000 L, used oil 1500 L, coolant 200 L, used coolant 170 L, contaminated fuels 170 L, solvent 40 L, DEF 100 L, used oil filters 340 L, auto detail cleaning supplies 230 L, assorted auto fluids 100 L, refrigerant 20 lbs, oxygen/acetylene 120 lbs, nitrogen gas 60 lbs, argon 60 lbs, helium 60 lbs, propane 30 lbs	overland flow
42	ST	H	RV Sales and service		90 m	gasoline 20 L, new oil 320 L, solvent 115 L, shop auto fluids 20 L, windshield cleaner 20 L, degreaser 20 L, carwash cleaners 20 L	overland flow
43	ST	H	RV Sales and service		155 m	antifreeze 4000 L, varsol tank 20 L, propane 300 lbs, assorted RV cleaners 20 L	overland flow

Survey ID/Hazard Number	Assessment Area	Rank	Contaminant Source (Type And Description)	Location	Approximate Distance To The River	Potential/Known Contaminants Of Concern	Contaminant Transport Mechanism
44	ST	H	new & used vehicle sales and service		125 m	new oil 1000 L, used oil 1000 L, antifreeze 130 L, used antifreeze 80 L, solvent 100 L, auto fluids 20 L, windshield wash 600 L, car cleaner 4 L, car wax 16 L, gasoline 20 L, diesel 20 L, refrigerant 20 L	overland flow
45	ST	M	agriculture supply sales and service, garden centre		115 m	fertilizer bags 1 m3, pesticide sprays 8500 grams, animal feed(protein/fibre/fat) 35 m3, dog food bags 3 m3, potting soil 1 m3, hydraulic fluid 20 L, liquid pesticides(malathion) 20 L, horse care cleaning products 20 L	overland flow
46	ST	H	wholesale petroleum distribution, card lock fuel sales		100 m	diesel 80,000 L, gasoline 20,000 L, new oil 32,500 L, used oil 4500 L, solvent 190 L, DEF 3000 L, carwash cleaner 20 L, kerosene 100 L, used oil filters 340 L, gasoline additives 25 L, window wash 1000 L, propane 60 lbs	overland flow
47	ST	M	car wash, windshield installation, U-Haul rental, no more upholstery		80 m	carwash soap 360 L, car wax 20 L, glass cleaner 12 L, assorted car cleaners 20 L	overland flow
48	ST	H	RV repairs, sale, maintenance, supplies		170 m	antifreeze 3000 L, RV cleaners/wax assorted 60 L, resin patch 4 L, touch up paint 12 L, propane 60 lbs	overland flow
49	ST	M	machine shop - rewind electric motors, pump repairs		250 m	varnish 170 L, new oil 12 L, used oil 170 L	overland flow
50	ST	H	auto repair and maintenance		80 m	new oil 1,680 L, used oil 1000 L, used oil filters 170 L, varsol 25 L, gasoline 20 L, grease tubes 12 L, tub grease 10 L, coolant 40 L, used coolant 170 L, heavy gear oil 170 L, brake cleaner 125 L, transmission fluid 120 L, refrigerant 30 lbs, oxygen/acetylene 120 lbs, argon 60 lbs, nitrogen 60 lbs	overland flow
51	ST	H	boat sales and service		127 m	new oil 1500 L, gasoline 380 L, assorted boat car products 20 L, coolant 20 L, propane 50 lbs	overland flow
52	ST	H	fast lube & oil change		300 m	new oil 3000 L, used oil 2000 L, new coolant 800 L, used coolant 250 L, used oil filters 200 L, fuel additives 75 L, grease 60 L, paint 2 L, DEF 175 L	overland flow
53	ST	H	light industrial equipment repairs and service, diesel generators sales and service		100 m	diesel 1000L, glycol 64 L, engine oil 12 L, used oil 400 L, paint 20 L, oxygen/acetylene 120 lbs, mig gas 60 lbs, propane 120 lbs	overland flow
54	ST	H	machine shop, welding and auto repairs		85 m	misc oil (engine, honing oil, hydraulic oil, machine oil) 170 L, solvent 75 L, spray paint 24 L, auto cleaning products 20 L, used oil filters 170 L, glass blasting beads 20 L, oxygen/acetylene 40 lbs, mig (panther) gas 20 lbs	overland flow
55	ST	M	lawn care and maintenance		265 m	dry fertilizer(av. mix: 25/5/10) 3 m3, liquid fertilizer and water 4000 L, organic fertilizer 2 m3, phosphoric acid(75%) 40 L, ultra kelp 20 L, herbicide(trillion)70 L, engine oil 80 L, gasoline 200 L, concrete mix 20 L	overland flow

Survey ID/Hazard Number	Assessment Area	Rank	Contaminant Source (Type And Description)	Location	Approximate Distance To The River	Potential/Known Contaminants Of Concern	Contaminant Transport Mechanism
56	ST	H	auto repair and maintenance		175 m	new oils 3000 L, used oil 2000 L, solvent 20 L, used oil filters 340 L, coolant 160 L, used coolant 100 L, carwash soap 20 L, degreaser 20 L, windshield washer fluid 100 L, touch up paints 10 L, oxygen/acetylene 120 lbs, mig gas 60 lbs, Freon 40 lbs	overland flow
57	ST	M	welding blacksmith services, springs		75 m	hydraulic oil 40 L, grease 12L, cleaner, soap 20 L, touch up paint/primer 20 L, oxygen/acetylene 480 lbs, argon 120 lbs	overland flow
58	ST	H	auto body repair and restoration		80 m	new oil 20 L, used oil 10 L, used coolant 20 L, solvent 60 L, water born car paint 100 L, paint reducer/blender/clear-coat 20 L, gasoline form cars 750 L, primer paint 12 L, "bondo" 75 L, sand blast or black sand 2 L, misc. adhesives/glues/cleaner 8 L	overland flow
59	ST	H	auto body repair and restoration		264 m	car paint 100 L, primer paint 10 L, paint reducer/blender/ clear-coat 20 L, solvent 12 L, sand blast or black sand 2 L, misc. adhesives/glues/cleaners 4 L, oxygen/acetylene 120 lbs, argon 60 lbs	overland flow
60	ST	M	manufacturing of cement products		0 m	diesel (double-walled steel tanks) 10,000 L, gasoline 10,000 L, grease 100 L, used oil 500 L, new oil 10,000L, solvents 20 L, sucrose 1000 L, solid fuels: coke 8000 tons/coal 10,000 tons, gypsum 2000 L, crushed limestone 10,000 tons, aluminum additive(granular catalysts) 3,000 tons, clinker 30,000 tons alternate fuels: wood chips 50 tons/industrial rags 10 tons/plastics 100 tons, iron filings 1000 L, metal paints 50 L, red shale 3000 tons, blasting(emulsion)products: blastex 1800 kg /ammonium nitrate 20,000 kg, alumina brick(refractory bricks) 100 tons, filter cake(from Kamloops. water treatment plant) 100 tons, cement powder in silos 5000 tons	overland flow
61	ST	H	manufacturing of railway maintenance equipment		265 m	new oil 500 L, used oil 1900 L, coolant 75 L, used coolant 170 L, varsol solvent 8 L, gasoline in truck tidy tanks 800 L, spray paint 12 l, oxygen/acetylene 120 lbs, argon gas 300 lbs, mig gas 300 lbs	overland flow
62	ST	H	self-serve gas bar, convenience store		290 m	gasoline 120,000 L, new oil 144 L, assorted auto fluids, 20 L, coolant 40 L, windshield wash 80 L	overland flow
63	ST	H	self-serve gas bar, convenience store		105 m	diesel 40,000 L, regular gasoline 80,000 L, prem. gasoline 40,000 L, new oil 122 L, windshield wash 160 L, coolant 80 L, assorted auto fluids 20 L, sani-dump pit (size unknown-not used much), propane 240 lbs	overland flow
64	ST	H	Self-serve gas bar, convenience store		270 m	gasoline 100,000 L, diesel 24,000 L, new oil 180 L, coolant 60 L, windshield wash 320 L, assorted auto fluids 20 L, propane 480 lbs	overland flow
65	ST	H	Auto repair and maintenance		270 m	new oil 600 L, used oil 1900 L, solvent 30 L, coolant 160 L, used coolant 45 L, used oil filters 170 L, spray paint 6 L, brake fluid 20 L, grease 6 L, misc. auto additives/fluids 20 L	overland flow
66	ST	H	Auto repair and maintenance, transmissions		240 m	new oil 1000 L, used oils 800 L, solvent 170 L, gasoline 20 L, coolant 170 L, used coolant 60 L, ATF 1100 L, used oil filters 170 L, assorted auto fluids/cleaners 20 L, propane 30 lbs, oxygen/acetylene 120 lbs	overland flow

Survey ID/Hazard Number	Assessment Area	Rank	Contaminant Source (Type And Description)	Location	Approximate Distance To The River	Potential/Known Contaminants Of Concern	Contaminant Transport Mechanism
67	ST	H	Auto repair and maintenance		320 m	new oils 600 L, used oils 500 L, coolant 100 L, used coolant 400 L, used oil filters 170 L, assorted auto fluids/cleaners 30 L	overland flow
68	ST	H	Auto repair and maintenance		325 m	new oil 1000 L, used oil 600 L, solvent 4 L, used oil filters 170 L, carwash soap and wax 60 L, misc. auto fluids/cleaners 20 L, oxygen/acetylene 360 lbs	overland flow
69	ST	H	auto repair and maintenance		325 m	new oil 650 L, used oil 1000 L, used oil filters 170 L, solvent 40 L, coolant 280 L, used coolant 200 L, gasoline 20 L, assorted auto fluids/cleaners 60 L, ATF 30 L	overland flow
70	ST	H	auto repair and maintenance		220 m	new oil 1900 L, used oil 1100 L, used oil filters 170 L, gasoline 2000 L, diesel 1000 L, solvent 20 L, coolant 190 L, used coolant 60 L, refrigerant 30 lbs, new batteries	overland flow
71	ST	H	auto repair and maintenance		200 m	new oil 250 L, used oil 250 L, solvent 40 L, coolant 500 L, used coolant 200 L, gasoline 20 L, gear oil 40 L, ATF 20 L, grease 12 L, assorted auto fluids 20 L, oxygen/acetylene 120 lbs, argon gas 300 lbs	overland flow
72	ST	H	auto body repair and restoration		145 m	car paint 75 L, primer paint 10 L, car "bondo" 4 L, paint reducer/blender/clear-coat 20 L, solvent 12 L, sand blast or black sand 2 L, misc. adhesives/glues/cleaners 4 L, oxygen/acetylene 120 lbs, argon 30 lbs, new oil 12 L, used oil 20 L, antifreeze 32 L	overland flow
73	ST	H	Motorcycle repair, service and misc. equipment sales		145 m	new oil 50 L, used oil 40 L, solvent 40 L, gasoline 20 L, grease 1 L	overland flow
74	ST	M	Sanitary landfill - private		630 m	diesel (plastic lined with berm) 22,700 L, used asphalt pile 5 m3, gypsum dumped into landfill	overland flow
75	ST	M	hydropower transformer site		0 m	PCBs from transformers & capacitors, oils, solvents, sludge, acid solution, metal plating solutions (chromium, nickel, cadmium)	overland flow
76	ST	H	truck sales, parts, repairs, rebuilding and body work		135 m	estimated to have: used oil, used oil filters, new oil, coolant, used coolant, diesel, gasoline, solvent, grease tubes, oxygen/acetylene, argon, nitrogen	overland flow
1	South Thompson & North Thompson (ST & NT)	H	sewage lines		no field observation	heavy metals, fecal coliforms	soil diffusion, overland flow
2	ST & NT	H	railway lines/yards		no field observation	heavy metals, hydrocarbons, sediment, pesticide (herbicide)	soil diffusion, overland flow

Survey ID/Hazard Number	Assessment Area	Rank	Contaminant Source (Type And Description)	Location	Approximate Distance To The River	Potential/Known Contaminants Of Concern	Contaminant Transport Mechanism
3	ST & NT	H	highways		no field observation	gasoline, antifreeze, aft, battery acid, engine and radiator flushes, engine and metal degreasers, hydraulic brake fluid and motor oils; herbicides, road salt (sodium and calcium chloride), anticaking additives, ferric Ferro cyanide, sodium Ferro cyanide, anticorrosives (phosphate and chromate)	overland flow/storm water
4	ST & NT	H	aquatic recreation		no field observation	diesel fuel, oil, seepage from boat waste, black/grey water discharge (fecal coliforms)	direct deposition
5	ST & NT	H	air traffic		no field observation	jet fuel, diesel fuel, (hydrocarbons)	indirect deposition (overland flow), direct deposition
6	ST & NT	H	residential development		no field observation	hydrocarbons, tetrachloroethylene, dichlorobenzene, methylene chloride, xylene, petroleum distillates, glycol esters, isopropanol, disinfectants, 1,1,1-trichloroethylene, caustic soda, automotive wastes (fuel/fluids noted above), pool chemicals, pet waste (microbiological contaminants), de-icers, fertilizer (nitrates)	overland flow, direct deposition
7	ST & NT	M	agriculture and range operations		no field observation	herbicide/pesticide, sediment, biological wastes	overland flow, soil diffusion
8	ST & NT	M	forestry/silviculture operations		no field observation	sediment, hydrocarbons, pesticide/herbicide	overland flow
9	ST & NT	M	transmission/comm unication lines		no field observation	herbicides from utility rights-of-way	overland flow, soil diffusion
10	ST & NT	M	terrestrial recreation		no field observation	sediment, fertilizer/pesticide (herbicide) from parks and golf courses, fecal coliforms, hydrocarbons (ATV use)	overland flow
11	ST & NT	M	air emissions/pollution		no field observation	nitrogen, sulphur, mercury, lead, cadmium, copper, zinc	indirect deposition (overland flow), direct deposition

Table 3.5: Module 2 hazard identification summary table for contaminant sources

Hazard No/Survey Id	Assessment Area	Contaminant Source Type	Contaminant Source	Drinking Water Hazard	Potential Effects	Preventative Measures In Place	Associated Barrier	Comments
1	North Thompson (NT)	INDUSTRY	mining /gravel pit	gravel pit operation	contamination of surface water	double-walled steel fuel containers	source water protection, water treatment	several very large gravel/sand piles on site; creek flows through property on the south side; HD equipment mostly stored at higher elevations, only two years left of operation at the pit, will likely sell at that time
2	NT	COMMERCE	fuel sales, car wash	oils, solvents, gasoline, miscellaneous wastes, soaps, detergents, waxes, miscellaneous chemicals	contamination of surface water - hydrocarbons	carwash interceptors and lot drains cleaned out 4x/yr., only uses biodegradable cleaners in carwash	source water protection, water treatment	all contaminants stored inside building or locking cabinets; separate storage room for carwash chemicals
3	NT	INDUSTRY	manufacturing - wood products	glues, stains, paints for cabinetry	contamination of surface water	contaminants usually stored in sealable drums(most inside building)	source water protection, water treatment	there are few contaminants on site, all are contained - will expand building and pave
4	NT	COMMERCE	sales - hardware, multiple chemicals	paint/varnish/stain, ice melt, road salt, concrete mix, fertilizers	contamination of surface water	none	source water protection, water treatment	all contaminants are stored in containers or plastic bags
5	NT	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	old underground fuel tanks have already been removed as they do not intend to sell fuel anymore; one large interceptor cleaned annually; all contaminants stored inside buildings	source water protection, water treatment	all contaminants stored inside and in secure containers
6	NT	COMMERCE	fuel sales	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	extra protection around raised bulk propane tank(no posts/bollards)	source water protection, water treatment	contaminants are secure and contained
7	NT	COMMERCE	fuel sales	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	special fuel shut down procedures(one switch turns off all)	source water protection, water treatment	Heffley Creek flows south of this property; property slopes toward the creek; above ground fuel tank with catwalk for filling and inspections(ground sloped down to creek from tanks)
8	NT	COMMERCE	fuel sales	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	immediate spill cleanup as per Petro-Can Environmental Policy	source water protection, water treatment	underground fuel tanks, contaminants stored inside and in secure containers, train track just behind property

