APPENDIX 3-I

EXISTING AIR QUALITY AND METEOROLOGY

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1 INTRODUCTION

This appendix provides a summary of the existing air quality and meteorological data collected in the Oil Sands Region near the Christina Lake Regional Project – Phase 3 (the Project) site. The purpose of this appendix is to provide an indication of the existing air quality and climatic conditions in the region and to provide a context for air quality predictions made in Section 1. The appendix includes the following components:

- A summary of the ambient air quality data collected in the region near the proposed Project site by the regional airshed associations.
- A summary of the long-term meteorological data that are used to define the climate of the region. This section summarizes the range of temperatures, precipitation and wind patterns in the Oil Sands Region.

2 EXISTING AIR QUALITY

2.1 AIR QUALITY DATA SOURCES

As part of the current Christina Lake Regional Project *Environmental Protection and Enhancement Act* (EPEA) approval (216466-00-01) issued on July 20, 2007, MEG is required to conduct ambient air quality monitoring. This monitoring will consist of one continuous station to monitor sulphur dioxide (SO_2), nitrogen dioxide (NO_2), hydrogen sulphide (H_2S) and Total Hydrocarbon (THC) and four passive stations to monitor SO_2 and H_2S. At the time of the writing of this appendix, the collection of ambient air quality monitoring data has not yet commenced and therefore has not been included.

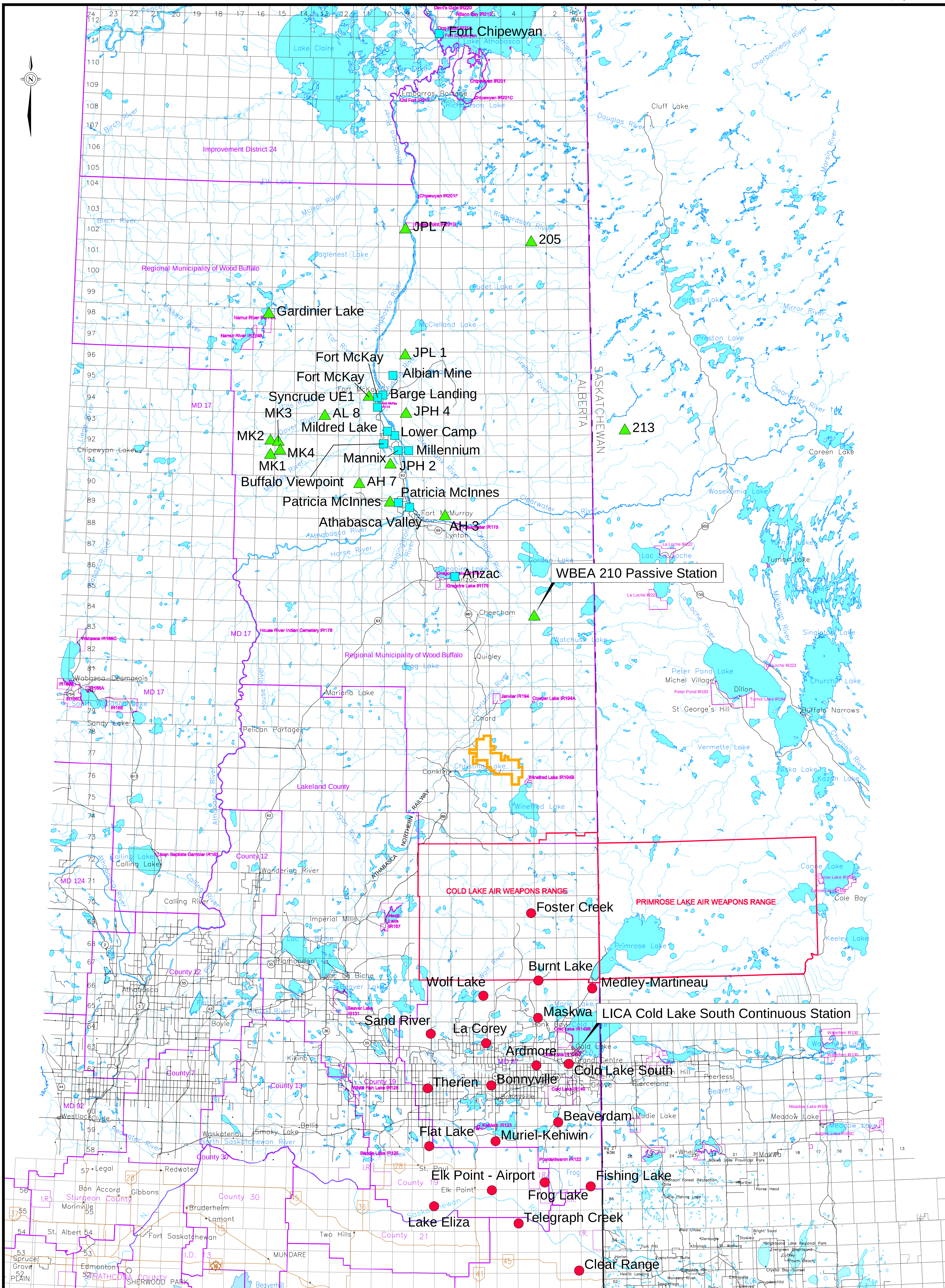
The focus of this appendix is on the ambient air quality monitoring data that has been collected as part of the regional networks that are currently operating in the Oil Sands Region. Specifically, this appendix summarizes the continuous, passive and mobile survey data collected at the locations nearest to the Project.

There are two regional ambient air quality monitoring networks in the Oil Sands Region: the Wood Buffalo Environmental Association (WBEA) and the Lakeland Industrial Community Association (LICA) networks. These associations are multi-stakeholder, non-profit organizations whose purpose is to provide third-party monitoring and analysis of regional air quality. Although the Project is located at the southern boundary of the Regional Municipality of Wood Buffalo (RMWB), and is therefore covered by the WBEA network, data from the LICA has also been included in this appendix, as it may provide a better representation of ambient air quality in the vicinity of the Project. This is because in the LICA airshed, the monitoring is primarily focused around in-situ oil sands developments as opposed to the large oil sands mining developments principally monitored by WBEA.

2.1.1 Continuous Air Monitoring Data

The WBEA administers an ambient monitoring network in the RMWB. This network includes 14 continuous air quality monitoring stations, stretching from Fort Chipewyan in the north to Anzac in the south. One of these 14 stations, Lower Camp B only measures meteorological parameters. In contrast, LICA administers a network from the Cold Lake Air Weapons Range in the north to the town of Marwayne in the south. Currently, the LICA network has only one continuous monitoring station in operation, which is the LICA Cold Lake South station located about 138 km south-southeast of the Project in the community of Cold Lake. The locations of the WBEA and LICA continuous monitoring stations are shown in Figure 1.

