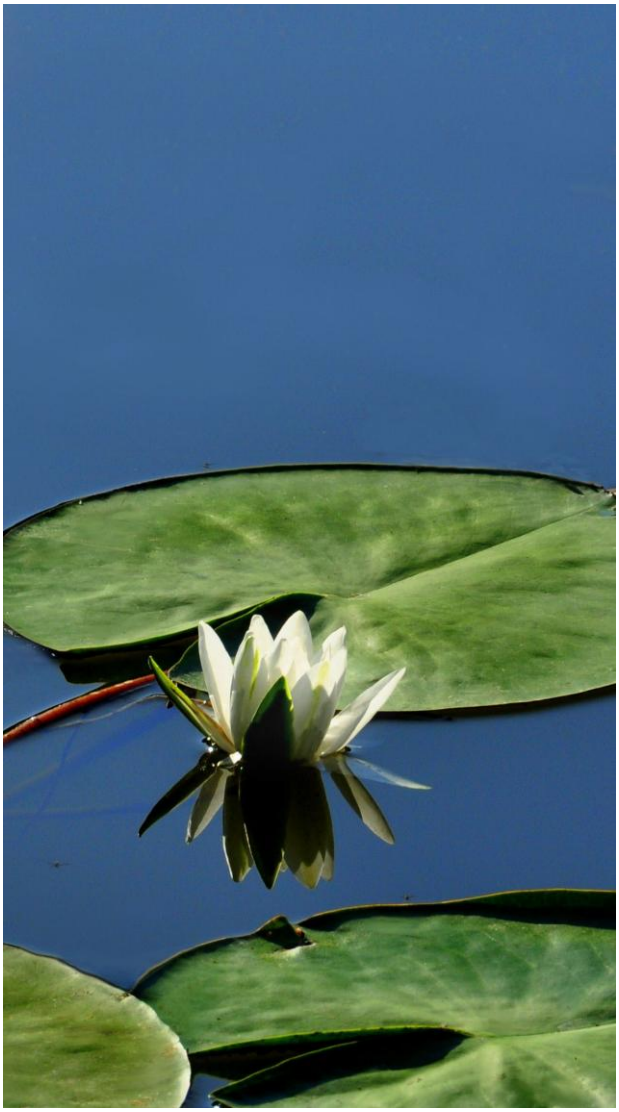

Part Five

The Vermilion River Drinking Water System

The Vermilion River watershed, which contributes to the surface water intake on the Vermilion River, covers approximately 3,764 km^2 and extends to the northern limit of the Greater Sudbury Source Protection Area.

Approved on September 2, 2014
Minor edits on March 1, 2017

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Chapter 26 - The Vermilion River Drinking Water System

The Vermilion River intake lies just below Cascade Falls located in the lower portion of the Vermilion River watershed. Owned and operated by Vale, the intake pumps raw water from the river to Creighton to be treated at the Vermilion Water Treatment Plant. The intake is considered to be a Type C[1] intake according to the Technical Rules.

Raw water is collected through a concrete structure located on the bottom of the river, protruding 6 metres from shore and is pumped through five coarse bar screens and two fine mesh screens. The raw water is then pumped 8.9 km from the pumphouse to the Vermilion Water Treatment Plant.

At the plant, the water is treated with liquid alum as a coagulant and prechlorinated before directed to the flash mixing chamber. A liquid polymer is added to aid coagulation and then the water is directed to the clarification and filtration process. Clarified water is directed to five single media sand filters and then discharged to a clearwell. Polyphosphate is added for iron and manganese sequestering, caustic soda is added for pH adjustment and chlorine is added for post disinfection.

Treated water is sent to the Creighton Mine and the City of Greater Sudbury distribution system. The distribution of the municipal water supply is owned and operated by the City of Greater Sudbury. The communities of Lively, Naughton, Whitefish and Copper Cliff are serviced by this intake. See Map 5.1 for the location of the intake and the distribution system. Table 5.1 summarizes water usage at the intake.

