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6.0 ASSESSMENT APPROACH

6.1 Introduction

6.1.1 Context

This section describes the environmental effects assessment approach that was used within both the Key Lines of Inquiry (KLOI) and Subjects of Note (SON) provided by the Terms of Reference (TOR) for the Fortune Minerals Limited NICO Cobalt-Gold-Bismuth-Copper Project (NICO Project) (MVRB 2009). According to the Environmental Effects Assessment Guidelines (MVRB 2004), the Developer’s Assessment Report (DAR) must contain sections on issue identification, mitigation, effects prediction, the developer’s determination of significance, and a cumulative effects assessment. This section describes the approach used to meet these requirements.

6.1.2 Purpose and Scope

The purpose of this section is to meet the requirements of the TOR for the NICO Project, which includes describing the methods and approach to analyzing and assessing impacts. Key elements of the DAR include the following:

- valued components (VCs);
- pathway analysis (also known as linkage analysis);
- spatial and temporal boundaries;
- NICO Project-specific effects;
- cumulative effects;
- impact assessment methods;
- uncertainty; and
- monitoring and follow-up.

The assessment approach presented here is based on ecological, cultural, and socio-economic principles, and environmental assessment best practice. Several elements of the approach can be consistently applied to all biophysical and socio-economic components. Alternately, certain elements of the assessment approach may have to be modified for some components.

For example, the definition of a VC can be applied to all environmental disciplines (e.g., hydrogeology, air, soil, wildlife, and socio-economics). There is general consistency in the approach for identifying pathways that link the NICO Project to potential effects on VCs of the biophysical and socio-economic environments. Likewise, the approach to determining the spatial and temporal boundaries for the effects analysis and assessment is similar across biophysical and human environment components.

In contrast, the methods for analyzing effects, classifying residual impacts (e.g., direction, magnitude, and duration), and predicting environmental significance can differ between biophysical and socio-economic components. For example, human effects of a specific project are difficult to isolate from the ongoing processes of interdependent social, cultural, and economic change. Evolving social trends, government policy and programming decisions, and individual choice all have effects that will be concurrent with potential NICO Project effects. Biophysical components also are influenced simultaneously by natural and human-related factors. However, for many disciplines, NICO Project-specific effects can be quantified (e.g., incremental changes to ground and surface water supply, air quality, soil, and fish and wildlife habitat).

Because the socio-economic status of different communities, subpopulations, and individuals may vary, a socio-economic effect may have both positive and negative aspects. An effect to a biophysical component is typically negative or positive. Therefore, differences in the overall approach and methods between biophysical and socio-economic environmental components are identified in this section, and details are provided in the human environment section of the DAR (Section 16).

6.1.3 Content

The structure of this DAR for the NICO Project is different from more ‘traditional’ environmental assessments conducted in the Northwest Territories (NWT) and Canada. This is due to the KLOI approach adopted by the MVRB. This approach was first used for the Gahcho Kué Project (MVEIRB 2007), and subsequently for the Taltson Hydroelectric Expansion Project (MVEIRB 2008). The following presents the 2 key features of the approach.

- The MVRB has not only identified issues, but prioritized the issues. The 3 KLOIs presented by the MVRB are “areas of the greatest concern that require the most attention during the environmental assessment and the most rigorous analysis and detail in the DAR” (MVRB 2009). Subjects of Note “require a thorough analysis, including a cumulative effects assessment, but do not require the same level of detail as Key Lines of Inquiry”. Through this approach, the MVRB has identified a 2-tiered approach to issues, and this is reflected in the level of detail in the DAR.
- Most of the KLOIs and SONs are multi-disciplinary. For example, the KLOI for Water Quality in the Nico Lake watershed must include an analysis of how changes to water quality may affect aquatic life, fish habitat, riparian vegetation and wildlife, and human use. In previous environmental assessments, this information would be distributed among several discipline-specific sections. However, for this assessment, the response to each KLOI and SON is stand-alone, with comprehensive analyses and minimal cross-referencing outside of the KLOI or SON.

The following sections present approaches and methods for assessing effects from the NICO Project on the biophysical and socio-economic environment (Table 6.1-1).

Table 6.1-1: Contents and Organization of Section 6.0

Section	Section Overview
Section 6.2	**Valued Components** – provides definitions of VCs and VC endpoints for biophysical and socio-economic attributes of the environment, which determines the effects that will be classified
Section 6.3	**Spatial and Temporal Boundaries** – links component-specific characteristics with the appropriate spatial and temporal scales for effects analyses, and gives definitions for broad spatial and temporal boundaries
Section 6.4	**Pathway Analysis** – provides the definition of pathways, environmental design features and mitigation, and the approach and methods for verifying no linkage, secondary (minor), and primary pathways

Table 6.1-1: Contents and Organization of Section 6.0 (continued)

Section	Section Overview
Section 6.5	**Residual Effects Analysis** – gives the general approach to analyzing NICO Project-specific and cumulative effects for biophysical and socio-economic components after implementing environmental design features and mitigation
Section 6.6	**Impact Assessment Methods** – introduces and provides generic definitions for residual impact criteria, and the approach and method for predicting environmental significance
Section 6.7	**Uncertainty** – introduces uncertainty and how it will be used to qualify impact predictions, and design adaptive management, and monitoring and follow-up programs
Section 6.8	**Monitoring and Follow-Up** – presents the concepts of adaptive management and different types of monitoring. Explains how monitoring and follow-up programs are used to verify the accuracy of impact predictions to reduce uncertainty and unexpected effects, and determine the effectiveness of mitigation

6.2 Valued Components

6.2.1 Identification of Valued Components

Valued components represent physical, biological, cultural, social, and economic properties of the environment that are considered to be important by society. The inter-relationships between components of the biophysical and socio-economic (human) environments provide the structure of a social-ecological system (Walker et al. 2004, internet site; Folke 2006). Examples of physical properties that can be considered VCs include groundwater, surface water, soil, and air. Aquatic and terrestrial plant and animal populations represent biological properties that can be considered VCs. Traditional and non-traditional uses of water, plants, and animals and other biophysical properties (e.g., ecological services or resources) can be VCs of the cultural, social, and economic environment. The DAR integrates NICO Project-related effects on biophysical, cultural, and socio-economic VCs for the people who likely will be directly and indirectly influenced by the NICO Project.

In nature, VCs can be found at the beginning, middle, or end of pathways, or analogously, at the bottom, middle, or top trophic level of food chains (Section 6.4). For example, benthic invertebrates and plankton are at the lower trophic level (towards the beginning of the pathway) in an aquatic ecosystem, while northern pike (*Esox lucius*) and lake trout (*Salvelinus namaycush)* are the top predators in some aquatic systems not fished by people (at the end of the pathway). In boreal terrestrial ecosystems, changes to soil and vegetation represent initial pathways to snowshoe hare (*Lepus americanus)*, caribou, and moose, which influence top trophic level predators such as lynx (*Lynx canadensis*) and wolves (*Canis lupus)*. Cultural and socio-economic VCs typically enter at the middle and top levels of pathways. For example, people hunt caribou that occur in the middle of the food chain, and fish for northern pike, which occur at the top of food chains. Exceptions include the drinking of water, and harvesting berries and medicinal plants that occur at the lower trophic level of food chains.

An initial technical screening and preliminary meetings with government, the public, and communities (Whatì, Gamètì, Behchokǫ̀, Wekweètì, and Yellowknife) identified a number of concerns related to the NICO Project (Section 4). Biophysical and socio-economic VCs related to these concerns include the following:

- water quality;
- caribou and caribou habitat;
- water quantity (water supply);
- fish and aquatic habitat;

- air quality;
- wildlife;
- vegetation;
- employment and training opportunities; and
- economic development.