Hazard No/Survey Id	Assessment Area	Contaminant Source Type	Contaminant Source	Drinking Water Hazard	Potential Effects	Preventative Measures In Place	Associated Barrier	Comments
9	NT	INDUSTRY	manufacturing - wood products	veneer and plywood plant	contamination of surface water	cleanup procedures as per Tolko Environmental Policy; during spring months they conduct regular visits to the river to monitor river levels and potential seepage on the lower property (river seepage noted only on this level of the property); contaminants, other than the chip piles, are stored inside and in secure containers	source water protection, water treatment	Tolko property laid out over four elevation levels (two above highway, two below); main plant is at level two from the river and is approx. 15 feet above the train tracks
10	NT	COMMERCE	golf course	fertilizer, sand	contamination of surface water - nutrients/turbidity	all fertilizer/fuel is stored in closed containers at the highest point of the property, adjacent to Westsyde Rd. Could load on to a truck in an emergency.	source water protection, water treatment	will build 14 houses and convert 22 acres back to farm land
1	South Thompson (ST)	INDUSTRY	manufacturing - wood products	white glue/contact cement	contamination of surface water	all chemicals are in closed containers	source water protection, water treatment	there are very few chemicals on site, all are contained.
2	ST	COMMERCE	sales - gardening supplies	gardening supplies	contamination of surface water	none - most of the fertilizer is in closed plastic containers - some in bags. Shut doors was the contingency plan	source water protection, water treatment	this is a small shop, this unit is at a higher elevation. Used to be an auto wrecker, could be soil contamination
3	ST	COMMERCE	recycling	recycling only, glass/paper/plastic	contamination of surface water	fuel tank is secured/perimeter fence to prevent product from entering water (plastic/paper etc.)/moving outdoor materials inside - pull offsite	source water protection, water treatment	very few chemicals on site. A big flood could wash paper etc. into the river.
4	ST	INDUSTRY	manufacturing - tire retread plant	tire retread plant	contamination of surface water	all chemicals are stored in steel cans, propane in cages, fire proof cabinet. Have done some repair on the bank to prevent sloughing	source water protection, water treatment	the land is sloughing, maybe needs to be reinforced
5	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	all chemicals/fuel are in sealed/caged crates.	source water protection, water treatment	the land is sloughing, maybe needs to be reinforced
6	ST	INDUSTRY	manufacturing - tire retread plant	tire retread plant	contamination of surface water	all chemicals/fuel are in sealed/caged crates.	source water protection, water treatment	the land is sloughing, maybe needs to be reinforced

Hazard No/Survey Id	Assessment Area	Contaminant Source Type	Contaminant Source	Drinking Water Hazard	Potential Effects	Preventative Measures In Place	Associated Barrier	Comments
7	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	cleaned immediately as per Finning Environmental Policy	source water protection, water treatment	main building is mostly administration and warehouse, rear buildings for equipment service
8	ST	INDUSTRY	manufacturing - hydraulic hose	hydraulic hose bulk	contamination of surface water	cleaned immediately as per Finning Environmental Policy	source water protection, water treatment	this is a separate small shop
9	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	no	source water protection, water treatment	very few chemicals on site, all are contained.
10	ST	COMMERCE	construction	sediment, hazardous chemical products in inventories	contamination of surface water - increased turbidity	none	source water protection, water treatment	mid-sized shop, the warehouse is at a higher elevation. Very few contaminants on site, not a significant threat to source water (this business was likely included as the original business list was based on existing business licenses however, many businesses have changed locations etc. without there being any changes to the licenses.
11	ST	INDUSTRY	metal fabrication	tanks for welding equipment	contamination of surface water	flood procedure in place to kill power(not current) and evacuate site	source water protection, water treatment	there are very few chemicals on site, all are contained.
12	ST	COMMERCE	sales - automotive chemicals	several types of automotive chemicals for farm and industrial equipment services	contamination of surface water	diesel in a raised/bolted down container - none other	source water protection, water treatment	there are very few chemicals on site, all are contained or secured
13	ST	COMMERCE	sales - equipment	few types of chemicals for heavy duty equipment sales and parts	contamination of surface water	no	source water protection, water treatment	there are very few chemicals on site, all are contained.
14	ST	INDUSTRY	mining research	chemicals used in lab process	contamination of surface water	none - a fire call as they have caustic chemicals on site, special Styrofoam boxes/containers and glass bottles used to store chemicals	source water protection, water treatment	other than argon tank all chemicals inside, building is raised - trucking dock style
15	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	none - oil interceptor from all service bays cleaned annually, used oil picked up several times per year as tank fills up	source water protection, water treatment	train tracks behind property, chemicals mostly inside and are in containers or storage lockers

Hazard No/Survey Id	Assessment Area	Contaminant Source Type	Contaminant Source	Drinking Water Hazard	Potential Effects	Preventative Measures In Place	Associated Barrier	Comments
16	ST	COMMERCE	fuel sales(propane) , transport	bulk propane transportation	contamination of surface water hydrocarbons	emergency shut off valves; if given enough notice, they can pump all propane tanks down and haul product away with their own trucks; oil interceptor from all service bays cleaned annually and used oil is picked up several times per year as tank fills up	source water protection, water treatment	large propane tanks are anchored securely off ground
17	ST	COMMERCE	fuel sales	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	no	source water protection, water treatment	underground fuel tanks, all other contaminants stored inside building in containers
18	ST	COMMERCE	sales - dangerous goods	battery acids	contamination of surface water	Class 8 dangerous goods/hazardous waste site. Procedure for: 7 batteries spill event(use internal procedures for cleanup), more than 7 batteries spill(must immediately call emergency national and provincial number for special cleanup team	source water protection, water treatment	all contaminants inside, well organized shop layout for recycling process
19	ST	INDUSTRY	transportation services - hauling	powder cement mixture	contamination of surface water	none	source water protection, water treatment	powder cement loaded from silos to trucks for delivery
20	ST	INDUSTRY	manufacturing - tire retread plant	tire retread plant	contamination of surface water	all water on property drains to engineered settling pond(north end)	source water protection, water treatment	retread building is built at truck dock height. Used to be Chevron distribution terminal, soil contamination possible
21	ST	COMMERCE	research	research- biomass to syngas testing	contamination of surface water	plant base secured to concrete	source water protection, water treatment	potable water piped underground from main Beaver Manufacturing building
22	ST	INDUSTRY	manufacturing - wood products	veneer and plywood plant	contamination of surface water	water from large roof area piped to catch-ponds(2) then to storm; large concrete moat around oil and glue storage containers	source water protection, water treatment	extra heavy rainfall from hills (behind) might be able to wash through property and building

Hazard No/Survey Id	Assessment Area	Contaminant Source Type	Contaminant Source	Drinking Water Hazard	Potential Effects	Preventative Measures In Place	Associated Barrier	Comments
23	ST	INDUSTRY	metal fabrication	manufacture steel balls for mining industry	contamination of surface water	pond liner was just replaced with new to prevent leakage; oil storage and pumps in separate building with additional concrete moat in case of a leak; many chemical containers are stored in cabinets as well	source water protection, water treatment	strong safety program - operational and safety concerns are discussed regularly. Currently building an identical plant adjacent to the existing one.
24	ST	INDUSTRY	metal fabrication	chemicals for welding process	contamination of surface water	none	source water protection, water treatment	most chemicals stored and secured inside building; borders train tracks
25	ST	COMMERCE	transportation services - hauling	water hauling business	contamination of surface water	none	source water protection, water treatment	this is a separate small shop, mostly paved lot
26	ST	COMMERCE	sales - meat distribution	assorted packaged meats for distribution	contamination of surface water	none	source water protection, water treatment	all packaged contaminants inside building and freezers, well organized shop layout for transportation process
27	ST	COMMERCE	fuel sales	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	none - gasoline and diesel tanks underground(double walled steel), easy process for emergency shutoff for tanks, propane tank bolted down with several barricades; fuel could be pumped/trucked off site easily enough	source water protection, water treatment	large paved lot - rain water looks to be diverted to a settling pond area before into the city's storm drain culvert. Adding a HD truck/car wash building
28	ST	INDUSTRY	forestry - mill	log debarking process	contamination of surface water	fuel bought off site for equipment as needed; (2) emergency spill kits: round absorbent, granular clay, and paper absorbent	source water protection, water treatment	large mostly paved lot - rain water looks to be diverted to a settling pond area before into the city's storm drain culvert
29	ST	COMMERCE	transportation services	trucking transportation services	contamination of surface water	several chemicals in shop raised up off floor, clay spill kits, no longer do truck oil changes on site	source water protection, water treatment	there are very few chemicals on site, all are contained.
30	ST	AGRICULTURE	sales - fertilizer	fertilizer (nitrogen)	contamination of surface water - increased nutrients	all contaminants kept in building, most in secure containers or plastic bags	source water protection, water treatment	the creek/pond seems to be connected to the city's drainage system

Hazard No/Survey Id	Assessment Area	Contaminant Source Type	Contaminant Source	Drinking Water Hazard	Potential Effects	Preventative Measures In Place	Associated Barrier	Comments
31	ST	INDUSTRY	landfill/recycling	landfill site	contamination of surface water	no oil or pesticides taken to this site; spill kits on site for gas/diesel spills; Freon removed from appliance and store in a separate location; batteries in a spill tote	source water protection, water treatment	could use barricades to protect the raised diesel tank
32	ST	INDUSTRY	mining - gravel pit	gravel pit operation	contamination of surface water	double walled, environmental tank for diesel genset; all contaminants in containers and locked up in "steel box"	source water protection, water treatment	well water on site for dust control; creek just across road from pit
33	ST	INDUSTRY	metal fabrication	manufacturing for mining, pumps	contamination of surface water	no liquid in containers outside; used oil taken off-site weekly	source water protection, water treatment	the land is sloughing, maybe needs to be reinforced
34	ST	INDUSTRY	metal fabrication	metal manufacturing of components mostly	contamination of surface water	yard drains work well	source water protection, water treatment	extra heavy rainfall from hills (behind) might be able to wash through property and building
35	ST	COMMERCE	mechanical service, concrete pumping	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons, sediment	double walled steel tank(seat sealed) and inside building, yard drains work well in front and back, sump tank with protective concrete apron is pumped 3 times per year	source water protection, water treatment	extra heavy rainfall from hills (behind) might be able to wash through property and building
36	ST	COMMERCE	mechanical service, auto body shop	waste oils, solvents, acids, paints, automotive wastes, miscellaneous wastes	contamination of surface water	all chemicals are in closed containers	source water protection, water treatment	extra heavy rainfall from hills (behind) might be able to wash through property and building. Moving to a new location
37	ST	COMMERCE	meat sales, distribution	packaged meat distribution	contamination of surface water - biological pathogens	meat freezers up higher in the main building or in a separate locked building	source water protection, water treatment	all packaged contaminants inside building and freezers, well organized shop layout for transportation process
38	ST	COMMERCE	fuel sales	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	emergency shutdown as per Petrocan policy; spill kits were recently upgraded(higher standard-Worksafe suggestion); three interceptors cleaned out 2-3x/year	source water protection, water treatment	all fuel tanks underground, only carwash soap containers exposed outside on pallets

Hazard No/Survey Id	Assessment Area	Contaminant Source Type	Contaminant Source	Drinking Water Hazard	Potential Effects	Preventative Measures In Place	Associated Barrier	Comments
39	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	shop interceptors cleaned out every 3-5 months, used oil picked up monthly, parking lot drains cleaned annually, contaminants stored inside and in containers	source water protection, water treatment	most chemicals stored and secured inside building
40	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	shop interceptors cleaned out every 3-5 months, used oil picked up monthly, parking lot drains cleaned annually, contaminants stored inside and in containers	source water protection, water treatment	most chemicals stored and secured inside building, drums on pallets outside could be easily moved into garage bays
41	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	sump tank and interceptors cleaned out annually	source water protection, water treatment	most chemicals stored and secured inside building
42	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	shop interceptors cleaned out every 6 months, parking lot drains cleaned 3x/year , contaminants stored inside and in containers	source water protection, water treatment	most chemicals stored and secured inside building
43	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	shop interceptors cleaned out annually, parking lot drains cleaned annually, contaminants stored inside and in containers, kitty litter for spills	source water protection, water treatment	most chemicals stored and secured inside building, asphalt parking lot very cracked
44	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	shop interceptors cleaned out every 6 months , used oil picked up every few months	source water protection, water treatment	most chemicals stored and secured inside building, one service bay and storage in basement(flood prone for this property?)
45	ST	AGRICULTURE	sales - fertilizer, feed	fertilizer (nitrogen), herbicide, pesticide, rodenticide, fungicide	contamination of surface water - increased nutrients	a number of higher racks for product storage in the old service bays	source water protection, water treatment	most chemicals stored and secured inside building, bags on pallets outside could be easily moved into old service bays
46	ST	COMMERCE	fuel sales	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	only one valve to shut down all fuel pumps; all fuel tanks underground; 1 large spill kit - spills cleaned as per Petrocan and Suncor Environmental policy (Kamloops office); large interceptor tank - samples taken monthly	source water protection, water treatment	higher truck dock to storage buildings, empty 45 gal oil drums stored up higher on back lot and in caged building

Hazard No/Survey Id	Assessment Area	Contaminant Source Type	Contaminant Source	Drinking Water Hazard	Potential Effects	Preventative Measures In Place	Associated Barrier	Comments
47	ST	COMMERCE	car wash	soaps, detergents, waxes, miscellaneous chemicals, leaked automobile fluids/oils/petrochemicals	contamination of surface water	interceptors cleaned every 6 months (tested by city), no large trucks allowed into carwash bays due to excessive oil/grease buildup, chemicals all stored inside in secure containers, bio pads for spills	source water protection, water treatment	this properties back lot is raised compared to neighbouring businesses
48	ST	COMMERCE	mechanical service/sales	typical garage chemicals	contamination of surface water	all RV maintenance chemicals kept inside and in secure containers, environmental products used where all possible	source water protection, water treatment	most chemicals stored and secured inside building
49	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	everything contaminant wise stored inside shop	source water protection, water treatment	most chemicals stored and secured inside building
50	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	shop interceptors cleaned out every 6 months, used oil picked up 3x/year, contaminants stored inside and in containers	source water protection, water treatment	most chemicals stored and secured inside building, business front area (asphalt) slopes down from roadway to building
51	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	shop interceptors and lot drains cleaned out annually, contaminants stored inside and in containers or in "steel box", gas tank chained to back wall, contaminants stored at lot level could be moved up to main building	source water protection, water treatment	half of the chemicals are stored and secured inside main building which is raised approx. 2 feet higher than the parking lot
52	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	shop interceptors and big holding tank cleaned annually, used oil and filters removed weekly	source water protection, water treatment	all contaminants inside and in secure containers, well organized shop layout
53	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	double-walled steel diesel tank, interceptors cleaned out annually, contaminants kept inside and secure	source water protection, water treatment	fill and sand used to build up lot so that the building would be higher
54	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	interceptor cleaned out every 6 months, contaminants bottled and/or boxed	source water protection, water treatment	there are very few chemicals on site, all are contained.
55	ST	AGRICULTURE	sales - fertilizer	fertilizer (nitrogen)	contamination of surface water - increased nutrients	herbicide stored in separate locked cabinet, contaminants always on pallets, bottled or bagged	source water protection, water treatment	all contaminants inside and in secure containers, well organized shop layout, train tracks 15 meters from bay doors. May change location.