Table 5.1 – Summary of pumping rates for the Vermilion River intake for 2004-2008

	Pumping Rate
Maximum annual	20,771,331 m^3 (2004)
Average annual	16,510,374 m^3
Average monthly	1,375,864 m^3

[1] A Type C intake is located in a river and neither the direction nor velocity of flow of the water at the intake is affected by a water impoundment structure.

Chapter 27 - Vermilion River Watershed Description

The Vermilion River watershed that contributes to the surface water intake on the Vermilion River covers approximately 3,764 km^2 and extends to the northern limit of the Greater Sudbury Source Protection Area. It includes the Whitewater, Whitson, Cameron, Sandcherry, Nelson, Rapid, Upper Vermilion, and Upper Onaping River watersheds. Map 5.2 illustrates the extent of the watershed. The watershed area is mostly forested, with approximately 302 km^2 of lakes. The geology in the Vermilion River watershed is dominated by bedrock and thin till. Overburden of greater than 1 m depth is generally the glaciolacustrine and glaciofluvial deposits in the Valley East area, and in some areas covered by sand dunes in the headwaters of the catchment.

Some of the water produced in the headwaters of this watershed is diverted towards the Spanish River at Onaping Lake (NDCA 2006a). Onaping Lake, which is a headwater reservoir for the Onaping River, eventually discharges in three directions: south to the Vermilion River, west to the Spanish River and north to the Mattagami River. The northern flow has been blocked and the water is mainly diverted towards the Spanish River through regulation of the Bannerman Dam. The Onaping River is the main outlet of the lake and a main tributary of the Vermilion River.

The Whitson River, another main tributary in the watershed, flows in a southwest direction and enters the Vermilion River in Creighton Township in the City of Greater Sudbury. The Whitson River drains an approximate area of 313 km^2. This river passes through the communities of Val Caron and Chelmsford and has been a source of a number of flooding events in the past.

Chapter 28 - Vermilion River Intake Water Budget and Stress Assessment

The Vermilion River drinking water system lies within the Vermilion River watershed. As previously described in Chapter 13, the Vermilion River watershed was given a water quantity stress level of low and therefore did not need to progress to the next level of a water quantity assessment. Nonetheless, a Tier 1 water budget and stress assessment was completed for the watershed contributing to the Vermilion River intake and is presented below. The methodology applied is described in greater detail in Chapter 3 and in Appendix 2.

28.1 Vermilion River Intake Water Budget

Table 5.2 displays the results of the water budget for the Vermilion River intake. For the period 1970-2005, the Vermilion River intake watershed had an estimated average annual moisture surplus of 354 mm. Runoff, stream discharge and recharge all displayed peaks during spring melt and again when soils were saturated in the fall months. Average annual groundwater recharge was calculated to be 191 mm/yr. On an annual basis, baseflow was estimated to have comprised 32% of total streamflow.

Table 5.2 – Water budget for the Vermilion River intake watershed

	Water Balance Element (mm)									
Month	Rainfall	Snowfall	Snowmelt	Total Input	PET*	AET**	Streamflow	Baseflow	Runoff	Recharge
January	0.6	62.6	3.4	4.0	0	0	15.2	4.5	10.6	0
February	1.6	48.2	8.4	10.1	0	0	10.5	3.2	7.4	0
March	15.0	49.0	56.0	71.0	0	0	20.5	4.1	16.4	53.5
April	39.8	16.2	160.6	200.4	19.7	19.7	87.6	17.5	70.1	110.5
May	75.3	1.9	10.5	85.8	74.2	73.3	63.1	15.8	47.3	1.6
June	7537	0.2	0.2	75.9	108.3	102.8	28.7	11.5	17.2	1.5
July	77.4	0	0	77.4	127.2	112.8	13.5	6.7	6.7	0
August	83.0	0	0	83.0	109.9	96.0	8.5	4.3	4.3	0.8
September	94.8	0.3	0.3	95.1	67.9	66.1	8.9	3.5	5.3	2.2
October	73.5	4.8	4.3	77.8	28.7	28.7	20.8	6.2	14.6	5.0
November	36.1	34.0	20.9	57.0	0.6	0.6	27.7	5.5	22.1	16.1
December	6.8	58.5	10.0	16.9	0	0	25.0	7.5	17.5	0
Annual Total	579.7	275.7	274.6	854.3	536.5	500.2	329.7	90.4	239.4	191.2

