AIR QUALITY

Fort McKay
Specific Assessment

Fort McKay
Industry Relations Corporation

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2.1 Fort McKay Key Concerns Related to Air Quality

2.1.1 Introduction

The effects of industrial air emissions on air quality and related health, environmental and quality of life is one the major concerns Fort McKay has regarding the existing, approved and planned oil sands developments in the region. These concerns relate to air quality in the Community of Fort McKay and also on and adjacent to the Community's Treaty Land Entitlement and Traditional Lands. Changes to air quality as a result of increased oil sands activities in the region have already had adverse impacts on Community members' quality of life and their enjoyment and use of the land. The air quality issues of particular concern to Fort McKay are:

- Deterioration of general air quality in the Community and potential associated adverse health effects;
- Odours, which are currently a major problem in the Community, and the adverse impact of odours on quality of life, regional wildlife and the enjoyment and use of Traditional Lands; and
- Potential adverse effects that are, either directly or indirectly, associated with air contaminant levels and deposition on regional vegetation and ecosystems within Fort McKay's Treaty Land Entitlement and Traditional Lands.

The following is a brief elaboration of each of these key concerns related to air quality. A more detailed discussion of each topic follows in Section 2.3.

2.1.2 Air Quality Deterioration and Health Concerns

Fort McKay's air quality has been adversely affected by existing regional oil sands air emissions as evidenced by continuous air quality monitoring data. The difference between estimated pre-development air quality and current air quality in the Community is shown in Table 2-1 and graphed in Figure 2-1 and Figure 2-2. Understanding pre-development and current air quality is important if the significance of past and possible future air quality changes is to be assessed.

In addition to the erosion of what was 'pristine' air quality, a major current and future concern is that adverse impacts will increase as industrial development increases. Currently, air quality in Fort McKay is generally only affected by regional industrial emissions when the wind is from the SW to SE (influence from Syncrude Base Mine operations and Suncor's Base Mine, Millennium and Steepbank Mine operations)

Table 2-1: Current vs. Pre-Development Air Quality in Fort McKay

Parameter	Pre-Development Air Quality[1]		Current Air Quality[2]	
	Annual Average (µg/m³)	Maximum 1 Hour (µg/m³)	Annual Average (µg/m³)	Maximum 1 Hour (µg/m³)
Sulphur Dioxide (SO_2)	0.9	3.2	3.9	481
Nitrogen Dioxide (NO_2)	5.5	23.1	13.2	99.7
Particulate Matter ($PM_{2.5}$)[3]	7.8	25.9	6.6	203.5

[1]Golder (2009)

[2]CASA Data Warehouse (***http://www.casadata.org/Reports/casareports_2.asp?PGID=1&RType=B6&Source=&CID=&ColTypes=1&CFlag=0&SFlag=2&PFlag=1&DFlag=3***) accessed June 15, 2009. Values are highest in period 1999 to 2008 inclusive

[3]PM values need to be interpreted with caution as forest fires can significantly affect levels

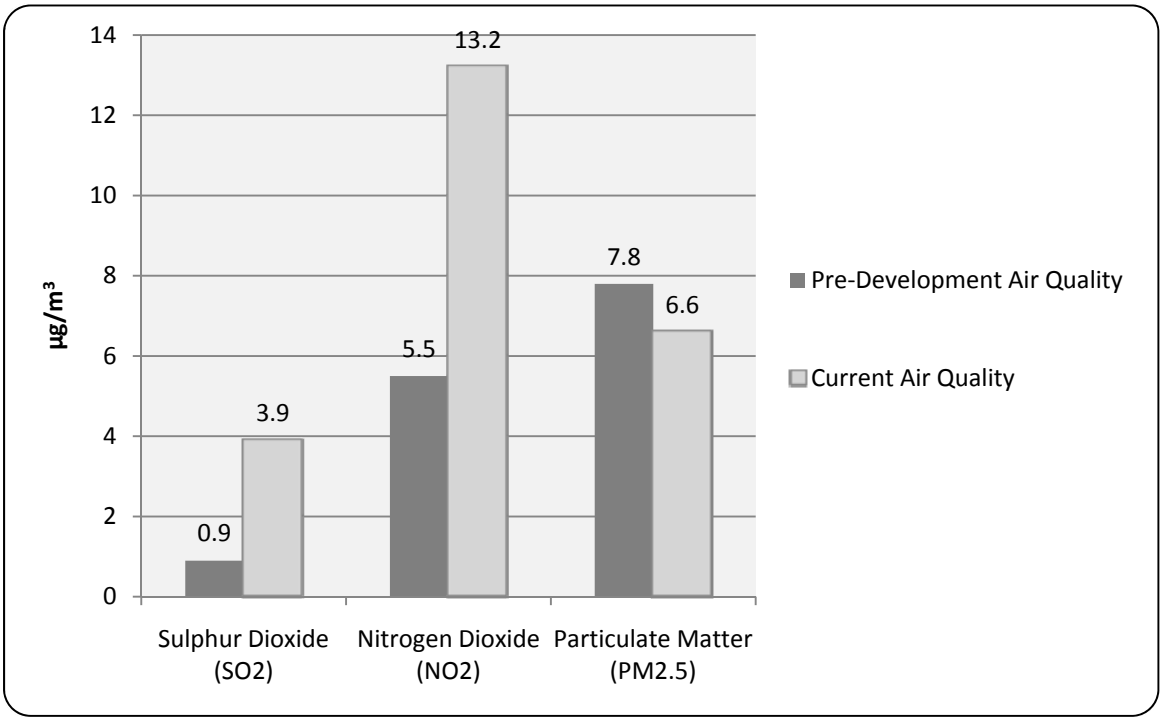


Figure 2-1: Current vs. Pre-Development (PD) Annual Average Air Quality in Fort McKay (SO_2, NO_2 and $PM_{2.5}$)

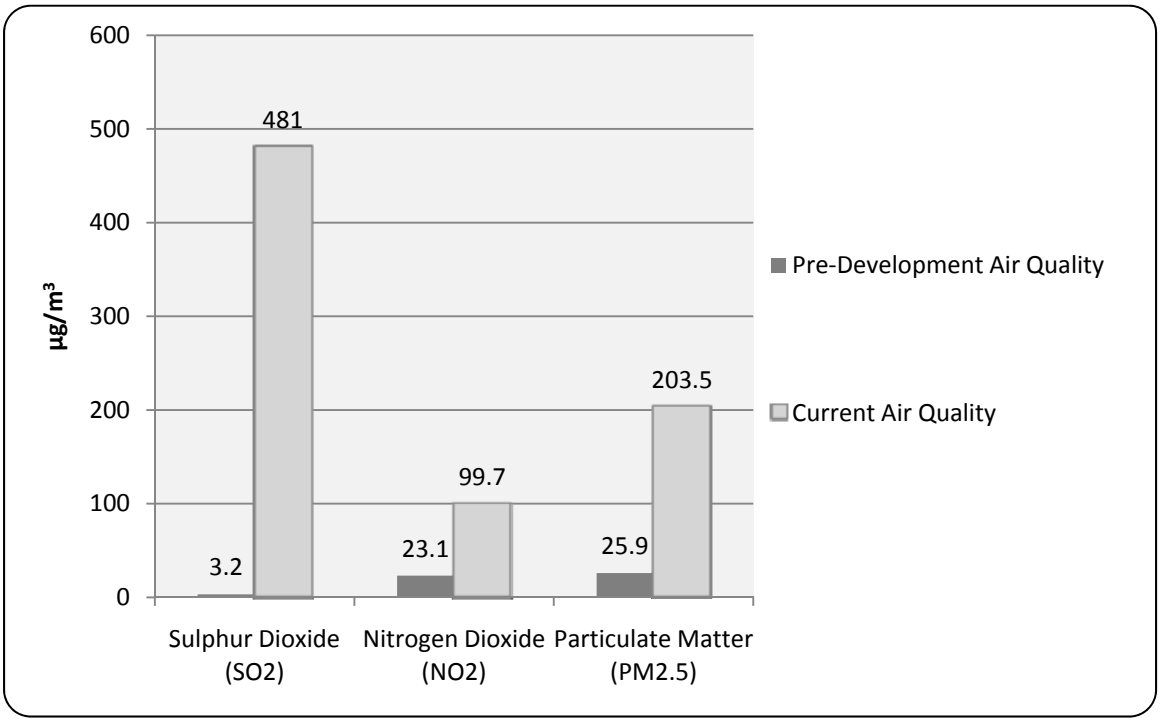


Figure 2-2: Current vs. Pre-Development (PD) Air Quality in Fort McKay (Maximum Hourly Values - SO_2, NO2 and $PM_{2.5}$)

and from the NE (influence from Syncrude Aurora North and Shell Albian and Jackpine Mines). As oil sands development occurs to the north (Suncor Fort Hills and the proposed Shell Pierre River Mine projects) and to the NW to W (CNRL Horizon project, which is currently being commissioned; and the proposed Total Joslyn North Mine project), air quality in Fort McKay will be progressively impacted by oils sands development emissions regardless of wind direction.

Fort McKay has consistently raised air emission- and air quality-related concerns in its reviews of proposed new or expanded oil sands development projects, in meetings with industry and government as well as at multi-stakeholder forums. These concerns have focused on the need for better emission controls to minimize the impacts that industrial developments have on regional air quality.

Fort McKay has also highlighted the need to assess air emission-related project impacts using ambient air quality objectives that are health based in order to provide a high level of health protection to the Community. Being in the vicinity of these proposed projects, the Community is extremely vulnerable to any adverse effects brought about by development and being the closest community to the major mining and upgrading projects it is the most at risk from air emission-related impacts.

In this assessment, the Community's focus is on:

- protecting air quality in Fort McKay through rigorous emissions management,
- the use of health-based air quality criteria to assess emission impacts, and
- the application of the principle of "Keeping Clean Areas Clean".

The air quality parameters specifically addressed are:

- sulphur dioxide (SO_2),
- nitrogen dioxide (NO_2), and
- particulate matter less than 2.5 microns in size ($PM_{2.5}$).

These parameters were selected because they are emitted by oil sands industrial operations and are substances that have potential health impacts. Ambient levels of these air contaminants in the Community are occasionally high and/or are predicted to increase in the future. They are parameters that are being monitored in the Community therefore good records of information on levels and trends are available. These substances also provide a good general indicator of past and possible future trends in air quality in the Community. Well-defined and researched health-based criteria also exist for each of these substances.

Fort McKay recognizes that its air quality will be impacted by regional industrial oil sands development. However, the ***goal and expectation*** of Fort McKay is that:

- in general, the Community's air quality will be maintained as closely as possible to natural levels, and
- in particular, the Community's air quality must always be below health-based criteria or health-effects levels.

2.1.3 Odour Concerns

Odours are a major problem in, and concern to, the Community of Fort McKay, which frequently experiences detectable levels of odour. These odours affect quality of life and also raise concerns regarding the possible health effects associated with both the substances causing the odour and other non-odourous air contaminants that might also be present.

The concerns regarding odours have been heightened by periodic extreme events in the Community that have made people ill. For example, Syncrude's flue gas desulphurization start-up problems in the spring of 2006 (AENV 2006) and Syncrude's diverter stack use event (Syncrude 2009) in February 2009 both resulted in emissions that created severe odours in Fort McKay. In particular, the spring 2006 event resulted in some students going to the hospital for treatment.

Odours are also prevalent in many areas of Fort McKay's Traditional Lands, generally near development sites. This adversely affects Community members' use

and enjoyment of the land and erodes quality of life. Odour occurrences also raise concerns amongst Community members regarding the impact that these odours might have on wildlife in terms of their availability and quality as a food source (e.g., do they move away, and are they healthy and suitable for human consumption?). Further, the Community of Fort McKay has a strong spiritual connection to the land, wildlife and vegetation, and odours are a persistent reminder that the land is being contaminated.

The subjective nature of odours, the difficulty in setting or determining a single representative odour threshold for compounds, and the difficulty in predicting the response to a complex mixture of odourous substances, combine to make quantitative odour assessment and management challenging. Fort McKay's focus in its assessment of odours is based on reduced sulphur compounds, such as hydrogen sulphide (H_2S) and certain hydrocarbons, as these are the two major classes of odourous compounds associated with oil sands developments.

The ***goal and expectation*** of Fort McKay is that:

- there should be no detectable odours in the Community under normal industrial operating conditions,
- odour episodes under industrial upset conditions are of short duration and do not create a severe nuisance problem and never represent a health risk, and
- odours on Fort McKay Traditional Lands outside development areas are very infrequent.

2.1.4 Air-Related Impacts on Vegetation and Ecosystems

Industrial air emissions have the potential to adversely impact vegetation and terrestrial ecosystems through:

- direct (fumigation) effects on vegetation,
- through fertilization, and/or
- alteration of the systems that support vegetation growth such as soils.

Fort McKay is concerned that areas that are not directly affected by land disturbance might be subject to one or more of these air-related impacts such as acidification and eutrophication/fertilization. The Community wants to ensure that vegetation and ecosystems on its Traditional Lands are protected from such impacts so that it can continue to use and enjoy at least a portion of its Traditional Lands in its natural state.

Considerable work has been done in the region by the Cumulative Environmental Management Association (CEMA) and the Wood Buffalo Environmental Association (WBEA) to develop management frameworks and monitoring programs to address

at least some of these potential air-related impact issues. Fort McKay has been an active participant in this work and is generally satisfied that a number of the air-vegetation impact issues are being adequately addressed.

There are some regional air-vegetation issues, however, that are not being addressed. Also the use of a large regional study area (RSA) has the effect of minimizing the relative areas of impact, which are generally all on Fort McKay's Traditional Lands. Impacts on vegetation and ecosystems are therefore more significant when viewed from a traditional land's perspective and when these impact areas are added to the large, direct, and often total destruction associated with surface mining operations – all of which are currently occurring on Fort McKay's Traditional Lands.

Fort McKay's assessment of air-vegetation impacts considers the following air contaminants and/or air-related effects:

- ***Sulphur Dioxide (SO_2)*** – direct adverse effects of SO_2 concentrations in the air on vegetation,
- ***Nitrogen Oxides (NO and NO_2)*** – direct adverse effects of NO and/or NO_2 concentrations in the air on vegetation,
- ***Ammonia (NH_3)*** – direct adverse effects of NH_3 concentrations in the air on vegetation,
- ***Ozone (O_3)*** – direct adverse effects of O_3 concentrations in the air on vegetation,
- ***Nitrogen Deposition*** – the eutrophication/fertilization effects of nitrogen deposition associated with NO, NO_2, HONO, HNO_3, NH_3, NH_4NO_3, $(NH_4)_2SO_4$ and other nitrogen species on the health of vegetation and species composition in the ecosystems within Fort McKay's Traditional Lands, and
- ***Acid Deposition*** – the effect of acid deposition on soils (e.g., pH, base saturation and base cation to aluminium ratios), and the subsequent impacts on plant and soil fauna communities supported by these soils.

These potential air-vegetation issues are considered to represent the most likely and/or significant potential impacts of regional industrial air emissions on vegetation and ecosystems on Fort McKay's Traditional Lands.

The ***goal and expectation*** of Fort McKay is that air emissions from industrial operations will not have an adverse effect on the vegetation and ecosystems on its Traditional Lands, except perhaps in very small areas adjacent to development sites where adverse effects are likely unavoidable.

2.2 Fort McKay Specific Assessment Approach

2.2.1 Introduction

2.2.1.1 Focus

Fort McKay's approach to assessing air-related issues and impacts focuses on only those issues that are of particular concern to the Community. As noted in Section 2.1, these issues are:

- ***Air Quality*** - the general deterioration of air quality in the Community and potential associated adverse health effects,
- ***Odours*** – emission related odours in the community and on Traditional Lands and the adverse impact of these odours on quality of life, regional wildlife and the enjoyment and use of Traditional Lands, and
- ***Vegetation/Ecosystem Effects*** – the potential adverse effects, either directly or indirectly, associated with air contaminant exposure and/or deposition on regional vegetation and ecosystems within Fort McKay's Treaty Land Entitlement and Traditional Lands.

2.2.1.2 General Assessment Approach and Philosophy

The residents of Fort McKay, their Traditional Lands, and their use of their Traditional Lands, are adversely affected by regional development and associated regional air emissions. The assessment therefore attempts to address each of these three issues in a format and context that is scientifically rigorous yet meaningful to Community members. This approach allows Community members to better understand impacts specifically associated with the proposed project, as well as the cumulative effects brought about by regional development in general. This is essential in order for the Community to be able to provide input as to what they consider to be acceptable levels of development and/or impacts.

Of particular note is that Fort McKay's assessment focuses on current or potential future regional air-related issues and how they need to be addressed – rather than trying to allocate a percentage of the issue to the proposed projects. This is considered to represent a holistic and integrated approach to impact assessment and management. This approach overcomes the current problem with EIAs and impact assessments, which is that each project has a real but small (i.e., few percentiles) incremental impact, whereas collectively 10 to 20 of such projects have a major impact.

The incremental approach currently used in project EIAs results in later projects appearing to have relatively smaller impact than current proposed projects. This occurs because the Base Case keeps getting larger as new projects are approved and

included in the Base Case calculations. The relative significance of the Application and Planned Development cases are therefore evaluated against this ever-increasing Base Case. Fort McKay believes this is a fundamental flaw with the current EIA process and its incremental change assessment approach. Fort McKay submits that if 10 individual projects came in as one project, or were treated as one project, much different assessment conclusions would be reached and much different and more rigorous environmental controls would be required.

In terms of regional industrial air emissions and their potential impact on health, environment and local quality of life, Fort McKay is principally interested in determining how its air and environment have been, are being, and will be affected by existing, approved and planned projects. The incremental increase in air emissions associated with individual projects is not particularly relevant to the Community, which wants to know what the long-term cumulative impact of all developments will be and whether or not these impacts are acceptable. The pre-development and current air quality and air-vegetation impact situations are the only meaningful benchmarks that can be used by Community members. Therefore these two conditions or scenarios (i.e., pre-development and current) factor significantly in Fort McKay's assessment in addition to the standard environmental impact assessment (EIA) Base, Application and Planned Development Case assessments.

2.2.1.3 Fort McKay's Assessment Criteria

Fort McKay's Healing the Earth Strategy

Fort McKay has developed a draft, Healing the Earth Strategy (HTES), which outlines the Community's expectations in terms of the acceptable levels of impact and the management of those impacts on air, water, land and wildlife within the Community, and on the Community's Traditional Lands. The air quality management section of the draft HTES guided this air-related assessment as it reflects the Community's goals, environmental criteria and outcomes and general expectations with respect to air quality and its impact on health and quality of life.

Fort McKay recognizes that new and/or expanded oil sands development results in additional air emissions regardless of how well emissions are managed, and therefore recognizes that air quality will continue to deteriorate. Fort McKay's position is that this deterioration should be minimized through "best practices" emissions management measures and ambient levels of air contaminants should be below health and/or environmental effect thresholds. Fort McKay, in the draft HTES, has developed thresholds that were used in this assessment and has also developed a position on emissions management that was used to guide the review of the adequacy of emission management in the region.

2.2.1.4 Information Sources

The information used by Fort McKay for its assessment was obtained from existing sources (i.e., no new modeling was done), which results in some limitations in data analysis and interpretation, but does not significantly affect Fort McKay's ability to determine impacts or potential impacts. Fort McKay's draft HTES uses criteria and effects thresholds from reliable and reputable sources that are both current and directly relevant to Fort McKay and the ecosystems on its Traditional Lands.

2.2.1.5 Intent and Goal

The intent of the assessment is to provide a scientific impact assessment using Fort McKay's perspective on protection goals and criteria with the goal being to provide recommendations that can be implemented to effectively manage identified impacts.

2.2.2 Data Needs, Sources and Limitations

The air component of environmental impact assessments requires knowledge and data in a number of areas, including:

1. past and current air quality;

2. environmental characteristics, e.g., pH and weathering rates of regional soils, areas of different sensitive ecosystem types, nutrient status of regional ecosystems, etc.;

3. health and environmental impacts that may be associated with the types of current and projected air emissions, e.g. direct adverse effects of certain air pollutants to certain plants, soil acidification due to deposition of air contaminants, etc.;

4. current and future air emissions sources (location, quantities, characteristics, which include composition and temperature, velocity, emission height, etc.) and temporal variability;

5. health and environmental effects levels and/or loadings (e.g., what are the no/negligible health effect levels for air pollutants like NO_2, $PM_{2.5}$ and SO_2, and what are the critical loads for acid and nitrogen deposition for different ecosystems?);

6. air-related environmental effects monitoring that provides actual, as opposed to modeled, data on the current status/health of the environment with respect to effects levels/loading thresholds and the effects that existing emissions are having;

7. models of/for atmospheric dispersion, transformation and deposition that provide good estimates of the ambient air quality and deposition levels that may be associated with increased or changed emissions; and

8. the possible significance of predicted changes in air quality and pollutant deposition associated with existing and future emissions on human and environmental health and quality of life.

Fort McKay has developed a good understanding of, and appreciation for, the challenges of conducting a comprehensive project EIA and the limitations and uncertainties associated with EIA conclusions. This understanding is based on:

- its review of numerous oil sands project EIAs,
- its extensive involvement in regional multi-stakeholder associations,
- its direct participation in regional environmental threshold development activities, and
- its participation in the development of, and ongoing review of data from, regional air quality and terrestrial effects monitoring programs.

The following is a summary of the key information sources used by Fort McKay in its assessment, and also identification of some of the limitations in data and knowledge that Fort McKay considers need to be recognized and understood when considering any air-related EIA assessment conclusions including the ones by Fort McKay.

2.2.2.1 Data Sources

The principle sources of air emissions, quality, effects and/or management information and data that Fort McKay used in its air assessment were:

1. Shell's Jackpine Mine Expansion and Pierre River Mine EIA and Application;

2. Fort McKay assessment specific information requested from Shell and provided by Shell and Golder Associates Ltd.;

3. EIA and Project approval applications for other recent oil sands development projects;

4. Reports, studies, frameworks etc. conducted or prepared by CEMA and WBEA;

5. Air quality monitoring data for Fort McKay and the RMWB from WBEA and from the CASA (Clean Air Strategic Alliance) Data Warehouse;

6. Air quality and emissions management reports and criteria from Alberta Environment (AENV);

7. Air Quality and Environmental Effects Criteria from other jurisdictions e.g., Health Canada, WHO and USEPA;

8. Scientific literature (note: in general, the focus was on using reliable sources that represented synthesis of current knowledge rather than on trying to undertake such a synthesis);

9. Data presented at TEEM (Terrestrial Environmental Effects Monitoring) and NSMWG ($NO_X SO_2$ Management Working Group) Researchers' Workshops; and

10. Air quality criteria and management strategies from Fort McKay's draft HTES.

Overall, the data sources are those that are commonly used in project impact assessments and approval decision processes. The sources and related information and data are adequate to conduct an air impact assessment that meets the needs of Fort McKay. The main limitation is that model outputs from others had to be used and in some cases assessment levels, areas within isopleths, and modeling approaches were not exactly what Fort McKay would have preferred to use for its assessment. However, these are not major issues.

The specific data sources used to assess air quality, odours and air-vegetation effects are referenced in each section. When and where appropriate, the limitations of the specific data sets are outlined. General limitations of the assessment data and approach are outlined below.

2.2.2.2 Assessment and Data Limitations

There are a number of data, modeling and assessment approach limitations that need to be considered when drawing conclusions from, and making decisions on, assessment results. The major data, modeling and assessment approach issues that Fort McKay has identified while undertaking this assessment, and while reviewing project EIAs over the last several years, are:

- ***Air quality data*** – Reliable regional air quality data only exists for the last 10 years and therefore long-term ambient air quality data trending in relation to air emission effects cannot be undertaken. The real effects of industrial emissions on air quality in Fort McKay must be estimated using assumptions and models, since pre-industrial air quality data for Fort McKay does not exist. Air quality monitoring has also been focused near industrial activities and along and in, the Athabasca River Valley. Ambient air quality data for the region is therefore limited in terms of spatial coverage, which results in an increased reliance on models. This also means that there are limited regional data upon which to check model predictions. See Figure 2-3 for the location of current continuous monitoring stations (note station #16 recently replaced station #10).

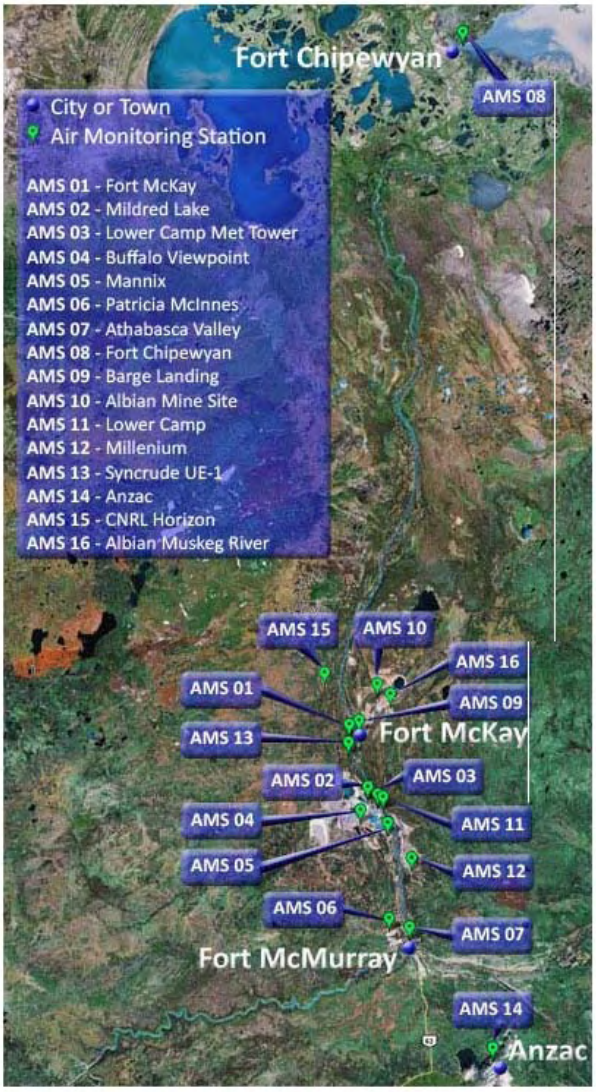


Figure 2-3: Ambient Air Monitoring Stations in the Regional Municipality of Wood Buffalo[1]

- ***Effects Thresholds*** – For many of the potential effects associated with industrial emissions there are a number of different threshold criteria that could be applied. Quite often criteria that are outdated or not specifically relevant to the potential impact are used. For example, continued use of, or reference to, Health Canada's 3-tiered National Ambient Air Quality Objectives system is considered inappropriate, as the criteria and approach are very outdated. Similarly, the use of AENV's health and/or vegetation ambient air quality objectives for NO_2 and SO_2 are considered inappropriate as the objectives are dated (NO_2 – 1975 and SO_2 -1987). In the case of vegetation effects of NO_2, the annual average limit is

[1] ***http://wbea.org/content/view/56/125/***; accessed June 15, 2009

not specifically linked to vegetation affects but is used as criteria for such affects. Also, the effects of NO on vegetation are not addressed (AENV 2009; Health Canada 2009). The limitations of, and basis for, threshold criteria are also often not given. This can lead to misunderstandings regarding the level of protection actually provided by the criteria used. Ideally, regional criteria and thresholds for key potential air-related impacts would be developed by, and agreed to, through regional multi-stakeholder forums. This would reduce subsequent debates on the assessment criteria that should be used. In its assessment, Fort McKay used the most current and relevant air quality and deposition critical levels and loads for the region that are based strictly on health and/or environmental protection.

- ***Modeling*** – CALMET/CALPUFF models are used to predict the changes in air quality and pollutant deposition for different emission scenarios. Predictions from different EIAs show that these models can give significantly different predictions for the same emissions scenarios depending on how the model is run – including how local wind data is used in the model. Table 2-2, which was prepared by the Fort McKay IRC as part of its review of the proposed Voyageur South Project, demonstrates the range of model predictions for very similar development cases.

  In comparisons between the measured and modeled ambient air quality summarized in the table on Page 14 it is clear that models have difficulty predicting air quality accurately near emission sources. These models have somewhat limited capability in terms of predicting atmospheric reactions and do not include all possible pollutants of interest in terms of ambient concentrations and/or deposition. This can lead to under-prediction of parameters like nitrogen deposition and $PM_{2.5}$ formation. Some inputs to models such as leaf area index (LAI), which is important in deposition estimates, have not been accurately measured and current values may be resulting in over-predictions (Golder 2009b). Fort McKay compared model predictions from different EIAs in its assessment and generally used the highest prediction when assessing potential impacts.

- ***Multi-pollutant Exposures*** – EIA assessments tend to focus on single parameter or impact issues and do not consider the effects of multi-pollutant exposures on health and/or the environment. This is because it is very difficult, if not impossible, to assess the impacts of complex mixtures of pollutants that might change spatially and temporally. Nevertheless, it is these complex mixtures that people and the environment are subjected to. The effects of mixtures might be additive (Bell and Treshow 2002; Walker et al 2006) or at low exposures might not act additively from a health perspective (COT 2002). For environmental effects, however, single-parameter effect analysis likely underestimates risks and effects. Assessments that are based solely on individual pollutants should therefore be considered as possible underestimates of potential impacts and

Table 2-2: Comparison of Predicted Air Quality Levels in the various recent EIAs for the Planned Development Case

Proponent		Suncor	Synenco	DCEL	DCEL	Imperial	Petro-Canada	
Year		2007	2007	2005	2006	2005	2005	
Project EIA		Voyageur South[1]	Northern Lights	Phase IIIA	North Mine	Kearl	MacKay River Expansion	
Parameter	Averaging Period	Modeled Air Quality in Fort McKay under the Planned Development Case (µg/m³)						Range (µg/m³)
SO_2	1-Hour	N/A[2]	78.	96	47	78	50	47-96
	24-Hour	N/A[2]	26	24	25	23	26	23-26
	Annual	N/A[2]	6	7	4	5	5	4-7
NO_2	1-Hour	127	199	177	131	107	329	107-329
	24-Hour	97	182	124	71	90	240	71-240
	Annual	31	60	81	24	28	57	24-81
CO	1-Hour	N/A[2]	1540	1300	1180	1020	1500	1020 -1540
	8 hr	N/A[2]	1470	1220	810	560	1480	563-1480
$PM_{2.5}$	98th %ile 24-Hour	25	49	43	25	26	48	25-49

[1] Peak 1-Hour, 24-Hour and annual average values.

[2] SO_2 and CO modeling for PDC was not conducted. Since they were both considered to have a "negligible impact" in the Application Case, an assessment for PDC was deemed not necessary.

effects. Multi-pollutant exposures and their health and environmental effects were considered by Fort McKay, where and when possible, in this assessment.

- ***Emissions*** – A good understanding of existing and future emissions characteristics is essential for meaningful project development assessments. Emissions monitoring data might provide good information on the performance of pollution control equipment, but might not represent what is actually emitted by a source. For example:
  - Particulate monitoring of stack emissions generally does not include condensable particulates, which are an important air contaminant.
  - Mine fleet emissions are a major source of regional NO_X emissions, but emissions are estimated using manufacturers' emission data and vehicle load and use adjustment factors. This creates considerable uncertainty around the accuracy of these projected emissions. Approved emission rates are generally used to estimate and model emissions, which likely results in an overestimate of the actual "real world" emissions.
  - Emissions during upset conditions have the potential to significantly affect air quality in Fort McKay (e.g., Syncrude's FGD start-up problems in 2006 and Syncrude's diverter stack event in February 2009) and these are events that are often not adequately captured in assessments.
  - Finally, emissions and emission sources that might be important are not always measured or considered (e.g., ammonia) and therefore some important health and environmental substances might not be receiving the appropriate attention in assessments.

These emission issues are either positive or negative in terms of over or under-prediction and must be recognized as contributing to general assessment uncertainty. Table 2-3, prepared by the Fort McKay IRC in its review of the proposed Voyageur South Project, demonstrates the range of emission predictions for very similar development cases (Note: in addition to differences in emission estimating methodologies and approaches, some of differences noted in Table 2-3 reflect the size of the regional study area used and the different dates of EIA preparation).

Table 2-3: Comparison of Estimated Emissions from Various Developments

Proponent	DCEL/TOTAL		Imperial		Petro-Canada		Synenco		Suncor	
Year	2006		2005		2005		2007		2007	
Project	Joslyn North Mine		Kearl		MacKay River Expansion		Northern Lights		Voyageur South	
	Emissions (t/d): Base Case (BC)/Planned Development Case (PDC)									
	BC	PDC	BC	PDC	BC	PDC	BC	PDC	BC	PDC
SO_2	204	244	245	298	236	279	239	401	270	315
NO*X*	312	444	398	538	403	554	418	598	476	643
CO	273	409	372	468	278	416	355	487	449	557
$PM_{2.5}$	24	32	28	34	27	35	27	44	36	47
VOCs	431*	628*	314	477	314	438	499	855	662	881

* The EIA did not give regional volatile organic compound (VOC) emissions and these values were taken from DCEL's (now TOTAL's) February 2005 Phase IIIA EIA.

It has been Fort McKay's experience that EIAs for oil sands projects in the region do not generally include such reviews. If they do, such reviews are cursory in nature and the control of air emissions is only to the level required by regulatory agencies. Fort McKay considers meeting current regulatory requirements the very minimum and that it represents a "given" level of air quality management. Based on the size and nature of industrial development in the region, combined with the already evident adverse air quality impacts being experienced by Fort McKay, the application of better-than-minimum air pollution control measures is required. In this assessment, Fort McKay has therefore provided its assessment of what constitutes Best Available Control Technology Economically Achievable (BATEA) for air emissions management.

The approach used by Fort McKay to assess the appropriate air emissions control requirements is based on approaches to pollution control requirements outlined by Alberta Environment, the Cumulative Environmental Management Association (CEMA) and the United States Environmental Protection Agency (USEPA). A brief summary of these follows.

Alberta Environment's ***"Industrial Release Limits Policy"*** (AENV 2000) outlines the general approach that it will use for setting emission limits. This approach involves both technology and environmental considerations. Principle 1 in this policy states:

> *"Industrial release limits will be established based on limits achievable using the most effective demonstrated pollution prevention/control technologies or the limits required to meet risk based and scientifically defensible ambient environmental quality guidelines, whichever are the more stringent. (Note: advanced technology limits may be adopted in lieu of ambient limits in certain circumstances)."*

The CEMA "Acid Deposition Management Framework for the Oil Sands Region of North-eastern Alberta" (CEMA 2004) states that:

> *"The framework is based on the following conceptual acidifying emissions management approaches:*
>
> *reasonable, cost effective measures in the design and operation of projects to minimize acidifying emissions. This will include the evaluation of Best Available Demonstrated Technology (BADT) in new project design, existing project expansions, and equipment replacement;"*

The definition of BADT is (CASA 1997):

> *"emission control technology based on the maximum degree of emission reduction that has been shown to be practicably and economically achievable for a given source and type."*

The CEMA ***"Ozone Management Framework"*** (CEMA 2006a) for the Regional Municipality of Wood Buffalo Area states:

> *"In order to provide consistency and industry-wide comparability in this time of rapid development, it is recommended that best available technology economically achievable (BATEA) based standards be established for the Region by a multi-stakeholder process led by AENV."*

BATEA refers to (CASA 2003):

> *"technology that can achieve superior emissions performance and that has been demonstrated to be economically feasible through successful commercial application across a range of regions and fuel types. BATEA is used to establish emission control expectations or limits. Generally it is the emission limit that is specified and not the specific BATEA. Facilities can opt for other technologies or emission strategies as long as the emission limit is met."*

In the United States, new major sources of pollutants or major modifications at existing sources for pollutants must install ***"Best Available Control Technology"*** (BACT; USEPA 2009).

