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Abbreviations

AAAQO	Alberta Ambient Air Quality Objectives
AADT	average annual daily traffic
ACFN	Athabasca Chipewyan First Nation
ADRP	Acid Deposition Research Program
AENV	Alberta Environment
Al-Pac	Alberta-Pacific Forest Industries Inc.
AI	Additional Information
BAF	bioaccumulation factor
BCF	bioconcentration factor
BMP	Best Management Practices
BOD	biochemical oxygen demand
CAC	Criteria Air Contaminant
CEMA	Cumulative Environmental Management Association
CNRL	Canadian Natural Resources Limited
CONRAD	Canadian Oil Sands Network for Research and Development
DFO	Fisheries and Oceans Canada
EIA	environmental impact assessment
EPL Subgroup	End Pit Lake Subgroup
FHOSP	Fort Hills Oil Sands Project
FMU	Forest Management Unit
HU	habitat unit
IFN	instream flow needs
ILM	integrated land management
JCR	Joslyn Creek Realignment
LSA	local study area

MCFN	Mikisew Cree First Nation
MFT	mature fine tailings
NFPL	Northland Forest Products Ltd.
NRBS	Northern River Basin Study
NWT	Northwest Territories
PAH	polycyclic aromatic hydrocarbon
PAI	Potential Acid Input
PDC	Planned Development Case
project	Joslyn North Mine Project
RAMP	Regional Aquatics Monitoring Program
RELAD	Regional Lagrangian Acid Deposition
RSA	regional study area
RWG	Reclamation Working Group
SAGD	steam-assisted gravity drainage
SEWG	Sustainable Ecosystem Working Group
SIR	Supplemental Information Request
TDS	total dissolved solids
TEPJ	Total E&P Joslyn Ltd.
TEK–TLU	traditional ecological knowledge and traditional land use
TSS	total suspended solids
TUa	acute toxicity units
TUc	chronic toxicity units
VOC	volatile organic compound

1.0 Cumulative Effects

Study Areas

Question 1

The regional study area for traditional land use is different than the regional study areas set for assessing cumulative effects on components such as fisheries and water quality.

Relying on available information, some of which is described in TOTAL's letter of September 12, 2008 and other information that can be made available, provide additional information on the traditional land use by the five Aboriginal Communities identified in Section D.12.3.1 of the application, the cumulative effects and their significance to traditional land use practise.

Provide an update of the status of the Traditional Ecological Knowledge Studies TOTAL has undertaken with the Mikisew Cree First Nation and the Athabasca Chipewyan First Nation, and if available provide copies of these studies.

Response:

Differences in Study Areas

The regional study area (RSA) for traditional land use defined in the 2006 Integrated Application, Volume 5, Consultant Report 12, Figure 1.3, is different than the RSAs defined for assessing cumulative effects on environmental components (see 2006 Integrated Application, Volume 2, Section C.6.2). However, the cumulative effects assessments have accounted for measurable changes to the receptors associated with each component arising from effects of the Joslyn North Mine Project (the project) combined with effects of other existing, approved and planned developments. By assessing the cumulative effects on the various environmental components in the 2006 Integrated Application, the 2007 SI Project Update and this Additional Information (AI) Project Update (AI Project Update, Section 14), the cumulative effects on traditional land use are considered to have also been assessed.

The study area boundaries used in the environmental assessments in the 2006 Integrated Application, the 2007 SI Project Update and the AI Project Update included all areas where measurable cumulative changes in the environment might be caused by the project combined with other developments. Specifically, the downstream limit of the RSA for fish and fish habitat (see AI Project Update, Section 14.8.2, Figure 14.8-1) includes the portion of the Athabasca River extending downstream from the vicinity of the project to the Embarras River. The RSA was established as the geographical extent in which project activities combined with other development activities had the potential to result in cumulative effects (both direct and indirect) on fish and fish habitat.

In determining the appropriate study boundary extent for fish and fish habitat, the study area limits for the hydrology assessment (see AI Project Update, Section 14.8, Table 14.8-1) and the surface water quality assessment (see AI Project Update, Section 14.11.3) were considered. As significant changes to water quality and hydrology were not predicted in the Athabasca River, the downstream limit of the RSA for fish was considered appropriate, and an extension of the RSA boundary farther downstream was unnecessary.

Several Supplemental Information Request (SIR) responses were provided to Alberta Environment (AENV) (see the responses to June 2007 AENV SIR 268 to SIR 273), further clarifying how the project, combined with other developments, might cumulatively affect surface water hydrology, water quality, ecological and socio-economic resources beyond the RSAs in the Peace–Athabasca Delta and Wood Buffalo National Park.

Responses were also provided to the Mikisew Cree First Nation (MCFN) Integrated Application Review Recommendations on Joslyn North Mine Project Joint Review Panel Canadian Environmental Assessment Agency Registry, which requested:

- further justification of the cumulative effects study areas – MCFN Integrated Application Review Recommendation 10
- clarification of how cumulative water quality contributions from all developments would comply with guidelines - MCFN Integrated Application Review Recommendation 24
- clarification as to whether the study area selected for fish would be representative of a broader regional context (MCFN Integrated Application Review Recommendation 51)

Additional Information on Traditional Land Use

Information sources that might be useful in regard to traditional land use of the Aboriginal groups affected by the project and the cumulative effects of development on traditional land use practices were reviewed. This review (see JRP AIR Appendix A) included the Cumulative Environmental Management Association's (CEMA) database on traditional environmental knowledge resources, community-based traditional land use and occupancy studies, and traditional knowledge components of applications for oil sands developments.

The 2006 Integrated Application and supporting documentation assessed the potential effects of the project, including any cumulative effects arising from other developments combined with the project, on Aboriginal groups in the area, their members and the current use of lands and resources for traditional purposes.

The 2006 Integrated Application established study areas for each environmental component that were subsequently used for the 2007 SI Project Update assessment and, with minor study area modifications identified, this assessment (see Section 14.1.2, Table 14.1-1).

For example, with respect to air quality, the RSA has a north–south extent of about 350 km and an east–west extent of 200 km. It extends north to near Fort Chipewyan and southward to near Conklin. It extends eastward about 25 km inside the Saskatchewan border. No significant cumulative air quality effects associated with the project are expected within or beyond the boundaries of the RSA. For assessments of air quality changes relevant to Aboriginal people or the current use of lands and resources for traditional purposes, see the 2006 Integrated Application, the 2007 SI Project Update and the AI Project Update.

With respect to other environmental components in the AI Project Update, again, study areas were established with a view to ensuring that any effects in a given environmental component were assessed, including:

- fish and fish habitat (see Section 14.4)
- soils and terrain (see Section 14.10)
- surface water quality (see Section 14.11)
- vegetation (see Section 14.13)
- wildlife (see Section 14.14)
- biodiversity (see Section 14.13 and Section 14.14)
- human health (see Section 14.7)
- groundwater (see Section 14.5)

For potential changes related to Aboriginal groups or the current use of lands and resources for traditional purposes, see the 2006 Integrated Application, the 2007 SI Project Update and the AI Project Update.

Status of Traditional Ecological Knowledge Studies

Total E&P Joslyn Ltd. (TEPJ) has provided funding to Aboriginal groups to undertake traditional ecological knowledge and traditional land use (TEK–TLU) studies.

TEPJ continues to work with MCFN to complete TEK–TLU studies. These TEK–TLU studies were originally to have been completed by September 2008. TEPJ was advised by MCFN on November 7, 2008 that their draft TEK report was being revisited in view of the broadened scope of inquiry requested by the Joint Review Panel. In June 2009, TEPJ was advised by MCFN that the target completion of their study would be November 2009.

TEPJ also continues to work with Athabasca Chipewyan First Nation (ACFN) to complete TEK–TLU studies. ACFN notified TEPJ in May 2009 that their study would be completed in fall 2009, but advised TEPJ in November 2009 that the study had not been started.

The Fort McMurray 468 First Nation published a traditional land use study in 2006 titled *Nistawayaw: Where Three Rivers Meet* and provided TEPJ with a copy in 2008.

TEPJ has also participated in joint-industry-funded traditional knowledge studies with Fort McMurray Elders' Society, Wood Buffalo Elders' Society and Fort McMurray Métis Local 1935. In 2008, the Wood Buffalo Elders Interview Project was completed and published as a consultant's report to the funding parties.

In 2008, TEPJ contributed funding to the Fort McMurray Métis Local 1935 project titled *Mark of the Métis*. The project effort included interviewing about 25 Elders from the area. TEPJ has not received a copy of this work, as Métis Local 1935 has stated the project is only in the first phase of completion.

2.0 Environmental Baseline Information

Question 2

Provide the Joint Review Panel with additional information on the pre-industrial (1965) baseline case. In particular, for key valued environmental components, provide information to allow a determination of the significance of any effects that may have already been experienced prior to the proposed project. Provide comments respecting the significance of effects, having regard for recognized thresholds (e.g., water quality and air quality).

In providing such information, focus on the following valued environmental components:

- **water quality and quantity**
- **air quality**
- **current use of lands and resources for traditional purposes by aboriginal persons**
- **wildlife and wildlife habitat for key species such as indicator and listed species (e.g., COSEWIC, SARA)**

Response:

Generally, the data required to assess pre-industrial (1965) conditions are limited for the requested environmental components. Assessment cases, as applied in the AI Project Update, represent cumulative industrial development scenarios, each of which, depending on the component being assessed, typically considers several snapshots in time. For example, an assessment case, depending on the component, might consider a snapshot representative of 2012 (pre-project), 2036 (operations), 2044 (closure) and 2144 (far-future). Therefore, a snapshot representing the environmental conditions in1965 (pre-oil sands development) for the requested valued environmental components has been considered. As a result, the terms pre-industrial reference condition, pre-industrial condition, pre-industrial period or pre-industrial are now used in the following response.

Water Quality

Three assessment locations are relevant to pre-industrial reference conditions for water quality in the Lower Athabasca River:

- Joslyn–Ells watersheds, in which the project would be located
- Lower Athabasca River
- acid-sensitive lakes

Joslyn–Ells Watersheds

For the pre-industrial reference conditions for water quality in the Joslyn–Ells watersheds, see the AI Project Update, Section 14.11.3., Table 14.11-1 and Table 14.11-2. The water quality data used to characterize pre-industrial conditions for the Joslyn–Ells watersheds span the period from 1976 to 2009 as watercourses in this basin have not been affected by existing or approved developments.

The results of modelling pre-industrial water quality constituents in Joslyn Creek indicate that several constituents naturally exceed water quality guidelines. Specifically, median concentrations of aluminum, chromium, iron, total nitrogen and total phosphorus exceed guidelines, as do peak values of arsenic, cadmium, copper, mercury, selenium, sulphide, total phenolics and zinc.

The results of modelling pre-industrial water quality constituents in the Ells River watershed indicate that several constituents naturally exceed water quality guidelines. In particular, median concentrations of aluminum and iron exceed guidelines, as do peak values of arsenic, cadmium, chromium, copper, lead, mercury, silver, sulphide, total nitrogen, total phenolics, total phosphorus and zinc.

In reference to the question of whether any significant water quality changes might have already been experienced before the proposed project in the Joslyn–Ells watersheds, because there have not been any previous oil sands development in this watershed and because the water quality guideline exceedances that are predicted to occur are unrelated to anthropogenic influences, it is likely that no significant changes have been experienced before the project.

The updated water quality assessment for Joslyn Creek, the Joslyn Creek Realignment (JCR) and the Ells River (see the AI Project Update, Section 14.11.3.1) indicates that the project will not cause significant changes to water quality or effects on aquatic health, consistent with the conclusions of the water quality assessments in the 2006 Integrated Application, Volume 2, Section D.11.4.1, and in the 2007 SI Project Update, Section 13.11.3.1.

Lower Athabasca River

Because the availability of water quality data for 1965 are limited for all constituents, two approaches were used for evaluating pre-industrial water quality in the Lower Athabasca River. The first approach qualitatively evaluated development upstream of Fort McMurray before oil sands development and the influence that this would have had on water quality in the Lower Athabasca River during the same period. The second, quantitative approach included modelling the Lower Athabasca River without oil sands development loading inputs.