*PET – Potential Evapotranspiration
**AET – Actual Evapotranspiration

28.2 Vermilion River Intake Water Quantity Stress Assessment

Table 5.3 summarizes the results of the water quantity stress assessment for the Vermilion River intake. Surface water demand for the Vermilion River watershed was highest in winter and late summer. Most of the surface water demand was a result of industrial permit to take water removals. Water reserve was highest in April (40 m^3/s) and the least volume of surface water was available in August. Calculated stress levels did not exceed 10% for any month, and February was estimated to have maximum monthly surface water stress at 9.2%. Therefore, the Vermilion River watershed contributing area to the surface water intake was classified as a 'low' surface water stress watershed. Forecasted increase in municipal demand did not significantly increase stress in the basin, as maximum monthly surface water stress was increased slightly above 9.2%.

Xeneca Power Development Inc. has a proposed hydro project just above Cascade Falls. The impact of this proposed project on water quantity will be assessed through the provincial review process for hydro projects.

Table 5.3 – Water quantity stress assessment for the Vermilion River intake watershed

	Supply (m^3/s)		Demand (m^3/s)				Stress (%)	
Month	Median	Reserve	Municipal	PTTW	Total	Forecast	Present	Forecast
January	20.05	10.61	0.02	0.55	0.58	0.58	6.11	6.14
February	15.97	9.62	0.02	0.56	0.58	0.59	9.20	9.23
March	18.69	10.8	0.02	0.54	0.56	0.56	7.09	7.12
April	109.09	39.96	0.02	0.53	0.55	0.56	0.80	0.80
May	76.68	28.05	0.02	0.55	0.58	0.58	1.19	1.19
June	31.39	16.11	0.02	0.52	0.54	0.55	3.56	3.57
July	15.10	7.68	0.02	0.53	0.55	0.55	7.38	7.40
August	10.25	3.95	0.02	0.54	0.57	0.57	8.99	9.03
September	10.07	3.08	0.02	0.54	0.56	0.56	8.05	8.08
October	22.77	5.32	0.02	0.54	0.57	0.57	3.25	3.26
November	31.40	12.34	0.02	0.54	0.57	0.57	2.97	2.98
December	31.12	14.88	0.02	0.54	0.56	0.56	3.43	3.45

Permit To Take Water Use

Excluding municipal removals, there were 32 recorded permits to take water in the Vermilion watershed that contribute to the intake at the time of report production. Seventeen of these permits were for surface water removals, while 15 permits were for groundwater removals. The consumed amounts were estimated to be $2.3x10^6$ m^3/yr for surface water and $2.3x10^6$ m^3/yr for the groundwater removals.

Agricultural Use

De Loe (2002) estimated an annual water removal of 269,501 m^3/yr in the Vermilion River watershed. It was assumed that all water for agriculture was from groundwater during summer months only and was 80% consumptive (Aqua Resource, 2005). Therefore, the total water consumed for agriculture in the Vermilion River watershed was estimated at 215,601 m^3/yr.

Municipal Use

Municipal removals in the Vermilion River Watershed are a combination of facilities owned by the City of Greater Sudbury and water purchased by the City from facilities owned by industry (Vale). Demand on these resources has remained relatively stable for the period of 2000-2005, with the

exception of the Valley wells, which have increased in demand. A recent report on water works infrastructure in Greater Sudbury noted a 33% loss in the Valley distribution system and an 8% loss in the Dowling distribution system (CGS 2005b). These losses were assumed as a return to the groundwater system.