Hazard No/Survey Id	Assessment Area	Contaminant Source Type	Contaminant Source	Drinking Water Hazard	Potential Effects	Preventative Measures In Place	Associated Barrier	Comments
56	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	used oil stored in underground tank(no tipping over),interceptors cleaned 3x/yr., bio-pads and floor dry clay for spills	source water protection, water treatment	all contaminants inside and in secure containers, well organized shop layout, train tracks 7 meters from back of business
57	ST	INDUSTRY	metal fabrication	welding gases mostly	contamination of surface water	all chemicals are in closed containers	source water protection, water treatment	there are very few chemicals on site, all are contained.
58	ST	COMMERCE	mechanical service, auto body shop	Auto-body shop paints, etc.	contamination of surface water	all chemicals are in closed containers, interceptors cleaned every 6 months, two types of spill kits on-site, separate paint storage room	source water protection, water treatment	all contaminants inside and in secure containers, well organized shop layout
59	ST	COMMERCE	mechanical service, auto body shop	auto body shop paints, etc.	contamination of surface water	separate room for paint storage, all chemicals in closed containers and stored inside	source water protection, water treatment	all contaminants inside and in secure containers; church parking lot behind is higher and has recently been paved - possibly more rainwater now travels onto #2021 Falcon property
60	ST	INDUSTRY	mining - cement plant	see list of contaminants list (column #2)	contamination of surface water	cleaned immediately as per Lafarge Environmental Policy, contract with Newalta for emergency cleanup, equipment on site to dyke/divert/contain water if necessary, several different types of emergency spill kits	source water protection, water treatment	very large scale cement plant with exposed mined product piles; plant uses water from river to cool equipment and returns it to the river at +/- 11° C of current river temperature; septic field on site as well
61	ST	INDUSTRY	metal fabrication	chemicals for welding process	contamination of surface water	none	source water protection, water treatment	all contaminants inside and in secure containers; church parking lot behind is higher and has recently been paved - possibly more rainwater now travels onto #2025 Falcon property
62	ST	COMMERCE	fuel sales	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	one large tank interceptor on property corner - levels monitored daily, underground fuel tanks, a few different spill kits - cleaning as per Chevron environmental policy	source water protection, water treatment	most contaminants are stored and secured inside building, and in underground tanks
63	ST	COMMERCE	fuel sales	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	separate sani tank and interceptor cleaned out annually, perzometer in underground fuel tanks to detect leaks, one large spill kit with property mapping to indicate low areas for spill kit setup(a ground level analysis is	source water protection, water treatment	most contaminants are stored and secured inside building, and in underground tanks

Hazard No/Survey Id	Assessment Area	Contaminant Source Type	Contaminant Source	Drinking Water Hazard	Potential Effects	Preventative Measures In Place	Associated Barrier	Comments
						performed annually to update these maps), additional spill kits: granular clay/absorbent material/blankets		
64	ST	COMMERCE	fuel sales	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	fuel tanks underground, granular clay and bio-pad spill kits	source water protection, water treatment	most contaminants are stored and secured inside building, and in underground tanks
65	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	used oil/antifreeze tanks (outside of garage) are locked up to prevent accidental or intentional tipping over , two stage interceptor system cleaned out every 6 months	source water protection, water treatment	most chemicals stored and secured inside building
66	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	interceptors cleaned annually	source water protection, water treatment	most chemicals stored and secured inside building, train tracks 5 meters from back of building
67	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	contaminants mainly stored inside and up against back walls of the service bay, one main interceptor cleaned every 6 months	source water protection, water treatment	most chemicals stored and secured inside building
68	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	soaps/waxes in carwash, one large interceptor cleaned out 3x/yr.	source water protection, water treatment	most chemicals stored and secured inside building
69	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	newer two stage interceptor cleaned 3x/yr., floor dry and granular clay spill kits	source water protection, water treatment	most chemicals stored and secured inside building
70	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	underground fuel tanks, one large interceptor cleaned out 3x/yr., small and large spill kits(granular clay, bio-pads and blankets)	source water protection, water treatment	most chemicals stored and secured inside building, this shop looks to be kept very clean
71	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	when it rains hard, they will sometimes use spare tires to create a berm at the edge of the street to slow down the water flow to their parking lot storm drain; soil samples for environmental analysis were taken a few years ago as a	source water protection, water treatment	most chemicals stored and secured inside building, no City storm Dr. ain adjacent to Meadowlark Terrace

Hazard No/Survey Id	Assessment Area	Contaminant Source Type	Contaminant Source	Drinking Water Hazard	Potential Effects	Preventative Measures In Place	Associated Barrier	Comments
						condition of the business selling - tested OK		
72	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	nothing is washed into drains - swept up or cleaned up first; one main water shut off for this complex (several rental bays for lease); all interceptors/drains cleaned out in this complex annually regardless of use	source water protection, water treatment	most chemicals stored and secured inside building
73	ST	COMMERCE	mechanical service	oils, solvents, gasoline, miscellaneous wastes	contamination of surface water - hydrocarbons	none beyond industry standards	source water protection, water treatment	most chemicals stored and secured inside building
74	ST	INDUSTRY	landfill/recycling	landfill site, regulated	contamination of surface water	none - plastic lined diesel tank with containment berm(situated on a higher point of the roadway)	source water protection, water treatment	
75	ST	LINEAR DEVELOPMENT	hydropower transformer site	hydropower transformer site	contamination of surface water	unknown, industry safety standards and best management practices (this site was viewed only from the road)	source water protection, water treatment	a big flood could possible knock down the transformer equipment; the land is sloughing, maybe needs to be reinforced
76	ST	COMMERCE	mechanical service, auto body shop	oils, solvents, gasoline, waste oils, solvents, acids, paints, automotive wastes, cutting oils	contamination of surface water - hydrocarbons	on the City's interceptor cleaning list	source water protection, water treatment	low area in the 200 yr. flood plain, heavy rainfalls will sometimes back up in this area, possibility of moving to Campbell Creek site
1	South Thompson & North Thompson (ST & NT)	AGRICULTURE	agriculture & range practices	herbicide/pesticide, sediment, biological wastes	contamination of surface water	unknown, industry safety standards and best management practices	source water protection, water treatment	
2	ST & NT	AIR POLLUTION	air emissions/pollution	nitrogen, sulphur, mercury, lead, cadmium, copper, zinc	across assessment area	industry standards; vehicle emissions are not covered	source water protection, water treatment	
3	ST & NT	INDUSTRY	Forestry/silviculture operations	sediment, hydrocarbons, pesticide/herbicide	contamination of surface water	unknown, industry safety standards and best management practices	source water protection, water treatment	There are many licensees with tenures in the assessment areas. An interview would need to be completed with each one to determine the type and timing of work planned.

Hazard No/Survey Id	Assessment Area	Contaminant Source Type	Contaminant Source	Drinking Water Hazard	Potential Effects	Preventative Measures In Place	Associated Barrier	Comments
4	ST & NT	INDUSTRY	air traffic	jet fuel, diesel fuel, (hydrocarbons)	flight path across assessment area	industry standards	source water protection, water treatment	
5	ST & NT	LINEAR DEVELOPMENT	Transmission/c ommunication lines	herbicides from utility rights-of-way	contamination of surface water	unknown, industry safety standards and best management practices	source water protection, water treatment	
6	ST & NT	LINEAR DEVELOPMENT	sewage lines	heavy metals, fecal coliforms	contamination of surface water	unknown, industry safety standards and best management practices	source water protection, water treatment	
7	ST & NT	LINEAR DEVELOPMENT	railway lines/yards	heavy metals, hydrocarbons, sediment, pesticide (herbicide)	contamination of surface water	unknown, industry safety standards and best management practices	source water protection, water treatment	
8	ST & NT	LINEAR DEVELOPMENT	highways	gasoline, antifreeze, ATF, battery acid, engine and radiator flushes, engine and metal degreasers, hydraulic brake fluid and motor oils; herbicides, road salt (sodium and calcium chloride), anticaking additives, ferric Ferro cyanide, sodium Ferro cyanide, anticorrosives (phosphate and chromate)	Hwy 1 and Hwy 97	Road salt and abrasive (Barnhartvale Road & Highway 1 adjacent to Tolko) are stored in covered storage areas with concrete floors. Both storage areas are well away from the 200 year flood mark.	source water protection, water treatment	
9	ST & NT	RECREATION	terrestrial	sediment, fertilizer/pesticide (herbicide) from parks and golf courses, fecal coliforms, hydrocarbons (ATV use)	throughout assessment area	best management practices in parks/golf courses (industry standards), unknown and unregulated everywhere else	source water protection, water treatment	
10	ST & NT	RECREATION	aquatic	diesel fuel, oil, from boats, black/grey water discharge (fecal coliforms)	heavy use proximal to Water Street intake and throughout the South Thompson River in the	best management practices within boating industry though it is unknown whether the public is following those standards and to what degree	source water protection, water treatment	

Hazard No/Survey Id	Assessment Area	Contaminant Source Type	Contaminant Source	Drinking Water Hazard	Potential Effects	Preventative Measures In Place	Associated Barrier	Comments
					assessment area			
11	ST & NT	RESIDENTIAL DEVELOPMENT	residential development	hydrocarbons, tetrachloroethylene, dichlorobenzene, methylene chloride, xylene, petroleum distillates, glycol esters, isopropanol, disinfectants, 1,1,1-trichloroethylene, caustic soda, automotive wastes (fuel/fluids noted above), pool chemicals, pet waste (microbiological contaminants), de-icers, fertilizer (nitrates)	throughout assessment area	Industry standards during construction/development. General public behaviour is unknown.	source water protection, water treatment	

4.0 Module 7 – Risk Characterization

4.1 Purpose & Methodology

The purpose of this module is to characterize the risks related to the source protection barrier as part of the Comprehensive Drinking Water Source–To–Tap Assessment Guideline (Assessment Guideline). This module characterizes risk for hazards identified in Modules 1 and 2 and provides an overall assessment of the system as a whole.

Each hazard in both the Lower North Thompson and Lower South Thompson assessment areas are assigned a likelihood (Appendix L) and consequence (Appendix M) rating, those ratings are then combined in the Qualitative Risk Analysis Matrix (Appendix N) as laid out in the Assessment Guideline, to determine the overall risk characterization.

4.1.1 Assumptions, Limitations, Sources of Uncertainty

Given the lack of on-the-ground evaluation of source water hazards in both of the Lower North Thompson and the Lower South Thompson assessment areas, there are several assumptions, limitations, and sources of uncertainty around source water protection. In addition, at this time there is no back-up water treatment system on the North Thompson River.

Assumptions of this risk assessment include:

- All industry, business, landowners, and others on the land base are following existing laws and regulation as they relate to water/drinking water and they are adhering to beneficial management practices for their respective activities/land use
- Several hazards included in Module 2 are potential (wild fire)
- Petrochemical hazards are considered to pose a greater risk as their presence could damage or even shut down the Water Street Water Treatment Plant on the South Thompson River

Limitations of this risk assessment include:

- The water treatment plant has not been developed on the North Thompson River – when the back-up plant is in place, risk will be lower for hazards
- If industry, businesses, and landowners are not compliant with laws/regulations and beneficial management practices around the handling of hazardous materials on or around source water, the risks may be higher
- The assessment areas, for the most part were not viewed on the ground, therefore alternate pathways of contamination (infiltration/leaching) may have been excluded
- In a 200-year (or more severe) flood event, the source water barrier may not effectively protect drinking water
- The hazard assessment does not include the absence/presence of aquatic invasive species; these species may not directly impact the quality of drinking water however, their impact may cause an increase in the cost of drinking water infrastructure operational maintenance
- This assessment does not include data from the Tk'emlups Indian Band Reserve located on the north side of the South Thompson River

- Source water in both assessment areas is surrounded by linear development – accidents that include a vehicle, train car entering the river(s) with any number of contaminants will likely take place
- Emergency events where deleterious substances enter the river(s) in water (water used to put out residential/industrial/vehicle fires) via unprotected storm drains will take place at some time and may not be associated as a drinking water hazard

Sources of uncertainty of this risk assessment include:

- Climate change and its effect on runoff, flooding, extreme weather events
- Increased mining, pipeline, and industrial development
- Wildfire frequency and intensity

4.2 Assessment Areas and Infrastructure Vulnerability

Surface water is more vulnerable to contamination from anthropogenic hazards and biophysical attributes/assessment area characteristics and related hazards than ground water. Both the Lower North Thompson and Lower South Thompson assessment areas are largely unprotected given their proximity to heavily used transportation corridors, industry, agriculture, and existing and ongoing urban development.

Both the Lower South and Lower North Thompson assessment areas lack active and coordinated aquatic invasive species prevention programs, specifically to address invasive zebra and quagga mussels. Shuswap Lake is a probable place for aquatic invasive species introduction and spread as there are thousands of boaters on the lake each year. Given that the South Thompson River flows out of Shuswap Lake it is likely that if the Shuswap becomes infested then the South Thompson River also become infested.

Lower South Thompson

The South Thompson assessment area is subject to many source water hazard types. There are a number of agriculture and ranching operations adjacent to the tributaries of the South Thompson River. The section of the South Thompson River that is east of the Water Street intake and treatment plant, has many industrial developments, urban and residential developments, and is a primary transportation corridor including highway and railroad. Storm water drains empty directly into the South Thompson from both in and outside the assessment area. In addition, there is heavy recreation use on and around the South Thompson River (and around the intake) during the spring, summer and fall months.

There are several measures in place to reduce the vulnerability of the Water Street intake including:

- Intake depth - lower than the 100 year low flow depths
- Intake location - in an area with continuous flow and stable banks
- Trash screens, intake port gates, fish screens
- Protection on the water and land from both animals and people

Lower North Thompson

The North Thompson assessment area is subject to many source water hazard types. Adjacent to the tributaries there are forestry, agriculture, and ranching operations; adjacent to the North Thompson River there are railroads, highways, residential/urban development, and industrial operations as described in Module 2. Past wildfires and ongoing agriculture and forestry activities are likely sources of increased overland flow and related sedimentation in the future.