L:\2007\1346 Oil Sands\07-1346-0009-MEG EXPANSION\8000\Appendix 3-I\Fig 1 Locations of WBEA+LICA-AAQ monitoring stations.dwg Apr 10, 2008 - 1:12pm Image:MEGcube-R.bmp Image:MEGcube-R_1.png



LEGEND

- ROAD
- RAILWAY
- RIVER
- OPEN WATER
- INDIAN RESERVE
- COLD LAKE AIR WEAPONS RANGE
- MEG LEASE BOUNDARY
- WBEA CONTINUOUS MONITORING STATIONS
- WBEA PASSIVE MONITORING STATIONS
- LICA CONTINUOUS MONITORING STATIONS
- LICA PASSIVE MONITORING STATIONS

30 0 30
SCALE KILOMETRES

REFERENCE

ALBERTA NTDB DATA SUPPLIED BY GEOMATICS CANADA, AUGUST 2001. NAD 83 ZONE 12. SHEETS 74D, E AND 74L IN NAD 27 ZONE 12. SASKATCHEWAN NTDB DATA SUPPLIED BY ISC, AUG. 2001. NAD 83 ZONE 13. ALL DATA CONVERTED TO NAD 83 UTM ZONE 12.

PROJECT
CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE
LOCATIONS OF THE WBEA AND LICA AMBIENT AIR QUALITY MONITORING STATIONS

MEG ENERGY CORP.

PROJECT	07.1346.0009.8000		FILE No.	monitoring stations
DESIGN	MS	28/11/07	SCALE AS SHOWN	REV. 0
CADD	TRE	28/03/08	**FIGURE: 1**	
CHECK	MS	28/03/08		
REVIEW	IGG	07/04/08		

The continuous ambient air quality monitoring station located nearest to the Project is the Anzac station, which is part of the WBEA network. Although this station was incorporated into the WBEA network in January 2007, at time of writing, quality controlled and validated data for this station is not yet available through Clean Air Strategic Alliance (CASA) or WBEA. The two next nearest stations are the Athabasca Valley and Patricia McInnes stations, which are also part of the WBEA network. However, these are located in Fort McMurray and are not representative of the air quality in the vicinity of the Project. The nearest continuous monitoring station that has valid data and is a better representation of the air quality in the vicinity of the Project is the LICA Cold Lake South station (although the station is located in an area that is more developed than the Project site). The data from the Cold Lake South station is summarized in this appendix.

The continuous monitoring data presented in this appendix for the LICA Cold Lake South station were obtained from the LICA and cover a monitoring period from November 2005 through December 2006 (G. Carling 2005, Pers. Comm.). The LICA Cold Lake South station continuously monitors sulphur dioxide (SO_2) NO_2, ozone (O_3), Total Hydrocarbons (THC), Total Reduced Sulphur (TRS) and particulate matter less than 2.5 microns ($PM_{2.5}$).

2.1.2 Passive Air Monitoring Data

Passive monitoring systems have been used for many years in the Oil Sands Region to gather long-term information. Passive monitoring techniques allow for the direct measurement of ambient SO_2, NO_2, H_2S and O_3 concentrations. The passive samplers are collected on a monthly basis and therefore, provide 1-month average concentrations of these compounds.

The WBEA currently maintains 17 passive monitoring sites throughout the region to complement their continuous monitoring stations. Of these 17 passive sites, two are co-located with the Patricia McInnes and Fort McKay continuous monitoring stations to confirm the accuracy of the samplers. The LICA operates a monitoring network of 20 passive sites, which includes a passive sampler co-located with the Cold Lake South continuous monitoring station. The locations of the WBEA and LICA passive monitoring stations are shown in Figure 1.

The LICA Foster Creek passive monitoring station is located about 71 km south-southeast of the Project; however, it is situated adjacent to several oil and gas developments and therefore is not representative of the Project. The nearest representative passive site to the Project is the WBEA 210 station, which is located about 70 km north-northeast of the Project. The passive monitoring data presented in this appendix for the WBEA 210 passive site are from the 2005 Annual Report (WBEA 2006) and cover the monitoring period from July 2005, when the site was commissioned, until December 2005. The WBEA 210 site passively monitors SO_2, NO_2 and O_3.

2.1.3 Mobile Air Monitoring Surveys

Alberta Environment (AENV) conducts mobile air monitoring surveys as part of its air quality monitoring program, using the AENV Mobile Air Monitoring Laboratory. These surveys provide a short-term "snapshot" of the air quality at the locations surveyed during the time monitored. These surveys typically monitor at several locations over a few days. Two surveys have been conducted in the region recently and are included in this appendix.

The first survey was conducted in 2001 and 2002. This survey monitored air quality for twenty days at sixteen sites in the Cold Lake, Bonnyville and Elk Point areas (south of the Project) (AENV 2002). Each site was monitored for a minimum of one hour and the survey obtained a total of 122 hours of air quality monitoring data.

The second survey was conducted in the Lakeland area in 2003 and 2004 (AENV 2005). This survey obtained 46 hours of air quality monitoring data over eighteen days at twelve sites. Each site was monitored for a minimum of one hour.

2.2 AIR QUALITY MONITORING RESULTS

The following sections summarize data from the continuous and passive air monitoring programs near the Project. The compounds included in this ambient air quality summary are SO_2, NO_2, H_2S, O_3, carbon monoxide (CO), THC, TRS and $PM_{2.5}$.

2.2.1 Sulphur Dioxide Concentrations

The ambient air quality monitoring data for SO_2 can be summarized as follows:

- **Continuous Monitoring**: The 1-hour, 24-hour and annual SO_2 monitoring data collected at the Cold Lake South monitoring station are summarized in Table 1. The maximum monitored 1-hour, 24-hour and annual SO_2 concentrations of 68.9, 7.2 and 1.5 $\mu g/m^3$ respectfully are below the respective Alberta Ambient Air Quality Objectives (AAAQOs).
- **Passive Monitoring**: The average monthly SO_2 concentration for the WBEA 210 site was 1.31 $\mu g/m^3$ for the June to December 2005 monitoring period.
- **Mobile Monitoring:** During the Cold Lake, Bonnyville and Elk Point AENV mobile air monitoring survey, the maximum 1-hour SO_2 concentration in the region was 44.5 $\mu g/m^3$, measured near an existing industrial facility (AENV 2002). During the Lakeland mobile air monitoring survey, the maximum 1-hour SO_2 concentration measured in the region was 23.6 $\mu g/m^3$ (AENV 2005). Both 1-hour SO_2 concentrations are below the AAAQOs.

Table 1 Ambient Sulphur Dioxide Concentrations at Cold Lake South

Station	1-Hour SO_2				24-Hour SO_2				Annual Average SO_2 [µg/m³]
	Mean [µg/m³]	95th Percentile [µg/m³]	Max. [µg/m³]	# >AAAQO[a][b]	Mean [µg/m³]	95th Percentile [µg/m³]	Max. [µg/m³]	# >AAAQO[a][c]	
Cold Lake South	1.4	3.7	68.9	0	1.4	3.0	7.2	0	1.5

[a] AAAQO = Alberta Ambient Air Quality Objective.