Non-permitted or rural use

Approximately 4,514 of the population of the Vermilion River watershed within the City are without municipal water service (CGS 2003). There are 1,828 available well records in the basin, all of which were considered non-consumptive for the calculations. Most of these well records are located in the southern third of the watershed.

Water Budget and Stress Assessment Uncertainty

Uncertainty in the Tier 1 process takes into account the quality of the available data. Municipal water removals and water use trends were obtained from the City of Greater Sudbury and from industry, and large volume permits to take water were checked for actual use and active status. For each Tier 1 water budget, the water surplus was in the range of that reported in the literature (e.g. Richards 2002). For the Vermilion water source, the estimated uncertainty is low.

Chapter 29 - Vermilion River Water Quality Risk Assessment

The following sections provide the results for the water quality risk assessment process for the Vermilion River drinking water system.

29.1 Vermilion River Intake Protection Zones

There are three intake protection zones (IPZs) delineated for each surface water intake. Rules 58 to 71 and Chapter 2 describe the methodology to be applied for each type of intake.

Intake Protection Zone 1

The intake is located in a basin below Cascade Falls. Here, the river widens and circulates within the basin before exiting downstream. Drogue studies were conducted in 2006 to map the direction of flow within the basin. Appendix 2 provides the details of the study (Intake Characterization, Determination of Intake Protection Zones, and Assigned Vulnerability Scores, for Inland River Intakes within the City of Greater Sudbury, January 2008). Based on the river flow conditions at the time of testing, the results of the dye tracer study indicated a relatively rapid initial response, which may be due to preferential current flows. Also a potential contaminant retention time of more than 24 hours was observed, possibly due to the geometry of the basin structure.

Rule 64 allows the modification of IPZ-1 to reflect local hydrodynamic conditions if necessary. IPZ-1 was delineated to reflect the current pattern present in the basin near the intake. A 400 m radius zone, centered over the intake to encompass the entire basin area was used instead of the semi-circle with a radius of 200 m prescribed in the Ministry of the Environment and Climate Change (MOECC) Technical Rules. Where this semi-circle abutted land, a 120 m setback from the high water mark was applied. The entire Cascade Basin is incorporated in the IPZ-1. See Map 5.3.

Intake Protection Zone 2

The delineation of IPZ-2 is based on a 2 hour time of travel to reflect the response time of an operator to shut down the water treatment plant in the event of an adverse water quality condition (Rule 65). Bankfull flow[2] conditions were encouraged by the MOECC to be used to determine a 2 hour time of travel delineation for an IPZ-2.

The Vermilion River changes frequently through its reaches from steep sided slopes to low lying wetland areas. This kind of topography makes it difficult to determine what a bankfull condition is as it varies widely throughout the river. Instead, return period flood discharges were estimated to

[2] Bankfull flow is considered the maximum amount of flow a stream channel can contain without spilling over the banks. Typically, bank full flow conditions are observed once every two years.

determine the appropriate flow conditions to calculate the IPZ-2 delineation. A two year return period was assumed to be a suitable flow condition to apply to the IPZ-2 delineation.

The 2 hour time of travel was estimated to be approximately 3,700 m upstream of the lower end of the model domain plus Cascade Falls and the total length of the intake pool adjacent to the WTP intake. The total distance of IPZ-2 from the WTP intake was estimated at 4,500 m. No information exists with regards to travel time within the basin. Therefore, the IPZ-2 is considered to be conservative and the travel time through the basin is considered a data gap. The hydraulic backwater model HEC-River Analysis System (HEC-RAS) was used to simulate water levels through the reaches of the river. More details regarding the modeling are located in the report on the IPZ-2 Update for the Vermilion and Wanapitei River Intakes in Appendix 2. Being that this intake is located in an unsettled, forested area, there are no storm sewers to affect the delineation of IPZ-2. IPZ-2 is illustrated in Map 5.4.