Qualitative Evaluation

In 1965, before oil sands development, water quality in the Lower Athabasca River was influenced by the Hinton Kraft pulp mill (commissioned in 1957) and municipal sewage releases. Information from the Alberta government reported in the Northern River Basins Study (NRBS 1996a) shows that loading of biochemical oxygen-demanding constituents to the Athabasca River from the single pulp mill on the river in 1965 was in excess of 20,000 kg of biochemical oxygen demand (BOD) per day. This contrasts with a present-day total BOD loading from five pulp mills on the Athabasca River of less than 4000 kg/d. It is unlikely that dissolved oxygen concentrations in the river would have been significantly depressed in the Lower Athabasca River because of the aerating effect of the Grand Rapids upstream of Fort McMurray.

The pulp mill would also have discharged quantities of chlorinated organics, including dioxins and furans, before the use of elemental chlorine in the bleaching process was eliminated in the 1990s. However, water quality information on chlorinated organics for the Lower Athabasca River during 1965 is not available.

Water quality monitoring data collected upstream of Fort McMurray could be affected by a number of factors, including municipal and industrial (non-oil sands) developments. Natural conditions associated with surficial geology, interactions between surface water and groundwater, physical features of the waterbody and its drainage basin, local weather and seasonal hydrological changes and a number of other factors can also influence water quality. For example, many constituents can be tightly bound to suspended sediments from spring runoff, resulting in elevated concentrations of metals (e.g., aluminum, iron and manganese) and nutrients (e.g., total phosphorus) in surface water. Water quality constituent concentrations are often found to be above regulatory guidelines in remote areas that are not directly affected by human activities. In most cases, the forms of the constituents that are associated with high total suspended solids (TSS) have low bioavailability.

Quantitative Evaluation

Pre-industrial conditions in the Athabasca River were represented by modelling long-term constituent concentrations in the Lower Athabasca River and accounting for background constituent concentrations in the Clearwater and Athabasca rivers upstream of Fort McMurray, as well as input from natural tributaries. Thus, the pre-industrial conditions represented by the model include post-1965 contributions from developments upstream of Fort McMurray, including non-point source releases, pulp mills and sewage treatment plants. However, pulp mill and sewage releases generally contribute different constituents than those of oil sands operations, so present-day upstream concentrations can be considered representative of pre-industrial concentrations for constituents relevant to oil sands operations.

Modelling results for the pre-industrial reference condition for the Athabasca River (see the AI Project Update, Section 14.11.3.2, Table 14.11-4 and Table 14.11-5) indicate that peak concentrations of aluminum, arsenic, cadmium, chromium, copper, iron, lead, mercury, selenium, silver, total nitrogen, total phenolics, polycyclic aromatic hydrocarbons (PAH) Group 5, total phosphorus and zinc exceed chronic aquatic guidelines. These exceedances are common to, and occur in, both the Clearwater River, which is unaffected by pulp mill development, and the Athabasca River upstream of Fort McMurray. Also, most of these exceedances occur during open-water, high-flow periods when the dilution potential of the rivers is much higher than winter low-flow periods, when the influence of development would otherwise be clear. Therefore, it is reasonable to infer that the predicted exceedances occur naturally and are not from existing developments upstream of Fort McMurray.

Summary of Lower Athabasca River Pre-Industrial Water Quality

In summary, pre-industrial water quality conditions in the Lower Athabasca River would have been influenced by the Hinton pulp mill and by municipal sewage discharges. These sources would have influenced:

- dissolved oxygen levels upstream of the Grand Rapids, but not likely downstream in the Lower Athabasca River because of the aerating effect of the rapids
- chlorinated organics levels in the Lower Athabasca River, the extent to which has not been determined

Modelled pre-industrial water quality conditions using observed water quality upstream of Fort McMurray would be different from that in 1965. However, given that most oil sands constituents are generally different from those contributed by the aforementioned sources, the modelled pre-industrial conditions are likely a reasonable facsimile of the conditions during that period. Modelled pre-industrial conditions indicates that peak concentrations of several constituents exceed aquatic life guidelines in the Lower Athabasca River.

In reference to the question of whether any significant water quality changes might have already been experienced before the proposed project in the Lower Athabasca River, it is unlikely that there would have been any significant changes related to dissolved oxygen depression, an obvious water quality implication otherwise related to pulp mill and municipal releases, because of the aerating effect of the Grand Rapids upstream of Fort McMurray.

In reference to chlorinated organics, the other potential water quality constituent of concern before the elimination of elemental chlorine in the 1990s, an analysis of change in water quality is not provided for two reasons. The first is that no known water quality data on chlorinated organics for the Athabasca River are available. The second reason is that this consideration is unrelated to cumulative effects associated with potential oil sands development. Reference to the Northern

River Basin Study (NRBS 1996a) studies completed by the provincial and federal governments might provide additional insight.

A comparison of modelled pre-industrial conditions with predicted Application Case or Planned Development Case (PDC) water quality conditions (see the AI Project Update, Section 14.11.3, Table 14.11-4 and Table 14.11-5) indicates no new guideline exceedances, indicating little difference between pre-industrial water quality and predicted water quality in 2044 (closure) and in 2144 (far-future). The project and other developments are predicted to cause insignificant changes in water quality or effects on aquatic health in the Athabasca River, consistent with the conclusions of the water quality assessment in the 2006 Integrated Application, Volume 2, Section D.11.4.1 and Volume 5, Consulting Report 11, Table 5.31 and Table 5.34.

Acid-Sensitive Lakes

For pre-industrial estimates of potential acid input (PAI) for 34 acid-sensitive lakes monitored by the Regional Aquatics Monitoring Program (RAMP), see the AI Project Update, Section 14.11.3.2, Table 14.11-6. Only three lakes are projected to potentially become acidified under the Baseline Case compared with pre-industrial conditions and no additional lakes are projected to become acidified in the Application Case or the PDC.

RAMP has been monitoring these 34 lakes in the oil sands region annually since 1999. A statistical analysis of the data collected to date found no evidence to conclude there have been any significant changes in lake chemistry in the RAMP lakes over the monitoring period (RAMP 2009).

In reference to the question of whether any significant water quality changes might have already been experienced in RAMP-monitored acid-sensitive lakes before the proposed project, it is clear that acidified, or low pH lakes are not uncommon in the region. Because RAMP monitoring has not detected chemistry trends in these lakes over a 10-year monitoring period, it is likely that these lakes have not been significantly affected by anthropogenic activities before the project.

The project, combined with other developments, is not predicted to cause significant cumulative changes to the acidification potential of waterbodies (see the AI Project Update, Section 14.11.3.2) consistent with the conclusions of the water quality assessments in the 2007 SI Project Update, Section 13.11.3.2.

Surface Water Hydrology

Joslyn–Ells Watersheds

The hydrologic characteristics of the Joslyn–Ells watersheds estimated for the pre-industrial period are expected to be the same as those described for the Baseline Case for the revised project (see AI Project Update, Section 14.8.3.2). Flow data on the Ells River and Joslyn Creek used to characterize pre-industrial conditions was for the period 1976 to 1993. These watersheds were in their natural state during these years.

In reference to the question of whether any significant hydrologic changes might have already been experienced before the proposed project in the Joslyn–Ells watersheds, because there have not been previous oil sands development in this watershed and because hydrologic fluctuations are unrelated to anthropogenic influences, it is likely that no significant changes have been experienced before the project.

The updated hydrology assessment for the Ells River and Joslyn Creek indicates that the project will cause insignificant changes to flow (see the AI Project Update, Section 14.8.3.2), consistent with the conclusions of the 2007 SI Project Update, Section 13.7.3.1.

Lower Athabasca River

Flows have been recorded on the Athabasca River at Fort McMurray since 1957. Using flow data from 1957 to 2004, a mean annual flow of 644 m^3/s and a (March) 10-year, seven-day low flow (also commonly referred to as 7Q10) of 108 m^3/s for the Athabasca River at Fort McMurray was reported in the 2006 Integrated Application, Volume 2, Section D.7.2.3. Water withdrawals from the Athabasca River for oil sands mine operations have in the past been compared with these flow statistics. For the pre-industrial flows for the Athabasca River, see the AI Project Update, Section 14.8.3.2 and Table 14.8-3.

In 2007, Alberta Environment and Fisheries and Oceans Canada (DFO) implemented a water management framework for specific reaches of the Athabasca River based on a CEMA instream flow needs (IFN) assessment (AENV and DFO 2007). The framework provides a mechanism to address the effects of water withdrawals from the Athabasca River on the aquatic ecosystem.

The flow data used to develop the flow statistics, which were then used to develop withdrawal restriction criteria, span the same 1957 to 2004 period. This period was assumed to represent long-term pre-industrial conditions, and the corresponding flow statistics were used as benchmarks for assessing effects of water withdrawals on fish habitat.

The flow statistics from the 1957 to 2004 period account for long-term variability in hydrologic and climatic conditions (wet and dry cycles). The 1950s and 1960s were generally wetter than normal, whereas the 1990s and recent years have been generally drier than normal. For a recalculation of the flow statistics (mean annual flow and 7Q10) for the Athabasca River at Fort McMurray using data from different periods, see Table 2-1.

Table 2-1 Stream Flow Statistics for the Athabasca River at Fort McMurray

Data Period	Mean Annual Flow (m^3/s)[1]	7Q10 (m^3/s)[2]
1957 to 2004	644	108
1958 to 2007	629 [135]	102 [32.4]
1958 to 1975	676 [110]	109 [28.9]
1976 to 2007	602 [142]	97.8 [34.1]

NOTES:
[1] [ ] Standard deviation of annual flow series (m^3/s).
[2] [ ] Standard deviation of 7Q flow series (m^3/s).

The results show that the differences in mean annual flow or 7Q10 between 1957 to 2004 and the 1958 to 1975 series (wetter hydrologic conditions representative of the pre-industrial conditions), and between the 1957 to 2004 and the 1976 to 2007 series (drier hydrologic conditions), are small relative to the standard deviation of the annual flow and 7Q flow series (at most less than half) and are therefore well within the expected range of flow variability.

The use of a shorter 1958 to 1975 series to represent pre-industrial conditions, however, results in flow statistics that are biased toward wet conditions and do not reflect long-term hydrologic conditions.

Given that industrial water withdrawals from oil sands operations are downstream and do not influence the flow statistics of the Athabasca River at Fort McMurray, any anthropogenic changes in flow would have been from industrial and municipal withdrawals upstream of Fort McMurray.

These upstream influences would have increased over time since the start of the first pulp mill in Hinton in 1957, with subsequent pulp mills built and operated in the 1980s and 1990s (five in total), accompanied by increased agricultural and municipal growth during that same period. Much of this water withdrawal, however, is returned to the river system. The current average annualized net withdrawal rate for these upstream demands is less than 5 m^3/s. The change in flow statistics because of these demands, therefore, would be insignificant in the Lower Athabasca River.

In reference to the question of whether any significant hydrologic changes might have already been experienced before the proposed project in the Lower Athabasca River, given that the pre-industrial Athabasca River flows have been largely unaffected by anthropogenic influences, it is reasonable to assume that no significant effects would have been experienced before the project.

The updated hydrology assessment (see the AI Project Update, Section 14.8.3.3) for the Athabasca River shows that the project combined with other developments will cause insignificant cumulative changes to flows, consistent with the conclusions of the 2006 Integrated Application, Volume 2, Section D.7.4.3 and the 2007 SI Project Update, Section 13.7.3.4).

Air Quality

The approach to estimating pre-industrial conditions for air quality is based on the pre-industrial approach used in the Gulf Surmont environmental impact assessment (EIA) air quality assessment (Gulf 2001). The concentration estimates presented here, except where otherwise noted, are from the Surmont EIA, Technical Appendix 1, Section 2 (Gulf 2001).

Existing ambient air quality was inferred from observations and dispersion model predictions as there were no ambient air quality observations available in the Surmont air quality RSA. Specifically, observational data were reviewed to determine representative air quality associated with air flow into northern Alberta, the characterization of which represented pre-industrial northern boreal forest conditions. Representative pre-industrial northern Alberta boreal forest values were based on observations for similar pre-industrial areas. Three background air quality stations in western Canada largely provided this type of information:

- Acid Deposition Research Program (ADRP) Fortress Mountain site in southern Alberta – 1985 to 1987 (Legge and Krupa 1990)
- West Central Airshed Society Hightower Ridge site north of Hinton – 1996 (West Central Airshed Society 1997)
- Environment Canada station near Cree Lake, Saskatchewan – 1988 to 1995 (Shaw 1997, pers. comm.)