At this time there is no City of Kamloops water treatment plant on the North Thompson River; there are Thompson Nicola Regional District water intakes upstream. Work on the proposed Yates Road emergency back-up water treatment plant is not yet underway. The treatment proposal includes the prevention of intake vulnerability with the following considerations:

- Intake location and depth
- Intake protection on the water from watercraft
- Intake protection on land from animals and human interference

4.3 Evaluation Source Water Protection Barriers & Supporting Mechanisms

This is an evaluation of source protection with regard to the contaminants/hazards identified in Modules 1 and 2; an evaluation of the other five Assessment Guideline barriers are not included. A brief description of the other barriers from the Assessment Team is as follows:

- **Treatment** – Water is treated using a state of the art membrane filtration process in the Kamloops Centre for Water Quality, followed by the addition of chlorine as a disinfectant.
- **Water System/Distribution System Maintenance** – Maintenance activities include freedom from cross-connections which could allow the introduction of foreign substances to the water supply. Maintenance includes pipe cleaning and carrying residual disinfectant (chlorine) through the system to ensure the water remains safe to the system's extremities.
- **Water Quality Monitoring** – Treated water is sampled and analyzed for conditions as per the BC Ministry of Environment guidelines.
- **Operator Training** – All water treatment operators at the Kamloops Centre for Water Quality receive ongoing training in compliance the Environmental Operators Certification Program (EOCP) standards.
- **Emergency Response Training** – Managers and supervisors are required to take part in the Justice Institute of BC Emergency Management Certificate Program. Emergency management is the universal term for the systems and processes for mitigating, preparing for, responding to, and recovering from emergencies and disasters.

Supporting mechanisms for safe drinking water include, supply system management, affordability and, effective governance. These mechanisms are in place, effective, and captured in the Sustainable Kamloops Plan.

The security of source water in the City of Kamloops is moderate given the following:

- There is no emergency back-up water system
- The purveyor (the City of Kamloops) does not control the area surrounding the source water
- Several known contaminant sources in the Lower South Thompson assessment area are high risk
- Potential contaminant sources (travelling by railroad or highway) in the Lower South Thompson assessment area likely present on an ongoing basis
- There are no source water protection plans in place upstream in the South Thompson or North Thompson Rivers
- Source water upstream from the Kamloops water intake is under Thompson-Nicola Regional District jurisdiction
- There are many jurisdictions within both the Lower South and Lower North South Thompson assessment areas, Provincial Crown Land, Thompson-Nicola Regional District, and private land including residential, industry, and agriculture. Multiple jurisdictions in any one area often add complexity to land management due to differing mandates and a lack of communication and coordination of efforts.

Lower South Thompson

Source water is largely unprotected in the Lower South Thompson assessment area. The strength of the barrier is based on the following attributes:

- The design and protective measures in place at the water intake (as listed above)
- Regular inspection and maintenance of the water intake
- Communication between safety authorities (City of Kamloops, Kamloops Fire Rescue/Kamloops Royal Canadian Mounted Police/Ministry of Environment) when a contaminant enters the river

The measures that are in place are adequate for providing safe drinking water. However, if there were a catastrophic flooding event, a large petrochemical spill or major damage to the intake or water plant, there is no emergency back-up treatment plant. “The Kamloops water treatment plant has enough water stored to last for up to three days with water restrictions in place, at the current rate of use, and with the existing population.” (Mike Firlotte, City of Kamloops, personal communication, 2014). This solution is limiting given the time required to mitigate damage to the water plant may exceed three days. The other factor is communication between emergency staff across all agencies and jurisdictions; it is unclear as to whether the private sector and the general public knows how, where, or if they should report a possible drinking water contaminant entering the water source.

Lower North Thompson

Source water is largely unprotected in the North Thompson assessment area. Given that at this time there is no water intake system on the North Thompson River, the barrier can only be assessed theoretically by looking at the proposal for the emergency water intake system at the Yates Road site. Given the nature of the source water, the proposed protection at the Yates Road intake will include:

- The proposed design and protective measures listed above
- Communication between safety authorities (City of Kamloops, Kamloops Fire Rescue/Kamloops Royal Canadian Mounted Police/Ministry of Environment) when a known contaminant enters the river

4.4 Characterization of Potential Risks

This section describes the risks present in the Lower South Thompson and Lower North Thompson assessment areas respectively and discusses the rationale that led to the assignment of risk. The approach for the characterization of potential risks to source water protection in both of the assessment areas is qualitative. See Appendix O for a definition of terms.

4.4.1 Rationale

The subjective assignment of likelihood included the consideration of the following variables related to hazards:

- Type of water treatment plant
- Type of hazard
- Distance from river
- Distance from intake
- Safety planning and safety measures in place
- Mandatory safety training for employees
- Existing regulations

Note - The storm-water system flows unchecked into the South and North Thompson Rivers; it is impossible to determine whether residents or businesses are knowingly/unknowingly dumping contaminants into it. In this module, the likelihood level is based on the variables above however, dumping contaminants into source water is an additional variable being considered.

In addition to the variables listed above, there is another set of variables related to the source water itself (the North and South Thompson Rivers) that must be considered. These variables have the ability to change the consequence of having a hazard enter the source water (personal communication, Rick Wagner, Ministry of Environment, 2014). These variables include:

- Temperature of the river
- Volume of the river
- Velocity of the water
- Suspended sediment
- Presence of ice
- Time of year (snow/ice melt, precipitation events)

There are several hazards that extend across both of the Lower South and Lower North Thompson assessment areas. In Module 2, hazards common to both assessment areas were recorded once; however, the assignment of likelihood and consequence is dependent upon the specific intake thus the common hazards were recorded twice, once for each of the assessment areas. These hazards include the following:

- Highways
- Railroads
- Forestry
- Agriculture
- Recreation
- Development
- Residential areas/storm water

Lower South Thompson

The likelihood and consequence values are increased in the Lower South Thompson assessment area due to the lack of an emergency back-up water treatment plant. When the proposed water plant is in place at the Yates Road site, the assignment of likelihood and consequence should be reviewed and updated accordingly. See Table 4.1 for the complete list of risk characterization for each of the hazards identified in Modules 1 and 2.

Table 4.1: Lower South Thompson Risk Characterization

Assessment Area	Hazard Number	Contaminant Source	Likelihood Level (A-E)	Consequence Level (1-5)	Risk Level
ST	1	wood work/store fixtures	C	4	VERY HIGH
ST	2	gardening supplies	C	2	MODERATE
ST	3	multi recycling facility	C	3	HIGH
ST	4	retreading medium truck tires	C	3	HIGH
ST	5	heavy duty auto mechanic shop	C	3	HIGH
ST	6	retreading mining truck tires	C	3	HIGH

Assessment Area	Hazard Number	Contaminant Source	Likelihood Level (A-E)	Consequence Level (1-5)	Risk Level
ST	7	heavy duty equipment dealership (sell, fix, repair)	C	4	VERY HIGH
ST	8	manufacturing of hydraulic hoses	D	1	LOW
ST	9	retail outlet motorbike sales and service	D	4	HIGH
ST	10	industrial contractor for pulp mill upgrades and heavy construction	D	3	HIGH
ST	11	manufacture highway petroleum tanks	E	2	LOW
ST	12	new and used farm and industrial equipment sales and service	D	2	LOW
ST	13	heavy duty equipment sales, mostly parts	D	3	MODERATE
ST	14	testing labs for mining/minerals industry	D	2	LOW
ST	15	heavy duty diesel engine sales & service	D	4	HIGH
ST	16	bulk propane sales	D	2	LOW
ST	17	gasoline station & heavy duty truck service	D	4	HIGH
ST	18	used battery recycling, warehouse and battery wholesale	D	3	MODERATE
ST	19	distribution of bulk cement powder to other distribution plants	D	1	LOW
ST	20	tire retread plant,, shipping & receiving, administration bldg.	C	1	LOW
ST	21	small energy company, research & development - testing facility of wood waste to syngas	C	3	HIGH
ST	22	veneer & panel (plywood) manufacturing	D	5	VERY HIGH
ST	23	manufacturing of steel grinding balls	C	4	VERY HIGH
ST	24	steel fabrication, repair of mining equipment, machine and welding shop	C	3	MODERATE
ST	25	bulk water hauling service	E	2	LOW
ST	26	wholesaler of meats	E	1	LOW
ST	27	fuel sales - larger truck stop	C	5	VERY HIGH
ST	28	log debarking & chipping	D	2	LOW
ST	29	trucking transportation services	C	2	MODERATE
ST	30	garden centre	E	2	LOW
ST	31	Barnhartvale landfill & recycling	D	1	LOW
ST	32	Gravel pit operation	D	2	LOW
ST	33	machine shop & repairs, manufactures pump sleeves, general welding/fabrication, mining truck repairs	C	2	MODERATE

Assessment Area	Hazard Number	Contaminant Source	Likelihood Level (A-E)	Consequence Level (1-5)	Risk Level
ST	34	welding & fabricating - manufactures components for HD equipment	D	2	LOW
ST	35	industrial truck repair shop, concrete truck pump repairs	D	4	HIGH
ST	36	HD truck body shop & repair	D	2	LOW
ST	37	wholesale meat sales- small quantity	E	1	LOW
ST	38	self-serve gas bar, carwash, convenience store	C	5	VERY HIGH
ST	39	new & used vehicle sales and service	D	4	HIGH
ST	40	new & used vehicle sales and service	D	4	HIGH
ST	41	new & used vehicle sales and service	D	4	HIGH
ST	42	RV Sales and service	D	2	LOW
ST	43	RV Sales and service	C	2	LOW
ST	44	new & used vehicle sales and service	C	3	HIGH
ST	45	agriculture supply sales and service, garden centre	D	3	MODERATE
ST	46	wholesale petroleum distribution, card lock fuel sales	C	5	VERY HIGH
ST	47	car wash, windshield installation, U-Haul rental	D	2	LOW
ST	48	RV repairs, sale of RV maintenance supplies	C	2	MODERATE
ST	49	machine shop - rewind electric motors, pump repairs	C	3	HIGH
ST	50	auto repair and maintenance	C	3	HIGH
ST	51	boat sales and service	C	2	MODERATE
ST	52	fast lube & oil change	D	4	HIGH
ST	53	light industrial equipment repairs and service, diesel generators sales and service	C	2	MODERATE
ST	54	machine shop, welding and auto repairs	C	2	MODERATE
ST	55	lawn care and maintenance	D	2	LOW
ST	56	auto repair and maintenance	D	4	HIGH
ST	57	welding blacksmith services, springs	C	2	MODERATE
ST	58	auto body repair and restoration	C	2	MODERATE
ST	59	auto body repair and restoration	D	2	LOW
ST	60	manufacturing of cement products	C	4	VERY HIGH
ST	61	manufacturing of railway maintenance equipment	D	3	MODERATE
ST	62	self-serve gas bar, convenience store	D	4	HIGH

Assessment Area	Hazard Number	Contaminant Source	Likelihood Level (A-E)	Consequence Level (1-5)	Risk Level
ST	63	self-serve gas bar, convenience store	C	4	VERY HIGH
ST	64	self-serve gas bar, convenience store	D	4	HIGH
ST	65	auto repair and maintenance	D	4	HIGH
ST	66	auto repair and maintenance, transmissions	C	3	HIGH
ST	67	auto repair and maintenance	C	3	HIGH
ST	68	auto repair and maintenance	D	4	HIGH
ST	69	auto repair and maintenance	D	4	HIGH
ST	70	auto repair and maintenance	D	4	HIGH
ST	71	auto repair and maintenance	D	4	HIGH
ST	72	auto body repair and restoration	C	3	HIGH
ST	73	motorcycle repair, service and misc. equipment sales	D	2	LOW
ST	74	sanitary landfill - private	D	2	LOW
ST	75	hydropower transformer site	D	4	HIGH
ST	76	truck sales, parts, repairs, rebuilding and body work	C	2	MODERATE
ST	77	sewage lines	C	2	MODERATE
ST	78	railway lines/yards	B	5	VERY HIGH
ST	79	highways	B	5	VERY HIGH
ST	80	aquatic recreation	B	2	HIGH
ST	81	air traffic/incident	E	4	HIGH
ST	82	residential development/storm drains	B	4	VERY HIGH
ST	83	agriculture and range operations	B	1	MODERATE
ST	84	forestry/silviculture operations	C	1	LOW
ST	85	transmission/communication lines	D	2	LOW
ST	86	terrestrial recreation	C	1	LOW
ST	87	air emissions/pollution	E	1	LOW
ST	88	wildfire	B	3	HIGH
ST	89	single water source	C	5	VERY HIGH

Lower North Thompson

The assignment of likelihood, consequence, and risk for the North Thompson River are all low as there is no water treatment plant. When an emergency back-up treatment plant is in place at the proposed Yates Road site, the likelihood, consequence, and risk values will likely remain low as it will be required only for emergency and or short term use. See Table 4.2 for the complete list of risk characterization for each of the hazards identified in Modules 1 and 2.

Table 4.2: Lower North Thompson Risk Characterization

Assessment Area	Hazard Number	Contaminant Source	Likelihood Level (A-E)	Consequence Level (1-5)	Risk Level
NT	1	gravel pit operation	E	1	LOW
NT	2	self-serve gas bar, carwash	E	1	LOW
NT	3	glues, stains, paints for cabinetry	E	1	LOW
NT	4	paint/varnish/stain, ice melt, road salt, concrete mix, fertilizers	E	1	LOW
NT	5	service shop	E	1	LOW
NT	6	self-serve gas bar	E	1	LOW
NT	7	self-serve gas bar	E	1	LOW
NT	8	self-serve gas bar	E	1	LOW
NT	9	veneer and plywood plant	E	1	LOW
NT	10	golf course & restaurant/banquet hall	E	1	LOW
NT	11	trans mountain pipeline	E	1	LOW
NT	12	sewage lines	E	1	LOW
NT	13	railway lines/yards	E	1	LOW
NT	14	highways	E	1	LOW
NT	15	aquatic recreation	E	1	LOW
NT	16	air traffic/incident	E	1	LOW
NT	17	residential development/storm drains	E	1	LOW
NT	18	agriculture and range operations	E	1	LOW
NT	19	forestry/silviculture operations	E	1	LOW
NT	20	transmission/communication lines	E	1	LOW

Assessment Area	Hazard Number	Contaminant Source	Likelihood Level (A-E)	Consequence Level (1-5)	Risk Level
NT	21	terrestrial recreation	E	1	LOW
NT	22	air emissions/pollution	E	1	LOW
NT	23	wild fire	C	1	LOW

4.5 Strengths, Weaknesses, Opportunities and Threats (SWOT) Analysis

The SWOT analysis will identify the variables that have the potential to threaten drinking water in the City of Kamloops. System strengths and weaknesses are identified as well as opportunities for improvement and ways to reduce threats.