The definition of BACT is (USEPA 2009):

> *"an emissions limitation (including a visible emission standard) based on the maximum degree of reduction for each pollutant subject to regulation under the Clean Air Act which would be emitted from any proposed major stationary source or major modification which the Administrator, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such source or modification through application of production processes or*

available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques for control of such pollutant."

In general, all these emission control approaches are similar and should result in similar emission control requirements, which, in almost all cases, ***would likely be more stringent than those currently being applied.***

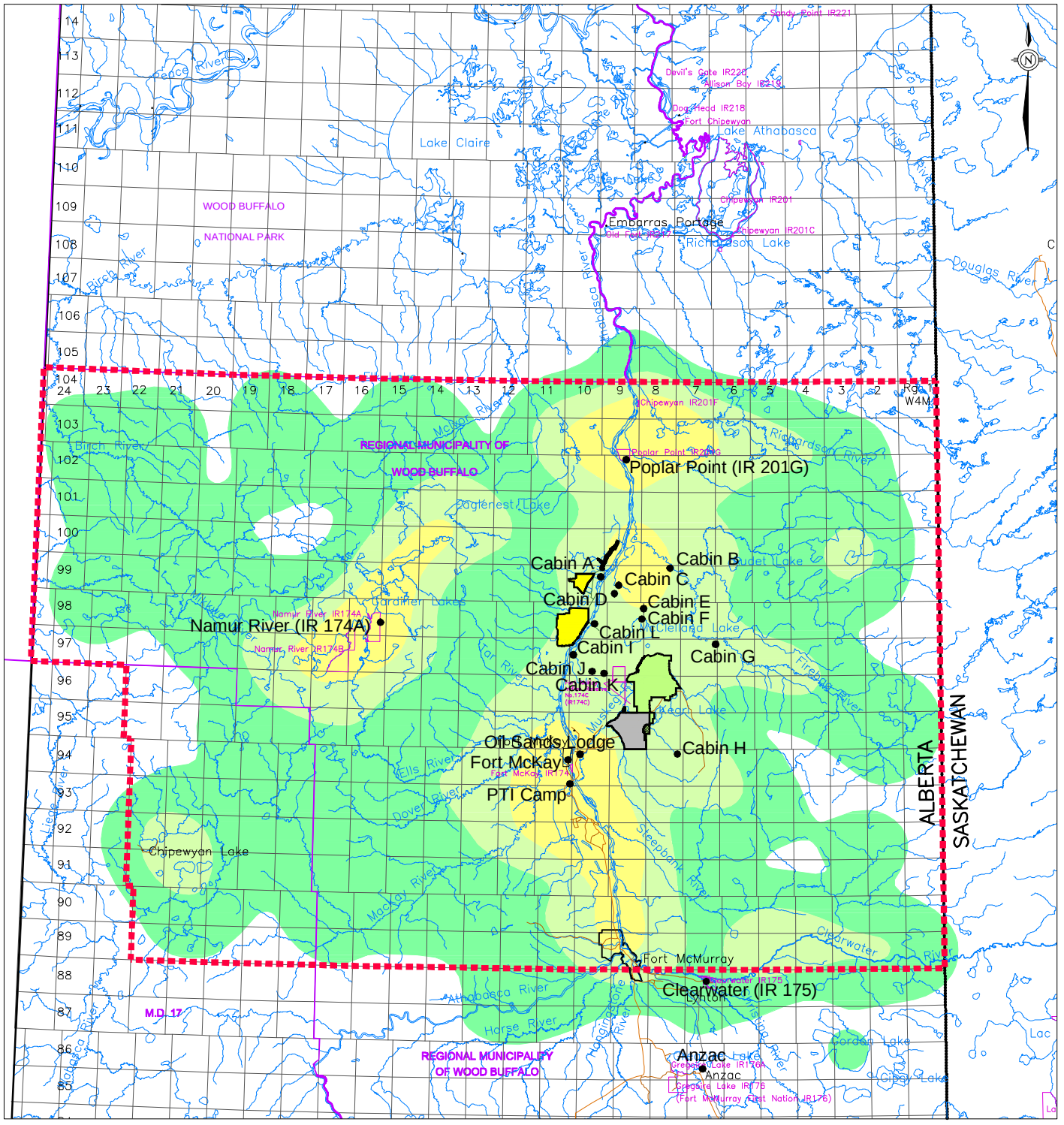
- ***Significance/Interpretation*** – The interpretation of assessment results is traditionally done using threshold criteria as a clear black and white "acceptable or unacceptable" line. Limits, however, are often just a numeric point along a continuum of possible effects. For example, a future maximum predicted hourly SO_2 value of 449 µg/m^3 would generally be assessed as acceptable, whereas a future maximum predicted hourly SO_2 value of 451µg/m^3 would generally be assessed as unacceptable – because Alberta's hourly ambient air quality objective for SO_2 is 450 µg/m^3. The reality is that these two numbers, i.e., 449 and 451 µg/m^3, are essentially the same and so are their respective health and environmental impacts. ***Since Fort McKay is a community that lives with the impacts of air emissions on their health and land, the Community's assessment of significance and impact therefore goes beyond strict numeric comparisons and tries to assess the real impacts to the Community of air emissions.***

2.2.3 Fort McKay Air Quality Study Areas

The air quality assessment study areas are shown in Figure 2-4 and include:

- Fort McKay's Traditional Lands – this was the area used for the assessment of potential adverse effects on vegetation, and
- the Community of Fort McKay for the assessment of potential health and odour impacts

The high, moderate and low use areas within Fort McKay's Traditional Lands, and the specific cabins identified as receptors, as shown in Figure 2-4 (Golder 2009), were not individually assessed, but were referred to in individual issue or parameter assessments when appropriate.



LEGEND

- RIVER OR STREAM
- ROADWAY
- INDIAN RESERVE
- PIERRE RIVER MINING AREA
- JACKPINE EXPANSION MINING AREA
- LEASE SWAPPED TO SYNCRUDE
- JACKPINE MINE – PHASE 1
- INTENSE USE CSE (50% UTILIZATION DISTRIBUTION)
- MODERATE USE CSE (75% UTILIZATION DISTRIBUTION)
- LOW USE CSE (95% UTILIZATION DISTRIBUTION)
- TRADITIONAL AREAS OF THE FORT McKAY FIRST NATIONS
- COMMUNITY RECEPTOR

30 0 30
SCALE KILOMETRES

ACKNOWLEDGEMENT

Traditional land use data for this figure was provided by the Fort Mckay IRC. This data has no wider implications and remains the property of Fort Mckay First Nation.

REFERENCE

Alberta NTDB Data Supplied By Geomatics Canada, August 2001. Nad 83 Zone 12. Sheets 74D, E and 74I in Nad 27 Zone 12. Saskatchewan NTDB Data Supplied by ISC, Aug. 2001. ACFN 2003, Tanner Et. Al. 2001 Projection: Transverse Mercator Datum: Nad 83 Coordinate System: Utm Zone 12 Nad 83 Zone 13. Used Under License.

PROJECT

JACKPINE MINE EXPANSION & PIERRE RIVER MINE PROJECT

TITLE

LOCATIONS OF COMMUNITY RECEPTORS (ALL TRADITIONAL USES)

PROJ	08.1346.0006.5722.01		FILE No. Community Receptors	
DESIGN	DC	19/01/09	SCALE AS SHOWN	REV. 0
CADD	PSR	20/01/09	FIGURE 2-4	
CHECK	GDU	20/01/09		
REVIEW	WES	20/01/09		

L:\2008\1346 Oil Sands\08-1346-0006-SHELL\5722-Fort McKay Assess\01\Petro-Canada Mckay River\ Drawing file: Fig 3.3-1 TLU – Ecosystems of Fort McKay First Nation.dwg Jan 23, 2009 – 10:09am

2.2.4 Fort McKay Air Quality Receptors

The specific receptors addressed or covered by Fort McKay in its assessment include:

- Residents in the Community of Fort McKay – health and odour impacts;
- Bogs and Jackpine stands on Fort McKay's Traditional Lands – adverse effects due to nitrogen deposition;
- All vegetation on Fort McKay's Traditional Lands – adverse effects due to ambient air quality levels of SO_2, $NO\chi$, NH_3 and O_3; and
- Mineral (sensitive) soils on Fort McKay's Traditional Lands – adverse effects due to acid deposition and subsequent adverse effects on soil and vegetation ecosystems.

Information on these receptors was obtained from Shell's EIA (2007) and other recent project EIAs.

2.2.5 Fort McKay Air Quality Assessment Criteria

2.2.5.1 Introduction

Air quality has been a longstanding issue for, and concern to, Fort McKay. The Community has therefore incorporated an air quality management strategy and related air quality criteria section into its draft Healing the Earth Strategy (HTES). See Appendix A for the full draft of the HTES air quality management strategy and related criteria. The emphasis is on ***retaining*** air quality at levels as close to natural levels as possible and ensuring that air quality does not adversely impact the health and/or well-being of residents in Fort McKay. There is also a focus on ensuring that best efforts are made to ***improve*** emissions management, thereby reducing the impact of development on the Community's air quality and also on air quality on Fort McKay's Traditional Lands.

Fort McKay's approach and/or expectations related to protecting and managing air quality in the community include:

1. establishing health and odour-based air quality criteria for the Community;
2. establishing "***keeping clean areas clean (KCAC)***" based air quality targets for the Community;
3. tracking air quality changes and trends in the Community relative to the above noted air quality criteria and targets;

4. notifying the Community when there is poor air quality in the Community or when there are releases that might result in significant air quality impacts in the Community;

5. implementing actions related to pollution prevention/control and continuous improvements in regional emission reduction strategies to minimize the impact of development on air quality in the Community, and

6. managing regional emissions to levels that prevent air-related environmental impacts on Fort McKay's Traditional Lands.

The following section outlines Fort McKay's air quality criteria and targets for the Community, as well as the related air quality management practices that it expects companies and regulators to follow. It is these criteria and approaches that Fort McKay used in its assessment.

2.2.5.2 Health and Odour Based Air Quality Criteria for the Community

Fort McKay's expectation for air quality in its community is that:

> *"The air smells fresh and contributes to the health of the land and animals and to the health and well-being of the people of Fort McKay"*

This expectation is consistent with the provincially adopted CASA vision for air quality in the province.[2]

Developing air quality criteria that are strictly health-based is a challenging task and one that is beyond the capability of Fort McKay. The Community believes that Health Canada's recently developed health-based air quality index (AQHI) is a positive step in helping to define and assess safe air quality, particularly since it is a multi-pollutant index (i.e., NO_2, O_3 and $PM_{2.5}$) that is based on actual air quality – health epidemiological data. Fort McKay has adopted the AQHI based criteria outlined in Table 2-4 for each of the risk category levels established by Health Canada (***http://www.ec.gc.ca/cas-aqhi/default.asp?lang=En&n=065BE995-1***).

For individual parameters, Fort McKay has adopted either World Health Organization (WHO) or Alberta Environment (AENV) limits, depending on the basis for the limit, i.e., whether or not it is health focused and/or if it is likely to ensure minimal odours and also how current the limit is; i.e., does it reflect the current state of knowledge. These limits are summarized in Table 2-5.

[2] CASA's Vision for air quality is: "The air will have no adverse odour, taste or visual impact and have no measurable short- or long-term adverse effects on people, animals or the environment." (***http://www.casahome.org***)

Table 2-4: Air Quality Health Index Criteria for the Community of Fort McKay

Risk Category1	Goal or Acceptable Frequency of Exceedence	Action Required if Exceeded
Low (AQHI value 1-3)	>95% of the hourly AQHI readings are 3 or less	Reviewed as part of annual trend analysis
Moderate (AQHI value 4-6)	<30 days per year have any AQHI readings of above 4	Reviewed as part of annual trend analysis
High (AQHI value 7-10)	<5 days per year have any AQHI readings above 6	Reviewed as part of annual trend analysis
Very High (AQHI value 10+)	no days per year have any AQHI readings above 10	Immediate reporting as per notification protocol

[1]Note: The AQHI values referred to are based on the use of $PM_{2.5}$ in the AQHI formula and not PM_{10}. Fort McKay conducted its first assessment of AQHI values for the Community in 2009 (see ***Appendix 2-2***) and is prepared to reconsider the criteria in this table as experience on, and data from, the AQHI grows but considers the criteria in Table 2-4 reasonable and appropriate at this time.

In this assessment Fort McKay used its health and odour based air quality criteria to assess the effects of:

- the Current Scenario,
- the Base Case,
- Shell's Application Case, and
- the Planned Development Cases

on air quality in Fort McKay.

2.2.5.3 Keeping Clean Areas Clean (KCAC) Based Air Quality Targets

Fort McKay expects, in addition to meeting health and odour-based criteria, that the principle of KCAC will be applied to air quality in its community. Fort McKay defines KCAC as:

> *"Ensuring that air quality in the Community of Fort McKay is maintained at as close to pre-industrial levels as possible through rigorous pollution prevention and control measures."*

Table 2-5: Fort McKay's Health and Odour based Ambient Air Quality Criteria for the Community and the Criteria Used in its Assessment

Parameter	Averaging Period	Fort McKay's Criteria (µg/m³)
Sulphur Dioxide (SO_2)	10 minute	500 (equivalent to approx. 300 µg/m³ for 1-Hour)
	24-Hour	20[1]
	Annual	No guideline
Nitrogen Dioxide (NO_2)	1-Hour	200[1]
	24-Hour	No guideline
	Annual	40[1]
Ozone (O_3)	1-Hour	No guideline
	8 hr daily maximum mean (May – September period)	100[1]
Particulate Matter ($PM_{2.5}$)	24-Hour	30[2]
	99th% 24-Hour annual value	25[1]
	Annual	10[1]
Particulate Matter (PM_{10})	99th percentile24-Hour	50[1]
	Annual	20[1]
Carbon Monoxide (CO)	1-Hour	15,000[3]
	8 hour	6,000[3]
Benzene	Lifetime	0.17[4]
Benzo-a-pyrene	Lifetime	0.000012[4]
Arsenic	Lifetime	0.00066[4]
Nickel	Lifetime	0.0025[4]
Total Reduced Sulphur (TRS)	30 minute	7[4] (equivalent to approx. 5.7 µg/m³ for 1-Hour)

[1]Based on 2005 WHO Air Quality Guideline update (***http://www.euro.who.int/Document/E87950.pdf***)

[2]Based on the CCME Canada Wide Standard (***http://www.ccme.ca/assets/pdf/pmozone_standard_e.pdf***) but applied without averaging

[3]Based on Alberta Ambient Air Quality Objectives (June 2008) (***http://environment.gov.ab.ca/info/library/5726.pdf***)

[4]Based on the WHO Air Quality Guidelines for Europe (2nd edition, 2000) (***http://www.euro.who.int/document/e71922.pdf***) using a 1 in a million risk level except for TRS

The Community has established clean air targets that it considers to be consistent with this KCAC principle. These targets are more stringent than Fort McKay's health and odour-based criteria and reflect the expectation that air quality in the Community can and will be maintained at levels much lower than health and nuisance effect levels. These levels are summarized in Table 2-6.

Table 2-6: Fort McKay's "Keeping Clean Areas Clean" (KCAC) Community-based Air Quality Targets[1]

Parameter	Averaging Period	Fort McKay's Target (µg/m³)
Sulphur Dioxide(SO_2)	Annual 95th Percentile 1-Hour concentration	31.4
	Annual 50th Percentile 1-Hour concentration	5
	Annual Average concentration	6
Nitrogen Dioxide(NO_2)	Annual 95th Percentile 1-Hour concentration	51
	Annual 50th Percentile 1-Hour concentration	9.4
	Annual Average concentration	20
Ozone(O_3)	Annual 95th Percentile 1-Hour concentration	48 ppb
	Annual 50th Percentile 1-Hour concentration	27 ppb
	Annual Average concentration	26 ppb
Particulate Matter($PM_{2.5}$)	Annual 95th Percentile 1-Hour concentration	21
	Annual 50th Percentile 1-Hour concentration	5
	Annual Average concentration	7.5
	98th Percentile annual 24-Hour value average over 3 years	20
Total Hydrocarbons (THC)	Annual 95th Percentile 1-Hour concentration	2.6 ppm
	Annual 50th Percentile 1-Hour concentration	1.9 ppm
	Annual Average concentration	2.4 ppm
Total Reduced Sulphur	Annual 95th Percentile 1-Hour concentration	2.8
	Annual	1

[1]Derived based on data from the CASA Data Warehouse; *The Ambient Air Quality Trends in Edmonton and Fort McKay, Alberta* – Report Prepared for: Wood Buffalo Environmental Association by W.B. Kindzierski, M. Gamal El-Din, and K. Faisal (July 2006); and *Trend Analysis of Historical Ambient Air Monitoring Data in Edmonton and Fort McKay, Alberta* by Wen Xu, M. Gamal El-Din and W. B. Kindzierski (AWMA Annual Conference June 2006).

Fort McKay used its Community-based KCAC air quality targets as assessment criteria to determine the effects and significance of existing, approved, Shell's proposed projects and the cumulative effect of all planned regional projects on air quality in Fort McKay. If EIA modeling predictions indicate that target levels are being, or might be, exceeded, then Fort McKay expects a detailed assessment of the causes for the predicted exceedences and a review of the actions that are necessary to prevent these conditions.

2.2.5.4 Vegetation and Ecosystems Protection Criteria

A substantial portion of Fort McKay's Traditional Lands has been subject to total surface disturbance (See ***Section 9 – Access and Disturbance*** of this assessment for details). The amount of total surface disturbance will increase significantly as recently approved projects become operational and as planned projects get

approval and also become operational. Fort McKay therefore expects that any undisturbed and undeveloped areas within its Traditional Lands will be protected from adverse air emissions-related impacts.

The Community recognizes that 100% protection for undisturbed and/or undeveloped areas might be impossible, since some emissions-related impacts adjacent to developments are likely unpreventable even with rigorous emissions management strategies. Fort McKay is therefore adopting a 95% protection level criterion for vegetation and ecosystems on the undisturbed and/or undeveloped areas of its Traditional Lands.

Fort McKay's 95% protection level criterion means, for example, that for a single project with a total disturbance of 10,000 hectares (ha), no more than 500 ha (i.e., 5% of 10,000 ha) of undisturbed and/or undeveloped area can exceed the criteria for protection of vegetation and ecosystems as a result of the project. In terms of Base Case and Planned Development Cases, the 5% protection level criteria means, for example, that for a total regional cumulative disturbance of 50,000 ha, no more than 2,500 ha of undisturbed and/or undeveloped area on Fort McKay's Traditional Lands should exceed the criteria for protection of vegetation and ecosystems as a result of Base or Planned Development cases.

Fort McKay's HTES does not include vegetation and ecosystem affects criteria. For this assessment Fort McKay used the air-vegetation protection criteria outlined in Table 2-7.

These air-vegetation protection assessment criteria have:

- in some cases been used in previous EIAs (e.g., SO_2, NO_2 and PAI criteria);
- been recommended for the region (e.g., ozone) by a multi-stakeholder forum; or
- been discussed extensively as the type of limits that might be relevant to the region (e.g., nitrogen deposition discussions at forums such as the CASA Science Symposium on Nitrogen (CASA 2006) and CEMA-NSMWG nitrogen critical loads workshop (NSMWG4 2008)).

The only parameter/criterion that has not been addressed in previous EIAs or as part of regional air management discussions is ammonia.

Table 2-7: Fort McKay's Vegetation and Ecosystem Protection Criteria used in its Assessment

Parameter	Criteria Used by Fort McKay in Assessment	
	Criteria	**Basis/Comments**
SO_2	10 µg/m³ annual average (for lichens) 20 µg/m³ annual and winter average (for forests and natural vegetation)	Based on WHO (2000) and CLRTAP (2004)
NO_2	75 µg/m³ 24-Hour average (as NO*X*, i.e. NO + NO_2) 30 µg/m³ annual average (as NO*X*)	Based on WHO (2000) and CLRTAP (2004)
NH_3	1 µg/m³ annual (lichens and bryophytes) 3 µg/m³ annual (forest ground flora)	Recommendations from ECE (2007a)
O_3	SUM60 values of: • 0 to 2000 ppb hours over a 3 month period (Baseline condition) • 2000 to 4400 ppb hours over a 3 month period (Surveillance condition) • 4400 to 6600 ppb hours over a 3 month period (Management condition) • greater than 6600 ppb hours over a 3 month period (Exceedance condition)	From CEMA (2007)
Nitrogen Deposition	8 kg N/ha/yr	Based on Recommendations from ECE (2007b) and, discussion at a CEMA/NSMWG December 2008 Nitrogen Critical Loads Workshop in Calgary
PAI	CEMA (2004) + CEMA (2006b) criteria	Fort McKay was heavily involved in the development of CEMA's Acid Deposition Management Framework and supports its implementation and use in assessing PAI impacts

2.2.5.5 Significance Criteria

Assessing the potential significance of predicted air quality and acid and nitrogen deposition on health and the environment is challenging and involves more than just comparing the predicted changes to criteria or thresholds. Predictions have a significant degree of uncertainty. In many cases thresholds and criteria don't represent a clear line between affects and no affects, and some impacts might be more acceptable than others depending on cultural, social and economic factors. Also, it has been Fort McKay's experience, based on its review of many project EIAs, that numerically derived significance values depend on arbitrary categorization of negligible, low, moderate and high impact magnitudes.

Fort McKay, in its assessment, uses its numeric assessment criteria but also incorporates judgments on uncertainties and how significant the predicted changes and/or impacts are to the Community. The following general guide was followed with respect to determining the possible significance of air quality and deposition changes and whether the predicted changes should be considered for more detailed assessment:

- ***Health limits*** – any current and/or predicted exceedence of Fort McKay's health-based ambient air quality guideline was considered as a significant adverse effect that required further analysis and specific discussion (a **red** situation),
- ***Keeping Clean Air Clean (KCAC) targets*** – if any of Fort McKay's KCAC targets were predicted to be exceeded under the Base, Application and/or Planned Development Case then this was viewed as ***a potentially significant adverse effect*** that required further analysis and specific discussion (a **yellow** situation),
- ***Odours*** – since odours are currently a major problem in Fort McKay, any predicted increase in odours in the Community was considered ***a significant adverse impact*** that required action to address/mitigate (a **red** situation),
- ***Vegetation/Ecosystem Impacts*** – any exceedence of Fort McKay's air-vegetation protection criteria on undisturbed and/or undeveloped areas of Fort McKay's traditional land that exceeded more than 5% of the project development area or 5% of total cumulative development areas was considered ***a significant adverse impact*** that required further analysis and specific discussion (a **red** situation),
- ***Application Project Impacts*** – a predicted increase of more than 5% in any ambient air quality parameter in Fort McKay as a result of the proposed project emissions was considered ***a potential adverse impact*** (a **yellow** situation), and a predicted increase of more than 10% was ***a potentially significant adverse*** impact that required further analysis and specific discussion (a **red** situation), and
- ***Knowledge Gaps/Uncertainties*** – where there is uncertainty as to whether or not there are potential adverse effects associated with an impact this was viewed as

a potentially significant adverse impact issue that required further analysis and specific discussion (a **yellow** situation).

Using these significance criteria as a guide, a matrix was prepared for each issue, which included the parameters (stressors) analyzed under that issue and the five different assessment scenarios/cases (Pre-Development, Current, Base, Application and Planned Development). An assessment with commentary was provided for each stressor and assessment case and colour coded as:

- **Green** (No or Minor Issue),
- **Yellow** (Possible Issue) and
- **Red** (Issue Requiring Immediate Action).

For **red** and **yellow** issues recommended actions were provided.

2.2.5.6 Emissions Management

Good air quality is in large part dependent on effective emissions control and management. Fort McKay expects that, as a minimum, the Best Available Technology Economically Achievable (BATEA) will be used to control emissions from all significant emission sources (see Section 2.2.2.2 – Emissions Management).

Fort McKay has been involved in the development of AENV's Policies 1B and 2 (AENV 2007 and 2008b) pertaining to emission limits for boilers, heaters and/or gas turbines using gaseous and non-gaseous fuels and is also aware of the BATEA review that was recently prepared for the CASA as part of the five-year review of the Electricity Framework (ERG 2009). Fort McKay has also reviewed BATEA requirements in other jurisdictions as part of its reviews of project EIAs. Fort McKay considers that it has a good understanding of current NO_X and SO_2 emission control options for the types of emission sources associated with oil sands projects. Fort McKay applied this knowledge and emission limit setting experience to this assessment.

In general, Fort McKay used the BATEA limits that would apply if the type of oil sands emission source being proposed was used in the United States in an attainment area (i.e., an area currently meeting National Ambient Air Quality Standards). These BATEA limits are obtained from the USEPA RBLC website (USEPA 2009) and reflect the application of the US Prevention of Significant Deterioration regulations under the US Clean Air Act. See Section 5 of the HTES (***Appendix 2-1***) for more information on this emissions management approach.

2.3 Air Quality Parameters Assessment

2.3.1 Introduction

There are a number of oil sands-related emission sources and types and therefore a number of specific air quality parameters that could have been reviewed as part of this assessment. The Fort McKay IRC decided to focus its air quality impact assessment on three air quality parameters that are of particular relevance in terms of their potential impacts on general air quality in the Community of Fort McKay, as well as their potential impact on health of community members. These air quality parameters are:

- ***Sulphur Dioxide (SO_2)*** – this is a criteria air contaminant that is emitted in relatively large quantities by Suncor and Syncrude. It will also be emitted by the proposed Shell projects. It is an emission that is regulated and ambient SO_2 levels are monitored throughout the region. Regional air emissions of SO_2 affect air quality in Fort McKay and at times SO_2 levels in the community are high. Fort McKay has proposed health and KCAC SO_2 levels for the Community of Fort McKay as part of its HTES. For these reasons Fort McKay assessed SO_2 emissions and impacts as part of its assessment.

- ***Nitrogen Oxides (NO_X, NO and NO_2)*** – this is also a criteria air contaminant that is emitted by all oil sands operators since it is formed when fossil fuels (e.g., coke, natural gas, bitumen, asphaltenes, coal, gasoline, diesel, etc.) are combusted with air. It is an emission that is predicted to increase with increasing oil sands development and the proposed Shell projects have a number of NO_X emission sources. Regional NO_X emissions affect air quality in Fort McKay and levels of the contaminant are increasing in the Community. Health and KCAC levels for NO_2 have been proposed in Fort McKay's HTES. For these reasons Fort McKay assessed NO_2 emissions and impacts as part of its assessment.

- ***Fine Particulate Matter ($PM_{2.5}$)*** – this is also an air contaminant that is both directly emitted by oil sands operations and also formed in the atmosphere from gaseous oil sands emissions such as water vapour, SO_2, NO_2 and VOCs. It is an air contaminant that can have significant health implications, is projected to increase in the region and which at times occurs at quite high ambient levels in the Community. Fort McKay has proposed health and KCAC levels for $PM_{2.5}$ in its HTES. For these reasons, Fort McKay assessed $PM_{2.5}$ emissions, levels and impacts as part of its assessment.

The other air contaminants commonly referred to as "criteria" air contaminants (i.e., VOCs, CO, ammonia and O_3) were not assessed in this section. Regional CO emissions and levels are not considered by Fort McKay to represent a direct significant environmental or health impact. There is insufficient information on ammonia emissions and levels to conduct a meaningful assessment. This issue is discussed in Section 2.5. Regional VOC emissions are projected to increase

significantly and some specific VOC compounds have health implications. VOC emissions are also a concern from the standpoint of odours and this is discussed in Section 2.5 and from the standpoint of contributing to ground-level ozone formation, which is discussed in Section 2.5. Ozone was not assessed because there is limited predictive data on possible future levels of ozone in the Community. There is, however, a concern about future ozone levels in Fort McKay as VOCs and NO_2 are precursors for ozone formation; emissions and levels of both of these precursors are projected to increase in Fort McKay. The potential effects of ozone on regional vegetation are assessed in Section 2.5.

Trace air contaminants such as polynuclear aromatic hydrocarbons (PAHs) and specific VOC compounds (e.g., benzene) and the potential health-effects associated with these contaminants were not assessed since the Shell EIA and Application (Shell 2007) are considered to generally represent a reasonable assessment of the impact of these emissions. Specific comments and concerns on Shell's assessment of these substances are covered in Fort McKay's technical review of Shell's EIA and Application.

The following is Fort McKay's assessment of the impacts of existing and projected regional emissions on SO_2, NO_2 and $PM_{2.5}$ levels in the Community of Fort McKay and the acceptability of those levels in terms of their potential health impacts and protecting the overall quality of the Community's air quality.

2.3.2 Sulphur Dioxide (SO_2)

Sulphur dioxide (SO_2) is one of the air contaminants that Fort McKay wished to address in its Community Specific Assessment. Fort McKay's concern regarding SO_2 is based on the following issues, which are outlined in greater detail later in this document:

- ***Regional SO_2 Emissions:*** Given the level of industrial activities in the region, cumulatively the total SO_2 emissions are significant (~300t/d).
- ***Proposed Project SO_2 Emissions:*** the proposed Pierre River and Jackpine Mine Expansion projects have SO_2 emission sources, which will add to the current emission levels.
- ***Health and Environmental Criteria, Objectives and Guidelines for SO_2:*** the existing criteria, objectives, and guidelines for SO_2 in ambient air vary from jurisdiction to jurisdiction, depending on how current the criteria are and whether the values are health, environment, or aesthetics based.
- ***Health and Environmental Impacts of SO_2:*** SO_2 has potential impacts on both human health and the environment. Ambient SO_2 levels in Fort McKay are on occasion elevated and the contaminant also contributes to acid deposition levels, which are elevated in some areas of Fort McKay's Traditional Lands.

- ***Emission Controls for SO_2:*** there are many technologies and a number of options and approaches available to control SO_2 emissions. Fort McKay wishes to ensure that Shell has assessed all available options and is implementing "best practice" SO_2 controls.
- ***Impacts of SO_2 Emission on the Community of Fort McKay:*** The Community is concerned about the past, current and possible future impacts of SO_2 emissions on their short-term and long-term health.

2.3.2.1 Regional SO_2 Emissions

SO_2 emissions are principally associated with the combustion (burning) of sulphur-containing fuels such as coke and some diesel fuels, but are also associated with sulphur recovery processes.

Table 2-8 outlines Shell and the other oil sands projects' estimate of the Planned Development Case (PDC) SO_2 emissions for the region, as indicated in their respective project EIAs. As the regional SO_2 emission estimates differ from EIA to EIA, the lack of consistency presents challenges when comparing EIA predications and results.

Table 2-8: Estimated Planned Development Case SO_2 Emissions from Various Project EIAs

Project	Year of EIA	Emission Estimate for SO_2 (Planned Development Case; Tonnes/day)
Shell Jackpine Mine	2002	447[1]
Imperial Kearl	2005	298
Suncor Voyageur South	2007	315
DCEL North Mine	2006	244
Petro-Canada MRE	2005	279
Synenco Northern Lights	2007	401
Shell Jackpine Mine Expansion	2008	323
Shell Pierre River Mine	2008	

[1]Does not reflect SO_2 emission reductions associated with Syncrude's flue gas desulphurization program.

In addition to the significant variation in emission estimates from project to project, much of the fuel currently used in oil sands projects is in the form of natural gas, which has a negligible sulphur content. Predictions for future regional SO_2 emissions are, generally, calculated based on the use of natural gas as an energy source. For this reason, future regional SO_2 emission estimates must be considered with caution. If there were a significant shift away from natural gas as a regional fuel source to fuels that contain high levels of sulphur, such as the asphaltene that Shell is proposing to burn in the co-generation units that are part of this project, then

regional sulphur emissions could increase drastically. The potential scale and significance of this type of fuel change is of concern to Fort McKay.

2.3.2.2 Proposed Project SO_2 Emissions

Table 2-9 summarizes the projected SO_2 emissions from the proposed Shell projects. As a basis for comparison, projected SO_2 emissions for other recent projects are also included.

Table 2-9: Projected Total SO_2 Emissions from the Proposed Shell Jackpine Mine Expansion and Pierre River Mine Projects Relative to Other Recently Proposed Projects and Their Respective Contribution to Total Regional Emissions

Project	Projected SO_2 Emissions (Tonnes/day)	Major Sources		Contribution to Total Regional SO_2 Emission
		Type	% of Overall Project SO_2 Emissions	
Suncor Voyageur South	0.13	Cogeneration and Boilers	92%	Negligible
Synenco	0.39	Mine Fleet	90%	0.2%
DCEL	0.85	Mine Fleet	90%	0.4%
Imperial Kearl	0.67	Mine Fleet	87%	0.3%
Shell Jackpine Mine Expansion	4.08	Cogeneration	99.8%	1.8%
Shell Pierre River Mine	4.09	Cogeneration	99.8%	1.8%

2.3.2.3 Health and Environmental Impacts of SO_2

SO_2 emissions can a have a broad range of health and environmental impacts. SO_2 is of interest and concern to Fort McKay because the air contaminant can have both direct and indirect effects on the quality of life in the community. These effects include:

- ***Direct health effects*** – SO_2 is linked to changes in pulmonary function and development of respiratory diseases in humans (USEPA 2008).
- ***Indirect health effects*** – SO_2 contributes to formation of fine particulate matter, which is associated with pulmonary and cardio-vascular effects in humans (USEPA 2008).
- ***Direct effects on vegetation*** – SO_2 can cause direct foliar injury and affects plant physiology and metabolism (discussed in Section 2.5.5).

- ***Indirect environmental effects*** – SO_2 also contributes to acid rain formation (discussed in Section 2.5.5).

2.3.2.4 Health and Environmental Criteria, Objectives and Guidelines for SO_2

Many jurisdictions have developed environmental and/or health related guidelines for air contaminants. In some cases, these guidelines vary significantly. A comparison of guidelines for SO_2 from different jurisdictions is provided in Table 2-10. The Fort McKay's HTES values were used to assess the impact of Shell's proposed projects and the impact of all planned regional projects on air quality in Fort McKay. The HTES values for SO_2 are more stringent than those in the Alberta Ambiance Air Quality Objectives (AAAQO). The HTES values only take into account:

1. health and odour-based air quality criteria, and

2. Keeping Clean Areas Clean (KCAC)-based air quality targets.

The values do not address the environmental impacts of the contaminant.

Table 2-10: A Comparison of Air Quality Guidelines for SO_2

Averaging Period	Fort McKay HTES		Alberta Ambient Air Quality Objectives	World Health Organization	
	Ambient Air Quality Criteria (Health and Odour-Based)[1]	Air Quality Targets (KCAC-Based)		2000	2005
10-Minute	500 µg/m³ (equivalent to approx. 300 µg/m³for 1-Hour)	--	--	500 µg/m³	500 µg/m³
1-Hour	--	31.4 µg/m³ (Annual 95th Percentile) 5 µg/m³ (Annual 50th Percentile)	450 µg/m³	--	--
24-Hour	20 µg/m³	--	150 µg/m³	125 µg/m³	20 µg/m³
Annual	No Guideline	6 µg/m³	30 µg/m³	50 µg/m³	--

[1]Based on 2005 WHO Air Quality Guideline update (***http://www.euro.who.int/Document/E87950.pdf***)

2.3.2.5 SO_2 Impact Assessment

SO_2 emission impacts on Fort McKay and its Traditional Lands under the Pre-development, Current, Baseline, Application and PDC scenarios were assessed based on existing SO_2 ambient air quality data and model predictions from Shell's EIA and

the Petro-Canada MacKay River Expansion and Synenco EIAs. The model predictions from other EIAs were used to provide a range of SO_2 predictions, which gives an indication of the range of future SO_2 levels that could occur. These predictions clearly indicate that model values cannot be considered as absolute estimates but rather as general approximations.