These areas were instrumented to measure low background concentration values. In comparison, the regional stations near Fort McMurray typically have a compliance monitoring functionality and are not instrumented to measure the lower concentration ranges.

For results of the Surmont pre-industrial air quality assessment for a range of gaseous and particulate nitrogen compounds, supplemented with more recent data on NO_X concentrations, see Table 2-2.

Table 2-2 Pre-Industrial Background NO_x, HNO_3, NH_4^+ and NO_3

Site	Gaseous NO_X (µg/m³)	Gaseous HNO_3 (ppm)	Gaseous HNO_3 (µg/m³)	Particle NH_4^+ (µg/m³)	Particle NO_3 (µg/m³)
Hightower Ridge (1996)[1]	0.21[4]	0.10	0.27	0.18[1]	0.09[1]
Fortress Mountain (1985 to 1987)[2]	NA	0.11	0.31	NA	0.13
Cree Lake (1988 to 1995)[3]	NA	0.06	0.15	0.20	0.05
SolvEx – Rural Wind Direction (1996 to 1997)	0.57[5]	NA	NA	NA	NA
Average	0.39	0.10	0.23	0.19	0.09

NOTES:
1 West Central Airshed Society (1997), Annual Report, Appendix 1.
2 Legge and Krupa (1990), p. 216.
3 Shaw, pers. comm. (1997)
4 October 2007 to October 2008 (from CASA data warehouse).
5 TrueNorth Energy (2002) Fort Hills Oil Sands Project (FHOSP) Environmental Baseline.
NA = Not available.

In the atmosphere, SO_2 gas can be converted into sulphate (SO_4^{2-}, a particle). For a summary of SO_2 and SO_4^{2-} background values representative of the air flow into the area, see Table 2-3.

Table 2-3 Pre-Industrial Background SO_2 and SO_4^{2-} Concentrations

Site	Gaseous SO_2 (ppm)	Gaseous SO_2 (µg/m³)	Particle SO_4^{2-} (µg/m³)
Hightower Ridge (1996)[1]	0.41	1.1	0.58
Fortress Mountain (1985 to 1987)[2]	0.51	1.4	0.51
Cree Lake (1988 to 1995)[3]	0.45	1.2	0.99
Average	0.46	1.2	0.69

NOTES:
1 West Central Airshed Society 1997, Annual Report, Appendix 1.
2 Legge and Krupa 1990, p. 216.
3 Shaw 1997, pers. comm.

Background CO concentrations in a pre-industrial boreal forest location (e.g., Cree Lake in Saskatchewan) are in the 115 to 230 µg/m³ range (Young et al. 1997).

The maximum 1-h average ozone concentrations observed at remote sites in Alberta were 133 µg/m³ (Hightower Ridge 1996) and 238 µg/m³ (Fortress Mountain 1985 to 1987). The mean ozone concentrations at these two sites were 74 and 84 µg/m³, respectively.

The total background PAI for the oil sands region was determined by Cheng (Cheng 2001, pers. comm.), who used Regional Lagrangian Acid Deposition (RELAD) to model emissions from communities but excluded industrial development. The model results are location-specific but generally range from a low of approximately 0.024 keq H^+/ha/a at the northern boundary of the study area to about 0.065 keq H^+/ha/a at the southern boundary (the values increase outside the study area south toward Cold Lake). For individually modelled pre-industrial PAI values for lakes, see the discussion in this response under Acid-Sensitive Lakes.

For a list of pre-industrial gaseous concentration estimates, see Table 2-4. All pre-industrial concentrations are very low compared with Alberta Ambient Air Quality Objectives (AAAQO).

Table 2-4 Pre-Industrial Gaseous Concentration Estimates

	NO_X (µg/m^3)	HNO_3 (µg/m^3)	SO_2 (µg/m^3)	CO (µg/m^3)	O_3 (µg/m^3)	CH_4 (µg/m^3)	Alkanes (µg/m^3)	Alkenes (µg/m^3)	Aromatics (µg/m^3)
Background	0.2 – 0.6	0.23	1.2	115 – 230	74 – 84	200	2.8 – 14.8	2.6 – 3.9	0.38
Alberta Air Quality Objective (1-h, 24-h, annual)	400 200 60	N/A	450 150 30	15,000 (1 h) 6000 (8 h)	160 (1 h)	N/A	N/A	N/A	N/A

NOTE:
N/A = Not applicable.

In reference to the question of whether any significant air quality changes might have already been experienced before the proposed project, given that the pre-industrial air quality was largely unaffected by anthropogenic influences, it is likely that no significant effects would have been experienced before the project.

The updated air quality assessment in the AI Project Update, Section 14.2.5, Table 14.2-11 shows that the project combined with other developments will not cause significant cumulative changes in air quality, consistent with the conclusions of the 2007 SI Project Update, Section 13.1.4, Table 13.1-11.

Traditional Land Use and Traditional Ecological Knowledge

Based on the extensive review of literature and information sources for this response (see JRP Appendix A), it was established that the Northern River Basins Study (NRBS 1996b) provides information with which to establish pre-industrial conditions for traditional land use by the Aboriginal communities in the region.

The NRBS was established on September 27, 1991 by the governments of Canada, Alberta and Northwest Territories (NWT) to examine how development has affected the Peace, Slave and Athabasca river basins in Alberta and the NWT. This broad, multi-year study was organized in a number of components, including contaminants, nutrients, food chain, drinking water, aquatic uses, hydrology/sediments and synthesis/modelling. It also included a comprehensive traditional knowledge report (NRBS 1996b), which represented an innovative advance in the way the knowledge of First Nations and Métis people living in the study area was sought and incorporated in study results. The authors of the NRBS recognized that effective involvement of First Nations and Métis peoples called for a different approach than does involving the general public. The final report for the project, submitted in 1996, included 16 synthesis reports and 150 technical reports.

The inclusion of a traditional knowledge study came about through the active involvement of Aboriginal residents of Fort Chipewyan and had the approval and support of the Treaty 8 Grand Council. Ten Aboriginal communities were involved in the study: Fort Smith and Fort Fitzgerald, Little Red River First Nations (Jean D'Or, Garden River and Fox Lake), Tall Cree First Nation, Fort Vermillion, Fort Chipewyan, Fort Resolution and Fort McMurray.

The traditional knowledge report consisted of three components:

- personal interviews with Aboriginal people
- completion of an extensive survey
- development of a unique database of archival records that describe the conditions of the river basins (including the Athabasca River) before modern records were kept

A separate report, addressing the topics of land, water, wildlife and fish, health, family and community relationships, traditional knowledge, future expectations and recommendations, was prepared for each community. The Fort Chipewyan report included 29 interviews with Elders and knowledge holders (23 Elder interviews were completed).

The archival subproject, in the traditional knowledge study, included information on the state of the environment before major development, a list of TEK information resources, abstracts of TEK of a biophysical nature contained in individual documents and records of specific information that document the influence of development on ecological systems previously subject to natural influences (NRBS 1996b).

Wildlife

Pre-industrial conditions were created for the RSA by replacing all visible surface disturbances on the landscape with probable original vegetation types that would have occupied the disturbance, had it not occurred (see the AI Project Update, Appendix K, Table K1-1 to Table K1-3). Major industrial developments removed from the landscape included Suncor Millennium, Syncrude Mildred Lake, Suncor (formerly) Petro-Canada UTF (Devon Dover), Petro-Canada MacKay River and MacKay River Expansion, Canadian Natural Resources Limited (CNRL) Horizon and TEPJ Joslyn SAGD Project Phase I and Phase 2. In addition, all other disturbances were removed, including Highway 63, seismic lines, trails, transmission lines, pipeline rights-of-way, cutblocks, municipalities, borrow sites, roads and wellsites.

Where available, pre-industrial baseline mapping information was used to assign vegetation types to landscape disturbances. Where such information was not available, pre-industrial conditions were approximated, based on natural vegetation and biophysical conditions in immediately adjacent undisturbed areas. The resulting vegetation data were used to estimate pre-industrial habitat availability, expressed as habitat units (HUs), for all VEC species included in the wildlife assessment (see the AI Project Update, Section 14.14.3).

A summary of the model results for pre-industrial conditions in the RSA was compared with habitat availability in the Baseline Case (see Table 2-5). Effects from cumulative Baseline Case disturbances were rated for significance based on the likelihood that these disturbances have contributed to the long-term or irreversible loss of wildlife diversity in the RSA.

A comparison of model results (see Table 2-5) shows that differences between pre-industrial conditions and the Baseline Case vary by VEC. Baseline Case disturbances have reduced available habitat in the RSA for Canadian toad, mixedwood forest birds, waterfowl, great grey owl, ruffed grouse, beaver, snowshoe hare and lynx by less than 20%.

These disturbances have reduced habitat in the RSA for old-growth forest birds, yellow rail, northern goshawk, fisher and black bear by 20 to 25% and for moose by 32.7%. The higher predicted loss for moose is largely a function of the more extensive disturbance buffers assigned to land disturbance features in the moose model. Potential habitat values were reduced within these disturbance buffers to reflect the potential adverse effects of sensory disturbance on wildlife use of these areas.

Although the distribution and abundance of some species in the RSA have undoubtedly changed with Baseline Case disturbances, more than 66% of pre-industrial habitat remains in the RSA for all assessed species, and it is unlikely that the RSA has experienced a loss of wildlife diversity. Populations have persisted and continued to use development areas and adjacent areas, as shown by the baseline field results and monitoring studies for various developments in the RSA (see the AI Project Update, Section 14.14.3 and Appendix L2, the 2006 Integrated Application, Volume 2, Section D.14 and Volume 5, Consultant Report 14). Therefore, cumulative Baseline Case disturbance to-date is not considered significant.

Table 2-5 Habitat Availability for Wildlife VECs in the RSA

Valued Ecosystem Component	Pre-Industrial Conditions (HU)	Baseline Case (HU)	Change (HU)	Percent Change (%)
Moose	206,610	139,135	-67,475	-32.7
Black bear	233,566	176,067	-57,499	-24.6
Fisher	170,356	128,541	-41,815	-24.5
Lynx	229,799	188,428	-41,371	-18.0
Snowshoe hare	228,413	193,277	-35,135	-15.4
Beaver	256,535	219,758	-36,777	-14.3
Ruffed grouse	151,118	124,763	-26,355	-17.4
Northern goshawk	151,795	114,957	-36,838	-24.3
Great gray owl	151,523	124,467	-27,056	-17.9
Yellow rail	6,613	5,248	-1,365	-20.6
Waterfowl	190,952	163,029	-27,923	-14.6
Mixedwood forest birds	132,938	107,651	-25,287	-19.0
Old-growth forest birds	132,310	101,476	-30,834	-23.3
Canadian toad	228,254	192,659	-35,595	-15.6

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3.0 Other Actions To Be Considered

Question 3

The Joint Review Panel understands that since the application was filed in 2005 several other projects and activities in the area have been proposed and are now in the application process. Include all operating, approved, and applied for in situ, oil sands mineable projects and other projects such as quarries.

Provide a summary of recently proposed projects not currently included in Total's cumulative effects assessment that may result in effects that combine with the effects of the proposed Project.

In providing such information, focus on the following valued environmental components:

- **water quality and quantity**
- **air quality**
- **current use of lands and resources for traditional purposes by aboriginal persons**
- **wildlife and wildlife habitat for key species such as indicator and listed species (e.g., COSEWIC, SARA)**

Response:

New developments that have been added to the PDC or developments that have been approved and moved to the Baseline Case since the 2007 SI Project Update environmental assessment are summarized in the developments inclusion list for each environmental component (see the AI Project Update, Section 14.1.2.3, Table 14.1-2).

Effects from these new developments and the revised assessment cases are described in each of the environmental component assessments (see the AI Project Update, Section 14). Specifically, in response to this question, the following assessments were undertaken:

- water quality - AI Project Update, Section 14.11.3
- air quality - AI Project Update, Section 14.2.3
- traditional environmental knowledge and land use - AI Project Update, Section 14.12
- wildlife - AI Project Update, Section 14.14.3

For a summary of these assessments and the other component assessments, see the AI Project Update, Section 14.19.