[b] The 1-hour AAAQO for SO_2 is 450 µg/m³.

[c] The 24-hour AAAQO for SO_2 is 150 µg/m³.

2.2.2 Oxides of Nitrogen Concentrations

The primary source of oxides of nitrogen (NO_X) in the region is the combustion of fossil fuels. This compound is emitted in two primary forms: nitric oxide (NO) and nitrogen dioxide (NO_2). Studies have shown that the majority of NO_X emissions are in the form of NO (Angle et al. 1997; Baukal and Eleazer 1998; Cole and Summerhays 1979). Since regulatory guideline levels are only available for NO_2 concentrations, only a fraction of the emitted NO_X is a primary concern. However, NO is reactive and converts to NO_2 by two common mechanisms, the most rapid of which involves the reaction of NO with ambient

O_3. The result of this reaction is NO_2 and O_2, as shown in the following equation:

$$O_3 + NO \rightarrow O_2 + NO_2$$

This reaction is the primary mechanism by which NO is converted to NO_2. Therefore, NO_X emissions can reduce the ambient ozone concentrations under appropriate conditions. This was recognized in the following statement by the authors responsible for developing Canada-Wide Standards for ozone (CWSDC 1999):

> "The second mechanism that results in the conversion of NO to NO_2 is the reaction of NO with molecular oxygen (O). This reaction is much slower and tends to occur more frequently when the concentrations of NO are very high."

The ambient air quality monitoring data for NO_X/NO_2 can be summarized as follows:

- **Continuous Monitoring**: The 1-hour, 24-hour and annual NO_2 and NO_X monitoring data collected at the Cold Lake South monitoring station are summarized in Table 2 and Table 3, respectively. The maximum monitored 1-hour, 24-hour and annual NO_2 concentrations of 70.8, 41.6 and 8.1 µg/m³, respectively, are all below the respective AAAQOs. A comparison of the two tables indicate that when the NO_X values are low (e.g., mean concentration), the corresponding NO_2 concentrations are similar in magnitude. However, when the NO_X concentrations are high (e.g., maximum concentration), the corresponding NO_2 concentrations are substantially smaller in magnitude.
- **Passive Monitoring**: The average monthly NO_2 concentration for the WBEA 210 site was 0.38 µg/m³ for the June to December 2005 monitoring period.
- **Mobile Monitoring:** During the Cold Lake, Bonnyville and Elk Point AENV mobile air monitoring survey, the maximum 1-hour NO_2 concentration measured in the region was 26.3 µg/m³ near an existing industrial facility. The median 1-hour NO_2 concentration during this survey was 5.6 µg/m³. The maximum 1-hour NO and NO_X concentrations observed were 46.6 µg/m³ and 88.4 µg/m³, respectively (AENV 2002). During the Lakeland mobile air monitoring survey, the maximum 1-hour NO_2 concentration measured in the region was 22.6 µg/m³. The median 1-hour NO_2 concentration during this survey was 3.8 µg/m³ (AENV 2005). For both surveys, the 1-hour NO_2 concentrations are below the AAAQO.

Table 2 Ambient Nitrogen Dioxide Concentrations at Cold Lake South

Station	1-Hour NO_2				24-Hour NO_2				Annual Average NO_2 [µg/m³]
	Mean [µg/m³]	95th Percentile [µg/m³]	Max. [µg/m³]	# >AAAQO[a][b]	Mean [µg/m³]	95th Percentile [µg/m³]	Max. [µg/m³]	# >AAAQO[a][c]	
Cold Lake South	7.3	27.3	70.8	0	7.3	23.0	41.6	0	8.1

[a] AAAQO = Alberta Ambient Air Quality Objective.

[b] The 1-hour AAAQO for NO_2 is 400 µg/m³.

[c] The 24-hour AAAQO for NO_2 is 200 µg/m³.

Table 3 Ambient Oxides of Nitrogen Concentrations at Cold Lake South

Station	1-Hour NO_X			24-Hour NO_X			Annual Average NO_X [µg/m³]
	Mean [µg/m³]	95th Percentile [µg/m³]	Max. [µg/m³]	Mean [µg/m³]	95th Percentile [µg/m³]	Max. [µg/m³]	
Cold Lake South	10.1	39.7	240.7	10.2	33.6	115.2	11.5

2.2.3 Hydrogen Sulphide Concentrations

Neither the LICA Cold Lake South continuous station nor the WBEA 210 station routinely monitor H_2S. There is, however, intermittent monitoring of H_2S that has been conducted as part of the AENV mobile air monitoring surveys.

During the Cold Lake, Bonnyville and Elk Point AENV mobile air monitoring survey, two hours of the data were above the 1-hour AAAQO of 14 µg/m³, with the maximum H_2S concentration recorded at 75.3 µg/m³. These concentrations were measured near an existing industrial facility. The 1-hour H_2S concentrations at the other monitoring locations surveyed were 4.2 µg/m³ or lower (AENV 2002).

During the Lakeland mobile air monitoring survey, the maximum 1-hour H_2S concentration measured in the region was 4.2 µg/m³ (AENV 2005). The overall median H_2S concentrations during this survey were below the detection limit of the instruments used.

2.2.4 Ozone Concentrations

The ambient air quality monitoring data for O_3 can be summarized as follows:

- **Continuous Monitoring**: The continuous 1-hour, 8-hour and annual O_3 monitoring data collected at the Cold Lake South monitoring station is summarized in Table 4. The maximum monitored 1-hour O_3 concentration is below the 1-hour AAAQO of 82 ppb. The maximum monitored 8-hour O_3 concentration is below the Canada-Wide Standard of 65 ppb.
- **Passive Monitoring**: The average monthly O_3 concentration for the WBEA 210 site was 19.30 ppb for the June to December 2005 monitoring period.
- **Mobile Monitoring**: During the Cold Lake, Bonnyville and Elk Point Alberta Environment mobile air monitoring survey, the maximum O_3 concentration measured in the region was 47 ppb. The overall median 1-hour O_3 concentration measured during this survey was 31 ppb (AENV 2002). During the Lakeland mobile air monitoring survey, the maximum 1-hour O_3 concentration measured in the region was 49 ppb. The median 1-hour measurement was 31 ppb (AENV 2005). The O_3 concentrations measured during the mobile air surveys are approximately 60% or less of the 1-hour AAAQO and are typical of concentrations found at other rural monitoring sites in Alberta.

Table 4 Ambient Ozone Concentrations at Cold Lake South

Station	1-Hour O_3				8-Hour O_3				Annual Average O_3 [ppb]
	Mean [ppb]	95th Percentile [ppb]	Max. [ppb]	# >AAAQO (a)(b)	Mean [ppb]	95th Percentile [ppb]	Max. [ppb]	# >CWS (c)(d)	
Cold Lake South	24.0	47.3	65.8	0	26.5	47.1	60.5	0	21.7

(a) AAAQO = Alberta Ambient Air Quality Objective.