Pre-Development Scenario

In the absence of industrial development, ambient SO_2 levels in Fort McKay would be expected to be very low and largely based on a regional background level. At Fort McKay's request, Shell had an assessment prepared that provided estimates of SO_2, NO_2 and $PM_{2.5}$ concentrations in Fort McKay for a period around 1965 which would represent pre-development air quality in the Community (Golder 2009). Table 2-11 provides the estimate of "pre-development" SO_2 levels in Fort McKay from this assessment.

Table 2-11: Predicted Pre-development SO_2 Levels in Fort McKay[3]

Maximum 1-Hour Concentration[1] (µg/m³)	Peak 24-Hour Concentration[1] (µg/m³)	Annual Average (µg/m³)	Annual Average (Fort McKay's value) (µg/m³)
3.2	3.1	0.9	0.9

[1]The peak concentrations represent the highest predictions from the CALPUFF model. The maximum 1-Hour concentration excluded the eight highest 1-Hour predictions.

These background levels are considered reasonable estimates of pre-development SO_2 levels for the respective averaging periods. These values were used by Fort McKay in its assessment of the impact of Current, Base, Application, and Planned Development Case emissions on SO_2 levels in the Community for these averaging periods.

Current Scenario

Assessment of the current impact of regional SO_2 emissions on ambient SO_2 levels in Fort McKay was based on:

- community-specific assessment information that Shell/Golder provided to Fort McKay (Golder 2009),
- SO_2 air quality summary data from WBEA, and
- SO_2 air quality data from the CASA Data Warehouse.

Table 2-12 provides a summary of ambient SO_2 data for Fort McKay for the period from 1999 to 2006 inclusive (Shell 2007,Vol. 3, Appendix 3.7). Ambient SO_2 levels in

[3] Circa 1965; Golder 2009.

Fort McKay in 2008 (CASA Data Warehouse 2009) and the predicted pre-development SO_2 levels are also included for comparison.

The data in Table 2-12 indicates SO_2 levels in Fort McKay in 2008 are similar to the levels in the 1999-2006 period, which reflects the fact that regional SO_2 levels have not changed significantly in the last 10 years. The data also indicates that SO_2 levels in the Community have increased significantly from pre-development levels, which would be expected based on the significant SO_2 emissions from Suncor and Syncrude.

To determine whether or not there were any statistically significant air quality trends in Fort McKay, a trending analysis for SO_2, $PM_{2.5}$ and NO_2 levels in Fort McKay was undertaken by Golder (2009). This analysis identified no statistically significant trends either upward or downward for SO_2 (Figure 2-5).

Table 2-12: Summary of Ambient SO_2 in Fort McKay for Years 1999-2006 and 2008 in Comparison to Pre-development Scenario SO_2 Levels

Averaging Period	Ambient SO_2 Level in Fort McKay (µg/m³)			% Increase From Pre-Development to 2008 Level
	1999 - 2006	2008	Pre-Development	
Maximum 1-Hour (range of annual Maximum 1-Hour values)	414 (168-414)	280	3.2	8650%
95th percentile 1-Hour	15.7	18.3	-	-
Maximum 24-Hour (range of annual Maximum 24-Hour values)	63.2 (21.5-63.2)	54.0	3.1	1640%
95th percentile 24-Hour	14.0	17.4	-	-
Mean Annual (range of annual Mean Annual values)	3.2 (2.4-4.0)	3.7	0.9	310%

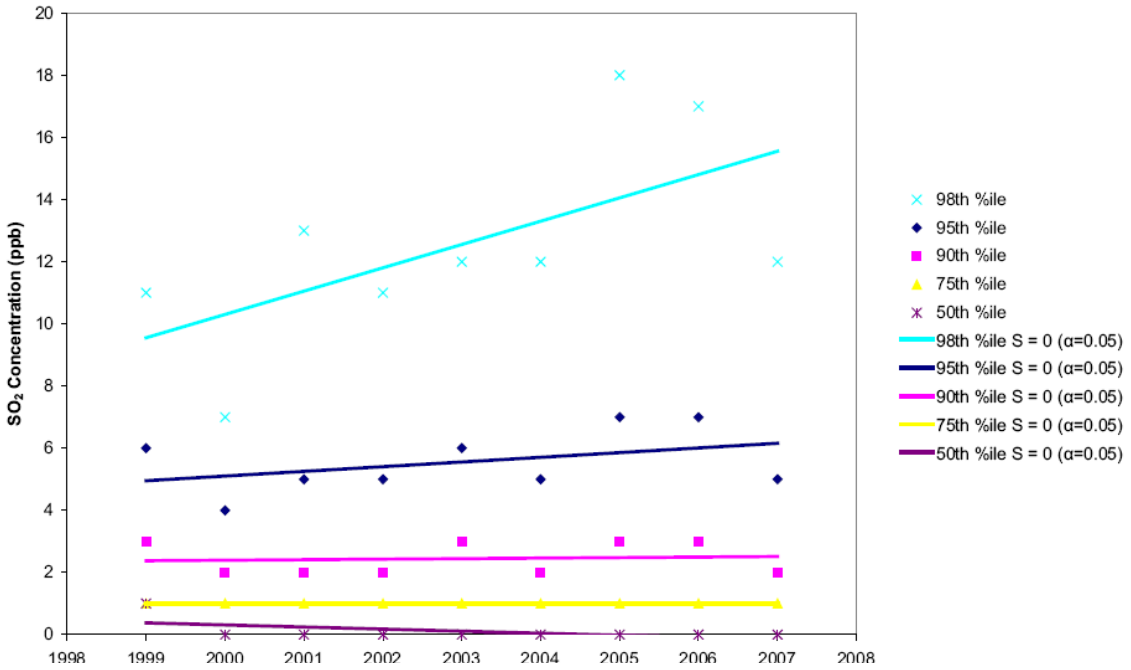


Figure 2-5: Fort McKay SO_2 Concentration Trends for Period 1999-2007[4]

Although at the 98th percentile frequency level there appeared to be a possible upward trend, the 2008 98th percentile is quite low (i.e., 20.9 µg/m^3 or 8 ppb). It appears, as would be expected, that high SO_2 levels occur relatively infrequently and are likely associated with process bypasses, flaring and/or certain meteorological conditions.

The influence of industrial emissions on SO_2 levels in Fort McKay is demonstrated in Figure 2-6. The 95th percentile value obtained from 2005 to 2008 air quality monitoring, as well as the KCAC Annual 1-Hr 50th and 95th percentile and Annual Average targets are used as references for comparison. This figure shows that, when 1-Hour SO_2 levels in Fort McKay are elevated (i.e., above the reference values), the winds are generally from the South-southeast (SSE) to Southwest (SW). This is a clear indication of industrial influence on ambient SO_2 levels in Fort McKay.

Based on the current air quality data, SO_2 levels in Fort McKay are relatively unchanging except at the upper range (i.e., 95th - 98th percentile) levels where values do vary significantly from year to year. In 2007, the Alberta 1-Hour objective for SO_2 was exceeded on one occasion (WBEA 2007), so levels can be high in the Community at times. In terms of the current situation with respect to SO_2 levels in the community relative to Fort McKay's health, KCAC and AQHI criteria, Table 2-13 provides a comparison between the current SO_2 levels and the Community's criteria.

[4]Golder 2009.

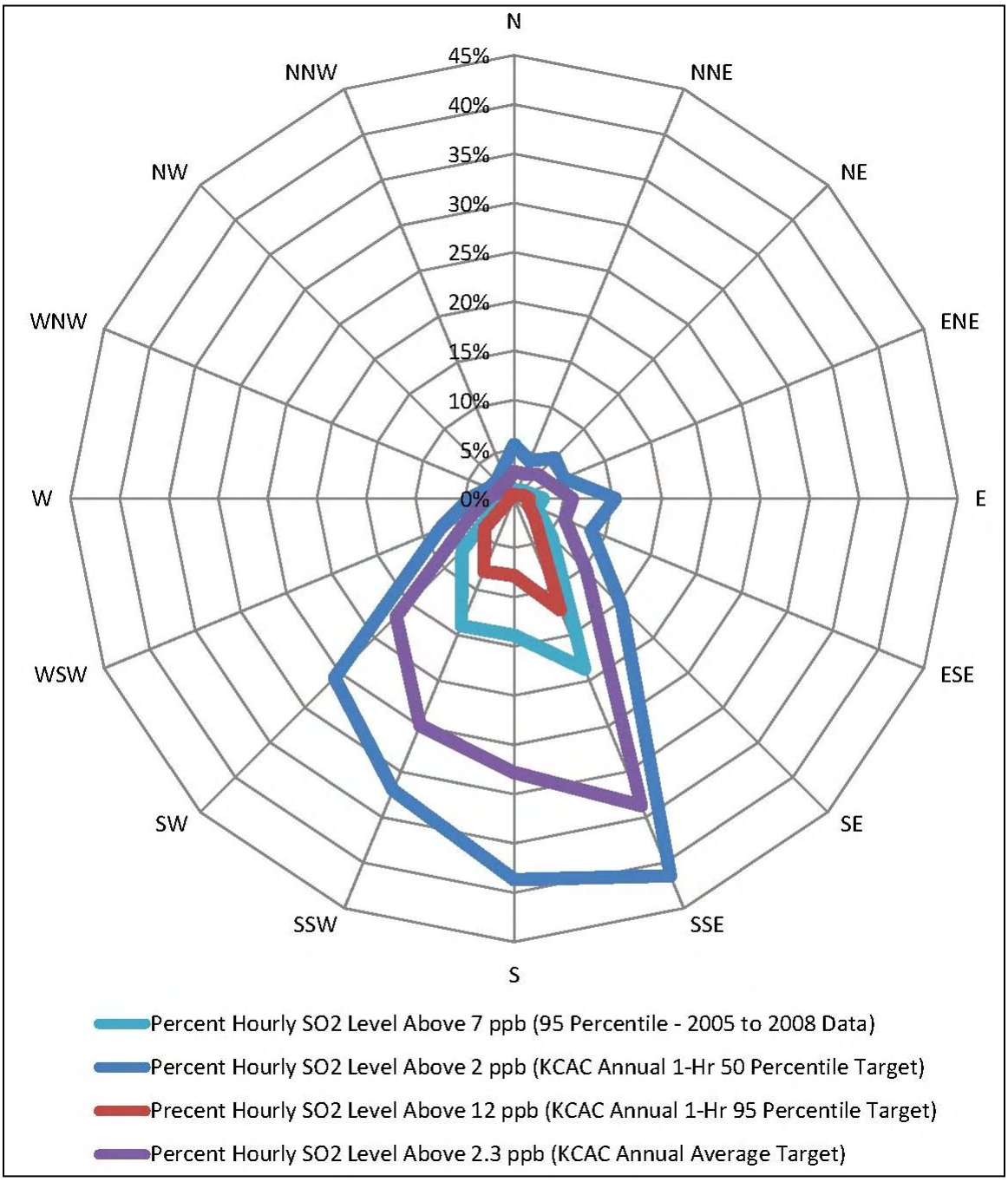


Figure 2-6: Wind Direction Influence on Hourly[5] SO_2 Level in Fort McKay (2005-2008)

[5] The plots give the % of the total hourly SO_2 levels above the specified level when the wind is from the noted wind direction.

Table 2-13: Comparison of Current SO_2 Levels (2008) in Fort McKay Relative to the HTES (2009) Criteria

Averaging Period	Fort McKay's SO_2 Criteria	Current Levels (µg/m³)	Assessment/ Comment
Health and Odour-Based Criteria			
10-Minutes	500 µg/m³ (equals approx. 300 µg/m³ as 1-Hour)	280 (1-Hour)	Close to criteria
24-Hour	20 µg/m³	23	Above criteria
KCAC-BasedTargets			
95th percentile 1-Hour	31.4 µg/m³	15	Well below criteria
50th percentile 1-Hour	5 µg/m³	3.3	Below criteria
Annual Average	6 µg/m³	5	Close to criteria

The Community is satisfied that the current SO_2 levels in the Community do not represent a significant health risk and are generally within the Community's health and KCAC criteria. However, the causes of the occasional high 1-Hour readings above provincial and/or Fort McKay criteria in the community warrant investigation and possible action. The occasional occurrence of the 24-Hour values above Fort McKay's criteria is also a concern. The current situation is therefore considered to represent a **yellow** condition.

Base Case

Table 2-14 from Golder (2009) summarizes the Base Case predicted SO_2 levels in Fort McKay based on: Shell's EIA (Shell 2007), the Petro-Canada MacKay River Expansion EIA (Petro-Canada 2005) and the Synenco Northern Lights EIA (Synenco 2007). These predictions are compared to Fort McKay and Alberta Environment SO_2 objectives.

With exception of the 1-Hour predictions, the data in Table 2-14 indicates that the predictions from the three recent EIAs are generally consistent for SO_2, which might reflect the fact that regional SO_2 emission sources are fairly easy to identify, quantify and model. Based on the Base Case SO_2 predictions, it is Fort McKay' assessment that SO_2 emissions and levels under this scenario are not a major concern, but the potential does exist for Fort McKay's daily SO_2 criteria of 20 µg/m^3 to be exceeded. Normally, such predicted 24-Hour exceedences of Fort McKay's criteria would be considered a **red** situation. However, as noted in the Current Scenario section, Fort McKay is satisfied that the current ambient SO_2 levels do not represent a significant health risk and are generally within the Community's health and KCAC criteria.

Table 2-14: Comparison of Predicted Base Case SO_2 Concentrations in Fort McKay from Various EIAs Relative to Fort McKay and Alberta Environment SO_2 Objectives

Project	Maximum[1] 1-Hour (µg/m³)	50th% 1-Hour (µg/m³)	95th% 1-Hour (µg/m³)	Peak[2] 24-Hour (µg/m³)	Peak[2] Annual (µg/m³)
Petro-Canada	43	—	—	18	3.4
Synenco	96	—	—	219	5.2
Shell (excluding developed area)	85	<3	~20	24	4.2
AAAQO	450	—	—	150	—
Fort McKay HTES	500 (10-min. average) (approx. 300 as 1-Hour)	5	31.4	20	6 (KCAC)

[1]Maximum predictions exclude the eight highest 1-Hour predictions.

[2]Peak predictions do not exclude the eight highest 1-Hour predictions.

It is anticipated that, with the new lower sulphur in diesel requirements and Syncrude's imminent completion of its major sulphur emission reduction project, the regional emissions of SO_2 will drop significantly. The Community is therefore concerned principally with upset or operational conditions that could result in periodic high SO_2 levels in the community and would like this issue addressed. As noted previously, there was an exceedence in Fort McKay in 2007 of the province's 1-Hour SO_2 limit of 450 µg/m^3 (WBEA 2007). Therefore, the Base Case is considered to represent a **yellow** condition.

Application Case

Table 2-15 summarizes the predicted Application Case SO_2 levels in Fort McKay. The values are based on predictions presented in Shell's EIA (Shell 2007) and are compared to Fort McKay and Alberta Environment SO_2 objectives.

The data in Table 2-15, when compared to data in Table 2-14 (Base Case), indicate that the proposed Shell projects do not significantly change the predicted SO_2 levels in Fort McKay. However, the proposed use of asphaltene-fired co-generation does significantly increase the SO_2 emissions from the proposed projects. The Application Case is therefore of interest to Fort McKay in terms of SO_2 emissions management, which is discussed in Section 2.3.2.7. Fort McKay's assessment for the Application Case is the same as for the Base Case, i.e., the scenario represents a **yellow** situation.

Table 2-15: Comparison of Predicted Application Case SO_2 Concentrations in Fort McKay Relative to Fort McKay and Alberta Environment SO_2 Objectives

Project	Maximum[1] 1-Hour (µg/m³)	50th% 1-Hour (µg/m³)	95th% 1-Hour (µg/m³)	Peak[2] 24-Hour (µg/m³)	Peak[2] Annual (µg/m³)
Shell (excluding developed area)	84.6	<3	~20	24	4.2
AAAQO	450	—	—	150	—
Fort McKay HTES	500 (10-min. average) (approx. 300 as 1-Hour)	5	31.4	20	6 (KCAC)

[1]Maximum predictions exclude the eight highest 1-Hour predictions.

[2]Peak predictions do not exclude the eight highest 1-Hour predictions.

Planned Development Case

Table 2-16 taken from Golder (2009) summarizes the predicted SO_2 levels for the Planned Development Case in Fort McKay based on: Shell's EIA (Shell 2007), the Petro-Canada MacKay River Expansion EIA (Petro-Canada 2005) and the Synenco Northern Lights EIA (Synenco 2007). These predictions are compared to the Fort McKay and AENV SO_2 objectives.

Table 2-16: Comparison of Predicted Planned Development Case SO_2 Concentrations in Fort McKay from Various EIAs Relative to Fort McKay and Alberta Environment SO_2 Objectives

Project	Maximum[1] 1-Hour (µg/m³)	Peak[2] 24-Hour (µg/m³)	Peak[2] Annual (µg/m³)
Petro-Canada	50	26	4.8
Synenco	97	24	5.7
Shell (excluding developed area)	101	32	5.4
AAAQO	450	150	—
Fort McKay HTES	500 (10-min. average) (approx. 300 as 1-Hour)	20	6 (KCAC)

[1]Maximum predictions exclude the eight highest 1-Hour predictions.

[2]Peak predictions do not exclude the eight highest 1-Hour predictions.

The data in Table 2-16, when compared to data in Table 2-14 (Base Case), indicates that the Planned Development Case will generally increase SO_2 levels in Fort McKay by 10 to 30% above Base Case values depending on the averaging period and

frequency value. Fort McKay's assessment for the Planned Development Case is therefore the same as for the Base Case, i.e., the scenario represents a **yellow** situation. It is Fort McKay's assessment that all future oil sands projects should be subject to rigorous SO_2 emission controls to minimize the increase in regional SO_2 emissions and the impact these emissions have on SO_2 levels in Fort McKay (Sections 2.3.2.7 and 2.3.2.8). This will be particularly important if or when alternate fuels such as coke, bitumen, asphaltenes, produced gas and refinery fuel gas are substituted for natural gas.

Traditional Lands

While the focus of Fort McKay's assessment with respect to SO_2 emissions was in the context of effects on air quality in the Community (this section) and vegetation effects (Section 2.5), a review of predicted SO_2 levels over all of Fort McKay's Traditional Lands was also undertaken.

Shell's Fort McKay Community Assessment report (Table 3.1-1 and Figures 3.1-1 to 3.1-9; Golder 2009) summarizes the SO_2 predictions within Fort McKay's Traditional Lands. SO_2 concentrations above the AAAQO and/or HTES criteria are expected in large areas of Fort McKay's Traditional Lands (Table 2-17). Locations of maximum concentration were predicted to be predominantly in the intense-use traditional area south and east of Fort McKay, as well as in the moderate-use traditional area north of the community. With the proposed Shell projects, higher SO_2 levels can be expected when the wind is from the north and/or east. Currently Fort McKay only experiences higher SO_2 levels when the wind is from the south quadrant (see Figure 2-6).

As shown in Figure 2-7, north and south are the most predominant wind directions observed in Fort McKay; together they account for 23% of the hourly observations between 2005 and 2008. As a result, emission sources north and south of the community are of particular concern and relevance to the community. SO_2 levels can be quite high on Fort McKay's Traditional Lands and Table 2-18 shows the number of exceedences of provincial SO_2 objectives at monitoring stations in the region for the period from 2000 to 2005.

Table 2-17: Summary of SO_2 Predictions above the Alberta Ambient Air Quality (AAAQOs) and/or Fort McKay's HTES Criteria on Fort McKay Traditional Lands

Culturally Significant Ecosystem (CSE) Use Category	Scenario	Objective/ Criteria	Number of Occurrences above Objective/ Criteria	Areal Extent Above Guideline (ha)
Low Use	24-Hour Base Case	HTES	25	18,200
Low Use	24-Hour Application Case	HTES	25	194,600
Low Use	24-Hour PDC	HTES	26	466,800
Moderate Use	24-Hour PDC	AAAQO	1	430
Moderate Use	24-Hour Base Case	HTES	69	165,700
Moderate Use	24-Hour Application Case	HTES	69	176,800
Moderate Use	24-Hour PDC	HTES	93	316,000
Intense Use	1-Hour PDC	AAAQO	2	130
Intense Use	24-Hour Base Case	HTES	31	84,900
Intense Use	24-Hour Application Case	HTES	32	84,700
Intense Use	24-Hour PDC	HTES	132	119,500

Table 2-18: Samples Count above AAAQOs at Industrial Monitoring Sites (2000-2005)

Monitoring Site	Count of Exceedances of AAAQOs	
	SO_2 1-Hour	SO_2 24-Hour
Albian	3	1
Buffalo	5	0
Lower Camp	4	0
Mannix	10	1
Mildred	4	0
Millenium	2	0
Syncrude	2	0

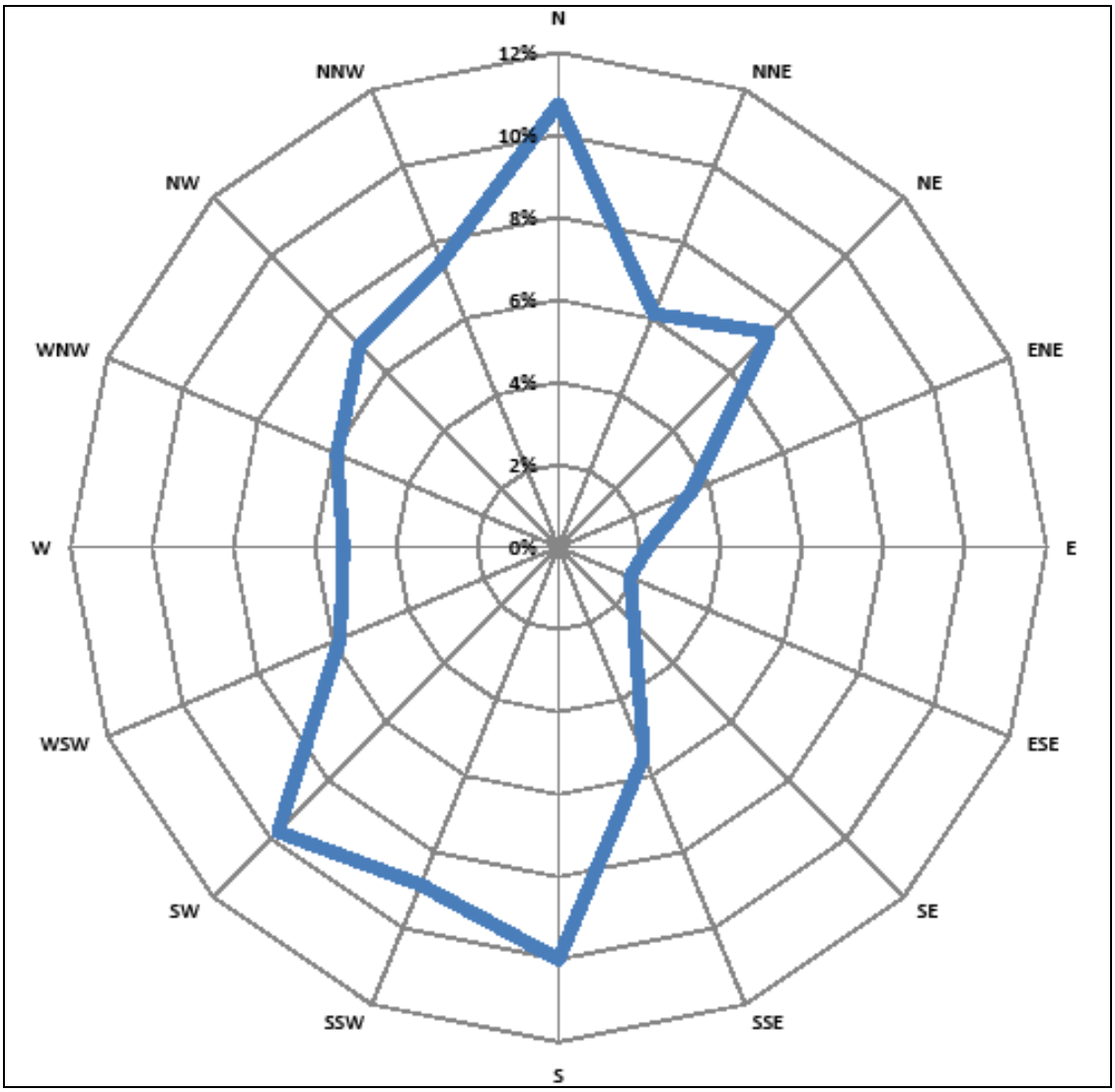


Figure 2-7: Windrose for Fort McKay (2005 to 2008)

Fort McKay presents this information as an example of how air quality on its traditional lands and in the region has been impacted by regional development, which demonstrates the need for rigorous emission controls.

2.3.2.6 Overall SO_2 Assessment Conclusion

Fort McKay's assessment conclusions regarding Pre-development, Current and predicted Base, Application and Planned Development SO_2 levels and trends in the Community are:

1. SO_2 levels in the Community have increased dramatically from pre-development levels as a result of regional developments;

2. Current SO_2 levels are generally below Provincial objectives and Fort McKay's health and Keeping Clean Areas Clean criteria/targets but provincial objectives have been exceeded in the Community on occasion;

3. Regional SO_2 emissions have generally been decreasing and will decrease further as sulphur emission controls are applied to large sulphur emission sources. This trend could reverse if alternate fuels with high sulphur content, such as coke, bitumen, asphaltenes, produced gas and refinery fuel gas, replace natural gas;

4. Analysis does not indicate any statistically significant upward trend in SO_2 levels in the Community over the last 10 years;

5. Under the Base, Application and Planned Development cases, exceedences of Fort McKay's 24-Hour SO_2 criteria are predicted;

6. Shell's proposed projects are not predicted to significantly impact SO_2 levels in Fort McKay, and it appears that Shell is employing best measures to control SO_2 emission from its proposed projects and

7. Fort McKay's principal concern with SO_2 relates to upset or operational conditions from existing operations that result in periodic high SO_2 levels in the community and believes that this issue needs to be addressed.

Fort McKay's assessment rating for each assessment case is summarized in Table 2-19. Exceedences of Fort McKay's 24-Hour SO_2 criteria are predicted. However, the impacts of existing, approved projects, Shell's proposed project and planned, but not yet approved projects, are, at this time, only considered to represent a potentially significant impact, i.e., a **yellow** situation. This significance rating is based on anticipated significant reductions in overall regional SO_2 emissions over the next few years. The occasional very high SO_2 levels in the community are a concern and an issue that needs to be addressed.

2.3.2.7 Shell's Proposed SO_2 Emissions Management

As indicated in Table 2-9, SO_2 emission from the proposed project is primarily associated with the asphaltene-fired cogeneration units. In terms of mitigation technologies, Shell has indicated in the integrated application that a control efficiency of 99% is to be adopted for controlling SO_2 emission from these cogeneration units. Although specifics on the design and performance of the technologies proposed to control emissions from the units are not provided, the general technologies proposed and the removal efficiencies outlined are considered to represent best available control technologies. Fort McKay is requesting that additional emission controls be required on the gas turbines to reduce the NO_X emission intensities (see Section 2.3.3.7). This will partially offset the significant increase in SO_2 emissions associated with the proposed asphaltene-fired boilers.

Table 2-19: Summary of Fort McKay's Assessment of the Impact of Regional SO_2 Emissions on SO_2 Levels in Fort McKay for each Development Scenario

Case/Scenario Assessment	Assessment of SO_2 Levels in Fort McKay
Background	No issues/effects
Current	Levels remaining constant but some periodic high levels and some 24-Hour HTES criteria exceedences
Base Case	Some exceedences of HTES 24-Hour criteria predicted
Application Case	Some exceedences of HTES 24-Hour criteria predicted
Planned Development Case	Some exceedences of HTES 24-Hour criteria predicted
General Comment – Position	See Sections 2.3.2.7 and 2.3.2.8

2.3.2.8 Fort McKay's SO_2 Recommendations

Based on the current and future potential for regional SO_2 emissions to impact SO_2 levels in the Community of Fort McKay, Fort McKay has a number of specific recommendations related to the understanding and management of SO_2 related air quality issues in Fort McKay. These are:

Project-Specific Recommendations

1. An "attribution" continuous air quality monitoring station be located between the Community and the proposed Pierre River mine that will monitor for NO_X, TRS, SO_2, $PM_{2.5}$ and PM_{10}, O_3, THC, VOCs and basic meteorological parameters, and that this station be incorporated into the WBEA ambient monitoring network. Such a monitoring station will assist in quantifying the impact of the proposed Pierre River Mine project on air quality in Fort McKay.

2. If Shell generates and/or uses significant volumes of produced and/or refinery fuel gas, that the TRS content of this gas be reduced through sulfur removal to less than 50 ppm, and ideally, to less than 30 ppm in order to minimize SO_2 emissions from this fuel source.

Cumulative Effects Recommendations

3. The regional models used to predict SO_2 concentrations in Fort McKay and on Fort McKay's Traditional Lands, be validated, updated and revised in order to:

    a. increase the accuracy and reliability of predictions of the impacts of existing and future SO_2 emissions, and

    b. identify, understand and manage the factors contributing to the occasional high hourly and daily SO_2 levels in Fort McKay

4. Specific procedures be developed for measuring and tracking air quality changes in the region, and in Fort McKay, including a process for formally reviewing air quality changes above specified levels, in consultation with Fort McKay. The purpose of this recommendation is to enable Fort McKay to understand current and future regional air quality changes and to ensure that significant deterioration, beyond acceptable levels (health and ecological protection and Keeping Clean Areas Clean) does not occur in the Community of Fort McKay and in the region.

5. Shell and other regional operators work with Fort McKay to finalize its HTES air quality criteria and targets. This recommendation is aimed at enabling Fort McKay's goals and strategies for air quality management to be implemented and will also assist in future project planning and air quality and emission management programs.

Note: Some of these recommendations are similar to those for odour, PM, NO_2, and vegetation effects impact management.

2.3.3 Nitrogen Oxides (NO_X, NO and NO_2)

2.3.3.1 Regional NO_X Emissions

NO_X emissions are associated with the combustion of fuels in vehicles, boilers, heaters, turbines and process units; therefore, there are a large number of NO_X sources in the region, including traffic and household heating emissions from the City of Fort McMurray. Regional estimates of NO_X have been prepared by Shell for three development scenarios and these are summarized in Table 2-20 (Shell 2007, EIA Vol. 3. Table 3.1-1, p. 3-4, December 2007).

Table 2-20: Estimated Regional Emissions of Nitrogen Oxides

Development Scenario Case			
Base (Tonnes/day)	**Project Only (Tonnes/day)**	**Application (Base + Application) (Tonnes/day)**	**Planned Development (Tonnes/day)**
483	12.19	495.2	634

These NO_X emission estimates have to be interpreted with caution for the following reasons:

1. The mine fleets are a major source of NO_X emissions and the emissions from mine fleet units is an estimated number based on many factors/considerations such as manufacturer dynamometer test results, load and use factors, etc. As such, the mine fleet emissions have a high degree of uncertainty. The estimating procedures likely result in an over prediction of NO_X emissions from mine fleets.

2. NO*X* emission values from point sources such as boilers and heaters are generally based on approved emission limits and units would be expected to operate below these levels. The estimated emissions are therefore likely higher than actual emissions.

3. Planned development emissions reflect announced but yet to be approved projects. This scenario is not representative of a full regional development scenario and therefore the Planned Development Case cannot be considered as an indicator of the maximum NO*X* emissions that will occur in the region.

Overall Fort McKay is satisfied that, except for the full planned development scenario, the NO*X* emission levels estimated by Shell are reasonable and were therefore used in its assessment.

2.3.3.2 Proposed Project NO*X* Emissions

Shell provides NO*X* emission estimates for the proposed Jackpine Mine Expansion and Pierre River Mine projects. The specific sources of NO*X* emissions from Shell's proposed projects are summarized in Table 2-21 (Shell 2007, EIA Vol. 3 Table 3.4-2, p. 3-53, December 2007).

As noted above, these estimated project emissions are subject to some uncertainty and conservatism. Conclusions drawn regarding the impact of these emissions are therefore likely conservative and represent a "worst case" Application Case scenario which is considered appropriate in an impact assessment.

Table 2-21: Specific Sources and Estimated Emission Rates of NO*X* from Shell's Proposed Jackpine Mine Expansion and Pierre River Mine Projects

Emission Source	Project and Emissions	
	Jackpine Mine Expansion	Pierre River Mine
	NO*X* (Tonnes/day)	NO*X* (Tonnes/day)
Co-generation	2.89	5.13
Mine fleet	3.89	7.31
Mine face fugitive	-	-
Tailings pond fugitive	-	-
Plant fugitive	-	-
Total[1]	6.45	12.45

[1]Note that the total NO*X* emissions are not the same as those in Table 2-13 because there are some NO*X* emission reductions at the existing Jackpine mine that are part of the Jackpine mine expansion project.

2.3.3.3 Health and Environmental Impacts of NO*X*

There are a number of potential health and environmental issues associated with industrial NO*X* emissions and their subsequent dispersion, reaction and deposition in the environment. These include:

- Human health effects associated with nitrogen dioxide (NO_2) in ambient air (USEPA 2008a);
- Environmental effects associated with direct exposure (fumigation) to NO and NO_2 (covered in Section 2.5);
- Environmental effects associated with nitrogen deposition (fertilization/ eutrophication) resulting from NO*X* emissions (covered in Section 2.5);
- Health and environmental effects associated with ozone (O_3) formation resulting from ambient NO_2 (partly addressed in Section 2.5);
- Health effects associated with fine particulates ($PM_{2.5}$) which NO and NO_2 can contribute to (addressed in Section 2.3.4.3);
- Environmental effects associated with acid deposition resulting from NO*X* emissions (e.g., NO*X* emissions reacting in the atmosphere to produce nitrous and nitric acid; addressed in Section 2.5).

The focus of the NO*X* assessment in this section is on NO_2 levels in the Community of Fort McKay and possible health effect and general air quality deterioration issues.

2.3.3.4 Health and Environmental Criteria, Objectives and Guidelines for NO_2

Fort McKay has developed health-based ambient air quality objectives for NO_2 (HTES 2009; see Section 2.2.5.2). This objective is based on a recent review and updating of the European air quality guideline for NO_2 (WHO 2005). The 1-Hour objective is consistent with the new 1-Hour NO_2 objective the US Environmental Protection Agency (USEPA) is currently considering for NO_2, which is also based on a thorough and updated review of the health effects associated with the substance (USEPA 2009a). A comparison of Alberta's current ambient air quality objectives, past and current WHO guidelines and Fort McKay's HTES health-based criteria for NO_2 are presented in Table 2-22.

Fort McKay has also developed a "Keeping Clean Areas Clean" criteria related to NO_2 (see Section 2.2.5.3) and these are summarized in Table 2-23.