4.5.1 Strengths

The strengths are the assets of the existing water system. Recommendations to improve strength areas will be addressed in Module 8.

Lower South Thompson

Strengths include:

- High volume of source water
- Relatively high quality source water
- Well-built/protected intake

Lower North Thompson

Strengths include:

- High volume of source water
- Relatively high quality source water
- Proposed site selection
- Proposed intake design

4.5.2 Weaknesses

Weaknesses are those areas that are deficient in the existing water system. Recommendations to improve system weaknesses will be addressed in Module 8.

Lower South Thompson

Weaknesses include:

- Unprotected source water
- Lack of source water protection/plan up stream
- Untreated storm water system
- High volume of industry, residential areas, highways/railroads present in assessment area
- Lack of back-up system
- Lack of education by business/industry/residents that could have a negative effect on source water quality/contamination
- Lack of an aquatic invasive species prevention program

Lower North Thompson

Weaknesses include:

- Lack of source water protection/plan upstream
- Unprotected source water
- Untreated storm water system
- High volume of industry, residential areas, highways/railroads present in assessment area
- Lack of education by business/industry/residents that could have a negative effect on source water quality/contamination
- Lack of an aquatic invasive species prevention program

4.5.3 Opportunities

These are areas where there are opportunities for improvement. Opportunities will be included in Module 8.

Lower South Thompson

Opportunities include:

- There is a plan and proposal in place for the development of a back-up system
- Residents/businesses/industry could be educated on source water protection and communication
- Local emergency service agencies could meet to establish improved communication and improved coordination of emergency response protocol regarding source water protection

Lower North Thompson

Opportunities include:

- Residents/businesses/industry can be educated on source water protection and communication
- Local emergency service agencies could meet to establish improved communication and improved coordination of emergency response protocol regarding source water protection

4.5.4 Threats

Threats are major hazards to the source water supply. Recommendations on how to address threats are included in Module 8.

Lower South Thompson

Threats include:

- Potential contaminant spill from a rail car or vehicle on the highway
- Potential contaminant spill/introduction via storm-water system (e.g. fire water)
- Potential lack of timely reporting of a contaminant spill
- Inability to switch to a back-up system in case of a long term (greater than the Water Street Water Plant water storage has capacity for)

Lower North Thompson

There are no major threats at this time given there is no water treatment plant in place however; the first three threats listed above will be relevant in the Lower North Thompson assessment area as well as the Lower South Thompson based on the nature of the source water.

4.6 Statement on Behalf of the Assessment Team

This report illustrates our achievements and continual commitment to source water protection. Over 20 Billion litres of water is produced and distributed to our customers every year with every drop exceeding Canadian Drinking Water Guidelines. I am strongly confident that the City of Kamloops Water Treatment and Distribution systems will continue to be a leader in the industry for decades to come.

- Mike Firlotte, City of Kamloops

5.0 Module 8 – Recommended Actions to Improve Drinking Water Protection

5.1 Purpose and Methodology

The purpose of Module 8 is to recommend management options and specific actions for the risks identified in the Lower North Thompson and Lower South Thompson assessment areas in Module 7. The options included are only those related to source protection and include prevention, reduction or mitigation.

The hazards identified in the Lower South and Lower North Thompson assessment areas and outlined in Module 2, were sorted based on the risk value (low to very high) and divided into the following tables:

- Table 5.1: Lower South Thompson Risk Management Actions
- Table 5.2: Lower North Thompson Risk Management Actions

Each of the risks were generally prioritized based on the following:

- Overall benefit
- Cost of implementation
- Timing of implementation for projects already underway (back-up water treatment plant)

Recommendations and associated actions for each of the prioritized risks were then made. In some cases, single actions address several hazards. Actions for each of the risks identified in Module 2 are listed in Tables 5.1 and 5.2.

5.2 Risk Management Recommendations & Actions

There are several risk management options for source water in the South and North Thompson assessment areas. Each of the options need to be prioritized and tailored (specific actions developed) to address each of the individual risks.

5.2.1 Management Options

Options for risk management regarding source water protection include but are not limited to the following:

- Improve or develop water intake infrastructure
- Increase drinking water storage capability
- Develop, update, and integrate emergency response plans to include the mitigation of source water risks
- Protect or limit access to source water
- Increase security measures to protect water intake and other infrastructure
- Inventory potential contaminants (new and existing) in the source water assessment areas
- Develop a community education program to address source water
- Protect sensitive areas within the assessment areas (riparian areas)
- Develop an interagency communication plan to address source water issues
- Develop a business education/communication program to address source water, contamination prevention and spill reporting

5.2.2 Recommendations to Manage Risk

Across the Lower South and Lower North Thompson assessment areas the following broad recommendations are required to help lower the health risk for drinking water:

- Complete the North Thompson River back-up water treatment plant – this will greatly reduce the risk values for all other hazards that have been recorded
- Work with all orders of government to improve interagency communication and coordination around source water protection and planning
- Develop an education program for industry, business, and residents on source water care and protection and beneficial management practices

5.2.3 Prioritization of Management Options

Risk level is a primary factor used to prioritize the risk management options; however, there are several factors that are also considered including:

- Identify what/where the most critical problems for the water supply system are.
- Direct resources to actions with the highest potential for improvement.
- Protect unimpaired areas from degradation.
- Identify areas where there is a need to coordinate multiple remedial/protective priorities.
- Follow the SMART principle to develop risk management actions that are: specific, measurable, achievable, realistic and time-bound. ~ *adapted from the Canadian Environmental Quality Guidelines, 2004*

The highest management priority is the construction of the back-up water treatment plant at the Yates Street site on the North Thompson River; when the plant is in place it will greatly reduce the risk values for other risks identified in Tables 5.1 and 5.2. Given that construction of the new plant will not begin until 2016, other actions that will be able to be implemented prior to 2016 are higher on the action list.

5.3 Risk Management Actions

The risk management actions developed for source water protection in the Lower South Thompson and Lower North Thompson assessment areas are listed below. The actions are in order of priority and have an assigned starting date. **As noted above, the highest priority is the development of an emergency back-up treatment plant; the water treatment plant is at the bottom of the list as construction will not begin until 2016.*

1. Communicate with all businesses identified as being “very high” or “high” risk and work with them on beneficial practices, safety planning and procedures, spill reporting, and employee training/testing (based on measures/training in place) respective of business type, to help prevent source water contamination. (2015 - 2016)
2. Identify funding partners (industry/business/provincial, federal and first nations governments) to aid in local source water protection, riparian area protection. (2015 - 2016)
3. Form an interagency committee including Kamloops Fire and Rescue, Ministry of Environment, Ministry of Transportation and Infrastructure, Transport Canada, and Fisheries and Oceans Canada. Develop a terms of reference for the committee and then develop a communication plan around source water protection. (2015)
4. Create a contaminant inventory in the South and North Thompson assessment areas; update biannually using business licenses and construction permits. (2015)
5. Work with the Ministry of Environment and the Ministry of Forests, Lands and Natural Resource Operations to share information regarding monitoring and communicating any changes to ongoing natural hazard risks (landslides, insect infestation, wildfire) in the assessment areas where on the ground monitoring by City staff may be limited. (2015)
6. Develop and deliver education programs tailored for business, industry, and residents regarding source water protection and reporting procedure in partnership with Kamloops Fire and Rescue, Ministry of Environment, Ministry of Transportation and Infrastructure, Transport Canada, and Fisheries and Oceans Canada. Develop messaging and signage/symbols near storm drains to raise awareness of source water protection. (2015 - 2016)
7. Protect riparian areas and conduct erosion control methods in areas where riparian areas are degraded and sloughing. (2015)
8. Begin the process of identifying and prioritizing future upgrades to the storm water system in the City of Kamloops to protect source water (the addition of oil/water separators, settling ponds). (2015)
9. Move forward with the proposed back-up water treatment plant at the Yates Street site on the North Thompson River. (construction scheduled to begin in 2016)

5.3.1 Risk Management Actions & Assignments

Below are lists of all of the identified hazards/risks identified in Modules 1, 2, and 7. Each of the risks has an assigned action number corresponding to the actions and associated time frame (year) for implementation above in section 5.3. See Table 5.1 and 5.2 for the assigned risk management actions for the Lower South Thompson assessment area and the Lower North Thompson assessment area respectively.

Table 5.1: Lower South Thompson – Risk Management Actions

Hazard Number	Contaminant Source	Risk Level	Action(S)
1	wood work/fixtures	VERY HIGH	1, 2, 4, 6
2	gardening supplies	MODERATE	6
3	multi recycling facility	HIGH	1, 2, 4, 6
4	retreading medium truck tires	HIGH	1, 2, 4, 6
5	heavy duty auto mechanic shop	HIGH	1, 2, 4, 6
6	retreading mining truck tires	HIGH	1, 2, 4, 6
7	heavy duty equipment dealership (sell, fix, repair)	VERY HIGH	1, 2, 4, 6
8	manufacturing of hydraulic hoses	LOW	6
9	retail outlet motor bike sales and service	HIGH	1, 2, 4, 6
10	industrial contractor for pulp mill upgrades and heavy construction	HIGH	1, 2, 4, 6
11	manufacture of highway petroleum tanks	LOW	6
12	new and used farm and industrial equipment sales and service	LOW	6
13	heavy duty equipment sales, mostly parts	MODERATE	6
14	testing labs for mining/minerals industry	LOW	6
15	heavy duty diesel engine sales & service	HIGH	1, 2, 4, 6
16	bulk propane sales	LOW	6
17	gasoline station & heavy duty truck service	HIGH	1, 2, 4, 6
18	used battery recycling, warehouse, and battery wholesale	MODERATE	4, 6
19	distribution of bulk cement powder to other distribution plants	LOW	4, 6
20	tire retread plant, shipping & receiving, administration	LOW	4, 6

Hazard Number	Contaminant Source	Risk Level	Action(S)
21	small energy company, research & development - wood waste testing facility	HIGH	1, 2, 4, 6
22	veneer & panel (plywood) manufacturing	VERY HIGH	1, 2, 4, 6
23	manufacturing of steel grinding balls	VERY HIGH	1, 2, 4, 6
24	steel fabrication, repair of mining equipment, machine and welding shop	MODERATE	4, 6
25	bulk water hauling service	LOW	4, 6
26	wholesaler of meats	LOW	4, 6
27	fuel sales - larger truck stop	VERY HIGH	1, 2, 4, 6
28	log debarking & chipping	LOW	4, 6
29	trucking transportation services	MODERATE	4, 6
30	garden centre	LOW	4, 6
31	Barnhartvale landfill & recycling	LOW	4, 6
32	gravel pit operation	LOW	4, 6
33	machine shop & repairs, manufactures pump sleeves, general welding/fabrication, mining truck repairs	MODERATE	4, 6
34	welding & fabricating - manufactures components for HD equipment	LOW	4, 6
35	industrial truck repair shop, concrete truck pump repairs	HIGH	1, 2, 4, 6
36	HD truck body shop & repair	LOW	4, 6
37	wholesale meat sales- small quantity	LOW	4, 6
38	self-serve gas bar, carwash, convenience store	VERY HIGH	1, 2, 4, 6
39	new & used vehicle sales and service	HIGH	1, 2, 4, 6
40	new & used vehicle sales and service	HIGH	1, 2, 4, 6
41	new & used vehicle sales and service	HIGH	1, 2, 4, 6
42	RV Sales and service	LOW	4, 6
43	RV Sales and service	LOW	4, 6
44	new & used vehicle sales and service	HIGH	1, 2, 4, 6
45	agriculture supply sales and service, garden centre	MODERATE	4, 6

Hazard Number	Contaminant Source	Risk Level	Action(S)
46	wholesale petroleum distribution, card lock fuel sales	VERY HIGH	1, 2, 4, 6
47	car wash, windshield installation, vehicle rental	LOW	4, 6
48	RV repairs, sale of RV maintenance supplies	MODERATE	4, 6
49	machine shop - rewind electric motors, pump repairs	HIGH	1, 2, 4, 6
50	auto repair and maintenance	HIGH	1, 2, 4, 6
51	boat sales and service	MODERATE	4, 6
52	fast lube & oil change	HIGH	1, 2, 4, 6
53	light industrial equipment repairs and service, diesel generators sales and service	MODERATE	4, 6
54	machine shop, welding, and auto repairs	MODERATE	4, 6
55	lawn care and maintenance	LOW	4, 6
56	auto repair and maintenance	HIGH	1, 2, 4, 6
57	welding blacksmith services	MODERATE	4, 6
58	auto body repair and restoration	MODERATE	4, 6
59	auto body repair and restoration	LOW	4, 6
60	cement products manufacturing	VERY HIGH	1, 2, 4, 6
61	manufacturing railway maintenance equipment	MODERATE	4, 6
62	self-serve gas bar, convenience store	HIGH	1, 2, 4, 6
63	self-serve gas bar, convenience store	VERY HIGH	1, 2, 4, 6
64	self-serve gas bar, convenience store	HIGH	1, 2, 4, 6
65	auto repair and maintenance	HIGH	1, 2, 4, 6
66	auto repair and maintenance	HIGH	1, 2, 4, 6
67	auto repair and maintenance	HIGH	1, 2, 4, 6
68	auto repair and maintenance	HIGH	1, 2, 4, 6
69	auto repair and maintenance	HIGH	1, 2, 4, 6
70	auto repair and maintenance	HIGH	1, 2, 4, 6
71	auto repair and maintenance	HIGH	1, 2, 4, 6

Hazard Number	Contaminant Source	Risk Level	Action(S)
72	auto body repair and restoration	HIGH	1, 2, 4, 6
73	motorcycle repair, service, and equipment sales	LOW	4, 6
74	sanitary landfill - private	LOW	4, 6
75	hydropower transformer site	HIGH	1, 2, 4, 6
76	truck sales, parts, repairs, rebuilding and body work	MODERATE	4, 6
77	sewage lines	MODERATE	4, 6
78	railway lines/yards	VERY HIGH	1, 2, 4, 6
79	highways	VERY HIGH	1, 2, 3, 4, 6
80	aquatic recreation	HIGH	6
81	air traffic/incident	HIGH	1, 2, 3, 4, 6
82	residential development/storm drains	VERY HIGH	1, 4, 6, 8
83	agriculture and range operations	MODERATE	2, 4, 5, 6, 7
84	forestry/silviculture operations	LOW	2, 4, 5, 6
85	transmission/communication lines	LOW	2, 6
86	terrestrial recreation	LOW	6
87	air emissions/pollution	LOW	1, 4, 6
88	wildfire	HIGH	5
89	single water source	VERY HIGH	9