6.2.2 Assessment Endpoints and Measurement Endpoints

Valued component assessment endpoints are general statements about what is being protected for future human generations. For example, protection of water supply and water quality, persistence of wildlife populations, and continued opportunities for traditional and non-traditional use of these ecological resources may be assessment endpoints for surface water, wildlife, and traditional and non-traditional land use. Identification of assessment endpoints for VCs in the DAR was determined partially from the outcome of the community, public, and regulatory engagement process (Section 4).

Measurement endpoints are defined as quantifiable (i.e., measurable) expressions of changes to assessment endpoints (e.g., changes to chemical concentrations, rates, habitat quantity and quality, and number and distribution of organisms). For example, measurement endpoints for assessing the protection of surface water quality may include NICO Project-related changes to physical and chemical properties of water. Measurement endpoints for predicting effects to air quality may include changes in concentrations of particulate matter (dust) and nitrogen oxides. Effects to long-term social, cultural, and economic values are predicted through analysis of measurement endpoints such as employment and income, education and training, and capacity of infrastructure, and heritage resources. Measurement endpoints also provide the primary factors for discussions concerning the uncertainty of impacts to VCs, and subsequently, are the key variables for study in monitoring and follow-up programs.

The overall determination of significance of impacts from the NICO Project on VCs is then predicted by linking residual changes in measurement endpoints to effects on the associated assessment endpoint (Section 6.6.3). For example, changes to habitat quantity and quality are used to assess the significance of impacts from the NICO Project on the persistence of wildlife populations (assessment endpoint). Impacts to wildlife are then used to determine the significance of the NICO Project on the continued opportunity for traditional and non-traditional use of wildlife (also an assessment endpoint, which incorporates sustainability). Valued components, assessment endpoints, and measurement endpoints used in this DAR are presented in Table 6.2-1.

It is important to note that all VCs have measurement endpoints, but not every VC necessarily has an explicit assessment endpoint. Valued components such as permafrost, groundwater, and hydrology influence surface water quality and aquatic habitat, which affect the persistence of fish populations. However, permafrost, groundwater, and hydrology do not have independent assessment endpoints. Instead they represent linkages to changes in the measurement endpoints of other VCs that are more directly associated with an assessment endpoint.

Consequently, not every VC in the DAR is carried through the residual impact classification and determination of significance. Again, this is because assessment endpoints represent the key properties of the VC or system that should be available for their use by future human generations. Assessment endpoints represent sustainability statements upon which to evaluate the significance of impacts.

Table 6.2-1: Assessment and Measurement Endpoints Associated with Valued Components and Key Lines of Inquiry and Subjects of Note

KLOI/SON	Valued Component	Assessment Endpoints	Measurement Endpoints
KLOI: Water Quality	Surface and groundwater quality	• Protection of surface water quality for aquatic and terrestrial ecosystems, and human use • Persistence of fish habitat and populations • Persistence of wildlife populations • Continued opportunity for traditional and non-traditional use of fish and wildlife	• Physical analytes (e.g., pH, conductivity, turbidity) • Major ions and nutrients • Total and dissolved metals
	Hydrology		• Flow rate and the spatial and temporal distribution of water • Surface topography, drainage boundaries, and waterbodies (e.g., streams, lakes, and drainages)
	Fish and aquatic habitat		• Survival and reproduction
	Wildlife		• Survival and reproduction
	People		• Access to fish and wildlife • Availability of fish and wildlife • Human health
KLOI: Closure and Reclamation	Surface and groundwater quality	• Protection of surface water quality for aquatic and terrestrial ecosystems, and human use • Persistence of fish habitat and populations • Persistence of plant populations (including species at risk) and communities • Persistence of wildlife populations • Continued opportunity for traditional and non-traditional use of plants, fish and wildlife	• Physical analytes (e.g., pH, conductivity, turbidity) • Major ions and nutrients • Total and dissolved metals
	Hydrology		• Flow rate and the spatial and temporal distribution of water • Surface topography, drainage boundaries, and waterbodies (e.g., streams, lakes, and drainages)
	Fish and aquatic habitat		• Habitat quantity and fragmentation • Habitat quality • Relative abundance and distribution of fish species • Survival and reproduction
	Soil		• Soil quality, quantity, and distribution • Permafrost distribution • Reclamation suitability
	Vegetation		• Plant community diversity • Plant community health • Relative abundance and distribution of plant species • Presence of invasive species

Table 6.2-1: Assessment and Measurement Endpoints Associated with Valued Components and Key Lines of Inquiry and Subjects of Note (continued)

KLOI/SON	Valued Component	Assessment Endpoints	Measurement Endpoints
KLOI: Closure and Reclamation (continued)	Wildlife		• Habitat quantity and fragmentation • Habitat quality • Relative abundance and distribution of wildlife species • Survival and reproduction
	People		• Access to fish, traditional plants, and wildlife • Availability of fish, traditional plants, and wildlife • Human health
KLOI: Caribou and Caribou Habitat	Caribou	• Persistence of caribou populations • Continued opportunity for traditional and non-traditional use of caribou	• Habitat quantity and fragmentation • Habitat quality • Relative abundance and distribution of caribou • Survival and reproduction
	People		• Access to caribou • Availability of caribou
SON: Air Quality	Atmospheric environment	• Compliance with applicable ambient air quality criteria	• Total suspended particulates, course particulate matter, and fine particulate matter • Sulphur dioxide, nitrogen oxides, carbon monoxide • Metals (e.g., arsenic) • Deposition rates
SON: Water Quantity	Hydrology	Not Applicable	• Flow rate and the spatial and temporal distribution of water • Surface topography, drainage boundaries, and waterbodies (e.g., streams, lakes, and drainages)
	Hydrogeology		• Groundwater flows and levels
SON: Fish and Aquatic Habitat	Fish and aquatic habitat	• Persistence of fish habitat and populations • Continued opportunity for traditional and non-traditional use of fish	• Habitat quantity and fragmentation • Habitat quality • Relative abundance and distribution of fish species • Survival and reproduction
	People		• Access to fish • Availability of fish

Table 6.2-1: Assessment and Measurement Endpoints Associated with Valued Components and Key Lines of Inquiry and Subjects of Note (continued)

KLOI/SON	Valued Component	Assessment Endpoints	Measurement Endpoints
SON: Terrain	Terrain	Not Applicable	• Quantity and distribution of terrain units • Topography and slope stability
	Soil		• Soil quality, quantity, and distribution • Permafrost distribution
SON: Vegetation	• Plant populations and communities • Listed (rare) plant species and rare plant habitat potential • Traditional use plants • Economic use plants)	• Persistence of plant populations and communities • Continued opportunity for use of traditional plants • Persistence of plant species at risk	• Plant community health and diversity • Relative abundance and distribution of plant species • Abundance and distribution of timber resources • Presence of invasive species
SON: Wildlife	• wolverine • black bear • marten • moose • muskrat • upland breeding birds • waterbirds • raptors	• Persistence of wildlife populations • Continued opportunity for traditional and non-traditional use of wildlife	• Habitat quantity and fragmentation • Habitat quality • Relative abundance and distribution of wildlife species • Survival and reproduction
	People		• Access to wildlife • Availability of wildlife
SON: Human Environment	Employment and Business Opportunities	• Persistence of Long-term Social, Cultural, and Economic Properties	• Employment and income • Business activity • Education, training, and opportunities for youth • Capacity of labour pool
	Distribution of Beneficial and Adverse Economic Impacts		• Capital and operating costs • Government revenues • Employment and income • Community infrastructure and services • Social disparity

Table 6.2-1: Assessment and Measurement Endpoints Associated with Valued Components and Key Lines of Inquiry and Subjects of Note (continued)

KLOI/SON	Valued Component	Assessment Endpoints	Measurement Endpoints
SON: Human Environment (continued)	Social Impacts		• Population demographics • Substance abuse • Crime rates • Health care • Child care • Education • Family and community cohesion
	Cultural Impacts		• Language use • Heritage resources • Tourism potential and wilderness character • Access to wildlife • Availability of wildlife

KLOI = key lines of inquiry; SON = subjects of note

6.3 Developer's Assessment Boundaries

6.3.1 Spatial Scales and Boundaries

Individuals, populations, and communities function within the environment at different spatial (and temporal) scales. In addition, the response of physical, chemical, and biological processes to changes in the environment can occur across a number of spatial scales at the same time (Holling 1992; Levin 1992). As a result, the scale of the investigation will determine the range of patterns and processes that can be observed and predicted with certainty (Wiens 1989; Harris et al. 1996).