Table 2-22: Comparison of Current AAAQO, Past and Current WHO Guidelines and Fort McKay's HTES Health-based Criteria for NO_2

Averaging Period	AAAQO (µg/m³)	WHO (2000) (µg/m³)	WHO (2005) (µg/m³)	Fort McKay's HTES Ambient Air Quality Criteria (µg/m³)
1-Hour	400	200	200	200
24-Hour	200	No guideline	No guideline	No guideline
Annual	60	40	40	40

Table 2-23: Fort McKay's "Keeping Clean Areas Clean" (KCAC) Community-based Air Quality Targets for NO_2

Averaging Period	Fort McKay's Target (µg/m³)
Annual 95th Percentile 1-Hour	51
Annual 50th Percentile 1-Hour	10.3
Annual Average	20

Fort McKay is also using the Health Canada Air Quality Health Index (AQHI) as an indicator of air quality in the Community (see Section 2.2.5.2). The equation for determining the AQHI is expressed as follows:

Equation 2-1: Health Canada Air Quality Health Index (AQHI)

$$AQHI = \left(\frac{1000}{10.4}\right)\left[\left(e^{0.000871[NO_2]} - 1\right) + \left(e^{0.000537[O_3]} - 1\right) + \left(e^{0.000487[PM_{2.5}]} - 1\right)\right]$$

Where:

- AQHI = air quality health index
- $[NO_2]$ = ambient air NO_2 concentration in ppb, 3-hour average
- $[O_3]$ = ambient air O_3 concentration in ppb, 3-hour average
- $[PM_{2.5}]$ = ambient air $PM_{2.5}$ concentration in µg/m^3, 24-Hour average

The equation weighs ambient NO_2 levels higher than O_3 and $PM_{2.5}$ and therefore the AQHI is relatively more sensitive to changes in ambient levels of NO_2 than it is to O_3 and $PM_{2.5}$. For this reason ambient NO_2 levels are of particular relevance and concern in terms of keeping AQHI values in the Community low.

The Community's health and KCAC objectives for NO_2 were used to determine the potential impacts of Background, Baseline, Application and Planned Development on air quality in Fort McKay.

2.3.3.5 NO*X* Impact Assessment

In this community based assessment, the impact of regional NO*X* emissions on NO_2 levels in the Community, and associated health and air quality impacts, are discussed, and to the extent possible, assessed, for the five development scenarios/ cases: Pre-development, Current, Base, Application and Planned Development. This assessment uses information from Shell's EIA and regional air quality data.

Pre-development Scenario

In the absence of industrial development, ambient NO_2 levels in Fort McKay would be expected to be very low and largely based on a regional background level. At the request of Fort McKay, Shell had an assessment prepared that provided estimates of NO_2, SO_2 and $PM_{2.5}$ concentrations in Fort McKay for a period around 1965 which would represent pre-development air quality in the Community (Golder 2009).

Table 2-24 provides the estimate of "pre-development" SO_2 levels in Fort McKay from this assessment.

Table 2-24: Predicted Pre-development NO_2 levels in Fort McKay[6]

Maximum 1-Hour Concentration[1] (µg/m³)	Peak 24-Hour Concentration[1] (µg/m³)	Annual Average (µg/m³)	Annual Average(Fort McKay's value) (µg/m³)
23	23	5.5	5.0

[1]The peak concentrations represent the highest predictions from the CALPUFF model. The maximum 1-Hour concentration excluded the eight highest 1-Hour predictions.

The maximum 1-Hour and peak 24-Hour concentrations are considered reasonable estimates of background NO_2 levels for these averaging periods and were used by Fort McKay in its impact assessment of Current and Base, Application and Planned Development case emissions on NO_2 levels in the Community for these averaging periods. The annual average NO_2 value is considered high as the 1998 annual average NO_2 in Fort McKay was 5.07 µg/m^3 and therefore an annual average value of 5 µg/m^3 was considered as background.

Current Scenario

An assessment of the current impact of regional NO*X* emissions on NO_2 levels in Fort McKay was based on:

[6]Circa 1965; Golder 2009.

- community-specific assessment information that Shell/Golder provided to Fort McKay,
- NO_2 air quality summary data from WBEA and
- NO_2 air quality data from the CASA Data Warehouse.

Table 2-25 provides a summary of ambient NO_2 data for Fort McKay for the period from 1998 to 2006 inclusive (Shell 2007, Vol. 3, Appendix 3.7). Ambient NO_2 levels in Fort McKay in 2008 (CASA Data Warehouse 2009) and the predicted pre-development NO_2 levels are also included for comparison.

The data in Table 2-25 indicates NO_2 levels in Fort McKay in 2008 are relatively higher compared to the 1998-2006 period, which would be expected as regional NO_X emissions have continued to increase during the last 10 years. It also indicates that NO_2 levels in the Community have increased significantly from pre-development levels.

Table 2-25: Summary of Ambient NO_2 in Fort McKay for Years 1998-2006 and Year 2008 in Comparison to Pre-development Scenario NO_2 Levels

Averaging Period	Ambient NO_2 Level in Fort McKay ($\mu g/m^3$)			% Increase From Pre-Development to 2008 Level
	1999 - 2006	2008	Pre-Development	
Maximum 1-Hour (range of annual Maximum 1-Hour values)	100 (55-100)	86	23	270%
95th percentile 1-Hour	38.	45	-	-
Maximum 24-Hour (range of annual Maximum 24-Hour values)	55 (36-55)	56.	23	140%
95th percentile 24-Hour	31	37	-	-
Mean Annual (range of annual Mean Annual values)	10.3 (6.8-12.3)	13	5	164%

To determine whether or not there was a statistically significant trend towards increasing NO_2 levels in Fort McKay, a trending analysis for SO_2, $PM_{2.5}$ and NO_2 levels in Fort McKay was undertaken by Golder (2009; Figure 2-8). This analysis identified a statistically significant trend towards increasing NO_2 levels in Fort McKay at the 98th, 95th and 90th percentile frequency levels. This means the frequency of higher concentrations of NO_2 in the Community is increasing. An

analysis of annual NO_2 levels in Fort McKay for the period 1998 to 2008 using the Spearman r_s nonparametric test was done by Fort McKay which also indicated a statistically significant (α=0.05) increase in annual NO_2 levels in the Community.

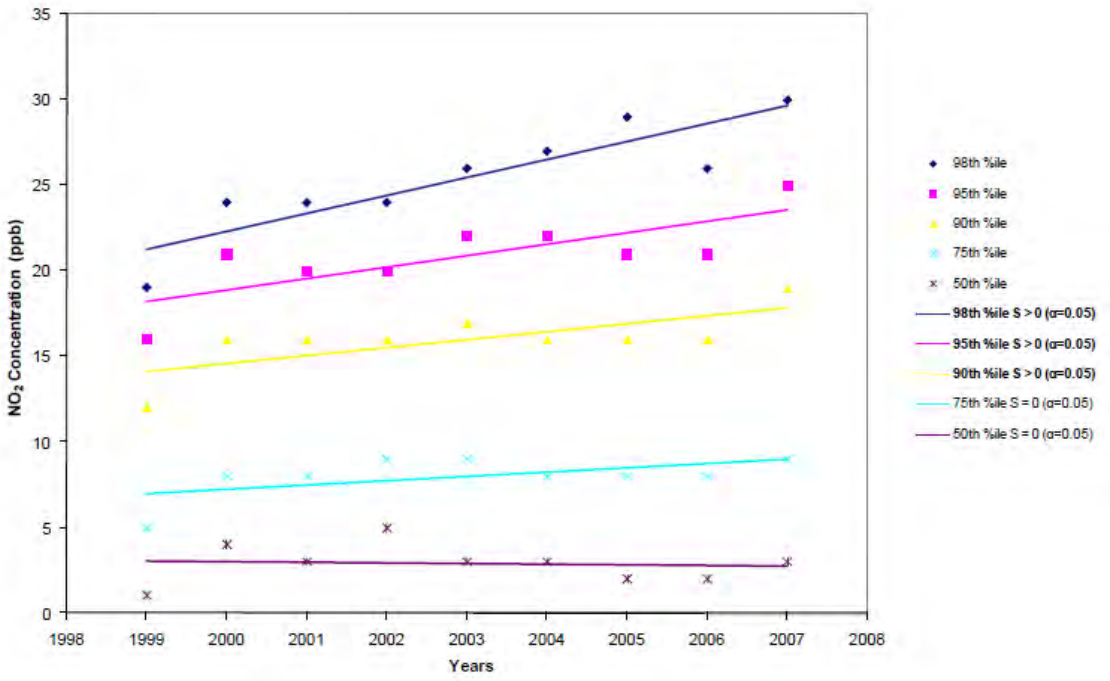


Figure 2-8: Fort McKay NO_2 Concentration Trends for Period 1999-2007 (Golder 2009)

The influence of industry emissions and possibly the City of Fort McMurray on NO_2 levels in Fort McKay is demonstrated in Figure 2-9. The 50th and 95th percentiles obtained from 2005 to 2008 air quality monitoring, as well as the KCAC Annual 1-Hour 50th and 95th percentile and Annual Average targets are used as references for comparision. This figure shows that when 1-Hour NO_2 levels in Fort McKay are elevated (i.e., above the reference values), the winds are generally from the South to Southwest. This is a clear indication of industrial and/or urban influence on ambient NO_2 levels in Fort McKay.

From the current air quality data, it is clear that NO_2 levels in the Community are increasing as a result of regional NO_X emissions and that these increases are relatively large. In terms of the current situation with respect to NO_2 levels in the Community relative to Fort McKay's health, KCAC and AQHI criteria, Table 2-26 provides a comparison between the current NO_2 levels and the Community's criteria.

The Community is satisfied that the current NO_2 levels in the Community do not represent a significant health risk and are within the Community's KCAC criteria (a **green** situation). The NO_2 criterion that is the closest to being exceeded is the KCAC 95th percentile level of 51 $\mu g/m^3$ with the 2008 95th percentile value at 45.2 $\mu g/m^3$.

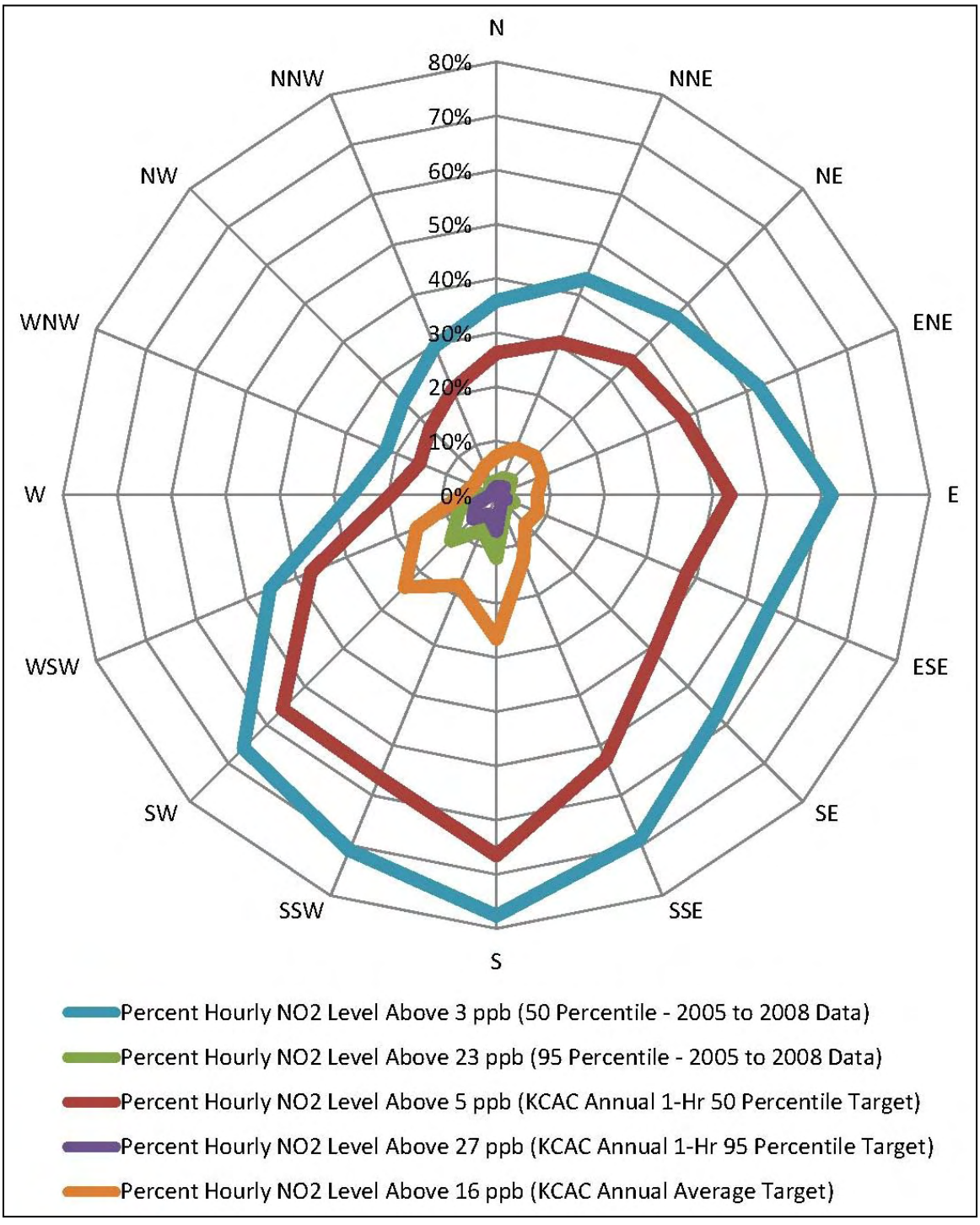


Figure 2-9: Wind Direction Influence on Hourly[7] NO_2 Level in Fort McKay (2005-2008)

[7] The plots give the % of the total hourly NO_2 levels above the specified level when the wind is from the noted wind direction

Table 2-26: Comparison of Current NO_2 Levels in Fort McKay Relative to the HTES (2009) Criteria

Averaging Period	Fort McKay's NO_2 Criteria ($\mu g/m^3$)	Current Levels ($\mu g/m^3$)	Assessment/ Comment
Health and Odour-Based Criteria			
1-Hour	200	86	Well below criteria
Annual Average	40	13.2	Well below criteria
KCAC-BasedTargets			
95th percentile 1-Hour	51	45	Close to criteria
50th percentile 1-Hour	9.4	5.6	Well below criteria
Annual Average	20	13	Well below criteria
Air Quality Health Index (AQHI)		See Appendix B	2008 analysis by Fort McKay indicated criteria being met with highest AQHI values associated with ozone and $PM_{2.5}$ – not NO_2 but NO_2 levels are affecting AQHI values

Based on a pre-development versus current ambient NO_2 comparison, the significant increases in NO_2 levels associated with industrial developments is a concern. Fort McKay believes that the current NO_2 emissions could be lower if industry was required to employ the best available NO_2 control technologies. This issue is discussed in Section 2.3.3.7.

Base Case

Table 2-27 from Golder (2009) summarizes the Base Case predicted NO_2 levels in Fort McKay based on: Shell's EIA (Shell 2007), the Petro-Canada MacKay River Expansion EIA (Petro-Canada 2005) and the Synenco Northern Lights EIA (Synenco 2007). These predictions are compared to Fort McKay and Alberta Environment NO_2 objectives.

The data in Table 2-27 highlights the variability (greater than 100% in some cases) in modeling predictions for basically the same Base Case development scenario, which complicates the assessment of the Base Case's potential impact on NO_2 levels in Fort McKay. Based on the Base Case NO_2 predictions, it is Fort McKay' assessment that:

1. Maximum 1-Hour NO_2 concentrations have the potential to exceed Fort McKay's criteria of 200 $\mu g/m^3$.

2. Peak annual NO_2 concentrations have a significant potential to exceed Fort McKay's criteria of 40 $\mu g/m^3$.

Table 2-27: Comparison of Predicted Base Case NO_2 Concentrations in Fort McKay from Various EIAs Relative to Fort McKay and Alberta Environment NO_2 Objectives

Project	Maximum[1] 1-Hour (µg/m³)	Peak[2] 24-Hour (µg/m³)	Peak[2] Annual (µg/m³)
Petro-Canada	260	187	50.7
Synenco	171	133	48.1
Shell	115.7	88.7	27.9
AAAQO	**400**	**200**	**60**
Fort McKay HTES	**200**	**—**	**40**

[1]Maximum predictions exclude the eight highest 1-Hour predictions.

[2]Peak predictions do not exclude the eight highest 1-Hour predictions.

Normally, these types of predicted exceedences of Fort McKay's health-based criteria would be considered a **red** situation. However, because of the uncertainties and general conservatism associated with industrial NOχ emissions and the range of model predictions presented in various EIAs (i.e., one predicting exceedence of the 1-Hour value and the other two not; and two predicting exceedence of the annual value and one not). Fort McKay considers the Base Case to represent a **yellow** situation requiring rigorous tracking of NO_2 levels in the community and the application of best available NO_2 controls on all new industrial emission sources and on existing sources when the opportunity arises.

Application Case

Table 2-28 summarizes the predicted Application Case NO_2 levels in Fort McKay. The values are based on predictions presented in Shell's EIA (Shell 2007) and are compared to Fort McKay and AENV NO_2 objectives.

Table 2-28: Comparison of Predicted Application Case NO_2 Concentrations in Fort McKay relative to Fort McKay and Alberta Environment NO_2 Objectives

Project	Maximum[1] 1-Hour (µg/m³)	50th percentile 1Hour (µg/m³)	95th percentile 1-Hour (µg/m³)	Peak[2] 24-Hour (µg/m³)	Peak[2] Annual (µg/m³)
Shell	117	20	75	89	28
AAAQO	400	—	—	200	60
Fort McKay HTES	200	10.3	51	—	40 (20 for KCAC)

[1]Maximum predictions exclude the eight highest 1-Hour predictions.

[2]Peak predictions do not exclude the eight highest 1-Hour predictions.

The data in Table 2-28, when compared to data in Table 2-26 (Base Case), indicates that the proposed Shell projects do not significantly change the predicted NO_2 levels in Fort McKay. Fort McKay's assessment for the Application Case is therefore the same as for the Base Case, i.e., the scenario represents a **yellow** situation. It is Fort McKay's assessment that the proposed Shell projects can further reduce NO_X emissions and this should be a requirement (see Section 2.3.3.7 and 2.3.3.8).

Planned Development Case

Table 2-29, taken from Golder (2009), summarizes the predicted NO_2 levels for the Planned Development Case in Fort McKay based on: Shell's EIA (Shell 2007), the Petro-Canada MacKay River Expansion EIA (Petro-Canada 2005) and the Synenco Northern Lights EIA (Synenco 2007). These predictions are compared to the Fort McKay and Alberta Environment NO_2 objectives.

The data in Table 2-29, when compared to data in Table 2-26 (Base Case), indicates that the Planned Development Case will generally increase NO_2 levels in Fort McKay by 10 to 20% above Base Case values depending on the averaging period or frequency value. Fort McKay's assessment for the Planned Development Case is therefore the same as for the Base Case, i.e., it represents a **yellow** situation. It is Fort McKay's assessment that all future oil sands projects should be subject to rigorous NO_X emission controls to minimize the increase in regional NO_X emissions and the impact of these emissions on NO_2 levels in Fort McKay (see Sections 2.3.3.7 and 2.3.3.8).

Table 2-29: Comparison of Predicted Planned Development Case NO_2 Concentrations in Fort McKay from Various EIAs Relative to Fort McKay and Alberta Environment NO_2 Objectives

Project	Maximum[1] 1-Hour (µg/m³)	50th percentile 1-Hour (µg/m³)	95th percentile 1-Hour (µg/m³)	Peak[2] 24-Hour (µg/m³)	Peak[2] Annual (µg/m³)
Petro-Canada	330	—	—	240	57
Synenco	175	—	—	135	53
Shell	119	25	80	97	31
AAAQO	**400**	**—**	**—**	**200**	**60**
Fort McKay HTES	**200**	**10.3**	**51**	**—**	**40 (20 for KCAC)**

[1]Maximum predictions exclude the eight highest 1-Hour predictions.

[2]Peak predictions do not exclude the eight highest 1-Hour predictions.

2.3.3.6 Overall NO_2 Impact Assessment Conclusion

Fort McKay's assessment conclusions regarding Pre-development, Current and predicted Base, Application and Planned Development NO_2 levels and NO_2 trends in the Community are:

1. NO_2 levels in the Community have increased significantly above pre-development levels as a result of regional developments;

2. Analysis indicates a statistically significant upward trend in NO_2 levels in the Community over the last 10 years;

3. Current NO_2 levels in Fort McKay are below Fort McKay's health and Keeping Clean Areas Clean criteria/targets;

4. Base and Planned Development Case NO_2 predictions indicate that NO_2 levels in Fort McKay will increase significantly based on projected industrial development and the associated $NO\chi$ emission rates. These increases are predicted to result in exceedences of some of Fort McKay's health and Keeping Clean Areas Clean criteria/targets and possibly some of Alberta's AAQOs;

5. Shell's proposed projects are not predicted to significantly impact NO_2 levels in Fort McKay but predicted impacts can be further reduced through application of better $NO\chi$ emission controls; and

6. There are emission and modeling uncertainties associated with the Base, Application and Planned Development NO_2 predictions for Fort McKay that were considered in assessing the significance of predicted NO_2 impacts.

Fort McKay's assessment rating for each assessment case is summarized in Table 2-30. Exceedences of Fort McKay's NO_2 criteria and targets are predicted. However, the impacts of existing, approved projects, Shell's proposed project and planned but not yet approved projects are, at this time, only considered to represent a potentially significant impact, i.e., a **yellow** situation. This significance rating is the result of model and emission uncertainties that are likely over-estimating the impact of future regional $NO\chi$ emissions on NO_2 levels in Fort McKay. Rigorous $NO\chi$ emission management is, however, considered necessary to reduce and ultimately reverse the current trend of increasing NO_2 levels in Fort McKay.

Table 2-30: Summary of Fort McKay's Assessment of the Impact of Regional NO$_X$ Emissions on NO_2 Levels in Fort McKay for each Development Scenario

Case/Scenario Assessment	Assessment of NO_2 Levels in Fort McKay
Background	No issues/effects
Current	Levels increasing but HTES criteria and targets are being met
Base Case	Some exceedences of HTES criteria and targets predicted
Application Case	Some exceedences of HTES criteria and targets predicted
Planned Development Case	Some exceedences of HTES criteria and targets predicted
General Comment – Position	See Sections 2.3.3.7 and 2.3.3.8

2.3.3.7 Shell's Proposed NO$_X$ Emissions Management

Shell has indicated that it will undertake a number of air emission management measures at its proposed projects. Many of these are directed at reducing NO$_X$ emissions. These measures include (information taken from EIA Vol. 3, Section 2.2.5.2, pp. 2-12 to 13, December 2007):

- The gas-fired cogeneration units and auxiliary boilers will meet the Emission Guidelines for Oxides of Nitrogen (NO$_X$) for New Boilers, Heaters and Turbines using Gaseous Fuels Based on a Review of Best Available Technology Economically Achievable (BATEA) - Interim Guideline (AENV 2007),
- Flaring will be minimized for the Project (e.g., upset/emergency conditions, start-up and commissioning) and will comply with the Alberta Energy and Utilities Board Directive 060,
- The asphaltene-fired cogeneration units will achieve 75% NO$_X$ control efficiency through the use of selective catalytic reduction (SCR) NO$_X$ control technology (note: this type of NO$_X$ control appears to be consistent with AENV's draft revised Policy 1 for Emission Standards for the Use of Non-gaseous Fossil Fuels for Steam Generation in In-Situ Bitumen or Heavy Oil Recovery Projects; AENV 2008b) and the emission limits proposed (Shell 2009 –Vol. 1 Question 230, pp. 11-24 to 27) are better than those in the draft revised Policy 1, and
- Vehicles in the mine fleet will meet applicable emission standards at the time of purchase and mine maintenance procedures will ensure fleet vehicles are regularly maintained.

Shell is also proposing to undertake stack surveys and sampling on new boilers and heaters, consistent with Shell's current Alberta EPEA Approval conditions and to continue to work with AENV and WBEA members to understand regional monitoring requirements.

These are all considered reasonable NOX emission management actions. But based on the application of best available NOX controls and the fact that there are predicted cumulative impacts associated with these and other regional NOX emissions, additional NOX controls (e.g., SCR), should be applied on the three gas-fired co-generation units being proposed by Shell.

Note: The NOX controls proposed for the asphaltene-fired cogeneration units are considered to represent best available control technology and additional controls on these units are not being requested.

2.3.3.8 Fort McKay's Nitrogen Oxides Recommendations

Based on the current potential for NOX emission-related effects on NO_2 levels in the Community of Fort McKay, Fort McKay has a number of specific recommendations related to the understanding and management of NO_2-related air quality issues in Fort McKay. These are:

Project-Specific Recommendations

1. Representative mine fleet units used by Shell be subject to emission testing during typical use conditions to confirm mine fleet NOX emissions (as opposed to relying on modelled emissions);

2. Shell's existing mine fleet be retrofitted with any NOX emission control retrofit devices that become commercially available to continuously improve regional NOX emissions management;

3. An "attribution" continuous air quality monitoring station be located between the Community and the proposed Pierre River mine that would monitor for NOX, TRS, SO_2, $PM_{2.5}$ and PM_{10}, O_3, THC, VOCs and basic meteorological parameters, and that this station be incorporated into the WBEA ambient monitoring network;

4. Reduction of NOX emissions from Shell's proposed gas-fired co-generation units that emit more than 100 tonne/yr of NOX be based on the use of post combustion selective catalytic reduction technology or equivalent, consistent with what Shell is proposing for its asphaltene-fired co-generation units. This is intended to minimize regional NOX emission sources and ensure "best practices" for NOX emission management.

Cumulative Effects Recommendations

5. Regional air quality models be validated, improved and updated to improve predictions of NO_2 and NO concentrations and nitrogen deposition in Fort

McKay and on its Traditional Lands, which will improve model predictions of the health and environmental impacts of ongoing and future NO*X* emissions;

6. That low NO*X* emission heavy hauler vehicles with NO*X* emissions similar to the USEPA Tier 4 limits for non-road vehicles in the 600-750 hp size range be developed and mandated to better manage NO*X* emissions from one of the major regional NO*X* emission source types i.e., heavy haulers.

7. Specific procedures for measuring and tracking air quality changes in the region, and in Fort McKay, including a process for formally reviewing air quality changes above specific levels (health and ecological protection and Keeping Clean Areas Clean levels), in consultation with Fort McKay. The purpose of this recommendation is to ensure that deterioration beyond acceptable levels does not occur in the Community of Fort McKay and in the region; and

8. Shell and other regional operators work with Fort McKay to finalize its HTES air quality criteria and targets. This recommendation is aimed at enabling Fort McKay's goals and strategies for air quality management to be implemented and will also assist in future project planning and air quality and emission management programs.

Note: Some of these recommendations are similar to those for odour, PM, SO_2, and vegetation effects impact management.

2.3.4 Fine Particulate Matter ($PM_{2.5}$)

2.3.4.1 Regional $PM_{2.5}$ Emissions

$PM_{2.5}$ emissions are associated with the combustion of some fuels in vehicles, boilers, heaters, turbines and process units and dust from construction and mining operations (primary $PM_{2.5}$). $PM_{2.5}$ is also formed in the atmosphere from water vapour and various sulphur, nitrogen and hydrocarbon compounds (secondary $PM_{2.5}$). Regional estimates of $PM_{2.5}$ emission have been prepared by Shell for three development scenarios (Table 2-31; Shell 2007, EIA Vol. 3, Tables 2.2-1, p. 2-8, December 2007). Shell indicates that the predictions provided in this EIA are considered conservative, as all particulate emissions in the region were assumed to be $PM_{2.5}$ (Shell 2007, EIA Vol. 3, p. 3-75, December 2007).

Table 2-31: Estimated Regional Emissions of Fine Particulate Matter ($PM_{2.5}$)

Development Scenario Case			
Base (Tonnes/day)	**Project Only (Tonnes/day)**	**Application (Base + Application) (Tonnes/day)**	**Planned Development (Tonnes/day)**
31.2	0.44	31.7	39.4

Table 2-32 summarizes the slight variability in the Planned Development $PM_{2.5}$ emission estimates as presented in some recent EIAs.

Table 2-32: Estimated Planned Development Case $PM_{2.5}$ Emissions from Various Project EIAs

Project	Year of EIA	Emission Estimate for $PM_{2.5}$ (Planned Development Case) (Tonnes/day)
Imperial Kearl	2005	34
DCEL North Mine	2006	31.5
Petro-Canada MRE	2005	35
Synenco Northern Lights	2007	44
Shell Jackpine Mine Expansion	2008	39.4
Shell Pierre River Mine	2008	

These $PM_{2.5}$ emission estimates have to be interpreted with caution for the following reasons:

1. The mine fleets are a source of $PM_{2.5}$ emissions and the emissions from mine fleet units is an estimated number based on a many factors/considerations such as manufacturer dynamometer test results, load and use factors, etc. As such, the mine fleet emissions have a high degree of uncertainty;

2. $PM_{2.5}$ emission values from point sources such as boilers and heaters are generally low or negligible if natural gas is the fuel source. If liquid (e.g., diesel) or solid (e.g., coke) is used as a fuel source, $PM_{2.5}$ emissions can be significant. However, emissions are generally based on approved emission limits and the units would be expected to operate below these levels. Consequently, the estimated emissions are likely higher than actual emissions;

3. Secondary $PM_{2.5}$ levels are modeled and therefore subject to modeling uncertainties such as regional background levels of ammonia (see Section 2.4.1) which affect fine particulate formation;

4. Estimates of plant fugitive dust emissions are not provided and at times (e.g., hot and windy conditions) mining operations and tailings ponds could be a significant source of $PM_{2.5}$ emissions; and

5. Planned development emissions reflect announced, but not yet approved projects. This scenario is not representative of a full regional development scenario and therefore cannot be considered as an indicator of the maximum $PM_{2.5}$ emissions that will occur in the region.

Overall, Fort McKay is satisfied that, except for the full future development scenario, the $PM_{2.5}$ emission levels estimated by Shell represent reasonably based figures and therefore Fort McKay used these in its assessment. However, at certain periods, project $PM_{2.5}$ emissions could be higher than estimated due to fugitive windblown project sources.

2.3.4.2 Proposed Project $PM_{2.5}$ Emissions

Shell provides $PM_{2.5}$ emission estimates for the proposed Jackpine Mine Expansion and Pierre River Mine projects. The specific sources of $PM_{2.5}$ emissions from Shell's proposed projects are summarized in Table 2-33 (Shell 2007, EIA Vol. 3, Table 3.4-2, p. 3-53, December 2007).

Table 2-33: Specific Sources and Estimated Emission Rates of $PM_{2.5}$ from Shell's Proposed Jackpine Mine Expansion and Pierre River Mine Projects

Emission Source	Project and Emissions	
	Jackpine Mine Expansion	Pierre River Mine
	$PM_{2.5}$(t/d)	$PM_{2.5}$(t/d)
Co-generation	0.18	0.30
Mine fleet	0.13	0.21
Boiler and heaters	-	-
Tailings pond fugitive	-	-
Plant fugitive	-	-
Total[1]	**0.31**	**0.51**

[1]Note that the total $PM_{2.5}$ emissions are not the same as those in Table 2-32 because there are some $PM_{2.5}$ emission reductions at the existing Jackpine mine that are included as part of the Jackpine mine expansion project. As noted above, these estimated project emissions are subject to some uncertainty.

Overall, the Jackpine Phase 1 (updated), Jackpine Expansion, and Pierre River Mine are expected to contribute 1.32 tonnes/day to the regional $PM_{2.5}$ emissions profile. This represents an additional 0.44 tonnes/day as compared to the approved Jackpine Mine Phase 1 project, which corresponds to 1.4% of the predicted Application Case emissions or 1.1% of the predicted Planned Development Case $PM_{2.5}$ emissions.

2.3.4.3 Health and Environmental Impacts of $PM_{2.5}$

Fine particulate matter ($PM_{2.5}$) is a relatively more complex parameter to assess because unlike the other air contaminants, particulate matter is not a specific chemical entity but a mixture of substances from different sources and of different chemical compositions and properties. For the proposed project EIA, Shell has assumed all particulate emissions in the region to be $PM_{2.5}$. The Community of Fort McKay recognizes $PM_{2.5}$ as a parameter of concern due to the direct and indirect

effects that fine particulate matter or its precursors might have on the quality of life in the community:

- ***Direct health effects*** – Short and long-term exposure to ambient $PM_{2.5}$ has been associated with adverse cardio-respiratory effects in humans. Though there are established guidelines for ambient $PM_{2.5}$ concentrations, epidemiological studies have been unable to identify a threshold level below which ambient particulate matter has no effect on human health (USEPA 2004; Pope and Dockery 2006).
- ***Indirect health effects*** – Constituents of $PM_{2.5}$, such as elemental metals and acidic aerosols may also have adverse health effects on humans (USEPA 2004; Pope and Dockery 2006).
- ***Indirect environmental effects*** – Particulate matter also contributes to the formation of haze and causes impairment in visibility (USEPA 2004; not covered in this assessment);
- ***Environmental effects associated with –***
  - nitrogen deposition (fertilization/ eutrophication) resulting from the deposition of particulate matter containing nitrogen compounds e.g., NH_4NO_3 (covered in Section 2.5);
  - acid deposition resulting from the deposition of particulate matter containing nitrogen compounds e.g., NH_4NO_3 and $(NH_4)_2SO_4$ (covered in Section 2.5);

The focus of the assessment of $PM_{2.5}$ in this section is on $PM_{2.5}$ levels in the Community of Fort McKay and possible health effect and general air quality deterioration issues.

2.3.4.4 Health and Environmental Criteria, Objectives and Guidelines for $PM_{2.5}$

Fort McKay has developed health-based ambient air quality objectives for $PM_{2.5}$ (HTES 2009; see Section 2.2.5.2). These objectives are based on a recent review and update of the European air quality guideline for $PM_{2.5}$ (WHO 2005). A comparison of Alberta's current ambient air quality objectives, past and current WHO guidelines and Fort McKay's HTES health-based criteria for $PM_{2.5}$ are presented in Table 2-34.

Table 2-34: Comparison of Current AAAQO, Past and Current WHO Guidelines and Fort McKay's HTES Health-based Criteria for $PM_{2.5}$

Averaging Period	AAAQO (µg/m³)	WHO (2000) (µg/m³)	WHO (2005) (µg/m³)	Fort McKay's HTES Ambient Air Quality Criteria (µg/m³)
1-Hour	80	No guideline but risk estimates provided	No guideline	30
24-Hour	30		25 (99th % annual value)	25 (99th % annual value)
Annual	No guideline		10	10

Fort McKay has also developed "Keeping Clean Areas Clean" criteria related to $PM_{2.5}$ (Section 2.2.5.3) and these are summarized in Table 2-35.

Table 2-35: Fort McKay's "Keeping Clean Areas Clean" (KCAC) Community-based Air Quality Targets for $PM_{2.5}$

Parameter	Averaging Period	Fort McKay's Target (µg/m³)
Fine Particulate Matter ($PM_{2.5}$)	Annual 95th Percentile 1-Hour	23.3
	Annual 50th Percentile 1-Hour	4.4
	Annual Average concentration	7.5
	98th Percentile annual 24-Hour (Average over 3 years)	20

Fort McKay is also using the Health Canada Air Quality Health Index (AQHI) as an indicator of air quality in the Community (see Section 2.2.5.2). The equation for determining the AQHI is expressed as follows:

Equation 2-2: Determining AQHI

$$AQHI = \left(\frac{1000}{10.4}\right)\left[\left(e^{0.000871[NO_2]} - 1\right) + \left(e^{0.000537[O_3]} - 1\right) + \left(e^{0.000487[PM_{2.5}]} - 1\right)\right]$$

Where:

- AQHI = air quality health index
- $[NO_2]$ = ambient air NO_2concentration in ppb, 3-hour average
- $[O_3]$ = ambient air O_3 concentration in ppb, 3-hour average
- $[PM_{2.5}]$ = ambient air $PM_{2.5}$ concentration in µg/m^3, 24-Hour average

Since $PM_{2.5}$ is part of the AQHI, $PM_{2.5}$ levels are of relevance and concern to Fort McKay in terms of keeping AQHI values in the Community low.