For many environmental component assessments, as appropriate, several new enhancements in the approaches and methods were incorporated (see the AI Project Update, Section 14.1.1.4, Table 14.1-3). For a comparison of the significance ratings for each component assessed in the 2007 SI Project Update and the AI Project Update, see Section 14.19.19, Table 14.19-1. The updated cumulative effects assessments indicate that the project combined with other developments will cause insignificant cumulative effects for all VECs and indicators.

Question 4

Provide available information on the potential effects of ongoing and future activities such as forestry, vehicle traffic increases, and hunting and poaching in combination with those of the proposed project. Focus the analysis on the following valued environmental components:

- **water quality and quantity**
- **air quality**
- **current use of lands and resources for traditional purposes by aboriginal persons**
- **wildlife and wildlife habitat for key species such as indicator and listed species (e.g., COSEWIC, SARA)**

For example:

- **Section D.18.2 of the application notes that Al-Pac forestry operations are projected to have an annual allowable cut of nearly 4.4Mm^3 within the regional study area. In the next decade Al-Pac expects that approximately 40,000 ha of productive forest land in their forest management unit will be affected by oil sands operations (D.18.5). Please indicate how additional harvesting of forest resources would combine with the effects of the proposed project for impacts to vegetation, wildlife and biodiversity.**
- **Section D.9.4.1 of the Application notes an expected increase in the traffic in Fort McKay from 350 to 2889 vehicles per day by 2014 (p D.96). Indicate how the increase in traffic along major and minor roadways may affect wildlife populations as a result of increased wildlife-vehicle collisions. Also indicate the effects additional noise, dust and human interactions may have on wildlife.**
- **Section D.12.7 of the Application notes that "in addition to having to accommodate oil and gas development and forestry companies, Fort McKay trappers and hunters compete with bear hunters in the spring and moose and deer hunters in the fall". Indicate the effects of increased hunting on wildlife populations in combination with the effects of other projects and activities.**

Response:

The potential cumulative effects of the project combined with other land use activities such as other oil sands operations, forestry, and utilities have been assessed for a number of VECs at the local and regional scale in the environmental assessment in the 2006 Integrated Application, in the 2007 SI Project Update and the AI Project Update. For a description of the developments and land use activities considered in the cumulative effects assessments, see the AI Project Update, Section 14.1.1.3, Table 14.1-2.

The project is in Forest Management Unit (FMU) 15 of Al-Pac's Forest Management Agreement (FMA) area. As one of the primary ecosystem management tools recommended by CEMA's Sustainable Ecosystem Working Group (SEWG), an integrated land management (ILM) approach with Alberta-Pacific Forest Industries Inc. (Al-Pac) and Northland Forest Products Ltd. (NFPL) has been initiated. This approach will integrate the clearing requirements of the project with the annual allowable harvesting needs of the forestry companies to reduce the cumulative footprint of the three parties in FMU 15. It is anticipated that timber from the Joslyn Lease area will largely satisfy timber supply requirements from FMU 15 for the next decade. As a result, new disturbances associated with timber harvest in FMU 15 will be minimized outside the Joslyn Lease area, reducing cumulative pressures and effects on traditionally used resources and land in the region.

Roads and utility corridors are being shared with other operators in the area to reduce linear corridor densities in the region. For example, the existing CNRL road will be used to access the project.

Water Quality

Forest clearing has been shown to result in increased stream temperatures, specifically during summer (Teti 1998). One study suggested that large-scale canopy clearing results in warmer shallow groundwater, potentially resulting in stream warming (Hewlett and Forston 1982). However, in a comprehensive review of the available literature, Teti (1998) suggested that effects of forest clearing on stream temperature are primarily related to the loss of riparian vegetation.

The permanent JCR will be constructed with a minimum necessary disturbance to riparian vegetation, and will include riparian revegetation as necessary. Consequently, the potential effects on stream temperature associated with riparian clearing will be mitigated.

The natural temperature regime of Joslyn Creek is influenced by the ponding effect of beaver activity. Summer temperatures in any given year are variable, depending on the amount of beaver activity at the time. The temperature regime in the JCR will continue to be influenced by beaver activity. The proposed realignment and closure drainage plan are expected to maintain a water temperature regime appropriate for cool-water fish species.

Once dewatering has begun, drainage is routed through release water ponds, which serve to remove the majority of eroded sediment. Release water ponds do not appreciably alter the receiving water temperature regimes. Water temperature measurements in active release water ponds at the Muskeg River Mine and in the Muskeg River upstream of that mine indicated that water temperatures tended to be similar to ambient conditions in the Muskeg River (Shell 2007).

In addition, data collected by RAMP indicated that water temperature upstream of Syncrude Aurora North, upstream of the Muskeg River Mine and downstream of both facilities was virtually identical through 1999 and 2000 (Golder 2000, 2001).

When dewatering is completed for various developments, the entire area to be developed is closed-circuited in preparation for mining, and rainwater falling in this area is used in the process. During reclamation, all previously closed-circuited areas are routed through constructed wetlands and pit lakes before reaching receiving streams. Sedimentation from erosion is minimized through reclamation practices and trapping of particles in the wetlands and pit lakes.

The potential for forest clearing for the project to affect stream temperatures is considered minimal. Joslyn Creek will be permanently realigned from the mine area and will receive little drainage from cleared areas. Drainage from the mine area (cleared area) will enter the Ells River via the remaining Joslyn Creek channel during operations and before full closed-circuiting of the project area. At project closure, the release volume from the pit lake will be low, and will not appreciably affect the temperature regime of the Ells River.

The potential for increased erosion from forest clearing will be addressed by implementing the surface water management plan described in the AI Project Update, Section 8, and the mine reclamation plan (see Section 11). Mine closure will include grading and recontouring the reclamation landscape for slope stability, replacing coversoil and revegetation to provide erosion-resistant plant cover.

Therefore, the project and other oil sands developments are mitigating erosion and temperature changes.

Surface Water Hydrology

Forest harvest activities and linear developments, such as roads, have the potential to alter normal hydrologic processes such as snowpack distribution, evapotranspiration and infiltration. The result is a potential increase in water yield after harvesting, generally peaking the first year following clearcutting (depending on climatic variability) and gradually decreasing to natural yields over time if the cut areas are allowed to revegetate. Flood flows might also increase in the short-term. In addition, harvested areas and areas with access roads can be subject to various forms of erosion, thereby increasing suspended sediment concentrations in receiving streams.

The hydrologic effects of forest activities and linear developments are mitigated through the use of Best Management Practices (BMPs). The BMPs include:

- maintaining undisturbed vegetation in buffer strips along streams
- constructing sediment traps
- designing road alignments that conform with terrain topography

The updated assessment (see the AI Project Update, Section 14.8.3) indicates that changes in stream flows in the Joslyn–Ells watercourses resulting from the revised project remain insignificant, consistent with the conclusion of the hydrology assessment for the 2007 SI Project Update, Section 13.7.3.1 and Section 13.7.3.2.

Air Quality

The effects of future vehicle traffic increases were explicitly included in the modelling for the air quality assessment described in the AI Project Update, Section 14.2.3. It is assumed for the PDC that highway emission rates of criteria air contaminants (CACs), volatile organic compounds (VOCs) and PAHs will increase at a rate of 3% per year for 25 years (i.e., 2.1 times the emissions from Baseline Case rates). Increasing emission rates were also assumed for communities to account for future emission increases from transportation, residential and commercial sources in the various communities. These increases in emission rates varied from 1.9 times (Fort McMurray) to 10.4 times (Fort McKay) over their corresponding Baseline Case emission rates.

Traditional Land and Resource Use

The project will be located on lands that have been traditionally used and continue to be used for hunting, trapping and plant-gathering activities. Project activities will alter natural biophysical conditions and will reduce traditional land use opportunities in the project development area (PDA) for much of the mine life. Such effects will act cumulatively with other mine operations and resource activities to reduce the land base available for tradition land use activities, but this reduction in land base will not be permanent. Mine closure plans will develop terrain, soil and moisture conditions that will support the re-establishment of native vegetation community diversity and sustainable wildlife habitat. The re-establishment of natural communities and wildlife capability will be accelerated where possible through direct upland soil and LFH transplants, where native soil material infused with a viable native seed bank will be used as the coversoil for reclaimed sites. First Nations will be consulted throughout the life of the mine to incorporate traditional land use needs into progressive reclamation and final closure planning.

Outside the PDA, project activities are expected to contribute little to cumulative effects on traditional land use activities such as hunting. The existing CNRL road will be used to access the project. Though traffic volumes on the road might increase as a result of the project, this road is already a heavily travelled corridor that wildlife has likely adapted to, and likely avoid to some degree. In addition, project personnel will be prohibited from hunting and possessing firearms in the project area. Consequently, the project is not expected to affect hunting pressures or patterns outside the PDA that could affect traditional hunting interests.

For a description of direct mortality risk for wildlife VEC indicators in the RSA for Baseline Case, Application Case and PDC, see the AI Project Update, Section 14.14.3, Table 14.14-3. In summary, because traffic volume increases are expected to be small, direct mortality risks to black bear and moose resulting from the project remain insignificant, consistent with the conclusions of the 2007 SI Project Update, Section 13.14.3.4.

As presented previously, forestry interests are being considered to reduce the collective footprint of all activities in the region, by integrating the clearing requirements of the project with the annual allowable harvesting plans of forestry companies. This will reduce cumulative pressures on traditionally used lands outside the PDA.

Wildlife and Wildlife Habitat

Loss of Habitat Availability

The development of the project will result in clearing and surface disturbance of 6980 ha (473 ha more than was proposed in the 2007 SI Project Update, Section 13.14.3.1). This equates to a reversible although relatively long-term habitat loss for wildlife species that occupy or could potentially occupy the habitat currently present in the area. This loss has been quantified for all VEC species (see the AI Project Update, Section 14.14.3.1).

Project contributions to changes in habitat values will be cumulative with habitat alterations associated with other land use activities, such as forestry. The assessment described in AI Project Update Section 14.14.3.1 includes the effects of all existing and approved developments, the project and all planned developments on habitat values for VEC species in the local study area (LSA) and RSA. For the developments and land use activities included in the cumulative effects assessment, see the developments inclusion list in the AI Project Update, Section 14.1.1.3, Table 14.1-2.

Forestry operations primarily shift the structural stage of vegetation communities without appreciably altering the basic terrain, nutrient (soils) and moisture regimes and vegetation successional patterns characteristic of the ecosite. Conversely, mining activity and subsequent closure planning results in the removal and reconstruction of soils and surficial terrain features, altering the distribution of ecological conditions across the PDA, relative to pre-industrial conditions. Collectively, forestry and mining can cause large scale and long-term changes in the ability of the land to support the natural diversity of habitats and wildlife.

To reduce effects on wildlife and wildlife habitat, the project's closure plans are designed to develop terrain, soil and moisture conditions that will support the re-establishment of native vegetation community diversity and sustainable wildlife habitat (see the AI Project Update, Section 11.3.4 and Section 11.3.5). In addition, re-establishment of natural communities and subsequent wildlife habitat capability will be accelerated where possible through direct upland soil and LFH transplants, where native soil material containing a viable native seed bank will be used as the cover soil for reclaimed sites.

Forestry and other oil sands operators' interests are being considered relative to ILM strategies to reduce the collective land use footprint in the region, by sharing utility corridors and integrating the clearing requirements of the project with the annual allowable harvesting plans of forestry companies. This will reduce the cumulative effects from developments and forestry activities on habitat values for wildlife in the RSA.

Traffic Effects on Wildlife

High-use roads and highways which encounter wildlife habitat are frequently a source of vehicle and wildlife collisions and associated wildlife mortality. Divided highways with large traffic volumes, greater than or equal to 10,000 average annual daily traffic (AADT) or more, often act as sources of mortality. Roads with relatively low traffic volumes (e.g., 5 to 100 vehicles per day) are less frequently associated with wildlife collisions (Beringer et al. 1990; Forman et al. 2003). It is generally accepted that wildlife mortality rates associated with roads increase with traffic volumes.

For a description of the direct mortality risk for black bear and moose in terms of current traffic levels and wildlife mortalities, see the AI Project Update, Section 14.14.3.3. Based on estimated correlations between traffic volume and moose collisions on Highway 63 north of Fort McMurray, approximately 0.3 additional moose and approximately 0.1 additional black bear collisions per year might result from the increased maximum traffic loads from the project. Because traffic volume increases are expected to be small, project direct mortality risks to black bear and moose will remain insignificant, consistent with the conclusions of the 2007 SI Project Update, Section 13.14.3.4.

