12 CUMULATIVE EFFECTS

12.1 Introduction

This section provides the biophysical cumulative effects assessment (CEA) for the Mackenzie Gas Project (the project), including its contribution to cumulative effects and overall cumulative effects.

For an assessment of socio-economic cumulative effects, see Volume 6, Socio-Economic Impact Assessment.

Cumulative effects are changes to the environment that "are likely to result from the project in combination with other projects or activities that have been or will be carried out" (Government of Canada 2003, s.16). The project's contribution to cumulative effects is assessed based on its effect on a valued component (VC) that is also affected by other land uses. Settlements, roads and hunting are examples of land uses. Overall cumulative effects are effects by all land uses on a VC, including effects caused by the project.

This CEA is based on the predictions of the potential project-specific effects (see Sections 2 to 10), which are effects on VCs by the project alone. This information is necessary to identify effects on VCs that might act cumulatively with effects of other land uses.

12.1.1 Meaning and Relevance of Assessing Cumulative Effects

An assessment of cumulative effects provides a more complete understanding of what might happen to VCs beyond the influence of the project alone. This is useful for regulatory decision makers and land and resource managers as they review and plan future development.

An assessment of cumulative effects therefore provides a glimpse into environmental conditions now and how they could change in the future. This contributes to a better understanding of what might happen if the project proceeds and what might not happen.

Although the project extends over a large area in the North, it represents a small footprint in the Northwest Territories landscape (see Figure 12-1). However, the project could cause some localized effects on the environment and some change in communities.

The long history of oil and gas development south of 60º latitude and the lessons and experience learned more recently from such development in the Northwest Territories, provide some indication of what those projects could entail and how they might change the future for those whose livelihood depends on the land and water around them.

Figure 12.1 has been removed for the purposes of reducing file size and can be viewed as a graphic separately. This document can be accessed through the link in the Table of Contents reference web page.

No cumulative effects assessment can predict all outcomes of industrial development. Those outcomes it does predict have a relatively low level of certainty that can only be expected of uncertain future conditions. Nevertheless, the assessment does provide information that suggests what is possible, and what actions might be practical and necessary to address possible changes, based on traditional knowledge and wisdom, regulatory review and evolving responsibilities for northern land and resource management and land use planning.

12.1.2 Organization of Assessment

The cumulative effects assessment is organized as follows:

- Introduction – introduces the basic and common aspects of the assessment, including definitions of study areas, definitions of reasonably foreseeable and hypothetical projects, identification of other land uses and an explanation of assessment method
- Effects of Land Use – assesses the contribution to cumulative effects by the Mackenzie Gas Project and considers past, current and reasonably foreseeable land uses
- Effects of Hypothetical Projects – assesses the contribution to cumulative effects by the Mackenzie Gas Project and considers past, current, reasonably foreseeable and hypothetical land uses
- Management of Effects – discusses options to manage cumulative effects
- References
- Appendix – describes data sources for land uses in the study area and includes the project inclusion list and baseline disturbance maps

12.1.3 Summary of Results

This assessment of cumulative effects has concluded that:

- the Mackenzie Gas Project does not contribute significant cumulative effects
- there are no significant overall cumulative effects
- the project contributes to one potential cumulative effect of management concern: direct grizzly bear mortality, which could be addressed with diligent monitoring and management by responsible parties

- based on the project footprint, the project will disturb a negligible proportion of the regional study area and therefore also a negligible proportion of the Northwest Territories

- the project might encourage other development, particularly gas exploration and production in the Northwest Territories; however, information to adequately assess potential cumulative effects contributions from such developments is not yet available

- the pattern of any future hydrocarbon development on the land, such as additional production fields, and any effects from such activities would likely be similar to effects predicted for current and reasonably foreseeable land uses. Those developments will be subject to their own environmental impact assessment, including cumulative effects.

These results indicate that, despite the size and duration of operations, the contribution to cumulative effects by the Mackenzie Gas Project on the regions and communities of the Northwest Territories are not expected to be significant. The results also mean there is no reason to believe, based on available information and assessment method, that in the future there will be an issue of management concern associated with cumulative effects on a valued component. These conclusions are based on the assumption that appropriate management and monitoring programs outlined in Volume 7, Environmental Management, will be carried out.

12.1.4 Spatial Boundary

12.1.4.1 Overview of Regional Study Areas

Cumulative effects were assessed in the following regional study areas (RSAs):

- air – assessment of potential effects on air quality

- noise – assessment of potential effects on noise

- aquatic – assessment of potential effects on groundwater, hydrology and fish and fish habitat

- terrestrial – assessment of potential effects on soils, landforms and permafrost, vegetation and wildlife

The air RSA is described in Volume 3, Section 2, Air Quality. This RSA was based on three large airsheds, their shape and size derived from air quality modelling requirements. Other land uses were represented by ground-based receptors such as communities and emission sources.

The noise RSA is described in Section 3, Noise. This RSA was based on a fixed distance from Mackenzie Gas Project noise-generating components.

The aquatic RSA is described in Section 5, Hydrology. This RSA was based on site-specific drainage areas associated with potential Mackenzie Gas Project contributions to effects. The maximum extent of this RSA is the Mackenzie River basin.

The terrestrial RSA is described in detail in Section 12.1.4.2, Terrestrial Regional Study Area. This RSA was based on wildlife distribution and occurrence and was the region in which other land uses that could interact with the Mackenzie Gas Project were mapped and identified.

12.1.4.2 Terrestrial Regional Study Area

The terrestrial RSA (see Figure 12-2) is an area large enough to adequately characterize other land uses with effects that could influence VCs also potentially affected by the Mackenzie Gas Project. Within that spatial boundary, VCs or project effects interact with other land uses by moving through and beyond the Mackenzie Gas Project local study areas (LSAs). For example, wildlife species such as marten might in one day travel through a clearing at a pipeline right-of-way and later through a timber harvesting operation. The marten will then have experienced a cumulative effect from the two land uses even though those land uses might be many kilometres apart.

The terrestrial RSA was based on the home range or farthest seasonal movements of certain wildlife VCs. In the production area, the RSA was based on the movement pattern and annual home range size of grizzly bears and the movement pattern and wintering range of the Cape Bathurst barren-ground caribou herd. The RSA along the pipeline corridor was based on the annual home range of woodland caribou.

The boundary was developed by moving outward from the project to a distance and position that represented a likely maximum extent of such movements for an individual animal or herd. The resulting shape and spatial extent of the terrestrial RSA is as follows:

- production area – an irregular shape following topographical landmarks, including the Mackenzie River to the west, a 10-km buffer extending from shore into the Beaufort Sea to the north, the Tuktoyaktuk peninsula as far as McKinley Bay and Miner River to the east, and Inuvik to the south
- pipeline corridor – a regular 30-km buffer along the pipeline right-of-way, representing a 60-km-wide area, except for a westward bulge to Tsiigehtchic to include the additional distance to the Mackenzie River. (The 40- or 50-m pipeline right-of-way width, centred in this area, is less than 0.1% of the study area width.)

Figure 12.2 has been removed for the purposes of reducing file size and can be viewed as a graphic separately. This document can be accessed through the link in the Table of Contents reference web page.

12.1.5 Temporal Boundary

12.1.5.1 Past and Current

Current and past land uses are projects and activities near the Mackenzie Gas Project and surrounding region as of year 2003.
To be assessed, a land use must in some way be represented on a map or be recognized by observable evidence. An historical baseline of conditions before human disturbance was not assessed because:

- the Mackenzie Gas Project region today has generally no or little recognizable human disturbance
- modelling of environmental conditions many decades ago is highly uncertain

Use of such *predisturbance* or *historical baseline* conditions in a CEA is more practical in areas that have had more extensive human development, as in many areas of southern Canada.

Specific past and current land uses are identified in Section 12.1.6.1, Past and Current Land Uses.

12.1.5.2 Future

Future land uses include the reasonably foreseeable and the hypothetical (based on Hegmann et al. 1999; CEAA 1999; Government of Canada 2003):

- reasonably foreseeable land uses include publicly disclosed land uses that have a high degree of certainty in proceeding, e.g., because of confirmed funding, submitted for regulatory review, approved or under construction
- hypothetical land uses are conjectural based on currently available information, which includes land uses that are publicly announced with few details and with unknown or low certainty of ever proceeding, implied by lease acquisition, identified through a planning process or possibly induced by the Mackenzie Gas Project but with no descriptive information

No specific number of years into the future is represented by these land uses. Generally, they will or could occur during the life of the Mackenzie Gas Project, which is expected to be the start of operations; i.e., 2009, followed by at least 25 to 30 years. It is possible, however, that some of these other land uses could occur before operations begin.

As proposed, the Mackenzie Gas Project includes a certain gas supply from the three anchor fields described in this assessment. Information adequate to support detailed assessment, such as location and project description, is not yet available to describe possible future gas supply to the project beyond those anchor fields.

Considering these unknowns, possible new future gas supply and other possible future land uses are therefore identified as hypothetical. These land uses are assessed to provide as complete an understanding as possible of likely future events; however, the results of such an assessment should not be considered a determining factor (CEAA 1999) in regulatory decisions regarding the Mackenzie Gas Project.

Specific reasonably foreseeable (see Section 12.1.6.2) and hypothetical land uses (see Section 12.1.6.3) are identified in the following sections.

12.1.6 Other Land Uses

All other land uses in the RSA are identified in a project inclusion list (PIL) that lists and briefly describes each type of land use or land use disturbance (see Appendix Table A-1). Many of these land uses are mapped in Figures A-1 to A-12. Section A.1, Information Sources, lists the information sources for these maps.

Land uses are identified either by specific project name or by generic type. The PIL identifies land uses (projects and activities) that are candidates for consideration in the assessment of potential cumulative effects. Inclusion of a specific current land use for assessment of cumulative effects is determined individually for each discipline assessed, based on relevant cause-effect relationships.

Following is a summary of identified land uses:

- past and current
- reasonably foreseeable
- hypothetical.

12.1.6.1 Past and Current Land Uses

Past and current land uses include:

- settlements – communities, private land, medical facilities, police facilities and military sites
- transportation infrastructure – all-weather roads, limited-use roads, airstrips, seaplane bases, barge landings, fuel caches, docks and wharves
- non-oil and gas industry – forestry operations, sawmills, mining, quarries, grazing, herding, power lines, telecommunications lines, outfitting camps, lodges, cabins and camp sites

- power generation, oil and gas – exploration leases, significant discovery leases, seismic lines, pipelines, artificial islands, well sites and other facilities
- designated areas – bird sanctuaries, national parks, international biophysical program sites, historical sites, points of interest, wildlife sanctuary and other sites

Cumulative effects on traditional use of the land, which includes renewable resource harvesting, are assessed in Volume 6, Socio-Economic Impact Assessment.

Land Use Areas

Table 12-1 lists the surface areas of all mapped land uses in the terrestrial RSA. These areas represent the land base cleared, i.e., footprints, or otherwise modified. The table compares land use areas with:

- local study areas, showing land uses in each of the Mackenzie Gas Project's component LSAs. This placed land uses in context relative to RSAs, recognizing that effects for some disciplines, e.g., soils and vegetation, are typically local to the project and do not always act cumulatively
- terrestrial regional study area, showing land uses in the production area and pipeline corridor. For this table, the production area lies entirely in the Inuvialuit Settlement Region, and the pipeline corridor lies entirely in the Gwich'in Settlement Area, Sahtu Settlement Area and Deh Cho Region.

The following summarizes key observations from the table:

- contribution of the Mackenzie Gas Project to cumulative disturbed area – total project footprint of 10,640 ha is 5.4% of all LSAs and 0.11% of the terrestrial RSA
- contribution of other land uses to cumulative disturbed area – area of seismic and other land uses is 2.7% of all LSAs and 0.52% of the terrestrial RSA
- overall cumulative disturbed area –area of all land uses is 6.5% of all LSAs and 0.64% of the terrestrial RSA
- lengths of rights-of-way: seismic lines are 44% of the rights-of-way in all LSAs and 55% of the rights-of-way in the terrestrial RSA

The footprint pattern of the project, which occupies a small fraction of the study area, can be generally characterized as a relatively narrow right-of-way along which facilities occur at various points. The proportion that the project footprint occupies in any part of the RSA is therefore similar.

Table 12-1: Summary of Land Use Areas for the Project and Past and Current Land Uses

Project/Study Component	Study Area (ha)	Area of Land Uses				Proportion of Land Uses in Study Area				Length of Rights-of-Way		
		Project (ha)	Seismic (ha)	Other (ha)	Total[1] (ha)	Project (%)	Seismic (%)	Other (%)	Total[1] (%)	Seismic (km)	Total (km)	Seismic (%)
Project Components in Local Study Areas												
Niglintgak[2, 3]	6,876	75	128	33	185	1.14	1.87	0.48	2.68	159	174	91
Taglu[3]	8,779	103	278	19	284	1.17	3.16	0.21	3.23	341	346	99
Parsons Lake[3]	41,105	329	622	196	885	0.80	1.51	0.48	2.15	772	849	91
Gathering system	17,187	912	192	21	1,004	5.30	1.12	0.12	5.84	237	414	57
Pipeline corridor	121,760	9,218	438	3,247	10,420	7.57	0.36	2.67	8.56	546	2,848	19
Total	195,708	10,640	1,658	3,515	12,778	5.44	0.85	1.80	6.53	2,054	4,632	44
Project Components in Terrestrial Regional Study Area												
Production area	2,184,105	1,422	14,958	2,386	18,765	0.07	0.68	0.11	0.86	1,508	1,783	85
Pipeline corridor	7,832,642	9,218	15,309	20,146	45,277	0.12	0.20	0.26	0.58	1,895	4,457	43
Total	10,016,747	10,640	30,267	22,532	64,043	0.11	0.30	0.22	0.64	3,404	6,240	55

NOTES:
1 Total is less than the sum of the land uses shown because overlapping areas are accounted for only once
2 Niglintgak area based on the land option (area for the barge option is smaller)
3 Areas include all project components associated with that field, including access roads and borrow sites

Interpretation of Land Use Areas Relative to Terrestrial Study Area

The terrestrial RSA was selected to be as inclusive as possible of land uses that could interact with the Mackenzie Gas Project, thereby providing a regional context. As a result, the percentage contribution of the project to disturbed area is quite small – about 0.1%.

The areas disturbed by other land uses, and these disturbances combined with Mackenzie Gas Project disturbances, are also relatively small compared with the local and regional study areas. This observation would remain unchanged, and the numbers would show a lower relative contribution, for larger study areas. The region in which the project occurs is relatively undisturbed by recognizable land uses when observed at large landscape scales; however, this does not detract from recognition of and possible importance to land users of some disturbances in specific localized areas.

Interpretation of Seismic Lines

Areas for seismic lines are provided separately in Table 12-1, shown previously. They occur in many areas and have been developed over a succession of activity periods. Seismic line widths were assumed to be 8 m because actual widths are not available from map sources. Widths, however, could vary considerably. Cleared areas for seismic lines were not included in quantitative analysis because their description from best available sources is incomplete (see Section A.1, Information Sources). The areas are provided to illustrate their occurrence and to support *qualitative* assessment of their contribution to cumulative effects.

As relatively narrow linear disturbances, seismic lines cannot be adequately correlated with vegetation and terrain conditions at the large map scale used. The ages of the lines are unknown, so partial or complete vegetation recovery might have occurred, although the existence of some mapped lines was verified by air photo interpretation.

The interpretation of seismic line disturbance therefore resulted in a conservative assessment, i.e., an overestimate of area disturbed. This is particularly true for geophysical programs done in the last decade and for land-based seismic lines in the production area, i.e., the Inuvialuit Settlement Region and the Tundra Ecological Zone. All current seismic programs in this region are winter based and rely on snow and ice cover to limit ground disturbance, in contrast to clearly observable lines in treed areas farther south. Offshore seismic lines leave no observable line and, although mapped in Figures A-1 to A-12, are not included in the disturbance table totals.

Recent Oil and Gas Activities

The baseline disturbance maps show past oil and gas production and exploration in the terrestrial RSA based on available map sources. This includes the Ikhil natural gas well and pipeline north of Inuvik and the oil production development at Norman Wells, which are also part of the current oil and gas production in the Northwest Territories. More recent oil and gas exploration activities are described in the following discussion.

In the terrestrial RSA, oil and gas exploration is currently focused on the Mackenzie-Beaufort and Mackenzie Valley central regions (DIAND 2003). This includes Norman Wells and Colville Lake. Two other areas of oil and gas exploration and production in the Northwest Territories, Cameron Hills and Fort Liard, are outside the terrestrial RSA and are already serviced by pipelines. Although hydrocarbon resources exist in the Yukon, e.g., Eagle Plains Basin, those fields are currently considered uneconomic to tie in to the Mackenzie Gas Project on a stand-alone basis.

After a hiatus in exploration in the Mackenzie region in the last decade, there has been a relatively modest level of activity in the last few years. Since 2001, when records became publicly available (RWED 2001–2003), there have been three winter seasons of exploration in the Inuvialuit Settlement Region, the Sahtu Settlement Area and the Deh Cho Region. Most exploration occurred during winter freezeup. In the last full winter season of activity for which complete records are publicly available, i.e., winter 2002 to 2003, five operators did seismic surveys or were drilling in the Mackenzie-Beaufort region.

This activity since 2001 has resulted in 1,322 km of 2-D seismic, 643 km^2 of 3-D seismic, which is an area represented by the outer boundary of 3-D programs, 48 wells, including eight re-entries and 455 km of roads in the Sahtu Settlement Area.

12.1.6.2 Reasonably Foreseeable Land Uses

Reasonably foreseeable land uses include:

- Devon Canada Corporation's proposed Beaufort Sea Exploration Drilling Program, an offshore exploration project north of Richards Island with various sites to be drilled between 2005 and 2009. The project proponents submitted a Comprehensive Study Report to the National Energy Board in April 2004.

- Deh Cho Corporation's proposed Mackenzie River bridge at the current ferry crossing at km 23 of Highway 3 near Fort Providence. This two-lane, 1-km bridge might have nine spans. The project was referred to Fisheries and Oceans Canada by the Mackenzie Valley Environmental Impact Review Board (MVEIRB) in January 2004.

- construction by the Government of the Northwest Territories (GNWT) of permanent winter bridges at 21 watercourse crossings and two major river crossings along the existing 482-km Mackenzie winter road between Wrigley and Fort Good Hope. Wrigley is currently serviced by an all-weather gravel road connecting with the territorial road system. These bridges would double the length of the winter road season to provide up to four months of road access. The major river crossings are over the Bear River and the Blackwater River; the watercourse crossings are over Big Smith Creek, Billy Creek, Bob's Canyon Creek, Christina Creek, Donnelly River, Elliot Creek, Francis Creek, Hanna Creek, Hellava Creek, Jackfish Creek, Jungle Ridge Creek, Little Smith Creek, Lynn Creek, No Name Creek (Gibson North), No Name Creek (Gibson South), Notta Creek, Oscar Creek, Snafu (Rachelle) Creek, South Snafu (Denise) Creek, Strawberry (Raspberry) Creek and Tsintu (Bluefish) Creek.

Construction of a bridge over the Bear River is less certain because of the span involved. The Government of Canada is determining funding for this bridge.

These projects were assessed qualitatively and were not mapped, nor were disturbance areas calculated. Most of these projects are over water and details are unavailable. Devon's exploration will be a temporary winter offshore project with minimal land-based disturbance. Details on the Mackenzie River bridge are not yet known. The Mackenzie Valley bridges are largely points over water along the existing winter access road.

12.1.6.3 Hypothetical Land Uses

Hypothetical land uses include possible future:

- hydrocarbon (oil and gas) exploration
- gas production to the Mackenzie Gas Project, additional to the project's anchor fields
- mineral exploration and production
- telecommunications line along the Mackenzie River
- all-weather resource access road southward from Tuktoyaktuk
- upgrading of the winter road between Wrigley and Fort Good Hope and completion of Mackenzie Highway access between Fort Good Hope and Tsiigehtchic

Preliminary disclosure of other gas suppliers to the Mackenzie Gas Project has not yet been filed. Details about further gas production linked to the project are therefore also not yet known. Such production would generally include well pads, conditioning facilities, gathering pipelines and winter or all-weather access roads. Proponents could include any of the current lease holders, and possibly new lease holders, in the Mackenzie-Beaufort, Mackenzie Valley and Yukon regions.

Details about exploratory drilling or geophysical programs are also not known. Such projects would generally include 2-D or 3-D seismic and delineation drilling.

The assessment of potential effects resulting from hypothetical projects focuses on hydrocarbon developments and infrastructure; in particular, transportation and communication developments.

Not included are downstream uses that consume gas produced by the Mackenzie Gas Project, either to northern markets, e.g., for domestic use, or to southern markets. Delivery of gas to southern markets begins at the interconnect between the project and the existing gas pipeline system in northern Alberta, after which gas is distributed as dictated by that system's demands. Assessment of subsequent downstream uses is considered outside the scope of this assessment.

12.1.7 Assessment Method

12.1.7.1 Past, Current and Reasonably Foreseeable Land Uses

Potential cumulative effects of the Mackenzie Gas Project and past, current and reasonably foreseeable land uses are assessed in Section 12.2, Effects of Land Use. Cumulative effects are assessed on key indicators (KIs) or VCs that the project-specific assessment predicted (Sections 2 to 10) could have a residual effect from the project and could also be affected by other land uses. Land uses that could interact in this way were identified by reviewing available maps, the project inclusion list (see Appendix A) and any other available information.

Generally, effects of most Mackenzie Gas Project components, such as pipeline segments and infrastructure, are in relatively undisturbed areas and are not expected to act cumulatively with effects from other land uses. This is because there are no other land uses to interact with and because of the limited duration and geographic extent of the project effects. For example, a relatively small effect of a previous land use, such as a pipeline watercourse crossing, would not act cumulatively with a project effect if there has been sufficient time between the developments for the habitat and fish populations to fully recover. Similarly, small effects that affect localized wildlife populations would not act cumulatively if the geographic extent of the populations did not overlap.

Cumulative effects are assessed quantitatively, if possible. Otherwise, they are assessed qualitatively. Distinctions are not made between various categories of effects, e.g., additive or synergistic. The ability to discern between these is rarely possible or useful in current assessment practice except for clearly unique cause-effect relationships, such as the chemical interaction of contaminants with organisms.

For further discussion of assessment methods, see Volume 1, Section 2, Assessment Method.