The Community's health and KCAC–based objectives for $PM_{2.5}$ were used to determine the potential impacts of Current, Base, Application and Planned Development cases on air quality in Fort McKay.

2.3.4.5 $PM_{2.5}$ Impact Assessment

Pre-Development Scenario

In the absence of industrial development, ambient $PM_{2.5}$ levels in Fort McKay would be expected to be relatively low and primarily associated with community or residential activities such as wood burning, forest fires as well as some background level from upwind sources. At the request of Fort McKay, Shell had an assessment prepared that provided estimates of SO_2, NO_2 and $PM_{2.5}$ concentrations in Fort McKay for a period around 1965 which would represent pre-development air quality in the Community (Golder 2009). Background $PM_{2.5}$ concentrations in Fort McKay were determined as the sum of two components: natural and anthropogenic background concentrations. Table 2-36 provides the estimate of "pre-development" $PM_{2.5}$ levels in Fort McKay from this assessment.

The maximum 1-Hour is considered a reasonable estimate of background $PM_{2.5}$ levels in the absence of unusual events (i.e., forest fires). For the other averaging periods the pre-development values are clearly high based on actual 1999 $PM_{2.5}$ levels in the community, although it is recognized that extensive wood burning in the community in the 1960s could have resulted in the types of background levels predicted. Fort McKay adopted the 1999 values for these other periods as its estimate of background community $PM_{2.5}$ levels.

Table 2-36: Predicted Pre-development $PM_{2.5}$ Levels in Fort McKay (circa 1965; Golder 2009) and 1999 Levels in Fort McKay

Parameter	Maximum 1-Hour Concentration[1] (µg/m³)	Peak 24-Hour Concentration[1] (µg/m³)	98th Percentile 24-Hour Concentration (µg/m³)	Annual Average (µg/m³)
$PM_{2.5}$ (circa 1965)	31	26	18	7.8
$PM_{2.5}$ (in 1999)	102	18	13	5.9
$PM_{2.5}$ (Fort McKay's selected value)	31	18	13	5.9

[1]The peak concentrations represent the highest predictions from the CALPUFF model. The maximum 1-Hour concentration excluded the eight highest 1-Hour predictions.

Current Scenario

An assessment of the current impact of regional $PM_{2.5}$ emissions on $PM_{2.5}$ levels in Fort McKay was based on:

- community-specific assessment information that Shell/Golder provided to Fort McKay,
- $PM_{2.5}$ air quality summary data from WBEA, and
- $PM_{2.5}$ air quality data from the CASA Data Warehouse.

Table 2-37 provides a summary of ambient $PM_{2.5}$ data for Fort McKay for the period from 1998 to 2006 inclusive (Shell 2007, Vol. 3, Appendix 3.7). Ambient $PM_{2.5}$ levels in Fort McKay in 2008 (CASA Data Warehouse 2009) and the predicted pre-development $PM_{2.5}$ levels are also included for comparison.

The data in Table 2-37 indicates $PM_{2.5}$ levels in Fort McKay in 2008 were within the general range of $PM_{2.5}$ values observed in the 1998-2006 period. In general, $PM_{2.5}$, levels in the Community have increased from the pre-development levels. Interpretation of $PM_{2.5}$ data is complicated by natural sources that can result in high levels for significant periods of time (e.g., days or even weeks in the case of forest fires).

Table 2-37: Summary of Ambient $PM_{2.5}$ in Fort McKay for Years 1998-2006 and Year 2008 in Comparison to Pre-developmentScenario $PM_{2.5}$ Levels

Averaging Period	Ambient $PM_{2.5}$ Level in Fort McKay ($\mu g/m^3$)			% Increase From Pre-Development to 2008 Level
	1999 - 2006[1]	2008	Pre-Dev[2]	
Maximum 1-Hour (range of annual Maximum 1-Hour values)	228 (48-228)	68	31	120%
95th percentile 1-Hour	22	21	-	-
Maximum 24-Hour (range of annual Maximum 24-Hour values)	82 (18-82)[1]	23	18	28%
95th percentile 24-Hour	17	14	13	8%
Mean Annual (range of annual Mean Annual values)	5.5 (4.1-8.4)	5.0	5.9	(-15%)

[1]Fort McKay's assessment found the maximum 24-Hour $PM_{2.5}$ level in 1999 to be 83.5 $\mu g/m^3$ rather than 82 $\mu g/m^3$.

[2]Pre-development $PM_{2.5}$ levels as adopted by Fort McKay (See Table 2-36).

To determine whether or not there was a statistically significant air quality trend in Fort McKay, a trending analysis for SO_2, $PM_{2.5}$ and NO_2 levels in Fort McKay was undertaken by Golder (2009; see Figure 2-10). This analysis identified a statistically significant trend towards decreasing $PM_{2.5}$ levels in Fort McKay at the 50th, 75th and 90th percentile frequency levels. This is a positive trend, but it does not mean that industrial emissions are not impacting $PM_{2.5}$ levels in Fort McKay. Also it is a somewhat unexpected finding since all model predictions are that industrial development will result in increased regional $PM_{2.5}$ emissions and ambient levels. This is an issue that requires further investigation to determine the factors influencing $PM_{2.5}$ levels in Fort McKay and the region.

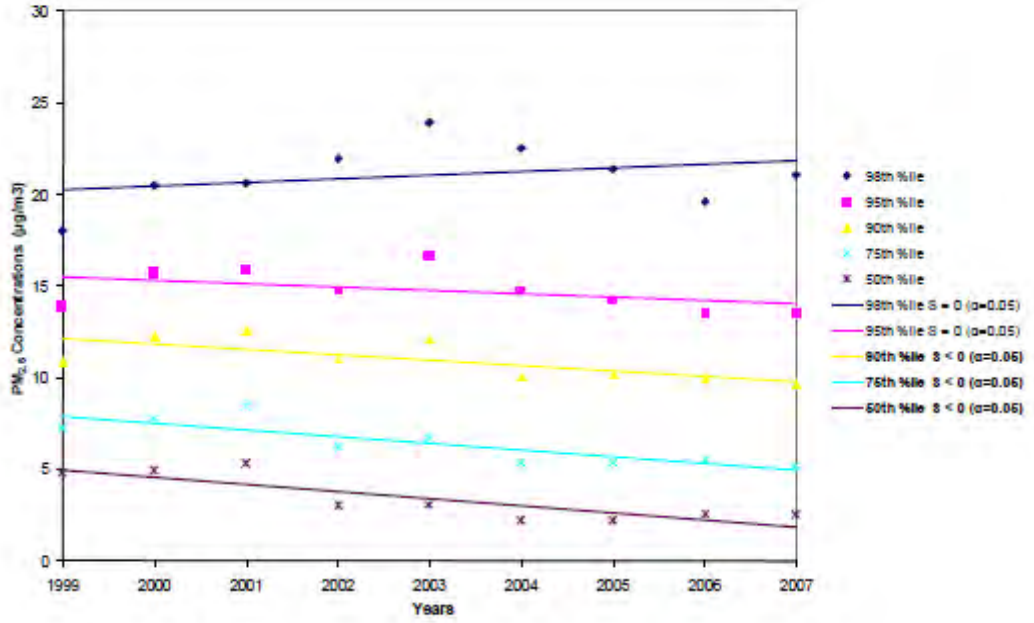


Figure 2-10: Fort McKay $PM_{2.5}$ Concentration Trends (1999-2007; Golder 2009)

The influence of industrial emissions on $PM_{2.5}$ levels in Fort McKay is demonstrated in Figure 2-11. The 50th and 95th percentiles obtained from 2005 to 2008 air quality monitoring and the KCAC Annual 1-Hr 95 percentile targets are used as references for comparison. This figure shows that, when 1-Hour $PM_{2.5}$ levels in Fort McKay are above elevated (i.e., above the reference values), the winds are generally from the South-southeast to Southwest. This is an indication that industrial activity is influencing ambient $PM_{2.5}$ levels in Fort McKay.

From the current air quality data it is clear that $PM_{2.5}$ levels in the Community have remained relatively constant or have decreased slightly in the last 10 years but are influenced by industrial emissions. Whether or not the nature of the $PM_{2.5}$ has changed significantly, and thus its potential impact on health, was beyond the scope of this assessment and is an issue requiring investigation.

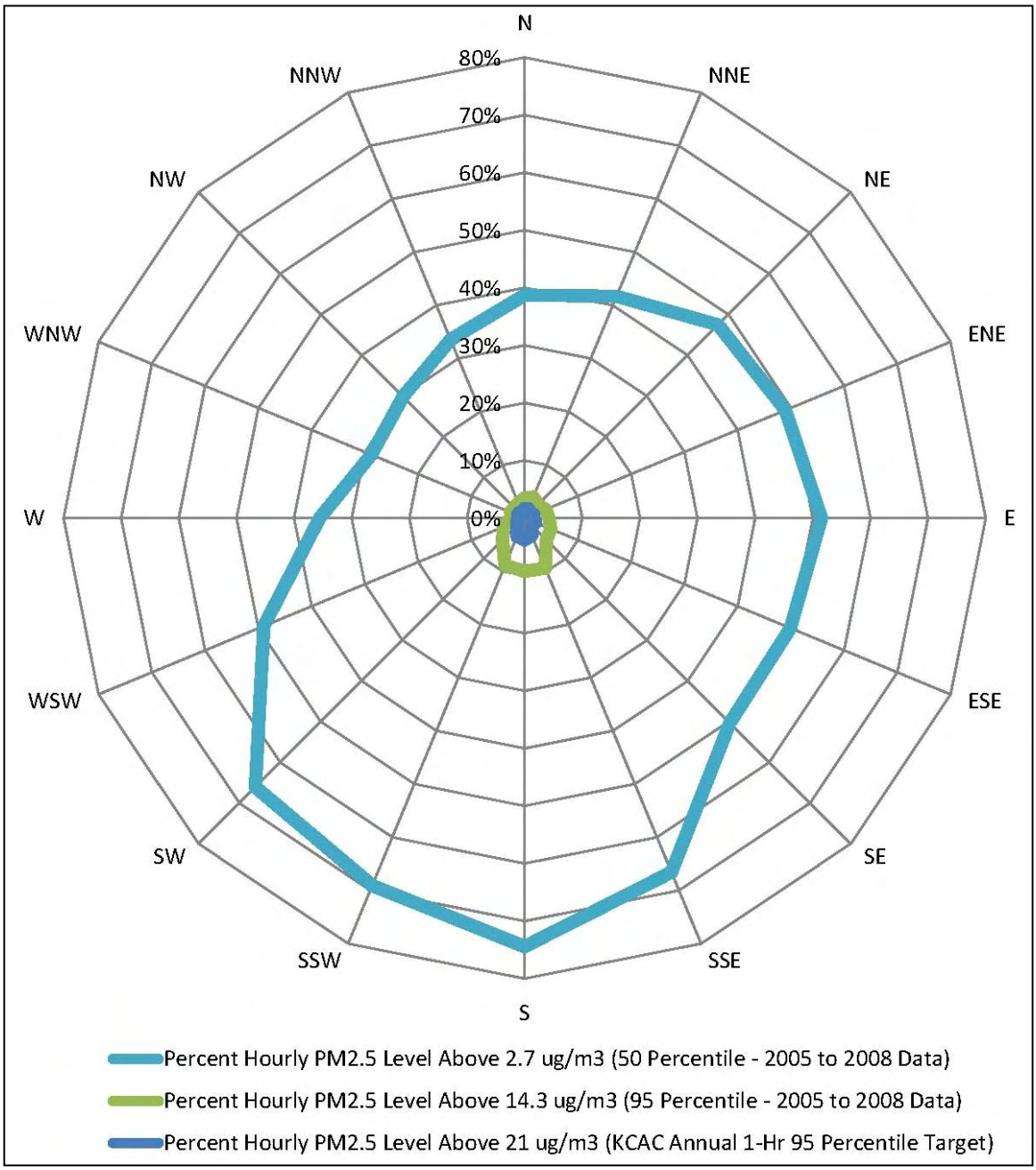


Figure 2-11: Wind Direction Influence on Hourly[8] $PM_{2.5}$ Level in Fort McKay (2005-2008)

[8]The plots give the % of the total hourly $PM_{2.5}$ levels above the specified level when the wind is from the noted wind direction.

In terms of the current situation with respect to $PM_{2.5}$ levels in the community relative to Fort McKay's health, KCAC and AQHI criteria, Table 2-38 provides a comparison between the current $PM_{2.5}$ levels and the Community's criteria.

Table 2-38: Comparison of Current $PM_{2.5}$ Levels in Fort McKay Relative to HTES (2009) Criteria

Averaging Period	Fort McKay's $PM_{2.5}$ Criteria	Current Levels (µg/m³)	Assessment/ Comment
Health and Odour-Based Criteria			
Maximum 1-Hour	30 µg/m³	68	Above criteria
99th percentile 24-Hour	25 µg/m³	14	Well below criteria
Annual Average	10 µg/m³	5	Well below criteria
KCAC-Based Targets			
95th percentile 1-Hour	23.3 µg/m³	15.3	Well below criteria
50th percentile 1-Hour	4.4 µg/m³	3.3	Well below criteria
99th percentile 24-Hour	20 µg/m³	19	Below but close to Criteria
Annual Average	7.5 µg/m³	5	Below Criteria
Air Quality Health index (AQHI)	See ***Appendix 2-2***		2008 analysis by Fort McKay indicated criteria being met with highest AQHI values associated with ozone and $PM_{2.5}$

The Community is satisfied that the current $PM_{2.5}$ levels in the Community do not represent a significant health risk and with the exception of the 1-Hour maximum health-based criteria are within all of the Community's air quality criteria. The cause(s) of the high 1-Hour $PM_{2.5}$ values that occasionally occur in the community need to be determined and, if these are associated with normal industrial emissions, then additional pollution control requirements should be applied to these sources. The issue of high 1-Hour $PM_{2.5}$ values that are associated with upset conditions, such as Syncrude's diverter stack events, also needs to be reviewed.

Base Case

Table 2-39 from Golder (2009) summarizes the Base Case predicted $PM_{2.5}$ levels in Fort McKay based on; Shell's EIA (Shell 2007), the Petro-Canada MacKay River Expansion EIA (Petro-Canada 2005) and the Synenco Northern Lights EIA (Synenco 2007). These predictions are compared to Fort McKay's and Alberta Environment's objectives for $PM_{2.5}$.

The data in Table 2-39 highlight the variability (greater than 200% in some cases) in modeling predictions for basically the same Base Case development scenario, which

complicates assessment of the Base Case's potential impact on $PM_{2.5}$ levels in Fort McKay.

Table 2-39: Comparison of Predicted Base Case $PM_{2.5}$ Concentrations in Fort McKay from Various EIAs Relative to Fort McKay and Alberta Environment $PM_{2.5}$ Objectives

Project	Maximum[1] 1-Hour (µg/m³)	98th percentile 24-Hour (µg/m³)	Peak[2] Annual (µg/m³)
Petro-Canada	——	33	——
Synenco	71	38	31
Shell	——	26	9.0
AAAQO	**80**	**30**	**——**
Fort McKay HTES	**30**	**20**	**10 (7.5 for KCAC)**

[1]Maximum predictions exclude the eight highest 1-Hour predictions.

[2]Peak predictions do not exclude the eight highest 1-Hour predictions.

Based on the Base Case $PM_{2.5}$ predictions, it is Fort McKay's assessment that:

1. Maximum 1-Hour $PM_{2.5}$ concentrations have the potential to exceed Fort McKay's criteria of 30 µg/m^3;

2. 98th Percentile 24-Hour $PM_{2.5}$ concentrations have the potential to exceed both Fort McKay and AENV's criteria; and

3. Annual average $PM_{2.5}$ concentrations have the potential to exceed Fort McKay's criteria of 10 µg/m^3 (health) and 7.5 µg/m^3 (KCAC) criteria.

Normally, these types of predicted exceedences of Fort McKay's health-based criteria and Alberta Environment's criteria would be considered a **red** situation. However, because of the uncertainties and possible conservatism associated with estimating industrial $PM_{2.5}$ emissions and modeling uncertainties, as demonstrated by the range of model predictions presented in Table 2-39, Fort McKay considers the Base Case to represent a **yellow** situation requiring rigorous tracking of $PM_{2.5}$ levels in Fort McKay and the application of best available $PM_{2.5}$ controls on all new industrial emission sources and on existing sources when the opportunity arises.

Application Case

Table 2-40 summarizes the Application Case predicted $PM_{2.5}$ levels in Fort McKay. The values are based on prediction presented in Shell's EIA (Shell 2007) compared to Fort McKay's and Alberta Environment's objectives for $PM_{2.5}$.

The data in Table 2-40, when compared to data in Table 2-39 (the Base Case), indicate that the proposed Shell projects do not significantly change the predicted

98th percentile 24-Hour $PM_{2.5}$ levels in Fort McKay. There are some prediction issues in that the Application Case annual prediction is greater than the Planned Development Case prediction. In its assessment for Fort McKay, Shell noted that it would be correcting this in subsequent project updates (Golder 2009). Fort McKay's assessment for the Application Case is therefore the same as for the Base Case, i.e., it represents a **yellow** situation.

Table 2-40: Comparison of Predicted Application Case NO_2 Concentrations in Fort McKay Relative to Fort McKay and Alberta Environment $PM_{2.5}$ Objectives

Project	Peak[1] 24-Hour (µg/m³)	98th percentile 24-Hour (µg/m³)	Peak[1] Annual (µg/m³)
Shell	194	25	10.6
AAAQO	30	—	—
Fort McKay HTES	25 (99th percentile annual value)	20	10 (7.5 for KCAC)

[1]Peak predictions include the eight highest 1-Hour predictions.

Planned Development Case

Table 2-41 taken from Golder (2009) summarizes the Planned Development Case predicted $PM_{2.5}$ levels in Fort McKay based on Shell's EIA (Shell 2007), the Petro-Canada MacKay River Expansion EIA (Petro-Canada 2005) and the Synenco Northern Lights EIA (Synenco 2007). These predictions are compared to Fort McKay's and Alberta Environment's objectives for $PM_{2.5}$.

The data in Table 2-41, when compared to data in Table 2-39 (Base Case), indicates that the Planned Development Case will generally increase $PM_{2.5}$ levels in Fort McKay by 10% to 40% above Base Case values, depending on the averaging period or frequency value. There are some prediction anomalies such as Synenco's peak annual prediction for the Base Case being much higher than the prediction for the Planned Development Case (i.e., 31 µg/m^3 for the Base Case as compared to 9.8 µg/m^3 for the Planned Development Case). Fort McKay's assessment for the Planned Development Case is therefore the same as for the Base Case, i.e., it represents a **yellow** situation. It is Fort McKay's assessment that all future oil sands projects should be subject to rigorous $PM_{2.5}$ emission controls to minimize the increase in regional $PM_{2.5}$ emissions and the impact of these emissions on $PM_{2.5}$ levels in Fort McKay (see Sections 2.3.4.7 and 2.3.4.8).

Table 2-41: Comparison of Predicted Planned Development Case $PM_{2.5}$ Concentrations in Fort McKay from Various EIAs Relative to Fort McKay and Alberta Environment $PM_{2.5}$ Objectives

Project	Maximum[1] 1-Hour (µg/m³)	98th percentile 24-Hour (µg/m³)	Peak[2] Annual (µg/m³)
Petro-Canada	——	48	——
Synenco	80	34	9.8
Shell	——	28	9.8
AAAQO	80	30	——
Fort McKay HTES	30	20	10 (7.5 for KCAC)

[1]Maximum predictions exclude the eight highest 1-Hour predictions.

[2]Peak predictions do not exclude the eight highest 1-Hour predictions.

2.3.4.6 Overall $PM_{2.5}$ Impact Assessment Conclusion

Fort McKay's assessment conclusions regarding the Pre-development, Current, predicted Base, Application, and Planned Development $PM_{2.5}$ levels in the community are:

1. Natural $PM_{2.5}$ sources such as forest fires complicate the assessment and interpretation of background and current $PM_{2.5}$ data relative to the provincial and Fort McKay air quality but in general current levels are below or well below Fort McKay's criteria for $PM_{2.5}$.

2. Current $PM_{2.5}$ levels in Fort McKay are generally above pre-development levels and higher levels in the community appear to be largely associated with industrial activity,

3. The 98th percentile 24-Hour $PM_{2.5}$ level in Fort McKay is predicted to be 25.5, 25.4, and 28.2 µg/m^3 for the Base, Application, and Planned Development Case, respectively. Relative to the Pre-development and Current scenarios, these figures correspond to a 39% to 64% increase.

4. The peak 24-Hour concentration in Fort McKay is predicted to be 33.1, 33.3, and 35.8 µg/m^3 for the Base, Application, and Planned Development Case, respectively. These figures correspond to an increase of 28% to 38% from the Pre-Development scenario.

5. The Fort McKay KCAC target of 20 µg/m^3 for the 98th percentile 24-Hour concentration is exceeded in the Base, Application, and Planned Development Case. In particular, the 98th percentile 24-Hour concentration for the Planned Development Case is approaching the Canada-Wide Standard (CWS) guideline of 30 µg/m^3.

6. Some model predictions of maximum 1-Hour and 24-Hour$PM_{2.5}$ levels show exceedences of both Alberta and Fort McKay's criteria.

Fort McKay's assessment rating for each assessment case is summarized in Table 2-42. As noted above, exceedences of Fort McKay's $PM_{2.5}$ criteria and targets are predicted.

Table 2-42: Summary of Fort McKay's Assessment of the Impact of Regional $PM_{2.5}$ Emissions on $PM_{2.5}$ Levels in Fort McKay for each Development Scenario

Case/Scenario Assessment	Assessment of $PM_{2.5}$ Levels in Fort McKay
Background	No issues/effects
Current	Levels have increased but HTES criteria and targets are generally being met (need to look at factors/sources affecting levels in Community)
Base Case	Some exceedences of HTES criteria and targets predicted
Application Case	Some exceedences of HTES criteria and targets predicted
Planned Development Case	Some exceedences of HTES criteria and targets predicted
General Comment – Position	See Sections 2.3.4.7 and 2.3.4.8

However, the impacts of existing, approved projects, Shell's proposed project and planned but not yet approved projects are, at this time, only considered to represent a potentially significant impact, i.e., a **yellow** situation. This significance rating is the result of model and emission uncertainties that might over-estimate the impact of future regional $PM_{2.5}$ emissions on $PM_{2.5}$ levels in Fort McKay. Rigorous $PM_{2.5}$ emission management is, however, considered necessary to control the impact of industrial development on $PM_{2.5}$ levels in Fort McKay.

2.3.4.7 Shell's Proposed $PM_{2.5}$ Emissions Management

Shell indicates that it will undertake a number of air emission management measures at its proposed projects. Measures related to reduction in emissions of $PM_{2.5}$ or its precursors include:

- The gas-fired cogeneration units and auxiliary boilers will meet the Emission Guidelines for Oxides of Nitrogen (NO_X) for New Boilers, Heaters and Turbines using Gaseous Fuels Based on a Review of Best Available Technology Economically Achievable (BATEA) – Interim Guideline (AENV 2007),
- The asphaltene-fired cogeneration units will achieve the following emissions control efficiencies:

- SO_2: 99%
- NOX: 75%
- PM: 99.97%

- Flaring will be limited to upset/emergency conditions, start-up and commissioning and will comply with the Alberta Energy Resources Conservation Board Directive 060,
- Vehicles in the mine fleet will meet applicable emission standards at the time of purchase and mine maintenance procedures will ensure fleet vehicles are regularly maintained,
- Slash burning will be managed and coordinated with other operators in the region, and
- Road dust will be managed by watering the roads during dry periods.

These are all considered reasonable $PM_{2.5}$ emission management actions, but as noted in Section 2.3.3.7, additional NOX controls should be applied on the three gas-fired co-generation units being proposed by Shell which will reduce secondary $PM_{2.5}$ formation.

2.3.4.8 Fort McKay's $PM_{2.5}$ Recommendations

The proposed project is not considered a large contributor to $PM_{2.5}$ emissions in the region. Based on the current potential for $PM_{2.5}$ emission-related effects on $PM_{2.5}$ levels in the Community of Fort McKay as predicted by models and as periodically experienced currently, Fort McKay has a number of specific recommendations related to the understanding and management of $PM_{2.5}$ related air-quality issues in Fort McKay. These are:

Project-Specific Recommendations

1. Representative mine fleet units used by Shell be subject to emission testing during typical use conditions to confirm mine fleet $PM_{2.5}$ emissions (as opposed to relying on modelled emissions);

2. Shell's existing mine fleet be retrofitted with any $PM_{2.5}$ emission control retrofit devices that become commercially available;

3. An "attribution" continuous air quality monitoring station be located between the Community and the proposed Pierre River mine that would monitor for NOX, TRS, SO_2, $PM_{2.5}$ and PM_{10}, O_3, THC, VOCs and basic meteorological parameters, and that this station be incorporated into the WBEA ambient monitoring network;

4. NO_X emissions from Shell's proposed gas-fired co-generation units that emit more than 100 tonne/yr of NO_X be reduced, based on the use of post combustion selective catalytic reduction technology or equivalent, consistent with what Shell is proposing for its asphaltene-fired co-generation units. NO_X is a contributor to fine particulate formation. The latter can be reduced by minimizing regional NO_X emissions from major NO_X emission sources and ensuring "best practices" for NO_X emission management.

Cumulative Effects Recommendations

5. Regional air quality models be validated, improved and updated to improve predictions of both primary and secondary $PM_{2.5}$ dispersion in Fort McKay on its Traditional Lands, which will improve model predictions of the impacts of ongoing and future $PM_{2.5}$ emissions;

6. Specific procedures for measuring and tracking air quality changes in the region, and in Fort McKay, including a process for formally reviewing air quality changes above specific levels (health and ecological protection, Keeping Clean Areas Clean), in consultation with Fort McKay. The purpose of this recommendation is to ensure that deterioration beyond acceptable levels does not occur in the Community of Fort McKay and on its Traditional Lands; and

7. Shell and other regional operators work with Fort McKay to finalize its HTES air quality criteria and targets. This recommendation is aimed at enabling Fort McKay's goals and strategies for air quality management to be implemented and will also assist in future project planning and air quality and emission management programs.

Note: Some of these recommendations are similar to those for odour, PM, SO_2, and vegetation effects impact management.

2.4 Odour Assessment

Air emissions can have a number of health, environmental and quality of life impacts. To the Community of Fort McKay, odours are one of the most significant issues associated with regional industrial air emissions and represent one of the major concerns to, and impacts on, Community residents.

Odours in the Community of Fort McKay are common and frequent at both detectable and often noisome levels. Odour levels occasionally reach noxious levels, e.g., during Syncrude's flue gas desulphurization start-up problem in April and May of 2006 (AENV 2006) and during Syncrude's diverter stack event in February 2009 (Syncrude 2009). An assessment of odour-related issues for Pre-development and Current scenarios, and for Base, Application and Planned Development Cases, is therefore part of Fort McKay's community based assessment.

Odours were also identified by Shell as a key air quality issue and question - i.e., key air quality question #5 asks (EIA Vol. 3, p. 1-26, Dec. 2007):

> *"What effects will air emissions from the Project and the existing and approved developments have on odours in regional communities?"*

2.4.1 Regional Emissions of Substances with the Potential to Produce Odours

Odours associated with oil sands developments can result from reduced sulphur compounds (TRS) and/or volatile organic compounds (VOC). These compounds are produced and/or released from:

- bitumen mining, extraction and upgrading,
- the use of produced gas (insitu projects) and refinery fuel gas (projects with upgraders),
- sulphur recovery processes and sulphur handling/blocking,
- final and/or intermediary product pumping, handling and storage,
- sour water treatment,
- tailings ponds,
- diluent recovery, and
- industrial and domestic water and/or wastewater treatment.

It must be noted that most of these emission sources are what are termed as "area" and "volume" sources and are subject to the influence of a variety meteorological, seasonal and/or operational factors. As such, the TRS and VOC emissions from these sources are very difficult to both quantify and accurately characterize over time and space. Regional estimates of TRS and VOCs have been prepared by Shell for three development cases and these are summarized in Table 2-43 (Shell 2007, EIA Vol. 3, Tables 3.4-4 (p. 3-56) and 3.5-2 (p. 1-114), December 2007).

A concern with these estimates for TRS and VOCs is that they are largely based on unpublished data and/or emission factors and assumptions, but there is no way to assess how representative they are of current and future emissions. The assessment also does not consider nitrogen-based odourous compounds, such as amines, that may be emitted by oil sands operations. The smells of ammonia, rotting flesh, fish and urine are associated with amines (Cheremisinoff 1993; Amine 2008, April 2) and they match well with some of the odours that Fort McKay residents have noted in the Community. Regional emission estimates of odourous compounds should therefore be considered as generalized guesses based on very limited actual source characterization data and quantification of emissions.

The issue of emission estimates for odourous compounds is discussed further under conclusions and recommendations (Sections 2.4.4.6 and 2.4.6).

Table 2-43: Estimated Regional Emissions – Potentially Odourous Compound Classes

Substances	Development Scenario Case			
	Base (Tonnes/day)	Project-Only (Tonnes/day)	Application (Base + Application) (Tonnes/day)	Planned Development (Tonnes/day)
TRS compounds	7.7	0.2	7.9	9.3
VOCs	682	25	707	880

2.4.2 Proposed Project Odourous Emissions

Shell indicates that the primary sources of odorous emissions from the Jackpine Mine Expansion and Pierre River Mine projects are the in-pit tailings ponds and the mine faces (Shell 2007, EIA Vol. 3, Section 3.4.7, p. 3-96, December 2007). This is considered a reasonable assumption based on the nature of these proposed projects, i.e., mining and extraction but no upgrading or sour gas treatment or use.

The specific sources of VOC and TRS emissions from the proposed projects are summarized in Table 2-44 (Shell 2007, EIA Vol. 3 Table 3.4-2, p. 3-53, December 2007).

As noted under the regional area emissions section above, these estimated project emissions are subject to a high degree of uncertainty and conclusions drawn regarding the impact of these emissions must therefore be interpreted accordingly.

2.4.3 Health and Environmental Impacts of Odours

The World Health Organization (WHO) indicates in their European Air Quality Guideline document (WHO 2000) that the response to odours depends on a number of psychological and socioeconomic factors, and therefore cannot be defined on concentration alone. The WHO also indicates that odours alone cannot be considered a health impact. However, there have been occasions when odours in the Community of Fort McKay have lead to complaints of headaches (e.g., during Syncrude's flue gas desulphurization start-up problem in April and May 2006). The WHO indicates that this type of impact from odours should be regarded as a health endpoint.

Table 2-44: Specific Sources and Estimated Emission Rates of VOCs and TRS Compounds from Shell's Proposed Jackpine Mine Expansion and Pierre River Mine Projects

Emission Source	Project and Emissions			
	Jackpine Mine Expansion		Pierre River Mine	
	VOCs (Tonne/day)	TRS (Tonne/day)	VOCs (Tonne/day)	TRS (Tonne/day)
Co-generation	0.16	-	0.21	-
Mine Fleet	0.48	-	0.87	-
Mine Face Fugitive	3.1	0.02	6.21	0.04
Tailings Pond Fugitive	4.96	0.02	9.92	0.05
Plant Fugitive	0.09	0.03	0.17	0.06
Total[1]	**8.79**	**0.07**	**17.38**	**0.15**

[1]Note that the total TRS emissions are 0.22 t/d, which is the same value as in the "project only" column of Table 2-29. The total VOC emissions are 26.17 t/d, which is greater than the value in the "project only" column of Table 2-30 by 0.77 t/d. This is due to some VOC emission reductions at the existing Jackpine mine that are part of the Jackpine mine expansion project.

It is Fort McKay's position that the prevalence of odours in the Community, and on their Traditional Lands, in particular on the highway between Fort McKay and Fort McMurray, raises concerns regarding both the health impacts of the compounds being smelled and the potential health effects of compounds that cannot be smelled. This creates concerns and anxieties that generate stress which in turn can affect one's general health and well being in a variety of ways. Some trappers also attribute declines in wildlife in the region in part due to odours that contribute to habitat deterioration.

Fort McKay, until relatively recently, i.e., the last 40 years, has been quite an isolated Community and has enjoyed a very natural environment. Odours in the Community were associated with natural environmental changes such as spring and fall, and Community activities such as wood burning and smoking of fish and meat. Now the Community is subject to hydrocarbon and sulphur-based odourous compounds, which significantly impact the quality of life in the Community and the enjoyment of activities on its Traditional Lands. This in turn, leads to stress, which would be expected to contribute to ill-health.

2.4.4 Health and Environmental Criteria, Objectives and Guidelines for Odourous Compounds

Alberta has established odour-based ambient air quality criteria for some substances as has the WHO (AENV 2008; WHO 2000). These criteria, along with the

odour threshold criteria used for these substances by Shell in its assessment (Shell 2007, EIA Vol. 3, Tables 3.4-26 amd-27, p. 3-97, December 2007) are summarized in Table 2-45.

Table 2-45: Comparison of Odour-based Ambient Air Quality Criteria and Odour Thresholds for Odourous Compounds

Parameter	Averaging Period	Alberta AAQO (µg/m³)	WHO(µg/m³)	Odour Threshold Used in EIA (µg/m³)
Ammonia (NH_3)	1-Hour	1,400	NA	NA
Carbon Disulphide (CS_2)	30-Minute	N/A	20	NA
	1-Hour	30	NA	749
Hydrogen Sulphide (H_2S)	30-Minute	NA	7	NA
	1-Hour	14	NA	14.1
	24-Hour	4	NA	NA
Formaldehyde (CH_2O)	30-Minute	NA	100	NA
	1-Hour	65	NA	18,725
Nitrogen Dioxide (NO_2)	1-Hour	400	NA	NA
	24-Hour	NA	NA	
	Annual	NA	NA	
Styrene[1]	30-Minute	NA	70	NA
	1-Hour	215	NA	4,147
Tetrachloro-ethylene (C_2Cl_4)	30-Minute	NA	8,000	NA
Toluene1 ($C_6H_5CH_3$)	30-Minute	NA	1,000	NA
	1-Hour	1,880	NA	4,583
	24-Hour	400	NA	NA

[1]Note: These may be health-based limits in terms of Alberta objectives

The WHO odour levels tend to be lower than Alberta's AAQOs (based on either the actual numerical value and/or a shorter averaging period of 30 minutes rather than 1-Hour as used for Alberta's AAQOs. Generally speaking, a 30-Minute average of 1 µg/m^{3}is equivalent to a 1-Hour average of approximately 0.8 µg/m^{3}under average atmospheric stability (Ontario 2004). The WHO levels are also much lower than the threshold odour levels used in the Shell's EIA.

Fort McKay is uncertain of the exact basis for the specific AAAQO odour objectives, i.e., how odour thresholds are translated into odour management control objectives. For example, AENV (2005b) reports an odour threshold of 0.5 to 37 mg/m^3 for NH_3, with an average of 3.5 mg/m^3, odour complaint levels of 12 to14 mg/m^3, but with the AAAQO set at 1.4 mg/m^3.

The WHO defines a nuisance threshold level as "… the concentration at which not more than a small proportion of the population (less than 5%) experiences annoyance for a small part of the time (less than 2%)" and indicates that exposure to levels below the threshold level "...will not create a nuisance of indirect health significance." On this basis, Fort McKay has adopted many of the WHO limits for preservation of air quality in the Community, as they are directed at minimizing annoyance.

