Chapter 7

Groundwater

Table of Contents

Figures

List of Tables

7. Introduction

This chapter forms part of a Comprehensive Study (CS) for the proposed Parallel Runway PRP (PRP) at Calgary International Airport (YYC). The process shadows the EA process under the *Canadian Environmental Assessment Act* (CEAA) and this chapter summarizes the potential effects of the YYC PRP on groundwater. The PRP consists of a 14,000 ft (4,267 m) runway and associated infrastructure. The PRP components are described in further detail in Volume II, Chapter 7 of the CS.

The PRP may require significant alteration to the existing environment. The environmental effects assessment identifies potential effects of the PRP on the natural resources in the Local Study Area (LSA) and Regional Study Area (RSA). PRP effects are changes to the biophysical or human environment caused by activities arising solely from the PRP. Effects may be direct or indirect. A direct effect is one in which the cause-effect relationship has no intermediary effects, and an indirect effect is one in which the cause-effect relationship between a PRP impact and the ultimate effect on a valued component (VC) has intermediary effects (Canadian Environmental Assessment Agency 1999).

The environmental effects assessment not only examines potential direct and indirect environmental effects that might result from the PRP, but also examines ways in which impact levels can be reduced through mitigation, and estimates residual effects following the implementation of mitigation measures. The general organization of this assessment of the potential effects of the PRP is as follows:

- Scoping;
- Baseline studies;
- Analysis of effects;
- Mitigation;
- Residual effects;
- Evaluation of significance and
- Follow-up.

Both the PRP-specific assessment and the cumulative effects assessment follow this sequence.

7.1 Scoping the Assessment

The groundwater assessment was scoped by reviewing the issues relating to groundwater that were raised by the public and other stakeholders in light of the baseline groundwater information and the PRP project description.

7.1.1 Issues Identification

Potential groundwater issues that could be associated with the PRP were identified in general terms through a knowledge gaps exercise. These issues were then described in a draft Project Description and Scoping Document, which provided a basis for further discussion of potential issues during public consultation meetings. Issues raised through public consultation were added to the scope of the assessment.

The following groundwater issues were identified by the public, other stakeholders and project scientists:

- How will the PRP affect the quantity of groundwater recharge to deeper aquifers used locally by water supply wells?

- How will the PRP affect the quantity of groundwater recharge that eventually provides groundwater discharge to downstream receiving streams (i.e., Nose Creek)?
- How will the PRP affect the quality of groundwater recharge to deeper aquifers used locally by water supply wells?
- How will the PRP affect the quality of groundwater recharge that eventually provide down slope groundwater discharge to downstream receiving streams (i.e., Nose Creek)?

7.1.2 Effects Hypotheses

Effects hypotheses were used to focus the assessment. As previously noted, issues were identified for each discipline, and effects hypotheses were developed that corresponded to those issues. The effects hypotheses describe the kind of effect that could occur as a result of the PRP.

The following effects hypotheses were developed:

- A reduction in the amount of groundwater recharge may occur due to the following PRP construction activities:
  a. levelling and grading of the PRP area (including the filling in of low wet areas);
  b. the construction of hard paved surfaces;
  c. the construction of stormwater drainage systems; and
  d. the construction of service underpasses.

  This effect is likely to continue for operational, closure and post-closure periods. This effect may affect groundwater levels in the regional bedrock aquifer used by local water wells. This effect may reduce groundwater discharge to downstream receiving streams (i.e., Nose Creek).
- The use of de-icing solutions, herbicides, petroleum fuels or other chemicals during PRP construction, operations and maintenance may adversely affect groundwater quality in the LSA.

7.1.3 Relevant Legislation

7.1.3.1 Federal

Canadian Environmental Assessment Act

The CEAA establishes a process to assess the environmental effects of projects requiring federal actions or decisions, and requires that the environmental effects of projects be considered early in their planning stages. At present, CEAA does not apply to the PRP (see Volume II, Chapter 5 for more information).

Federal Policy on Wetland Conservation

An unregulated document, the policy is applied with an objective to *"promote the conservation of Canada's wetlands to sustain their ecological and socio-economic functions, now and in the future"* on all federal lands, providing guidance to the development of mitigation and/or compensatory measures, where appropriate.