(b) The 1-hour AAAQO for O_3 is 82 ppb.

(c) CWS = Canada wide standard.

(d) The 8-hour CWS for O_3 is 65 ppb.

2.2.5 Carbon Monoxide Concentrations

There is no continuous monitoring of CO at the LICA Cold Lake South station. There is also no passive monitoring of CO in the region, as passive CO monitors are not available. There is, however, intermittent CO monitoring data collected as part of the AENV mobile surveys.

During the Cold Lake, Bonnyville and Elk Point AENV mobile air monitoring survey, the maximum CO concentration measured in the region was 1.6 mg/m³. The overall median 1-hour CO concentration measured during this survey was 0.2 mg/m³ (AENV 2002). During the Lakeland mobile air monitoring survey, the maximum 1-hour CO concentration measured in the region was 1.0 mg/m³. The median 1-hour measurement recorded was 0.2 mg/m³ (AENV 2005). The CO concentrations measured during the mobile air surveys are well below the 1-hour AAAQO of 15 mg/m³.

2.2.6 Total Hydrocarbon Concentrations

The ambient air quality monitoring data for THC can be summarized as follows:

- **Continuous Monitoring**: The maximum 1-hour, 24-hour and annual THC concentrations, presented in Table 5, are 3.2, 2.2 and 1.3 mg/m^3, respectively.
- **Passive Monitoring**: Passive monitoring of THC is not technically feasible.
- **Mobile Monitoring**: During the Cold Lake, Bonnyville and Elk Point areas mobile air monitoring survey, the maximum THC concentration measured in the region was 6.4 mg/m³. The median THC concentration measured during this survey was 1.4 mg/m³ (AENV 2002). During the Lakeland mobile air monitoring survey, the maximum 1-hour THC concentration measured in the region was 4.7 mg/m³. The median THC concentration measured was 1.7 mg/m³ (AENV 2005).

Table 5 Ambient Total Hydrocarbon Concentrations at Cold Lake South

Station	1-Hour THC			24-Hour THC			Annual Average THC [mg/m³]
	Mean [mg/m³]	95th Percentile [mg/m³]	Max. [mg/m³]	Mean [mg/m³]	95th Percentile [mg/m³]	Max. [mg/m³]	
Cold Lake South	1.3	1.7	3.2	1.3	1.6	2.2	1.3

2.2.7 Total Reduced Sulphur Concentrations

The ambient air quality monitoring data for TRS can be summarized as follows:

- **Continuous Monitoring**: The maximum 1-hour, 24-hour and annual TRS concentrations, presented in Table 6, are 12.0, 2.0 and 0.6 µg/m³, respectively.

- **Passive Monitoring:** Passive monitoring of TRS was not conducted in the region as this type of monitoring is not technically feasible.
- **Mobile Monitoring**: During the Cold Lake, Bonnyville and Elk Point mobile air monitoring survey, the maximum TRS concentration measured in the region was 78 µg/m³. The overall median TRS concentration measured was 1.4 µg/m³ (AENV 2002). During the Lakeland mobile air monitoring survey, the maximum 1-hour TRS concentration measured in the region was 4.2 µg/m³. The overall median TRS concentration was below the lower detection limit of the instruments (AENV 2005).

Table 6 Ambient Total Reduced Sulphur Concentrations at Cold Lake South

Station	1-Hour TRS			24-Hour TRS			Annual Average TRS [µg/m³]
	Mean [µg/m³]	95th Percentile [µg/m³]	Max. [µg/m³]	Mean [µg/m³]	95th Percentile [µg/m³]	Max. [µg/m³]	
Cold Lake South	0.5	1.0	12.0	0.5	0.9	2.0	0.6

2.2.8 Particulate Matter

The ambient air quality monitoring data for $PM_{2.5}$ can be summarized as follows:

- **Continuous Monitoring**: As shown in Table 7, the maximum 1-hour monitored concentration of 80.5 µg/m³ is above the 1-hour AAAQO of 80 µg/m³on one occasion, while the maximum 24-hour monitored concentration of 21.6 µg/m³ is below the AAAQO of 30 µg/m³. The 98th percentile 24-hour concentration monitored is below the Canada-Wide Standard of 30 µg/m³.
- **Passive Monitoring:** Passive monitoring of $PM_{2.5}$ has not been conducted in the region because this type of monitoring is not available for $PM_{2.5}$.
- **Mobile Monitoring**: During the Cold Lake, Bonnyville and Elk Point AENV mobile air monitoring survey, the maximum 1-hour $PM_{2.5}$ concentration measured was 72 µg/m³, which is below the AAAQO. The overall median 1-hour $PM_{2.5}$ concentration in this survey was 2 µg/m³ (AENV 2002). During the Lakeland mobile air monitoring survey, the maximum 1-hour $PM_{2.5}$ concentration measured in the region was 127 µg/m³, which is above the AAAQO. There was only one 1-hour event that exceeded the AAAQO The median $PM_{2.5}$ concentration was 1 µg/m³ (AENV 2005).

Table 7 Ambient $PM_{2.5}$ Concentrations at Cold Lake South

Station	1-Hour $PM_{2.5}$			24-Hour $PM_{2.5}$					Annual Average $PM_{2.5}$ [µg/m³]
	Mean [µg/m³]	Max. [µg/m³]	# > AAAQO	Mean [µg/m³]	Max. [µg/m³]	98th Percentile [µg/m³]	# > AAAQO	# >CWS	
Cold Lake South	3.4	80.5	1	3.4	21.6	10.0	0	0	3.0

AAAQO = Alberta Ambient Air Quality Objective.
The 1-hour AAAQO for PM2.5 is 80 µg/m³.
The 24-hour AAAQO for PM2.5 is 30 µg/m³.

2.3 MONITORING OF ACID-FORMING COMPOUNDS

Acid deposition includes both wet and dry processes and can result in the long-term accumulation of compounds in aquatic and terrestrial ecosystems. Wet processes involve the removal of emissions released into the atmosphere by precipitation. Dry processes involve the removal by direct contact with surface features (e.g., vegetation). Both wet and dry deposition values are expressed in units of mass per area per year (e.g., kg/ha/yr). The deposition of sulphur and nitrogen compounds to the environment has been associated with changes in water and soil chemistry, and with the acidification of water and soil.

The CASA acid deposition management framework (CASA 1999) recommends using Potential Acid Input (PAI) as the method for evaluating the level of acidic deposition from existing, approved and planned operations. Potential acid input has become the preferred measure of acidic input for AENV, since it incorporates the effects of both nitrogen and sulphur species, in both dry and wet forms, as well as the effect of base cations in mitigating acidity. Potential Acid Input is expressed in units of kilo-equivalent per area per time (e.g., keq/ha/yr).