12.1.7.2 Hypothetical Land Uses

Potential cumulative effects of the Mackenzie Gas Project and hypothetical land uses are assessed in Section 12.3, Effects of Hypothetical Projects. Cumulative effects are assessed qualitatively based on possible future scenarios. Effects are not assessed quantitatively because of the considerable uncertainty in characterizing specific project details, e.g., location, footprint and equipment. This approach is based on the view that a useful and meaningful cumulative effects assessment for future projects is best accomplished by giving useful information to communities, government and regulators to assist their decision-making about land and resource management options.

In most cases, a detailed numerical analysis is not required because of the uncertainties involved, nor is an evaluation of project significance required. This approach is considered a reasonable interpretation of federal guidelines regarding the assessment of hypothetical projects (Hegmann et al. 1999; CEAA 1999).

Landscape-scale models that forecast land use change and predict potential effects based on possible future scenarios are not readily applied to project-specific CEAs and the Mackenzie Gas Project in particular because of the:

- limited spatial extent of the project at any point along the pipeline routes
- limited level of current and reasonably foreseeable land uses
- uncertainty and lack of detail about hypothetical projects

As these models require clearly defined land use footprints, quantitative analysis of conjectured projects is more suitable as part of regional land use planning and other similar initiatives.

However, assessment of cumulative effects for hypothetical projects is done in recognition of the interest of northern residents in possible future outcomes if the Mackenzie Gas Project were to proceed, particularly their interest in future potential hydrocarbon development.

12.1.7.3 Significance

Class Approach

The evaluation of cumulative effects significance uses three *classes* (adopted from AXYS 2002), based on concepts used to evaluate project-specific effects attributes. These classes provide a more meaningful evaluation of significance than the project-specific assessment does because the lack of available information and uncertainty in data and analysis do not allow meaningful ranking of effects attributes, given the complexities of interacting effects and large spatial scales involved.

The class approach is based on a professional judgement interpretation of whether long-term and regional effects on KIs or VCs are currently or could become a management concern, depending on whether their current state is or could become unacceptable and require action to address the effects.

The classes are:

- Class 1: the predicted trend in the KI or VC under projected levels of development could threaten its sustainability in the RSA and should be considered a management concern. Research, monitoring and recovery initiatives should be considered under an integrated resource management framework.
- Class 2: the predicted trend in the KI or VC under projected levels of development will likely result in its decline to lower than baseline, but stable, levels or quality in the RSA after Mackenzie Gas Project decommissioning and abandonment, and into the foreseeable future. Regional management actions such as research, monitoring and recovery might be required if additional land use activities are proposed for the study area before project closure.
- Class 3: the predicted trend in the KI or VC under projected levels of development could result in no change or could decline in the RSA during the life of the Mackenzie Gas Project, but its level or quality should recover to baseline after decommissioning and abandonment. No immediate management initiatives, other than requirements for responsible industrial operational practices, are required.

Class 1 represents effects of most concern, and typically leads to a conclusion of *significant effect*. Classes 2 and 3 represent effects of less concern and typically lead to a conclusion of *not significant* effects.

Regional Context

Opportunities to establish a meaningful regional context, for the purposes of evaluating significance in a cumulative effects assessment (CEA), include:

- thresholds – exist for some air- and water-based constituents and are applied as appropriate to the air- and water-based disciplines. Wildlife-based thresholds are evolving and in some cases being considered or implemented in land use planning and regulatory review, e.g., in the Cameron Hills (MVERIB 2004). Habitat-based thresholds are identified and used in the assessment of cumulative effects on wildlife habitat availability (see Section 12.2.9.3, Habitat Availability) and mortality (see Section 12.2.9.5, Mortality).

- regional frameworks and studies – the Northwest Territories Cumulative Effects Assessment and Management (CEAM) Strategy and Framework is expected to provide information that will assist in establishing regional context. It is recognized that Section 16.2 of the amended *Canadian Environmental Assessment Act* (November 2003) indicates that such studies "may be taken into account" in considering cumulative effects.

- land use plans – examples of land use planning in the Northwest Territories include the Inuvialuit Community Conservation Plans (IJS 2000), Gwich'in Land Use Plan (GLUPB 2003), Sahtu Preliminary Draft Land Use Plan (SLUPB nd.) and the plan under development by the Deh Cho Land Use Planning Committee. Context for a CEA from these plans and initiatives is provided through the identification of valued environmental features and land use goals. This information can assist in identifying VC, KIs, sensitive areas and land use priorities.

12.2 Effects of Land Use

This section assesses cumulative effects from the Mackenzie Gas Project and past, current and reasonably foreseeable land uses. An assessment is provided for each of the nine biophysical disciplines. Each assessment includes:

- identification of potential interactions, such as interactions between residual effects, and between the project and other land uses, thereby indicating possible cumulative effects
- description of the focus of the assessment, e.g., the VC, KI and associated pathways
- qualitative or quantitative analysis for each of the interacting VCs and KIs
- significance of the project's contribution to cumulative effects and of overall cumulative effects

The class and significance conclusions for all disciplines are summarized in Section 12.2.10, Summary of Cumulative Effects.

12.2.1 Air Quality

12.2.1.1 Potential Interactions

The effect of existing activities on air quality is measured as background concentrations. The addition of these concentrations to predictions from the Mackenzie Gas Project provides the cumulative concentrations. Other reasonably foreseeable projects are distant from the project or have no or negligible emissions, so no additional cumulative effects on air concentrations are expected from those sources.

Therefore, it is possible that residual effects of the project on air quality will interact with other land uses.

12.2.1.2 Focus of Assessment

The assessment of potential cumulative effects for air was quantitative, focusing on modelling of air quality constituents in the northern, central and southern airsheds (see Volume 3, Section 2, Air Quality, Figures 2-2 to 2-4) for the following key indicators:

- sulphur dioxide (SO_2)
- nitrogen dioxide (NO_2)
- carbon monoxide (CO)
- particulate matter ($PM_{2.5}$)
- benzene
- benzene, toluene, ethylbenzene and xylene (BTEX)
- potential acid input (PAI)

12.2.1.3 Northern Airshed

Table 12-2 is a summary of the predicted cumulative airborne concentrations in the northern airshed of the KIs considered in the Mackenzie Gas Project air quality assessment. All the cumulative key air indicator concentrations were below their respective guideline levels.

Table 12-3 is a summary of the cumulative potential acid input (PAI) predictions for the northern airshed. Background levels of acid-forming compounds in the northern airshed are the result of long-range transport of sulphur and nitrogen compounds from large industrial facilities elsewhere in the northern hemisphere. None of the cumulative maximum PAI values exceeded 0.25 keq/ha/a, and none of the area PAI values exceeded 0.17 keq/ha/a.

12.2.1.4 Central Airshed

Table 12-4 is a summary of the cumulative air concentrations in the central airshed for the KIs considered in the Mackenzie Gas Project air quality assessment. All cumulative predictions for the key indicators were less than guideline levels.

Table 12-5 is a summary of the cumulative PAI predictions in the central airshed. None of the cumulative area PAI predictions exceeded the Clean Air Strategic Alliance (CASA 1999) critical load of 0.25 keq/ha/a for sensitive ecosystems, and none of the PAI values exceeded the CASA monitoring load of 0.17 keq/ha/a. This load is the level of acid deposition that should trigger monitoring or research. The peak PAI values exceeded 0.25 keq/ha/a, though the management numbers described in the CASA framework were not developed to manage PAI on a local scale.

A conservative methodology was applied to determine the magnitude of Mackenzie Gas Project effects of PAI. An *area* PAI was calculated by averaging the PAI predictions over the local study area. The area PAI predictions were then compared with the CASA monitoring and critical load values for ecosystems with a high sensitivity, even though some of the areas affected could have low sensitivity. Table 12-5 suggests maximum local PAI values near the facilities could exceed 0.25 or 0.17 keq/ha/a. However, the size of the area where these PAI values occur is well below the monitoring and critical load guideline values recommended by CASA for sensitive ecosystems.

Table 12-2: Cumulative Air Predictions in the Northern Airshed

Key Indicator	Criterion	Key Indicator Concentration (µg/m³)											
		Niglintgak (Land-Based Option)			Taglu			Parsons Lake			Inuvik Area Facility		
		Background	Project	Cumulative	Background	Project	Cumulative	Background	Project	Cumulative	Background	Project	Cumulative
1-hour SO_2	450[a]	0.5	6.2	6.7	0.5	2.2	2.7	0.5	10.3	10.8	0.5	5.5	6.0
24-hour SO_2	150[a]	0.5	1.5	2.0	0.5	0.4	0.9	0.5	3.3	3.8	0.5	1.7	2.2
Annual SO_2	30[a]	0.5	0.1	0.6	0.5	0.0	0.5	0.5	0.1	0.6	0.5	0.2	0.7
1-hour NO_2	400[b]	0.9	147.2	148.1	0.9	158.0	158.9	0.9	285.3	286.2	0.9	227.2	228.1
24-hour NO_2	200[b]	0.9	33.6	34.5	0.9	54.5	55.4	0.9	92.1	93.0	0.9	38.9	39.8
Annual NO_2	100[b]	0.9	3.9	4.8	0.9	2.7	3.6	0.9	4.5	5.4	0.9	17.7	18.6
1-hour CO	15,000[b]	0.0	777.4	777.4	0.0	752.9	752.9	0.0	1,290.0	1,290.0	0.0	705.9	705.9
8-hour CO	6,000[b]	0.0	315.0	315.0	0.0	333.8	333.0	0.0	813.4	813.4	0.0	269.7	269.7
24-hour $PM_{2.5}$	30[a]	0.0	9.9	9.9	0.0	1.5	1.5	0.0	8.6	8.6	0.0	12.3	12.3
1-hour benzene	30[c]	3.0	0.1	3.1	3.0	0.6	3.6	2.6	0.9	3.5	2.6	0.1	2.7
1-hour total BTEX	30[d]	4.9	2.3	7.2	4.9	1.4	6.3	3.7	3.7	7.4	3.7	1.2	4.9

NOTES:
BTEX = benzene, toluene, ethyl-benzene and xylene
a *Northwest Territories Ambient Air Standards* (RWED 2002)
b *Federal Ambient Air Quality Objectives* as set out in *The Clear Air Act* (Environment Canada 1981)
c *Alberta Ambient Air Quality Guidelines* (AENV 2000)
d *Alberta Ambient Air Quality Guidelines* (AENV 2000) value for benzene was used for BTEX because it is the most stringent of available criteria

Table 12-3: Cumulative Potential Acid Input Predictions in the Northern Airshed

Area	Parameter	Results		
		Background	Project	Cumulative
Niglintgak (land-based option)	Maximum PAI[1] (keq/ha/a)	0.03	0.18	0.21
	Area PAI (keq/ha/a)	0.03	0.006	0.036
	Maximum sulphate deposition[2] (kg/ha/a)	0.96	0.07	1.03
	Maximum nitrate deposition[3] (kg/ha/a)	0.62	11.31	11.93
	Area with PAI >0.17 keq/ha/a (ha)	0	0	0
	Area with PAI >0.25 keq/ha/a (ha)	0	0	0
Taglu	Maximum PAI[1] (keq/ha/a)	0.03	0.05	0.08
	Area PAI (keq/ha/a)	0.03	0.005	0.035
	Maximum sulphate deposition[2] (kg/ha/a)	0.96	0.05	1.01
	Maximum nitrate deposition[3] (kg/ha/a)	0.62	3.35	3.97
	Area with PAI >0.17 keq/ha/a (ha)	0	0	0
	Area with PAI >0.25 keq/ha/a (ha)	0	0	0
Parsons Lake	Maximum PAI[1] (keq/ha/a)	0.03	0.13	0.16
	Area PAI (keq/ha/a)	0.03	0.006	0.036
	Maximum sulphate deposition[2] (kg/ha/a)	0.96	0.05	1.01
	Maximum nitrate deposition[3] (kg/ha/a)	0.62	7.88	8.50
	Area with PAI >0.17 keq/ha/a (ha)	0	0	0
	Area with PAI >0.25 keq/ha/a (ha)	0	0	0
Inuvik area facility	Maximum PAI[1] (keq/ha/a)	0.03	0.10	0.13
	Area PAI (keq/ha/a)	0.03	0.000	0.030
	Maximum sulphate deposition[2] (kg/ha/a)	0.96	0.08	1.04
	Maximum nitrate deposition[3] (kg/ha/a)	0.62	6.06	6.68
	Area with PAI >0.17 keq/ha/a (ha)	0	0	0
	Area with PAI >0.25 keq/ha/a (ha)	0	0	0

NOTES:

1 PAI predictions include a background value of 0.03 keq/ha/a derived from monitoring at Snare Rapids, Northwest Territories (Golder and Conor Pacific 1998)

2 Sulphate deposition predictions include a background value of 0.96 kg/ha/a derived from monitoring at Snare Rapids, Northwest Territories (Golder and Conor Pacific 1998)

3 Nitrate deposition predictions include a background value of 0.62 kg/ha/a derived from monitoring at Snare Rapids, Northwest Territories (Golder and Conor Pacific 1998)

Table 12-4: Cumulative Air Predictions in the Central Airshed

Key Indicator	Criterion	Key Indicator Concentration (µg/m³)					
		Little Chicago Compressor Station			Norman Wells Compressor Station		
		Background	Project	Cumulative	Background	Project	Cumulative
1-hour SO_2	450[a]	0.5	6.5	7.0	0.5	3.8	4.3
24-hour SO_2	150[a]	0.5	1.4	1.9	0.5	0.8	1.3
Annual SO_2	30[a]	0.5	0.2	0.7	0.5	0.1	0.6
1-hour NO_2	400[b]	0.9	254.5	255.4	0.9	151.9	152.8
24-hour NO_2	200[b]	0.9	109.2	110.1	0.9	47.3	48.2
Annual NO_2	100[b]	0.9	9.8	10.7	0.9	6.2	7.1
1-hour CO	15,000[b]	0.0	483.7	483.7	0.0	699.2	699.2
8-hour CO	6,000[b]	0.0	121.0	121.0	0.0	300.1	300.1
24-hour $PM_{2.5}$	30[a]	0.0	2.0	2.0	0.0	6.7	6.7
1-hour benzene	30[c]	2.6	0.2	2.8	2.6	0.5	3.1
1-hour total BTEX	30[d]	3.7	1.0	4.7	3.7	1.2	4.9

NOTES:
BTEX = benzene, toluene, ethyl-benzene and xylene
a *Northwest Territories Ambient Air Standards* (RWED 2002)
b *Federal Ambient Air Quality Objectives* (Environment Canada 1981)
c *Alberta Ambient Air Quality Guidelines* (AENV 2000)
d *Alberta Ambient Air Quality Guidelines* (AENV 2000) value for benzene was used for BTEX as it is the most stringent of available criteria

12.2.1.5 Southern Airshed

Table 12-6 is a summary of the cumulative air concentrations in the southern airshed for the key indicators considered in the air quality assessment. None of the cumulative predictions exceeded guideline levels.

Table 12-7 is a summary of the cumulative PAI predictions in the southern airshed. The area PAI predictions at all locations are below the CASA monitoring load of 0.17 keq/ha/a.

Table 12-5: Cumulative Potential Acid Input Predictions in the Central Airshed

Area	Parameter	Results		
		Background	Project	Cumulative
Little Chicago compressor station	Maximum PAI[1] (keq/ha/a)	0.03	2.21	2.24
	Area PAI (keq/ha/a)	0.03	0.007	0.037
	Maximum sulphate deposition[2] (kg/ha/a)	0.96	0.40	1.36
	Maximum nitrate deposition[3] (kg/ha/a)	0.62	136.26	136.88
	Area with PAI >0.17 keq/ha/a (ha)	0	45	71
	Area with PAI >0.25 keq/ha/a (ha)	0	18	25
Norman Wells compressor station	Maximum PAI[1] (keq/ha/a)	0.03	1.33	1.36
	Area PAI (keq/ha/a)	0.03	0.008	0.038
	Maximum sulphate deposition[2] (kg/ha/a)	0.96	0.26	1.22
	Maximum nitrate deposition[3] (kg/ha/a)	0.62	82.12	82.74
	Area with PAI >0.17 keq/ha/a (ha)	0	25	37
	Area with PAI >0.25 keq/ha/a (ha)	0	12	16

NOTES:
1 PAI predictions include a background value of 0.03 keq/ha/a derived from monitoring at Snare Rapids, Northwest Territories (Golder and Conor Pacific 1998)
2 Sulphate deposition predictions include a background value of 0.96 kg/ha/a derived from monitoring at Snare Rapids, Northwest Territories (Golder and Conor Pacific 1998)
3 Nitrate deposition predictions include a background value of 0.62 kg/ha/a derived from monitoring at Snare Rapids, Northwest Territories (Golder and Conor Pacific 1998)

12.2.1.6 Significance

The significance of the Mackenzie Gas Project contribution to cumulative effects on air quality is Class 3, i.e., not significant.

The significance of overall cumulative effects on air quality is Class 3, i.e., not significant.

12.2.2 Noise

12.2.2.1 Potential Interactions

Noise levels from a facility will generally be inaudible within a few kilometres of the site. Therefore, for cumulative effects to occur, other land uses must be near the Mackenzie Gas Project.

As the project is generally remote from all current and reasonably foreseeable human sources of noise, cumulative noise effects would not occur except near Norman Wells. There, the proposed pipeline corridor facility is located near an existing Imperial Oil facility and the Norman Wells airport. Therefore, it is likely that residual effects of the project on noise will interact with other land uses.

Table 12-6: Cumulative Air Predictions in the Southern Airshed

Key Indicator	Criterion	Key Indicator Concentration ($\mu g/m^3$)											
		Blackwater River Compressor Station			Trail River Compressor Station			Trout River Heater Station			NGTL[1] Interconnect Facility		
		Background	Project	Cumulative	Background	Project	Cumulative	Background	Project	Cumulative	Background	Project	Cumulative
1-hour SO_2	450[a]	0.5	3.8	4.3	0.5	5.9	6.4	0.5	1.5	2.0	0.5	2.1	2.6
24-hour SO_2	150[a]	0.5	1.2	1.7	0.5	1.8	2.3	0.5	0.4	0.9	0.5	0.5	1.0
Annual SO_2	30[a]	0.5	0.2	0.7	0.5	0.2	0.7	0.5	0.1	0.6	0.5	0.1	0.6
1-hour NO_2	400[b]	0.9	132.6	133.5	0.9	150.4	151.3	0.9	91.2	92.1	0.9	126.0	126.9
24-hour NO_2	200[b]	0.9	38.9	39.8	0.9	41.9	42.8	0.9	41.5	42.4	0.9	51.1	52.0
Annual NO_2	100[b]	0.9	5.8	6.7	0.9	5.4	6.3	0.9	3.1	4.0	0.9	3.4	4.3
1-hour CO	15,000[b]	0.0	585.0	585.0	0.0	751.3	751.3	0.0	197.2	197.2	0.0	284.4	284.4
8-hour CO	6,000[b]	0.0	316.2	316.2	0.0	368.6	368.6	0.0	83.2	83.2	0.0	104.2	104.2
24-hour $PM_{2.5}$	30[a]	0.0	9.5	9.5	0.0	12.1	12.1	0.0	2.8	2.8	0.0	3.1	3.1
1-hour benzene	30[c]	2.6	0.4	3.0	2.6	0.5	3.1	2.6	0.0	2.6	2.6	0.0	2.6
1-hour total BTEX	30[d]	3.7	1.0	4.7	3.7	1.3	5.0	3.7	0.1	3.8	3.7	0.1	3.8

NOTES:
BTEX = benzene, toluene, ethyl-benzene and xylene
a *Northwest Territories Ambient Air Standards* (RWED 2002)
b *Federal Ambient Air Quality Objectives* (Environment Canada 1981)
c *Alberta Ambient Air Quality Guidelines* (AENV 2000)
d *Alberta Ambient Air Quality Guidelines* (AENV 2000) value for benzene was used for BTEX as it is the most stringent of available criteria
1 NOVA Gas Transmission Ltd.

Table 12-7: Cumulative Potential Acid Input Predictions in the Southern Airshed

Area	Parameter	Results		
		Background	Project	Cumulative
Blackwater River compressor station	Maximum PAI[1] (keq/ha/a)	0.03	1.20	1.23
	Area PAI (keq/ha/a)	0.03	0.009	0.039
	Maximum sulphate deposition[2] (kg/ha/a)	0.96	0.41	1.37
	Maximum nitrate deposition[3] (kg/ha/a)	0.62	73.73	74.35
	Area with PAI >0.17 keq/ha/a (ha)	0	23	34
	Area with PAI >0.25 keq/ha/a (ha)	0	10	14
Trail River compressor station	Maximum PAI[1] (keq/ha/a)	0.03	1.11	1.14
	Area PAI (keq/ha/a)	0.03	0.008	0.038
	Maximum sulphate deposition[2] (kg/ha/a)	0.96	0.46	1.42
	Maximum nitrate deposition[3] (kg/ha/a)	0.62	68.05	68.67
	Area with PAI >0.17 keq/ha/a (ha)	0	23	34
	Area with PAI >0.25 keq/ha/a (ha)	0	10	14
Trout River heater station	Maximum PAI[1] (keq/ha/a)	0.03	0.49	0.52
	Area PAI (keq/ha/a)	0.03	0.006	0.036
	Maximum sulphate deposition[2] (kg/ha/a)	0.96	0.10	1.06
	Maximum nitrate deposition[3] (kg/ha/a)	0.62	30.39	31.01
	Area with PAI >0.17 keq/ha/a (ha)	0	35	54
	Area with PAI >0.25 keq/ha/a (ha)	0	14	20
NGTL[4] interconnect facility	Maximum PAI[1] (keq/ha/a)	0.03	0.49	0.52
	Area PAI (keq/ha/a)	0.03	0.009	0.039
	Maximum sulphate deposition[2] (kg/ha/a)	0.96	0.11	1.07
	Maximum nitrate deposition[3] (kg/ha/a)	0.62	30.18	30.80
	Area with PAI >0.17 keq/ha/a (ha)	0	43	71
	Area with PAI >0.25 keq/ha/a (ha)	0	16	23

NOTES:
1 PAI predictions include a background value of 0.03 keq/ha/a derived from monitoring at Snare Rapids, Northwest Territories (Golder and Conor Pacific 1998)
2 Sulphate deposition predictions include a background value of 0.96 kg/ha/a derived from monitoring at Snare Rapids, Northwest Territories (Golder and Conor Pacific 1998)
3 Nitrate deposition predictions include a background value of 0.62 kg/ha/a derived from monitoring at Snare Rapids, Northwest Territories (Golder and Conor Pacific 1998)
4 NOVA Gas Transmission Ltd.