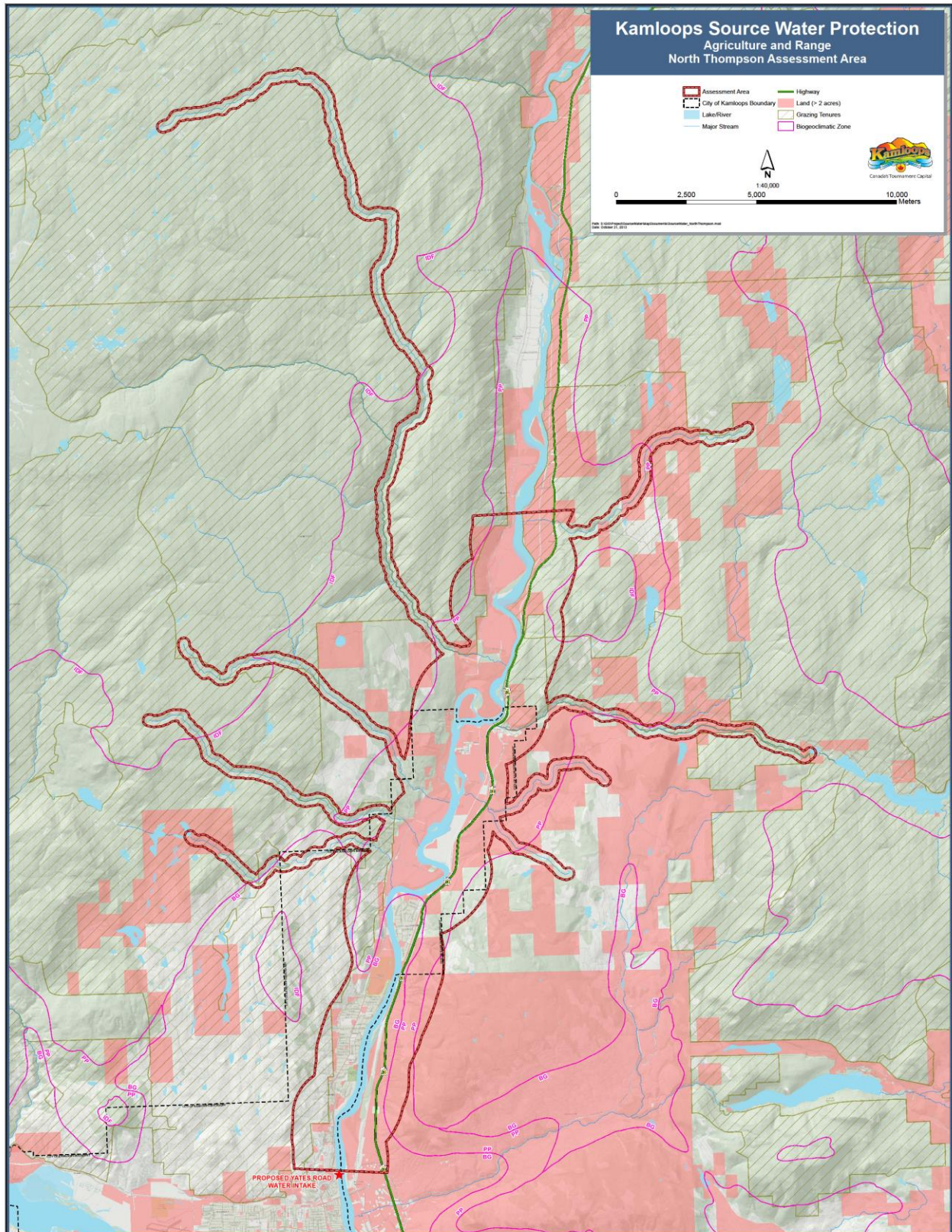
Table 5.2: Lower North Thompson – Risk Management Actions

Hazard Number	Contaminant Source	Risk Level	Action(S)
1	gravel pit operation	LOW	6
2	self-serve gas bar, carwash	LOW	6
3	glues, stains, paints for cabinetry	LOW	4, 6
4	paint/varnish/stain, ice melt, road salt, concrete mix, fertilizers	LOW	4, 6
5	service shop	LOW	4, 6
6	self-serve gas bar	LOW	4, 6
7	self-serve gas bar	LOW	4, 6

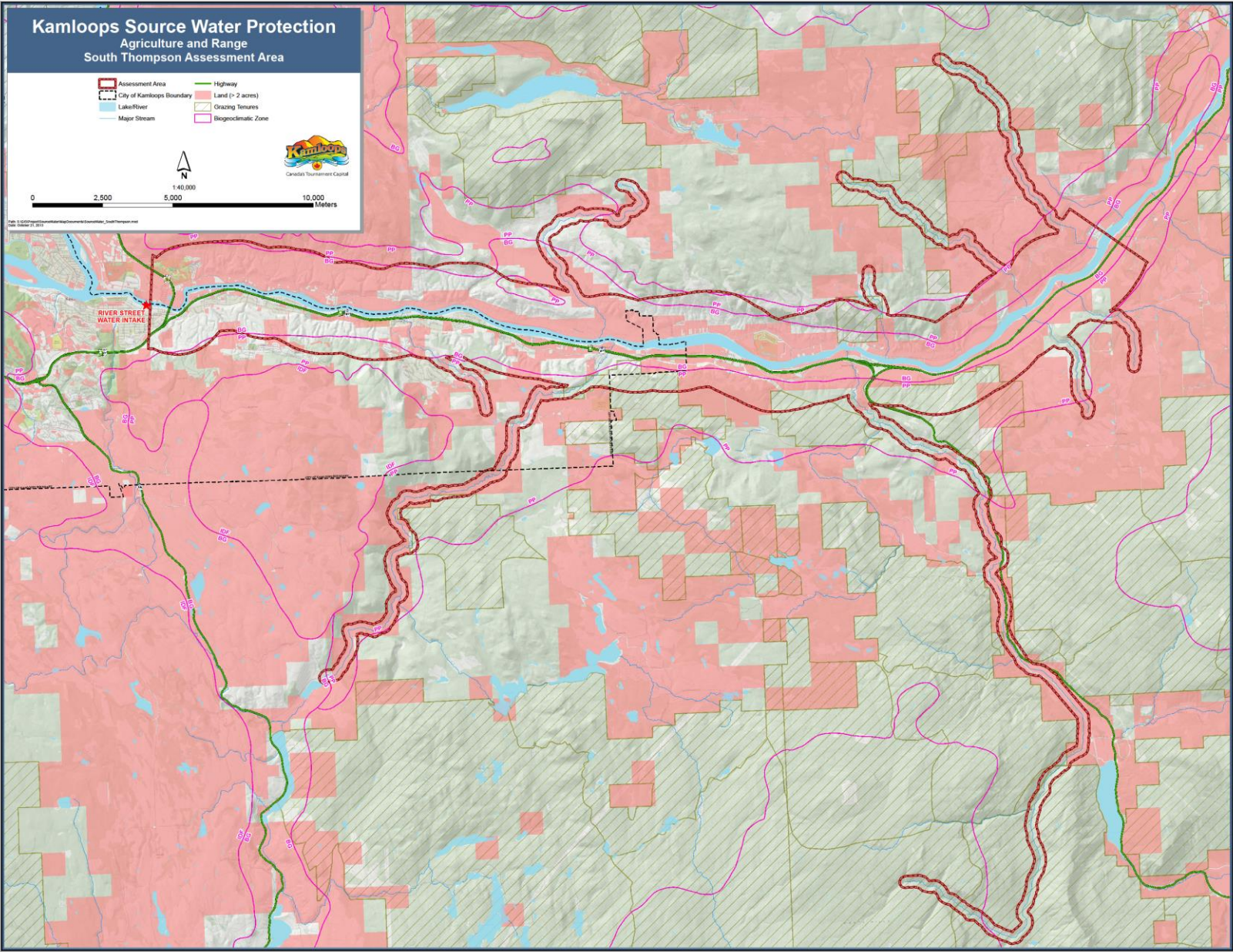
Hazard Number	Contaminant Source	Risk Level	Action(S)
8	self-serve gas bar	LOW	4, 6
9	veneer and plywood plant	LOW	4, 6
10	golf course & restaurant/banquet hall	LOW	6
11	Trans Mountain pipeline	LOW	1, 2, 4, 6
12	sewage lines	LOW	4, 6
13	railway lines/yards	LOW	1, 2, 4, 6
14	highways	LOW	1, 2, 3, 4, 6
15	aquatic recreation	LOW	6
16	air traffic/incident	LOW	1, 2, 3, 4, 6
17	residential development/storm drains	LOW	1, 4, 6, 8
18	agriculture and range operations	LOW	2, 4, 5, 6, 7
19	forestry/silviculture operations	LOW	8
20	transmission/communication lines	LOW	2, 6
21	terrestrial recreation	LOW	6
22	air emissions/pollution	LOW	6
23	wild fire	LOW	5

6.0 Appendices

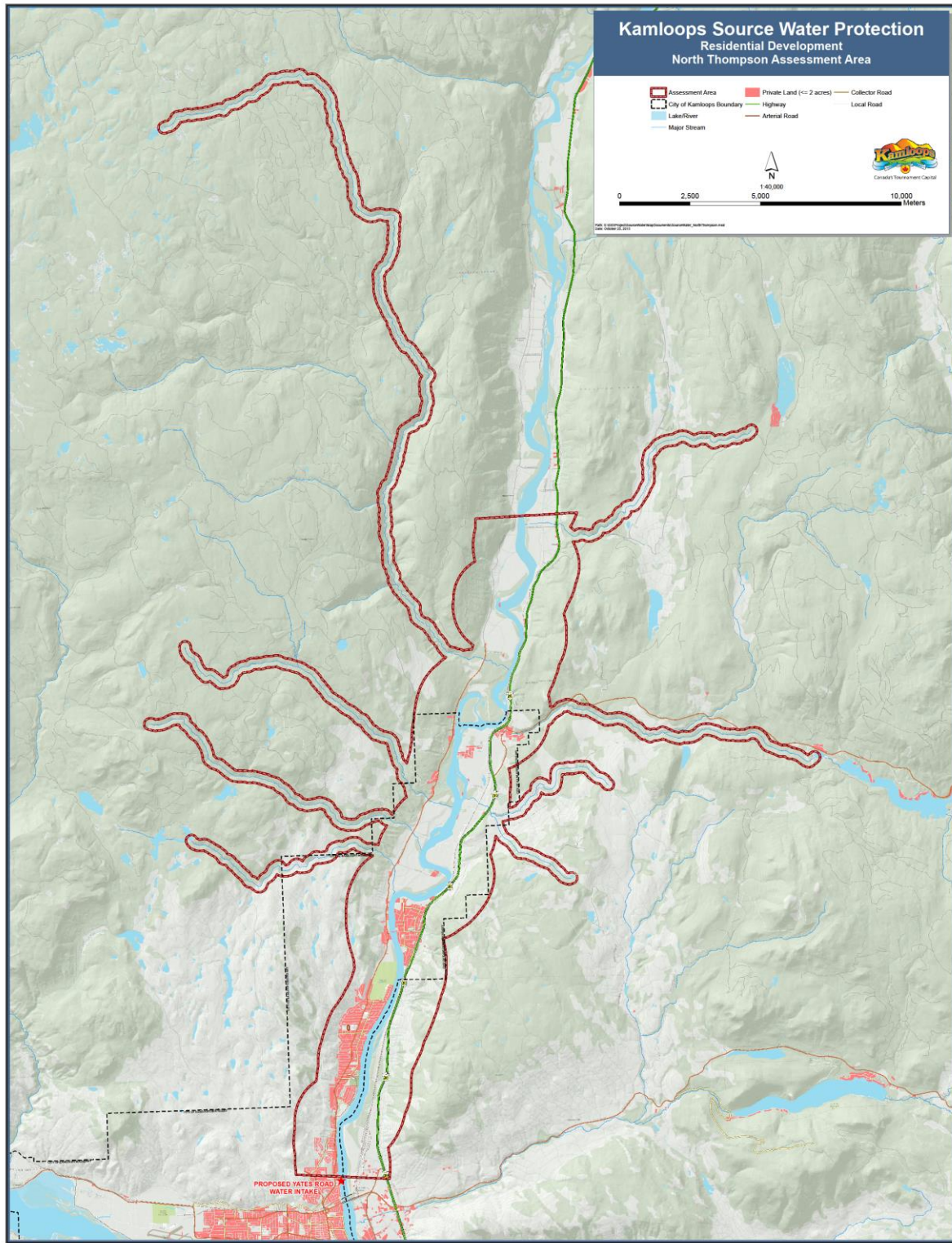
Appendix A: Lower North Thompson Assessment Area Agricultural Map



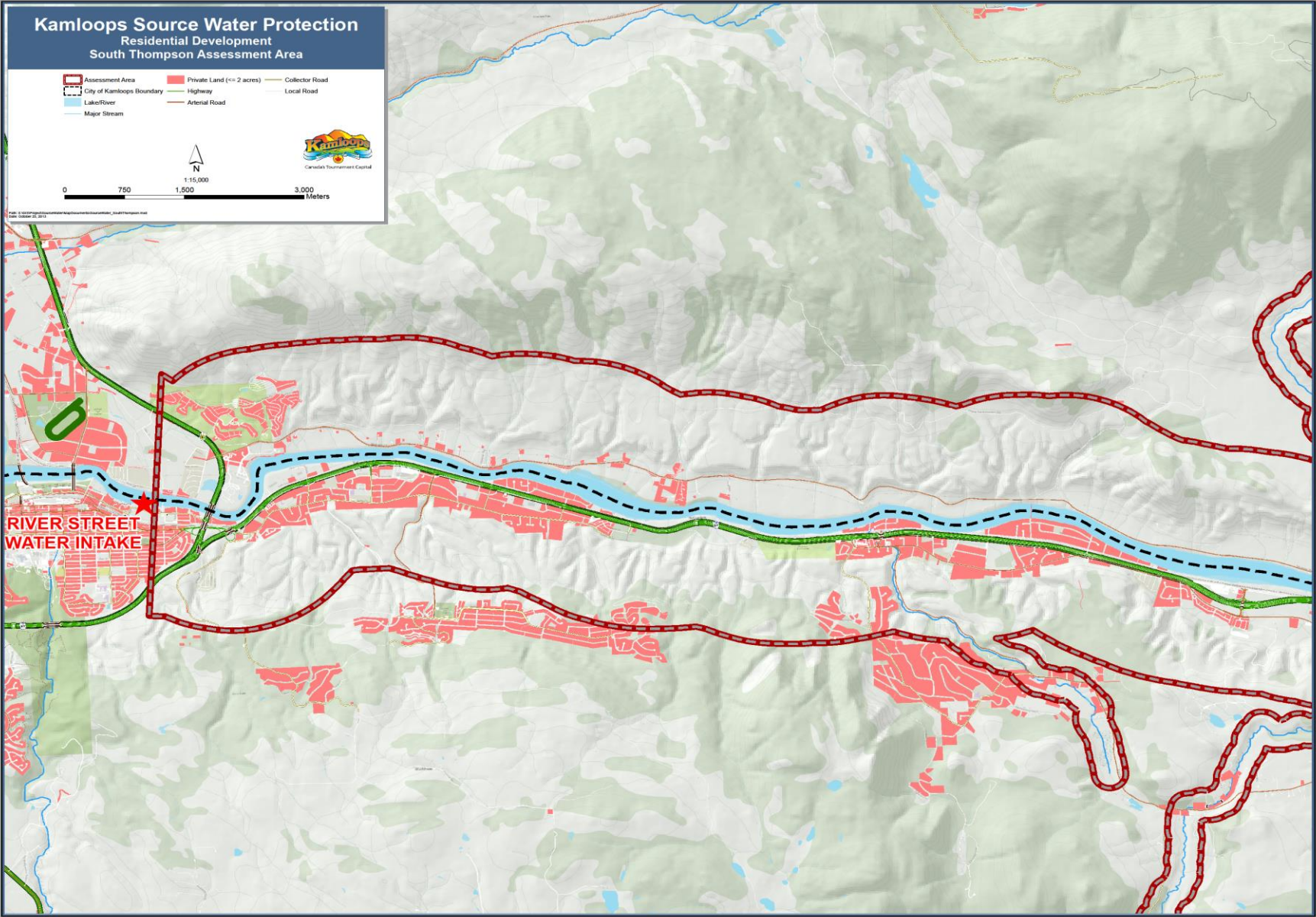
Appendix B: Lower South Thompson Assessment Area Agricultural Map