2.3.1 Wet Deposition and Potential Acid Input (PAI_{wet})

The level of acidification caused by rain (PAI_{wet}) depends on a balance between the amount of acid forming compounds (e.g., SO_4^{2-}, NO_3^- and NH_4^+) and the available cations (e.g., magnesium (Mg^{2+}), calcium (Ca^{2+}) and potassium (K^+)) in the precipitation.

The average wet potential acidic input (PAI_{wet}) observed in Cold Lake was 0.07 keq/ha/yr (Suncor 1998a). Regional data (Table 8) indicates a range of 0.00 to 0.09 keq/ha/yr and an average background-level of PAI_{wet} of 0.040 keq/ha/yr (Suncor 1998a).

Table 8 Wet Potential Acid Input (PAI_{wet}) Observations

Site	Observed Wet PAI [keq/ha/yr]				
	1993	1994	1995	1996	Average
Beaverlodge	0.05	0.09	0.07	0.06	0.07
Fort Chipewyan	0.00	-	0.01	-	0.01
Fort McMurray	0.08	0.06	0.10	0.09	0.08
Fort Vermilion	0.02	0.03	0.00	-	0.02
High Prairie	0.03	-	-	-	0.03
Vegreville	-	0.11	0.05	0.10	0.09
Cree Lake	0.00	0.00	0.00	0.00	0.00
Snare Rapids	0.03	0.03	0.03	0.05	0.04
Average[(a)]	**0.03**	**0.05**	**0.04**	**0.06**	**0.04**
Cold Lake	-	0.07	0.05	0.09	0.07

(a) The average wet deposition was calculated excluding the data from Cold Lake.

- = No data available.

2.3.2 Dry Deposition and Potential Acid Input (PAI_{dry})

The contribution of dry deposition mechanisms to acidification is calculated in a similar manner to that of wet deposition. The average concentration of acid-forming compounds (e.g., SO_2, SO_4^{2-}, HNO_3, NO_3^- and NH_4^+) and the available cations (e.g., Mg^{2+}, Ca^{2+} and K^+) are converted into dry deposition rates by multiplying by an appropriate deposition velocity.

2.3.3 Existing Concentrations of Sulphur Compounds

The primary contributors to dry PAI are SO_2 and SO_4^{2-}. There are limited locations where reliable annual average concentration measurements are collected. Available data are presented in Table 9 (Suncor 1998b). The SO_2 air concentration of 1.2 µg/m³ is much larger than the Environment Canada value of 0.25 µg/m³ assumed for the Cheng et al. (1997) western Canadian modelling study.

Table 9 Existing Sulphur Dioxide and Sulphate Concentrations

Site	SO_2		SO_4^{2-}
	[µg/m³]	[ppb]	[µg/m³]
Hightower Ridge (1986)	1.1	0.41	0.58
Fortress Mountain (1985 to 1987)	1.4	0.51	0.51
Cree Lake (1988 to 1995)	1.2	0.45	0.99
Average	**1.2**	**0.46**	**0.69**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

2.3.4 Existing Concentrations of Nitrogen Compounds

Nitrate equivalent includes NO, NO_2, HNO_3, NH_4^+ and NO_3^-. Background values for some of these components are available from the same sites as the sulphate data listed in Table 9. The average values were adopted for the Oil Sands Region. There are no direct measurements available for NO and NO_2. Ridley (1991) suggests that NO and NO_2 are typically 10% of total nitrate equivalent; however, the values in Table 10 have not been adjusted to account for this (Suncor 1998b).

Table 10 Existing Nitric Acid, Ammonia and Nitrate Concentrations

Location	HNO_3		NH_4^+	NO_3^-
	[µg/m³]	[ppb]	[µg/m³]	[µg/m³]
Hightower Ridge (1986)	0.10	0.27	0.18	0.09
Fortress Mountain (1985 to 1987)	0.11	0.31	-	0.13
Cree Lake (1988 to 1995)	0.06	0.15	0.20	0.05
Average	**0.10**	**0.23**	**0.19**	**0.09**

- = No data available.

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

2.3.5 Existing Concentrations of Base Cations

Data on base cation deposition is limited. The approach adopted by Environment Canada has been to infer base cation deposition rates from precipitation chemistry. This approach is based on the work of Draaijers et al. (1997). Additional base cation values were available from Legge and Krupa (1990).

A summary of base cation concentrations for selected sites in the areas surrounding the study is given in Table 11 (Suncor 1998b).

Table 11 Existing Base Cation Concentrations

Location	Ca^{2+}		Mg^{2+}		K^+	
	[mg/L]	[µg/m³]	[mg/L]	[µg/m³]	[mg/L]	[µg/m³]
Cree Lake (1983 to 1992)	0.068	0.10	0.015	0.026	0.028	0.071
Snare Rapids (1989 to 1996)	0.047	0.07	0.010	0.018	0.023	0.058
Fort Chipewyan (1992 to 1996)	0.258	0.39	0.076	0.063	0.082	0.207
Fort McMurray (1992 to 1996)	0.237	0.36	0.058	0.102	0.034	0.086
Fort Vermillion (1990 to 1993)	0.160	0.25	0.020	0.035	0.090	0.227
High Prairie (1990 to 1993)	0.210	0.32	0.030	0.053	0.110	0.277
Cold Lake (1990 to 1993)	0.140	0.21	0.030	0.053	0.050	0.126
Birch Mountain (1976)	-	0.026	-	0.021	-	0.024
Fort Smith (1970)	-	0.033	-	-	-	0.044

- = No data available.

3 CLIMATE OF THE OIL SANDS REGION

The climate of a region is defined as the average meteorological conditions, including wind, temperature and precipitation, measured over a period of many years. The Project is located in the Oil Sands Region which is generally described as having a cool, continental climate. This section summarizes the range of temperatures, precipitation and wind patterns for the Oil Sands Region.

Three Environment Canada stations were selected to represent the range of climate conditions in the Oil Sands Region: Fort Chipewyan (north), Fort McMurray (central) and Cold Lake (south). Tables 12 through 14 show the 1971 to 2000 climate normals for Fort Chipewyan, Fort McMurray and Cold Lake, respectively.

The meteorological data used for the air quality assessment and how it compares to average conditions is presented in Appendix 3-II.

3.1 WIND

Figure 2 presents the average wind patterns observed at Fort Chipewyan, Fort McMurray and Cold Lake from 1971 to 2000. Wind direction and speed data can be displayed by plotting the frequency distribution as a “windrose”. The windrose is comprised of bars, the length of which indicates the frequency the wind blows from a given direction. Wind direction information is displayed for the 16 points of a compass. The windrose also indicates the frequency of wind speed for each of the 16 compass points.