Given the primary distribution of project traffic and the known distribution of key wildlife ranges in the area, it is highly probable that project-related mortalities will involve more common species in the area with stable populations (e.g., deer), rather than species at risk such as caribou, where the loss of one or more additional animals annually could have measurable implications on herd sustainability.

A number of measures to reduce the potential for vehicle-wildlife collisions involving project vehicles will be implemented. North of Fort McKay to the project, reduced speed limits will be established for all traffic. Brushing and other vegetation management measures along road shoulders will be designed to provide sufficient field of vision to react to wildlife on or entering the roadway and eliminate attractive wildlife forage close to the road edge. Wildlife-vehicle near-misses and encounters will be tracked throughout the life of the project, and resulting information will be used to reduce speeds and warn drivers of wildlife hazards in problematic areas. With such measures, the increased traffic loads associated with the project are not expected to measurably affect wildlife populations in the area.

Effects of Industrial Noise on Wildlife

The response of wildlife to noise associated with traffic and other industrial activities is highly species and setting specific. The frequency and intensity of industrial noise, such as traffic, can disturb songbirds (Slabbekoorn and Peet 2003; Habib et al. 2007). Chronic noise can limit the ability of birds to communicate vocally, potentially leading to reduced territory defence (Brumm 2004) and pairing success (Habib et al. 2007; Swaddle and Page 2007). Noise could be one reason that many mammal species avoid high-use anthropogenic disturbances (SCL 2008). For a review of the effects of various types of human disturbance for each VEC species, see the AI Project Update, Appendix L2.

To accommodate the uncertainties of noise effects on wildlife, the wildlife assessment (see the AI Project Update, Section 14.14.3.4) used predictive models to assess core security habitat associated with the project and cumulative habitat loss that recognized buffers of reduced habitat suitability around the boundaries of disturbances on the landscape. Although these zones of influence contain intact native vegetation conditions, lower habitat values were assigned to reflect the level of sensory disturbance in the areas, and to reflect their lower wildlife habitat effectiveness. Consequently, the assessment has accounted for the effects of both direct alteration from industrial footprints, and indirect habitat loss from sensory disturbance.

In summary, the updated cumulative effects assessment (see the AI Project Update, Section 14.14.3.4) indicates that because there will be sufficient core security habitat in the RSA to sustain viable populations of Canada lynx, black bear and moose, effects on habitat availability for these species in the RSA under a worst-case cumulative effects scenario resulting from the project combined with other developments will remain insignificant, consistent with the conclusions of the wildlife assessment in the 2007 SI Project Update, Section 13.14.3.4.

Effects of Dust on Wildlife

There is potential for airborne dust and dust deposition to affect wildlife health when wildlife regularly inhale dust, or where dust settles on forage plants and is ingested regularly by wildlife. In a worst-case scenario, health implications could include respiratory problems, metal ingestion and accelerated tooth wear.

Dust can be generated during high wind events from unreclaimed external tailings ponds, where unvegetated, beached sands and fines can be picked up by wind and deposited offsite. Such occurrences are commonly observed at active mines, and, under certain wind conditions, dust particles can be deposited a considerable distance from the active mine site. These events have a greater probability of reaching habitats used by wildlife, although no known studies have been undertaken to assess potential effects.

Dust could also be generated from nonpaved or nonsealed roads associated with other components of the mine site (e.g., project camp). The effects of dust from traffic could have on wildlife depend on the volume of material transferred to occupied habitats offsite. The 2006 Integrated Application, Volume 5, Consultant Report 13, Section 2.3 indicated that effects from dust on vegetation have been detected up to 400 m on either side of roads, with the majority of effects occurring within 100 m. From a traffic safety perspective, dust suppressants will be used on more heavily travelled roads and mine haul roads. Chronic dust will largely be limited to secondary and tertiary roads with lower traffic loads. Such events are unlikely to have measurable effects on vegetation or wildlife health.

Effects of Human Interactions with Wildlife

The potential for major adverse interactions between project personnel and wildlife will be limited. The project, as development progresses, will not provide attractive habitats for wildlife, and BMPs will be implemented for the project camp and other facilities to ensure that such areas do not become attractive to wildlife species, such as black bears. All personnel will also receive bear awareness training as part of the project's overall environmental orientation program.

The majority of the construction staff will commute to the site and not pursue outdoor recreational activities in the region. Project personnel will not be permitted to have firearms or pets onsite and hunting will be prohibited. In addition, as discussed previously, the existing CNRL road will be used to access the project. Consequently, the project is not expected to create new recreational opportunities or influence recreational distribution patterns in areas not already accessible to the public.

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4.0 Accidents and Malfunctions

Question 5

Provide information on the probability of potential accidents and malfunctions related to the proposed project, including the potential consequences and environmental effects related to such events.

Potential accidents and malfunctions may include those associated with the following components:

- **tailings structure failure**
- **wildlife deterrent systems (e.g., birds)**
- **a major tailings spill to such watercourses as the Ells River and Athabasca River under low flow, ice and spring flood conditions**
- **waste management and disposal**
- **use, handling or spills of fuels, chemicals and hazardous materials onsite**
- **the increase in road traffic, and the risk of road accidents**
- **potential effects of accidents from nearby SAGD wells and mining operations, particularly with respect to the proximity to Pond 1**
- **breach of site security**
- **any other project components or systems that have the potential, through accident or malfunction, to adversely affect public safety or the environment**

Consider the sensitive elements of the environment (e.g., communities, homes, natural sites of interest, areas of major use) that may be affected in the event of an accident or a major malfunction. Consider the likelihood of occurrence and potential consequences of the accidents and malfunctions.

Provide information on plans, measures and systems to reduce the potential occurrence of an accident or malfunction. Indicate how these plans will reduce the effects or consequences of an accident or malfunction.

Response:

Following is a summary of potential project accidents and malfunctions and a qualitative evaluation, unless otherwise noted, of their likelihood and potential consequences. The summary also includes design and mitigation measures that have been incorporated or proposed to lessen or eliminate their occurrence and associated consequences.

For further information on potential accidents and malfunctions associated with other project components, see JRP AIR Appendix B.

Tailings Dyke Failure

The external tailings areas (Pond 1, DDA 1 and SBA 1) dykes (see the AI Project Update, Section 3, Figure 3.3-2, Figure 3.4-1 and Figure 3.4-6) are designed conservatively, in accordance with Canadian Dam Association *Dam Safety Guidelines*. These tailings areas will be operated in accordance with proven practices and an observational approach to stability management will be used during construction and operations. Failure of a tailings area could occur as a result of inadequate strength of the foundation or dyke construction materials, seepage, erosion or overtopping. A catastrophic failure of the external tailings dyke could result in a release of tailings to the surrounding area which, depending on failure location, could include the JCR channel (see the AI Project Update, Section 8.4) and associated drainage features. However, given the conservative approach to tailings dyke design, the likelihood of failure of a tailings area is remote. For further information on potential accidents and malfunctions associated with tailings structure failure, see JRP AIR Appendix B, Section B2.2.

Wildlife Deterrent Systems

The potential for wildlife interactions with tailings areas will be managed through implementation of various land-based and floating deterrent systems such as propane cannons, lights and mechanical devices, possibly combined with radar detection. Previous incidents have shown that the consequences of waterfowl interaction with tailings areas can be significant, with a large number of birds potentially affected by contact with bitumen and other substances. The above measures are expected to minimize the likelihood of adverse encounters; however, bird recovery and treatment plans will also be implemented. For further information on wildlife deterrent systems, see JRP AIR Appendix B, Section B7.2.

Major Tailings Water Spill to Watercourses

A tailings water spill could occur as a result of failure of an external dyke or a tailings pipeline. The likelihood of a dyke failure is remote. Although it is unlikely, a rupture of a tailings line would be the most probable worst-case release of tailings water. Any major tailings line rupture would be detected by a pressure drop and the line would be shut down within two hours. Given the presence of the landform berm along the east side of the JCR, such a release would have to occur in the northwest portion of the Pond 1 (see JRP AIR Attachment B1, Figure B1-1) area to reach the channel and any associated drainage features. Modelling was done to predict the potential consequences of such a release.

Chronic toxicity levels, dilution ratios and travel times for a spill originating from a modelled tailings water pipeline break in the northwest portion of the site were modelled for three receiving-stream flow scenarios at various locations along the JCR, the Ells River and the Athabasca River. The modelled spill scenario considered a tailings line rupture that resulted in 3400 m^3 of tailings water reaching the JCR before it is detected and stopped. After dilution of such a spill with the wetland upstream of the compensation lake, a tailings water spill of this magnitude would not significantly affect aquatic life in the fish habitat compensation lake or downstream in the JCR, the Ells River or the Athabasca River.

For modelling results, see JRP AIR Appendix B, Section B2.9. For further information on potential tailings releases, see JRP AIR Appendix B, Section B2.2.

Waste Management and Disposal

Waste generation will be minimized by reduction and recycling practices. Nonhazardous solid and liquid waste will be disposed of in an onsite Class II/III landfill. Hazardous waste will be collected and stored onsite at a transfer facility pending shipment to an approved offsite facility. Landfills will be sited, designed, constructed and operated in accordance with applicable regulatory requirements to minimize any release of leachate or other waste. Storage and transfer facilities will include appropriately designed containment systems. Spill contingency and response plans and soil and groundwater monitoring will also be implemented. For further information on waste management, see the AI Project Update, Section 10.4. For further information on potential accidents and malfunctions associated with waste management and disposal, see JRP AIR Appendix B, Section B4.1.

Onsite Use, Handling or Spills of Fuels, Chemicals and Hazardous Materials

Substances are stored, handled and transported onsite, including hydrocarbons (bitumen and diluent), solvent, tailings, flocculants, coolants, lubricants and motor fuels. Spills or releases could occur because of failure of tanks, pipelines and other storage components. All storage facilities will be designed and constructed with adequate containment systems and, where appropriate, leak detection systems, and will be operated in accordance with applicable regulatory guidelines. An oil spill contingency plan and site-specific emergency response plan will be implemented to ensure prompt detection and recovery of any spills or releases. Soil and groundwater monitoring will facilitate detection of any substances entering the subsurface. For further information on potential accidents and malfunctions associated with spills of chemicals or hazardous materials, see JRP AIR Appendix B, Section B5.1.

Increased Road Traffic and Risk of Road Accidents

A number of planning and mitigation measures are proposed to reduce the risk of accidents associated with increased road traffic. These include physical separation of project and highway traffic, use of a camp-based operation, improvement of highway intersections at the plant and community access points and investigation of alternative methods (other than by road) for transporting fuel and solvent. For further information on potential for traffic accidents, see JRP AIR Appendix B, Section B6.1.

Potential Effects Arising from Proximity of SAGD and Mining Operations

The steam-assisted gravity drainage (SAGD) operations are suspended. Geotechnical offsets between the SAGD area and the external tailings area are based on an operating SAGD project, and are therefore conservative. Though steam migration and release from SAGD operations have the potential to affect tailings dyke stability, either through an increase in foundation pore pressures or through crater formation, these considerations will not arise as long as SAGD operations are suspended. For further information on the potential accidents and malfunctions associated with interaction with SAGD and project operations, see JRP AIR Appendix B, Section B7.4.

Breach of Site Security

The potential exists for trespassers to encroach on the project and operations areas, possibly resulting in personal injury or property damage or, in an extreme scenario (e.g., wilful damage) release of substances to the environment. A number of security measures, including warning signs, video surveillance, security patrols and perimeter checks will be implemented. In addition, the plant site and other key facilities will be fenced and gated. Designated safe passage routes for hunters through portions of the lease will be identified. The potential consequences of a security breach include personal injury, property damage or, in an extreme scenario, release of substances to the environment. However, the planned security measures will minimize the likelihood of unauthorized access to the site and any resultant health or environmental impacts. For further information potential accidents and malfunctions associated with a breach of site security, see JRP AIR Appendix B, Section B7.3.

Other Project Components

Potential accidents and malfunctions that might be associated with other project components include process accidents or malfunctions (see JRP AIR Appendix B, Section B7.1). The main potential process malfunction of concern would be failure of the solvent recovery system or related upset in the froth treatment system. Such an upset would lead to the release of greater than planned solvent volume to Pond 1 and Pond 2 and could create a fire risk in the presence of an ignition source. Mitigation measures include monitoring of solvent levels in the tailings stream and at the pond surfaces and suspension of production in the event of a greater than acceptable solvent release. The unplanned release of additional solvent to the pond is not expected to result in significant public health or environmental consequences.