12.2.2.2 Focus of Assessment

The assessment of potential cumulative effects for noise is qualitative and focuses on the key indicator of sound level.

12.2.2.3 Sound Levels

Although the potential for cumulative noise effects exists at Norman Wells, measured baseline sound levels are low, averaging 32 dBA, including the contribution of the Imperial Oil facility and Norman Wells airport. The location of the baseline sound survey was 1 km from the proposed compressor station site and about 1.5 km west of an existing Imperial Oil facility, on the north side of Norman Wells. The monitoring location was about 5 km from the Norman Wells airport.

Noise from the Imperial Oil facility was generally inaudible at the measurement location, with the exception of low-frequency noise at night. The measured existing sound levels are low and consistent with an average rural ambient noise level of 35 dBA. Therefore, noise cumulative effects do not occur at Norman Wells.

12.2.2.4 Significance

There are no cumulative effects for noise.

12.2.3 Groundwater

12.2.3.1 Potential Interactions

Land uses that could reduce recharge to the groundwater system that are located in the same groundwater flow system have the potential to act cumulatively. Borrow site development is an example of such land use. There are only two areas, at Norman Wells and south of Wrigley, where proposed Mackenzie Gas Project borrow sites could be in the same groundwater flow system as existing borrow sites.

Other Mackenzie Gas Project components that could affect the same groundwater systems as other land uses are pipeline and road segments within existing developments, particularly linear features, camps, borrow sites, airstrips and helipads.

Therefore, it is likely that residual effects of the Mackenzie Gas Project on groundwater will interact with other land uses.

12.2.3.2 Focus of Assessment

The assessment of potential cumulative effects for groundwater is qualitative and focuses on the following key indicators:

- groundwater quantity and flow patterns
- groundwater quality

12.2.3.3 Groundwater Quantity and Flow Patterns

Changes in groundwater quantity and flow patterns could occur through changes in surface water flow patterns, interference with groundwater discharge areas or shallow groundwater flow and changes in permafrost distribution. Effects of the Mackenzie Gas Project on groundwater quantity and flow patterns could be cumulative where existing disturbances and project disturbances share a common area.

Changes in Recharge to Groundwater

Existing borrow sites near Norman Wells and south of Wrigley are near several proposed Mackenzie Gas Project borrow sites, within 4 km of the Mackenzie River. Both surface water and groundwater flow from these areas is expected to be toward the Mackenzie River. Removal of materials from the borrow sites has the potential to increase surface runoff and decrease recharge to groundwater aquifers. The net effect at the Mackenzie River would be expected to be zero as both shallow groundwater and surface water runoff would discharge into the Mackenzie and the only difference could be a change in the proportion of surface water versus groundwater volumes recharging the river.

Effects predicted for Mackenzie Gas Project activities related to borrow sites are low to medium. The cumulative effect of existing and project activities is not expected to substantially increase the magnitude of potential changes in groundwater quantity and flow patterns. Therefore the cumulative effects are expected to be similar to predicted project effects.

Significance

The significance of the Mackenzie Gas Project contribution to cumulative effects on groundwater quantity and flow patterns is Class 3, not significant.

The significance of overall cumulative effects on groundwater quantity and flow patterns is Class 3, not significant.

12.2.3.4 Groundwater Quality

Effects to groundwater quality from the Mackenzie Gas Project are expected to be low and local, and are not expected to affect the same groundwater systems as other land uses. Therefore project activities are not expected to contribute to cumulative effects.

Significance

The significance of the Mackenzie Gas Project contribution to cumulative effects on groundwater quality is Class 3, not significant.

The significance of overall cumulative effects on groundwater quality is Class 3, not significant.

12.2.4 Hydrology

12.2.4.1 Potential Interactions

Effects of the Mackenzie Gas Project on hydrology could interact with the effects from the land uses described in Section 12.2.3, Groundwater. As effects on hydrology likely will vary depending on the specific project component, the following assessment is organized by project component or activity with the potential to contribute to a measurable cumulative effect.

12.2.4.2 Focus of Assessment

The assessment of potential cumulative effects for hydrology is qualitative and focuses on the following KIs and VCs:

- runoff amount and drainage pattern
- water levels and flow velocity
- sediment concentration
- channel morphology

12.2.4.3 Runoff Amount and Drainage Patterns

Rights-of Way

The pipeline corridor is adjacent to the Enbridge pipeline for parts of the route between Norman Wells and the Alberta boundary. The length of adjacent line, about 400 km, is 33% of the proposed 1,200 km-pipeline corridor. The Enbridge pipeline corridor was reclaimed after operations began in 1985, and surface runoff and drainage patterns have mostly returned to stabilized conditions. Cumulative effects on runoff amount with effects from the Enbridge pipeline are therefore likely negligible.

The gathering pipeline will be separated from the existing Ikhil pipeline by more than 10 km. This will limit cumulative effects on runoff amount and drainage patterns to a negligible amount.

The Mackenzie Gas Project could result in cumulative effects associated with forestry, both present and future harvesting, where project disturbances are within a harvested basin. Although the location and size of timber harvesting areas associated with two small sawmills near Fort Good Hope and Fort Simpson are unknown, project disturbances in a given basin would likely be small compared with the harvested area. The project’s contribution to cumulative effects on runoff amount and drainage patterns is therefore expected to be undetectable to low.

The project might result in cumulative effects on runoff and drainage patterns where project-specific effects coincide with effects from reasonably foreseeable projects. However, none of the reasonably foreseeable projects are near land-based project developments, so no cumulative effects are expected.

These observations on the contribution to cumulative effects on runoff and drainage patterns of reasonably foreseeable projects apply to camps, borrow sites, airstrips and helipads.

Camps

The proposed Mackenzie Gas Project camps at Swimming Point, Lucas Point, Tununuk Point (Bar-C), Inuvik and Camp Farewell will be developed by expanding existing facilities. The cumulative effect on runoff amount and drainage patterns from the expansions will be proportional to the increase in disturbed area. Because runoff and drainage from these locations is dispersed into Mackenzie Delta channels, any potential increase would be negligible relative to the flow in large channels. Cumulative effects on runoff and drainage patterns are therefore expected to be undetectable.

Borrow Sites

Cumulative effects on runoff and drainage patterns could also be caused by Mackenzie Gas Project camps:

- near an old borrow site at Fort Good Hope
- beside a gravel road at Norman Wells
- near a clearing and the existing ferry landing at Camsell Bend
- beside the Mackenzie Highway
- west of the existing Enbridge pump station at McGill Station

The magnitude of these effects will depend on the increase in basin disturbance. Project-related disturbances at these locations are assumed to represent most of the basin disturbance, so cumulative effects will be only slightly greater than predicted project-related effects alone. Because project-related effects on runoff at these sites are low to moderate, cumulative effects from possible interactions of the project with other disturbances could also be low to moderate.

Most of the proposed 70 borrow sites will be new. Expansion of existing borrow sites would cause additional disturbance. It is assumed that the total disturbance at each site will be 10 ha, including both the existing disturbance and the expansion area. As a result, cumulative effects on runoff will be equivalent to project-related effects alone and are expected to be low at all sites. The effects of the expanded sites on drainage patterns are expected to be low relative to existing conditions because drainage to natural receiving waterbodies will be maintained.

Airstrips and Helipads

Cumulative effects on runoff amounts will occur at sites where existing airstrip and helipad facilities will be extended and widened. As a conservative assumption, these existing sites were treated as new disturbance sites in the project effects assessment. Project-related effects ranged from low to moderate. The cumulative effects of site development in areas of existing disturbance will be less than the project-related effects alone where new development was assumed. As a result, cumulative effects on runoff amount at the expanded sites are expected to remain low to moderate. Where there are no existing helipads and airstrips, new facilities are not expected to cause cumulative effects on runoff amount.

The proposed expansions would cause cumulative effects on drainage patterns at these sites, though the effects are expected to be low relative to existing conditions because drainage to natural receiving waterbodies will be maintained.

Significance

The significance of the Mackenzie Gas Project contribution to cumulative effects on runoff amount and drainage patterns is Class 3, not significant.

The significance of overall cumulative effects on runoff amount and drainage patterns is Class 3, not significant.

12.2.4.4 Water Levels and Velocities

Watercourse Crossings and Bridges

The effects of existing roads, bridges and culverts on water levels and velocities are measurable only locally in that the effects do not extend to the regional study area. Proposed pipeline watercourse crossings might act cumulatively on water levels and velocities if they are near existing road crossings. Cumulative effects would only occur during pipeline crossing construction when flow could be disrupted for a short period. Locations and magnitude of cumulative effects would depend on proximity to existing crossings, stream size, flow during construction and the crossing method used.

Proposed road crossings would act cumulatively on water levels and velocities if they were within the zone of influence of existing road crossings. Based on available mapping, there are few Mackenzie Gas Project roads near existing roads, so the cumulative effects on water levels and velocities are expected to be negligible.

A new bridge across the Mackenzie River near Fort Providence will likely have a localized effect on water levels, surface water flow and velocities in the river. There is potential for cumulative effects if these effects extend to areas affected by the proposed project. The Mackenzie Gas Project component nearest the bridge, however, is a pipeline crossing near Fort Simpson about 240 km downstream. Any localized effects on water levels and velocities from the bridge would not extend such a distance downstream, so no cumulative effects are expected.

Permanent Mackenzie Valley winter road bridge crossings could obstruct flow and have a local effect on water level, stream flow and velocities. The project could result in cumulative effects on water levels, flow and velocities during construction of pipeline watercourse crossings, depending on the crossing locations and the construction method used. Cumulative effects could occur at 13 of 28 watercourse crossings where bridges are within 500 m upstream or downstream of the proposed pipeline corridor. However, the magnitude of cumulative effects is expected to be low to moderate, depending on the amount of flow obstruction and the distance between the bridge and pipeline crossing. Any cumulative effects from in-stream construction activities would be short duration.

Water Withdrawal and Disposal

Cumulative effects could occur on water levels and velocities where water is withdrawn from a single waterbody for multiple purposes, e.g., for potable water, pipeline testing and winter road construction. Cumulative effects would likely be undetectable if the water source was the Mackenzie River or another large waterbody, but could be detectable if there is limited water availability during the withdrawal period, as in smaller waterbodies.

Inuvik is the only settlement in the production area that has measurable water consumption. Water supply for the town is from a nearby lake. Cumulative effects would occur on lake water levels if potable water for the Mackenzie Gas Project is drawn from the same supply and delivered by truck. The estimated potable water requirement during project construction is 363 m^3/d for the Inuvik area facility and the Campbell Lake camp, based on a camp population of 1,600 people. Assuming comparable per capita water requirements, this represents about a 50% increase in water supply from the same source.

Cumulative effects on water levels would depend on currently unknown lake characteristics such as surface area, volume and depth. However, based on water licence requirements, regulatory constraints and the short duration of project withdrawals, any cumulative effects on water levels would likely be undetectable, depending on physical and hydrological lake characteristics.

The only settlements in the pipeline corridor that have a measurable net water consumption are Fort Good Hope, Norman Wells and Fort Simpson. Other smaller communities, such as Trout Lake, Wrigley and Tulita, are assumed to have much smaller consumption. For this assessment, water supplies are assumed to be from the Mackenzie River, where water requirements would be a small fraction of river flow. The potential reduction in river flow would likely not be measurable. Water withdrawal for use at these settlements is a loss from the surface water system in the river and is therefore a cumulative effect, but the magnitude would be undetectable.

Barge Landings and Marine Environment

Cumulative effects on localized flow velocities might occur where the project uses existing or historical barge locations. There are currently 11 permanent and three seasonal locations for temporary spud barges, and six historical seasonal barge landings that could be used by the project. No cumulative effects would be expected at the two new barge landing locations at Taglu and Camsell Bend.

There are several well sites on artificial islands in the Mackenzie River near Norman Wells. These islands have a localized effect on river velocities. The potential for cumulative effects on velocities because of the Mackenzie Gas Project is considered low because there will be no project-related components in the river channel.

The Beaufort Sea Exploratory Drilling Program using offshore well pads will have a localized effect on velocities in those near-shore areas of the delta. However, no Mackenzie Gas Project components occur in the affected areas. Dredging route options for the Niglintgak barge-based gas conditioning facility likely do not exist in these areas. No cumulative effects on water levels and velocities are therefore expected.

Significance

There is a moderate effect at some borrow site locations, however, the significant of the Mackenzie Gas Project contribution to cumulative effects on water levels and velocities is Class 3, not significant.

The significance of overall cumulative effects on water levels and velocities is Class 3, not significant.

12.2.4.5 Sediment Concentration

Pipeline and Road Segments

The interaction of the Mackenzie Gas Project with the Enbridge pipeline and the Ikhil pipeline is the same as described for runoff amount and drainage patterns.

The effects of existing roads, bridges and culverts on sediment concentrations are only measurable locally. Proposed pipeline watercourse crossings can act cumulatively on sediment concentration if they are near existing road crossings. Cumulative effects would only occur during pipeline crossing construction during the short period when sediment is mobilized. Locations and magnitude of cumulative effects would depend on proximity to the existing crossing and on the amount of sediment mobilized, which depends on stream size, flow during construction and the crossing method used.

Proposed road crossings could act cumulatively on sediment concentrations if they are within the zone of influence of existing road crossings. Based on available mapping, there are few Mackenzie Gas Project roads near existing roads, so the cumulative effects on sediment concentrations are expected to be negligible.

Potential interaction with reasonably foreseeable land uses is the same for sediment concentration as for water levels and velocities.

Camps, Borrow Sites, Airstrips and Helipads

Potential interaction with camps, borrow sites, airstrips and helipads is the same as for runoff amount and drainage patterns. Because Mackenzie Gas Project - related effects on runoff at these sites are low, cumulative effects on sediment concentrations will likely remain low.

Barge Landings and Traffic

Cumulative effects for localized sediment concentrations can occur at the same locations as those described for water levels and velocities.

Barge-induced waves and direct disturbance to the riverbed and banks from barge traffic can cause increased sediment concentrations over background levels. Cumulative effects on sediment concentration could result from increased barge traffic related to the project. Assessment of barge-related sediment concentrations indicates that the annual wave energy generated by project barges is less than that from wind waves. The noticeable increase in barge traffic along the Mackenzie River will be limited to Mackenzie Gas Project construction. As a result, cumulative effects on sediment concentrations from barge traffic are considered low during construction and undetectable during operations and decommissioning.

Significance

The significance of the Mackenzie Gas Project contribution to cumulative effects on sediment concentration is Class 3, not significant.

The significance of overall cumulative effects on sediment concentration is Class 3, not significant.

12.2.4.6 Channel Morphology

The key indicators of runoff amount, drainage patterns, water levels and velocities, and sediment concentrations combine to affect channel morphology.

Aside from existing borrow sites, barge landings, airstrips and camps, few Mackenzie Gas Project components or activities on land or in the water would contribute to cumulative effects on channel morphology. The effects of the project will be mostly local and are not expected to act cumulatively because they will not overlap with relatively widespread existing activities.

Where project effects might be regional, as when water levels are changed by withdrawals and sediment is released by dredging, the effects are either low in magnitude relative to the large stream channels involved or they affect only a small portion of the channel for a short period, as with dredging at barge landings or for navigation. Changes in channel discharges that are a small fraction of Mackenzie River flow will not change channel morphology.

Similarly, regional changes in sediment concentrations are expected only intermittently and along a limited length of one channel of the Mackenzie River during dredging. Existing and proposed dredging to improve navigation might affect a larger proportion of the channel width, but the effects would be of short duration and at isolated locations. Potential changes in sediment concentration are expected to cause negligible changes in channel morphology. A marked change in sediment concentration across the entire channel width for extended periods (years) and over extensive channel reaches would be required to affect stream morphology.

There are limited cumulative effects of the project with other reasonably foreseeable land uses because of the large distances separating from those other land uses. Although the proposed pipeline is within 500 m of 13 watercourse crossings along the Mackenzie Valley winter road, any effects on water levels, surface water flow, velocities and sediment concentrations are expected to be limited to the short construction period. As these changes will not be sustained over a long period, no overall or cumulative changes in channel morphology are expected.

Significance

The significance of the Mackenzie Gas Project contribution to cumulative effects on channel morphology is Class 3, not significant.

The significance of overall cumulative effects on channel morphology is Class 3, not significant.

12.2.5 Water Quality

12.2.5.1 Potential Interactions

Effects by the Mackenzie Gas Project on water quality could interact with effects from the land uses described in Section 12.2.3, Groundwater.

Therefore, it is likely that residual effects of the project on water quality will interact with other land use effects.

12.2.5.2 Focus of Assessment

The assessment of potential cumulative effects for water quality is qualitative and focuses on the VC of water quality using the following key indicators:

- wastewater releases
- suspended sediment

12.2.5.3 Wastewater Releases

Receiving waterbodies for releases of hydrostatic test water and domestic wastewater have not yet been identified. Wastewater will be treated to ensure that effects will be negligible and localized. It is likely that wastewater releases will have negligible potential to contribute to cumulative effects on surface water quality.

Significance

The significance of the Mackenzie Gas Project contribution to cumulative effects on water quality from wastewater releases is Class 3, not significant.

The significance of overall cumulative effects on water quality from wastewater releases is Class 3, not significant.

12.2.5.4 Suspended Sediment

Disturbance of Bottom and Bank Sediments

Niglintgak Barge Option

Predicted effects on water quality from sediment inputs are localized in the near-shore coastal areas of Kugmallit and Kittigazuit bays and in East, Middle and Kumak channels along the proposed dredging routes. There are no other existing or planned activities that could affect water quality by disturbing bottom sediments and suspended sediment inputs. Therefore, cumulative effects on water quality are not expected.

Barge Landings

The Mackenzie Gas Project will use 22 barge landing sites, 11 of which are existing permanent sites. With the exceptions of the Liard River Ferry Crossing and the Hay River barge landing site, barge landings are situated in the Mackenzie River mainstem and delta channels. The only potential for cumulative effects on water quality resulting from disturbance of bottom sediments is from dredging activities at other upstream sites, or from other activities that would cause increased sediment inputs from disturbance of bottom sediments in the Mackenzie River.

Because of the high dilution capacity and high baseline sediment levels of the Mackenzie River, any effects from dredging are not expected to be detectable downstream. Cumulative effects on water quality resulting from disturbance of bottom sediments from dredging at upstream locations are therefore not expected.

The only other regional activity or reasonably foreseeable project with potential to disturb bottom sediments in the Mackenzie River is construction of the Mackenzie River Bridge at Fort Providence. However, as the next downstream barge landing location to be used by the Mackenzie Gas Project is more than 240 km away at Fort Simpson, any effects from bridge construction will not be detectable there. Cumulative effects on water quality resulting from disturbance of bottom sediments by upstream construction activities are therefore not expected.

Barge Traffic

Cumulative effects of barge traffic on sediment concentration are predicted to be low (see Section 12.2.4.5, Sediment Concentration) during construction. Effects on water quality are therefore predicted to be negligible to low during construction and no cumulative effects are predicted during other project phases.

Watercourse Crossings

Cumulative effects of watercourse crossings during pipeline construction on sediment concentration are predicted to be negligible (see Section 12.2.4.5, Sediment Concentration). Effects on water quality are therefore also predicted to be negligible.

Land Disturbance

Cumulative effects of land disturbance on sediment concentration are predicted to be low (see Section 12.2.4.5, Sediment Concentration). Effects on water quality in the form of increased levels of sediment-associated KIs, e.g., nutrients, metals and hydrocarbons, are therefore predicted to be negligible to low.

Significance

The significance of the Mackenzie Gas Project contribution to cumulative effects on suspended sediment is Class 3, not significant.

The significance of overall cumulative effects on suspended sediment is Class 3, not significant.

12.2.6 Fish and Fish Habitat

12.2.6.1 Potential Interactions

Existing infrastructure and land uses might already be affecting fish populations and fish habitat in the local and regional study areas. The following Mackenzie Gas Project components could interact cumulatively with current land uses:

- pipeline and road watercourse crossings near existing pipeline, bridge or winter road crossings
- camps, borrow sites, airstrips and helipads near existing sites and fishbearing waters
- barge landings, site alterations or increased frequency of site use
- potential dredging for the Niglintgak barge-based gas conditioning facility option
- large workforce and new permanent access to fishbearing streams or waterbodies, which could increase fishing pressure and harvest

Most project components are not expected to act cumulatively because any potential interacting effects with most other land uses are limited in duration and spatial extent. However, effects of some project components could interact cumulatively.

Therefore, it is possible that residual effects of the project on fish and fish habitat will interact with other land uses.

12.2.6.2 Focus of Assessment

The assessment of potential cumulative effects of fish and fish habitat is qualitative and focuses on the following key indicators:

- fish habitat (includes channel alteration, sediment entrainment and deposition, frost bulb formation, water withdrawal and land subsidence)
- fish health (includes water quality and sediment)
- fish abundance and distribution

12.2.6.3 Fish Habitat

Overview

Cumulative effects on fish habitat are linked primarily to effects on hydrology, e.g., channel alteration, flow quantity and sediment entrainment, resulting from the project's expansion of existing camps and construction of new camps near existing land uses, development of about 70 borrow sites, most of which are new, and expansion or construction of new helipad and airstrip facilities.

Cumulative effects are expected only at those expansion sites with hydrological effects on fishbearing waters. These effects are predicted to be low relative to existing conditions and measurable only locally.

The loss of riparian habitat because of oil and gas exploration activity, particularly in forested areas, would act cumulatively with any loss resulting from the project. The magnitude of cumulative effects would depend on the characteristics and use of the habitat by biotic systems in affected parts of the channel; however, the extent of lost riparian habitat would typically be small relative to the overall length of stream channel in the RSA.

Watercourse Crossings and Rights-of-Way

Effects of proposed pipeline watercourse crossings on fish habitat could be cumulative if the crossings are near existing pipeline or road crossings that have also affected the same fish habitat in the stream. Cumulative effects could occur during construction from streambed or bank approach alteration, and temporary flow blockages or increased sedimentation. Whether cumulative effects would occur depends on the proximity of the new crossing to the existing crossing, on hydraulic conditions at the site and on the crossing method used. Any cumulative effects from these interactions, however, are expected to be measurable only locally.

Much of the proposed pipeline is beside the existing Enbridge pipeline between Norman Wells and Alberta. Although drainage and surface runoff have mostly stabilized in the reclaimed Enbridge corridor, and hydrologic-related cumulative effects might not occur, the Mackenzie Gas Project right-of-way clearing will cause a cumulative effect because of the alteration and loss of riparian habitat.