Shell reported in its EIA the odour threshold ranges for a large number of reduced sulphur and VOCs that might be associated with regional industrial operations (EIA Vol. 3, p. 3-97, December 2007). From this range, a threshold value was selected based on the most representative number from the literature, and the value was then used in the assessment. Based on the values in Table 2-49 it is apparent that, at least for compounds for which AENV and WHO have nuisance odour threshold values, Shell is using much higher threshold values. It is therefore likely that the EIA is under predicting potential odour impacts. This issue is discussed further in Section 2.4.4.6.

With respect to odourous substances, Fort McKay has adopted the 7 $\mu g/m^3$ – 30 minute H_2S WHO limit as a 30-minute limit for total reduced sulphur (TRS). The rationale for this is that H_2S is not the only reduced sulphur compound that contributes to regional odour, and assuming that, ***on average***, other reduced sulphur compounds have the same nuisance odour threshold level as H_2S, then this criteria should address all reduced sulphur odour-based issues. It is acknowledged that this is a very simplistic assumption and approach to assessing and managing TRS odours, since most inorganic reduced sulphur compounds have odour thresholds above those of H_2S, while many mercaptans have odour thresholds much below those of H_2S. A more thorough assessment of regional odour sources and the quantities and composition of reduced sulphur compound in Fort McKay are necessary to fully address the appropriate odour-based reduced sulphur limit(s) that would ensure that reduced sulphur-based nuisance odours do not occur in Fort McKay.

Odour Impact Assessment

Shell undertook an assessment of odour impacts that focused on the Application Case, i.e., the impacts of Shell's proposed projects on regional odours at a number of receptors such as cabins and the Community of Fort McKay. In this community-based assessment, odour issues and impacts are discussed, and to the extent possible, assessed, for the five development scenarios/cases: Background, Current, Base, Application and Planned Development, using assessment information from Shell's EIA and regional air quality data.

A quantitative assessment of odour impacts is not really possible due to:

- the uncertainties regarding the quantity and characteristics of odourous emissions,
- the limitations and uncertainties in predicting the dispersion and fate of emitted odourous substances which results in further uncertainties in ambient concentration predictions,
- the impossibility of using single odour threshold levels or nuisance values to assess odour impacts due to the variability in human detection and response to odourous substances, and
- the difficulty of predicting odour responses to complex mixtures of substances which will vary in composition over time and space.

The emphasis of this Community-based assessment was therefore focused on the relative predicted increase in time when odours might be detected or might be an issue and where these increases occur relative to Fort McKay's uses of its Traditional Lands.

Pre-development Scenario

In the absence of industrial development, it is considered reasonable to assume that odours within Fort McKay and on Fort McKay's Traditional Lands would be associated with either Community or residential activities such as wood burning, meat or fish smoking and cooking, hide curing, etc., and natural forest and peatland odours (e.g., decaying vegetation, flowers, biogenic emissions from trees, the occasional forest fire, etc.) In some locations where bitumen deposits are at or near the surface, there could be some localized hydrocarbon and possibly sulphur odours, particularly on hot days. However, in the background scenario, hydrocarbon and reduced sulphur odours are considered to have been negligible and therefore these types of odours were not a factor that adversely affected the quality of life in the Community or on Fort McKay's Traditional Lands.

2.4.4.2 Current Scenario

An assessment of current air quality in Fort McKay was based on information provided in Shell's EIA for its projects, air quality summary data from WBEA and air quality data from the CASA Data Warehouse. Table 2-46 provides a summary of TRS and Total Hydrocarbons air quality data from Fort McKay for the period 1998 to 2006 inclusive (information taken from Shell 2007,EIA Vol. 3, Appendix 3.7, Dec. 2007).

Table 2-46: Summary of Ambient Total Reduced Sulphur (TRS) and Total Hydrocarbon (THC) Concentrations in Fort McKay for Period 1998-2006 Inclusive

Measurement Period/Value	Concentration in Fort McKay	
	THC (mg/m³)	TRS(µg/m³)
Maximum 1-Hour (range of annual maximum 1-Hour values)	7.3 (2.3-7.3)	71 (7-71)
95th percentile 1-Hour	1.6	2.8
Maximum 24-Hour value (range of annual maximum 24-Hour values)	2.3 (1.6-2.3)	6.8 (2-6.8)
95th percentile 24-Hour value	1.5	2.0
Mean Annual (range of annual values)	1.3 (1.2-1.4)	0.7 (0.4-1.3)

The Wood Buffalo Environmental Association's (WBEA) 2007 Annual Report provides the following results related to the concentrations of certain VOCs in Fort McKay in 2007 based on 24-Hour canister sampling approximately every thirteen days.

> *"Volatile organic compounds (VOCs) were measured on 28 days at Fort McKay (AMS 1). The three VOC compounds with the highest average sampled concentration were Methanol, detected on 4 days with an average concentration of 9.7 ppb, Acetone, detected on 25 days with an average concentration of 1.7 ppb, and Acetaldehyde, detected on 4 days with an average concentration of 1.7 ppb. The three VOCs detected most often in the 28 samples were Benzene, detected on 28 days with an average concentration of 0.2 ppb, Acetone, detected on 25 days with an average concentration of 1.7 ppb, and Isopentane, detected on 24 days with an average concentration of 0.5 ppb."*

Peak concentrations were not provided. None of these compounds have low odour thresholds with the possible exception of acetaldehyde and therefore might not be significant contributing factors to the hydrocarbon odours frequently detected in Fort McKay.

The following information related to compliance with AAAQOs related to H_2S/TRS was provided in the WBEA 2007 Annual report.

> *"The Alberta 1-Hour ambient air quality of 10 ppb objective for H_2S was exceeded 412 times in 2007. At industry stations, it was exceeded 174 times at Mildred Lake (AMS 2), 93 times at Mannix (AMS 5), 72 times at Lower Camp (AMS 11), 22 times at Buffalo Viewpoint (AMS 4) and 18 times at Millenium Mine (AMS 12). At community stations it was exceeded 32 times at Anzac (AMS 14) and once at Fort McKay (AMS 1)".*

The 1998 to 2006 ambient THC and TRS air quality data and the 2007 VOC and TRS data for Fort McKay clearly indicate that Fort McKay is at times subject to high

hydrocarbon and reduced sulphur levels that would be expected to result in odour issues, particularly related to reduced sulphur compounds.

An example of a recent noxious odour episode in the Community was associated with a Syncrude CO boiler problem that commenced early Saturday afternoon on February 14, 2009 and ended late Tuesday evening February 17, 2009. The problem necessitated the use of a diverter stack, which resulted in significantly increased air emissions relative to normal operation.

During this diverter event, Fort McKay experienced significant odours. Complaints regarding these odours were made to AENV. To assess whether or not air quality monitoring in the Community recorded any significant air quality changes during the diverter event, a very general comparison was made of community air quality data before, during and following the diverter event for parameters that might be expected to be impacted by a diverter stack event, i.e., TRS, $PM_{2.5}$ and THC levels. Environment Canada's daily air quality health index (***http://www.ec.gc.ca/cas-aqhi/default.asp?lang=En&n=065BE995-1***) reporting noted high index values in Fort McKay on February 17, therefore air quality on this particular day was also assessed.

Table 2-47 and Table 2-48 summarize average and maximum hourly values for TRS and THC in Fort McKay for a four-day period before the diverter stack event, during the diverter stack event, on February 17 (the last day of the event) and for approximately four days after the event.

The data in Table 2-47 and Table 2-48 clearly indicate that the diverter event significantly increased the levels of TRS and THC in Fort McKay. The highest levels of TRS occurred on February 17 and the average and peak hourly values for that day are shown in Table 2-48. The levels of TRS on February 17 were near AENV's 24-Hour compliance level, exceeded the Fort McKay's HTES level, and were at levels where odour issues would be expected. (It should be noted that the air quality data in the tables were taken from the WBEA website and are not considered validated data. Also it is recognized that the impact of this type of diverter event on the Community depends largely on meteorological factors such as wind direction and wind speed. On February 17 during the diverter event, meteorological conditions were a major factor in making this the worst day of the diverter event in terms of air quality impacts on Fort McKay.)

Table 2-47: Summary of Total Reduced Sulphur (TRS) Levels in Fort McKay Before, During and After Syncrude's February 14-17, 2009 Diverter Stack Event

Date/Period (inclusive)	Average Daily TRS Value (ppb)	Max Hourly TRS Value (ppb)	Comments	Alberta Objective (ppb; for H_2S)	Fort McKay's Proposed HTES TRS Limit (ppb)
Feb 10-13 (before event)	0.45	0.93	wind not generally from south	10 (hourly) 3 (daily)	5 (30 min)
Feb 14 (2pm) to Feb 17 (during event)	1.86	6.25	variable wind directions		
Feb 17 (during event)	2.97	6.25	wind generally from direction of Syncrude (close to non-compliance for daily average)		
Feb 18 (6am) to Feb 21 (after event)	1.03	2.56	variable wind direction		

Table 2-48: Summary of Total Hydrocarbon (THC) Levels (ppm) in Fort McKay Before, during and After Syncrude's Diverter Stack Event on February 14-17, 2009

Date/Period (inclusive)	Average Daily Value (ppm)	Max Hourly Value (ppm)	Comments	Alberta Objective (ppm)	Fort McKay's Proposed HTES Limit (ppm)
Feb 10-13 (before event)	2.0	2.49	wind not generally from south	no limit	no limit
Feb 14 (2pm) to Feb 17 (during event)	2.4	4.2	variable wind directions (higher THC values may have contributed to odours)		
Feb 17 (during event)	2.6	4.2	wind generally from direction of Syncrude (higher THC values may have contributed to odours)		
Feb 18 (6am) to Feb 21 (after event)	2.1	11.2	variable wind direction		

Pollutographs for THC and TRS levels in Fort McKay for the period 2000 to 2008 inclusive are shown in Figure 2-12. This figure indicates that higher THC and TRS levels in the Community of Fort McKay occur when the wind is from the direction of existing industrial operations. As industrial growth in the region continues, and gradually fully surrounds Fort McKay, the concern is that odour levels might not only intensify, but that they will occur more frequently as well, since there will be no wind direction that doesn't transport some odourous oil sands facility emissions. The Community is also concerned that oil sands-related odours will be prevalent throughout their Traditional Lands, which would in turn significantly compromise their use and enjoyment of the land. For these reasons, Fort McKay is very concerned about the potential increase in odour, which the Community currently considers to be barely tolerable and definitely an ongoing nuisance.

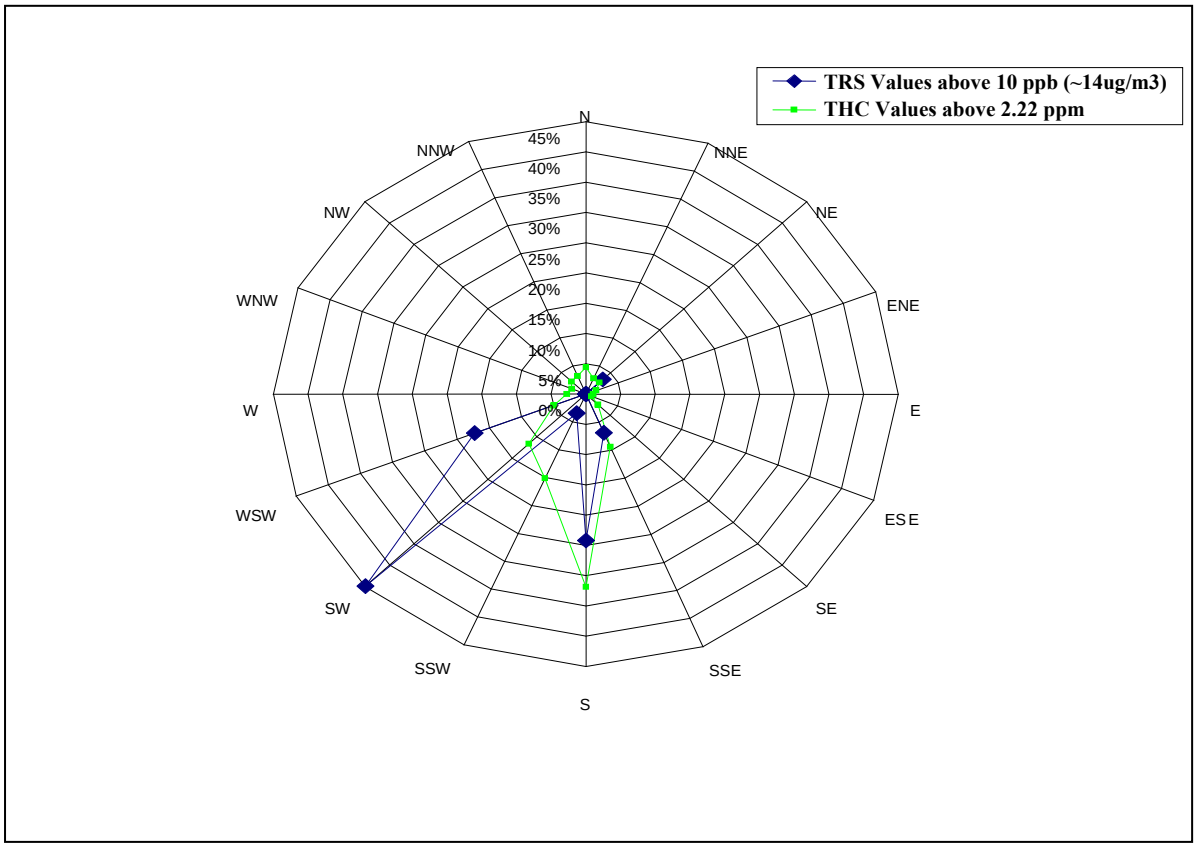


Figure 2-12: TRS and THC Levels in Fort McKay as a Function of Wind Direction (2000 to 2008 inclusive)

2.4.4.3 Base Case

Table 2-49 and Table 2-50 summarize assessment data from Shell's EIA (Shell 2007 and Shell 2009) and from Suncor's Voyaguer South EIA (Suncor 2007) related to the potential impact of odourous emissions on odour levels in Fort McKay and at cabins located within Fort McKay's Traditional Lands. The actual number of hours that

hourly average and peak concentrations of odourous substances are predicted to be above odour threshold levels are given in Table 2-49 (Shell 2007, Shell 2009).

Fort McKay and Cabins G, H, J, and K (all in moderate use areas of Fort McKay's Traditional Lands) are predicted to have hours when ambient levels of odourous substances are above threshold values under the Base Case (existing plus approved projects). The locations of these cabins are illustrated in Figure 2-13. In the area of Cabin G (northeast of the proposed Jackpine mine expansion) frequent values above odour threshold levels are predicted.

Table 2-49: Comparison of Shell's Base Case and Application Case 1-Hour, Peak[1] and 3-Minute Peak[2] Odour Threshold Exceedence Predictions at Key Fort McKay Traditional Land Receptors

Receptor/Impact Location	Number of hours annually that hourly average concentration is above threshold		Number of hours annually that peak concentration is above threshold		Number of hours annually that that 3 minute concentration is above threshold	
	Base Case	Application Case	Base Case	Application Case	Base Case	Application Case
Fort McKay	20	22	336	363	576	587
Cabin A	0	0	7	363	16	149
Cabin B	0	0	23	26	16	24
Cabin C	0	0	13	16	19	24
Cabin D	0	0	20	27	34	75
Cabin E	0	0	29	36	47	64
Cabin F	0	0	27	37	53	81
Cabin G	303	307	768	783	398	422
Cabin H	8	11	198	240	211	293
Cabin I	0	0	135	144	221	242
Cabin J	108	120	545	573	646	681
Cabin K	96	107	545	582	685	725
Cabin L	0	0	73	278	161	447

[1]Based on multiplying hourly concentration by a factor of 2 or 10 depending on the Distance of the receptor to the odour source

[2]Based on multiplying the hourly concentration by a factor of 2.314 to convert an hourly concentration into a 3 minute concentration

Table 2-50 gives the predicted concentrations of various reduced sulphur compounds in Fort McKay under the Base Case. The maximum predicted hourly and 24-Hour values for TRS are such that odours would be expected during periods when values in this range are reached. For example, strong odours were detected in

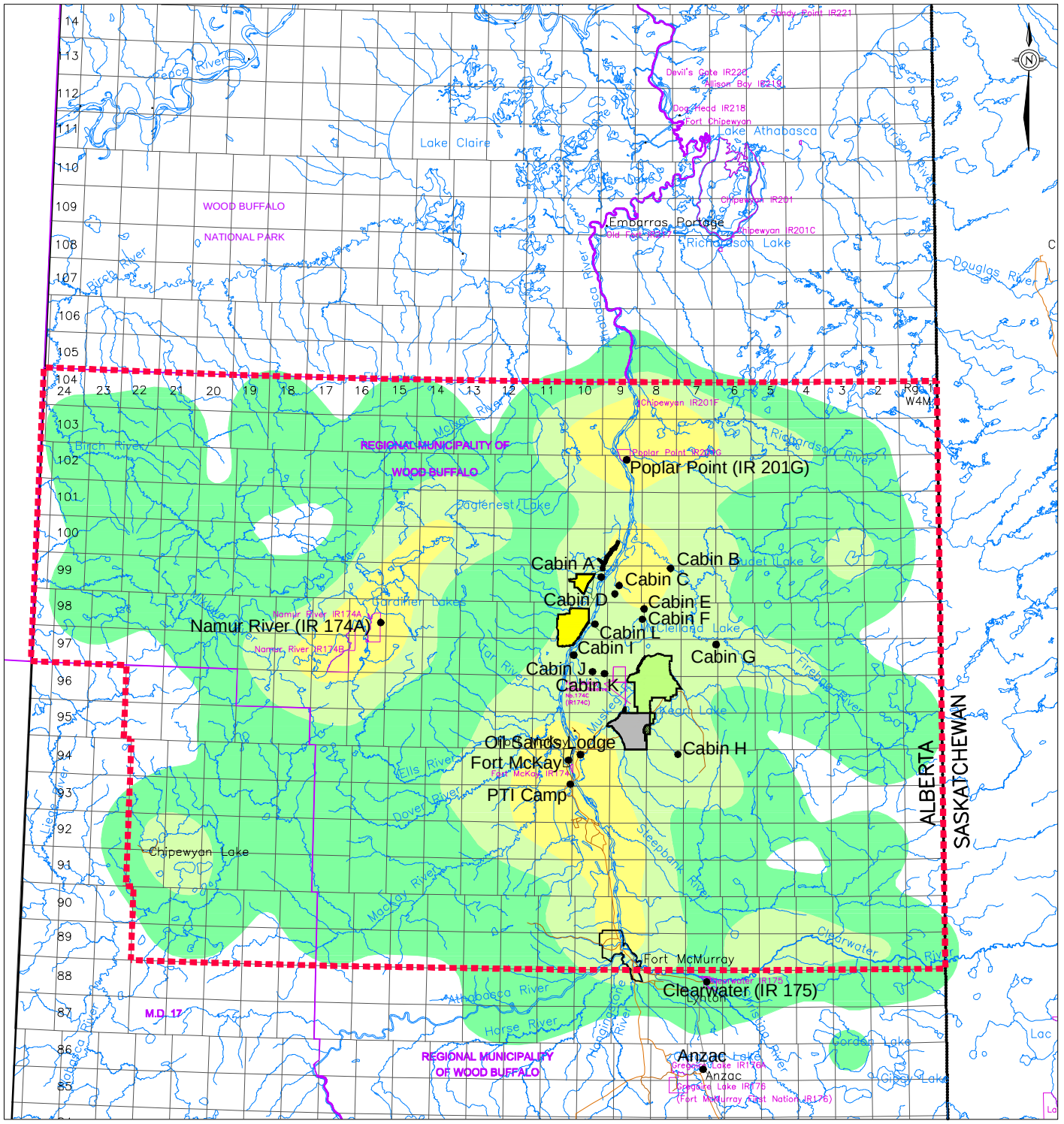
Fort McKay on February 17, 2009 when the maximum hourly TRS level was 6.25 µg/m^3 and the daily average TRS value was 2.97 µg/m^3 (see Section 2.4.4.2). It should be noted, however, that the odours identified in Fort McKay on February 17, 2009 were not likely solely attributable to reduced sulphur compounds and likely included odourous hydrocarbons.

Table 2-50: Predicted Reduced Sulphur Compound(s) Concentrations in Fort McKay under Base and Planned Development Cases[9]

Averaging Period and Substance	Base Case Predicted Concentration (µg/m³)	Planned Development Case Predicted Concentration (µg/m³)
1 Hour Maximum		
TRS	17.0	21.9
H_2S	1.1	1.3
COS	0.6	0.7
CS_2	0.6	0.7
Mercaptans	0.4	0.48
Thiophenes	8.7	11.3
24 Hour Maximum		
TRS	3.8	4.0
H_2S	0.4	0.4
COS	0.3	0.3
CS_2	0.3	0.3
Mercaptans	0.08	0.09
Thiophenes	1.5	2.0
Annual Average		
TRS	0.8	0.9
H_2S	0.8	0.9
COS	0.04	0.04
CS2	0.03	0.04
Mercaptans	0.02	0.02
Thiophenes	0.26	0.28

The concern with this Base Case assessment is that odours already occur in Fort McKay on a regular basis, i.e., several times weekly. Therefore Shell's base prediction of 22 hours of peak concentrations above odour thresholds (Table 2-49) indicates that odour modeling is grossly under-predicting odour potential. The Shell assessment can therefore only be used to perhaps provide a general indication as to

[9]Suncor 2007.



LEGEND

- RIVER OR STREAM
- ROADWAY
- INDIAN RESERVE
- PIERRE RIVER MINING AREA
- JACKPINE EXPANSION MINING AREA
- LEASE SWAPPED TO SYNCRUDE
- JACKPINE MINE – PHASE 1
- INTENSE USE CSE (50% UTILIZATION DISTRIBUTION)
- MODERATE USE CSE (75% UTILIZATION DISTRIBUTION)
- LOW USE CSE (95% UTILIZATION DISTRIBUTION)
- TRADITIONAL AREAS OF THE FORT McKAY FIRST NATIONS
- COMMUNITY RECEPTOR

SCALE 30 0 30 KILOMETRES

ACKNOWLEDGEMENT

Traditional land use data for this figure was provided by the Fort Mckay IRC. This data has no wider implications and remains the property of Fort Mckay First Nation.

REFERENCE

Alberta NTDB Data Supplied By Geomatics Canada, August 2001. Nad 83 Zone 12. Sheets 74D, E and 74I in Nad 27 Zone 12. Saskatchewan NTDB Data Supplied by ISC, Aug. 2001. ACFN 2003, Tanner Et. Al. 2001 Projection: Transverse Mercator Datum: Nad 83 Coordinate System: Utm Zone 12 Nad 83 Zone 13. Used Under License.

PROJECT

JACKPINE MINE EXPANSION & PIERRE RIVER MINE PROJECT

TITLE

LOCATIONS OF COMMUNITY RECEPTORS (ALL TRADITIONAL USES)

PROJ 08.1346.0006.5722.01			FILE No. Community Receptors	
DESIGN	DC	19/01/09	SCALE AS SHOWN	REV. 0
CADD	PSR	20/01/09	FIGURE 2-13	
CHECK	GDU	20/01/09		
REVIEW	WES	20/01/09		

L:\2008\1346 Oil Sands\08-1346-0006-SHELL\5722-Fort McKay Assess\01\Petro-Canada Mckay River\ Drawing file: Fig 3.3-1 TLU – Ecosystems of Fort McKay First Nation.dwg Jan 23, 2009 – 10:09am

where the highest levels of odours may occur and the possible relative increase in odour events.

This under prediction issue is further demonstrated when the base predictions in Table 2-50: are compared to the 10-year average TRS in Fort McKay (1998-2007) and the 2006 and 2007 TRS values in Fort McKay (WBEA 2007). The Base Case model prediction for Fort McKay is for an annual average TRS concentration of 0.8 $\mu g/m^3$. The actual 10-year annual average, however, has been 0.83 $\mu g/m^3$ and in 2006 and 2007 the annual average was 1.1 $\mu g/m^3$.

Fort McKay's assessment clearly indicates that, under the Base Case, odour threshold levels will likely be exceeded within the Community of Fort McKay, as well as in areas of its Traditional Lands. The predicted levels will at times be at unpleasant, odourous levels. These predictions are not surprising since odours are already an issue in Fort McKay under the Current Scenario. The situation can only be expected to worsen as approved but not yet operating projects are commissioned. Examples of projects that are expected to commence operation in the area include: Horizon, Jackpine, Muskeg River Mine Expansion and Kearl.

2.4.4.4 Application Case

Table 2-51 summarizes the odour assessment data related to the potential impacts of Shell's proposed projects on odour levels in Fort McKay and on cabins located within its Traditional Lands. This data indicates that Shell's proposed projects could have a significant adverse impact on odour levels within Fort McKay – an approximate 10% increase is expected in the number of hours and peak periods above odour threshold levels, and also on odour levels in parts of the high and moderate use traditional land use areas north and east of Fort McKay along the Athabasca River valley.

Since the Application Case odour detection predictions are likely very low, based on current odour issues/occurrences within Fort McKay (see Base Case), the Application Case assessment results would indicate that additional efforts need to be taken to reduce odourous emissions from Shell's existing and proposed projects. Without such measures, odours within Fort McKay, and on its Traditional Lands, could significantly increase.

2.4.4.5 Planned Development Case

Shell does not provide a specific assessment of the number of hours that threshold odour levels might be reached in Fort McKay and at regional cabins under the Planned Development Case. Table 31 from the Suncor's Voyaguer South EIA (Suncor 2007) indicates, as would be expected, that reduced sulphur compound concentrations in Fort McKay increase under the Planned Development Case by approximately 5 to 30%, depending on the reduced sulphur compound(s) and the averaging period. As noted above under the Application Case assessment, this

further highlights the need for rigorous regional controls on odourous emissions from existing, approved and planned developments.

2.4.4.6 Overall Odour Impact Assessment Conclusions

The odour assessment and experience of Fort McKay, and the odour assessments by Shell and other oil sands project proponents would clearly indicate that, at times, current ambient air quality levels of certain odourous substances in Fort McKay are above threshold odour levels and on occasion at nuisance odour levels. The Shell EIA would also indicate that a significant increase in the number of hours (3 to 356 hours – see Table 2-49) of odourous substances being above odour threshold levels will likely occur in Fort McKay and on Fort McKay's Traditional Lands in the northeast to northwest area north of Fort McKay.

Table 2-51 is a summary of Fort McKay's assessment of the significance of odours associated with the five development scenarios/cases: Background, Current, Base, Application and Planned Development. Since odours are currently significantly adversely impacting the community of Fort McKay and the use and enjoyment of Fort McKay's Traditional Lands by Fort McKay residents, and Base, Application and Planned Development. All results in predicted increases in odours in Fort McKay and on Fort McKay's Traditional Lands, the Current Scenario and all development cases are considered to represent a **red** significance level, i.e., at a significant adverse effect level. Immediate actions to address existing and projected odour issues are therefore being recommended (Section 2.4.6).

2.4.5 Shell's Proposed Odourous Emissions Management

Shell has indicated that it will undertake a number of air emission management measures at its proposed projects. Many of these will reduce the emissions of odourous substances. These odourous emissions management measures include: (information taken from EIA Vol. 3, Section 2.2.5.2, p. 2-12 to 53, December 2007):

- above-ground storage tanks will conform to Environmental Guidelines for Controlling Emissions of Volatile Organic Compounds from Above-ground Storage Tanks,
- plant-wide fugitive emissions identification and control using the protocol recommended by the Canadian Association of Petroleum Producers Management of Fugitive Emissions at Upstream Oil and Gas Facilities, as well as other relevant guidelines and codes of practice, aimed at minimizing fugitive emissions,
- flaring will be minimized for the Project (e.g., upset/emergency conditions, start-up and commissioning) and will comply with the Alberta Energy and Utilities Board Directive 060, and

Table 2-51: Summary of Fort McKay's Assessment of the Impact of Regional Emissions on Odours for each Development Scenario and Case

Case/Scenario Assessment	Assessment of Odours in Fort McKay	Assessment of Odours in Fort McKay's Traditional Lands
Background	No issues/effects	No issues/effects
Current	Significant issues/effects	Significant issues/effects in high use areas
Base Case	Expected increases in an already unacceptable situation	Expected increases in adverse effects on use and enjoyment of the land
Application Case	Expected increases in an already unacceptable situation	Expected increases in adverse effects on use and enjoyment of the land
Planned Development Case	Expected increases in an already unacceptable situation	Expected increases in adverse effects on use and enjoyment of the land
General Comment – Position	See Sections 2.4.5 and 2.4.6	See Sections 2.4.5 and 2.4.6

- Tailings Solvent Recovery Unit (TSRU) tailings deposition will be managed to maintain an annual average rate of 4 volumes of solvent per 1,000 volumes of bitumen produced.

Shell is also proposing the following source and ambient monitoring as part of the proposed projects, which it indicates will be determined in consultation with WBEA and AENV:

- expanding the existing Leak Detection and Repair Program to detect, measure and control emissions from equipment leaks from new facilities as per the Canadian Association of Petroleum Producers Management of Fugitive Emissions at Upstream Oil and Gas Facilities,
- continuing to monitor VOCs through grab samples at ambient trailers per WBEA requirements, and
- continuing to conduct fugitive emission surveys on the External Tailings Disposal Area (ETDA) and mine surfaces on site and at ambient trailers to quantify and speciate VOCs and TRS compounds by source.

These are all considered reasonable odourous emission management actions. However as the tailings ponds are predicted to be a major source of both hydrocarbon and reduced sulphur emissions from the project, there should an extra focus on reducing solvent and associated TRS compound losses to tailings ponds.

Strategies also need to be in place for reducing plant fugitive emission since this is the other source of controllable odourous emissions.

2.4.6 Fort McKay's Recommendations

Based on the current issue with odours in the Community, the projected increases in odours associated with the Base, Application and Planned Development Cases and some of the obvious issues in accurately measuring and predicting odour issues, Fort McKay has a number of specific recommendations related to odour management.

2.4.6.1 Odourous Emissions Management Recommendations

Project-Specific Recommendations

1. Solvent losses from the Jackpine Mine Expansion and Pierre River Mine tailings ponds be restricted to less than 3 bbl per 1000 bbl of bitumen within five years of commencing bitumen production at these mines. This will reduce potential odour causing solvent related emissions;

2. To better characterize and quantify odourous emissions:

    a. a detailed and ongoing emission characterization and quantification monitoring program for the tailings ponds be developed in conjunction with Fort McKay with the results of the monitoring reported to Fort McKay at regular intervals; and

    b. develop a comprehensive plant site fugitive emissions detection, monitoring and characterization program and associated repair and reduction program that includes periodic DIAL (Differential Absorption Lidar) or equivalent monitoring and that this program be developed in conjunction with the Fort McKay IRC with the results of the monitoring reported to the Fort McKay IRC at regular intervals, and

Cumulative Effects Recommendations

3. All hydrocarbon and reduced sulphur monitoring data that has been generated to date related to mine faces, tailings ponds and fugitive bitumen processing and upgrading emissions be collected, collated and published. This will enable a better understanding and thus management of odour sources.

4. To better understand and relate odourous emissions to actual odour responses and to improve odour modeling, predictions and management:

a. A regional odour study be designed and implemented in consultation with Fort McKay, at key areas within Fort McKay's Traditional Lands and within the Community of Fort McKay;

b. Odour panels be used to relate the data collected from this monitoring program to human characterization and response to air quality at the time of sampling, and

c. Odour modeling and other predictive tools be developed that can be used to assess the potential odour impacts of oil sands projects.

2.4.6.2 Odour Management in the Community of Fort McKay

Cumulative Effects Recommendations

To address odour issues within the Community of Fort McKay it is recommended that:

1. A notification protocol that is currently being developed by Fort McKay to address episodic air quality issues including odours, be adopted and compliance assured through regulatory measures; and

2. An ongoing odour monitoring program be developed for the Community which includes human response-based odour monitoring and recording as well as an odour-based air sampling program.

2.5 Vegetation and Ecosystem Assessment

Protection of vegetation and ecosystems within its Traditional Lands is a priority for, and expectation of, Fort McKay. The potential for adverse air emission effects on vegetation is therefore part of Fort McKay's Community-based assessment.

Oil sands emissions in the Regional Municipality of Wood Buffalo (RMWB) have the potential for direct adverse, acidification and/or eutrophication (fertilization) effects on vegetation and ecosystems with SO_2, NO_X, total nitrogen deposition, potential acid input (PAI), NH_3 and O_3 being the principal parameters of concern. These were therefore the parameters that are the focus of the Fort McKay's assessment of the potential effects of regional and project emissions on vegetation. Regional levels of SO_2, NO_X, total nitrogen deposition, PAI, NH_3 and O_3 are strongly impacted by regional industrial emissions. In particular, regional NO_X and ozone levels are predicted to increase as is regional nitrogen deposition and PAI. Recent regional monitoring data also indicates that regional ammonia levels might be at effect levels and significantly contribute to regional nitrogen deposition loads.

In its environmental input assessment for the proposed Jackpine Mine Expansion and Pierre River Mine projects, Shell included an assessment of SO_2, NO_X, O_3, PAI

and total nitrogen deposition on vegetation. Potential NH_3 impacts were not assessed by Shell. The assessment by Fort McKay largely uses the results of Shell's assessment, as well as recent regional monitoring data and information from other recent project EIAs. Fort McKay, however, uses its own assessment criteria and provides its own interpretation of the results.

2.5.1 Regional Emissions Related to Vegetation Effects

Major regional emission sources of the parameters of interest in terms of vegetation effects are:

- SO_2:
  - coke combustion
  - sulphur recovery plants
  - fuel gas and produced gas use in boilers, heaters and turbines
- NO_2:
  - boilers, heaters and gas turbines
  - mine fleets
  - urban areas
  - general transportation
- NH_3:
  - ammonia-based flue gas desulphurization
  - limited information or uncertainty regarding other sources (possibilities include other stack emissions, fugitive emissions from sour water processes, tailings ponds, mine faces and wastewater treatment processes)
- VOCs : (a precursor along with NO_2 for ozone formation)
  - bitumen mining, extraction and upgrading,
  - final and intermediary product pumping, handling and storage,
  - tailings ponds, and
  - diluent recovery.

Regional emission estimates for SO_2 are considered to be quite accurate as the major sources of SO_2 are monitored or can be calculated by converting the S content of fuels used in the region (e.g., diesel fuel and produced gas) into SO_2 emissions based on fuel use.

NO_X emissions from stationary sources are easily quantified but there is considerable uncertainty around NO_X emissions from mine fleets, which are a major source of NO_X emission in the region.

Ammonia emissions are not well quantified in the region. In a ***Summary of State of the Issues Sheets for Trace Metals and Air Contaminants Priority Pollutants*** report, regional ammonia emissions were estimated at 1,097 tonnes/annum in 2003 - all from stack sources (AENV 2005). Syncrude has subsequently added a flue gas desulphurization system that uses ammonia and there are some ammonia emissions from this source. Also some fugitive ammonia releases from oil sands processing operations, tailings ponds and mine faces would be expected and recent regional passive monitoring for ammonia shows reasonably high ambient ammonia levels at certain times and in certain areas of the region. Identification and quantification of regional ammonia emissions therefore appear to be an area requiring further work.

Emissions of VOCs are difficult to quantify as they are largely from "area", "volume" and/or "fugitive" sources and are subject to the influence of a variety of meteorological, seasonal and operational factors.

Regional estimates of VOCs, SO_2 and NO_X have been prepared by Shell for three development scenarios and these are summarized in Table 2-52 (Shell 2007, EIA Vol. 3, Tables 3.1-1 (p. 3-4), December 2007).