Intake Protection Zone 3

The delineation of IPZ-3 follows the entire contributing area upstream of the intake and includes a 120 m setback from the high water mark (Rule 70). The Vermilion River IPZ-3 reaches to the Arctic Divide and is approximately 105 km long. It encompasses the Lower Vermilion, Mid-Vermilion, Cameron, Whitson, Whitewater, Lower Onaping, Upper Onaping, Sandcherry Creek, Nelson River, Rapid River and the Upper Vermilion watersheds. See Map 5.5 for the illustration of IPZ-3.

Intake Protection Zone Delineation Uncertainty

As required by Rule 108, an uncertainty analysis of the delineation of intake protection zones and vulnerability scoring is presented in Table 5.4.

Table 5.4 - Summary of uncertainty analysis for the Vermilion River intake protection zones

IPZ	Level of Uncertainty	Comments
IPZ-1	High	The drogue studies completed in 2006 provided some information regarding current patterns within the basin where the intake is located, however there still remains a lack of data regarding velocity of flow within the basin.
IPZ-2	High	The field data was limited by the upstream rapids which resulted in the 2 hour ToT reaching beyond the model domain. Along with this, the travel time through Cascade Falls and the pool at the WTP intake remains a data gap.
IPZ-3	High	The delineation for the IPZ-3 was prescribed under Rule 70. The resulting IPZ-3 includes the entire watershed to the Arctic Divide. Detailed mapping is not available for the upper reaches of the watershed; therefore there is little confidence in the 120 m setback delineation.

29.2 Intake Protection Zone Vulnerability Assessment

Vulnerability scoring for intake protection zones followed Rules 86 to 95 which require a source vulnerability factor and area vulnerability factor to be determined (see Chapter 2). Due to the sheer size of the Vermilion River intake protection zones, the area vulnerability factor was determined based on subwatersheds. Each subwatershed was characterized and given one overall score as explained in the subsequent pages.

Source Vulnerability Factor

The source vulnerability factor was given a score of 1.0 due to the close proximity of the intake to shore and the exposure of the intake.

Area Vulnerability Factor

The area vulnerability factor for IPZ-1 is fixed at 10. The remaining IPZ area vulnerability factors were given scores based on land cover, proximity to the intake, topography and geology.

The sheer size of the vulnerable areas for the Vermilion River made it necessary to divide the area into sections. IPZ-3 was divided into sub-watersheds and evaluated as a whole. Proximity was determined based on the outlet of each sub-watershed to the main stem of the Vermilion River.

IPZ-2 was given a moderate score of 7. The area within IPZ-2 is undeveloped, forested and primarily bedrock with pockets of wetland. This zone remains moderately vulnerable given the close proximity to the intake.

The Mid-Vermilion watershed, below the Stobie Dam, is much like the area within IPZ-2. Given the proximity is relatively close to the intake, this zone was given a score of 7. Vermilion Lake sits just upstream of the Stobie Dam, which filters much of the upper reaches of the watersheds. Because of the longer residence time within the lake coupled with the relatively undeveloped area, these watersheds were given a score of 1 to reflect the low vulnerability to contamination.

Both the Whitson and Whitewater watersheds drain most of the Valley area. This area consists of relatively flat agricultural areas with increasing urban development. The geology of the region is different than the bedrock areas typically found in the Sudbury region. There is a greater amount of overburden present and therefore more infiltration capacity than in other areas of the Vermilion watershed. Increased urban development in these watersheds reduces infiltration and increases surface runoff and therefore increases its vulnerability to contamination. These watersheds were given a score of 6 to reflect the moderate vulnerability of these watersheds to contamination.

Summary of Vulnerable Area Scoring

Table 5.5 shows the source vulnerability and area vulnerability factors for the Vermillion drinking water system intake protection zones.