Bridges

Permanent bridge crossings built or proposed for the Mackenzie River winter road are expected to cause cumulative hydrologic effects on the quantity of water flow and velocities at 13 of the 28 watercourse crossings where bridges are within 500 m of the pipeline corridor. Cumulative effects on fish habitat might result from hydrologic effects, but would likely only occur if construction activities overlapped. Additional alteration of channel conditions, bank approaches and stabilization of bridge abutments might also cause cumulative effects. Few Mackenzie Gas Project all-weather roads will be near existing roads and are not expected to create a cumulative effect.

The proposed Deh Cho bridge across the Mackenzie River is expected to result in a net benefit to the fish and habitat resources in the area (Golder Associates Ltd. 2004; Andrew Gamble and Associates and Jivko Engineering 2004). Although short-term habitat disturbances are expected during construction, largely from sediment input, these adverse effects will be offset by long-term gains in fish habitat availability resulting from: reduced causeways penetration into the channel, removal of existing ferry landings and staging areas, and subsequent reduction in annual sediment input. Based on the net positive effects expected and the location of the development more than 200 km upstream of the areas affected by the project, no adverse cumulative effects are expected to occur.

Barging

Cumulative effects on fish habitat might occur at existing or historical barge landing locations because of increased Mackenzie Gas Project barge traffic. Effects would be in the form of localized changes in microhabitat flow velocities and localized sediment concentration increases. As most effects will be from increases in barge traffic, cumulative effects are expected to be low during construction and undetectable during other project phases.

Water Use

Cumulative effects on fish and fish habitat could occur if water is withdrawn from a single waterbody for multiple purposes, e.g., for potable water, process water, pipeline hydrostatic testing and ice road construction. There also could be cumulative effects on water levels and surface water flow, which could affect fish habitat, if water is taken from the same or connected waterbodies by existing communities (see Section 12.2.4, Hydrology). However, the selection and use of water supply lakes for the project will conform to water withdrawal protocols (Cott and Moore 2003). This protocol has been designed to protect fish and fish habitat and would presumably limit the total withdrawal by multiple users during the permitting process. Therefore, water withdrawal from lakes should not have a significant cumulative effect on fish or fish habitat.

Significance

The significance of the Mackenzie Gas Project contribution to cumulative effects on fish habitat is Class 3, not significant.

The significance of overall cumulative effects on fish habitat is Class 3, not significant.

12.2.6.4 Fish Health

Wastewater

Wastewater releases by the project will be treated to ensure that the magnitude of effects on receiving aquatic environments will be negligible to low and that the geographic extent will be localized. Consequently, the water quality assessment (see Section 12.2.5, Water Quality) concluded that wastewater releases would have negligible potential for cumulative effects on surface water quality. Based on this assessment, it is unlikely there would be any cumulative effects on fish health from project wastewater discharge combined with other land uses.

Bridges and Rights-of-Way

Exposure to suspended sediment can affect health of fish and other aquatic organisms, with the extent of adverse effects ranging from minor physiological stress to mortality. The magnitude of the effect is a function of the suspended sediment concentration and duration of exposure. Most project effects of increased suspended sediments during construction of the gathering pipelines and pipeline crossings will be short duration and localized within a short distance downstream of the crossing site. Therefore, the likelihood that these effects will be cumulative with other land uses is low, although potential projects such as Mackenzie winter road bridge construction could increase suspended sediment effects if construction is in the same year as the project crossing.

Cumulative effects on fish health resulting from the Deh Cho bridge construction are not expected because the two projects are 200 km apart.

Increased suspended sediment levels would also result from erosion of streambanks and other disturbed lands. Increased sediment loads in surface runoff would continue to occur during Mackenzie Gas Project operations until the banks are stabilized and the disturbed habitat is revegetated. This effect could be cumulative with any increased suspended sediment loads from other existing land uses, such as seismic lines, winter roads or existing pipelines. However, cumulative effects on fish health would likely be negligible because many of the current land uses, such as the Enbridge pipeline and most of the seismic lines, will have revegetated and stabilized so erosion would be low.

Barging

The Niglintgak barge-based gas conditioning facility option could require dredging of bottom sediments in parts of Kugmallit and Kittigazuit bays and in East, Middle and Kumak channels. This would elevate suspended sediment levels in these areas, which could affect fish health, depending on suspended sediment concentrations and duration. Because there are no other existing or planned nonproject-related activities in the local area that would substantially increase suspended sediment levels at the same time of year, there is low potential for cumulative effects on fish health from this project component.

Potential dredging associated with the Niglintgak barge-based option could cause entrainment and mortality of marine and freshwater fish and invertebrates in the Mackenzie estuary and delta channels. However, cumulative effects are not expected because there are no other existing or planned activities that would likely significantly affect fish or invertebrate survival in the same area. This assessment assumes that the route chosen for barge transport and associated dredging would avoid the area of the proposed Beaufort Sea offshore drilling program.

Some dredging or filling might be required at new barge landing sites at Taglu and Niglintgak. In addition, the Mackenzie Gas Project will require upgrading at 15 existing permanent or temporary barge landing sites and installing landings at five existing sites not currently in use. Potential dredging or infilling could increase suspended sediment concentrations downstream of these sites, which could affect fish health. The effect, however, would be low in magnitude, short term and localized. It would likely not be cumulative because any increase in suspended sediment levels at one site would not be detectable at the next downstream site because of dilution in Mackenzie River flow. Cumulative effects with other land uses are not expected because of the short duration of potential effects.

Significance

The significance of the Mackenzie Gas Project contribution to cumulative effects on fish health is Class 3, not significant.

The significance of overall cumulative effects on fish health is Class 3, not significant.

12.2.6.5 Fish Abundance and Distribution

Harvesting

Increased harvest by the Mackenzie Gas Project workforce would not contribute to cumulative effects because of the no-fishing policy that will be enforced while project workers are on-site.

Fish harvest could increase because of possible increased access to fishbearing waterbodies along the pipeline right-of-way, access roads or from camps. As economic activity in the area increases and the need for workers in the service industries in northern communities increases, some workers will come from outside the region. The increase in population will put pressure on recreational resources, including fishing. Much of the increase in workforce will be seasonal, however, typically occurring in winter when conditions are not generally conducive to fishing, although some ice fishing might be done.

Access

Increased access to fishbearing waterbodies along the pipeline corridor and infrastructure access roads could result in an increased fish harvest that would be cumulative with the effects of other land uses. For the sections of pipeline corridor that closely follow the existing Enbridge pipeline or winter road, the effects would not be cumulative because winter access to waterbodies already exists along those corridors. Where the pipeline corridor deviates substantially from the existing winter road or pipeline corridor, it could facilitate winter access to waterbodies that are currently inaccessible. However, this access would be primarily in the winter, so the cumulative effect on fish abundance and distribution would likely be low.

At new or expanded airstrip and helipad locations, which will be accessible during open-water periods, some additional harvest of nearby fish could result from improved access and increased facility use. However, this effect is likely to be low in magnitude, and cumulative effects with existing or future activities are expected to be low.

Significance

Because of the abundance of fishing opportunities and the currently small human population in the region, harvest pressure in most lakes and streams is low. Fish, therefore, could likely withstand any expected additional fish harvest associated with the project, mostly resulting from potential increased access to fishing areas.

The significance of the Mackenzie Gas Project contribution to cumulative effects on fish abundance and distribution is Class 3, not significant.

The significance of overall cumulative effects on fish abundance and distribution is Class 3, not significant.

12.2.7 Soils, Landforms and Permafrost

12.2.7.1 Potential Interactions

The magnitude of existing and expected disturbance on soils and landforms varies with the facility type, activity and mitigation measures.

Seismic lines and winter roads, collectively the largest areas of existing land use, typically cause relatively low levels of disturbance to landform components and indicators. Higher-magnitude existing disturbances, such as towns, all-weather roads, airstrips, structures and gravel extraction collectively are much smaller in area. Existing pipelines combine medium effects on landforms with medium area.

Pipeline rights-of-way cause the most Mackenzie Gas Project disturbance on soils and landforms. The second-largest areas of project disturbance are borrow sites and winter roads. The project's infrastructure and facility sites are the smallest areas of disturbance. Infrastructure sites, such as camps, are temporary. Facility sites cause disturbance over a longer time, and are eventually reclaimed.

The project will be relatively remote from current high-disturbance areas such as towns, highways and structures. The pipelines will likely cross many existing seismic lines and winter roads and will add to the existing low effects in these areas. Facilities with greater effects such as pads and borrow sites will add to existing and new disturbance areas. Infrastructure sites will be on new sites and in areas of existing disturbance.

Existing land uses have affected soil quality by changes in soil drainage, soil loss, and soil physical and chemical characteristics. Effects of disturbance on soil quality are mostly caused by changes in drainage or by loss of soil through burial. Other effects include damming and diversion, thaw settlement and drainage disruption, contamination, replacement of soil with fill, erosion, mixing, soil excavation if salvage is not performed and dust deposition.

Therefore, it is likely that residual effects of the Mackenzie Gas Project on soils, landforms and permafrost will interact with other land uses.

12.2.7.2 Focus of Assessment

The assessment of potential cumulative effects for soils, landforms and permafrost is qualitative and focused on the following valued components:

- ground stability (KIs are drainage, thaw settlement and pond formation, erosion and slope instability)
- uncommon landforms (KIs are pingos, patterned or polygonal ground, and glaciofluvial and aeolian deposits)
- soil quality, (KIs are soil drainage, soil loss, and soil physical and chemical properties)

12.2.7.3 Ground Stability

Mackenzie Gas Project effects might be cumulative with those of existing land uses in common areas. For example, proposed clearing of the pipeline right-of-way will result in increased thaw depth and possibly pond formation, and erosion or slope instability in areas of existing disturbances such as seismic lines or road crossings. The magnitude of effects varies with project component, existing disturbance level and landform conditions. Most areas will experience minor increases in effects.

Reasonably foreseeable bridge installation activities might affect ground stability indicators, but will cover relatively small areas with limited duration effects because of mitigation measures. These effects are relatively small, but they might have a cumulative effect with the effects of the project.

Possible areas of effects from the project and other land uses represent conservative estimates of cumulative effects. Much existing disturbance is considered low in magnitude and occurs in areas where the project will have low to moderate cumulative effects on ground stability.

Significance

The significance of the Mackenzie Gas Project contribution to cumulative effects on ground stability is Class 3, not significant.

The significance of overall cumulative effects on ground stability is Class 3, not significant.

It is possible that VCs and KIs could in some cases not return to predisturbance conditions because of thaw settlement and pond formation. However, the geographic extent of these changes is localized and unlikely to interact cumulatively.

12.2.7.4 Uncommon Landforms

The key indicators of uncommon landforms include features such as pingos, patterned or polygonal ground and glaciofluvial and aeolian deposits. Cumulative changes in these key indicators could occur in areas where Mackenzie Gas Project facilities intersect with other land uses. There is little information about effects of existing and future land uses on these uncommon landforms. Project facilities and activities could result in cumulative effects on the occurrence of patterned ground and granular resource locations. Project facilities will be located to avoid pingos.

Effects on patterned ground will be incrementally small in the Inuvialuit Settlement Region and Gwich'in Settlement Area. Relatively modest effects on granular deposits will occur in all portions of the regional study area.

Reasonably foreseeable bridge construction will likely not affect uncommon landforms.

Possible areas of effects from the project and other land uses represent conservative estimates of cumulative effects. Much existing disturbance is considered low in magnitude and is in areas where the project will cause low to moderate cumulative effects on landforms.

Significance

The significance of the Mackenzie Gas Project contribution to cumulative effects on uncommon landforms is Class 3, not significant.

The significance of overall cumulative effects on uncommon landforms is Class 3, not significant.

It is possible that VCs and KIs could in some cases not return to predisturbance conditions, but the geographic extent of these changes is localized and unlikely to interact cumulatively.

12.2.7.5 Soil Quality

Soil Drainage

Cumulative changes in soil drainage can occur where seismic lines intersect the Mackenzie Gas Project pipelines and facilities. Existing effects on soil quality are minimal in the Tundra Ecological Zone because seismic surveys are done in winter, reducing surface disturbance and requiring generally no or minimal clearing. However, if the seismic survey was done before 1971, when summer operations were allowed, soil quality might have been affected by thaw settlement and erosion. Such sites would likely have stabilized in the past 35 years and will be addressed by project design where they intersect the project.

Cumulative effects on soil quality are likely where seismic lines, all-weather roads and winter roads cross the project pipeline rights-of-way in sensitive landform types. However, cumulative effects are likely negligible because of the small areas affected relative with to distribution of the affected landform types in the RSA.

Soil drainage might also be affected by existing granular pads; e.g., for airstrips, pump stations, wells and all-weather roads. Project disturbance could exacerbate existing changes in soil drainage. Where project pads encompass an existing pad, as on the Taglu and Parsons Lake leases, any existing drainage concerns would be addressed in design of these pads. Granular pads elsewhere are not expected to interact with project developments because existing effects on soil drainage would be localized.

Soil Loss

Soil loss could occur from burial of native soils during construction of granular pads and all-weather roads. Soil might also have been lost from existing disturbances including along existing pipelines where ice-rich soil and subsoil have been replaced by select backfill.

The Mackenzie Gas Project will contribute to cumulative soil loss by burying or replacing native soils in thaw-unstable terrain. However, effects on regional soil distribution are expected to be minor because of the relatively small areas involved.

Soil Physical and Chemical Properties

Existing pipelines, built-up areas and facility sites such as well sites and pump stations, might contain areas of contamination. Contamination can affect soil physical and chemical properties and alter nutrient cycling processes, adversely affecting soil quality. Existing soil contamination is not predicted to interact with project-related contamination because of the localized nature of most leaks and spills.

Dust deposition has the potential to affect soil quality by changing soil physical and chemical characteristics and changing soil drainage. Increased traffic from project activities on existing highways and other permanent roads would increase dust and have a cumulative effect on soil quality. However, effects on soil quality are generally confined to the roadside and are not expected to be measurable at a regional scale.

Continued extraction of granular resources, air emissions from other sources and projects to be developed in the foreseeable future will likely compound these effects. Granular resource extraction will likely increase changes in soil physical and chemical properties.

The cumulative effects of air emissions (see Section 12.2.1, Air Quality) are not expected to exceed guidelines. Therefore, effects on soil quality from air emissions are not predicted.

Bridge construction has the potential to erode soil on and beside riverbanks. Soil physical and chemical properties can be affected by soil erosion, which will be localized at bridge sites and is therefore not expected to interact with the project. Where the winter road and pipeline rights-of-way are beside each other, further surface disturbance from bridge construction might exacerbate soil erosion. However, this will occur on a local scale and can be addressed through mitigation measures.

Significance

The significance of the Mackenzie Gas Project contribution to cumulative effects on soil quality is Class 3, not significant.

The significance of overall cumulative effects on soil quality is Class 3, not significant.

It is possible that VCs and KIs could in some cases not return to predisturbance conditions, For example, there could be changes in soil chemistry from mixing, and changes in the ability of soil to support vegetation. However, the geographic extent of these changes is localized and unlikely to interact cumulatively.

12.2.8 Vegetation

12.2.8.1 Potential Interactions

Existing land uses already cause effects on the abundance, distribution and health of vegetation. Effects of the Mackenzie Gas Project could interact cumulatively with these effects through:

- removal and alteration of vegetation through land clearing
- creation of an edge along cleared areas
- air emissions and dust
- introduction and dispersal of persistent or invasive non-native species
- removal of standing timber
- removal of granular resources
- change in terrain

The effects of reasonably foreseeable developments on vegetation could not be determined quantitatively because no information on the footprint of these potential developments exists. However, it is assumed that development footprints will be small relative to the size of the RSA, suggesting at most a minor contribution to cumulative effects.

Therefore, it is likely that residual effects of the Mackenzie Gas Project on vegetation will interact with other land use effects.

12.2.8.2 Focus of Assessment

The assessment of potential cumulative effects on vegetation is quantitative and qualitative and focuses on the following key indicators:

- abundance and distribution of vegetation species and associations
- health of vegetation species

12.2.8.3 Abundance and Distribution of Vegetation Species and Associations

Effects

The potential effects of the Mackenzie Gas Project on vegetation are:

- permanent reduction in vegetation types, communities and species caused by granular substrate removal

- introduction and dispersal of persistent or invasive non-native species because of reclamation activities, linear corridors and new access roads

Project mitigation will result in low magnitude effects on rare plants and vegetation communities of concern. However, effects on the dry saxifrage tundra vegetation type in the LSA and the equivalent class in the RSA commonly associated with granular substrates, were disproportionately large in the LSA relative to their extent on the landscape. The nonrenewable nature of these vegetation types, their contribution to biodiversity and their association with some rare plant species identifies granular substrate excavation as a particularly important contributor to cumulative effects.

Increased access will increase vegetation disturbance, soil disturbance and dispersal of persistent and invasive non-native species. This will occur through disturbance and dispersal of existing populations of persistent or invasive non-native plant species, through reclamation activities and through unintentional introduction of such species from outside the region.

Recovery

Many existing disturbances are temporary. Revegetation essentially nullifies their effects. However, some vegetation will not recover from disturbance. For example, tall forest and rare plants might not be replaced, and granular substrates excavated for the Mackenzie Gas Project and other projects could also be permanently removed and not available for revegetation despite reclamation efforts.

Duration of an effect on vegetation, which depends on the rate of vegetation recovery, varies with latitude. Vegetation in southern areas of the RSA generally recovers more quickly than in northern areas.

The predicted period (based on project monitoring studies discussed in Volume 3, Section 9, Vegetation) to achieve the reclamation goal of establishing a stabilized surface and native plant community is:

- 10 years after the end of disturbance in the North Taiga Plains and South Taiga Plains ecological zones
- 30 years after the end of disturbance in the Transition Forest and Tundra ecological zones

Cumulative Effects by Ecological Zone

Cumulative effects on vegetation are assessed by comparing areas disturbed with the areal extent of each of the four ecological zones. Table 12-8 shows the extent of the area disturbed by the project for each vegetation class in each ecological zone. Table 12-9 shows current land use disturbances by ecological zone. Table 12-10 shows overall cumulative effects by ecological zone.

Table 12-8: Project Contribution to Cumulative Effects on Vegetation Abundance and Distribution

Ecological Zone	Vegetation Description	Vegetation Class	Baseline Area[3] (ha)	Proportion of Ecological Zone[3] (%)	Project Disturbance Area (ha)	Project Disturbance Proportion of Baseline[4] (%)
Tundra	Dwarf shrub heath	2	267,454	10.62	261.00	0.10
	Riparian shrub	7	240,090	9.53	100.62	0.04
	Upland shrub (all)	3	221,668	8.80	284.85	0.13
	High-centred polygons	5	141,910	5.63	168.21	0.12
	Black spruce/ground birch	h3[2]	93,680	3.72	5.22	0.01
	Low-centred polygons	6	83,647	3.32	52.11	0.06
	Dry saxifrage tundra	1*	72,355	2.87	108.36	0.15
	Riparian sedge–cotton-grass	8*	63,059	2.50	32.22	0.05
	Delta sedge–cotton-grass	10	60,739	2.41	31.50	0.05
	Sedge–cotton-grass tussock	4	55,721	2.21	98.64	0.18
	Delta low-centred polygons	12	55,230	2.19	50.58	0.09
	Delta shrub	9	48,069	1.91	29.07	0.06
	Riparian black spruce/shrub[1]	13*	17,323	0.69	9.09	0.05
	Water emergents	WE	2,760	0.11	0.00	0.00
	Recent burn <2 years since burn	Charred	16	0.00	0.00	0.00
	Totals		1,423,729	56.51	1,231.47	0.09
Transition Forest	Black spruce/ground birch	Th3	257,420	30.30	376.56	0.15
	Recent burn <2 years since burn	Charred	126,163	14.85	0.54	0.00
	Upland black spruce/lichen	Th4	73,541	8.66	100.71	0.14
	Shrub fen	Tk4	58,580	6.90	82.62	0.14
	Black spruce–tamarack	Tg1	45,669	5.38	50.13	0.11
	Upland shrub (all)	3	42,872	5.05	69.39	0.16
		2	38,023	4.48	0.9	0.00
		Td5*	35,252	4.15	30.24	0.09
	Graminoid fen	Tk3	32,803	3.86	58.68	0.18
	Water emergents	WE	20,435	2.41	1.89	0.01
	Black spruce/Labrador tea/cloudberry	Ti3*	14,610	1.72	4.32	0.03
	2–10 years since disturbance	Regen	5,413	0.64	0	0.00

Table 12-8: Project Contribution to Cumulative Effects on Vegetation Abundance and Distribution (cont'd)

Ecological Zone	Vegetation Description	Vegetation Class	Baseline Area[3] (ha)	Proportion of Ecological Zone[3] (%)	Project Disturbance	
					Area (ha)	Proportion of Baseline[4] (%)
Transition Forest (cont'd)	Willow–river alder	Tf5	326	0.04	0	0.00
	Totals		751,107	88.44	775.98	0.10
North Taiga Plains	g1/h2 combined black spruce–tamarack and black spruce/ground birch/red bear	Ng1/Nh2	953,602	30.89	1759.59	0.18
	Upland white spruce–Alaska birch	Nd5	440,898	14.28	558.63	0.13
	2–10 years since disturbance	Regen	313,291	10.15	825.21	0.26
	g1/h2 combined black spruce–tamarack and black spruce/ground birch/red bear	Nh2b	252,782	8.19	385.65	0.15
	d3/d4 combined white spruce/stair-step moss and white spruce–black spruce/shrubby cinquefoil	Nd3*/Nd4*	157,629	5.11	286.11	0.18
	Upland white spruce–Alaska birch	Nd5b	148,340	4.80	91.8	0.06
	Recent burn <2 years since burn	Charred	137,269	4.45	100.17	0.07
	k3/k4 combined graminoid wetland /ground birch/water sedge wetland	Nk3/Nk4	132,423	4.29	250.92	0.19
	k3/k4 combined graminoid fen/ground birch/water sedge wetland	Nk3b/Nk4b	77,938	2.52	91.62	0.12
	Black spruce/cloudberry–lichen bog	Ni3*	55,290	1.79	48.24	0.09
	Water emergents	WE	33,760	1.09	4.68	0.01
	d3/d4 combined white spruce/stair-step moss and white spruce–black spruce/shrubby cinquefoil	Nd3b*/Nd4b*	20,538	0.67	22.41	0.11
	Riparian willow–grey alder	Nf5*	14,841	0.48	6.75	0.05
	Black spruce/cloudberry–lichen bog	Ni3b*	8,054	0.26	3.06	0.04