5.0 Process-Affected Water

Question 6

Discuss the level of naphthenic acids in end pit lake water that creates a direct chronic effect to each of the following; plankton, algae, macrophytes vegetation species, aquatic insects, burbot, and yellow perch. Discuss the chronic effects to each of the species. Clarify the levels:

- **above which an adverse effect would occur**
- **below which there is not an effect**

Compare this to the level of naphthenic acids predicted for the proposed end pit lake.

Response:

Most toxicity studies for naphthenic acids have been carried out using commercial preparations of naphthenic acids rather than those isolated from oil sands process-affected waters and have evaluated acute toxicity rather than chronic toxicity (Headley and McMartin 2004; Clemente and Fedorak 2005; Armstrong et al. 2008). As a result, specific data regarding chronic toxicity of naphthenic acids present in oil sands process-affected waters to aquatic life are not available. Furthermore, naphthenic acids content and composition in process-affected waters, and their toxicity, vary because of differences in the oil sands processed, processing methods, age of the water analyzed and possibly other factors. These constraints allow only general conclusions regarding naphthenic acids toxicity.

The response to the project's October 2007 Secondary AENV SIR 33a indicated that research and monitoring on specific ecosystem components had not been carried out because of the absence of operational pit lakes. CEMA's Reclamation Working Group (RWG) End Pit Lake (EPL) Subgroup is leading regional research and modelling initiatives on pit lakes with the goal of developing guidelines that will help these systems develop into healthy, functioning ecosystems.

Some of the studies described have not specifically investigated naphthenic acids; nevertheless, all of these studies deal with process-affected waters that contain naphthenic acids. However, naphthenic acids dose-response information and the level above which chronic aquatic effects could occur have not been provided in these studies.

Several studies on experimental ponds and wetlands have contributed information on the aquatic dynamics of pit lake water quality and the capacity of these systems to develop into healthy, functioning ecosystems. Results of studies indicate that aquatic species can survive and grow in wetlands and test pits containing process-affected waters at higher concentrations than those likely to occur in pit lakes. In field and laboratory experiments, Siwik et al. (2000) found that fathead minnow larvae exposed to oil sands process-affected water and mature fine tailings (MFT) exhibited similar growth over 56 days compared with controls with unaffected waters.

Pit lake research and development as part of the oil sands reclamation landscape has evolved over the last three decades. In the early 1980s, Suncor and Syncrude began the conceptual development of wet landscapes for reclamation, which led to laboratory testing and field testing using experimental pits. Demonstration ponds were added to their program in 1993. Key physical, chemical, biological and toxicological issues have since been identified and examined.

Early evaluations indicated that a pit lake (using the "sludge-capping concept") was viable and would result in a biologically productive lake ecosystem (Nix and Power 1988). The Nix and Power study identified several factors that would be important for future study. These included the evaluation of the optimum depth for cap water, lake morphology and shoreline construction, possible nutrient limitations, biological characteristics of the tailings and possible contamination of groundwater.

Since research on the water-capping approach began, a series of experimental test ponds at the Syncrude site were constructed. These ponds contained MFT with both natural and process-affected water capping layers and composite tailings water in large outdoor lined pits.

Syncrude's wet landscape field research facility includes seven small experimental pits, two large experimental pits, a demonstration pond, four composite tailing pits, Mildred Lake, South Bison Pond, a settling basin seepage pond, Base Mine Lake and the west interceptor ditch. Researchers at Syncrude and the University of Waterloo studied the biota (phytoplankton, zooplankton, macrophytes, benthic invertebrates and fish communities) in Syncrude's experimental ponds compared with regional lakes (Harris 1998).

These studies showed that after four years, MFT and natural cap waters were able to support phytoplankton communities, but there were differences in species composition. The differences were related to the elevated concentrations of naphthenic acids and salts. In two experimental pits containing aged MFT (four to eight years old), phytoplankton communities were similar to those in Mildred Lake.

These studies also found that macrophyte growth was limited in tailings compared with natural substrates, but most productive when organic material, such as peat, was introduced to tailings sand. Plant growth was inhibited by salinity only at levels well above those in the experimental ponds. In related studies, ecological effects thresholds for phytoplankton were estimated at 6 to 19 mg/L (Leung et al. 2001) and greater than 6.5 mg/L (Leung et al. 2003) of naphthenic acids.

Zooplankton communities were influenced by suspended solids, naphthenic acids and salts, with lower abundance found in the experimental ponds compared with regional lakes. With time and establishment of a littoral zone, these water quality effects on plankton were predicted to decrease (Harris 1998).

Benthic invertebrate communities were slow to establish in the experimental ponds, and differed in both abundance and species composition compared with regional lakes. As a main food source for adult fish, benthic invertebrate communities must have enough time to become established. This might mean initially stocking pit lakes with smaller forage fish to reduce predation and allow a greater benthic community to develop (Harris 1998).

To evaluate the capacity of MFT-cap water to support fish, yellow perch were transplanted from Mildred Lake to the demonstration pond. The perch successfully reproduced, which allowed studies to be completed on perch at all life stages. The transplanted perch and their offspring showed physiological stresses, such as reduced immune function, but had improved nutrition relative to fish in Mildred Lake because of the abundance of prey and lack of competition. Overall, the health of the perch were similar to that of perch found in natural lakes in the oil sands region (van den Heuvel et al. 1999a, 1999b).

Researchers from the University of Saskatchewan, Environment Canada and elsewhere have collaborated on five studies that examined the health of tree swallows that inhabited reclaimed wetlands. The reclaimed wetlands were the demonstration pond, previously mentioned, and constructed wetlands that received tailings pond water at the adjacent Suncor mine. Tree swallows were also observed at nearby reference wetlands throughout the studies. Tree swallows were considered representative of avian species that could bioaccumulate oil sands byproducts, because over 80% of their diet was based on aquatic invertebrates (Smits et al. 2000).

The first study, completed in 1997 and 1998, found few differences in reproductive, immune and physiological end points between tree swallows from the reclaimed and reference sites (Smits et al.

2000). After a harsh winter in 2003, the researchers observed that tree swallows inhabiting the reclaimed wetlands had higher mortality rates compared with those at reference wetlands (Gentes et al. 2006). The researchers concluded that these swallows would have lower success because of the decreased ability to withstand environmental stressors.

In 2004, the researchers completed three studies on the tree swallows. First, they examined the tree swallows and found that those nesting near reclaimed wetlands were highly parasitized compared with those at control sites (Gentes et al. 2007a). They speculated that the higher mortality observed during the preceding winter might have been related to these parasites. However, they noted that the parasitism might have resulted from factors unrelated to the reclamation wetlands, and that parasitism did not result in observed mortality or reproductive success.

Subsequently, researchers dosed nestling tree swallows for one week with naphthenic acids at concentrations 10 times higher than they would be exposed to through routine contact with the reclaimed wetlands. The nestlings showed little or no response, indicating that naphthenic acids would have no acute toxicity on these species at relevant concentrations (Gentes et al. 2007b).

Researchers also euthanized nestling tree swallows at reclaimed and reference sites and analyzed their thyroidal hormone content. The results indicated increased thyroidal hormone synthesis, which could negatively affect several physiological processes in the swallows (Gentes et al. 2007c). Again, it was suspected that the reclaimed wetlands were a contributing factor to the hormonal activity, but the cause was not clear.

Other studies of wetlands, experimental ponds and test pits containing MFT (Leonhardt 2003; MacKinnon and Boerger 1986; Zyla and Prepas 1995) have found that aquatic species can survive and grow in wetlands and pit lakes containing MFT and that there were no observed effects on species that feed on aquatic organisms in these environments.

In addition, benthic invertebrates were found in demonstration ponds containing MFT capped with both tailings water and clean water (Leonhardt 2003). Abundance and richness were not substantially different in the process-affected water ponds from those observed in the clean-water ponds.

The results of these studies support the viability of the pit lake concept. Although more research is necessary to refine management options and optimize conditions, current research suggests that pit lakes will be capable of supporting life at all trophic levels.

In the absence of chronic toxicity data for aquatic organisms, whole effluent toxicity testing has emerged as the most useful approach to characterize toxicity of process-affected waters. Whole effluent toxicity testing accounts for the large variety of naphthenic acids typically present in oil sands wastewater and is therefore the preferred approach to evaluate potential effects related to water containing naphthenic acids.

Alberta Environment (AEP 1995) recognizes whole effluent toxicity testing as an effective method of accounting for synergistic or additive toxic effects of complex mixtures (e.g., tailings water and naphthenic acids). Chronic toxicity units (TUc) are considered to be the most reliable predictor of chronic aquatic toxicity. The generally applied threshold for evaluating chronic effects on aquatic organisms is a TUc of 1.

For an updated evaluation of the project pit lake water quality using refractory and labile naphthenic acids and chronic toxicity units and other toxicity and chemistry variables, see the AI Project Update, Section 14.11.3.1, Table 14.11-3.

The modelling for the updated water quality evaluation included both labile and refractory naphthenic acids. Labile naphthenic acids are the low-molecular weight fraction of naphthenic acids that are associated with whole effluent toxicity, and are selectively degraded from mixtures of naphthenic acids during aerobic biodegradation (Holowenko et al. 2002; Clemente et al. 2004). Although no distinctive feature has been found to classify specific compounds as either labile or refractory, they can be differentiated based on:

- molecular weight (Clemente et al. 2004; Biryukova et al. 2007)
- number of carbons (Holowenko et al. 2002; Han et al. 2008)
- number of rings and alkyl branches (Lo et al. 2006; Han et al. 2008)
- boiling point (Frank et al. 2008)
- carboxylic acid content, and therefore hydrophilic nature (Frank et al. 2009).

For modelling degradation of process-affected naphthenic acids, concentrations are divided into two fractions based on the results of Scott et al. (2005). For each process-affected source, 70% of naphthenic acids concentrations were defined as labile, and 30% were defined as refractory. The labile fraction is assigned an aerobic decay rate, whereas the refractory fraction is assumed not to decay. The assumption of no decay has been found to be conservative, as the half-life of refractory naphthenic acids has been estimated at approximately 13 years (Han et al. 2009).

The results of this assessment show that labile naphthenic acids concentrations are predicted to be 0.71 mg/L in the pit lake. In addition, levels of chronic toxicity (0.25 TUc during the first year after filling) is well below the threshold value of 1 TUc, indicating that toxicity contributed by naphthenic acids in the pit lake water is not expected to adversely affect aquatic life.

The views of the Joint Review Panel for the Kearl Project in their discussion relative to ecosystem effects associated with pit lakes is also relevant to this response as follows (EUB and CEAA 2007, Section 11.2.4 Views of the Joint Panel):

> *"The Joint Panel notes that the concept of EPLs has been proposed for a number of oil sands projects and that EPLs have been approved subject to successful full-scale demonstration of this reclamation method. The Joint Panel also notes that the CEMA's EPLSG, CONRAD's Fish Tainting group, and others are conducting research to address many of the uncertainties regarding the viability of EPLs and their ability to support higher trophic levels, including fish."*

…and…

> *"The Joint Panel also notes that the decisions on the Shell Jackpine and Canadian Natural Resources Limited (CNRL) Horizon applications requested that the efficacy of EPLs be proven within 15 years following 2003. The Joint Panel expects that an EPL's ability to support higher trophic levels, including what would be the most appropriate species composition of an EPL, will be a part of those determinations."*

It is anticipated that, if approved, this project will be subject to similar conditions, and TEPJ will work with regional working groups and stakeholders to research and refine assumptions regarding pit lake development many years before constructing the pit lake for this project.

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Question 7

Discuss the level of naphthenic acids in end pit lake water required to create a bioaccumulative effect on aquatic benthic species, vegetation that affect fish, aquatic birds and mammals. Compare this to the level of naphthenic acids predicted for the proposed end pit lake.