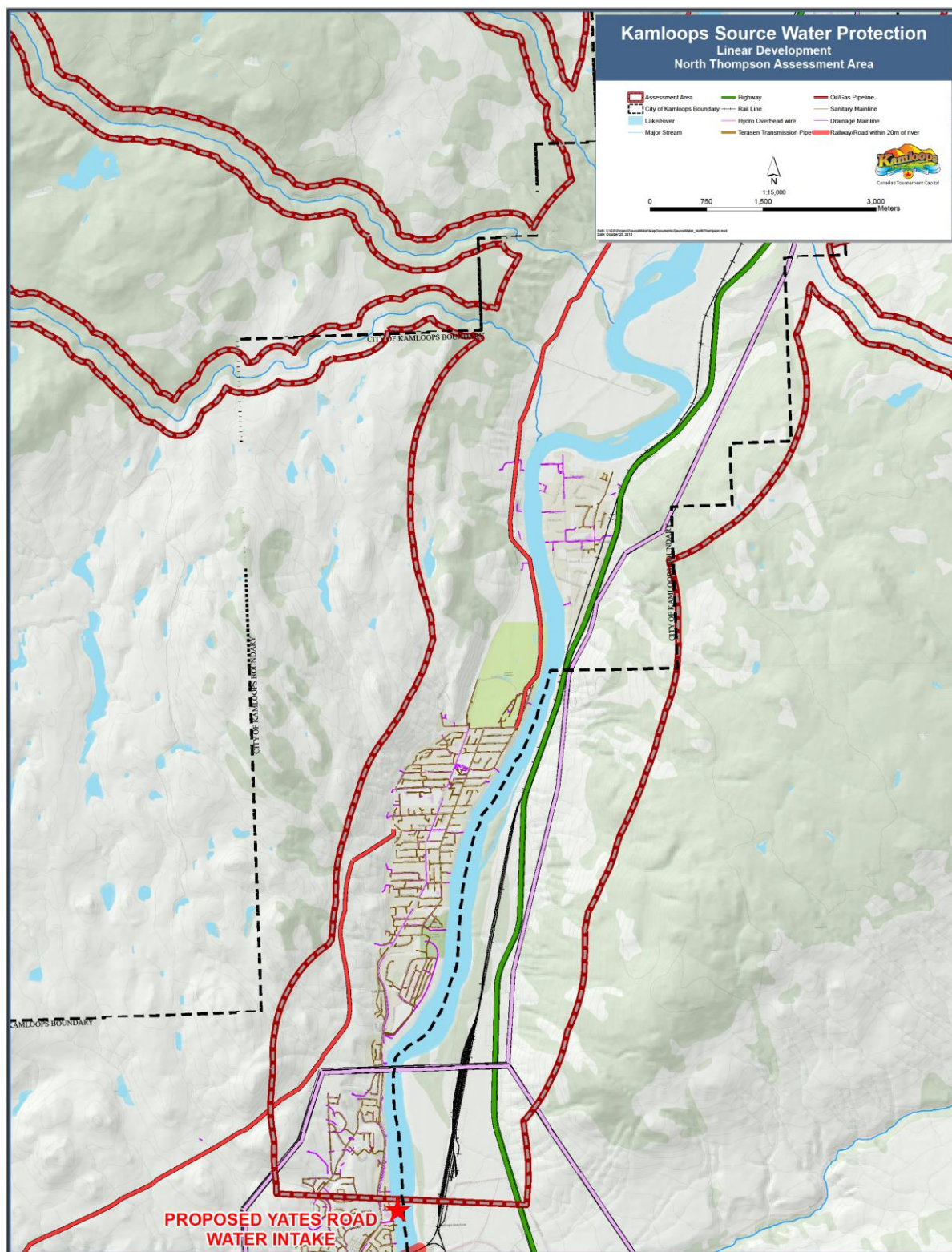
Appendix C: Lower North Thompson Assessment Area Residential Development Map



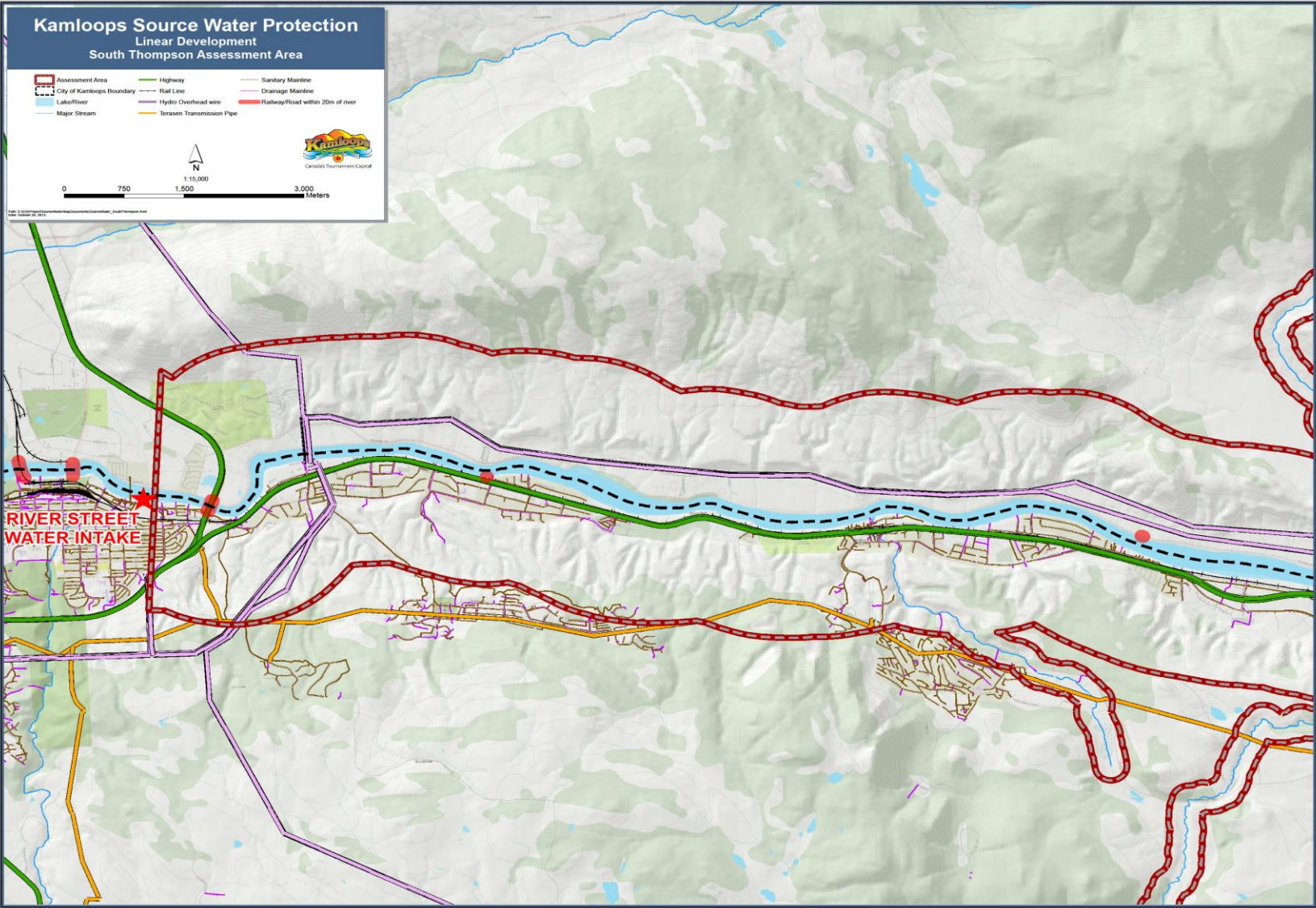
Appendix D: Lower South Thompson Assessment Area Residential Development Map



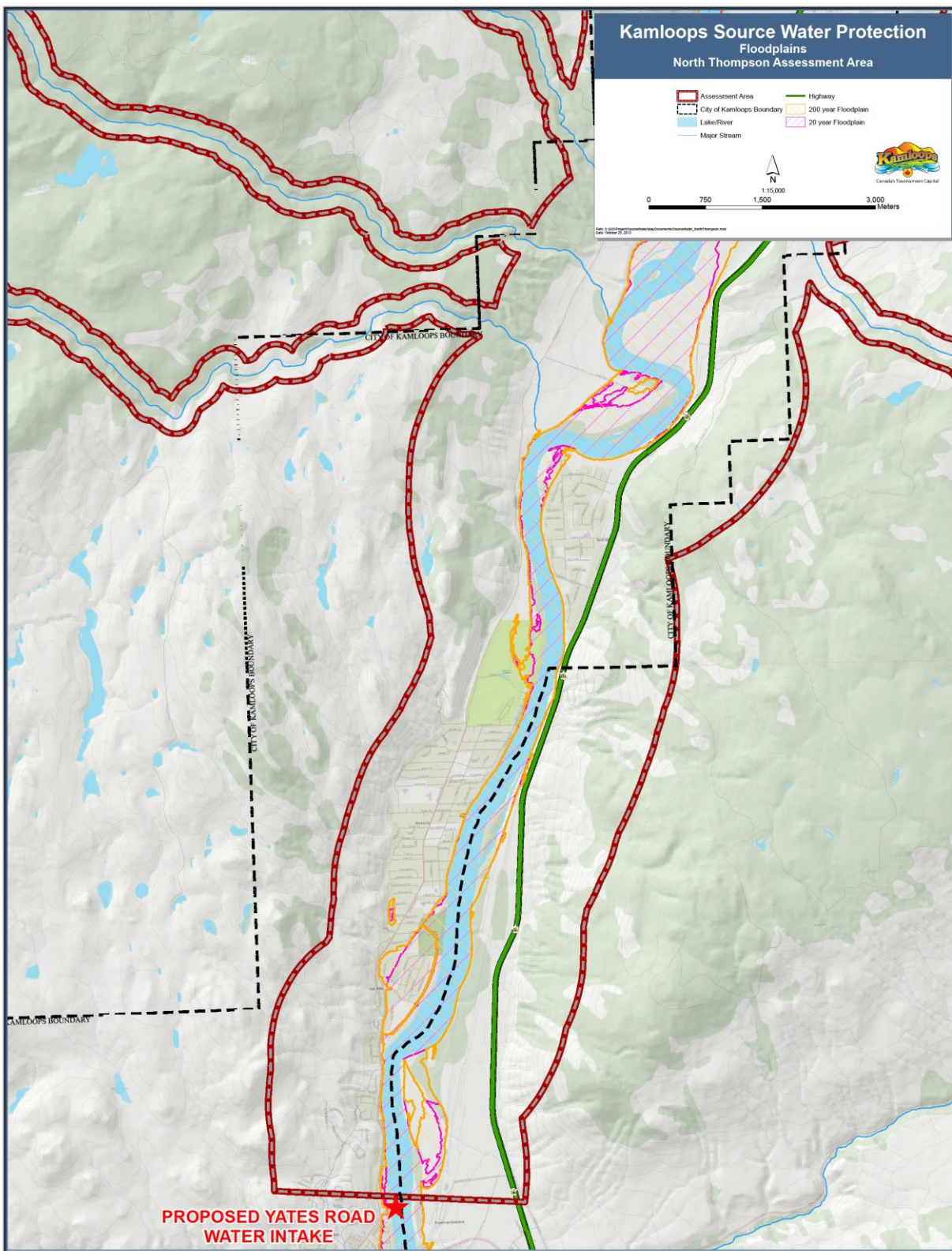
Appendix E: Lower North Thompson Assessment Area Linear Development Map (large scale)



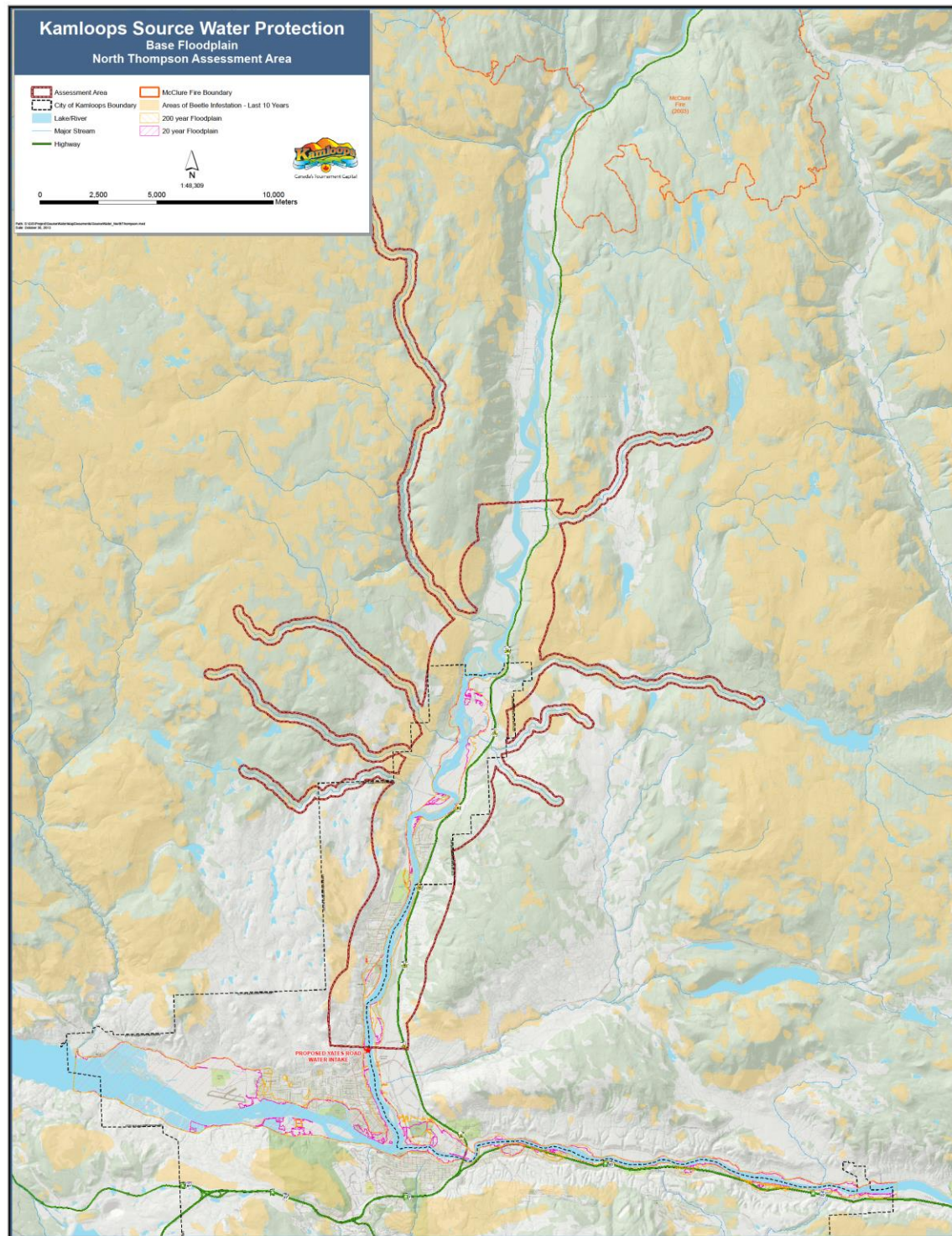
Appendix F: Lower South Thompson Assessment Area Linear Development Map (large scale)