Effects from the NICO Project on the biophysical environment are typically stronger at the local scale, and larger scale effects are more likely to result from other ecological factors and human activities. For example, effects from the NICO Project on environmental components with limited movement (e.g., soil and vegetation) will likely be limited to local changes from mining and NICO Project infrastructure. Some indirect changes to vegetation from dust deposition and air emissions may occur, but the effect should be limited to the local scale of the NICO Project. Similarly, for species with small home ranges, any effects from the NICO Project on a local population will likely not be transferred to other populations in the region. Depending on the species, an increase in distance among local populations can decrease effective dispersal and result in subpopulations that fluctuate independently (Schlosser 1995; Steen et al. 1996; Sutcliffe et al. 1996; Ranta et al. 1997; Bjørnstad et al. 1999). In other words, changes in the number of individuals within subpopulations over time are more related to local factors that influence reproduction and survival rates than the movement of individuals between populations.

For VCs with more extensive distributions, such as fish that can move within a watershed and wildlife species with large home ranges, effects from the NICO Project have a higher likelihood of combining with effects from other human developments and activities. Watersheds may be influenced by multiple users, who generate cumulative effects to these resources. Similarly, larger animals (e.g., caribou) that are influenced by the NICO Project will likely encounter other human activities and developments in their daily and seasonal ranges. Consequently, effects from the NICO Project could combine with influences from other developments in the individual's home range. In addition, the home ranges of several individuals may be affected, which results in cumulative effects to the population.

The purpose of the examples above is to emphasize the different levels of organization in natural systems, and the correspondent need to analyze and predict NICO Project effects to VCs at the appropriate spatial scales. For the DAR, the spatial scope must be able to capture the scale-dependent processes and activities that influence the geographic distribution and movement patterns specific to each VC. Because the responses of physical, biological, cultural, and economic properties to natural and human-induced disturbance will be unique and occur across different scales, studies should use a range of spatial (and temporal) scales (Wiens 1989; Levin 1992). Accordingly, the DAR has adopted this multi-scale approach for describing baseline conditions (existing environment) and predicting effects from the NICO Project on VCs.

For the DAR, the spatial boundaries of the local study areas were designed to measure baseline environmental conditions and then predict direct effects from the NICO Project footprint and activities on the VCs and associated measurement endpoints (e.g., changes to ground and surface water quality, physical disturbance to vegetation, soil admixing). Local study areas were also defined to assess small-scale indirect effects from NICO Project activities on VCs such as changes to soil and vegetation from dust and fuel emissions.

The boundaries for regional study areas were designed to quantify baseline conditions at a scale that was large enough to assess the maximum predicted geographic extent (i.e., maximum zone of influence) of direct and indirect effects from the NICO Project on VCs and measurement endpoints. NICO Project-related effects at the regional scale include potential changes to downstream water quality and quantity, vegetation communities, wildlife habitat quality, wildlife and fish, and people that use these ecosystem services. Cumulative effects are typically assessed at a regional spatial scale and, where relevant, may consider influences that extend beyond the regional study area.

6.3.2 Temporal Boundaries

Spatial and temporal boundaries are tightly correlated because processes that operate on large spatial scales typically occur at slower rates and have longer time lags than processes that operate on smaller spatial scales (Wiens 1989; Chapin et al. 2004; Folke et al. 2004). An example of a large spatial scale process that occurs at a slow rate is the change in the northern and southern extents of the boreal forest. Alternately, rapid changes in plant transpiration rates and animal behaviour typically occur at smaller spatial scales.

The approach used to determine the temporal boundaries of effects from natural and human-related disturbances on VCs is similar to the approach used to define spatial boundaries. In the DAR, temporal boundaries are linked to 2 concepts:

- the development phases of the NICO Project (i.e., construction, operation, and closure); and
- the predicted duration of effects from the NICO Project on a VC, which may extend beyond closure.

Thus, the temporal boundary for a VC is defined as the amount of time between the start and end of a relevant project activity or stressor (which is related to development phases), plus the duration required for the effect to be reversed.

After removal of the stressor, reversibility is the likelihood and time required for a VC or system to return to a state that is similar to the state of systems of the same type, area, and time that are not affected by the NICO Project. Reversibility does not imply returning to environmental conditions prior to development of the NICO Project. Ecological and socio-economic systems continually evolve through time (Chapin et al. 2004; Folke 2006). Subsequently, the physical, biological, social, and economic properties of social-ecological system at closure likely will be different than the current observed patterns, independent of NICO Project effects. Return or recovery to pre-NICO Project conditions may not be possible or even desirable. Ecological systems are complex, non-equilibrium systems and the assumption that ecosystems can be managed to preserve or return to some pre-stressed state is false (Landis and McLaughlin 2000; Sandberg and Landis 2001). The state of ecological and socio-economic systems at and beyond NICO Project closure may be equally functional with the desired structure, but likely will not be the same as before development.

For those effects that are reversible, the DAR evaluates the duration or time required to reverse the effect on the VC or system. Some effects may be reversible soon after removal of the stressor, such as effects to air quality from equipment operation. Other effects may require a longer duration before changes are reversed. Damage to archaeological sites is an example of an irreversible or permanent effect.

6.4 Pathway Analysis

Pathway analysis identifies and assesses the linkages between NICO Project components or activities, and the correspondent potential residual effects to VCs (e.g., water quantity, soil, wildlife, and socio-economics). Potential pathways through which the NICO Project could affect VCs were identified from a number of sources including the following:

- a review of the Development Description and scoping of potential effects by the environmental and engineering teams for the NICO Project;
- scientific knowledge, and experience with other mines in the NWT;
- engagement with the public, Aboriginal people, communities, and government; and
- consideration of potential effects identified from the TOR for the NICO Project.

The first part of the analysis is to produce a list of all potential effects pathways for the NICO Project. Each pathway is initially considered to have a linkage to potential effects on VCs. This step is followed by the development of environmental design features and mitigation that can be incorporated into the Development Description to remove a pathway or limit (mitigate) the effects to VCs. Environmental design features include NICO Project design elements, environmental best practices, management policies and procedures, and social programs. Environmental design features are developed through an iterative process between the NICO Project's engineering and environmental teams to avoid or mitigate effects.

Knowledge of the environmental design features and mitigation is then applied to each of the pathways to determine the expected amount of NICO Project-related changes to the environment and the associated residual effects (i.e., effects after mitigation) on VCs. Changes to the environment can alter physical measurement endpoints (e.g., water and soil chemistry, and amount of habitat) and biological measurement endpoints such as animal behaviour, movement, and survival (Table 6.2-1). For an effect to occur there has to be a source (NICO Project component or activity) that results in a measurable environmental change (pathway) and a correspondent effect on a VC.