Table 12-8: Project Contribution to Cumulative Effects on Vegetation Abundance and Distribution (cont'd)

Ecological Zone	Vegetation Description	Vegetation Class	Baseline Area[3] (ha)	Proportion of Ecological Zone[3] (%)	Project Disturbance	
					Area (ha)	Proportion of Baseline[4] (%)
North Taiga Plains (cont'd)	Herbaceous/graminoid	HG	470	0.02	0.45	0.10
	Totals		2,747,125	88.99	4,435.29	0.16
South Taiga Plains	g1/i1 combined black spruce–tamarack and black spruce/ground birch	Sg1/Si1	994,714	25.27	1,104.39	0.11
	2–10 years since disturbance	Regen	618,562	15.72	630.18	0.10
	k4/k5 combined	Sk4*/Sk5	492,199	12.51	563.85	0.11
	Black spruce/cloudberry–lichen bog	Si3*	477,457	12.13	399.69	0.08
	d2/d5 combined aspen/white spruce/low-bush cranberry and white spruce–black spruce–paper birch/green	Sd2/Sd5	362,799	9.22	532.35	0.15
	Upland jack pine	Sa1	252,554	6.42	342.45	0.14
	d3/d4 combined white spruce/stair-step moss and black spruce–white spruce/stair-step moss	Sd3*/Sd4	182,492	4.64	241.02	0.13
	Graminoid fen	Sk3*	166,291	4.23	201.87	0.12
	Water	W	151,490	3.85	17.64	0.01
	Aspen/prickly rose/fireweed	Sd1	109,887	2.79	181.89	0.17
	Leatherleaf/bog rosemary–peat moss	Si4*	40,046	1.02	19.8	0.05
	Recent burn <2 years since burn	Charred	30,697	0.78	0	0.00
	Water emergents	WE	9,740	0.25	1.89	0.02
	Riparian willow–red-osier dogwood	Sf5*	8,671	0.22	4.23	0.05
	Herbaceous/graminoid	HG	5,115	0.13	2.43	0.05
	Totals		3,902,715	99.18	4,243.68	0.11

NOTES:
1 Riparian black spruce/shrub will not be affected.
2 Satellite classification did not accurately differentiate between vegetation classes 13 and h3
3 The amount or proportion of the ecological zone occupied by each vegetation class. Nonvegetation land cover classes have not been included.
4 The proportion of the baseline levels of a particular vegetation class that has been disturbed by the project.
* Vegetation types of concern

Table 12-9: Current Land Use Contribution to Cumulative Effects on Vegetation Abundance and Distribution

Ecological Zone	Disturbance Category	Area Disturbed by Other Land Uses	
		Area (ha)	**Proportion of Ecological Zone** (%)
Tundra (2,518,428 ha total)	Clearings	98.55	<0.01
	Permanent disturbance	397.89	0.02
	Pipeline rights-of-way	127.62	0.01
	Winter road	1586.79	0.06
	Subtotal	2,210.85	0.09
Transition Forest (849,470 ha total)	Clearings	2.25	<0.01
	Permanent disturbance	1990.35	0.23
	Pipeline rights-of-way	3.06	<0.01
	Winter road	13.23	<0.01
	Subtotal	2,008.89	0.24
North Taiga Plains (3,087,286 ha total)	Clearings	158.22	0.01
	Permanent disturbance	2031.57	0.07
	Pipeline rights-of-way	230.04	0.01
	Winter road	783.99	0.03
	Subtotal	3,203.82	0.10
South Taiga Plains (3,935,819 ha total)	Clearings	69.21	<0.01
	Permanent disturbance	3989.70	0.10
	Pipeline rights-of-way	1999.53	0.05
	Winter road	950.76	0.02
	Subtotal	7,009.20	0.18
Total (10,391,003.28 ha total for the RSA)		14,432.76	N/A
NOTE: N/A = not applicable			

Analysis of overall cumulative effects can only be done at the ecological zone level because the classification of project disturbance by vegetation classes does not correspond to the classification of vegetation classes for current land uses. The classification differs because current data does not indicate which vegetation classes previously occupied the footprint areas of permanent disturbances or other existing land uses. Therefore, existing land uses have only been classified according to one of four disturbance categories for the RSA (see following).

Table 12-10: Overall Cumulative Effects on Vegetation Abundance and Distribution

Ecological Zone	Total Ecological Zone Area	Baseline Disturbance (ha)[1]	Project Disturbance (ha)[2]	Total Disturbance (Baseline + Project)	
				Area (ha)	Proportion of Ecological Zone (%)
Tundra	2,518,428	2,210.85	1,231.47	3,442.32	0.14
Transition Forest	849,470	2,008.89	775.98	2,784.87	0.33
North Taiga Plains	3,087,286	3,203.82	4,435.29	7,639.11	0.25
South Taiga Plains	3,935,819	7,009.20	4,243.68	11,252.88	0.29
Totals	10,391,003	14,432.76	10,686.42	25,119.18	0.24

NOTES:
1 from Table 12-9
2 from Table 12-8

The disturbance categories in Table 12-9, shown previously, group current land uses in four disturbance categories, each with similar vegetation recovery responses. The disturbance categories are characterized as follows:

- clearings – previously forested areas that were cleared and are now vegetated in an early seral stage. Clearings, cut blocks and seismic lines are expected to return to a natural vegetation type.
- permanent disturbances – areas with long-term ground disturbance, usually more than two years old, where re-establishment of the original vegetation type is unlikely. These areas have continued human activity, including pipeline valve sites and pump stations, well pads, well sites, gravel extraction sites, all-weather roads, summer roads, barge landings, stockpile sites, fuel storage sites, temporary and permanent camp sites, air strips, helicopter pads and communication centres.
- pipeline rights-of-way – short-term ground disturbances, usually less than two years old, with the potential to re-establish the original vegetation type. Reclamation and permafrost degradation of the pipeline trench could result in alternative vegetation types on the ditchline.
- winter roads – disturbances associated with two types of winter road:
  - permanent – winter roads at least 15 m wide with complete removal of trees and shrubs and with some form of disturbance of the ground surface organic layer from levelling, compaction or construction of berms. Permanent winter roads along the proposed route begin at Fort Wrigley and continue as far north as Fort Good Hope and Colville.

- temporary – winter roads narrower than 15 m, with limited effects on vegetation from selective tree removal and brush cutting and with limited surface disturbance of the organic layer by maintaining minimum snow depth

The proportion of each ecological zone disturbed by other land uses is relatively small, ranging from 0.24% of the Transition Forest Ecological Zone to 0.09% of the Tundra Ecological Zone. At the overall RSA level, the combined disturbance from other land uses is about 14,433 ha or 0.14% of the total RSA.

Overall cumulative effects (Table 12-10, shown previously) are negligible, ranging from 0.33% in the Transition Forest Ecological Zone to 0.14% in the Tundra Ecological Zone. The total area disturbed by all land uses is 25,119 ha or 0.24% of the RSA.

The area cleared by the Mackenzie Gas Project is negligible and there are no disproportionately large effects on any relatively uncommon vegetation classes or vegetation types of concern.

Significance

The significance of the Mackenzie Gas Project contribution to cumulative effects on the abundance and distribution of vegetation is Class 3, not significant.

The significance of overall cumulative effects on the abundance and distribution of vegetation is Class 3, not significant.

Cumulative effects on the distribution and abundance of vegetation types or classes of concern are negligible. Thresholds are not currently available to provide a regional context. However, the influence of edge effect and the dispersal and establishment of invasive non-native species will exacerbate these effects, extending their influence into areas near the Mackenzie Gas Project. Cumulative effects are expected to cause relatively minor declines in vegetation types of concern in the RSA. In most cases, these declines will be reversed through vegetative recovery, both during operations and after decommissioning.

Cumulative effects on the distribution and abundance of rare plants and vegetation communities of concern are likely to occur. As noted previously, key pathways include the introduction and dispersal of persistent and invasive non-native plant species and the removal of granular deposits. However, these species are not suitable indicators of cumulative effects because there is little data available to assess their distribution and abundance on the landscape at a regional level. Furthermore, these species are typically uncommon and it is generally not possible with any degree of confidence to predict their abundance or distribution on the landscape. Therefore, cumulative effects on rare plants and vegetation communities of concern have not been assessed; however, project-specific effects on rare plants and vegetation communities of concern are assessed in the project-specific assessment (see Section 9, Vegetation).

Limited information on traditional plant use is available for the RSA. Information on plant species and collecting areas of concern will be provided by community-based traditional knowledge studies and then assessed.

12.2.8.4 Health of Vegetation Species and Associations

Changes in thermal regime, drainage patterns, air emissions and dust will affect the health of vegetation species and associations.

Dust is not expected to contribute substantially to cumulative effects on the health of vegetation species and associations because the effects are typically localized and seasonal. It is likely that small areas of sensitive vegetation species and classes will be affected, particularly related to road use in the region.

Air emissions are expected to be localized because there will be little opportunity for the project air emissions to interact with emissions from other activities. In populated areas, such as Inuvik and Norman Wells, the addition of incremental production and support facilities will add to existing municipal and industrial emissions.

Herbicides might be used to control populations of persistent or invasive non-native species, though they are a secondary measure for use only where mechanical controls are not effective. Herbicide use is expected to be limited in extent and frequency of occurrence, and cumulative effects of herbicide use on vegetation health are expected to be negligible.

Significance

The significance of the Mackenzie Gas Project contribution to cumulative effects on the health of vegetation species and associations is Class 3, not significant.

The significance of overall cumulative effects on the health of vegetation species and associations is Class 3, not significant.

Overall cumulative effects on vegetation health are expected to result in minor effects in some areas of the RSA during Mackenzie Gas Project construction and operations. This reflects the cumulative dust generation from existing roads and developments and the project, dispersal of compressor station air emissions beyond the LSA during operations and the long-term effects of dust and air emissions on vegetation. Effects are expected to be more limited in extent during decommissioning and vegetation health is expected to recover after project closure, although vegetation community composition might shift.

12.2.9 Wildlife

12.2.9.1 Potential Interactions

Existing land uses and marine activities have the potential to contribute to wildlife cumulative effects. Effects of the Mackenzie Gas Project could interact with these effects through:

- changes in habitat availability and quality resulting from vegetation clearing, sensory disturbance, and air and water emissions
- changes in movements resulting from sensory disturbance and physical barriers
- increased mortality resulting from sensory disturbance, attraction to facilities and rights-of-way and altered human-predator access

The effects of reasonably foreseeable developments on wildlife could not be determined quantitatively because no information on the footprint of these developments exists. However, it is assumed that development footprints will be small relative to the size of the RSA, suggesting at most a minor contribution to cumulative effects.

Therefore, it is likely that residual effects of the project on wildlife will interact with other land use effects.

12.2.9.2 Focus of Assessment

The assessment of potential cumulative effects on wildlife is quantitative and qualitative and focuses on the following key indicators:

- habitat availability
- wildlife movements
- mortality

Six terrestrial species were selected for assessment of cumulative effects from the 17 wildlife VCs assessed in the project-specific assessment: caribou, moose, grizzly bear, marten, lynx and beaver. They were assessed in ecozones most representative of their range within the RSA (see Table 12-11). The table includes subspecies for caribou and grizzly bear.

A species was selected if an individual or population adversely affected by the project could potentially also be affected by other land uses or marine activities. Effects from the project-specific assessment that were low magnitude and short term are unlikely to contribute to cumulative effects.

Table 12-11: Species Assessed and Applicable Ecozones

Species VC	Ecozone			
	Tundra	Transition Forest	North Taiga Plains	South Taiga Plains
Barren-ground caribou: Cape Bathurst herd	●	N/A	N/A	N/A
Barren-ground caribou: Bluenose West herd	N/A	●	●	N/A
Woodland caribou	N/A	●	●	●
Moose	N/A	●	●	●
Barren-ground grizzly bear	●	●	N/A	N/A
Northern interior grizzly bear	N/A	N/A	●	●
Marten	N/A	●	●	●
Lynx	N/A	●	●	●
Beaver	N/A	●	●	●

NOTES:
● = the species was assessed in that ecozone
N/A = not applicable

To determine whether a wildlife VC might interact with other land uses, its migration pattern was examined, using:

- migration parameters of long-distance, short-distance or no migration
- home range size
- dispersal pattern

Individuals or populations that migrate or disperse over large distances in the RSA, or have large home ranges, are more likely to interact with the project and other land uses. Table 12-12 summarizes the results of this selection process for wildlife species.

Amphibians were not selected as VCs because their movements are highly localized and they have little or no interaction with other projects.

Marine mammals selected are discussed in the following section.

Bird species were not selected for reasons discussed in the following section.

Marine Mammal Species

The beluga whale was selected as a VC because of its local importance for harvesting. Bowhead whales and polar bears were selected because of their protected status.

Table 12-12: Selection of Terrestrial Wildlife Valued Components for CEA

Valued Component	Adverse Project Effect			Migration Distance[2]	Home Range Size[2]	Dispersal Distance[2]
	Habitat[1]	Movement	Mortality			
Barren-ground caribou	Y	Y	Y	200–400 km	NA	NA
Woodland caribou	Y	Y	Y	100–200 km	600–2,000 km^2	Unknown
Moose	Y	Y	Y	10–100 km	40–1,000 km^2	Unknown
Grizzly bear	Y	Y	Y	Nonmigratory	600–2,000 km^2	Unknown
Marten	Y	Y	Y	Nonmigratory	1.5–15 km^2	Up to 60 km
Lynx	Y	Y	Y	Nonmigratory	10–40 km^2	Up to 1,000 km
Beaver	Y[3]	N	Y	Nonmigratory	<1 km^2	Up to 30 km

NOTES:
NA = not applicable
Y = Occurrence of an adverse project effect resulting from any project component of low, moderate or high magnitude and long-term or far-future duration
N = Occurrence of a neutral or positive project effect or an adverse effect of low magnitude and short- or medium-term duration
1 Refers to habitat availability.
2 See Volume 3, Section 10, Wildlife, for information sources
3 Living habitat could not be determined for beaver in the RSA because no information was available on stream locations. Therefore, cumulative effects could not be determined quantitatively.

Effects on habitat availability and movement were assessed for beluga whale. Effects on mortality were assessed for beluga whale, bowhead whale and polar bear.

Bird Species

Birds were not assessed for cumulative effects because all project effects on birds are predicted to be low in magnitude. Birds with ranges extending far beyond the RSA during seasonal migrations are not assessed for cumulative effects throughout that range because:

- effects from other land uses occur beyond the administrative jurisdiction of the regulatory review of this assessment
- characterization of those remote land uses regarding their contribution to cumulative effects is not possible

Applying the concept of cumulative effects assessment to the bird VCs, especially the migratory species, differs from its application to terrestrial mammals. Mammal VCs travel within or near the RSA throughout the year and are potentially subject to the effects of other projects and activities in the RSA for long periods. All but one of the bird VCs, the boreal chickadee, are absent from the RSA for most of the year. When the individuals or populations of migratory bird VCs are present in the RSA, they tend to remain within very limited areas, such as their nesting territory. Consequently, even when present, individuals that might interact with the Mackenzie Gas Project are unlikely to interact with other projects and activities. They might interact with other developments during migration, but those interactions would likely be brief.

The migratory bird VCs travel far between nesting or summering areas in the Northwest Territories and wintering areas farther south. Within that large annual home range, they are affected by many varied land uses. An assessment of all projects and activities within the combined summer and winter migration ranges of the migratory VCs is beyond the scope of this assessment.

The boreal chickadee is nonmigratory and might be more likely to interact with other developments in the RSA. Little is known of the annual movements and home range sizes of boreal chickadees (Ficken et al. 1996), though available information suggests they usually move within relatively small areas. Nesting territories are not much larger than 5 ha, and the species is not known to undertake annual migrations. Consequently, those boreal chickadees that might interact with the project are unlikely to also interact with other land uses at other locations in the RSA.

12.2.9.3 Habitat Availability

Results of the habitat availability analysis for each assessed VC are outlined in the following discussion. Available and disturbed areas were calculated for the baseline case, representing past and current land uses as well as the cumulative case, representing overall cumulative effects of the project and other land uses during Mackenzie Gas Project construction and operations.

Total key habitat refers to the total of very high, high and moderate quality habitat, and also accounts for the effects from both direct and indirect habitat loss. Direct habitat loss refers to the area removed by the project footprint; indirect habitat loss refers to the area alienated by sensory disturbance beyond the footprint.

Thresholds

Thresholds, if available and applicable, can be used to determine the acceptability of effects. A threshold, as applied here, is an objective, science-based standard that defines a point at which an indicator changes from an acceptable to an unacceptable condition (Salmo Consulting Inc. et al. 2003).

In this assessment, key habitat area is compared with a generalized wildlife habitat threshold of at least 10% to 40% of the RSA for terrestrial wildlife VCs. This is based on an interpretation of the following range of threshold values for habitat availability:

- more than 10% to 30% of the landscape is habitat suitable for birds and mammals
- more than 40% of the landscape is habitat suitable for habitat specialists
- more than 25% to 35% of the landscape is habitat suitable for habitat generalists

Values *below* 10% key habitat availability indicate high risk, meaning a species will be affected. Values *within* threshold, from 10 to 40%, indicate moderate risk, suggesting a species might be affected. Values in excess of 40% indicate little or no risk and, therefore, species will not likely be affected.

Barren-Ground Caribou

Cape Bathurst Herd

Cumulative habitat loss for Cape Bathurst barren-ground caribou was assessed in the Tundra Ecological Zone (see Table 12-13). Of the 25,178 km^2 that comprise this area in the RSA, 167 km^2, or 0.7%, has been disturbed by existing land uses. An additional 16 km^2 will be affected by Mackenzie Gas Project construction and operations, resulting in little additional direct habitat loss in the RSA.

Table 12-13: Habitat Availability for Cape-Bathurst Barren-Ground Caribou

Habitat Availability		Baseline Case		Cumulative Case			
				Construction		Operations	
		Area (km^2)	RSA (%)	Area (km^2)	RSA (%)	Area (km^2)	RSA (%)
Area available in RSA		25,178	N/A	25,178	N/A	25,178	N/A
Area disturbed		167	0.7	183	0.73	183	0.73
Winter forage habitat	Very high/high	3,477	13.8	3,386	13.4	3,456	13.7
	Moderate	3,776	15.0	3,675	14.6	3,763	14.9
	Total key habitat	7,253	28.8	7,061	28.0	7,219	28.6

NOTE:
N/A = not applicable

Based on direct and indirect habitat losses, more than 7,253 km^2 of key winter foraging habitat, or 28.8% of the RSA, is available. Mackenzie Gas Project construction and operations will cause little change, less than 1%, in the availability of key forage habitat for caribou, indicating that the project will contribute negligibly to cumulative habitat loss.

The area of suitable habitat is within the habitat generalist threshold, defined as, 10 to 40%, for the baseline and cumulative cases. However, because caribou is a habitat specialist, a high habitat-suitability risk could result but this might simply reflect the fact that the RSA does not include the entire Cape Bathurst Herd winter range. The overall availability of key habitat suggests that caribou habitat should be monitored closely under any future development scenarios.

Bluenose West Herd

Cumulative habitat loss for Bluenose West barren-ground caribou was assessed in the Transition Forest and North Taiga Plains ecological zones (see Table 12-14). Of the 39,374 km^2 that comprise this area in the RSA, 125 km^2, or 0.3%, have been disturbed by existing land uses. An additional 55 km^2 will be affected by Mackenzie Gas Project construction and operations, resulting in a 44% increase in the amount of cleared habitat in the RSA; the seemingly high number simply reflects the current relatively undisturbed state of that region. The total area cleared by all land uses is 0.5% of the RSA.

Table 12-14: Habitat Availability for Bluenose West Barren-Ground Caribou

Habitat Availability		Baseline Case		Cumulative Case			
				Construction		Operations	
		Area (km^2)	RSA (%)	Area (km^2)	RSA (%)	Area (km^2)	RSA (%)
Area available in RSA		39,374	N/A	39,374	N/A	39,374	N/A
Area disturbed		125	0.3	180	0.5	180	0.5
Winter forage habitat	Very high/high	166	0.4	161	0.4	161	0.4
	Moderate	1,200	3.0	1,173	2.9	1,188	3.0
	Total key habitat	1,366	3.4	1,339	3.3	1,349	3.4
NOTE: N/A = not applicable							

Based on direct and indirect habitat losses, more than 1,366 km^2 of key winter foraging habitat, or 3.4% of the RSA, is available in the baseline case. Mackenzie Gas Project construction and operations will cause little change, less than 1%, in the availability of key forage habitat for caribou, indicating that the project will contribute negligibly to cumulative habitat loss.

The area of suitable habitat is below threshold (less than 10%), therefore high risk, during both the baseline and cumulative cases. The pipeline corridor occurs at the very western edge of the Bluenose West herd range, which might explain the small amount of high-quality habitat in this area.

Grizzly Bear

Barren-Ground Grizzly Bear

Cumulative barren-ground grizzly bear habitat loss was assessed in the Tundra and Transition Forest ecological zones (see Table 12-15). Of the 33,678 km^2 that comprise this area in the RSA, 200 km^2, or 0.6%, have been disturbed by existing developments. An additional 23.4 km^2 will be affected by The Mackenzie Gas Project construction and operations, resulting in a 12% increase in the amount of cleared habitat in the RSA. However, the total area cleared by all land uses is 0.7% of the RSA.

Table 12-15: Habitat Availability for Barren-Ground Grizzly Bear

Habitat Availability		Baseline Case		Cumulative Case			
				Construction		Operations	
		Area (km^2)	RSA (%)	Area (km^2)	RSA (%)	Area (km^2)	RSA (%)
Area available in RSA		33,678	N/A	33,678	N/A	33,678	N/A
Area disturbed		200	0.6	223.4	0.7	223.4	0.7
Denning habitat	Very high/high	4,900	14.5	4,781	14.2	4,864	14.4
	Moderate	61	0.2	94	0.3	88	0.3
	Total key habitat	4,961	14.7	4,875	14.5	4,952	14.7
Spring forage habitat	Very high/high	4,913	14.6	4,855	14.4	4,859	14.4
	Moderate	6,667	19.8	6,599	19.6	6,615	19.6
	Total key habitat	11,580	34.4	11,454	34.0	11,474	34.0
Fall forage habitat	Very high/high	1,285	3.8	1,259	3.7	1,260	3.7
	Moderate	2,282	6.8	2,268	6.7	2,275	6.8
	Total key habitat	3,567	10.6	3,527	10.4	3,535	10.5

NOTE:
N/A = not applicable

Based on direct and indirect habitat losses, more than 4,961 km^2 of key denning habitat, 11,680 km^2 of key spring foraging habitat and 3,567 km^2 of key fall foraging habitat is available in the baseline case. Mackenzie Gas Project construction and operations will cause little change, less than 1%, in the availability of key denning and foraging habitat for bears, indicating that the project will contribute negligibly to cumulative habitat loss.