Similar wind patterns are observed at Fort Chipewyan, Fort McMurray and Cold Lake. There is a general east-west wind pattern at all stations; however, east-northeasterly winds are observed more frequently at Fort Chipewyan, while east-south-easterly winds are observed more frequently at Fort McMurray. Calm conditions occur 16% of the time at Fort Chipewyan, 17% of the time at Fort McMurray and 13% of the time at Cold Lake.

Table 12 Fort Chipewyan Climate Normals (1971 to 2000)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature													
daily average (°C)	-23.2	-19.3	-11.8	-0.1	+8.6	+14.2	+16.7	+14.8	+8.2	+0.8	-11.3	-20.5	-1.9
daily maximum (°C)	-17.6	-13.3	-5.0	+5.8	+14.8	+20.2	+22.6	+20.7	+13.3	+5.1	-6.8	-15.2	+3.7
daily minimum (°C)	-28.7	-25.2	-18.6	-6.0	+2.4	+8.1	+10.7	+8.9	+3.2	-3.5	-15.7	-25.8	-7.5
extreme maximum (°C)	+10.5	+11.0	+14.5	+27.1	+32.0	+34.4	+34.0	+34.0	+29.0	+26.5	+17.0	+8.8	-
extreme minimum (°C)	-50.0	-46.7	-43.5	-34.1	-10.6	-4.0	-0.9	-4.2	-12.2	-30.0	-39.0	-47.8	-
Precipitation													
rainfall (mm)	0.2	0.2	0.1	4.6	22.7	51.7	70.8	47.6	36.7	16.8	0.9	0.1	252.4
snowfall (cm)	20.0	16.4	18.3	14.1	2.6	0.0	0.0	0.0	1.7	17.1	30.4	24.6	145.2
total precipitation (mm)	19.3	15.7	17.8	18.5	25.3	51.7	70.8	47.6	38.4	34.0	29.1	23.7	391.9
extreme daily total precipitation (mm)	14.2	18.6	16.3	19.3	35.6	71.8	47.2	30.2	42.0	32.5	23.0	14.8	-
days with precipitation >0.2 mm	13.1	10.0	8.8	6.2	7.7	11.3	13.5	13.0	12.1	11.6	14.7	12.7	134.7
Wind													
average speed (km/h)	n/a	9.3	10.2	11.5	13.3	11.5	10.6	9.9	10.7	n/a	9.5	9.2	n/a
most frequent direction	n/a	NE	NE	NE	NE	NE	W	W	W	n/a	W	W	n/a

n/a = Not available.

- = Not applicable.

Source: Environment Canada (2006), Website.

Table 13 Fort McMurray Climate Normals (1971 to 2000)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature													
daily average (°C)	-18.8	-13.7	-6.5	+3.4	+10.4	+14.7	+16.8	+15.3	+9.4	+2.8	-8.5	-16.5	+0.7
daily maximum (°C)	-13.6	-7.6	0.3	+10.0	+17.4	+21.4	+23.2	+21.9	+15.4	+7.8	-4.2	-11.6	+6.7
daily minimum (°C)	-24.0	-19.8	-13.2	-3.3	+3.3	+7.9	+10.2	+8.6	+3.3	-2.2	-12.8	-21.4	-5.3
extreme maximum (°C)	+13.1	+15.0	+18.9	+30.2	+34.8	+36.1	+35.6	+37.0	+32.4	+28.6	+18.9	+10.7	-
extreme minimum (°C)	-50.0	-50.6	-44.4	-34.4	-13.3	-4.4	-3.3	-2.9	-15.6	-24.5	-37.8	-47.2	-
Precipitation													
rainfall (mm)	0.5	0.8	1.6	9.3	34.2	74.8	81.3	72.6	45.0	18.8	2.4	1.1	342.2
snowfall (cm)	27.0	20.6	20.4	14.5	2.9	0.0	0.0	0.0	2.4	13.1	29.0	25.9	155.8
total precipitation (mm)	19.3	15.0	16.1	21.7	36.9	74.8	81.3	72.7	46.8	29.6	22.2	19.3	455.5
extreme daily total precipitation (mm)	16.0	13.2	29.7	26.8	39.4	50.0	52.5	94.5	60.5	29.4	15.7	22.6	-
days with precipitation >0.2 mm	12.3	10.3	9.2	8.1	10.9	14.1	15.8	13.5	12.6	11.1	12.2	12.4	142.6
Wind													
average speed (km/h)	8.4	9.1	9.6	10.9	10.8	9.7	9.0	8.7	9.7	10.5	9.0	8.6	9.5
most frequent direction	E	E	E	E	E	E	SW	SW	E	E	E	E	E

- = Not applicable.

Source: Environment Canada (2006), Website.

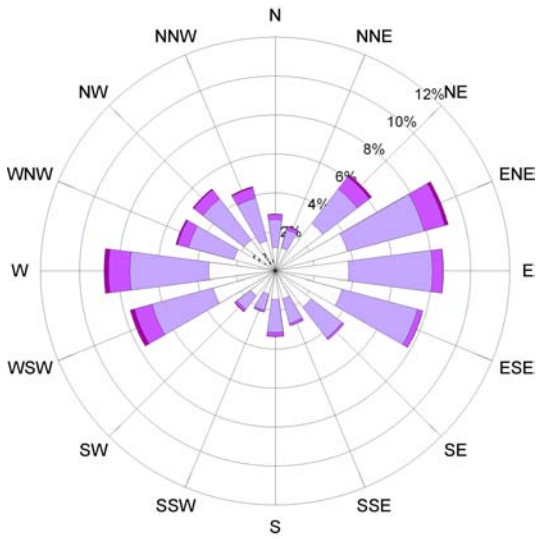
Table 14 Cold Lake Climate Normals (1971 to 2000)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature													
daily average (°C)	-16.6	-12.4	-5.3	+4.1	+10.7	+14.8	+16.9	+15.8	+10.0	+4.0	-6.7	-14.6	+1.7
daily maximum (°C)	-11.4	-6.7	+0.5	+10.1	+17.2	+20.9	+22.9	+22.0	+15.9	+9.2	-2.6	-9.9	+7.3
daily minimum (°C)	-21.7	-18.0	-11.0	-1.9	+4.1	+8.7	+11.0	+9.6	+4.1	-1.3	-10.8	-19.1	-3.9
extreme maximum (°C)	+10.6	+14.1	+17.9	+29.4	+32.5	+35.6	+36.1	+36.1	+32.8	+27.4	+18.9	+10.0	-
extreme minimum (°C)	-48.3	-42.8	-41.1	-34.4	-7.8	-3.3	0.0	-1.5	-9.4	-23.5	-36.7	-44.4	-
Precipitation													
rainfall (mm)	0.6	0.4	1.2	14.2	37.6	72.1	77.4	67.6	38.4	10.6	1.5	0.9	322.4
snowfall (cm)	22.9	16.4	16.8	11.7	4.2	0.0	0.0	0.1	1.6	7.0	24.5	24.7	130.0
total precipitation (mm)	17.9	12.4	15.1	24.9	41.7	72.1	77.4	67.8	39.9	17.5	20.1	19.9	426.6
extreme daily total precipitation (mm)	20.8	10.8	22.8	42.4	44.4	93.7	52.8	50.8	46.7	39.9	30.5	15.2	-
days with precipitation >0.2 mm	11.0	8.1	7.1	7.8	10.2	13.2	14.6	12.7	10.6	7.9	9.3	10.8	123.2
Wind													
average speed (km/h)	9.1	9.9	10.7	12.7	12.7	11.9	11.0	10.2	11.3	11.7	10.1	9.4	10.9
most frequent direction	SW	SW	SW	E	NE	W	W	W	W	W	SW	SW	W