NICO Project activity → change in environment → effect on VC

Pathway analysis is a screening step that is used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the NICO Project. This screening step is largely a qualitative assessment, and is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects on VCs (Figure 6.4-1). Pathways are determined to be primary, secondary (minor), or as having no linkage using scientific and traditional knowledge, logic, and experience with similar developments and environmental design features. Each potential pathway is assessed and described as follows:

- no linkage – pathway is removed by environmental design features and mitigation so that the NICO Project results in no detectable environmental change and residual effects to a VC relative to baseline or guideline values;
- secondary – pathway could result in a minor environmental change, but would have a negligible residual effect on a VC relative to baseline or guideline values (e.g., an increase in a water quality parameter that is

small compared to the range of baseline values and is well within the water quality guideline for that parameter); or

- primary – pathway is likely to result in a measurable environmental change that could contribute to residual effects on a VC relative to baseline or guideline values.

Primary pathways require further effects analysis and impact classification to determine the environmental significance from the NICO Project on VCs (Figure 6.4-1). Pathways with no linkage to a VC or that are considered minor (secondary) are not analyzed further or classified in the DAR because environmental design features and mitigation will remove the pathway (no linkage) or residual effects to the VC can be determined to be negligible through a simple qualitative evaluation of the pathway. Pathways determined to have no linkage to a VC or those that are considered secondary are not predicted to result in environmentally significant effects on VCs.

All primary pathways are assessed in the DAR. However, primary pathways for one VC may end up being secondary or having no linkage to other VCs. For example, local changes to surface water levels may be a primary pathway for effects on aquatic vegetation, but may be considered a minor pathway for effects on wildlife populations with a larger home range.

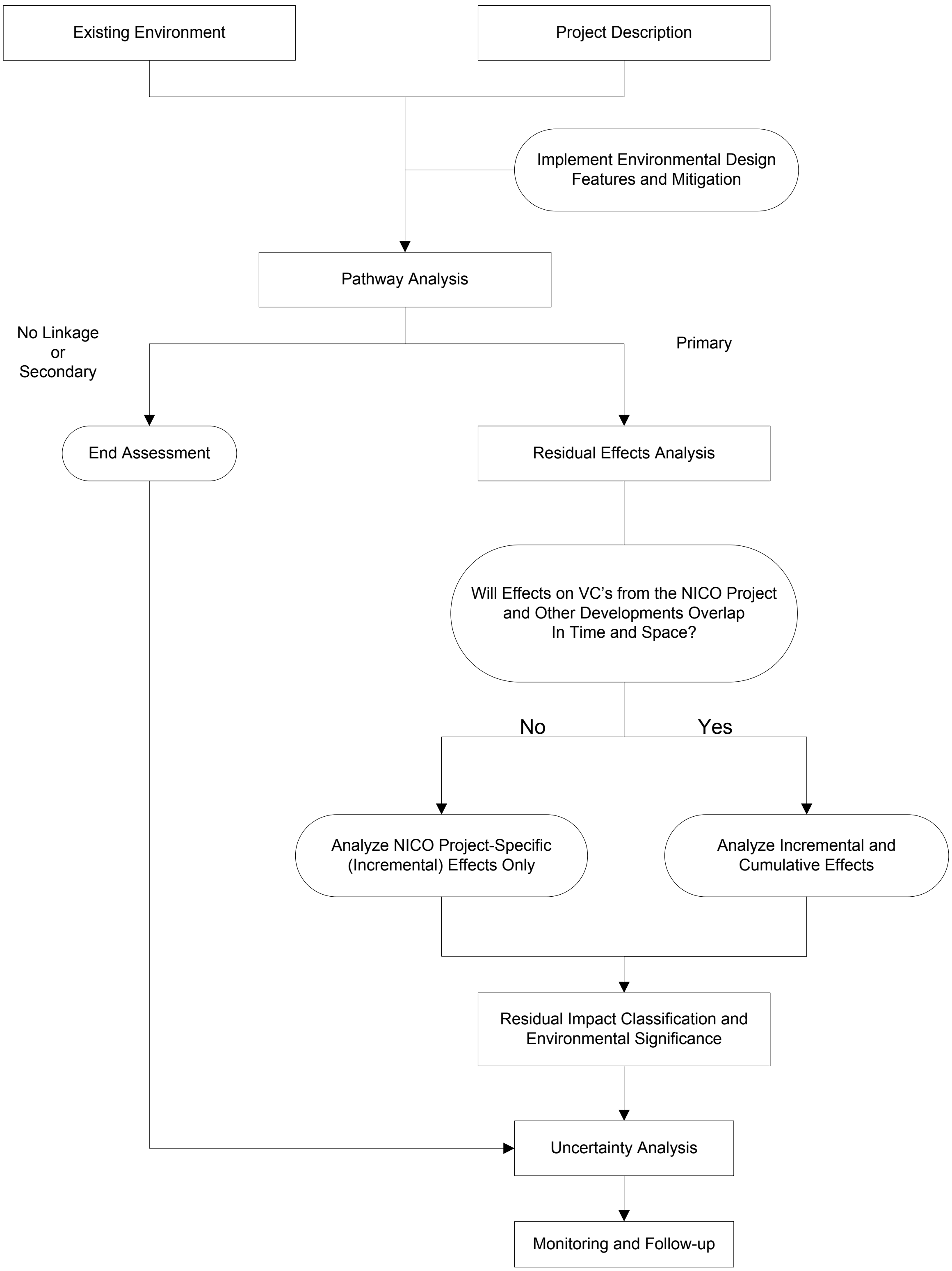

Figure 6.4-1: Flow Diagram for the Assessment Approach

6.5 Residual Effects Analysis

6.5.1 NICO Project-Specific Effects

In the DAR, the effects analysis considers all primary pathways that likely result in measurable environmental changes and residual effects to VCs (i.e., after implementing environmental design features and mitigation). Thus, the analysis is based on residual NICO Project-specific (incremental) effects that are verified to be primary in the pathway analysis (Section 6.4). Residual effects to VCs are analyzed using measurement endpoints and expressed as effects statements in the DAR (e.g., Effects to Water Quality, Effects to the Abundance and Distribution of Caribou, and Effects to Plant Populations and Communities). Effects statements may have more than one primary pathway that link a NICO Project activity with a change in the environment and an effect on a VC. For example, the pathways for effects to fish and aquatic habitat include alteration of local flows and drainage areas and water quality. Incremental effects from the NICO Project to the abundance and distribution of wildlife populations may include changes in habitat quantity and quality, and survival and reproduction.

Effects to social, economic, and cultural properties include positive and negative changes to employment, training, and education, family income, traditional land use, family and community cohesion, and long-term social, cultural, and economic sustainability. Some of these measurement endpoints can be analyzed quantitatively (e.g., number of jobs created and estimated income levels). Other endpoints such as community cohesion and traditional land use are more difficult to quantify, and involve information from public engagement, literature, examples from similar projects under similar conditions, and experienced opinion. The effects analysis considers the interactions among the unique and common attributes, challenges, and opportunities related to social, cultural, and economic measurement endpoints. A key aspect of the effects analysis is to predict the influence from the NICO Project on the development and sustainability of socio-economic conditions in the defined study area.

Residual effects to traditional and non-traditional land use practices (e.g., hunting, fishing, plant and berry gathering) are assessed through the analysis of VCs that are directly associated with these assessment endpoints. For example, analysis of NICO Project-specific effects to plant populations and communities is used to determine the associated influence on the land to sustain listed species and traditional use plants. Analysis of changes to caribou abundance and distribution is used to assess the effect of the NICO Project on the continued opportunity for harvesting caribou. Therefore, effects to assessment endpoints for traditional and non-traditional land use are analyzed and assessed within KLOIs and SONs that contain the applicable biophysical or socio-economic VC.