The area of suitable habitat is within the moderate-risk threshold, 10 to 40%, for the baseline and cumulative cases. Although habitat availability exceeds the 10% high-risk threshold, the overall availability of key habitat indicates that grizzly bear habitat should be monitored closely under any future development scenarios.

Northern Interior Grizzly Bear

Cumulative northern interior grizzly bear habitat loss was assessed in the North Taiga Plains and South Taiga Plains ecological zones (see Table 12-16). Of the 70,232 km^2 that comprise this area in the RSA, 269 km^2, or 0.4%, have been disturbed by existing land uses. An additional 90 km^2 will be affected by Mackenzie Gas Project construction and operations, resulting in a 33% increase in the amount of cleared habitat in the RSA. However, the total area cleared by all land uses is 0.5% of the RSA.

Table 12-16: Habitat Availability for Northern Interior Grizzly Bear

Habitat Availability		**Baseline Case**		**Cumulative Case**			
				Construction		**Operations**	
		Area (km^2)	**RSA** (%)	**Area** (km^2)	**RSA** (%)	**Area** (km^2)	**RSA** (%)
Area available in RSA		70,232	N/A	70,232	N/A	70,232	N/A
Area disturbed		269	0.4	359	0.5	359	0.5
Denning habitat	Very high/high	9,514	13.5	8,448	12.0	9,371	13.3
	Moderate	5,589	8.0	5,416	7.7	5,528	7.9
	Total key habitat	15,103	21.5	13,864	19.7	14,899	21.2
Spring forage habitat	Very high/high	37,479	53.4	36,808	52.4	36,900	52.5
	Moderate	18,945	27.0	18,862	26.9	19,037	27.1
	Total key habitat	56,424	80.4	55,670	79.3	55,937	79.6
Fall forage habitat	Very high/high	27,509	39.2	27,002	38.4	27,076	38.6
	Moderate	13,129	18.7	13,117	18.7	13,243	18.9
	Total key habitat	40,638	57.9	40,119	57.1	40,319	57.5

NOTE:
N/A = not applicable

Based on direct and indirect habitat losses, 15,103 km^2 of key denning habitat, 56,424 km^2 of key spring forage habitat and 40,638 km^2 of key fall forage habitat are available in the baseline case. Mackenzie Gas Project construction and operations will cause little change, less than 2%, in the availability of key denning and foraging habitat, indicating that the project will contribute negligibly to cumulative habitat loss.

The area of suitable habitat exceeds the 40% threshold, indicating little or no risk to grizzly bears.

Moose

Cumulative moose habitat loss was assessed in the Transition Forest, North Taiga Plains and South Taiga Plains ecological zones (see Table 12-17). Of the 78,733 km^2 that comprise this area in the RSA, 302 km^2, or 0.4%, have been disturbed by existing land uses. An additional 98 km^2 will be affected by Mackenzie Gas Project construction and operations, resulting in a 32% increase in the amount of cleared habitat in the RSA. However, the total area cleared by all land uses is 0.5% of the RSA.

Table 12-17: Habitat Availability for Moose

Habitat Availability		Baseline Case		Cumulative Case			
				Construction		Operations	
		Area (km^2)	RSA (%)	Area (km^2)	RSA (%)	Area (km^2)	RSA (%)
Area available in RSA		78,733	N/A	78,733	N/A	78,733	N/A
Area disturbed		302	0.4	400	0.5	400	0.5
Winter foraging habitat	Very high/high	22,572	28.7	22,067	28.0	22,378	28.4
	Moderate	23,913	30.4	23,334	29.6	23,809	30.2
	Total key habitat	46,485	59.1	45,401	57.6	46,187	58.4

NOTE:
N/A = not applicable

Based on direct and indirect habitat losses, more than 46,485 km^2 of key winter foraging habitat is available for moose in the baseline case. This represents 59% of the RSA. Mackenzie Gas Project construction and operations will cause little change, less than 2%, in the availability of key foraging habitat for moose, indicating that the project will contribute negligibly to cumulative habitat loss.

The area of suitable habitat exceeds the 40% threshold, indicting little or no risk to moose.

Woodland Caribou

Cumulative woodland caribou habitat loss was assessed in the Transition Forest, North Taiga Plains and South Taiga Plains ecological zones. Of the 78,733 km^2 that comprise the area in this RSA, 302 km^2, or 0.4%, have been disturbed by existing developments (see Table 12-18). An additional 98 km^2 will be affected by Mackenzie Gas Project construction and operations, resulting in a 32% increase in the amount of cleared habitat in the RSA. However, the total area cleared by all land uses is 0.5% of the RSA.

Based on direct and indirect habitat losses, more than 38,660 km^2 of key winter foraging habitat is available for woodland caribou in the baseline case. This represents 49% of the RSA. Mackenzie Gas Project construction and operations will cause little change, less than 2%, in the availability of key foraging habitat for woodland caribou, indicating that the project will contribute negligibly to cumulative habitat loss.

The area of suitable habitat exceeds both habitat specialist and generalist thresholds of 40%, indicating little or no risk to woodland caribou.

Table 12-18: Habitat Availability for Woodland Caribou

Habitat Availability		Baseline Case		Cumulative Case			
				Construction		Operations	
		Area (km^2)	RSA (%)	Area (km^2)	RSA (%)	Area (km^2)	RSA (%)
Area available in RSA		78,733	N/A	78,733	N/A	78,733	N/A
Area disturbed		302	0.4	400	0.5	400	0.5
Winter foraging habitat	Very high/high	23,546	29.9	23,097	29.3	23,451	29.8
	Moderate	15,114	19.2	14,741	18.7	15,069	19.1
	Total key habitat	38,660	49.1	37,838	48.0	38,520	48.9

NOTE:
N/A = not applicable

Marten

Cumulative marten habitat loss was assessed in the Transition Forest, North Taiga Plains and South Taiga Plains ecological zones (see Table 12-19). Of the 78,733 km^2 that comprise the area in this RSA, 302 km^2, or 0.4%, have been disturbed by existing land uses. An additional 98 km^2 will be affected by Mackenzie Gas Project construction and operations, resulting in a 32% increase in the amount of cleared habitat in the RSA. However, the total area cleared by all land uses is 0.5% of the RSA.

Table 12-19: Habitat Availability for Marten

Habitat Availability		Baseline Case		Cumulative Case			
				Construction		Operations	
		Area (km^2)	RSA (%)	Area (km^2)	RSA (%)	Area (km^2)	RSA (%)
Area available in RSA		78,733	N/A	78,733	N/A	78,733	N/A
Area disturbed		302	0.4	400	0.5	400	0.5
Winter foraging habitat	High	29,734	37.8	29,482	37.4	29,677	37.7
	Moderate	28,762	36.5	28,638	36.4	28,735	36.5
	Total key habitat	58,496	74.3	58,120	73.8	58,412	74.2

NOTE:
N/A = not applicable

Based on direct and indirect habitat losses, more than 58,496 km^2 of key winter foraging habitat is available for marten in the baseline case. This represents 74% of the RSA. Mackenzie Gas Project construction and operations will cause little change, less than 1%, in the availability of key foraging habitat for marten, indicating that the project will contribute negligibly to cumulative habitat loss.

The area of suitable habitat exceeds the 40% threshold, indicating little or no risk to marten.

Lynx

Cumulative lynx habitat loss was assessed in the Transition Forest, North Taiga Plains and South Taiga Plains ecological zones (see Table 12-20). Of the 78,733 km^2 that comprise the area in this RSA, 302 km^2, or 0.4%, have been disturbed by existing land uses. An additional 98 km^2 will be affected by Mackenzie Gas Project construction and operations, resulting in a 32% increase in the amount of cleared habitat in the RSA. However, the total area cleared by all land uses is 0.5% of the RSA.

Table 12-20: Habitat Availability for Lynx

Habitat Measurement		Baseline Case		Cumulative Case			
				Construction		Operations	
		Area (km^2)	RSA (%)	Area (km^2)	RSA (%)	Area (km^2)	RSA (%)
Area available in RSA		78,733	N/A	78,733	N/A	78,733	N/A
Area disturbed		302	0.4	400	0.5	400	0.5
Winter foraging habitat	High	20,822	26.4	20,654	26.2	20,786	26.4
	Moderate	41,602	52.8	41,307	52.5	41,543	52.8
	Total key habitat	62,424	79.2	61,961	78.7	62,329	79.2

NOTE:
N/A = not applicable

Based on direct and indirect habitat losses, more than 62,424 km^2 of key winter foraging habitat is available for lynx in the baseline case. This represents 79% of the RSA. Mackenzie Gas Project construction and operations will cause little change, less than 1%, in the availability of key foraging habitat for lynx, indicating that the project will contribute negligibly to cumulative habitat loss.

The area of suitable habitat exceeds the 40% threshold, indicating little or no risk to lynx.

Beluga Whale

Mackenzie Gas Project effects on beluga whale habitat might result from potential dredging in Kugmallit and Kittigazuit bays. No other dredging activities are known in that area, however, other marine transport in the region will contribute to noise. This would include river tug and barge vessel traffic that routinely travels the Mackenzie River East Channel to Tuktoyaktuk and back each summer. Vessels involved in the annual beluga hunt will also be active in the area.

The beluga whale population in its traditional habitats appears unaffected by current levels of marine traffic. The addition of the project is not expected to cause a cumulative effect of concern.

Significance

The significance of project contribution to cumulative effects on habitat availability for all species is Class 3, not significant.

The significance of overall cumulative effects on habitat availability for all species is Class 3, not significant.

12.2.9.4 Movements

The project could contribute to cumulative effects on wildlife movements through sensory disturbance, which can cause habitat avoidance and changes in movement patterns. Project effects of physical barriers, vegetation clearing and attraction to facilities and rights-of-way are negligible and therefore not relevant.

Barren-Ground Caribou

Cape Bathurst Herd

Movements of radio-collared caribou indicate that the wintering area of the Cape Bathurst herd encompasses over 10,000 km^2 of tundra habitat in the Inuvialuit Settlement Region (Wright et al. 2002; Nagy, personnel communication). Radio-collared caribou move onto their wintering grounds in October, and by November many concentrate near Parsons Lake (Nagy, personnel communication). Most radio-collared caribou move southeast in December and January and concentrate northeast of Sitidgi Lake. In April and May, most begin moving east to their calving grounds.

Existing land uses that can affect barren-ground caribou movements on their wintering range include oil and gas exploratory drilling and seismic operations, Ikhil pipeline maintenance activities, and travel and hunting by local residents.

Information on the effects of existing land uses on caribou movements in the RSA is lacking. It is possible that combined activities have displaced some caribou from the western edge of their winter range, though this cannot be confirmed because historical information on caribou movements is not available.

Existing oil and gas exploration beside Richards Island is at the edge of the herd's winter range and could cause increased but highly localized caribou disturbances.

The project's largest contribution to cumulative effects will be during construction. The magnitude of the effect will be low to moderate. Sensory disturbance during operations is expected to decrease, resulting in lower effects on caribou during operations than during construction.

Overall cumulative effects will have an adverse effect on Cape Bathurst caribou movements in the RSA. However, because these effects will be concentrated in the western part of the herd's winter range, land uses are only expected to affect part of the caribou population. Although changes in movement patterns should not influence population viability, because habitat is not limited in the RSA, local harvest opportunities might be affected.

Bluenose West Herd

The wintering range of the Bluenose West herd encompasses over 100,000 km^2 of tundra and taiga habitat in the Inuvialuit Settlement Region, Gwich'in Settlement Area and Sahtu Settlement Area (Wright et al. 2002). Most of the herd winters in the Gwich'in Settlement Area and Sahtu Settlement Area. The RSA is at the western edge of the Bluenose West wintering range. Radio-collared caribou move into this area in late October and leave in April and May.

Existing land uses that can affect the movement of Bluenose West caribou in the RSA include winter roads, other linear corridors used for winter travel, hunting, and current oil and gas drilling and seismic programs in the Colville Lake and Norman Wells areas.

Information on the effects of these land uses on caribou movement in the RSA is lacking. Anecdotal information suggests that caribou might have recently moved away from their winter range between Colville Lake and Fort Good Hope because of current exploration activity in this area (Veitch 2003, personal communication). However, no data is available to confirm this. Also, natural variability in range use can make it difficult to determine the causes of range shifts.

The project's largest contribution to cumulative effects will occur during construction. The magnitude of the effect will be low to moderate. Sensory disturbance during operations is expected to decrease, resulting in lower effects on caribou during operations than during construction.

Overall cumulative effects will have an adverse effect on Bluenose West caribou movements in the RSA. However, because these effects will be concentrated in the western part of the Bluenose West winter range, they are only expected to affect part of the population. Changes in movement patterns should not influence population viability because habitat is not limited for caribou in the RSA. However, local harvest opportunities might be affected.

Grizzly Bear

Barren-Ground Grizzly Bear

Little information is available on the movement of barren-ground grizzly bears in the Tundra and Transition Forest ecological zones. Grizzly bear home ranges can be as large as 2,000 km^2, indicating that individuals can move considerable distances in search of suitable foraging and denning habitat. Bears in the production area are known to move to low-lying coastal areas in June and shift to upland habitats during green-up of vegetation (Pearson and Nagy 1976).

Existing land uses that might affect the movement of barren-ground grizzly bears in the RSA include:

- maintenance activities at oil and gas development sites and infrastructure sites such as Swimming Point
- human activity at camps, hunting and fishing lodges
- human activity along all-weather roads in the Inuvik area

Information on the effects of existing land uses on grizzly bear movements in the RSA is lacking. Because grizzly bears can be sensitive to disturbance, existing activities might have disrupted or altered movements of some grizzly bears within their home ranges. However, because most oil and gas exploration occurs in winter when bears are hibernating, the level of disturbance is low. Disturbance might be greatest when bears leave their dens in spring because there could still be some exploration activity and off-road snowmobile travel.

The project's contribution to cumulative effects on the movements of barren-ground grizzly bears will be low to moderate. Construction will be concentrated in winter, but some activities will occur all year. Operational activities will also occur all year and will cause only localized disturbances.

Overall cumulative effects will have an adverse effect on barren-ground grizzly bear movements in the RSA. Although some disturbances will occur during the snow-free period, most will occur during construction in the winter when bears are denning.

Northern Interior Grizzly Bear

Northern interior grizzly bear home ranges can be as large as 2,000 km^2, indicating that individuals can move considerable distances in search of suitable foraging and denning habitat. No information is available on the movements of bears in the North Taiga Plains and South Taiga Plains ecological zones, though riparian areas in river valleys might provide important movement and travel corridors.

Existing land uses that might affect movements of northern interior grizzly bears include:

- all-weather roads
- camps and hunting and fishing lodges
- hunting
- oil and gas exploration and production near Colville Lake and Norman Wells

Cumulative effects on northern interior grizzly bear will be the same as those for barren-ground grizzly, discussed previously.

Woodland Caribou

Woodland caribou are widely dispersed at low densities of 1 to 3/100 km^2 (Olsen et al. 2001) throughout the western part of the Northwest Territories. Woodland caribou typically associate in small herds and move locally and seasonally, though their movement patterns in the Transition Forest, North Taiga Plains and South Taiga Plains ecological zones are not known and seasonal movement or migration corridors have not been identified.

Land uses that can affect the movements of woodland caribou in the RSA are the same as those identified for barren-ground caribou of the Bluenose West herd. Information on the effects of these land uses on caribou movements in the RSA is lacking. Caribou might avoid rights-of-way such as roads, pipelines and seismic lines, as has been demonstrated in northeastern Alberta (James and Stuart-Smith 2000; Dyer et al. 2001). Suspected causes of this avoidance include predation pressure and human disturbance or both.

The project’s largest contribution to cumulative effects on caribou movements will occur during construction. The magnitude of this effect is low to moderate. Sensory disturbance during operations is expected to decrease, resulting in less effect on caribou during operations than during construction.

Overall cumulative effects will have an adverse effect on woodland caribou movements in the RSA. However, because caribou habitat is not limited in the RSA, changes in movement patterns should not affect population viability, though local harvest opportunities might be affected.

Moose

Little information is available on the movements of moose in the Transition Forest, North Taiga Plains and South Taiga Plains ecological zones. Moose might move seasonally or shift between winter ranges on the islands and floodplain of the Mackenzie River and adjacent upland summer ranges (Ruttan 1974). However, studies by Stenhouse et al. (1995) near Norman Wells indicated that seasonal ranges overlapped widely and that moose in this part of the Mackenzie Valley were nonmigratory.

Information on the effects of land use on moose movements in the RSA is lacking although effects are likely similar to those described for caribou. Moose might avoid pipelines, seismic lines and roads during periods of human activity (Horejsi 1979; Morgantini 1984; Rudd and Irwin 1985), resulting in local changes in movement patterns.

The project’s largest contribution to cumulative effects on moose movements will occur during construction. The magnitude of this effect is low and sensory disturbance is expected to decrease during operations, resulting in negligible effects on moose movements.

Overall cumulative effects will have an adverse effect on movements of moose in the RSA. However, because moose habitat is not limited in the RSA, changes in movement patterns should not affect population viability, though local harvest opportunities might be affected.

Marten

Marten are widespread in the Transition Forest, North Taiga Plains and South Taiga Plains ecological zones and are one of the most abundant furbearers in the region, though little is known about their movement patterns. Marten move daily within home ranges in search of food and denning and resting sites. Juvenile marten might also disperse over long distances in the fall.

Existing land uses that can affect the movements of marten in the RSA include winter roads, other linear corridors used for winter travel, such as Enbridge pipeline and seismic lines, and current oil and gas drilling and seismic programs in the Colville Lake and Norman Wells areas.

Information on the effects of these land uses on marten movements in the RSA is lacking. Noise from construction sites and busy roads could cause localized changes in daily movement patterns and foraging activities of individuals whose home ranges are affected. However, marten are generally tolerant of human activities; therefore, disruption of movements, including dispersal, will likely be low.

The project’s contribution to cumulative effects on marten movements is negligible because marten are tolerant of human activity and the magnitude of project effects on their movements is low.

Lynx

Lynx are similar to marten in their response to land uses, so the discussion for marten also applies to lynx.

Beaver

Little information is available on the movements of beaver in the RSA. Home ranges are generally small, less than 0.2 km^2, and vary with the season (Aleksiuk 1968). Dispersal distances from natal territories are not known in the Northwest Territories, but distances of up to 30 km have been reported in southern Canada.

The effects of existing and potential future projects on aquatic and riparian habitats in the RSA are small. Beaver are tolerant of human activities, and in winter when disturbance will be greatest, beaver remain in their lodges and forage on their food caches under the ice. As a result, they are insulated to some degree from noise and human activity.

Beluga Whale

Disruption of beluga whale movement in Kugmallit and Kittigazuit bays could result from potential dredging, and dredging support vessels. Barges and various support vessels will add cumulatively to current marine and river traffic.

The beluga whale population in its traditional habitats appears unaffected by current levels of marine traffic. The addition of the project is not expected to cause a cumulative effect of concern.

Significance

The significance of project contribution to movements for all species is Class 3, not significant.

The significance of overall cumulative effects on movements for all species is Class 3, not significant.

12.2.9.5 Mortality

Introduction

The project can contribute to cumulative effects on wildlife mortality through:

- sensory disturbance
- attraction to facilities and rights-of-way
- altered human and predator access

Direct mortality can occur when animals are attracted to facilities and rights-of-way, resulting in removal of problem animals or collisions with vehicles. Indirect mortality can result from increased hunting, trapping or predation along new or improved access routes created by the project and from energetic stress caused by sensory disturbance.

The project's potential effects resulting from vegetation clearing and subsequent destruction of dens and nests are low in magnitude and short term and have not been assessed further.

Direct mortality from attraction to facilities and rights-of-way was assessed quantitatively, where practical, using available mortality data and information from other land uses. Mortality from altered human access was also assessed quantitatively by analyzing core security habitat and access density. Indirect mortality from energetic stress was assessed qualitatively.

Core Security Analysis

Development of linear corridors, such as roads, seismic lines and pipeline rights-of-way can cause wildlife mortality by increasing hunting and trapping pressure. Hunting and trapping is often near linear corridors. For example, Boer (1990) reported that more than 90% of moose killed by hunters in New Brunswick were taken within 1 km of a road. Similarly, in southwestern Alberta, 96% of human-caused grizzly bear mortalities occurred within 500 m of roads and 200 m of trails (ESGBP 1998).

Core security habitat is defined as the area of the landscape that is secure from human disturbances, such as hunting and trapping. To calculate core security habitat, increased hunting and trapping pressure was assumed to occur near major linear corridors, such as roads and seismic lines and near minor linear corridors, such as pipeline rights-of-way. Hunting and trapping pressure, and thus mortality risk, was assumed to be highest within 1 km of major corridors and within 500 m of minor corridors for all wildlife VCs. The area of the RSA outside these buffers and other human developments was considered core security habitat.

The analysis assumed that all access corridors visible at baseline or created during project construction remained open for all-terrain vehicle travel or snowmobile travel. These assumptions and distance buffers likely present the worst-case scenario (Salmo Consulting Inc. et al. 2003), so the amount of core security habitat available for each VC in the RSA is likely underestimated.

Core security analysis was only done for VCs within forested landscapes in the RSA: i.e., Transition Forest, North Taiga Plains and South Taiga Plains ecological zones, where travel is mostly limited to access corridors. Access is not limited in the Tundra Ecological Zone in winter, so hunting pressure is not concentrated along linear features. As a result, core security analysis was not done for Cape Bathurst barren-ground caribou and barren-ground grizzly bear.

Core security analysis was done in the ecological zones that best reflect the range of the VCs in the RSA. For example, core security habitat for the Bluenose West caribou herd was calculated in the Transition Forest and North Taiga Plains ecological zones, whereas for moose it was calculated in the Transition Forest, North Taiga Plains and South Taiga Plains ecological zones.