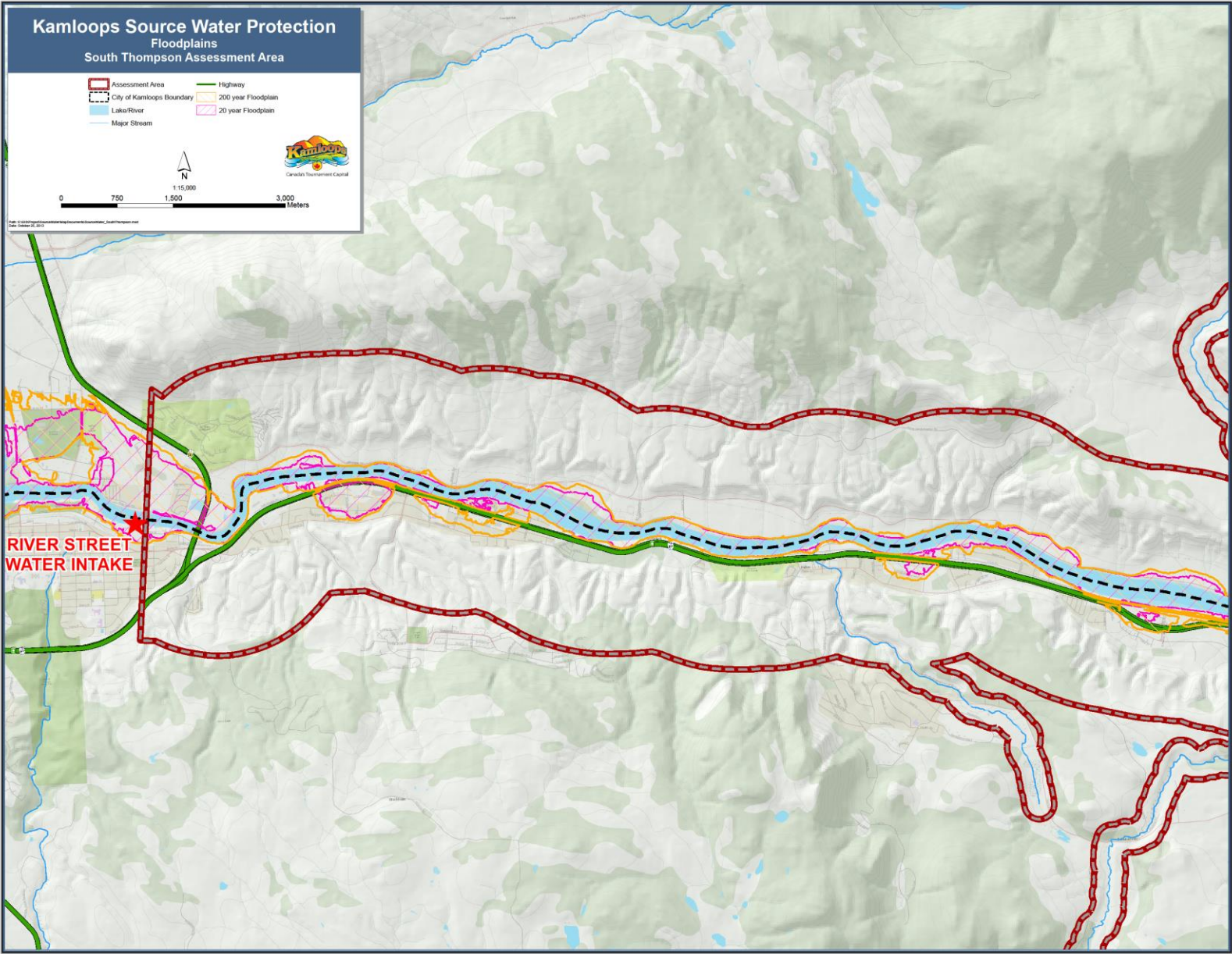
Appendix G: Lower North Thompson Floodplains Map (large scale)



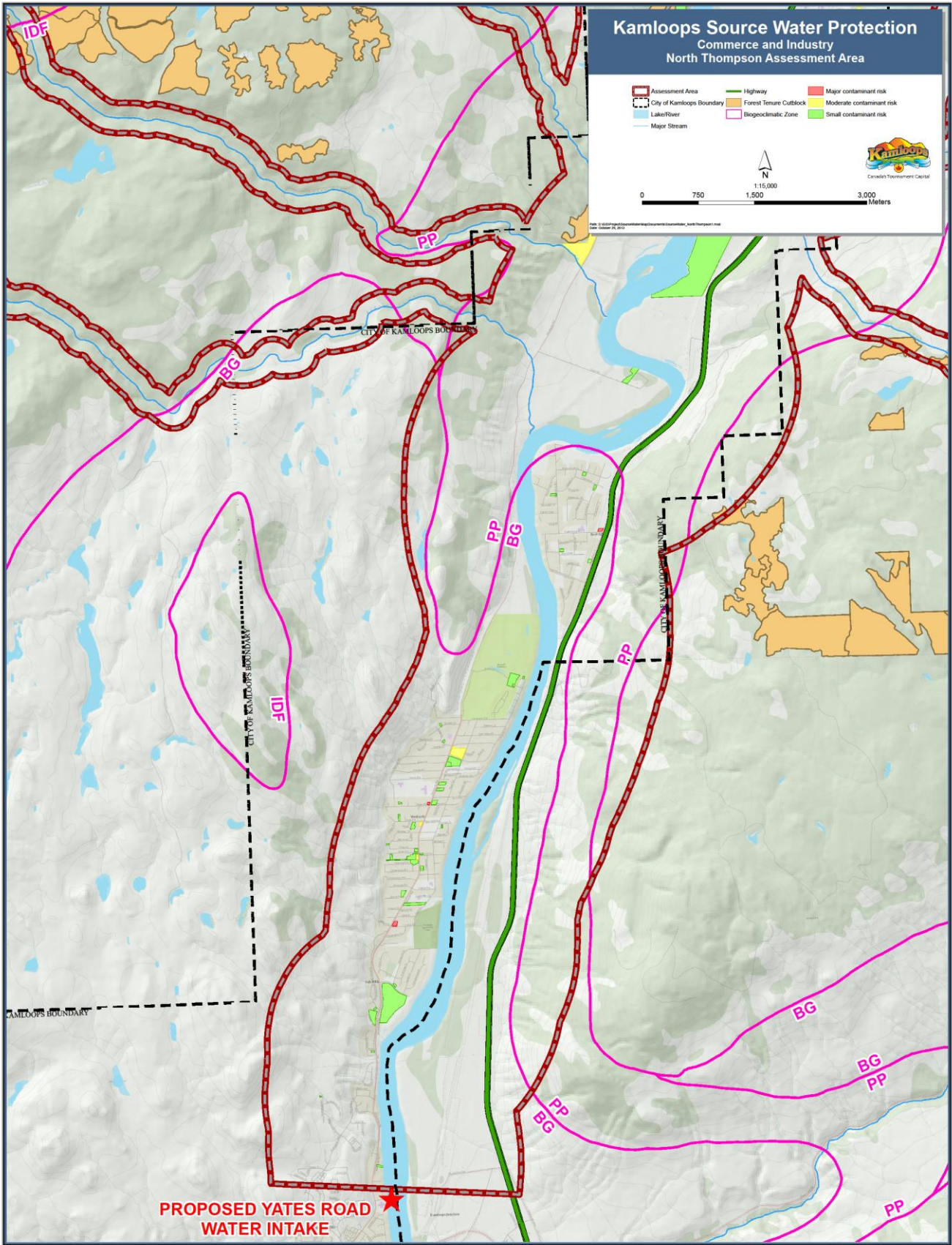
Appendix H: Lower North Thompson Floodplains Map (small scale)



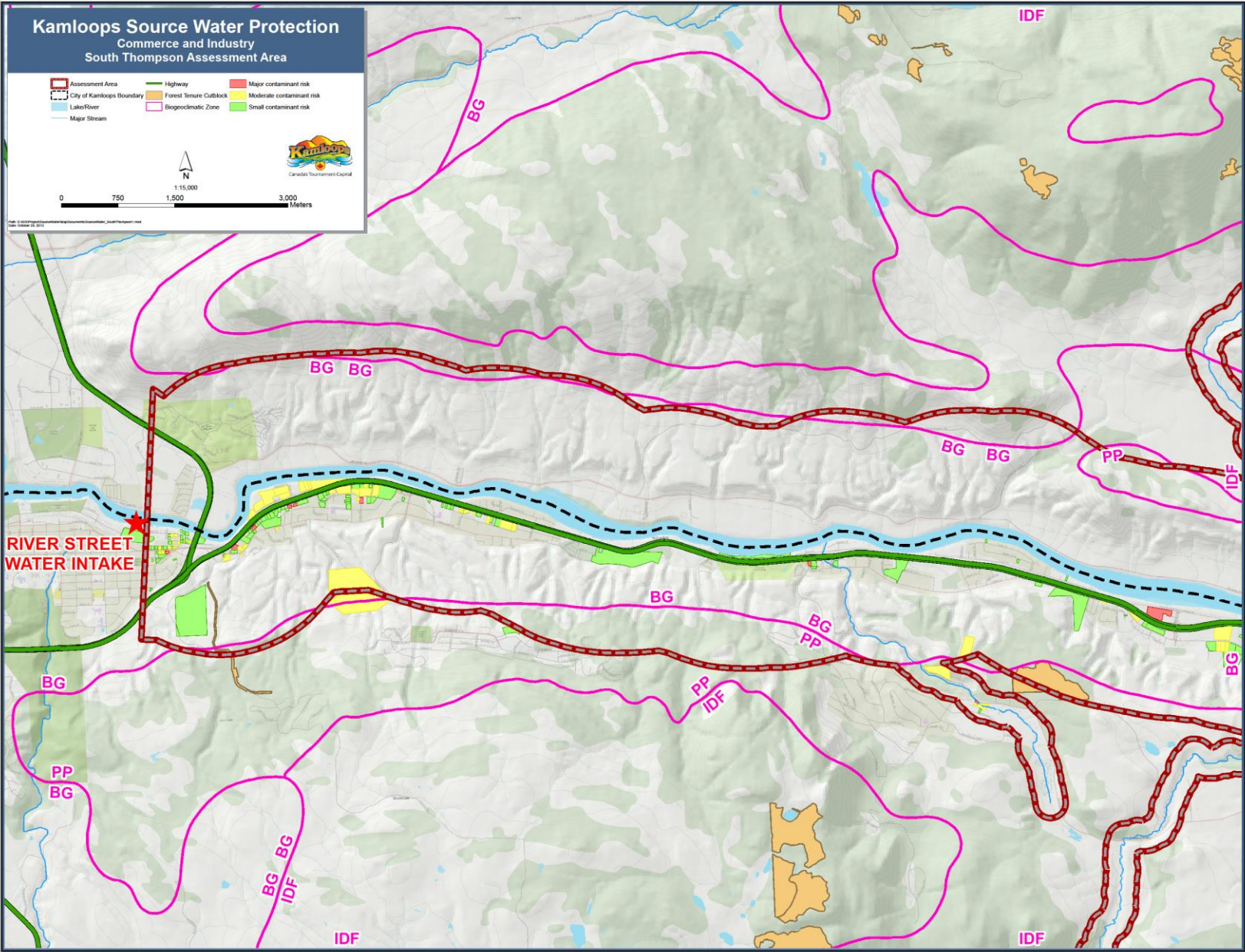
Appendix I: Lower South Thompson Floodplains Map (large scale)



Appendix J: Lower North Thompson Assessment Area Business and Industry Map



Appendix K: Lower South Thompson Assessment Area Business and Industry Map



Appendix L: Qualitative Measures of Likelihood

QUALITATIVE MEASURES OF LIKELIHOOD		
LEVEL	DESCRIPTOR	DESCRIPTION
A	ALMOST CERTAIN	is expected to occur in most circumstances
B	LIKELY	will probably occur in most circumstances
C	POSSIBLE	will probably occur at some time
D	UNLIKELY	could occur at some time
E	RARE	may only occur in exceptional circumstances

Appendix M: Qualitative Measures of Consequence

QUALITATIVE MEASURES OF CONSEQUENCE		
LEVEL	DESCRIPTOR	DESCRIPTION
1	INSIGNIFICANT	insignificant impact, no illness, little disruption to normal operation, little or no increase in normal operating costs
2	MINOR	minor impact for small population, mild illness, moderately likely, some manageable operation disruption, small increase in operating costs
3	MODERATE	minor impact for large population, mild to moderate illness probable, insignificant modification to normal operation but manageable, operating costs increase, increased monitoring
4	MAJOR	major impact for small population, severe illness probable, systems significantly compromised and abnormal operation if at all, high level monitoring required
5	CATASTROPHIC	major impact for large population, severe illness probable, complete failure of systems

Appendix N: Risk Characterization Matrix

QUALITATIVE RISK ANALYSIS MATRIX					
LIKELIHOOD	CONSEQUENCES				
	1 - INSIGNIFICANT	2 - MINOR	3 - MODERATE	4 - MAJOR	5 - CATASTROPHIC
A - ALMOST CERTAIN	moderate	high	very high	very high	very high
B - LIKELY	moderate	high	high	very high	very high
C - POSSIBLE	low	moderate	high	very high	very high
D - UNLIKELY	low	low	moderate	high	very high
E - RARE	low	low	moderate	high	high

Appendix O: Definition of Terms

The characterization of risk includes the following terms as described in the Comprehensive Drinking Water Source-To-Tap Assessment Guideline:

- Likelihood – *the probability of the potentially harmful event or condition happening and the probability that the water quality contamination or negative impacts on water quality would result*
- Consequence – *if a drinking water hazard does manifest, the nature and potential degree of effects are estimated by measures of consequence – including unacceptable water quality at point of intake and potential for acute or long-term health impacts for water consumers*
- Risk – *the assignment of risk (low, moderate, high, very high) are the result of combining the likelihood and consequence scores*

7.0 References

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