A detailed description of the methods used to analyze residual effects from the NICO Project on VCs is provided in each KLOI and SON section (e.g., water quality, caribou and caribou habitat, fish and aquatic habitat, terrain, air quality, wildlife, socio-economics). Where possible and appropriate, the analyses are quantitative, and may include data from field studies, modelling results, scientific literature, government publications, effects monitoring reports, and personal communications. Available traditional knowledge and community information are incorporated into the analysis and results. Due to the amount and type of data available, some analyses are qualitative and include professional judgement or experienced opinion.

Following the effects analysis, a summary of residual effects is provided for each discipline. Results from the effects analyses are used to describe the direction, magnitude (intensity), duration, and geographic (spatial) extent of the predicted residual effects to VCs. Where possible and appropriate, expected changes are expressed quantitatively or numerically. For example, the magnitude of the effect may be expressed in absolute or percentage values above baseline (existing) conditions or a guideline value. Duration (which is linked to reversibility) of the change is estimated (in years) relative to NICO Project phases, and the geographic extent of effects is be expressed in area (hectare [ha]) or distance (metre [m], kilometre [km]) from the NICO Project. In addition, the likelihood, and frequency of effects may also be described, where applicable.

Expressions such as “short-term” duration or “moderate” magnitude will not be used in the summary of residual effects. These expressions are reserved for the classification of impacts, where definitions of these expressions are provided.

6.5.2 Approach to Cumulative Effects

6.5.2.1 Definition and Application

Cumulative effects represent the sum of all natural and human-induced influences on the physical, biological, cultural, and economic components of the environment through time and across space. Some changes may be human-related, such as increasing industrial and mineral development, and some changes may be associated with natural phenomena such as extreme rainfall events, and periodic harsh and mild winters. It is the goal of the cumulative effects assessment to estimate the contribution of effects from the NICO Project and other developments on VCs, in context of natural changes in the system.

Not every VC requires an analysis of cumulative effects. The key is to determine if the effects from the NICO Project and one or more additional developments/activities overlap (or interact) with the temporal or spatial distribution of the VC (Section 6.3). For some VCs, NICO Project-specific effects are important and there is little or no potential for cumulative effects, because there is little or no overlap with other developments (e.g., soils). For other VCs that are distributed or travel over large areas and can be influenced by a number of developments (e.g., surface water quality and caribou) the analysis of cumulative effects can be necessary and important. Socio-economic components also must consider the potential cumulative effects of the NICO Project and other developments and human activities.

In this DAR, cumulative effects are identified, analyzed, and assessed in the section on the VC where applicable, and follows the approach used for the NICO Project-specific effects analysis (Section 6.5.1), and impact classification and determination of significance (Section 6.6).

6.5.2.2 Assessment Cases

For VCs that require cumulative effects analysis, the concept of assessment cases is applied to the associated spatial boundary (effects study area) to estimate the incremental and cumulative effects from the NICO Project (Table 6.5-1). The approach incorporates the temporal boundary for analyzing the effects from previous, existing, and reasonably foreseeable developments before, during, and after the anticipated life of the NICO Project.

Table 6.5-1: Contents of Each Assessment Case

Baseline Case	Application Case	Future Case
Range of conditions from little or no development to previous and existing developments[a] prior to the NICO Project	Baseline Case plus the NICO Project	Application Case plus reasonably foreseeable developments

[a] includes approved projects.

The Baseline Case represents a range of conditions over time within the effects study area prior to application of the NICO Project, and not a single point in time (as do the Application and Future cases). Environmental conditions on the landscape prior to mineral and other development activity (e.g., forestry, oil and gas, and transportation), which represent reference conditions, also were considered part of the Baseline Case. Baseline conditions also include all previous and existing developments (i.e., 2010 baseline conditions) in the VC effects study area prior to application of the NICO Project. Analyzing the temporal changes to the landscape is fundamental to predicting the cumulative effects from development on VCs that move over large areas such as caribou and traditional land users.

Baseline conditions represent the historical and current environmental selection pressures that have shaped the observed patterns in VCs. Environmental selection pressures include both natural (e.g., weather, changes in gene frequencies, predation, and competition) and human-related factors (e.g., mineral development, forestry, and sport hunting/fishing). Depending on which selection pressures are currently driving changes to the VC and system, baseline conditions typically fluctuate within a range of variation through time and space. The fluctuations are generated by variation in natural factors (natural variation) and variation associated with human influences. Relative to ecological time and space, baseline conditions are in a constant state of change due to the pushing and pulling of environmental selection pressures. Thus, baseline conditions can be thought of as a distribution of probability values, and the location of the value (e.g., middle or ends of the distribution) is dependent on which environmental factors are currently playing a key role in the trajectory of the VC and system.

The temporal boundary of the Application Case begins with the anticipated first year of construction of the NICO Project, and continues until the predicted effects are reversed (Section 6.3.2). For several VCs, the temporal extent of some effects likely will be greater than the lifespan of the NICO Project because the effects will not be reversible until beyond closure. For other VCs, the effects may be determined to be irreversible within the temporal boundary of assessment. Such effects may be permanent, or the duration of the effect may not be known, except that it is expected to be extremely long (say more than 100 years past closure).

The Future Case includes the predicted duration of residual effects from the NICO Project, plus other previous, existing, and reasonably foreseeable projects and activities. Thus, the minimum temporal boundary for the Application and Future Case is the expected lifespan of the NICO Project, which like the Baseline Case, includes a range of conditions over time. The difference between the application and Future Case is that the Application Case considers the incremental effect from the NICO Project in isolation of potential future land use activities.

Analyses of the effects for the Baseline and Application cases are largely quantitative. Alternately, effects analyses for the Future Case may be more qualitative due to the large degree and number of uncertainties. There are uncertainties associated with the timing, rate, type, and location of developments in the study areas for each VC. There are also uncertainties in the direction, magnitude, and spatial extent of future fluctuations in ecological, cultural, and socio-economic variables, independent of NICO Project effects.

6.5.2.3 Previous and Existing Developments

Previous and existing developments in the Tłı̨chǫ/North Slave region includes mineral exploration programs, historic remediated and non-remediated contaminated sites, winter roads, all-weather roads, hydro power development, transmission line, communities, hunting and fishing lodges, proposed and existing protected areas, mines, mineral exploration camps, staging areas, quarries, and communication structures. Data on the location and type of developments were obtained from the following sources:

- Mackenzie Valley Land and Water Board: permitted and licensed activities within the NWT;
- Indian and Northern Affairs Canada: permitted and licensed activities within the NWT;
- Indian and Northern Affairs Canada: contaminated sites database;
- National Resources Canada GeoGratis Website: Geographical Information System (GIS) file of community locations;
- Government of the Northwest Territories (GNWT): location of parks within the NWT;
- company websites; and
- knowledge of the area and project status.

Initially, data indicating permitted and licensed activities were obtained in spreadsheet format. The file was examined for information duplication (e.g., a water license and a land use permit for the same development). In cases where 2 or more pieces of location information for the same activity were present, the extra information was deleted from the file so that it contained only one point per development. Data associated with the location attributes (e.g., permit status, feature name) also were edited in some instances to update the information for running modeling scenarios efficiently. The information was used to generate a temporally and spatially explicit development layer within a Geographical Information System platform. Details on the data and assumptions used to estimate the area of each development are provided in the applicable KLOI and SON sections.