Response:

Available studies where observations can be drawn about bioaccumulation of naphthenic acids to organisms associated with oil sands process-affected waters are limited. The following observations are relevant:

- Bioaccumulation of smaller, labile naphthenic acids is thought to be limited by the presence of side chains and the low log K_{ow} (octanol–water partition coefficient) values, which lead to quick metabolism and excretion. Bioaccumulation of larger, refractory naphthenic acids is limited by their molecular size. As a result, estimated bioaccumulation factor (BAF) values in fish tissue for labile and refractory naphthenic acids are 3.15 and 1.26, respectively (Synenco 2007), suggesting that naphthenic acids are unlikely to bioaccumulate to high levels.
- Young et al. (2008) analyzed tissues of fish exposed to a known concentration of naphthenic acids (3 mg/L) in the laboratory and reported a bioconcentration factor (BCF) of about 2. They also found that naphthenic acids in fish tissues reached a constant level after about two days of exposure and that fish depurated 95% of naphthenic acids in about one day after transferring them back to naphthenic acids-free water.
- Based on naphthenic acids dosing experiments (Rogers et al. 2002), effects on mammals from exposure to these compounds were thought to occur at worst-case exposure conditions (i.e., highest concentrations expected for fresh, nondegraded tailings) that are much higher than concentrations expected in any pit lake.
- Field experiments that exposed mallard duckings to reclamation wetlands resulted in decreased growth in these waterfowl (Gurney et al. 2005). However, the naphthenic acids concentrations in these wetlands (greater than 60 mg/L) were much higher than concentrations expected in any pit lake.

Though not specifically designed as bioaccumulation investigations, studies of wetlands, experimental ponds and test pits containing MFT (Leonhardt 2003a; MacKinnon and Boerger 1986; Zyla and Prepas 1995) found that aquatic species could survive and grow in wetlands and pit lakes containing MFT and that there were no observed effects on species that feed on the aquatic organisms in these environments. In addition, benthic invertebrates were found in demonstration ponds containing MFT capped with both tailings water and clean water (Leonhardt 2003). Abundance and richness were not substantially different in the process-affected water ponds from those observed in the clean-water ponds.

The results of the updated water quality modelling for the proposed pit lake (see the AI Project Update, Section 14.11.3.1, Table 14.11-3) show that labile and refractory naphthenic acids concentrations are predicted to be 0.71 and 9.7 mg/L in the pit lake once it reaches its full supply level and decline to 0.52 and 8.7 mg/L, respectively in the far-future.

Though no specific dose-response information exists to facilitate prediction of bioaccumulative effects on species associated with pit lakes, it is unlikely that there will be bioaccumulative effects beyond those occurring naturally based on the following observations:

- In field and laboratory, Siwik et al. (2000) found that fathead minnow larvae exposed to oil sands process wastewater and MFT exhibited similar growth over 56 days compared with controls with unaffected waters.
- Aquatic species studies by Leonhardt (2003b), MacKinnon and Boerger (1986), Zyla and Prepas (1995) on wetlands, experimental ponds and pit lakes containing both MFT and process-affected water, concluded there were no observed effects on species that feed on aquatic organisms in these environments.
- The recent study by Young et al. (2008) indicated that a persistent bioaccumulative tainting effect of naphthenic acids in fish is unlikely at water concentrations of up to 3 mg/L.
- The predicted pit lake labile naphthenic acids concentrations of 0.71 to 0.52 mg/L is lower than the concentrations in the bioconcentration study completed by Young et al. (2008) where it was concluded that a persistent bioaccumulative tainting effect of naphthenic acids in fish would be unlikely.
- The bioaccumulation of larger, refractory naphthenic acids is limited by their molecular size.

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Question 8

Discuss end pit lake water chemistry, including salinity, that would have a negative effect to aquatic biota, vegetation, native fish species, aquatic birds and mammals. Consider effects from process affected water and adjacent drainage. Compare this to the levels predicted for the proposed end pit lake.

Response:

Water quality of the pit lake is expected to reflect the combined quality of Athabasca River water, surface runoff, residual process-affected recycle water and seepage from reclaimed areas. The parameters of primary concern in pit lake water include the following (MacKinnon et al. 2001; Clearwater 2007):

- Salt concentrations, in particular sodium, chloride and sulphate, are typically elevated in pit lakes relative to natural surface waters, reflecting the elevated salt content of process-affected waters. High salinity levels can limit the survival and growth of aquatic plants and animals. Other parameters with elevated levels related to salinity include total dissolved solids (TDS) and alkalinity.
- pH might be elevated in pit lakes (i.e., greater than eight), because of the addition of caustic chemicals used to separate bitumen from sand (however, there are no plans to use caustic for the project).
- Concentrations of dissolved organics, such as naphthenic acids, phenols, hydrocarbons and PAHs might be elevated in pit lakes. Of these, naphthenic acids are thought to be the most toxic components of process-affected waters.
- In stratified, productive pit lakes, bottom waters could have very low oxygen concentration, which could prevent development of diverse aquatic communities in pit lakes. Additionally, potential low dissolved oxygen concentration in winter under ice could also hinder the development of aquatic communities throughout the water column.

For an updated evaluation of project pit lake water quality, see the AI Project Update, Section 14.11.3.1, Table 14.11-3. The predicted salt concentration in the pit lake (TDS of 919 mg/L) is elevated relative to typical levels in natural lakes in the region (25 to 1100 mg/L), based on a regional dataset of 74 lakes (see the AI Project Update, Section 14.11.3.1, Table 14.11-3). Dominant ions include sodium, chloride and sulphate. The level of pH was not predicted, but based on the fact that a pH of just above eight is frequently observed in the region, it is unlikely to be of concern to aquatic life.

Sensitivity to salinity varies by species and depends on both the absolute concentration of all ions in solution (i.e., the absolute TDS concentration) and their relative abundance. In general, water containing multiple ions tends to be less toxic than di-ionic solutions, and sulphate-rich solutions tend to be less toxic than those dominated by potassium or magnesium (Mount et al. 1997). The project pit lake will contain a mix of major ions. The predicted initial TDS level of 919 mg/L is expected to remain relatively stable into the far-future. Beadle (1969), as cited in Bierhuizen and Prepas (1985), noted that freshwater species (algae, plants, invertebrates, fish) tend to be routinely found in water with TDS levels of less than 1000 mg/L, whereas they tend to disappear when TDS levels exceed 3000 mg/L (Hammer et al. 1975). Based on these results, the predicted TDS levels in the pit lakes are not expected to inhibit aquatic life.

Previous studies have indicted toxicological responses on slimy sculpin, pearl dace (Tetreault et al. 2003) and fathead minnows (Colavecchia et al. 2004) from exposure to oil sands sediment, both natural and process-affected. The assessment of the toxicity of pit lake water quality relied on the use of whole effluent toxicity data to predict acute (TUa) and TUc at various times after filling the pit lake. Predictions for acute and chronic toxicity (TUa=0.13 and TUc=0.25) are below threshold values of 0.3 TUa and 1.0 TUc, respectively. This suggests that adverse toxic effects on aquatic life from the combined concentrations of all organics (and potentially other parameters) are unlikely to be of concern to aquatic life in the pit lakes.

Predicted concentrations of a number of trace metals and nutrients in the pit lake is also elevated relative to typical values in regional lakes. However, the aquatic health analysis has shown that, based on multiple lines of evidence, water quality in the pit lake is predicted to have insignificant effects on aquatic health in the local and regional study area (see the AI Project Update, Section 14.11.3), consistent with the conclusions of the water quality assessment in the 2007 SI Project Update, Section 13.11.3.1.

In summary, the lake design and management of water quality during the filling of the pit lake is expected to reduce concerns regarding adverse conditions for aquatic life, by providing sufficient time for settling of suspended sediments and biodegradation of organic compounds such as naphthenic acids. Salinity of the pit lake is expected to be somewhat higher than in natural lakes in the region, but well below the range considered to inhibit aquatic life. Therefore, the pit lake is expected to be nontoxic and capable of supporting aquatic life by the time it is filled.

If monitoring data indicate that these concerns are not addressed during filling, additional treatment (see the response to Question 11) might be required to improve the quality of lake water before filling is completed.

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Question 9

Discuss the potential consequences from project specific and regional cumulative loading of naphthenic acids to the Athabasca River due to predicted end pit lake outflow for all existing, approved and applied for oil sands mine development. Include a discussion of the accuracy of predicted effects.

Response:

The updated Athabasca River modelling described in the AI Project Update, Section 14.11.3.2, Table 14.11-4 and Table 14.11-5) accounted for cumulative process-affected water inputs to the river via groundwater migration and pit lake releases for all existing, approved and planned oil sands mine developments (see AI Project Update, Section 14.1.2.3, Table 14.1-2 for updated developments included in the modelling). For a discussion of the regional cumulative loading of naphthenic acids to the Athabasca River from groundwater seepage alone, see the response to Question 10.

The regional, average pit lake discharges to the Athabasca River (including indirect discharges to tributaries) for the updated PDC is about 6.4 m^3/s, which is roughly representative of the initial and far-future release levels. The project's portion of this is estimated to be 0.18 m^3/s.

The average concentration of total naphthenic acids in all regional pit lake releases is approximately 4.1 mg/L at initial release and approximately 2.2 mg/L in the far-future. This translates to a loading of total naphthenic acids to the Athabasca River of about 1945 kg/d at initial release and 1548 kg/d in the far-future. (Direct calculation of loadings cannot be done with average flows and concentrations as individual pit lake loadings vary.)

The project's portion of this would be approximately 162 kg/d and 135 kg/d, respectively (see the AI Project Update, Section 14.11.3.2, Table 14.11-3). The labile naphthenic acids loadings are predicted to be 11 and 8 kg/d, at initial release and in the far-future, respectively.

Though no water quality guidelines exist for naphthenic acids, the increase from background levels is small. For example, at Embarras, the peak, pre-industrial background level of naphthenic acids is predicted to be 0.62 mg/L, the concentration at initial release for all pit lakes in the PDC, including background concentrations, is predicted to be 0.78 mg/L and the far-future PDC level is predicted to be 0.82 mg/L. Under these same conditions, labile naphthenic acids concentrations are predicted to be 0.03 and 0.027 mg/L, at initial release and far-future, respectively.

The predicted peak PDC chronic toxicity levels under initial discharge and far-future conditions (which integrate all toxicity levels from all sources) is 0.062 and 0.031 TUc, respectively, which is well below the chronic toxicity threshold level of 1 TUc. These predictions include naphthenic acids and toxicity contributions from all sources. The project's contribution to all these estimates is negligible.

Model predictions of naphthenic acids for all regional pit lakes are highly conservative and thus overestimate the level of naphthenic acids both in individual pit lakes and in receiving streams. Conservative assumptions are used to address uncertainties related to the exact levels of naphthenic acids levels in the source waters, the attenuation process that would operate on naphthenic acids as reclamation waters pass through soil matrices and constructed wetlands and the biological and physical processes that would ultimately take place in the pit lakes. Because the predicted pit lake and receiving water naphthenic acids concentrations are overestimated, there is high confidence that there will be no predicted consequences to downstream aquatic resources.

Specific examples of the conservative assumptions applied to the pit lake modelling are as follows:

- **Settling of TSS and associated constituents**: As runoff enters the pit lakes, the resulting reduction in velocity will cause a portion of suspended sediments to settle to the bottom of the lakes. This settling will result in decreased concentrations of constituents attached to or associated with the suspended sediments. Where settling is included in modelling, conservative deposition rates are used that result in overestimating the concentration of any constituents associated with TSS, such as several metals and nutrients.

- **Chemical partitioning, precipitation and adsorption-desorption**: Organic substances and metals can exist in dissolved or particulate form. The chemical partitioning of the substance is described by the equilibrium between the two forms, which depends on the environmental conditions, including pH, temperature and redox potential. However, the water quality modelling considered total metals and treated them as if they were conservative. Therefore, the model will tend to overpredict the concentrations of some metals and nutrients because it does not account for reductions that could occur because of partitioning, precipitation and adsorption–desorption.

- **Decomposition, biodegradation or decay**: Modelling includes decay of organic constituents. As a conservative measure, the lowest available rates are used for each constituent. Consequently, the modelling would tend to predict a slower decay (and therefore higher concentration over time) of degradable constituents.

Question 10

Discuss the potential for cumulative effects from process affected water, including naphthenic acids, on the Athabasca River via groundwater migration. Consider peak and mean effects to the Athabasca River during the proposed project as measured in 10 year periods, and over a 100 year timeframe. Discuss the level of accuracy of the predicted effects. Discuss how the accuracy of predictions might be improved over time with the use of monitoring information.