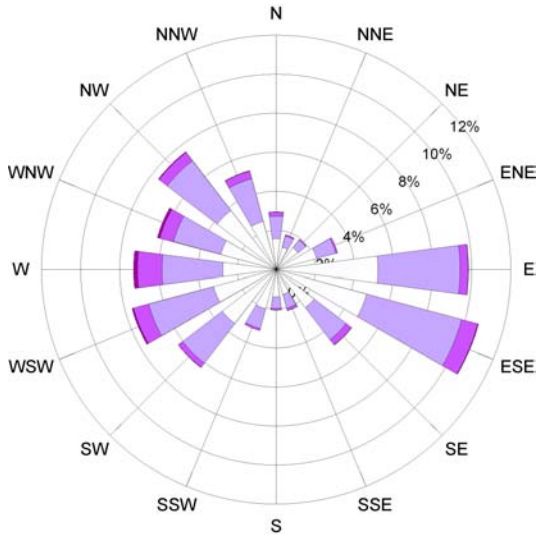
- = Not applicable

Source: Environment Canada (2006), Website.

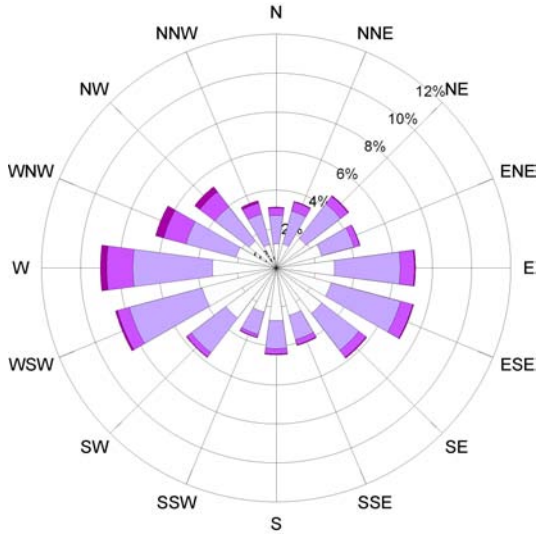
FORT CHIPEWYAN

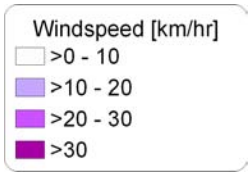


FORT McMURRAY



COLD LAKE





PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

FORT CHIPEWYAN, FORT McMURRAY AND COLD LAKE WINDROSES

MEG ENERGY CORP.

PROJECT 07.1346.0009.8000			FILE No.	Windroses
DESIGN	MS	31/01/08	SCALE AS SHOWN	REV. 0
CADD	PSR	05/02/08		
CHECK	MS	05/02/08		
REVIEW	IGG	07/04/08		

FIGURE: 2

3.2 TEMPERATURE

Figure 3 provides a comparison of the observed long-term average monthly temperatures at Fort Chipewyan, Fort McMurray and Cold Lake. Similar temperatures are observed at all stations during the summer months. The average temperature in July is +17°C. There are greater differences during the winter months when Fort Chipewyan is about 4°C cooler than Fort McMurray and Cold Lake is about 2°C warmer than Fort McMurray. The lowest winter temperatures occur in January when the averages are -23°C at Fort Chipewyan, -19°C at Fort McMurray and -17°C at Cold Lake. The average annual temperature is -1.9°C at Fort Chipewyan, +0.7°C at Fort McMurray and +1.7°C at Cold Lake.

3.3 PRECIPITATION

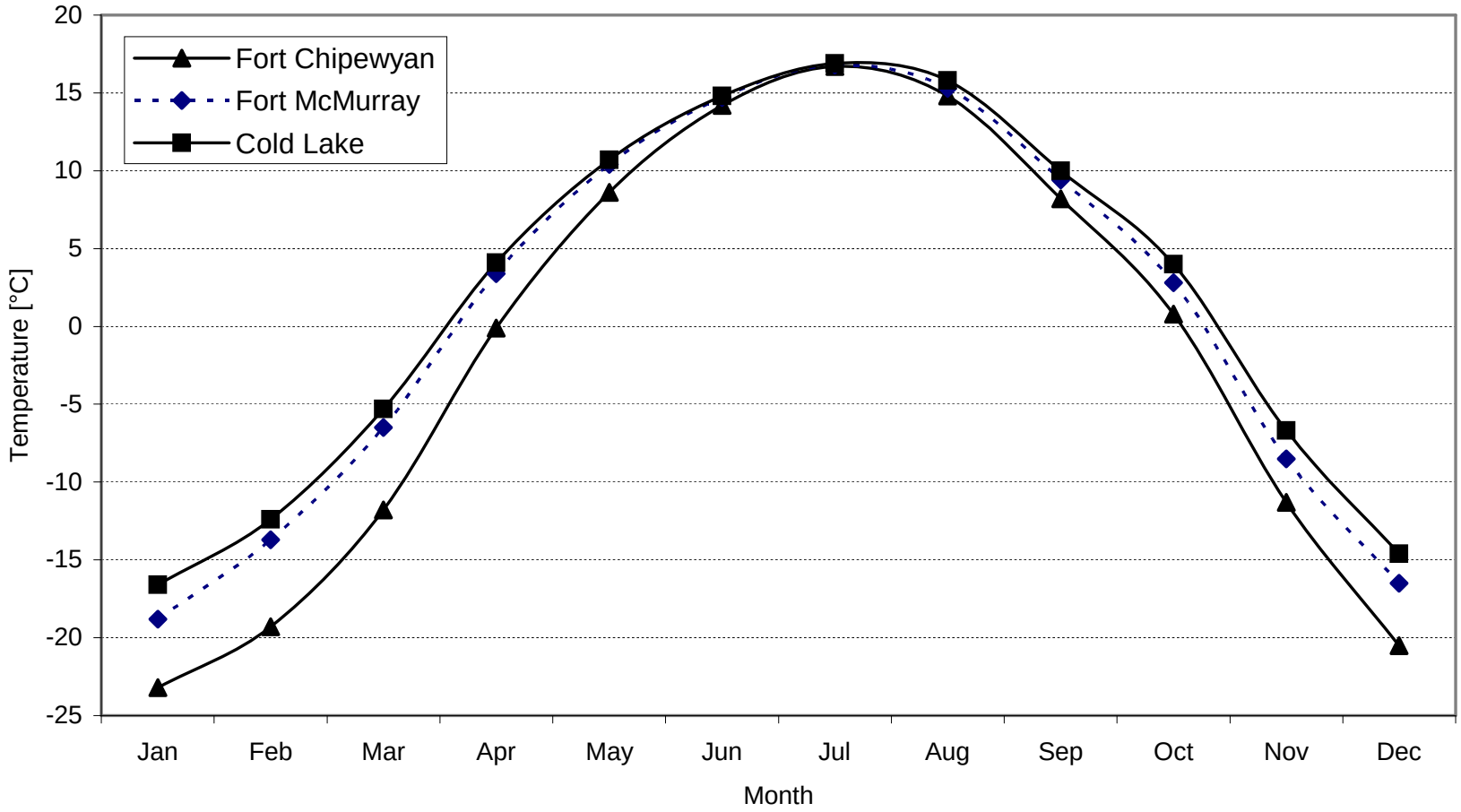
Figure 4 shows the average monthly precipitation at Fort Chipewyan, Fort McMurray and Cold Lake. The three stations show the same seasonal pattern where most of the precipitation occurs during May to September. Fort McMurray and Cold Lake receive about 70% of the annual precipitation during the summer months while Fort Chipewyan receives about 60%.