The TOR asks for potential impacts of the NICO Project on fish and wildlife in combination with impacts from past or present pollution from contaminated sites in the area, including Rayrock and Colomac mines (MVRB 2009). Closure and reclamation of these mines included the following:

- the town sites were demolished;
- mine buildings were removed;
- the tailings areas were covered;
- the shafts were capped;
- landfill sites were isolated and stabilized;
- garbage was collected and removed; and
- all slopes prone to erosion were stabilized or are monitored annually (INAC 2010a, b, internet sites).

The Rayrock mine was remediated between 1996 and 1997, and long-term monitoring data have indicated that caribou in the area have the normal range of radionuclides for the NWT, very little risk remains to humans from radionuclides, and downstream water quality is not affected by the former mine (INAC 2010a, internet site). Remediation at the Colomac mine was initiated in 2008 and is ongoing. The water quality is improving; however, monitoring will continue until all remediation is complete in 2011 (INAC 2010b, internet site). These sites are considered in the cum'ulative effects assessment and are addressed in KLOI: Caribou, SON: Wildlife, KLOI: Water Quality, and SON: Fish and Aquatic Habitat.

6.5.2.4 Reasonably Foreseeable Developments

Cumulative effects assessment should include all other human activities that substantially affect the VC, including past, present, and reasonably foreseeable future projects (MVEIRB 2004). As stated above, the Future Case includes the predicted residual effects from the NICO Project, plus other previous, existing, and reasonably foreseeable projects and activities. Reasonably foreseeable developments included in the DAR were projects or activities that:

- have been proposed and scoped to a reasonable level of detail;
- may be induced by the NICO Project;
- are currently undergoing regulatory review; and
- have the potential to change the NICO Project or the impact predictions.

Using these criteria, the following proposed projects have been selected as a suite of major developments that may occur in the reasonably foreseeable future:

- the proposed Tłįchǫ Road Route;
- the Nailii Hydro Project;
- the Yellowknife Gold Project at the Discovery Mine site;
- the Nechalacho Project at Thor Lake;
- the Damoti Lake Gold Project;
- the Gahcho Kué Project;
- the Taltson Hydroelectric Expansion Project;
- the East Arm National Park;
- the North Arm National Wildlife Area; and
- the Mackenzie Gas Project.

For the purposes of this assessment, it is assumed that each of the reasonably foreseeable future projects are carried forward to full development, and their effects have both spatial and temporal overlap with effects from the NICO Project.

The Proposed Tłįchǫ Road Route

The Department of Transportation, GNWT currently operates and maintains a winter road system that connects the Tłįchǫ communities of Whatì and Gamètì with Highway 3. This route functions in the region as a seasonal resupply conduit, but other interests within the Tłįchǫ Settlement Area are also served by the system. The existing winter road alignment traverses frozen rivers, lakes, and ponds, as well as wetland areas, but warmer temperatures in recent winters have caused construction and, operational delays for the sections of the route that cross these areas. The result has been an overall reduction of the winter road's operational season, which substantially impacts residents and commercial interests who depend on the road for travel and resupply. As such, a second road alignment has been developed that is predominantly over land. This route will initially be a winter road also, but could be upgraded to an all-season road.

The Nailii Hydro Project

The Nailii Hydro Project would include a run-of-river hydro plant constructed on the La Martre River downstream of the community of Whatì. The largest scale plan includes a 12 megawatt hydro facility connected to Whatì to reduce their dependency on diesel generated power, and a transmission line to the existing Snare Hydro Complex to distribute power to Behchokǫ̀ and Yellowknife. Surplus power could be made available to the NICO Project through a purpose-built transmission line.

The Yellowknife Gold Project

The Yellowknife Gold Project proposed by Tyhee NWT Corporation anticipates a combination open pit and underground mining operation with a lifespan of 8 to 13 years depending on production rates. It is expected that approximately 190 people would be employed at the site when in full operation (Tyhee 2008, internet site). The property is located 90 km north of Yellowknife on the former Discovery Mine site and is located 140 km east of the NICO Project. Access would be via an existing winter road route and by air.

The Nechalacho Project

The Nechalacho Project is a rare earth elements deposit, owned by Avalon Rare Metals Inc. The property is located approximately 100 km southeast of Yellowknife near Hearne Channel on the East Arm of Great Slave Lake and 270 km east of the NICO Project. The Nechalacho Project has submitted environmental assessment applications and is currently in the scoping stage. A mine plan has not yet been developed and there is uncertainty regarding the size and duration of the Nechalacho Project.

The Damoti Lake Gold Project

The Damoti Lake Gold Project is a gold deposit owned by Merc International Minerals Inc. The property is located approximately 140 km northeast of the NICO Project, 20 km south of the Colomac Mine, and accessed via the winter road to Colomac and Wekweètì. A bulk sample was completed in 1996 by previous owners, and Merc has completed drill programs in 2009 and 2010 to expand the knowledge of resources. As the Damoti Lake Gold Project is currently in exploration stage and a mine plan has not yet been developed there is uncertainty regarding the size and duration of the Damoti Lake Gold Project.

The Gahcho Kué Project

The Gahcho Kué Project proposed by De Beers Canada Inc. is located in the Kennedy Lake region, and would be the fourth diamond mine in the NWT and the third open-pit diamond mine. It is located 90 km southeast of the Snap Lake Mine and approximately 300 km northeast of Yellowknife, and 360 km east of the NICO Project. The development includes 3 open pits and would have winter road access and likely lead to employment for approximately 300 people for 15 years.

The Taltson Hydroelectric Expansion Project

The Taltson Hydroelectric Expansion Project is proposed by Dezé Energy Corporation and includes enhancements to existing power generating facilities and the construction of a new power transmission line to the Snap Lake, Diavik, and Ekati mines, and the proposed Gahcho Kué Project. The proposed project would supply hydro produced electric energy from facilities located on the Taltson River to reduce or replace power generation by diesel fuel at the mines. The proposed project is currently in the permitting process, but further advancement of the Taltson Hydroelectric Expansion Project has been put on hold by the proponent (Dezé Energy 2011).

The East Arm National Park

The proposed East Arm National Park would include McLeod Bay, Reliance, Pike Portage, the Lockhart River, and Artillery Lake at the East Arm of Great Slave Lake. Although there have been some recent advances in the Park proposal, the concept is now over 40 years old and the East Arm National Park may not be created until the NICO Project is well into the operations phase. There remains uncertainty in the status of the existing fishing, hunting lodges, and camps in the proposed park area. Overall, the proposed East Arm National Park would be beneficial to the environment, and may lead to local jobs.

The North Arm National Wildlife Area (Kwets`òòtłàà)

The proposed North Arm National Wildlife Area or Kwets`òòtłàà includes a 660 square kilometre combination of mainland shoreline, numerous islands, and water located in the northern end of the North Arm of Great Slave Lake, and adjacent to the community of Behchokǫ̀. In June of 2010, the Canadian Wildlife Service agreed to sponsor this area as a candidate National Wildlife Area. This area is currently at Step 4 of 8 in the Protected Area Strategy process, where a formal request for interim protection has been made with the Federal government. Overall, the proposed East Arm National Park would be beneficial to the environment and may increase tourism.

The Mackenzie Gas Project

The Mackenzie Gas Project (MGP) is a proposed 1196 km natural gas pipeline system along the Mackenzie Valley of Canada's NWT to develop natural gas fields in the Mackenzie Delta and deliver the natural gas to markets through a pipeline system built along the Mackenzie Valley. The MGP would have 3 main components; the development of 3 or more natural gas fields, a gathering system to transport the natural gas and natural gas liquids to a processing facility near Inuvik, and a pipeline system to transport the processed gas to southern markets (MGP 2011, internet site). The 6-year regulatory process for the MGP was recently concluded when the Federal cabinet approved the project, and the National Energy Board issued a Certificate of Public Convenience and Necessity (NEB 2011). The MGP proponents have yet to state if the project will proceed, based on feasibility studies currently underway. The MGP would not pass through the Tłı̨chǫ region. The pipeline route would roughly follow the Mackenzie River, but the nearest natural gas fields are in the Inuvialuit Settlement Region.