Table 5.5– Vermilion River vulnerable area scoring

Intake Protection Zone	Source Vulnerability Factor	Area Vulnerability Factor	Vulnerability Score	Comments
IPZ-1	1.0	10	10	Fixed score
IPZ-2	1.0	7	7	Undeveloped Forested Bedrock Closest to intake
IPZ-3 Mid Vermilion below Stobie Dam	1.0	7	7	Undeveloped Forested Bedrock Closest to intake
IPZ-3 Whitewater	1.0	6	6	Low lying Agricultural Urban development
IPZ-3 Whitson River	1.0	6	6	
IPZ-3 Mid Vermilion above Stobie Dam	1.0	1	1	Undeveloped Forested Bedrock geology Pockets of wetlands Many lakes From 15 to 105 km from the intake
IPZ-3 Cameron	1.0	1	1	
IPZ-3 Lower Onaping River	1.0	1	1	
IPZ-3 Sandcherry Creek	1.0	1	1	
IPZ-3 Nelson River	1.0	1	1	
IPZ-3 Rapid River	1.0	1	1	
IPZ-3 Upper Vermilion	1.0	1	1	
IPZ-3 Upper Onaping River	1.0	1	1	

Intake Protection Zone Vulnerability Scoring Uncertainty

Uncertainty surrounding the vulnerable area scoring assignment is based on the ability of the vulnerability factors to effectively assess the relative vulnerability of the hydrological features. The vulnerability scores for the Vermilion River intake protection zones were primarily based on land cover within the watershed and are shown in Table 5.6.

Table 5.6– Uncertainty analysis for the vulnerable area scoring

	Uncertainty	Comment
Source Vulnerability Factor	Low	As the source vulnerability factor has been scored conservatively, there is high confidence that this factor will address any concerns up to the intake.
Area Vulnerability Factor – Score of 6 and 7	Low	These areas are heavily vegetated. The time of travel and moderate score should be sufficient to protect the intake from contamination.
Area Vulnerability Factor – Score of less than 6	Low	These contributing subwatersheds become progressively less vulnerable as the proximity to the intake decreases and the land cover becomes less vulnerable to contamination. There is high confidence that the score is sufficient.

29.3 Vermilion River Drinking Water Quality Threats Activities

The assessment of potential threats to drinking water quality followed Technical Rules 118 to 125 and the methodology as outlined in Chapter 2. The list of prescribed drinking water threats is located in Table 1.7 in Part 1 of this report.

Identification of areas where threats can occur

The areas where a potential threat is or would be significant, moderate or low are illustrated on Maps 5.3 to 5.5. According to the Technical Rules:

- Areas with a vulnerability score of 8 or greater has the potential for a significant, moderate or low threat.
- Areas with a vulnerability score of 6 or greater has the potential for a moderate or low threat to occur.
- Areas with a vulnerability score of 4 or greater has the potential for a low threat to occur.
- Areas with a vulnerability score of less than 4 cannot contain a drinking water threat.

The MOECC has established an online tool that incorporates the Provincial Tables of Circumstances into an interactive mapping tool, accessible via http://swpip.ca/. With the address search function, this tool lets you identify what vulnerable area(s) a property is located in and what the vulnerability score is at that location. It also identifies a list of circumstances of all is or would be significant, moderate or low drinking water threats. For more detailed instructions on how to use the above mentioned website refer to Appendix 5.

Managed Lands

The storage, handling and application of agricultural source material, non-agricultural source material, pesticides and fertilizers can result in potential contamination of municipal water supplies. The methodology used to calculate percentage of managed lands in the vulnerable areas is described in Chapter 2.

The percentage of managed lands in the area was assessed to be under 40% (low) and is illustrated on Map 5.6.