Table 2-52: Estimated Regional Emissions of Substances with Direct Vegetation, Acid or Eutrophication Effects

Substances	Development Case			
	Base (Tonnes/day)	Project Only (Tonnes/day)	Application (Base + Application; Tonnes/day)	Planned Development (Tonnes/day)
Volatile Organic Compounds (VOCs)	682	25.4	707	880
Sulphur Dioxide (SO_2)	274.	7.9	282	323
Nitrogen Oxides (NOx)	483	12.2	496	634
Ammonia (NH_3)	Not provided			

A concern with these estimates for mine fleet NO_X emissions and VOCs is that they are largely based on unpublished data and/or emission factors or assumptions, but there is no way to assess how representative they are of current and future emissions. Therefore, regional emission estimates of VOCs, NO_X and ammonia have to be considered as generalized guesses based on very limited actual source characterization and data quantification data. The issue of emission estimates for NO_X and NH_3 is discussed further under conclusions and recommendations.

2.5.2 Emissions from Shell's Proposed Projects Related to Vegetation Effects

The primary sources of emissions from Shell proposed Jackpine Mine Expansion and Pierre River Mine projects that could have direct or nitrogen and/or acid deposition related impacts on vegetation are the tailings ponds, the mine fleets and the asphaltene-fired cogeneration boilers.

The specific sources of VOC, NO_X and SO_2 emissions from the proposed projects are summarized in Table 2-53 (Shell 2007,EIA Vol. 3, Table 3.4-2, p. 3-53, December 2007).

As noted under the regional area emissions section above, the estimated project emissions for NO_X and VOC are subject to a high degree of uncertainty and conclusions drawn regarding the impact of these emissions must therefore be interpreted with caution.

Table 2-53: Specific Sources and Estimated Emission Rates of VOCs, SO_2 and NO_X from Shell's Proposed Jackpine Mine Expansion and Pierre River Mine Projects

Emission Source	Project and Emissions					
	Jackpine Mine Expansion			Pierre River Mine		
	VOCs (t/d)	SO_2 (t/d)	NO_X (t/d)	VOCs (t/d)	SO_2 (t/d)	NO_X (t/d)
Co-generation	0.16	4.07	2.89	0.21	4.08	5.13
Mine fleet	0.48	0.01	3.89	0.87	0.01	7.31
Mine face fugitive	3.1	-	-	6.21	-	-
Tailings pond fugitive	4.96	-	-	9.92	-	-
Plant fugitive	0.09	-	-	0.17	-	-
Total	**8.79**	**4.08**	**6.45**	**17.38**	**4.10**	**12.45**

2.5.3 Impacts of Emissions on Vegetation

Fort McKay has been involved in a number of regional initiatives that are intended to manage or prevent adverse effects associated with acid and nitrogen deposition and ozone and also to measure possible adverse effects of air emissions on regional vegetation. This involvement has included active participation in:

- development of CEMA's Acid Deposition Management Framework Recommendations for the Oil Sands Region of North-Eastern Alberta (CEMA 2004),

- development of CEMA's recommendations on how to treat nitrogen in terms of acidification and eutrophication effects (CEMA 2006b),
- development of the time-to-effect model necessary to fully implement the CEMA Acid Deposition Management Framework Recommendations for the Oil Sands Region of North-Eastern Alberta (CEMA 2004),
- a stage 2 implementation model run of the CEMA Acid Deposition Management Framework Recommendations for the Oil Sands Region of North-Eastern Alberta (CEMA 2004),
- development of CEMA's Ozone Management Framework (CEMA 2006a),
- development of CEMA's Interim Nitrogen (Eutrophication) Management Recommendations and Work Plan (CEMA 2008),
- development of regional air quality and terrestrial effects monitoring through WBEA, and
- tracking and interpretation of air quality trends and environmental effects monitoring results.

This involvement has satisfied Fort McKay that there is no evidence, or reason to suspect, that current regional air emissions are presently having a significant adverse effect on vegetation except perhaps immediately adjacent to emission sources.

However, Fort McKay has identified direct effects on vegetation as a potential future issue that could significantly impact the nature, and use and enjoyment, of its Traditional Lands based on:

- predicted possible future regional emissions and associated ambient air quality levels,
- ozone formation potential and predictions,
- current estimated and future predicted nitrogen deposition loads and PAI, and
- the potential for subtle adverse effects that can have significant long term impacts.

2.5.4 Relevant Environmental Criteria, Objectives and Guidelines for Direct Effects on Vegetation

Criteria have been developed that establish limits or effects levels for air contaminants that can impact vegetation. Criteria for contaminants and inputs that are relevant to this assessment are summarized in Table 2-54.

Table 2-54: Air Quality Critical Level, Nitrogen Critical Load and PAI Criteria Related to Vegetation Effects

Parameter	Source for Criteria/Objectives/Guidelines		
	AAAQO (AENV 2008)[1]	**WHO (2000)**	**Other**
SO_2	30 µg/m³ annual average	10 µg/m³ annual average (for lichens) 15 µg/m³ annual and winter average (for forests and natural vegetation)	-
NO_2	60 µg/m³ annual average	• 75 µg/m³ 24-Hour average (as NO*X*, i.e., NO + NO_2) • 30 µg/m³ annual average (as NO*X*)	-
NH_3	-	• 270 µg/m³ 24-Hour average • 8 µg/m³ annual average	• 1 µg/m³ annual (lichens and bryophytes) • 3 µg/m³ annual (forest ground flora) • Recommendations from ECE (2007a)
O_3	-	10 ppm-h AOT 40[2] (6 months –daylight hours)	SUM60[3] values of: • 0 to 2000 ppb hours over a 3 month period (Baseline) • 2000 to 4400 ppb hours over a 3 month period (Surveillance) • 4400 to 6600 ppb hours over a 3 month period (Management) • >6600 ppb hours over a 3 month period (Exceedance) • From CEMA (2007)
Nitrogen Deposition	-	• 5-10 kg N/ha/yr ombrotrophic bog • 10-15 kg N/ha/yr coniferous trees	• < 8 kg N/ha/yr for bogs • 5-10 kg N/ha/yr boreal forests • Recommendations from ECE (2007b)
PAI	Not considered	Not considered in this assessment	CEMA (2004a)

[1]Note: it is not clear to Fort McKay how the SO_2 and NO_2 annual average ambient air quality objectives relate to vegetation protection

[2]AOT 40 – ***A***ccumulated exposure to ozone ***O***ver a ***T***hreshold of 40 ppb

[3]SUM 60 - SUM60 is the sum of all hourly ozone readings at or above 60 ppb between 8:00am and 8:00pm over any consecutive 3-month period in the period May 1 to September 30

The assessment criteria used by Fort McKay are summarized in Table 2-55 (the assessment criteria used by Shell are also presented for comparison purposes).

The criteria used by Fort McKay are:

- based on current science,
- come from very reputable sources and organizations,
- directly applicable to the types of vegetation and ecosystems on Fort McKay's Traditional Lands, and/or
- based on extensive input from Fort McKay i.e., CEMA management frameworks.

Fort McKay therefore considers its assessment criteria to represent a reasonable and responsible approach for assessing the potential impacts of regional air emissions on vegetation and for guiding the management of these impacts.

2.5.5 Assessment of Impacts of Emissions on Vegetation

The following potential air-related adverse impacts on vegetation are addressed in this assessment:

1. The direct effects of gaseous SO_2, NO_X, ozone and NH_3 on vegetation;
2. The eutrophication/fertilization effects of nitrogen deposition; and
3. The acidification of soil due to acid deposition leading to adverse effects on vegetation.

In this Fort McKay Specific Assessment, potential air emission effects on vegetation are discussed, and to the extent possible, assessed, for the five development scenarios/cases. We used assessment information from Shell's EIA and previous regional project EIAs as well as regional air quality data. Due to the uncertainties associated with predicting ambient NO_2, O_3, and nitrogen and acid deposition levels, the emphasis of this Community-based assessment is on the relative predicted increases in areas that might exceed effects levels as a function of the different development scenarios/cases.

Pre-Development Scenario

In the absence of industrial development, it is considered reasonable to assume that air quality would not have any adverse impacts on regional vegetation. Therefore, the background scenario is assumed to represent the natural and healthy environmental condition with industrial activity and related air emissions for each of the development scenarios representing a potentially adverse and increasing change from this condition.

Table 2-55: Air Quality and Nitrogen Critical Load Criteria Used by Shell and Fort McKay in the Assessment of Air Emissions Effects on Vegetation

Parameter	Criteria Used in Assessment by:		
	Fort McKay	**Shell (2007)**	**Comments**
SO_2	10 µg/m³ annual average (for lichens) 20 µg/m³ annual and winter average (for forests and natural vegetation)	• 10 µg/m³ annual average (for lichens) • 20 µg/m³ annual and winter average (for forests and natural vegetation)	Both the Same and Based on WHO (2000) and CLRTAP (2004)
NO_2	• 75 µg/m³24-Hour average (as NO_X, i.e., NO + NO_2) • 30 µg/m³ annual average (as NO_X)	• 60 µg/m³ annual average as NO_2 and 200 µg/m³ for a 24-Hour average	Fort McKay's assessment criteria based on WHO (2000) and CLRTAP (2004), considered more relevant to vegetation protection than AENV (2008) annual average and 24-Hour limits of 60 µg/m³ and 200 µg/m³ respectively
NH_3	• 1 µg/m³ annual (lichens and bryophytes) • 3 µg/m³ annual (forest ground flora)	Not assessed	Recommendations from ECE (2007a)
O_3	SUM60 values of: • 0-2000 ppb hours over a 3 month period (Baseline) • 2000-4400 ppb hours over a 3 month period (Surveillance) • 4400-6600 ppb hours over a 3 month period (Management) • >6600 ppb hours over a 3 month period (Exceedance)	No criteria used in assessment	From CEMA (2007)
Nitrogen Deposition	8 kg N/ha/yr	• 0.25 keq N/ha/yr (3.5 kg N/ha/yr) as a possible effect level (increased growth of moss in bogs) • 2.0 keq N/ha/yr (28 kg N/ha/yr) as an adverse effect level in bogs	Based on Recommendations from ECE (2007b), discussion at CEMA/NSMWG Dec. 2008 Nitrogen Critical Workshop in Calgary and conclusion that significant impacts would be expected at Shell's criteria based on ECE (2007b) and CLRTAP (2004)
PAI	CEMA (2004) + CEMA (2006b) criteria	CEMA (2004) + CEMA (2006b) criteria (with a slight variation)	Fort McKay was heavily involved in the development of CEMA's Acid Deposition Management Framework and supports its implementation and use in assessing PAI impacts

Current Scenario

A review of current air quality in Fort McKay and at monitoring stations on its Traditional Lands, as related to possible vegetation impacts, was undertaken and the following assessments made:

- ***SO_2***– current annual average SO_2 levels within Fort McKay's Traditional Lands range from approximately 2.5 to 7.8 µg/m^3 (WBEA 2007a) and are therefore below Fort McKay's 10 µg/m^3 annual average criteria for lichens and 20 µg/m^3 annual and winter average criteria for forests and natural vegetation (see Table 2-36). Current SO_2 levels in terms of vegetation effects are therefore not a concern to Fort McKay.

- ***NOX*** – current annual average NO_2 within Fort McKay's Traditional Lands range from approximately 9 to 28 µg/m^3(WBEA 2007a). Regional annual average NO levels since 1999 have ranged from approximately 1 to 40 µg/m^3 (CASA 2009). The 40 µg/m^3 NO value was measured at the Millennium Air Monitoring Station and exceeds the Fort McKay 30 µg/m^3 annual average NOX criteria. The potential therefore exists that current NOX levels at certain locations in the region, likely near NOX emissions sources, are exceeding NOX direct effects thresholds.

- ***Ozone*** – While hourly ozone levels are measured at a number of monitoring stations in the region, the monitoring data is not routinely converted into SUM 60 values, which provide a measure of potential effects of ozone on vegetation. A study conducted for the NSMWG calculated SUM 60 values for a number of the continuous ozone monitoring sites in the region i.e., Pat McInnis, Athabasca Valley, Fort McKay, Syncrude UE1 and Fort Chipewyan (NSMWG 2006). The highest calculated SUM 60 value was 1702 ppb –hours at Fort McKay in 2003 and this value is within Fort McKay's baseline criteria level (see Table 2-36). It should be noted that all of WBEA's hourly monitoring of ozone (hourly monitoring is required to calculate SUM 60 values) are at urban or industrial sites and do not capture rural/forest ozone levels which are likely higher than the non-rural levels due to ozone scrubbing by NOx emissions at urban/industrial locations. In 2005/6, Environment Canada (2007) modeled regional ozone levels based on year 2000 regional emissions and calculated SUM 60 values for the entire region. In the area around Fort McMurray, SUM 60 values of between 2000 and 4399 ppb-hours were modeled. These levels are within Fort McKay's "surveillance condition" category (see Table 2-36). Another ozone modeling run project is currently being undertaken by the NSMWG of CEMA. This model run will use 2006 emission inventory information and this work is scheduled for completion by the end of 2009. Overall, based on current measured and modeled regional SUM 60 values, Fort McKay is not concerned that current ozone levels are adversely impacting regional vegetation.

- ***NH_3*** – There are two continuous ammonia monitors as part of WBEA's monitoring network. These are located in Fort McKay and in Fort McMurray at the Patricia McInnis Station (WBEA 2009). These monitors are used to determine compliance with Alberta Environment's odour-based air quality objective for ammonia, which is 2 ppm (1.4 µg/m^3). The monitors used are not calibrated to measure ammonia at the lower concentrations that are relevant for assessing the potential impacts of ammonia on vegetation and nitrogen deposition. Since 2005 WBEA has had passive NH_3 monitors at a number of sites throughout the region. This network of NH_3 monitors has continually been expanded. Today the network includes 38 sites throughout the region. The sample period for the passive monitors is one or two months. This passive monitoring network provides a good indication of regional ambient ammonia concentrations and whether or not these concentrations are currently at potential effects levels. Data from the NH_3 passive monitoring for the period May 2005 to May 2008 inclusive is presented in Table 2-56.

Table 2-56: Summary of Ambient Ammonia (NH_3) Levels from WBEA's Passive Ammonia and Nitric/Nitrous Acid Monitoring Network

Month	Ammonia Levels by Month (µg/m³)					
	2005	2006	2007	2008	Average (µg/m³)	Average (ppb)
January	No data	0.95	1.31	1.08	**1.11**	**1.59**
February	No data	1.09	1.79	0.76	**1.18**	**1.69**
March	No data	0.80	1.79	0.76	**1.08**	**1.55**
April	No data	1.68	1.47	0.76	**1.29**	**1.86**
May	1.49	1.72	1.50	1.30	**1.50**	**2.16**
June	1.23	2.35	1.90	No data	**1.94**	**2.79**
July	3.22	2.34	2.35	No data	**2.63**	**3.78**
September	1.40	0.86	1.71	No data	**1.32**	**1.90**
October	1.43	1.65	1.43	No data	**1.50**	**2.15**
November	1.24	1.01	0.98	No data	**1.08**	**1.55**
December	0.73	1.06	1.08	No data	**0.96**	**1.37**

Note: 24 Sites covering the May 2005 to May 2008 period inclusive – note: not all sites were sampled for this entire period.

The data were obtained from Dr. Andrzej Bytnerwicz of the USDA who is the WBEA contractor responsible for this passive monitoring program. An annular denuder intermittent sampler was located in Fort McKay in 2003 and 2004 and this sampler measured ammonia concentrations every sixth day. Based on this sampling the average ammonia concentration in Fort McKay was 0.78 µg/m^3. This passive and denuder ammonia monitoring would indicate that ammonia

values may currently be at levels that could adversely affect sensitive vegetation receptors such as lichens, and therefore regional ammonia levels are a concern to Fort McKay.

- ***Nitrogen Deposition*** – Nitrogen deposition occurs from wet and dry deposition of reactive nitrogen species that have the potential to affect vegetation through fertilization effects. Dry nitrogen deposition is very difficult to measure directly and is generally determined using inferential deposition models. A number of studies and monitoring programs are currently directed at improving regional information and understanding related to nitrogen deposition. These include:

    a. A NSMWG study done on nitrogen deposition as predicted by the CALPUFF dispersion/deposition model (NSMWG 2005),

    b. A mapping of model predicted N deposition for 2001 and 2002 (from the NSMWG study referred to above, NSMWG 2005) using 5, 10 and 15 kgN/ha/yr isopleths and determining the area of various vegetation covers that would be affected if the isopleths represented critical loads (Figure 2-14),

    c. WBEA measurement of certain nitrogen species associated with throughfall and bulk deposition (since 2005),

    d. WBEA measurement of ambient air concentrations of NO_2, HNO_3/HNO_2 and ammonia through passive monitoring,

    e. Development by WBEA of an inferential model (CASTNet MLM) to translate ambient air concentrations of nitrogen species to predicted deposition levels,

    f. A study done for Alberta Environment on dry deposition modeling (WBK 2006),

    g. Acid deposition monitoring conducted by WBEA (2007), and

    h. The development of a regional nitrogen eutrophication management plan by CEMA (CEMA 2008).

Estimates of current general regional nitrogen deposition, based on the above studies and monitoring, appear to range from 3 to 4 kg N/ha/yr to 5 to10 kg N/ha/yr with the uncertainty around possible ammonia deposition being the major contributor to this large range in current nitrogen deposition estimates. Figure 2-9 indicates that between 20,000 (at a critical load of 5 kg N/ha/yr) and 3,000 ha (at a critical load of 10 kgN/ha/yr) of sensitive ecosystem/vegetation types (i.e., bogs, black spruce and coniferous), on Fort McKay Traditional Lands could be currently being affected by nitrogen deposition. While the model predictions used in Figure 2-14 are likely high (see NSMWG (2005)) they do not include all nitrogen

species (e.g., HONO, NH_3 and NH_{4+}) and may therefore be underestimates of total nitrogen deposition. Based on the current information available related to nitrogen deposition in the region it appears that current levels on Fort McKay's Traditional Lands in the vicinity of current mining developments may be at effect levels and therefore regional nitrogen deposition is a current concern to Fort McKay (a **yellow** situation).

- ***PAI*** – Acid deposition, like nitrogen deposition, results from the wet and dry deposition of chemical species that have the potential to result in pH changes to soils groundwater and surface water. PAI inputs to soils above certain "critical levels" can result in chemical and biological changes that lead to adverse effects on vegetation. CEMA (2006b) has recommended that all nitrogen deposition not be considered as acidifying. The recommendation was that all nitrogen above 10 kg N/ha/yr and 25% of the first 10 kg N/ha/yr deposition be included in PAI determinations. This change in determining PAI has resulted in reduced PAI estimates. Fort McKay was involved in developing this recommendation and supports the approach. Considerable monitoring (WBEA 2007b) and modeling work (project EIA's and WBEA dry deposition determinations) related to acid deposition in the region has been undertaken all of which would indicate that current PAI levels are below effects levels except perhaps in very close proximity to emission sources. Fort McKay is therefore not concerned that current PAI levels are having a significant adverse effect.

Current Case Summary

Overall there is sufficient information to indicate that current ambient air quality levels of NO/NO_2, NH_3 and/or nitrogen deposition levels may be approaching, at, or even above, vegetation affect levels. Fort McKay is therefore concerned that further regional industrial development has the potential to adversely impact the vegetation on its Traditional Lands.

Base Case

For the Base Case the following assessments, as related to possible vegetation impacts of existing and approved developments, were made:

- ***SO_2*** – Fort McKay used Shell's (2007) Base Case which assessed the areas that would have annual ambient current annual average SO_2levels above 10 µg/m^3, 20ug/$m^3$and 30 µg/m^3 based on high, medium and low vegetation sensitivity areas (EIA Vol. 3,Section 5.5.4.3, p.5-213, Dec. 2007). The 10 µg/m^3 criteria used for high sensitivity vegetation was predicted to be exceeded in an area of 327ha that occurred near developments. There were no predicted exceedences in the medium to low sensitivity vegetated areas. The criteria used and resultant predictions are considered reasonable. Fort McKay does not therefore have concerns regarding the impacts of the Base Case SO_2 emissions on vegetation within its Traditional Lands. However, since localized impacts from SO_2

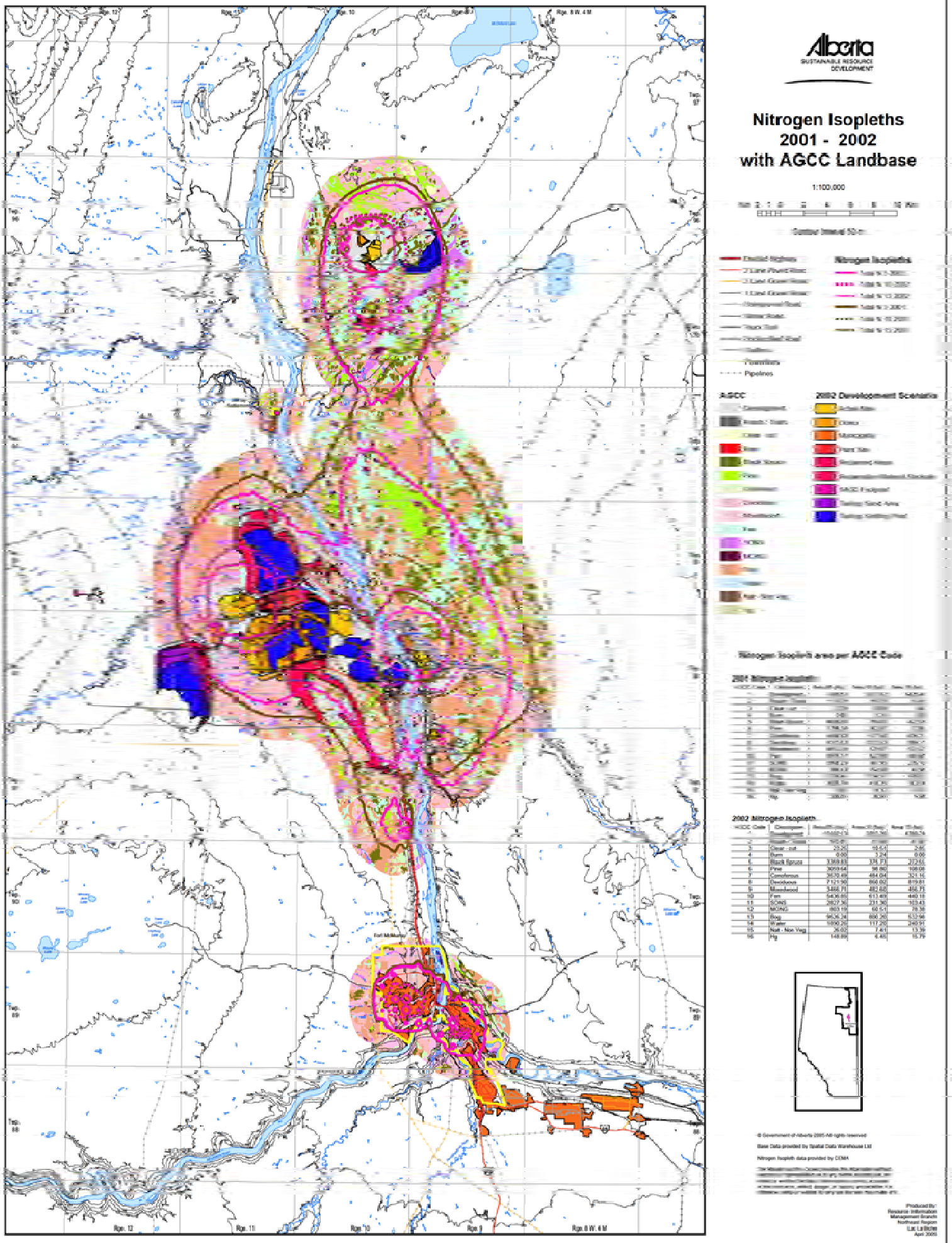


FIGURE 2-14: Model Estimated Nitrogen Deposition Isopleths

emissions on vegetation are possible under the Base Case, this issue needs to be a consideration in both the Shell approvals and in SO_2 emission management requirements for future new projects (a **green** situation).

- ***NOX*** – assessing the impact of predicted ambient annual NO*X* levels under the Base Case is challenging because all the available modeling is based on NO_2 but the vegetation effect criteria of the WHO (2000), which is used by Fort McKay, is based on NO*X*. To address this issue the WHO value for NOx effects on vegetation of 30 µg/m^3 (annual average) was divided by 2 to give a critical level of 15 µg/m^3 for NO_2 which is based on the assumption that, NOx is comprised of 50% NO_2 on a regional basis. This approach has been used in previous EIAs (e.g., the Imperial Kearl Project EIA). Using this criteria and regional Base Case annual average NO_2 model predictions from:
  - the Petro-Canada McKay River Expansion EIA (2005), which were calculated by Golder (2009) for Fort McKay,
  - the Shell EIA (2007), and
  - and the Imperial Kearl EIA (2005)

The following approximate areas that may be subject to vegetation effects associated with regional NO*X* emissions were estimated:

a. all or part of 73 townships (from Petro-Canada McKay River Expansion EIA (2005) NO_2 predictions),

b. all or part of 42 townships (approximately 308,000 ha by graphical integration; from Shell EIA (2007) NO_2 predictions), and

c. 152,851 ha (this is value presented in the EIA for the Kearl project; from Imperial Kearl EIA (2005).

The potential vegetation effects areas calculated using the annual NO_2 contour isopleth data provided by Golder (2009) are in generally agreement with the modeled effects area presented in the Imperial Kearl and indicate that a very large area within Fort McKay's Traditional Lands is either at risk or already being impacted (a **red** situation).

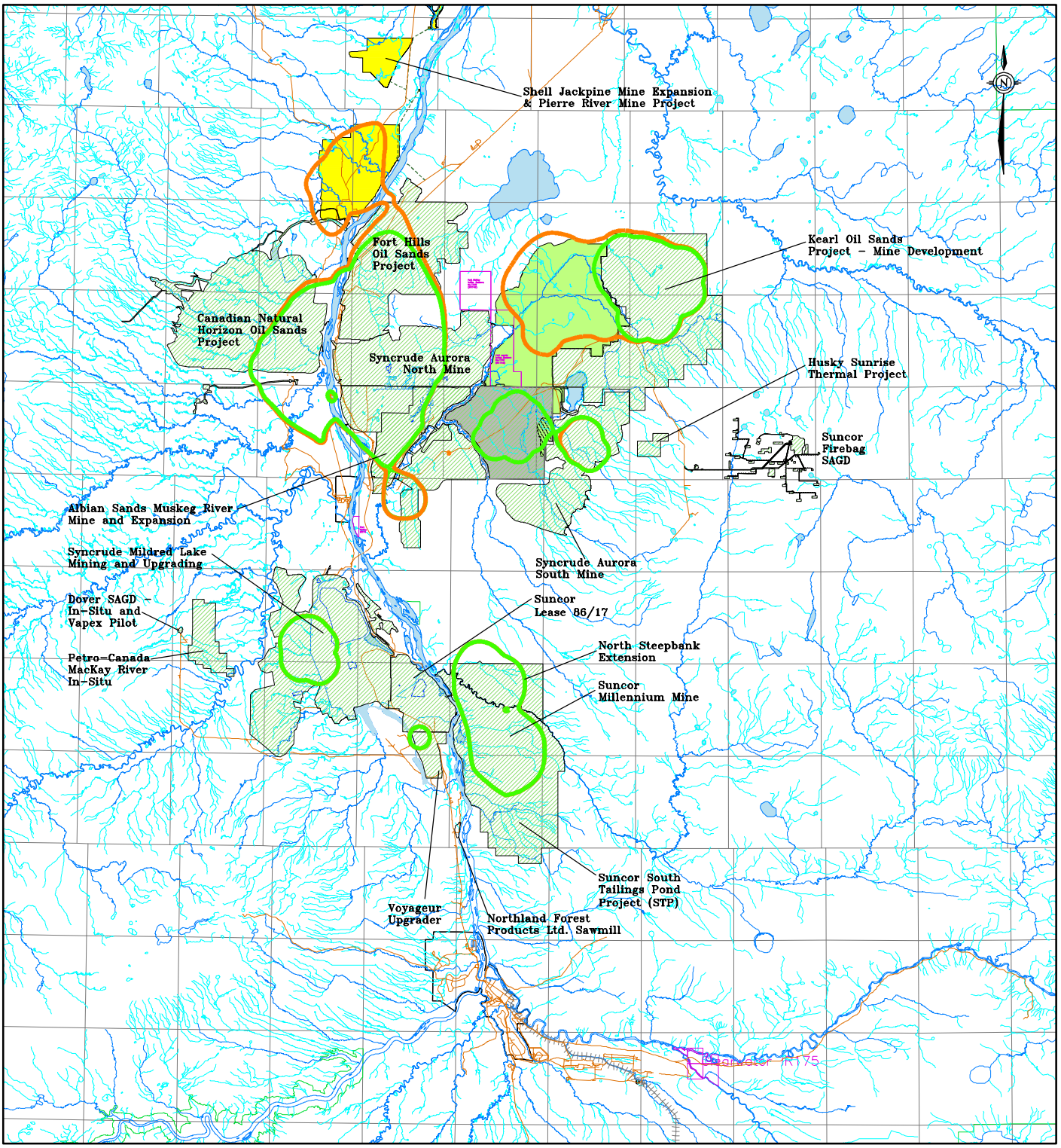
- ***Ozone*** – No EIAs have quantitatively assessed Base Case ozone levels and therefore Fort McKay had no data upon which to assess Base Case scenario predictions ozone. A future emission scenario ozone modeling run was conducted by Environment Canada in 2005/2006 (see Current Scenario ozone discussion above for details) and this included a future emissions scenario ozone modeling run. The results of this modeling are discussed under the Planned Development Case.

- ***NH_3*** – Regional ammonia level predictions under the Base Case were not part of Shell's assessment. Also insufficient information on ammonia emissions from current and approved projects is available to allow Fort McKay to assess the potential regional annual ammonia level increases that will result from the Base Case. Increases would be expected and as noted under the Current Scenario and levels may already be at or near effect levels (a **yellow** situation).

- ***Nitrogen Deposition*** – The model predicted area exceeding Fort McKay's 8 kgN/ha/yr regional critical load for nitrogen, is approximately 55,000 ha under the Base Case. Approximately 5500 ha of this is outside current or approved project development areas. These areas are based on graphical integration using the nitrogen deposition isopleths provided by Golder (2009) and in the Shell (2007) EIA - Vol. 3, Figure 5.5-6, p.5-223, December 2007; Figure 2-15).

In its assessment of the eutrophication impacts of nitrogen deposition, Shell indicated that: "In total, 145,011 ha of vegetated areas fall within the 0.25 and 2.0 keq N/ha/yr isopleths (all land cover classes)." (Shell 2007,EIA Vol. 3, p. 5-218, December 2007). If the nitrogen deposition levels are assumed to decrease proportionally between these two deposition levels as a function of the square of distance, then the Shell EIA data would translate to approximately 64,000 ha above the deposition level of 8 kg N/ha/yr (0.57 keq/ha/yr), which is in general agreement with the graphical integration estimate. Much of this area is within current or planned development areas. In the Imperial Kearl EIA (2005), critical nitrogen loads of 15 and 20 kg N/ha/yr (based on vegetation cover) were used and a Base Case area exceedence of these critical loads was predicted to be 6210 ha. It needs to be noted again that nitrogen deposition is difficult to model and that modeling is likely over-predicting nitrogen deposition (NSMWG 2005) for the nitrogen species being modeled but that models do not include nitrous acid, ammonium and ammonia, which are likely significant regional sources of nitrogen deposition. Therefore it is assumed that model predictions may be giving an approximate estimate of total regional nitrogen deposition for the various development scenarios. Using Fort McKay's criteria of 95% protection, 5500 ha above the regional critical loads translates to approximately translates to approximately 3.5% of the Base Case disturbed area on Fort McKay's Traditional Lands (based on regional disturbance data from Shell EIA - Vol. 5, Section 7, p. 7-27, Dec. 2007). Normally this would be a **green** situation but due to the uncertainties associated with predicting N deposition the Current Scenario is considered a **yellow** situation.

- ***PAI*** – the PAI isopleths and impact area estimates from Shell (2007) were used by Fort McKay in its assessment of Base Case PAI impacts. The estimated area exceeding soil-series-specific critical loads is1,836 ha of soils outside existing and approved developments. This exceedence occurs within Fort McKay's Traditional Lands. The areas where these exceedences occur are shown on



LEGEND

- PIERRE RIVER MINING AREA
- JACKPINE EXPANSION MINING AREA
- JACKPINE MINE – PHASE 1
- NITROGEN DEPOSITION AT A RATE OF 8 kg/ha/yr (BASELINE CASE)
- NITROGEN DEPOSITION AT A RATE OF 8 kg/ha/yr (APPLICATION CASE)
- EXISTING AND APPROVED PROJECT DEVELOPMENT AREAS
- LEASE SWAPPED TO SYNCRUDE

12 0 12
SCALE KM

REFERENCE

Alberta Digital Data Obtained From AltaLIS Ltd. (September 2004.) used under license.
Projection: Transverse Mercator Datum: Nad 83 Coordinate System: Utm Zone 12

PROJECT

JACKPINE MINE EXPANSION & PIERRE RIVER MINE PROJECT

TITLE

AREAS WITH TOTAL NITROGEN DEPOSITION RATE ABOVE 8 kg/ha/yr

PROJECT 06-1344-022.7900			FILE No.Nitrogen Baseline-App	
DESIGN	LD	28/08/07	SCALE AS SHOWN	REV. 0
CADD	TY	26/11/07		
CHECK	ZK	25/09/07	**FIGURE 2-15**	
REVIEW	WES	04/12/07		

L:\2006\1344-OIL SANDS\1346\06-1346-022 Shell\7900\7920\ Drawing file: Fig 5.5-6 Nitrogen Deposition at 8kg.dwg Dec 05, 2007 - 3:47pm

Figure 2-11. CEMA is currently conducting a Base Case acid deposition model run as part of its Acid Deposition Management Framework (CEMA 2004) implementation. The results of this modeling should be available by January 2010. CEMA is also developing a dynamic time-to-effect acid deposition model as part of its Acid Deposition Management Framework (CEMA 2004) implementation and this model should be ready for regional use in the 2011/2012 period. Until results from this more detailed type modeling are available, Fort McKay considers the current Base Case model PAI estimates and impact area calculations to be the best available information. Based on this available information, Fort McKay is not concerned regarding PAI exceedences under the Base Case scenario (a **green** situation) but nevertheless considers that the predictions warrant an emphasis on rigourous emission management.

Base Case Summary

These Base Case assessments would indicate that the nitrogen emissions associated with this level of development are such that they could result in adverse impacts on significant areas of vegetation due to NOx, NH_3 and possibly ozone.

Application Case

The following is Fort McKay's assessment of the potential impacts of Shell's proposed Jackpine Mine Expansion and Pierre River Mine projects on regional vegetation.

- ***SO_2*** –Shell is proposing to use asphaltenes as the fuel source for two large co-generation units (one at the Jackpine Mine Expansion project and one at the Pierre River Mine). Asphaltenes have relatively high sulphur content (in the 5% range). The proposed projects would therefore increase regional sulphur dioxide emissions and ambient SO_2 levels and could have a SO_2 related direct (fumigation) impact on vegetation. Shell assessed this possibility and concluded that an additional 7 ha of sensitive vegetation (lichens) could be impacted by the proposed projects. Fort McKay's concurs with these estimates and does not consider the SO_2 related vegetation impacts that might be associated with the proposed projects to be significant (a **green** situation).