6.6 Impact Assessment Methods

6.6.1 Application of Residual Impact Classification

In the DAR, the term “effect” used in the effects analyses and residual effects summary (Section 6.5), is regarded as an “impact” in the residual impact classification. An effect represents an unclassified change in a VC. The term “impact” is only used during the classification process. Therefore, in the residual impact classification, all residual effects are discussed and classified in terms of impacts to VCs.

Quantitative and qualitative descriptions of the direction, magnitude, geographic extent, and duration of changes to measurement endpoints for all VCs with primary pathways are provided in the residual effects summary for each environmental discipline (Section 6.5). Frequency and likelihood of effects also are described where applicable. However, the classification of residual impacts from associated pathways and the determination of environmental significance are only completed for those VCs that have assessment endpoints. This is because assessment endpoints represent the key properties of the VC that should be protected for their use by future human generations (i.e., assessment endpoints consider sustainability; Section 6.2.2). Results from the residual impact classification are then used to determine the environmental significance from the NICO Project on assessment endpoints.

6.6.2 Residual Impact Criteria and Definitions

The purpose of the residual impact classification is to describe the residual incremental and cumulative (if applicable) effects from the NICO Project on VCs using a scale of common words (rather than numbers and units). The use of common words or criteria is accepted practice in environmental assessment. The following criteria will be used to assess the residual impacts from the NICO Project in the DAR:

- direction;
- magnitude;
- geographic extent;
- duration;
- reversibility;
- frequency; and
- likelihood.

Generic definitions for each of the residual impact criteria are provide below.

Direction: Direction indicates whether the impact on the environment is negative (i.e., less favourable), positive (i.e., beneficial), or neutral (i.e., no change). While the main focus of the impact assessment is to predict whether the development is likely to cause significant adverse impacts on the environment or cause public concern, the positive changes associated with the NICO Project also are reported. Neutral changes are not assessed.

Magnitude: Magnitude is a measure of the intensity of an impact, or the degree of change caused by the NICO Project relative to baseline conditions (Section 6.5.2.2) or a guideline value. It is classified into 4 scales: negligible, low, moderate, and high. For each VC, the scales of magnitude are defined. Magnitude can relate to relative (percentage) or absolute changes that are above or below baseline, guidelines, or threshold values. Where possible, magnitude is reported in absolute and in relative terms.

Geographic Extent: Geographic extent refers to the area affected, and is categorized into 3 scales of local, regional, and beyond regional. Local-scale impacts mostly represent changes that are directly related to the Project footprint and activities, but may also include small-scale indirect effects. Changes at the regional scale are largely associated with indirect impacts from the NICO Project, and represent the maximum predicted spatial extent of direct and indirect effects from the NICO Project (zone of influence). Impacts beyond the regional scale are mostly associated with VCs that have large spatial distributions and are influenced by cumulative effects such as caribou and socio-economics.

Duration: Duration is defined as the amount of time (usually in years) from the beginning of an impact to when the impact on a VC is reversed, and is expressed relative to NICO Project phases (Section 6.3.2). Both the duration of individual events (e.g., waste water discharges) and the overall time frame during which the impact may occur (e.g., phases of a NICO Project during construction, operation, and closure) are considered. Some impacts may be reversible soon after the effect has ceased, while other impacts may take longer to be reversed. By definition, impacts that are short-term, medium-term, or long-term in duration are reversible.

In some cases, available scientific information and professional judgement may predict that the impact is irreversible. Alternately, the duration of the impact may not be known, except that it is expected to be extremely long (say more than 100 years), and any number of factors could cause the VC and system to never return to a state that is unaffected by the NICO Project. In other words, science and logic predict that the likelihood of reversibility is so low that the impact is irreversible.

Reversibility: After removal of the stressor, reversibility is the likelihood and time required for a VC or system to return to a state that is similar to the state of systems of the same type, region, and time period that are not affected by the NICO Project. This term usually has only one alternative: reversible or irreversible. The time frame is provided for reversibility (i.e., duration) if an effect is reversible. Permanent impacts are considered irreversible. In terms of the socio-economic environment, the manageability of impacts is considered rather than their reversibility. Where appropriate, the evaluation identifies the resources that may be diverted to facilitate recovery.

Frequency: Frequency refers to how often an impact will occur and is expressed as isolated (confined to a discrete period), periodic (occurs intermittently, but repeatedly over the assessment period), or continuous (occurs continuously over the assessment period). Frequency is explained more fully by identifying when it occurs (e.g., once at the beginning of the Project). If the frequency is periodic, then the length of time between occurrences, and the seasonality of occurrences (if present) is discussed.

Likelihood: Likelihood is the probability of an impact occurring and is described in parallel with uncertainty. Four categories are used: unlikely (impact is likely to occur less than once in 100 years), possible (impact will occur at least once in 100 years), likely (impact will likely occur at least once in 10 years), and highly likely (impact has 100% chance of occurring within a year).

For criteria such as frequency and likelihood, the scales can be applied consistently across all biophysical and socio-economic VCs (e.g., isolated, periodic, or continuous frequency). In contrast, the scale of classifications for direction, magnitude, geographic extent, and duration are dependent on each VC. To provide transparency in the DAR, the definitions for these scales are ecologically, socially or logically based on the VC, and provided in each KLOI and SON. Although professional judgement is inevitable in some cases, a strong effort is made to classify impacts using scientific principles and supporting evidence.

6.6.3 Residual Impact Classification and Environmental Significance

As explained in Section 6.5.1, effects statements are used to focus the analysis of effects to VCs that are associated with one or more primary pathways. The residual effects summary presents a numerical and/or qualitative description of magnitude, geographic extent, duration, and frequency of residual effects from each pathway. From the summary of residual effects, each pathway that is linked to an assessment endpoint is classified using categorical scales for each impact criterion (e.g., low magnitude, regional geographic extent, long-term duration, high likelihood) (Section 6.6.2).

The classification of residual impacts on primary pathways provides the foundation for determining environmental significance from the NICO Project on assessment endpoints. Magnitude, geographic extent, and duration are the principal criteria used to predict significance (FEARO 1994, internet site). Other criteria, such as frequency and likelihood are used as modifiers (where applicable) in the determination of significance. Duration of impacts, which includes reversibility, is a function of ecological resilience, and these ecological principles are applied to the evaluation of significance.

Although difficult to measure, resilience is the capacity of the system to absorb disturbance, and reorganize and retain the same structure, function, and feedback responses (i.e., properties of the social-ecological system) (Holling 1973; Walker et al. 2004, internet site; Folke 2006). Resilience includes resistance, capability to adapt to change, and how close the system is to a threshold before shifting states (i.e., precariousness). Highly resistant systems require stronger disturbances over a longer duration and larger geographic area to change the system's current path or trajectory, even if it is close to a threshold. In contrast, a similar system with lower resistance would be less resilient to a weaker disturbance, and may generate a change in state or a regime shift with a subsequent impact on the ecosystem and society (Folke et al. 2004; Walker et al. 2004, internet site).

The adaptive capability of a system is related to the evolutionary history and adaptations accumulated by communities, species, and populations while experiencing a range of disturbances and fluctuations through space and time (Holling 1973; Gunderson 2000). If the frequency, duration, geographic extent, and/or intensity (magnitude) of a disturbance are beyond that historically encountered by the system, and outside the adaptive capability of species, then the likelihood of a regime shift increases. Regime shifts and changes in state of the population or ecosystem can be reversible or irreversible.