Table 15 presents the average annual precipitation for the three stations. Typically, Fort McMurray receives more rain and snow than Fort Chipewyan or Cold Lake. Fort Chipewyan receives about 64 mm less precipitation annually compared to Fort McMurray and about 35 mm less than Cold Lake.

Table 15 Regional Average Precipitation (1971 to 2000) – Oil Sands Region

Station	Rain [mm]	Snow [cm]	Total Precipitation [mm]
Fort Chipewyan	252.4	145.2	391.9
Fort McMurray	342.2	155.8	455.5
Cold Lake	322.4	130.0	426.6

Source: Environment Canada (2006), Website.



PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

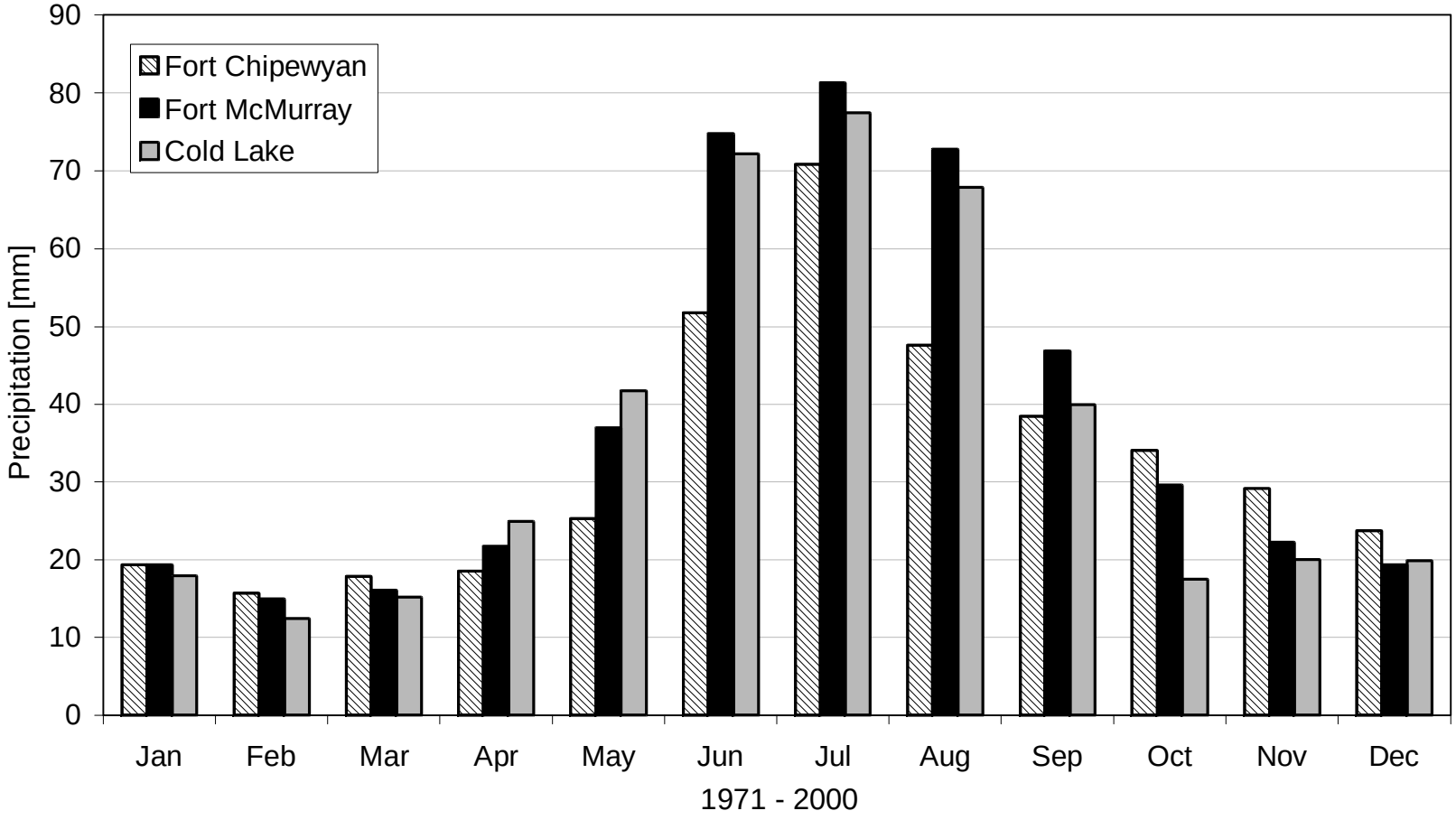
TITLE

MONTHLY AVERAGE TEMPERATURE (1971 TO 2000) - OIL SANDS REGION

MEG ENERGY CORP.

PROJECT 07.1346.0009.8000			FILE No. Average Month-Temp	
DESIGN	MS	31/01/08	SCALE AS SHOWN	REV. 0
CADD	TRE	31/01/08		
CHECK	MS	31/01/08		
REVIEW	IGG	07/04/08		

FIGURE: 3



PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

MONTHLY AVERAGE PRECIPITATION (1971 TO 2000) - OIL SANDS REGION

MEG ENERGY CORP.

PROJECT 07.1346.0009.8000			FILE No. AverageMonth-Precip	
DESIGN	MS	31/01/08	SCALE AS SHOWN	REV. 0
CADD	TRE	31/01/08	**FIGURE: 4**	
CHECK	MS	31/01/08		
REVIEW	IGG	07/04/08		

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