Impervious Surfaces

Impervious surfaces are measured as an indicator of the amount of area where road salt can be applied. The percentage of surface area within a vulnerable area which will not allow surface water or precipitation to be absorbed into the soil is calculated. Most of the vulnerable areas in the Vermilion River intake watershed, including the area immediately around the municipal drinking water intake, have less than 1% impervious area. However, there are some built up areas in the Vermilion River intake watershed where impervious area is in the 8-80% range. The Valley municipal residential drinking water supply in one of these areas; see Chapter 33 for an assessment of the impervious area in the Valley area. Map 5.7 shows the percentage of impervious area in the Vermilion River intake watershed. The calculation of impervious surfaces led to the vulnerable area being designated as a moderate threat or a low threat for the application of road salt depending on the vulnerability score.

The methodology used to calculate percentage of impervious surfaces in the vulnerable areas is described in Chapter 2.

Livestock Density

The calculation of livestock density is based on the calculation of nutrient units per acre of agricultural managed lands. The methodology used to calculate the livestock density in the vulnerable areas is described in Chapter 2. Most of the Vermilion River watershed is forested, however, there are some pockets of agricultural activity, primarily in the Whitson River subwatershed. Overall, there was a score of under 0.5 nutrient units per acre. The results are illustrated on Map 5.8.

The combination of livestock density and managed land calculations assigns a threat rating for the application of commercial fertilizer. Table 5.7 illustrates this threat in different vulnerability areas.

Enumeration of Significant Threats

Table 5.7 lists an estimate of the current number of moderate and low drinking water quality threats in the Vermilion River drinking water system in accordance with the Drinking Water Threats Tables.

Table 5.7 – Drinking water quality threats for the Vermilion River drinking water system

Drinking Water Threat Category	Number of Occurrences with Threat Classification		
	Significant	Moderate	Low
IPZ-1			
The application of commercial fertilizer to land.		1	
The handling and storage of fuel.		1	
The application of road salt.		1	
Local threat: Transportation of hazardous substances along transportation corridors.			
IPZ-2			
The application of commercial fertilizer to land.			1
The application of road salt.			1
Local threat: Transportation of hazardous substances along transportation corridors.			
IPZ-3			
The establishment, operation or maintenance of a waste disposal site within the meaning of Part V of the Environmental Protection Act.		2	
The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.			450
The application of commercial fertilizer to land.			1
The application of road salt.			1
Local threat: Transportation of hazardous substances along transportation corridors.		1	6

29.4 Vermilion River Drinking Water Threats Conditions

A drinking water condition is a situation that results from a past activity and meets the criteria laid out in Chapter 2. For a more detailed review of the methodology for identifying drinking water conditions, please refer to Part 1, Chapter 2.

The areas where a significant, moderate or low threat condition could exist are the same as the areas where a potential threat could occur. For an illustration, please see Map 5.3 to 5.5.

Currently, there are no identified significant conditions within the Vermilion River intake vulnerable areas.

29.5 Vermilion River Drinking Water Quality Issues

Drinking water quality issues were assessed based on the methodology outlined in Chapter 2 and Rules 114 and 115.

Currently, there are no known water quality issues in the raw water at the Vermilion River intake.

Xeneca Power Development Inc. has a proposed hydro project just above Cascade Falls. The impact of this proposed project on water quality will be assessed through the local and provincial review process for proposed projects.

Chapter 30 - Data Gaps

The analyses for this drinking water system were carried out using the best data available to meet the assessment report requirements. Completing scientific assessments on the quality and quantity of water undoubtedly raises a number of questions and uncertainties regarding the methodologies used, availability of data, reliability of data and overall outcome. As new information arises, either from increased or continuous monitoring, improved models or a change in methodology, the results from this report will have to be updated.

The assessment report is a constantly evolving document as new information becomes available and refinements in approaches are made. Changes in land use will also impact the identification of potential threats to water quality and quantity. Therefore, there will be a need to continue filling in identified data gaps and to carry out studies in the future. Data gaps for the Vermilion River intake include:

- travel time through Cascade Falls and the pool at the WTP intake; and
- detailed contaminant mixing effects at higher discharge rates.