Reversibility is the likelihood and time required for a system to recover after removal of the stressor, and is a function of resilience. Due to the complex relationships among biophysical components and unpredictable events, the recovery of the system following disturbance can result in the same or altered state (Gunderson 2000; Folke 2006). In other words, the impact from disturbance may be reversible, but the exact nature of ecosystem properties and services, and human uses are different. In some cases, the shift in ecological properties and services may not be reversible and will have a consequence to socio-economics and land use (Gunderson 2000; Scheffer and Carpenter 2003; Folke et al. 2004; Carpenter and Brock 2006).

Human development and natural disturbances erode the resilience of existing ecosystems by stressing and disrupting the relationships among species and their environment. Through the implementation of management and policy, humans also can increase or maintain resilience by making the system more resistant, moving the system away from threshold boundaries, and/or moving the boundary further away from the system (Folke et al. 2004; Walker et al. 2004, internet site). People have the ability to exert change across several spatial and temporal scales and levels of organization in the system, although some more strongly and quickly than others. Through the actions of adaptive management, mitigation, and changes to land use practices, humans have the ability to modify resilience in a positive way, and potentially decrease environmental significance.

The evaluation of significance for biophysical VCs considers the entire set of primary pathways that influence a particular assessment endpoint, but significance is not explicitly assigned to each pathway. Rather, the relative contribution of each pathway is used to determine the significance of the NICO Project on assessment endpoints, which represents a weight of evidence approach. For example, a pathway with a high magnitude, large geographic extent, and long-term duration would be given more weight in determining significance relative to pathways with smaller scale effects. The relative impact from each pathway is discussed; however, pathways that are predicted to have the greatest influence on changes to assessment endpoints would also be assumed to contribute the most to the determination of environmental significance.

In contrast, the determination of significance from NICO Project impacts on the assessment endpoint for the socio-economic environment is completed on a subset of VCs (e.g., quality of life, employment, income, education, and community services), and typically, each VC is directly associated with an individual pathway. Because people have an ability to modify the system across several spatial and temporal scales, each pathway can result in different levels of effects on individuals, communities, and the region. Consequently, it is more practical to independently classify and predict the significance of the impact from each pathway on a socio-economic VC than to classify the entire set of pathways and generate a single evaluation of significance on the socio-economic environment. However, after evaluating the significance the pathways associated with the subset of VCs, the overall significance of the NICO Project on the assessment endpoint for the socio-economic environment is provided.

Environmental significance is used to identify predicted impacts that have sufficient magnitude, duration, and geographic extent to cause fundamental changes to a VC. Significance is determined by the risk to the persistence and function of populations (i.e., population level effects) within aquatic and terrestrial ecosystems. It is difficult to provide definitions for environmental significance that are universally applicable to each VC assessment endpoint. Consequently, specific definitions are provided for each assessment endpoint in the DAR. The evaluation of significance uses ecological principles, to the extent possible, but also involves professional judgement and experienced opinion.

In summary, results from the effects analysis and residual impact classification of primary pathways are used in the evaluation of the significance of impacts from the NICO Project on VCs with an assessment endpoint. Some of the key factors considered in the determination of environmental significance include the following:

- results from the residual impact classification of primary pathways;
- magnitude, geographic extent, and duration (which includes reversibility) of the impact are the principal criteria, with frequency and likelihood as modifiers; and
- professional judgment and ecological principles, such as resilience, are used to predict the duration and associated reversibility of impacts.

The following is an example of definitions for assessing the significance of impacts on the persistence of wildlife VCs, and the associated continued opportunity for traditional and non-traditional use of wildlife.

Not significant – impacts are measurable at the individual level, and strong enough to be detectable at the population level, but are not likely to decrease resilience and increase the risk to population persistence.

Significant – impacts are measurable at the population level and likely to decrease resilience and increase the risk to population persistence. A number of high magnitude and irreversible impacts at the population level would likely be significant.

These lower and upper bounds on the determination of significance are relatively straightforward to apply. It is the area between these bounds where ecological principles and professional judgment are applied to determine significance.

Classification of socio-economic residual effects and determination of significance generally follows the methods used for biophysical VCs; however, there are some differences in the selection and definitions of impact criteria. For socio-economic VCs, direction, magnitude, geographic extent, and duration are the criteria used to classify impacts and evaluate the significance of changes to assessment endpoints. The assessment of significance considers the scale of these criteria (e.g., low magnitude, regional geographic extent, and long-term duration) and professional opinion, which is based on the context of the communities involved, and the informed value and judgements of interested and affected organizations and specialists. The level of significance also assesses the efficacy of the proposed environmental design features (policies, practices, and investments) to limit negative impacts and foster positive impacts on the continued persistence of long-term sustainable social, cultural, and economic features of the environment.

6.7 Uncertainty

Most assessments of impacts embody some degree of uncertainty. The purpose of the uncertainty section of the DAR is to identify the key sources of uncertainty and discuss how uncertainty is addressed to increase the level of confidence that effects will not be worse than predicted. Confidence in effects analyses can be related to many elements, including the following:

- adequacy of baseline data for understanding existing conditions and future changes unrelated to the NICO Project (e.g., extent of future developments, climate change, catastrophic events);
- model inputs (e.g., change in chemical concentrations in water over time and space);
- understanding of NICO Project-related impacts on complex ecosystems that contain interactions across different scales of time and space (e.g., how and why the NICO Project will influence wildlife); and
- knowledge of the effectiveness of the environmental design features for reducing or removing impacts (e.g., environmental performance of the waste rock management area).

Uncertainty in these elements can result in uncertainty in the prediction of environmental significance. Where possible, a strong attempt is made to reduce uncertainty in the DAR to increase the level of confidence in impact predictions, as shown in the following examples:

- using the results from several models and analyses to help reduce bias and increase precision in predictions;

- using data from effects monitoring programs at existing mines and the literature as inputs for models rather than strictly hypothetical or theoretical values; and
- implementing a conservative approach when information is limited so that impacts are typically overestimated.

Where appropriate, uncertainty may also be addressed by additional mitigation, which would be implemented as required. Each discipline section includes a discussion of how uncertainty has been addressed and provides a qualitative evaluation of the resulting level of confidence in the effects analyses and impact classifications.

6.8 Monitoring and Follow-Up

In the DAR, monitoring programs are proposed to deal with the uncertainties associated with the impact predictions and environmental design features. In general, monitoring is used to test (verify) impact predictions and determine the effectiveness of environmental design features (mitigation). Monitoring is also used to identify unanticipated effects and implement adaptive management. Typically, monitoring includes one or more of the following categories, which may be applied during the development of the NICO Project.

- Compliance inspection: monitoring the activities, procedures, and programs undertaken to confirm the implementation of approved design standards, mitigation, and conditions of approval and company commitments.
- Environmental monitoring: monitoring to track conditions or issues during the development lifespan, and subsequent implementation of adaptive management (e.g., monitoring for soil erosion and rare (listed) plant species during construction, monitoring fresh water intake and discharge volumes).
- Follow-up: programs designed to test the accuracy of impact predictions, reduce uncertainty, determine the effectiveness of environmental design features, and provide appropriate feedback to operations for modifying or adopting new mitigation designs, policies, and practices. Results from these programs can be used to increase the certainty of impact predictions in future environmental assessments.

These programs form part of the environmental management system for the NICO Project. If monitoring or follow-up detects effects that are different from predicted effects, or the need for improved or modified design features, then adaptive management will be implemented. This may include increased monitoring, changes in monitoring plans, or additional mitigation.

6.9 References

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