Thresholds for Core Security Habitat

Few thresholds for core security habitat have been established, and estimates are only available for grizzly bear and woodland caribou. Thresholds for grizzly bear include (from Salmo Consulting Inc. et al. 2003):

- more than 60% of available habitat as core area, the management threshold for Banff National Park
- more than 58 to 68% of land area as core area, the management threshold for Montana and Idaho national parks
- more than 60% area as core roadless wildlife habitat, the management recommendation for Yukon Territory

A threshold for woodland caribou in Alberta was identified as more than 60% core area (Salmo Consulting Inc. et al. 2003). A decline in their population was observed at a threshold of less than 50% core area.

Based on the previous information, core security habitat thresholds for grizzly bear and woodland caribou were set at a minimum desirable core area of 60%, meaning that the available core area is less than 60% and represents a management risk for the species.

Access Density

Linear corridor development can cause increased wildlife mortality by providing access routes for hunters and trappers. For example, median road and trail density in northeast British Columbia had a statistically significant effect on harvest success of moose. As road and trail density increased, harvest success also increased (Salmo Consulting Inc. et al. 2003). Predators, such as wolves, often travel along corridors, resulting in increased search efficiency, travel distance and predation (Bergerud et al.1984; Stuart-Smith et al. 1997; James and Stuart-Smith 2000). As a result, corridor density can be used as an indicator of mortality risk on wildlife.

Corridor density can also be a measure of habitat fragmentation and effectiveness. Increased corridor density can fragment large patches of habitat and diminish habitat effectiveness for forest interior species. Using habitat models and associated disturbance coefficients and zones of influence, the effects of linear corridors on habitat effectiveness were incorporated in the assessment of effects on habitat availability.

Table 12-21 shows mean road and corridor densities in the three forested ecological zones. Roads includes trails, all-weather roads and seasonal roads. Corridors include roads and other types of linear rights-of-way, such as seismic lines, that could provide access to motorized vehicles.

Table 12-21: Road and Corridor Densities in Forested Ecological Zones

Ecological Zone	Baseline Case Density (km/km^2)		Cumulative Case Density (km/km^2)	
	Road	Total Corridor	Road	Total Corridor
Transition Forest	0.04	0.19	0.05	0.20
North Taiga Plains	0.05	0.26	0.05	0.28
South Taiga Plains	0.03	0.35	0.04	0.37

Thresholds for Access Density

Certain wildlife might avoid areas with moderate or high corridor densities because of increased predation and mortality risk, and increased human disturbance, from vehicles or human activity, or both. Threshold corridor density values have been established for several wildlife species, including grizzly bear and woodland caribou.

Threshold values for grizzly bears are based on road densities rather than total corridor densities (Salmo Consulting Inc. et al. 2003). Human use of cutlines, utility corridors and trails is low and might not affect grizzly bear habitat effectiveness. Threshold road densities identified for grizzly bears have ranged from less than 0.6 km/km^2 to 0.68 km/km^2 in British Columbia and northern Montana. Consequently, a threshold range of 0.6 to 0.68 km/km^2 was selected to assess the effects of road density on grizzly bears in the RSA. Road densities that exceed this range indicate decreased use of habitat because of increased mortality risk and disturbance.

In contrast to grizzly bears, threshold values for woodland caribou are based on both road and total corridor densities. Total corridor density has been used because caribou are susceptible to wolf predation near cutlines, as demonstrated in northeastern Alberta (Stuart-Smith et al. 1997; James and Stuart Smith 2000). Caribou populations in Alberta have declined when total corridor densities exceeded 1.8 km/km^2 (Salmo Consulting Inc. et al. 2003).

Threshold road densities for woodland caribou are lower than threshold total corridor densities, possibly because roads represent a greater disturbance or mortality risk for caribou. In west-central Alberta, the threshold value for road density is 0.6 km/km^2. Effects of corridor density on woodland caribou in the RSA were assessed using threshold values of 1.8 km/km^2 for total corridors and 0.6 km/km^2 for roads.

Barren-ground Caribou

Direct Mortality

Although human activity and vehicle traffic will increase in the RSA in winter, particularly during Mackenzie Gas Project construction, few caribou are likely to be killed by vehicles. Firearm restrictions at work camps and facilities will also limit direct mortality of caribou. Because of the large size of the Cape Bathurst and Bluenose West herds, 88,000 to 106,000 animals in 1992 (Nagy et al. 1999), the loss of several animals through direct mortality will have a negligible effect on population viability.

Indirect Mortality

Energetic stress from repeated disturbances can affect the body condition and female productivity of caribou (Bradshaw et al 1998; Murphy and Lawhead 2000). The effects of energetic stress on body condition are likely exacerbated by limited foraging habitat.

Land use will likely increase disturbance of Cape Bathurst and Bluenose West caribou in the western part of their winter range. These disturbances will be highly localized and, although there will be some energetic stress, caribou will likely respond by avoiding areas with human activity. Because considerable foraging habitat occurs in the RSA, the energetic cost of altered movements is likely small. As a result, the magnitude of cumulative effects on caribou mortality through energetic stress is low.

Core security analysis indicates that considerable security habitat is available for the Bluenose West caribou herd in the Transition Forest, North Taiga Plains and South Taiga Plains ecological zones in the baseline case (see Table 12-22). The project will cause a small decrease in available core habitat. Threshold core habitat values do not exist for barren-ground caribou, though values for the baseline and project cases exceed the threshold value of more than 60% for woodland caribou, indicating no management risk for the species.

Table 12-22: Core Security Habitat for Bluenose West Barren-Ground Caribou

Habitat Measurement	Baseline Case		Cumulative Case			
			Construction		Operations	
	Area (km^2)	RSA (%)	Area (km^2)	RSA (%)	Area (km^2)	RSA (%)
Total area available in RSA	39,374	N/A	39,374	N/A	39,374	N/A
Core security habitat available	28,621	72.7	27,717	70.4	27,717	70.4
NOTE: N/A = not applicable						

Threshold values for barren-ground caribou access density are not known, though road and corridor densities in the RSA are generally low relative to woodland caribou thresholds in the baseline and project cases. Although access densities are generally low, part of the RSA currently has some winter access (North Taiga Plains Ecological Zone, north of Norman Wells). New winter access to this area, even along a single pipeline right-of-way or road, could greatly increase mortality above current levels. However, because most mortality occurs near access corridors, the affected area, as indicated by availability of core security habitat, would be relatively small.

Grizzly Bear

Direct Mortality – Introduction

Although human activity and vehicle traffic will increase in the RSA, particularly during Mackenzie Gas Project construction, few grizzly bears will likely be killed by vehicles. This is supported by observations of bears in Alaska's North Slope oil fields (Shideler and Hechtel 2000). However, nuisance bears might be killed at camps and facility sites. Bears habituated to human foods might be more vulnerable to hunting (Shideler and Hechtel 2000).

Direct Mortality – Population and Quotas

Grizzly bear densities in the RSA range from 3 to 8 bears/1,000 km^2. Densities are higher in the Inuvialuit Settlement Region and Gwich'in Settlement Area at 6 to 8 bears/1,000 km^2 (from Nagy, personal communication; GRRB 2000) than in the Sahtu Settlement Area at 4 to 5 bears/1,000 km^2 (from Veitch 2003, personal communication). Based on these estimates, 150 to 205 barren-ground grizzly bears might be in the Inuvialuit Settlement Region portion of the RSA, 110 to 125 bears might be in the Gwich'in Settlement Area portion of the RSA and 122 to 150 bears might be in the Sahtu Settlement Region portion of the RSA.

Direct grizzly bear mortality from development will affect annual allowable harvest rates. Two grizzly bear harvest and management areas overlap the RSA in the Inuvialuit Settlement Region: the Tuktoyaktuk Grizzly Bear Management Area (GBMA) and the Inuvik GBMA. Recent grizzly bear population estimates are 214 bears over the age of two years and a density of 6 bears/1,000 km^2 for the Tuktoyaktuk GBMA and 29 bears over the age of two years at a density of 4.2 bears/1,000 km^2 for the Inuvik GBMA.

This has resulted in allowable total harvests of seven bears per year for the Tuktoyaktuk GBMA and three bears per year for the Inuvik GBMA (Branigan et al. 2003). Of these, the maximum number of females that can be harvested is two in the Tuktoyaktuk GBMA and one in the Inuvik GBMA.

Direct Mortality – Mortality Rate

Bear mortality from 1998 and 1999 to 2003 in the Inuvik GBMA was 12 grizzly bears, including four females. This was slightly below the total quota for those six years of 15 bears, including five females. Bear mortality in the Tuktoyaktuk GBMA has met quota levels, though the number of females killed over the last three years has exceeded recommended levels. Because bear mortality rates are at or near quota levels, any additional grizzly bear losses resulting from development could affect population levels and annual allowable harvest rates for local residents.

In the Gwich'in Settlement Area, allowable human-caused grizzly bear deaths was calculated to be 12 bears per year (GRRB 2000), including the combined effects of subsistence hunting, mortalities resulting from defence of life and property, sport hunting and illegal kills. No information was available on actual mortality rates.

The low grizzly bear densities in the RSA, and the species' long reproductive interval, late age of maturity and small litter sizes (McLoughlin and Messier 2001), suggest that mortality associated with developments might increase the risk of population decline. Grizzly bear populations are particularly sensitive to mortality rates of females (McLellan et al. 1999). McLoughlin and Messier (2001) used computer simulation models to demonstrate that the addition of only six bear mortalities to a stable or slightly increasing bear population in the central Arctic resulted in a greater than 40% chance of a decrease in population size by one-quarter over the next 50 years. The annual removal rate of bears from the population was 13.4 bears.

The threshold bear mortality values that could initiate population decline in the RSA is not known, and the population status and demographic parameters of bears in the RSA are not known. Without this information, it is difficult to predict the risk of grizzly bear population decline in the RSA.

There is currently little grizzly bear mortality in the RSA because of industrial activities, primarily because these activities are largely restricted to the winter season when bears are hibernating (Nagy 2003, personal communication; Veitch 2003, personal communication). However, some bears will likely be killed in the RSA because of spring, summer and fall Mackenzie Gas Project operations and other land uses, based on observations from Alaska's North Slope oil fields and at industrial camps in the central Arctic. For example, in the Slave Geological Region, BHP (2000) estimated that 0.12 to 0.24 grizzly bears were killed per year at each industrial camp in their assessment area between 1986 and 1997, representing 20 bears over that period.

Extrapolating the yearly bear mortality rate from industrial camps in the central Arctic to the Mackenzie Delta and Mackenzie Valley should be done with caution because of potential differences in bear densities and population dynamics, measured by sex ratios, fecundity and survival rates. Differences also occur in movement patterns, encounter rates, forage availability, sensitivity to developments, encounter rates with developments, camp design and environmental protection measures between development areas.

Direct Mortality – Rates after Mitigation

Protection measures implemented in the central Arctic during the 1980s and early 1990s, which resulted in 20 bear mortalities at industrial camps over a 12-year period, were likely less stringent than those used today.

Based on recent experiences at the Diavik Diamond Mine, where no bear mortalities have occurred (Diavik Diamond Mines Inc. 2004), the mitigation and protection measures proposed for the project will reduce bear mortalities. As a result, assuming effective mitigation measures are implemented, predicted rates of bear mortalities for the project will likely fall within the lower range estimated for camps in the central Arctic, i.e. less than 0.12 bear per year per camp.

Based on this lower estimate of bear mortalities, the project could cause less than one bear mortality per year during Mackenzie Gas Project construction and operations (see Table 12-23). These estimates are based on the number of camps that will be operational during spring, summer and fall. Most construction camps along the pipeline corridor will be used only during the period when bears are hibernating and will not, therefore, contribute to bear mortality.

Table 12-23: Estimated Grizzly Bear Mortality Resulting from the Project

Administrative Region	Construction		Operations	
	Number of Camps[1]	Potential Annual Bear Mortality	Number of Camps[2]	Potential Annual Bear Mortality
Inuvialuit Settlement Region	6	<0.7	5	<0.6
Gwich'in Settlement Area	0	0	0	0
Sahtu Settlement Area	0	0	1	<0.1
Deh Cho Region	0	0	3	<0.3
Total project	6	<0.7	9	<1

NOTES:
1 Estimated number of drilling camps used during spring, summer and fall. Pipeline and facility camps are assumed to only be operational during winter when bears are hibernating.
2 Estimated number of camps used during project operations (all year)

Direct Mortality – Conclusions

There could be an additional mortality rate in the Inuvialuit Settlement Region portion of the RSA of less than 0.7 bears per year during construction, or one bear every 1.5 years and less than 0.6 bears per year during operations, or one bear every 1.7 years. This is considerably less than the annual allowable harvest of bears in the Inuvik GBMA of three bears or in the Tuktoyaktuk GBMA of seven bears.

This level of mortality would not affect the viability of bear populations in the Inuvialuit Settlement Region, but would affect local harvest opportunities. Estimated bear mortality in the Gwich'in Settlement Area, Sahtu Settlement Area and Deh Cho Region is also low, less than 0.3 bears per year during operations, and is also not expected to affect population viability of bears in each administrative region.

Grizzly bear mortality can also result from disturbance and subsequent abandonment of den sites. However, because denning habitat in the RSA is not limiting and densities of bears are low, the likelihood is low that a den site will be disturbed during Mackenzie Gas Project construction and operations. As a result, the probability is low that additional bear mortality would result from extraction of granular resources.

The project's contribution to cumulative grizzly bear mortality will not be significant assuming that effective and long-term mitigation measures are implemented. It is likely that a small number of bears will be killed during the life of the project; however, numbers will likely be well below allowable annual quotas. Assuming yearly quotas can be adjusted to account for this mortality, the project will not affect the viability of grizzly bear populations in the RSA, although it could affect harvest opportunities.

Reasonably foreseeable developments in the RSA are either offshore or winter based and will therefore likely not contribute to grizzly bear mortality. Subsistence hunting, outfitter operations and defence of life and, property are the primary existing causes of grizzly bear mortality in the RSA. Currently, mortality rates are within allowable annual quotas: three bears in the Inuvik GBMA and seven bears in the Tuktoyaktuk GBMA, although female mortality in the Tuktoyaktuk GBMA has exceeded recommended levels.

The additional mortality of bears resulting from project construction in the Inuvialuit Settlement Region might be unsustainable if the current process of quota adjustment is not continued, i.e., quota limits are not adjusted. If other sources of mortality, e.g., defence of life and property, are unexpectedly high and, especially if females are killed, then maintenance of viable bear populations will require careful management.

Current research projects in the Mackenzie Delta will provide much-needed data on bear population dynamics in the region, which will provide a better estimate of sustainable mortality rates.

Indirect Mortality

Core security analysis indicates that 66% of the RSA is core security habitat for northern interior grizzly bear in the baseline case (see Table 12-24). The project will cause a small decrease in core habitat availability. The availability of core security habitat exceeds the 60% threshold value derived for grizzly bear, indicating no management risk for the species.

Table 12-24: Core Security Habitat for Northern Interior Grizzly Bears

Habitat Measurement	Baseline Case		Cumulative Case			
			Construction		Operations	
	Area (km^2)	RSA (%)	Area (km^2)	RSA (%)	Area (km^2)	RSA (%)
Total area available in RSA	70,232	N/A	70,232	N/A	70,232	N/A
Core security habitat available	46,115	65.7	44,537	63.4	44,537	63.4

NOTE:
N/A = not applicable

An analysis of linear corridors indicated that road density during either the baseline or project case does not exceed the threshold level of 0.6 to 0.68 km/km^2 established for grizzly bear. However, some roads might provide access to previously remote and inaccessible areas in spring, summer and fall, which could increase the rate of bear mortality in these areas.

Moose

Direct Mortality

Although human activity and vehicle traffic will increase in the RSA in winter, particularly during Mackenzie Gas Project construction, few moose will likely be killed by vehicles. Firearm restrictions at work camps and facilities will also limit direct mortality of moose. Based on the minimum moose density in the Mackenzie Valley of 0.03 $moose/km^2$, at least 2,300 moose might live in the RSA's Transition Forest, North Taiga Plains and South Taiga Plains ecological zones. Loss of several animals will have a negligible effect on population viability.

Indirect Mortality

Core security analysis indicates that 67% of the RSA is core security habitat for moose in the baseline case (see Table 12-25). The project will result in a small decrease in core habitat availability. Threshold values are not available for moose, though values for the baseline and project cases exceed the threshold value of more than 60% for woodland caribou, indicating no management risk for the species.

Table 12-25: Core Security Habitat for Moose

Habitat Measurement	Baseline Case		Cumulative Case			
			Construction		Operations	
	Area (km^2)	**RSA** (%)	**Area** (km^2)	**RSA** (%)	**Area** (km^2)	**RSA** (%)
Total area available in RSA	78,733	N/A	78,733	N/A	78,733	N/A
Core security habitat available	52,788	67.0	51,027	64.8	51,027	64.8

NOTE:
N/A = not applicable

Threshold values for moose access density are not available, though road and corridor densities in the RSA are generally low relative to woodland caribou thresholds in the baseline and project cases. Although access densities are low, portions of the RSA currently have some winter access, i.e. the North Taiga Plains Ecological Zone, north of Norman Wells. New winter access into this area, even along a single pipeline right-of-way or road, could greatly increase mortality above current levels. However, because most mortality occurs near access corridors, the affected area, as indicated by availability of core security habitat, would be relatively small.

Woodland Caribou

Direct Mortality

Although human activity and vehicle traffic will increase in the RSA in winter, particularly during Mackenzie Gas Project construction, few caribou will likely be killed by vehicles. Firearm restrictions at work camps and facilities will also limit direct mortality of caribou. Based on the minimum regional density of 0.01 caribou/km^2, 700 woodland caribou might live in the RSA's Transition Forest, North Taiga Plains and South Taiga Plains ecological zones. Loss of several animals will therefore have a low effect on population viability.

Indirect Mortality

Loss of core security habitat for woodland caribou is similar to that for moose, and the potential effects of increased access density are similar to those described for barren-ground caribou. Although access density is below threshold levels for woodland caribou, increased access to previously inaccessible and remote areas could greatly increase barren-ground caribou mortality. However, as described previously, because most mortality occurs near access corridors, the affected area as indicated by availability of core security habitat, would be relatively small.

Marten

Direct Mortality

Marten are abundant in the RSA. Their densities range from 0.4 to 2.4 animals/km^2 throughout their range in the Northwest Territories. Loss of several animals from vehicle collisions or by removal from facility sites will have a negligible effect on population viability.

Indirect Mortality

Loss of core security habitat for marten is similar to that for moose and, as described previously, access density is generally low during baseline and project cases. However, increased access to previously inaccessible and remote areas could greatly increase trapping levels in some areas. Because most trapping will occur near access corridors, the affected area, as indicated by availability of core security habitat, would be relatively small.

Lynx

Direct Mortality

Lynx densities in the Northwest Territories range from 0.03 animals/km^2 during population lows to over 0.4 animals/km^2 during population highs. As a result, more than 2,000 lynx might live in the RSA's Transition Forest, North Taiga Plains and South Taiga Plains ecological zones during population lows. Loss of several animals from vehicle collisions or by removal from facility sites, even during population lows, will have a negligible effect on population viability.

Indirect Mortality

The effects of indirect mortality on lynx populations are the same as those for marten.

Beaver

Direct Mortality

Direct mortality of beaver might result from removal of dams during Mackenzie Gas Project construction and other land uses. Because beaver are widespread and relatively abundant in the RSA, these activities will have little effect on population viability.

Indirect Mortality

Increased access might increase trapping pressure on beaver, particularly in areas previously inaccessible to trappers. However, because beaver are widespread and relatively abundant in the RSA, these activities will have little effect on population viability.

Beluga and Bowhead Whales

Direct Mortality

Direct mortality to beluga and bowhead whales might result from vessel impacts although the likelihood of this is very small.

Indirect Mortality

Any temporary reduction in water quality from dredging or accidental spills during any phase of the project will add cumulatively to other sources of contamination in the Mackenzie Delta. However, major point sources of contamination are not expected.

Polar Bear

Direct Mortality

Polar bears attracted to facilities during Mackenzie Gas Project construction and operations might have to be removed or killed, although the likelihood of this is low because the density and use of dens is low near facilities.

Indirect Mortality

Indirect mortality of polar bears is negligible and unlikely.

Significance

The significance of project contribution to mortality for all species is Class 3, not significant, except for grizzly bear, which is Class 2, not significant.

The significance of overall cumulative effects on movements for all species is Class 3, not significant.

Effects of mortality on grizzly bear will likely increase because of their attraction to camps and facilities and because of increased access during the snow-free period. Because of the small population size and low reproductive rate of bears, loss of several bears can have serious consequences on harvesting. Effects are long term because excessive mortality of bears, coupled with their low reproductive rate, could depress populations for a considerable time.

Strict, long-term environmental protection plans to effectively minimize bear mortalities at industrial camps and facilities are required. Ineffective management planning could result in increased bear mortalities and a potential decrease in population viability.

12.2.10 Summary of Cumulative Effects

Table 12-26 shows the results of the cumulative effects assessment for past, current and reasonably foreseeable land uses.

Table 12-26: Summary of Significance for Cumulative Effects of Past, Current and Reasonably Foreseeable Land Uses

Discipline	Key Indicators or Valued Components	Interaction[1]	Cumulative Effect[2]		Significance	
			Project	Overall	Project	Overall
Air	NO_2	Yes	3	3	Not significant	Not significant
	SO_2	Yes	3	3	Not significant	Not significant
	CO	Yes	3	3	Not significant	Not significant
	$PM_{2.5}$	Yes	3	3	Not significant	Not significant
	Benzene	Yes	3	3	Not significant	Not significant
	BTEX	Yes	3	3	Not significant	Not significant
	PAI	Yes	3	3	Not significant	Not significant
Noise	Sound level	No	NE	NE	Not significant	Not significant
Groundwater	Groundwater quantity and flow patterns	Yes	3	3	Not significant	Not significant
	Groundwater quality	Yes	3	3	Not significant	Not significant
Hydrology	Runoff amount and drainage patterns	Yes	3	3	Not significant	Not significant
	Water levels and flow velocities	Yes	3	3	Not significant	Not significant
	Sediment concentration	Yes	3	3	Not significant	Not significant
	Channel morphology	Yes	3	3	Not significant	Not significant
Water Quality	Wastewater releases	Yes	3	3	Not significant	Not significant
	Suspended sediments	Yes	3	3	Not significant	Not significant
Fish and Fish Habitat	Habitat	Yes	3	3	Not significant	Not significant
	Health	Yes	3	3	Not significant	Not significant
	Abundance and distribution	Yes	3	3	Not significant	Not significant
Soils, Landforms and Permafrost	Ground stability	Yes	3	3	Not significant	Not significant
	Uncommon landforms	Yes	3	3	Not significant	Not significant
	Soil quality	Yes	3	3	Not significant	Not significant
Vegetation	Abundance and distribution of vegetation species and associations	Yes	3	3	Not significant	Not significant
	Health of vegetation species	Yes	3	3	Not significant	Not significant

Table 12-26: Summary of Cumulative Effects for Current and Reasonably Foreseeable Land Uses (cont'd)

Discipline	Key Indicators or Valued Components	Interaction[1]	Cumulative Effect[2]		Significance	
			Project	Overall	Project	Overall
Wildlife[3]	Habitat availability	Yes	3	3	Not significant	Not significant
	Movements	Yes	3	3	Not significant	Not significant
	Mortality	Yes	3, 2 for grizzly bear	3	Not significant	Not significant

NOTES:

1 *Yes* indicates the project causes a residual effect that might interact measurably with other land uses on the same KI or VC. *No* indicates no cumulative effect interaction.