Response:

The Athabasca River modelling described in the AI Project Update (see Section 14.11.3.2, Table 14.11-4 and Table 14.11-5) accounted for cumulative process-affected water inputs to the river via groundwater migration and pit lake releases for all existing, approved and planned oil sands mine developments. For information on the regional cumulative loading of naphthenic acids to the Athabasca River from pit lakes, see the response to Question 9.

Conservative estimates of seepage from all developments near the Athabasca River were compiled from EIAs and included in the model. These estimates are highly conservative and most will not occur during the operating lives of the mines or even in the far-future. Water quality modelling for oil sands are highly conservative with the stated purpose of ensuring that predictions are not underestimated so that project-specific mitigation is appropriately considered at the planning stage of the project.

At closure of the project (2044), regional, cumulative process-affected seepages are predicted to be 0.28 m^3/s. The total flux of seepage to the river in the far-future (2144) is predicted to be 0.41 m^3/s (see the AI Project Update, Appendix J, Table J1-2). The project's portion of this is conservatively predicted to be a constant 0.00005 m^3/s in the far-future (see the AI Project Update, Section 14.5.3.4).

Seepage flux rates are assumed to be relatively constant and long lasting once they start. The difference in seepage rates between 2044 and 2144 is the result of additional seepage sources, and it was assumed that all seepages would be entering the river in the far-future (2144) snapshot. This is conservative as travel times for seepage can vary from one year to more than a 1000 years depending on the travel path. In addition, the amount of attenuation and decay of organic parameters, such as naphthenic acids, is underestimated in the model as these processes are either not considered or are estimated using highly conservative assumptions. However, as the difference between the levels of seepage at closure and in the far-future is so small (0.28 vs. 0.41 m^3/s, respectively), modelling snapshots every 10 years between those years would not yield predictions that are appreciably different.

The regional, cumulative total naphthenic acids loading associated with seepage flux at closure and in the far-future is predicted to be 841 kg/d and 1226 kg/d, respectively. This would result in increases of about 0.1 and 0.14 mg/L, respectively, for fully mixed conditions under 7Q10 flows in the Athabasca River. As discussed in the response to Question 9, although no water quality guidelines exist for naphthenic acids, the increase from background levels is small.

The probabilistic model predictions for naphthenic acids (from all sources) in the AI Project Update for the updated PDC at Embarras on the Athabasca River range from a median and peak of 0.13 and 0.61 mg/L for background levels, 0.23 and 0.78 mg/L for the 2044 snapshot, to 0.25 and 0.82 mg/L for the 2144 far-future snapshot, respectively (see the AI Project Update Section 14.11.3.2, Table 14.11.5). Labile naphthenic acids median and peak concentrations are predicted to be zero for background level, 0.005 and 0.03 mg/L for the 2044 snapshot, to 0.005 and 0.027 mg/L for the far-future snapshot, respectively.

In addition, predicted chronic toxicity levels are small. For the probabilistic model predictions for chronic toxicity (from all sources) for the updated PDC at Embarras on the Athabasca River, see the AI Project Update, Section 14.11.3.2, Table 14.11-5. The chronic toxicity predictions range from a mean and peak of less than 0.001 TUc (both the same for background levels), 0.009 and 0.062 TUc for the 2044 snapshot, to 0.005 to 0.031 TUc for the 2144 far-future snapshot. These levels are all well below the chronic toxicity threshold of 1 TUc. The project’s contribution to these estimates is negligible.

Based on the modelling results, even with the conservative assumptions, process-affected water via groundwater migration is not predicted to cause any new constituent guideline exceedances in the Athabasca River at Embarras.

As with the conservative assumptions used for pit lakes in response to Question 9, seepage assumptions are similarly conservative and overestimate the level of naphthenic acids both for seepage modelling and for receiving streams. The amount of attenuation and decay of organic parameters, such as naphthenic acids, is underestimated in the model as these processes are either not considered or are estimated using highly conservative assumptions. Because the predicted naphthenic acids concentrations are overestimated, there is high confidence that there will be no predicted consequences to downstream aquatic resources.

Ongoing monitoring by RAMP is confirming that current oil sands operations are not contributing to a discernible change in water quality of the Athabasca River. Given the small predicted influence of the oil sands operations on constituent levels now and in the future, the frequency of existing RAMP monitoring might be appropriate. The accuracy of model predictions will improve in the future as observed levels of constituents in process-affected waters in seepages and pit lake releases becomes available regionally and supplements a growing database of information. However, there will continue to be an emphasis on applying conservative assumptions to modelling as uncertainties associated with future outcomes will be inevitable.

Question 11

Discuss treatment options proposed to address potential chronic environmental effects due to process affected water and naphthenic acids.

Response:

Because seepage from the project will be negligible (less than 0.00005 m^3/s; see the AI Project Update, Section 14.5.3.4) and there are no other pathways of process-affected releases to the environment, this discussion focuses on releases to the Ells and Athabasca rivers from the pit lake. Treatment and mitigation options for process-affected waters in the pit lake could, if necessary, include the following:

- reducing the rate at which Athabasca River water is initially added to the pit lake to provide a longer initial residence time in the lake if organic constituents prove to be higher than anticipated
- adding nutrients to pit lake water to increase productivity, which in turn could result in increased biodegradation of naphthenic acids (Lai et al. 1996)
- aerating the pit lake water to enhance aerobic biodegradation of naphthenic acids (Lai et al. 1996)
- treating pit lake outflow by adding wetlands to the outflow channel that connect the lake to the receiving environment
- if nondegradable constituents prove to be higher than anticipated then increasing the rate at which Athabasca River water is initially added to the pit lake will provide dilution

Several local and international field and pilot studies on wetlands have contributed pertinent information on management and operational options to enhance treatment of reclamation waters (EVS and NOVATEC 1995; EVS 1996; Lai et al. 1996; Bendell-Young et al. 1997; Schley et al. 1998; Mills et al. 2003; Greer et al. 2003; Mills et al. 2004; Simon et al. 2004). In addition, several avenues of research have recently indicated conditions that might be modified in pit lakes to optimize natural bioremediation of naphthenic acids and other compounds. For example, when model compounds were degraded by specially-cultured microbial populations, naphthenic acid decay was found to be most rapid at high pH, with maximum rates occurring near a pH of 10 (Paslawski et al. 2009a). The concentrations and rates were much higher than would be anticipated in the field, but this work might indicate conditions that could be replicated with the aim of increasing degradation.

Recent research with macrophytes native to the oil sands region has also indicated the potential to enhance decay through phytoremediation (Armstrong et al. 2009; Headley et al. 2008, 2009a). In these studies, macrophytes were able to reduce the acute toxicity of naphthenic acids solutions extracted from oil sands process water.

In the highly unlikely event that natural bioremediation is proven to be less successful than anticipated, there are several active treatment options available for treating pit lake water:

- One method that is being developed specifically for oil sands wastewaters is treatment using ozonation (Scott et al. 2008) which reduces the toxicity of oil sands tailings waters by oxidizing naphthenic acids.
- Toxicity might also be reduced through the application of adsorptive media. By partitioning naphthenic acids to suspended particles, the naphthenic acids become less bioavailable and, therefore, less toxic. This method has been applied to other petroleum wastewaters (Calvillo and Alexander 1996; Speitel and DiGiano 1987), and might be applicable to oil sands waste.

Many other researchers are developing treatment methods for naphthenic acids based on conventional water treatment methods. Examples of conventional treatment methods that might be optimized and adapted to oil sands process waters are bio reactors (Paslawski et al. 2009b; Wang et al. 2008), irradiation (Headley et al. 2009b), carbon filtration (Small et al. 2009) and nanofiltration (Mohamed et al. 2008). These are proven technologies that, although likely cost-prohibitive for currently planned, routine pit lake use, are options that might be used in a worst-case scenario.

The Canadian Oil Sands Network for Research and Development (CONRAD) wetlands and aquatics working group research program is involved in projects evaluating degradation of naphthenic acids in natural and reclamation environments. This research will assist in determining whether a system to enhance degradation is required.

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6.0 Reclamation of Forest Vegetation

Question 12

Discuss the level of vegetative diversity for the range of ecosites targeted for reclamation. Clarify if it is Total's intent to reclaim to forested ecosites that would have near natural species diversity. Discuss what TOTAL would do to achieve this level of vegetative diversity.

Response:

Conditions for a diversity of forested ecosites will be provided on the reclaimed landscape. The goal is to maintain a level of natural diversity that reflects analogous ecosites in the region.

For the range of target ecosites planned for the conceptual closure landscape, see the AI Project Update, Section 11.3.1. As the performance of terrestrial and wetlands ecosystems in the far-future (80 to 120 years after vegetation planting) will depend on many factors (e.g., climate and management), the future soils, vegetation, wetlands, wildlife habitats and biodiversity cannot be accurately predicted. Annual monitoring programs on reclaimed areas will be completed to assess herbaceous vegetation growth and use of reclamation areas and other areas adjacent to the project by wildlife. The biodiversity of reclaimed ecosites will be monitored to allow for improvements to the reclamation process.

A variety of regional reclamation initiatives in the oil sands region will continue to contribute to ongoing research to improve reclamation technology. As new technology to improve biodiversity emerges through research and operations, these new techniques will be adopted on the reclamation landscape.

Several mechanisms will be used, as applicable, to enhance biodiversity of the reclaimed landscape including:

- progressive reclamation techniques, where possible through the life of the mine providing for a diversity of stand ages on the closure landscape
- landform variability, providing for establishment of diverse moisture and topographic regimes at the landscape level
- inclusion of surface microtopography (e.g., ridges and swales) providing for variation in slope and aspect to encourage the development of diverse moisture regimes, soil types and vegetation types at the site level
- soil salvage and handling procedures to maximize direct placement of upland soils that will provide seeds and propagules to enhance the diversity of the reclaimed landscape
- using a variety of reclamation soil prescriptions with available materials to provide diverse soil types
- planting woody species according to the types and densities outlined in OSVRC 1998, or the most current regulatory guideline, for each target ecosite
- seeding herbaceous species typical to each target ecosite as required to meet biodiversity qualifications outlined in the most current reclamation certification guidelines
- designing and constructing wetlands according to the Guideline for Wetlands Re-establishment on Reclaimed Oil Sands Leases (CEMA 2007) and applicable reclamation certification guidelines

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Question 13

Having regard for observed success in achieving vegetation diversity in reclaimed forests within the region, discuss any adjustments to Tables 13.14-4, 13.15-8 (Summary of Effects Significance for Wildlife; Summary of Effects Significance on Biodiversity) that may result. Consider how any amendments made to these tables may effect Total's determination of impact significance.

Response

The *CEMA Soil and Vegetation Working Group's Long-Term Soil and Vegetation Monitoring Program* is examining natural and reclamation plots. Results indicate that total vascular plant species richness is statistically higher in natural plots (AXYS and Paragon 2006, 2007). Differences were largely a result of the higher number of shrub species in natural versus reclaimed plots. However, revisited reclaimed plots do show slightly higher numbers of total plant species, shrubs, graminoids and forbs relative to the original baseline survey (AXYS and Paragon 2007).

Revisited reclaimed plots were between 10 and 33 years old at the date of the revisit assessment (AXYS and Paragon 2007). This trend was observed across all reclamation soil series and could be attributable to the successful colonization of additional species new to the site from natural areas adjacent to the mines, in addition to the continued presence of early seral species already established in plots (AXYS and Paragon 2007).

Though an ordination of all natural and reclaimed soil series does indicate reclaimed plots are experiencing succession and moving toward a composition similar to that of natural plots, documentation is not yet available to indicate the period required to achieve native plant species richness similar to pre-disturbance on reclaimed land. As indicated in the Closure, Conservation and Reclamation Plan (see the AI Project Update, Section 11.3.4 and Section 11.3.5), it is anticipated that the target reclamation ecosites will resemble analogous ecosites in the region as succession occurs on the landscape. It is also anticipated that this will result in a landscape capable of supporting the diversity of wildlife species currently occupying the area.

No changes to the determination of significance provided in the 2007 SI Project Update, Section 13.14, Table 13.14-4, and Section 13.15, Table 13.15-8 resulted from the reassessments of vegetation and wildlife diversity (see the AI Project Update, Section 14.13.5, Table 14.13-5 and Section 14.14.5, Table 14.14-3).

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