- ***NOX*** – based on the use of a 15 µg/m^3 NO_2 isopleth (see NO_2 section under Base Case) the area possibly adversely impacted by Base Case + Application Case NOX emissions includes all or part of 45 townships and by graphical integration covers approximately 280,000 ha. This represents a project related increase in possibly affected area of 19,000 ha. Shell's proposed combined project development area (Jackpine Mine Expansion and Pierre River Mine) is 21,339 ha and therefore the potentially affected undeveloped area represents approximately 90% of the proposed development which is much higher than the 5% impact criteria being used by Fort McKay (see section 3.2.5.4). This indicates

that a very large area within Fort McKay's Traditional Lands could be affected from the NO_X emissions associated with Shell's proposed project (a **red** situation).

- ***Ozone*** – As noted under the Base Case discussion, Fort McKay's assessment of possible ozone related impacts was limited because the issue was not assessed quantitatively by Shell and has not been assessed quantitatively in any recent EIAs. Therefore, no numeric Application Case predictions are available for ozone. Increased regional emissions of NO_X and VOCs, resulting from proposed projects like Shell's, have been modeled in terms of future ozone levels and significant increases and potential impacts identified. The results of this modeling are discussed under the Planned Development Case. It is Fort McKay's assessment that the potential impact of Shell's proposed projects on future regional ozone levels and vegetation impacts cannot be considered as negligible and need to be considered when establishing emission limits for the project (a **yellow** situation).

- ***NH_3*** – As noted under the Base Case scenario discussion, regional ammonia level predictions were not part of Shell's assessment and no ammonia emissions from the proposed projects were identified. There is therefore insufficient information on Base Case and Application Case ammonia emissions to allow Fort McKay to assess the potential regional annual ammonia level increases that could result from the Application Case. As noted under the Current Scenario, existing ambient ammonia levels may already be at, or near, effect levels and therefore, this is a potential impact issue requiring further evaluation (a **yellow** situation).

- ***Nitrogen Deposition*** – Based on Fort McKay's use of 8 kg N/ha/yr as a regional critical load for nitrogen, and graphical integration of the regional area with nitrogen deposition isopleths above this value (provided by Golder (2009) and Shell (2007) – see Figure 2-10), the model predicted area exceeding 8 kg N/ha/yr is approximately 55,000 ha under the Base Case scenario and approximately 60,000 ha under the Application Case scenario. The proposed projects would therefore increase the area with a nitrogen loading of greater than 8 kg N/ha/yr by approximately 5,000 ha. This increase occurs in the areas adjacent to the two proposed mines and approximately 2000 ha of this land is outside current or approved project development areas and Shell's proposed project areas. Shell's proposed combined project development area (Jackpine Mine Expansion and Pierre River Mine) is 21,339 ha and therefore the potentially affected undeveloped area represents approximately 9% of the proposed development which is higher than the 5% impact criteria being used by Fort McKay (see Section 2.2.5.4). This indicates that a significant area within Fort McKay's undisturbed Traditional Lands could be affected from the N deposition associated with Shell's proposed project emissions (a **red** situation).

- ***PAI*** – the PAI isopleths and impact area estimates from Shell (2007) were used by Fort McKay in its assessment of Application Case PAI impacts. The estimated area exceeding soil-series-specific critical loads in the Base Case was 1,836 ha of soils outside existing and approved developments and the area is 1,829 ha in the Application Case. Shell indicates that this decrease is not related to emissions management but is attributed to the modeled location of the Jackpine mine fleet, which was relocated in the Application Case (Shell EIA Vol. 3, p.5-226, Dec. 2007). Fort McKay considers the Application Case model PAI estimates and impact area calculations to be the best available information. Based on this available information, Fort McKay is not concerned regarding PAI exceedences under the Application Case (a **green** situation) but nevertheless considers that the predictions warrant an emphasis on rigorous emission management particularly since 806 ha of this area is woodland caribou habitat with high lichen food value (Shell EIA Vol. 3, p.5-234, December 2007); see Figure 2-16.

Application Case Summary

This Application Case scenario assessment would indicate that nitrogen emissions associated with Shell's proposed projects are such that they could contribute to adverse impacts on significant areas of vegetation due to NO_X and nitrogen deposition effects and possibly ozone. The potential project impacts on vegetation due to NH_3 and ozone are difficult to assess because of the lack of data.

Planned Development Case (PDC)

The following is a summary of Fort McKay's assessment of the potential impacts of current and approved, Shell's proposed Jackpine Mine Expansion and Pierre River Mine projects and other planned developments on regional vegetation. Table 2-57 summarizes the difference in regional emissions between the Application Case and Planned Development Case as provided in Shell's EIA (2007). The estimated increases in SO_2, NO_X and VOC (as relates to ozone formation) emissions are of interest in terms of potential impacts on vegetation.

- ***SO_2***–Annual maximum regional average SO_2 levels predicted in the Shell (2007), Synenco (2007) and Petro-Canada (2005) EIAs under a Planned Development Case scenario were all below 10 µg/m^3. If these predictions are accurate, and if future SO_2 emissions are correct, then Fort McKay does not consider the SO_2 related vegetation impacts that might be associated with the current Planned Development Case to be significant (a **green** situation).

- ***NO_X*** – Based on the use of a 15 µg/m^3NO_2 isopleth (see NO_2 section under Base Case) the area possibly adversely affected under the PDC includes all or part of 48 townships and by graphical integration covers approximately 310,000 ha. This represents a 30,000 hectare increase over the Application Case predictions. From the Petro-Canada EIA (2005) the predicted area above an annual average NO_2 value of 15 µg/m^3 is approximately 750,000 ha under the PDC. Based on the

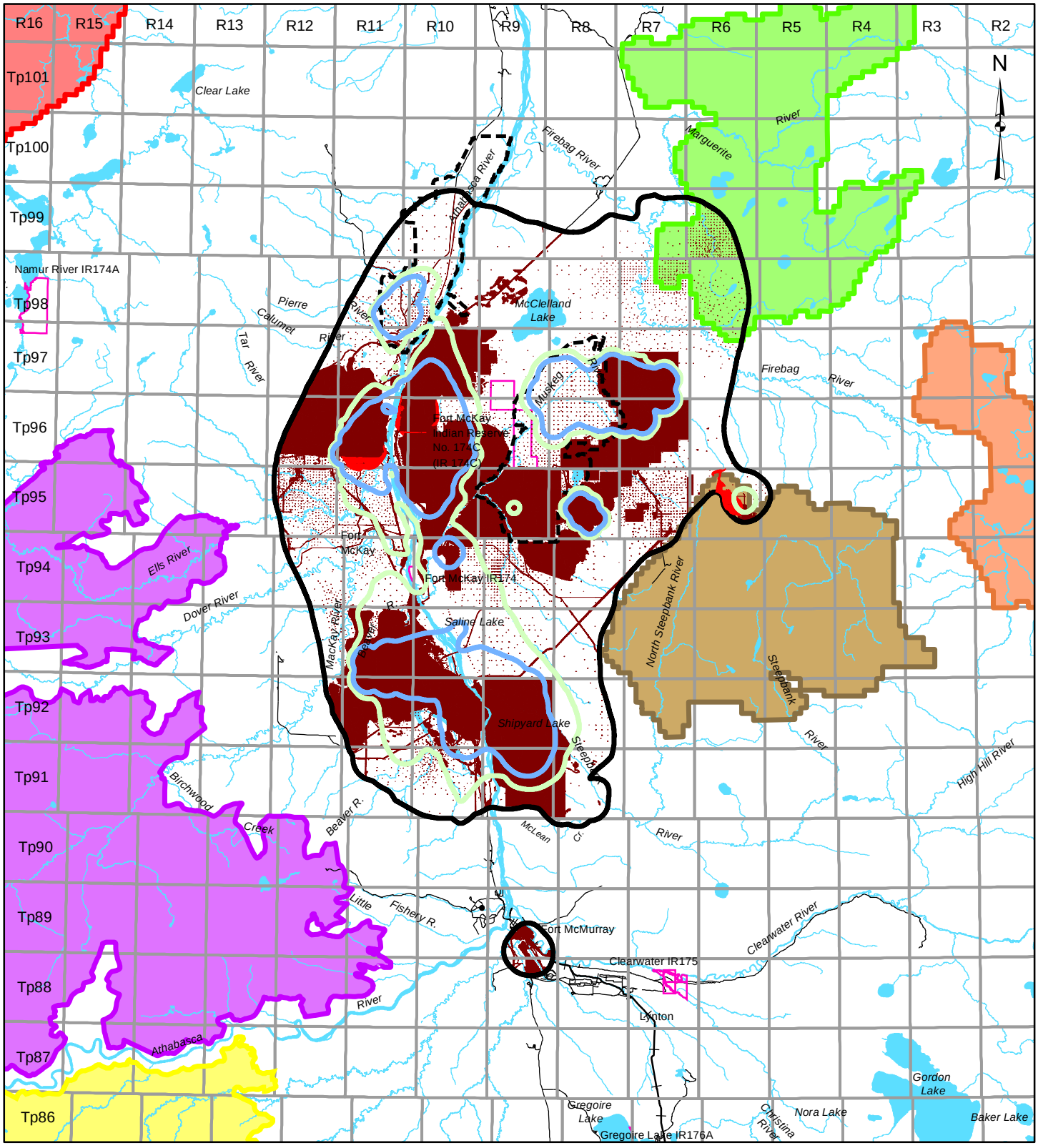
Synenco EIA (2007), the predicted area above an annual average NO_2 value of 25 µg/m^3 is approximately 300,000 ha under the PDC (Synenco did not provide a 15 µg/m^3 isopleth so a 25 µg/m^3 was used). The much larger areas predicted to have annual NO_2 levels above 15 µg/m^3 in the Petro-Canada and Synenco EIAs, versus the Shell (2007) EIA reflect different model inputs/approaches. The disturbance associated with the PDC is difficult to accurately determine but the predicted undisturbed area with NO_2 levels above 15 represents a very large percentage of the disturbance area and definitely exceeds Fort McKay's 5% criteria (a **red** situation).

Table 2-57: Estimated Increase in Regional Emissions Associated with the Planned Development Case

Parameter	Application Case Emissions (t/d)	Planned Development Case Emissions (t/d)	Increase in Regional Emissions (t/d) (and as a percentage)
SO_2	281.94	326.67	44.8 (16%)
NOx	495.55	633.90	138.4 (28%)
CO	439.29	511.43	72.1 (16.4%)
$PM_{2.5}$	31.69	39.44	7.8 (24.6%)
VOCs	707.23	880.38	173.2 (24.5%)
TRS	7.90	9.33	1.4 (17.7%)

- ***Ozone*** – As noted under the Base Case discussion, ozone was not assessed quantitatively by Shell and therefore no numeric PDC predictions are available for ozone. However, a future emission scenario ozone modeling run was conducted by Environment Canada (2007) and this included a future emissions scenario ozone modeling run. This model run can be considered to represent a PDC. This modeling indicated the potential for the area of the region where SUM 60 levels were above 2000 ppb-hrs to substantial increase and for some areas to have SUM 60 values above 4400 ppb-hrs (the recommended "management" level) and some areas to have SUM 60 values above 6600 ppb-hrs (the recommended "exceedence" level; CEMA 2007). Future levels of ozone may therefore have an adverse impact on regional vegetation (a **yellow** situation).

- ***NH_3*** – As noted under the Base Case and Application Case scenarios Shell did not include an assessment of ammonia in its EIA and there is insufficient information to allow Fort McKay to assess the potential regional annual ammonia level increases that could result from planned development projects. As noted under the Current Scenario, existing ambient ammonia levels may already be at, or near, effect levels and therefore, a potential effect issue requiring further evaluation (a **yellow** situation).



LEGEND

- TERRESTRIAL RESOURCES AIR EMISSIONS EFFECTS STUDY AREA
- TERRESTRIAL LOCAL STUDY AREAS
- INDIAN RESERVE
- OPEN WATER
- PUBLIC ROADWAY
- RAILROAD

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

- EXCEEDANCE
- 0.17 keq/ha/yr ISOPLETH
- 0.25 keq/ha/yr ISOPLETH

CARIBOU ZONES

- ALGAR CARIBOU AREA
- AUDET CARIBOU AREA
- BIRCH CARIBOU AREA
- FIREBAG CARIBOU AREA
- STEEPBANK CARIBOU AREA
- WABASCA/DUNKIRK CARIBOU AREA

20 0 20

SCALE 1:750,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), AOSERP (1982), EUB, AGS, LANDSAT 7 ETM Imagery (July 2006), and Alberta SRD, used under license. Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT

JACKPINE MINE EXPANSION & PIERRE RIVER MINE PROJECT

TITLE

SOIL AND VEGETATION PAI CRITICAL LOAD EXCEEDANCES IN THE TERRESTRIAL RESOURCES AIR EMISSIONS EFFECTS STUDY AREA: BASE CASE

PROJECT No. 06-1346-022.8090			SCALE AS SHOWN	REV. 0
DESIGN	VR	22 Jan. 2007		
GIS	VR	22 Nov. 2007		
CHECK	AA	30 Nov. 2007		
REVIEW	WES	04 Dec. 2007		

FIGURE **2-16**

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- ***Nitrogen Deposition*** – Shell did not assess the impact of the Planned Development Case emissions on regional nitrogen deposition and therefore Fort McKay was unable to assess the area that might exceed an 8 kg N/ha/yr critical load for nitrogen under this case. An estimate of the area that might exceed an 8 kg N/ha/yr critical load for nitrogen under the PDC was obtained using the approximate 28% increase in NOx emissions associated with planned projects and linearly extrapolating from the area above the 8 kg N/ha/yr from the Application Case. This extrapolation approach would give an area of approximately 9,750 ha exceeding this critical load. In the absence of more details on the individual planned development projects it is not possible to assess whether or not all or some of these planned projects would exceed Fort McKay's 5% impact criteria (see section 2.2.5.4). Based on the 9,750 ha exceedence area the PDC impact is considered significant by Fort McKay (a **red** situation).
- ***PAI*** – Fort McKay used the projected increase in acidifying emissions i.e., SO_2 and NOx, to estimate the impacts of PAI under the PDC. This approach was partly necessitated by the lack of a PDC PAI assessment in the Shell EIA (2007) that could be used to provide data for Fort McKay's assessment. A 30% increase in the area exceeding critical soil PAI levels under the PDC versus the Application Case was estimated. This estimate was based on using the full 16% estimated increase in SO_2 emissions and one-half of the 28% i.e., 14%, of the estimated increase in NOx emissions to give a very approximate estimate of the increase in area where PAI levels would exceed critical soil PAI levels. Using this method gives an additional 550 ha that would exceed critical soil PAI levels as a result of planned projects and a total area of 2,379 ha that would exceed critical soil PAI levels under the PDC. In the Imperial Kearl EIA (2005) it was estimated that PAI critical loads were exceeded on 21,751 ha under the PDC (Vol.7 p. 3-65). See Figure 2-12, which was taken from the Imperial Kearl EIA (2005) and shows the areas where soil PAI exceedences were predicted under the PDC. This larger prediction of impacted area is at least partly the result of all nitrogen deposition being included in the PAI. Fort McKay does not consider PAI exceedences under the PDC as significant (a **green** situation) but nevertheless considers that the predictions warrant an emphasis on rigourous emission management.

Planned Development Case Summary

This Planned Development Case assessment indicates that the emissions associated with current and approved projects, Shell's proposed projects and planned regional developments are collectively such that they could contribute to adverse impacts on significant areas of vegetation due to NO*X*, ozone and nitrogen deposition effects. The potential project impacts on vegetation due to NH_3 are difficult to assess but ambient monitoring indicates concentrations at potential effect levels.

2.5.6 Overall Conclusions of Impacts of Emissions on Vegetation Assessment

The assessment of the effects of current and approved projects, Application and Planned Development Case emissions on regional vegetation and Fort McKay's reliance on this vegetation to support its traditional land uses is complicated by a number of factors. These include:

- no Alberta or RMWB ambient air quality criteria that are specifically directed at vegetation effects management/protection which leads to the use of criteria from other jurisdictions or the use of Alberta criteria that are perhaps not appropriate and assessment conclusions that range from no effects to significant effects simply based on the use of different assessment criteria;
- the difficulties in modeling dry nitrogen deposition and the fact that current modeled nitrogen deposition does not include all nitrogen species that may contribute to regional nitrogen deposition (e.g., ammonia, ammonium and nitrous acid);
- the exclusion of ammonia from regional assessments despite the relatively high, and much higher than generally assumed, regional ambient ammonia levels that have been measured in the region since ammonia passive monitoring commenced in 2005 and the lack of oil sands related ammonia emission data to help assess the source(s) of these ambient ammonia levels;
- simplified assumptions regarding the contribution of project emissions to ozone formation, lack of rural regional ozone monitoring and the lack of consideration given to Environment Canada's recent ozone modeling results; and
- uncertainties around nitrogen emissions from mine fleets, which makes quantitative assessments of nitrogen impacts difficult.

These information, criteria and model limitations reduce the certainty with which assessment conclusions can be made regarding the impacts that current and future regional emissions may have on vegetation. There are however a number of conclusions regarding current and possible future impacts of air emissions on vegetation, which are:

- SO_2 emissions at current and future predicted levels do not appear to represent a significant threat to regional vegetation through fumigation (direct) exposure,
- NOx emissions represent a significant potential threat, and may already be at effect levels in certain areas, through fumigation (direct) exposure effects, through nitrogen deposition and associated eutrophication (fertilization) effects and through contribution to ozone formation and direct effects of ozone,

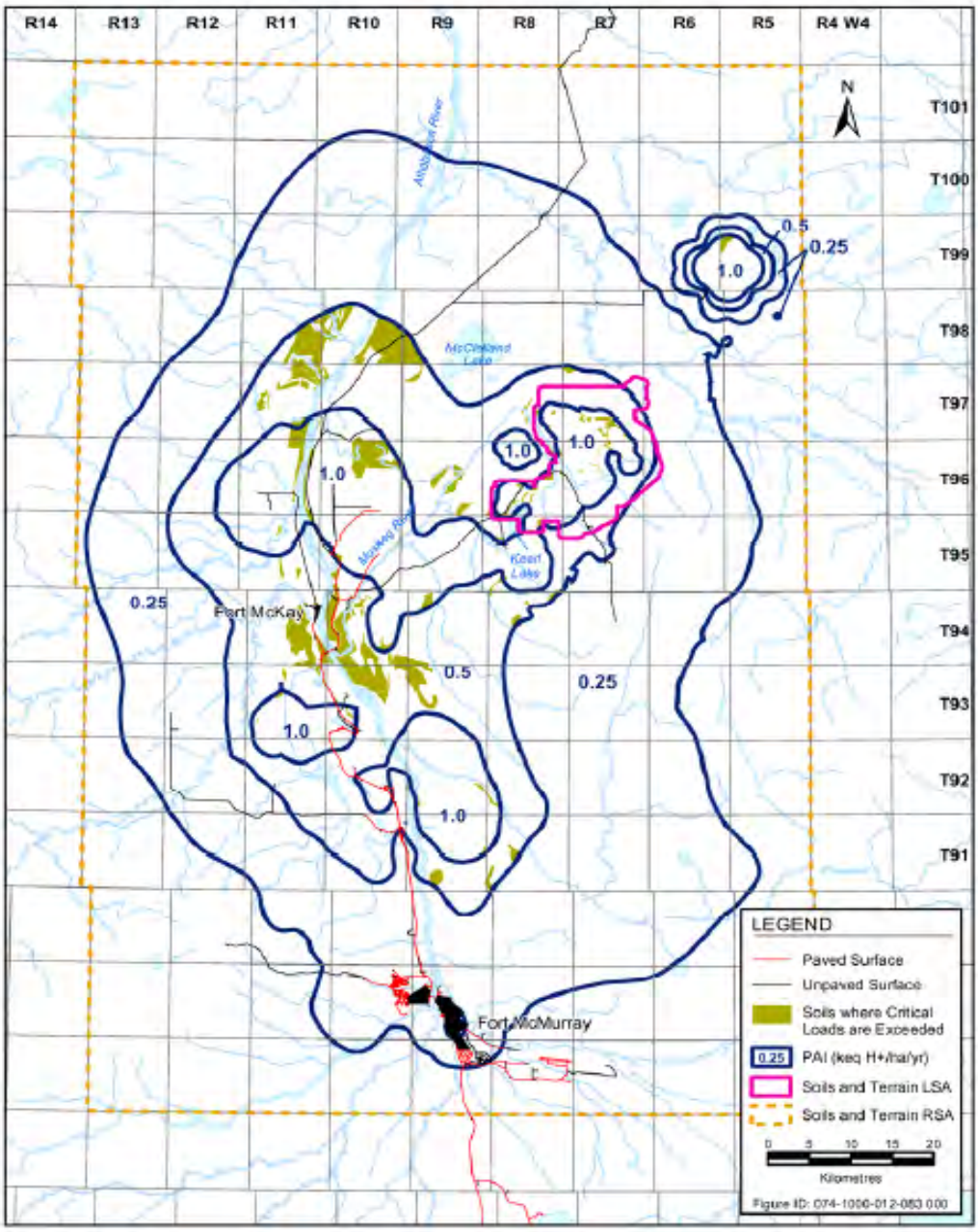

Figure 2-17: PDC Predicted PAI Exceedences[10]

[10]From Imperial Kearl EIA, Vol. 7, p. 3 64, July 2005

- increased future VOC emissions might contribute to ozone formation with subsequent ozone-related vegetation effects of ozone,
- regional ambient ammonia concentrations are at environmentally significant levels and the sources/causes of these levels, anthropogenic and/or biogenic, need to be determined, and
- current and predicted PAI are not at levels that are likely to have significant adverse effect.

These conclusions are summarized in Table 2-58 for each of the assessment scenarios the **green-yellow-red** issue significance rating is identified for each issue and scenario.

Overall the potential vegetation impacts of regional nitrogen emissions from existing, approved, Shell's proposed and planned projects are considered high (a **red** significance level). This impact potential is an issue that needs to be addressed through the rigorous management of NO_X emissions (and VOC emissions from the standpoint of O_3 formation) and an understanding of sources and potential impacts of ammonia emissions. The significance of NH_3 impacts is difficult to assess and is given a **yellow** level with more study required.

2.5.7 Shell's Proposed NO_X and VOC Emissions Management

Shell has indicated that it will undertake a number of air emission management measures at its proposed projects. Many of these will reduce the emissions of NO_X and/or VOCs which contribute to the potential for air emission-related effects on vegetation. These measures include (Shell 2007, EIA Vol. 3 Section 2.2.5.2, pp. 2-12 to 53, December 2007):

- above-ground storage tanks will conform to Environmental Guidelines for Controlling Emissions of Volatile Organic Compounds from Above-ground Storage Tanks,
- plant-wide fugitive emissions identification and control using the protocol recommended by the Canadian Association of Petroleum Producers Management of Fugitive Emissions at Upstream Oil and Gas Facilities, as well as other relevant guidelines and codes of practice, aimed at minimizing fugitive emissions,
- flaring will be minimized for the Project (e.g., upset/emergency conditions, start-up and commissioning) and will comply with the Alberta Energy and Utilities Board Directive 060,
- Tailings Solvent Recovery Unit (TSRU) tailings deposition will be managed to maintain an annual average rate of 4 volumes of solvent per 1,000 volumes of bitumen produced,

Table 2-58: Summary of Fort McKay's Assessment of the Impact of Regional Emissions on Vegetation for each Development Scenario and the Actions Currently Required

Issue	Case /Scenario Assessment					General Comment –Position
	Background	Current	Base Case	Application Case	Planned Development Case	
SO_2	No issues/ effects	Minimal issues/effects and very local in nature				No action required unless future SO_2 emissions increase above forecasts
NO*X*	No issues/ effects	Potential direct effects but likely local in extent	Likely direct effects local to regional in extent		Strong likelihood of direct effects regional in scope	Emission control actions required
Ozone	No issues/ effects	Minimal issues/effects	Some possible effects but likely small in extent	Some possible effects	Likely effects with areal extent uncertain	NO*X* and VOC emission control actions required
NH_3	No issues/ effects	Uncertainty around significance or effects of current levels	Uncertain			Additional study required
Nitrogen deposition	No issues/ effects	Potential effects but likely local in extent	Likely effects local to regional in extent	Likely effects local to regional in extent	Strong likelihood of effects regional in scope	Emission control actions required
Potential Acid Input	No issues/ effects	Potential effects but likely local in extent	Potential effects but likely local in extent	Potential effects but likely local in extent		Continued monitoring and full implementation of Acid Deposition Management Framework

- cogeneration units and auxiliary boilers will meet the Emission Guidelines for Oxides of Nitrogen (NOχ) for New Boilers, Heaters and Turbines using Gaseous Fuels Based on a Review of Best Available Technology Economically Achievable (BATEA) – Interim Guideline (AENV 2007),
- asphaltene-fired cogeneration units: will achieve 75% NOχ control efficiency through the use of selective catalytic reduction (SCR) NOχ control technology (note: this type of NOχ control appears to consistent with AENV's draft revised Policy 1 for Emission Standards for the Use of Non-gaseous Fossil Fuels for Steam Generation in In-Situ Bitumen or Heavy Oil Recovery Projects; AENV 2008b) and the emission limits proposed (Shell 2009, Vol. 1, Question 230, pp. 11-24 to 27) are better than those in the draft revised Policy 1, and
- vehicles in the mine fleet will meet applicable emission standards at the time of purchase and mine maintenance procedures will ensure fleet vehicles are regularly maintained.

Shell is also proposing the following source and ambient monitoring as part of the proposed projects, which it indicates will be determined in consultation with WBEA and AENV:

- expand the existing Leak Detection and Repair Program to detect, measure and control emissions from equipment leaks from new facilities as per the Canadian Association of Petroleum Producers Management of Fugitive Emissions at Upstream Oil and Gas Facilities,
- continue to monitor VOCs through grab samples at ambient trailers per WBEA requirements, and
- continue to conduct fugitive emission surveys on the External Tailings Disposal Area (ETDA) and mine surfaces on site and at ambient trailers to quantify and speciate VOCs and TRS compounds by source.

Shell also indicates that it will:

- continue its active participation in the Wood Buffalo Environmental Association (WBEA) and the Terrestrial Environmental Effects Monitoring (TEEM) program for matters relating to monitoring and assessment of air emissions in the Oil Sands Region,
- work with AENV and WBEA members to understand regional monitoring requirements, and
- meet the requirements of the Acid Deposition Management Framework developed through the NSMWG of CEMA and of the Trace Metals Management Framework developed through the Trace Metals and Air Contaminants Working Group (TMAC), also of CEMA.

These are all considered reasonable NO*X* and VOC emission management actions if there were no predicted impacts associated with these emissions. Since, based on Fort McKay's assessment, this is not the case, additional emission controls and management strategies are required and these are outlined under recommendation (Section 2.5.8).

2.5.8 Fort McKay's Recommendations

Based on the current potential for emission-related adverse effects on vegetation, and the clear potential for significant areas of adverse vegetation impacts under future emission scenarios, Fort McKay has a number of specific recommendations related to management of these potential impacts and adverse effects. These are:

2.5.8.1 NO*X* and VOC Emissions Management Recommendations

Project-Specific Recommendations

1. Solvent losses to its Jackpine Mine Expansion and Pierre River Mine tailings ponds be restricted to less than 3 bbl per 1,000 bbl of bitumen within five years of commencing bitumen production at these mines. This will reduce the regional precursor concentrations of ozone forming compounds.

2. That Shell be required to undertake a detailed and ongoing emission characterization and quantification monitoring program from the tailings ponds at its Jackpine Mine Expansion and Pierre River Mine tailings and that this program be developed in conjunction with Fort McKay with the results of the monitoring reported to Fort McKay IRC at regular intervals. This will improve understanding and management of the potential health odour and environmental effects of tailings pond emissions.

3. Shell be required to develop and implement a comprehensive plant site fugitive emissions detection, monitoring/characterization program and associated repair and reduction program that includes periodic DIAL (Differential Absorption Lidar) or equivalent monitoring and that this program be developed in conjunction with Fort McKay, with the results of the monitoring reported to Fort McKay at regular intervals and upon request. This will enable better understanding and management of potential health, odour and environmental effecs of tailings pond emissions.

4. Shell be required to reduce the NO*X* emissions from all gas-fired boilers, heaters and gas turbines that emit more than 100t/yr of NO*X* and that these reductions be based on the use of post combustion selective catalytic reduction technology, or equivalent, which Shell is proposing for its asphaltene-fired co-generation units. This will reduce the regional precursor concentrations of ozone forming compounds.

Cumulative Effects Recommendations

5. All the hydrocarbon monitoring data that has been generated to date related to mine faces, tailings pond and fugitive bitumen processing and upgrading facility emissions be collected, collated and published to improve the availability of information and understanding of the VOC emissions from regional industrial operations and the potential impact of these emissions.

Note: Recommendations 1, 2, 3 and 5 are similar to those for odour management (see Section 2.4.6.1) and Recommendation 4 is the same as provided in Section 2.3.3 (the Nitrogen Oxides Assessment Section).

2.5.8.2 Ammonia Monitoring Studies

Project-Specific Recommendations

1. An assessment be undertaken in consultation with Fort McKay of the potential for ammonia releases from Shell's proposed projects and that methods be developed and implemented to minimize any such emissions.

Cumulative Effects Recommendations

2. A regional ammonia monitoring study be designed and implemented in consultation with Fort McKay to monitor both point and area emission sources in the region for ammonia using low detection ammonia monitors.

2.5.8.3 Vegetation Effects Measurement and Management in the Regional Municipality of Wood Buffalo

Cumulative Effects Recommendations

1. To improve understanding of current and potential future regional air-related environmental effects and impacts, and the factors contributing to these effects and the development of management plans;

    a. Implementation of the recommendations and work plan work as outlined in CEMA's Interim Nitrogen (Eutrophication) Management Recommendations and Work Plan which requires the development of nitrogen critical loads for sensitive regional ecosystems;

    b. Implementation of CEMA's Acid Deposition Management Framework including full development and deployment of the time-to-effect dynamic acidification model for the entire region;

c. Implementation of CEMA's Ozone Management Framework and using the results of the Framework's ozone model predictions in the development of regional ozone monitoring programs and ozone precursor emission management planning;

d. Sensitive and spatially representative ecosystems be indentified and vegetation effects and exposure monitoring programs be developed that can accurately determine if, when and where adverse air-related vegetation effects are occurring and to validate and calibrate model predictions; and

e. Development of ambient air quality critical limits/levels for NO, NO_2 and NH_3 based on potential impacts on vegetation relevant to Fort McKay and its Traditional Lands.

2.6 Summary and Conclusions

This air assessment identified a number of significant air-related impact issues that need to be addressed, in some cases immediately addressed, to protect the quality of life in Fort McKay. Air impact issues have been, and continue to be, a major concern to the Community and this assessment confirmed that there are air issues that need to be given priority in terms of either immediate mitigative action or development of plans and strategies to address before critical impacts or effects occur. The following is a summary of the air assessment and its key conclusions.

The Fort McKay Specific Assessment was conducted by Fort McKay to better understand the past, current and possible influences of oil sands projects on the health and quality of life of its Community members. In the air quality portion of this assessment, possible air emission-related effects were assessed using criteria that were both scientifically credible and relevant to the Community in terms of its expectations, desires and needs. The air assessment focused on the effects of industrial air emissions on air quality and their associated health and environmental impacts on the Community of Fort McKay (Community) and the Community's Treaty Land Entitlement and Traditional Lands are considered.

The air quality issues of most interest to the community, and that were the specific focus of this air assessment, were:

- overall air quality deterioration and the possible related adverse health effects;
- odours, and
- potential adverse effects associated with acid deposition on regional vegetation and soils within Fort McKay's Treaty Land Entitlement and Traditional Lands.

The assessment criteria and impact significance rating was guided by Fort McKay's Healing the Earth Strategy (HTES) draft document. The HTES has air-related health impact criteria, odour criteria and "Keeping Clean Areas Clean" (KCAC) air quality

targets for air quality parameters in the Community. Fort McKay's expectation is that every reasonable effort will be made to reduce and control industrial air emissions so that air quality impacts in the Community and on its Traditional Lands are minimized. The HTES does not yet include criteria for parameters related to vegetation and ecosystem effects. Therefore vegetation impacts related to SO_2, NO_X, ozone, ammonia, nitrogen deposition and Potential Acid Input (PAI) were evaluated using regional, provincial and/or national or international criteria.

The air-related impacts associated with industrial development were assessed for five scenarios/cases which were:

- Pre-development,
- Current,
- Base Case,
- Application Case, and
- Planned Development Case.

This five scenario/case approach provided a comprehensive perspective on how industrial emissions have, are and will possibly affect air quality and quality of life and the environment in the Community and on Fort McKay's Traditional Lands.

A color-coded system was used to represent the significance of air quality issues under the five different assessment scenarios/cases (i.e., Pre-development, Current, Base, Application, and Planned Development). Issues with little or minor concerns were categorized as **green.** Issues that are possibly significant were classified as **yellow**. Lastly, issues that were significant and/or require immediate action were considered **red**.

A number of **red** and **yellow** issues and actual or potential impacts were identified. These are:

- ***Odours*** – there are currently significant odour problems and issues in the Community which will multiply with increasing development and this issue is a **red** situation requiring immediate action;
- ***SO_2*** – The periodic high releases of SO_2 in the region create the potential for SO_2 related air quality issues in Fort McKay and this is considered a **yellow** issue requiring further analysis. SO_2 impacts on vegetation are not considered an issue;
- ***NO_2/NOX*** – Regional NO_X emission are predicted to increase significantly in the future and some possible exceedences of Fort McKay's HTES health and KCAC air quality criteria for the Community are predicted and therefore this is considered a **yellow** issue. In terms of impact on vegetation there are potential direct effects

that are likely local in extent (**yellow**) under the Current and Base Case scenarios but there are likely direct effects local to regional in extent (**red**) in the Application and Planned Development scenarios;

- ***$PM_{2.5}$*** – Regional $PM_{2.5}$ emissions and $PM_{2.5}$ precursors (that result in secondary $PM_{2.5}$ formation) are predicted to increase in the future and some possible exceedences of Fort McKay's HTES health and KCAC air quality criteria for the Community are predicted and therefore this is considered a **yellow** issue;
- ***Ozone*** – Currently it appears that there are no vegetation-effect related issues with ozone (based on modelling) however some possible effects might occur under the Application and Planned Development cases (a **yellow** situation);
- ***NH_3*** - There are some uncertainties around the possibility and significance of NH_3 effects on vegetation at current regional levels (a **yellow** situation), and the potential effects of NH_3 in the Base, Application, and Planned Development cases are also uncertain (a **yellow** situation);
- ***PAI*** – no issues were identified in that CEMA Acid Deposition Management Framework is adequately addressing/managing this issue;
- ***Nitrogen Deposition*** – Potential effects associated with nitrogen deposition were identified under the Current Scenario and Base Case which are likely local to regional in extent in the Current and Base cases (a **yellow** situation), the likelihood of these effects extending to regional in scope is stronger in the Application and Planned Development cases (a **red** situation);

For each air quality parameter, recommendations related to the understanding and management of air quality issues were provided by Fort McKay. These recommendations are directed at better assessment tools for predicting impacts (e.g., improvements to air dispersion and deposition models) and better air emission controls (e.g., post-combustion emission controls on the larger NO_X sources). Regarding odours a detailed odour management strategy is outlined.

Based on this air assessment, it is Fort McKay's view that industrial development can occur without significant air-related health, environment and quality of life impacts but that this is only possible if more rigorous air emission control and management strategies are pursued. Under the current approach to air emissions management and air quality protection a number of potentially significant air-related impacts might occur. As noted in this assessment, the current problems with odours in the Community are an example of the type of issue that can occur in the absence of an overall air quality management in the region. Fort McKay believes that its Healing the Earth Strategy provides a framework for addressing air quality issues in the Community and in the region.

2.7 References

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