2 Indicates the class of the cumulative effect. *Project* is that project's contribution to cumulative effects. *Overall* is the overall cumulative effect of and considers all past, current and reasonably foreseeable land uses. Section 12.1.7.3 defines classes 1 to 3. *NE* indicates no (cumulative) effect.

3 Conclusions for all species assessed unless indicated otherwise

12.3 Effects of Hypothetical Projects

12.3.1 Introduction

This section assesses cumulative effects from the Mackenzie Gas Project and hypothetical projects. Types of land uses generally considered hypothetical are defined in Section 12.1.5.2, Future. Examples of these land uses in the terrestrial RSA are identified in Section 12.1.6.3, Hypothetical Land Uses and include:

- hydrocarbon development, i.e., gas exploration and production
- infrastructure, i.e., roads and telecommunications

Hydrocarbon development, beyond the project's three anchor fields, might occur if the project proceeds. This would include further exploration and the addition of gas supply from other fields. Section 12.3.2, Hydrocarbon Development, discusses these land uses and their potential effects.

Infrastructure might be developed as part of evolving transportation and communication corridors in the region, likely in response to increased likelihood of future hydrocarbon production. Section 12.3.3, Infrastructure Development, discusses these projects and their potential effects.

12.3.1.1 Approach

Assessment of potential cumulative effects of hypothetical projects is qualitative. Effects are not assessed quantitatively because of the limitations and uncertainties in assessing such projects. Effects are based on:

- Mackenzie Gas Project-specific assessment
- assessment of cumulative effects with past, current and reasonably foreseeable land uses
- extensive experience with similar patterns of development elsewhere

The assessment is organized in three parts:

1. History – background information on past and current conditions that establishes the basis for developing a future scenario.
2. Future Scenario – description of a possible outcome based on known current conditions and a possible future trend. A scenario is meant only to describe a conceptual and plausible future representing one of many options of what might happen. Therefore, quantities shown are provided only as examples and should not be interpreted as actual predictions. Specific locations and footprints are not conjectured.

3. Effects Observations – qualitative description of how cumulative effects, assessed for past, current and reasonably foreseeable land uses, would remain the same or change based on occurrence of the future scenario.

The contribution of hypothetical projects to cumulative effects will occur in ways identified and assessed earlier. Each successive project will incrementally cause additional effects that will act on VCs through similar cause-and-effect pathways. How this occurs is usually known with a level of certainty that allows for an understanding of what will likely happen because of individual projects.

Limitations

The information available, and the uncertainty of that information, does not provide an adequate basis for including hypothetical projects in a meaningful quantitative assessment. Assessing the unknown will not have the same certainty as would assessment of project-specific effects. Speculation about possible future projects does not necessarily provide further certainty to regulatory decision makers or communities, especially if:

- there is no long-term historical trend from which future possible scenarios might be projected, e.g., most hydrocarbon development in the Northwest Territories is relatively recent, with the exception of oil production in the vicinity of Norman Wells
- changes occur in world markets and in the economics of arctic gas recovery over the life of the project, combined with the uncertainty and low confidence of predicting effects over such extended periods
- thresholds are not available for many VCs, particularly terrestrial, against which to compare project contribution and to identify possible cumulative effects of concern

Opportunities

Land and resource use priorities and thresholds are required to adequately consider potential cumulative effects in anticipation of possible future projects such as transportation corridors and gas production and delivery. Such priorities are emerging to some degree through evolving land use plans and equivalent initiatives in the various administrative regions overlapping the project.

In an adaptive process, potential environmental effects of future projects can be assessed based on more certain project descriptions and in the context provided by the objectives established by each administrative region. This can be accomplished within the now well-advanced regulatory review process for individual project applications and through regional and collaborative initiatives to manage and monitor effects, such as the initiatives discussed in Section 12.4, Management of Cumulative Effects.

12.3.2 Hydrocarbon Development

12.3.2.1 History

Further hydrocarbon development in the region is expected if the project proceeds. Although there is discovered and undiscovered gas potential, the timing, location and physical description of projects that might be built and operated to access this resource is uncertain. Development of such projects depends, among other factors, on costs and global commodity markets.

If other gas fields are developed, their construction and operations would follow conventional design and operational practices of the time, likely including wells in current and future exploration licences (ELs) and significant discovery licences (SDLs), with their associated facilities, access roads, gathering pipelines and other infrastructure.

Following is a description of potential hydrocarbon sources, in the form of resource volumes, leases and Mackenzie Gas Project capacity. This resource potential can then be compared with the project's future potential, forming the basis of a possible hydrocarbon development scenario.

Potential Resource Sources

Resources

The estimated resource in the Mackenzie Gas Project anchor fields is 5.7 Tcf (162 Mm^3). This is 59% of the estimated 9.6 Tcf (273 Mm^3) contingent recoverable resource in the Mackenzie Delta, central Mackenzie Valley, northern Yukon and shallow offshore areas less than 30 m deep.

Few gas volumes from recent discoveries are publicly known. Petro-Canada's Tuk M-18 well, 24 km south of Tuktoyaktuk, was estimated at 300 Bcf or 0.3 Tcf (PN 2002), and is an example of a field that might be a candidate for future production.

Hydrocarbon resources other than conventional natural gas are not currently considered applicable to the project:

- gas hydrates – the resource potential of gas hydrates is currently unknown, though 4 Tcf (114 Mm^3) of gas in hydrate form was estimated from the one gas hydrate exploratory program in the Mackenzie-Beaufort region (Hyndman and Dallimore 2000). This resource is not commercially viable with current technology.
- oil – although technically possible, transport of oil in the NGL pipeline is not currently proposed

Leases

Hydrocarbon activities occur in two types of lease dispositions regulated by the Government of Canada. Exploration licences (ELs) are for exploration and significant discovery licences (SDLs) are designated when flowing hydrocarbon is found. Figure 12-3 (from DIAND 2003) shows locations of existing licences in the Northwest Territories. Information on dispositions, including maps, is based on the latest information available in 2003.

Although gas resources also exist in the Yukon, and the Fort Liard and Cameron Hills areas, the regions with the greatest immediate potential to contribute gas to the project are likely to be from leases located in the:

- Mackenzie-Beaufort region (see Figure 12-4)
- Mackenzie Valley-Central Region (see Figure 12-5)
- vicinity of Colville Lake (Figure 12-6)

Of the 80 current leases in the Mackenzie-Beaufort region (DIAND 2003), 65 are SDLs and 15 are ELs, 54 overlap the Beaufort Sea and 17 are entirely offshore. The ELs are owned by nine leaseholders and the SDLs are owned by seven leaseholders. Imperial's Taglu lease has the largest contingent resource of all gas SDLs in the region.

In the central Mackenzie region, there are four SDLs owned by two leaseholders and 15 ELs owned by nine leaseholders (DIAND 2003).

Not all SDLs contain nonassociated gas resources. In the Mackenzie-Beaufort region, of the 53 SDLs known at the time (NEB 1998), 20 were for gas. Eight of these were offshore and 12 were onshore. Of the 53 SDLs in 1998, 20 were for both gas and oil, and 14 of these were offshore and six were onshore. Information to distinguish gas and oil leases for the latest (2003) disposition maps is not yet available.

Project Capacity – Base Case

For this assessment and based on preliminary engineering design, estimated production rates from the anchor fields are 4.4 Mm^3/d for Niglintgak, 12.6 Mm^3/d for Taglu and 7.8 Mm^3/d for Parsons Lake for a total production of 24.8 Mm^3/d. Base case pipeline capacity, however, is designed at 34 Mm^3/d, or 1.2 Bcf/d. This leaves an additional capacity of 9.2 Mm^3/d for possible gas from other sources. About half of this gas is expected from the Mackenzie-Beaufort region; i.e., north of the Inuvik area facility.

The additional capacity from anchor fields to base case, 9.2 Mm^3/d, might be met by one or more additional gas field sources. It is unknown, beyond just one more field, how many more fields would supply this additional gas. This would depend on the timing and rate of anchor field depletion and expansion, as each field has an option to add expansion wells.

Figure 12.3 has been removed for the purposes of reducing file size and can be viewed as a graphic separately. This document can be accessed through the link in the Table of Contents reference web page.

Figure 12.4 has been removed for the purposes of reducing file size and can be viewed as a graphic separately. This document can be accessed through the link in the Table of Contents reference web page.

Figure 12.5 has been removed for the purposes of reducing file size and can be viewed as a graphic separately. This document can be accessed through the link in the Table of Contents reference web page.

Figure 12.6 has been removed for the purposes of reducing file size and can be viewed as a graphic separately. This document can be accessed through the link in the Table of Contents reference web page.

Additional fields are likely to each be smaller than the Mackenzie Gas Project anchor fields, but would have to be large enough to justify the long-term economics of their development. It is likely that two to three additional fields are needed, assuming a production rate similar to that of the smallest anchor field production, i.e., Niglintgak, not accounting for reservoir depletion over the life of the project.

It is unknown how many more fields might be developed in the Mackenzie-Beaufort region to access the additional gas resources.

Project Capacity – Expansion Case

The pipeline is expandable to 51 Mm^3/d or 1.8 Bcf/d. This is an increase of 17 Mm^3/d from base case and 26.2 Mm^3/d beyond the anchor fields alone. The addition of 10 compressor stations and two pump stations would be required to increase pipeline capacity from base to expansion case. Block valves would be constructed in the base case pipeline to accommodate these additional facilities.

The design of these additional facilities would likely be similar to the design of facilities proposed for the base case. Therefore, biophysical effects would likely be similar to those in this assessment; mitigation of these effects would also be similar. As the expansion case is entirely conceptual at this time, possible effects are not assessed here. Any such assessment would accompany a possible future application.

Further addition of fields would be required to fill the capacity between base and expansion case. As a conservative estimate, the equivalent of three to four fields similar in size to Niglintgak would be required, not accounting for reservoir depletion over the life of the project. This number could easily change given the many possible combinations of reservoir volumes, location, economics and other factors.

12.3.2.2 Future Scenario

A scenario for future hydrocarbon development is based on potential access to known resource, historical field development trends south of 60º latitude and the application of typical industry build-out conditions. A similar exercise was done for the Beaufort-Mackenzie region in 1989 (CPA), with results that are still relevant.

New projects would require a certain number of well pads, kilometres of access roads, kilometres of pipelines and hectares of area cleared for well pads and other facilities. It is not possible, however, to estimate possible total areas, especially for rights-of-way, with any useful accuracy because the numbers can vary considerably depending on the number of well pads, location and other factors.

As an example, the area of the anchor field components ranges from about 20 ha to 50 ha per field to accommodate well pads, sumps, flow lines and the gas conditioning facility. As shown in Table 12-1, shown previously, the total disturbed area associated with those sites, including access and borrow sites, is a larger area. The existing SDLs indicate likely general locations for other possible fields.

A possible long-term future development scenario is as follows:

1. The Mackenzie Gas Project is built to meet base case capacity. The rate of exploration and development increases, including development of existing SDLs, in response to availability of a pipeline to ship gas to market.
2. The project begins operations with anchor fields only, i.e., under capacity, or, with the addition of two or three other fields under a binding precedent agreement, operates close to or at base case capacity at start-up. These additional fields would likely be smaller than the anchor fields but similar in design. These fields would likely be onshore, in the Mackenzie Delta or Mackenzie Valley, likely near the project and available conditioning facilities. The new fields could be a few to hundreds of kilometres away from Mackenzie Gas Project infrastructure.
3. There is more exploration in the Beaufort-Mackenzie, Mackenzie Valley and Yukon regions. More operators offer additional gas supplies to the Mackenzie Gas Project and build their lateral or collector lines to link up with the project. The Mackenzie Gas Project operator decides to expand the project from the base case to the expansion case, principally by adding 10 compressors.
4. As many as five new fields are developed and tied into the Mackenzie Gas Project. Some fields are offshore in the Beaufort Sea once undersea pipelines are proven and built. Onshore and offshore resources continue to be exploited. Common resources for construction and logistics are possibly centralized and shared, e.g., processing plants, access roads, aggregate pits, waste disposal, base camps, stockpile yards and barge landings. More winter and all-weather access is built with increasing levels of road, air and marine traffic.
5. Exploration continues, and production facilities and pipelines are built over the design life of the Mackenzie Gas Project to offset reservoir depletion in the original anchor fields. This activity is highly variable and is influenced by market conditions and other factors. Production is first limited by the volume of technically recoverable gas at the time and, ultimately, by the volume of discovered resources. Because the project currently accounts for only a portion of the known economically recoverable gas in the Mackenzie region, further production in that region would come from the remaining contingent resources and other gas yet to be proven recoverable.

Alaska North Slope

The most valuable precedent for a future scenario is similar operations in similar environmental conditions. Although there is no reason to assume that energy development in Canada's north will be as extensive, Alaska's North Slope provides insight into patterns of development and the expectations and limitations of conducting meaningful cumulative effects assessments.

Oil has been produced on Alaska's North Slope since the early 1970s and development now includes a broad network of pads, processing plants, pipelines and roads. A recent comprehensive cumulative effects study of this development (NAS 2003) provided conclusions that could be relevant to potential energy development in Canada's Arctic:

1. Regarding the modelling or prediction of effects, it was clear that despite a considerable amount of information with acknowledged data gaps and almost 30 years of observation, there remained considerable uncertainty about the long-term implications of the development on some key VCs.

2. The ability to predict future development was also uncertain given vagaries in energy markets, despite identification of a historical trend.

3. Few specific cumulative effects were identified as likely major concerns, including damage to tundra from off-road travel, effects of roads in general, effects on animal populations, effects of oil spills and questionable long-term recovery of abandoned infrastructure and unrestored landscapes.

   As a general observation, *Continued expansion [of oil and gas activities] will exacerbate existing effects and create new ones* (NAS 2003, p. 159), is likely the most definitive and useful conclusion for predicting cumulative effects in the distant future in regions influenced principally by industrial resource-based development.

4. Acceptability, i.e., significance, of these effects, or even the basis of establishing acceptability from the available information, could not be established. The report recommended that acceptability could only be determined through a larger forum of response to public debate and reliance on successful implementation of regulatory mechanisms. This would require understanding and acceptance that *trade-offs are inevitable*. The cumulative effects assessment was viewed as only one source of information to assist the decision-making process for project applications and land use planning.

12.3.2.3 Effects Observations

Following are key observations of potential cumulative effects from a possible future hydrocarbon development scenario:

- air – overlapping emissions plumes and areas of deposition from additional, stationary facilities (processing plants) combined with flaring and mobile sources (ground vehicles), could result in new but localized areas of concern
- noise – more point sources of noise and greater frequency of noise along roads, increase the likelihood of overlapping noise levels and possibly result in new but localized areas of concern
- groundwater – further localized changes in flow patterns and recharge rates, caused by additional surface facilities and rights-of-way, might combine to cumulatively modify aquifer quantities and quality
- hydrology – localized changes in runoff amount, drainage patterns, water levels and velocities caused by additional surface facilities and rights-of-way, might combine to cumulatively modify surface water quantities and distribution
- water quality – localized changes in sediment concentration, caused by additional surface facilities and rights-of-way, might combine to cumulatively modify surface water quality, possibly resulting in reduced quality
- fish and fish habitat – localized introductions of sediment and alteration of habitat, caused by more watercourse crossings, might modify fish distribution. This could cause increased mortality through increased fishing resulting from new or improved access to waterbodies and increased human presence.
- soils, landforms and permafrost – localized changes could result in changes to surface landforms, permafrost and soil drainage, including soil loss and changes in physical and chemical properties, caused by additional surface facilities and rights-of-way
- vegetation – localized loss and change in vegetation species and communities, caused by additional surface facilities and rights-of-way, might alter the regional diversity of vegetation
- wildlife – increased direct and indirect loss of habitat caused by additional surface facilities and rights-of-way and increased mortality from greater hunting activity resulting from new or improved access across the region and increased human presence. These pressures could cause displacement of individuals or populations from their historical range.

The most noticeable changes caused by cumulative effects would likely result from increased access, especially in forested areas. With exploration and production distributed over large areas, it is less likely that direct clearing or other effects would result in effects that interact to cause cumulative effects. In areas of more intensive activity, such as exploration and production in areas of new and substantial economically recoverable resources, more rapid development might occur. In such cases, effects management and monitoring options (see Section 12.4, Management of Effects) can be considered to address increased cumulative effects risk; i.e., the effects of change over relatively short periods and in relatively confined areas.

Because of the current relatively low level of development in the region, no effects are currently likely to exceed guideline thresholds, if applicable, for air and water quality and noise. It is also unlikely that thresholds for wildlife species will be exceeded, based on scientific study and traditional knowledge. The degree of development required to change this conclusion, and when that might occur, is unknown and cannot be determined based on currently available information.

12.3.3 Infrastructure Development

12.3.3.1 History

The level of industrial activity in the Northwest Territories has increased in the last decade, largely from diamond mining and oil and gas exploration and production. Upgrading and construction of new transportation and telecommunications infrastructure is being considered in response to this development.

GNWT's (2002) *Corridors for Canada* proposes two road and resource corridors in the Northwest Territories: the Mackenzie Valley Corridor and the Slave Geologic Province Corridor. GNWT is seeking partnership funding with the Government of Canada. The purpose of the Mackenzie Valley Corridor is to *facilitate the exploration and development of oil and gas deposits, along with the construction of the gas pipeline* (GNWT 2002, p. 18).

The Mackenzie Valley Corridor proposal identifies two new road-related projects:

- an all-weather road from Tuktoyaktuk to about 22 km south of the community to access gravel sources. This would be the first phase of a possible all-weather road between Inuvik and Tuktoyaktuk. There is currently only winter road access between the two communities.
- completion of bridges over the Bear and Blackwater rivers along the existing Mackenzie River winter road between Wrigley and Fort Good Hope. This would complete access improvement underway by GNWT along this route.

A third project under this proposal is an upgrading of selected parts of the Dempster Highway.

Although not part of the current GNWT proposal, a road connection between Fort Good Hope and Tsiigehtchic has been considered by northern residents for many years as the final link to connect the territorial road system in the far north with the Yukon's Dempster Highway. Only a trail currently exists between Fort Good Hope and Tsiigehtchic. It is also reasonable to assume that eventually a telecommunications line, e.g., fibre optic cable, would be constructed alongside such a road to service the Mackenzie Delta.

The Slave Geologic Province Corridor would service another region in the Northwest Territories. This corridor includes the Deh Cho Bridge at Fort Providence, already identified in this assessment as a reasonably foreseeable project. Its location on the Mackenzie River makes possible a cumulative effects interaction with the Mackenzie Gas Project. Other more eastern components of this corridor are likely too distant from the project to result in measurable biophysical interactions, so are not discussed further here.

12.3.3.2 Future Scenario

A possible future scenario for infrastructure is as follows:

1. The winter bridges are completed along the existing Mackenzie River winter road. Winter exploration occurs earlier and later in the year than before the bridges were built. This facilitates oil and gas exploration near Colville Lake, already accessible by a new winter road from Fort Good Hope.
2. The resource access road from Tuktoyaktuk is built. Vehicles for exploration and construction (for accessing granular resources), use the road throughout the year, including stockpiling in summer to support winter activities.
3. The Tuktoyaktuk resource access road is extended southward to Inuvik. Oil and gas exploration and development continues.
4. The existing Mackenzie winter road is upgraded to an all-weather road. The level of vehicular travel increases.
5. An all-weather Mackenzie Highway is completed to Tsiigehtchic. Some vehicles from farther south now access the Mackenzie Delta directly through the Northwest Territories rather than through the Yukon on the Dempster Highway.
6. A telecommunications fibre optic cable is constructed along the Mackenzie Highway.

12.3.3.3 Effects Observations

The key observations of potential cumulative effects of the infrastructure development are similar to those described in Section 12.3.2.3, Effects Observations.

12.4 Management of Effects

The most effective means of managing the project's contribution to cumulative effects is through the application of monitoring and management plans described in Sections 2 to 10 and in Volume 7, Environmental Management. In this way, many effects can be reduced to prevent interactions with other land uses, thereby avoiding cumulative effects altogether. The measures include accepted and proven industry practices and, as necessary, additional measures, such as multi-well drilling from single well pads to reduce the disturbed area.

Where this is not possible or not effective in reducing cumulative effects, additional measures might be required. These mitigation and monitoring measures are most successful, and in some cases only successful, if implemented as a regional and jointly coordinated initiative led by government and involving the public, local communities and industry. These and other initiatives might lead to the establishment of land use thresholds.

Two current initiatives in the Northwest Territories are already addressing cumulative effects in this way. The Cumulative Effects Assessment and Management Framework, supported by Environment Canada and Indian and Northern Affairs, provides a basis for directing and coordinating various initiatives to manage cumulative effects. These initiatives include, for example, regional baseline data collection and derivation of regional thresholds. Also, the Northwest Territories Cumulative Impact Monitoring Program, a northern multistakeholder partnership-based initiative, is working to develop monitoring programs for various environmental indicators, such as changes in caribou population and habitat, and water quality.

Cumulative effects are also addressed through land use plans or equivalent means of designating land use over large regions. By indicating areas of some, minimal or no acceptable land use, land values in various parts of the plan region are maintained, thereby offsetting the potential and often uncertain long-term effects of future land uses on some VCs. This has already been accomplished in the Inuvialuit Settlement Region with the Community Conservation Plans and in the Gwich'in Settlement Area with the final Gwich'in Land Use Plan. Land use plans are currently being developed for the Sahtu Settlement Area and Deh Cho Region.

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