7.1.3.2 Provincial

Alberta Environmental Protection and Enhancement Act

Alberta Environment is responsible for evaluating effects that a project may have on the environment and for the administration of Alberta's laws governing environmental assessment. The Environmental Assessment Regulation and the Environmental Assessment (Mandatory and Exempted Activities) Regulation provide direction on matters related to the administration of the environmental assessment process. The PRP is not subject to the EA provisions of AEPEA. However, if the PRP affects groundwater beyond airport lands, the effect enters into Alberta jurisdiction and AEPEA's guidelines for soil and groundwater remediation would be relevant.

Alberta Water Act and Water Regulation

According to the *Canada Water Act* (R.S., 1985, c. C-11), waters that lie solely within a province's boundaries fall within the constitutional authority of that province and, as such, the *Alberta Water Act* and Water Regulations of the Alberta Government (AG) are discussed for the purpose of this report. The *Alberta Water Act* specifies requirements for any activities that may have the potential to disturb or alter surface water bodies. Requirements for water diversions, transfer, water well drilling, and reclamation are also provided (either in the *Act* or as supplemental codes of practice) and require written authorization from the Ministry. Such activities include but are not limited to drilling water wells, crossing watercourses, constructing canals or dams, installing pipelines, and telecommunication cables.

According to the Water Act and the Water (Ministerial) Regulation, water wells that are abandoned or no longer used by a landowner must be reclaimed. To reclaim a water well, the well must first be flushed and cleaned of all foreign materials followed by disinfecting with a minimum of 200 mg of chlorine per litre in water. All equipment and materials including the casing, liner and riser must be removed or if removal is not practical, must be cut off at least 0.5 metres below ground surface. The well must be completely filled to effectively and permanently prevent vertical movement of water within the well bore. Fill material recommended to fill the well bore may include suitable cement, grout, concrete, bentonite or equivalent provided it does not have an adverse effect on the environment. The upper 0.5 metres of the well bore should be backfilled with material appropriate for its intended land use (AG 1998 and 2009).

Provincial Wetland Restoration/Compensation Guide

The Guide is designed to ensure “no net loss” of wetland function on provincial lands, providing guidance to the development of mitigation and/or compensatory measures, where appropriate.

7.1.3.3 Municipal

Calgary Wetland Conservation Plan

The City of Calgary’s Wetland Conservation Plan is administered through the *Municipal Government Act*. In short, it was developed to ensure the maintenance or improvement of local water quality and quantity within City boundaries.

7.1.4 Valued Components

VCs can be defined as environmental attributes or components that are perceived as important for ecological, social, cultural, and/or economic reasons.

7.1.4.1 VC Selection

Groundwater is an integral part of the environment and is valued by the public. Groundwater is used as the principal source of water supply for residential, agricultural and commercial properties to the north and east of the LSA. Groundwater discharge is beneficial for maintaining stream flow in Nose Creek during dry periods when there is no surface runoff. Groundwater provides potential linkages to surface water flow and quality.

Two VCs were identified for groundwater:

- Groundwater Quantity, and
- Groundwater Quality.

7.1.4.2 Indicators

Indicators are used to measure impacts to VCs. Table 7-1 provides the indicators that have been chosen for the two VCs:

- Groundwater Quantity – groundwater elevations in LSA; and
- Groundwater Quality – concentrations of Contaminants of Concern in groundwater relative to Canadian and Alberta aquatic life and drinking water standards.

These indicators were chosen because they are measurable and will measure the specific effects of the PRP. Other indicators were considered, such as water elevations in deeper bedrock aquifers used by water wells or low flow volumes in Nose Creek (i.e., base flow during extended dry periods assumed to be equivalent to groundwater discharge). However, these potential indicators would be affected by other factors (i.e., other well water users, urbanization, etc.) and it would not be possible to differentiate the specific effects of the PRP from other unrelated development.

Table 7-1 Groundwater Indicators

Issue	VC	Indicator
Reduced groundwater recharge due to runway construction may affect groundwater elevations in deeper bedrock aquifers used for water supply. Reduced recharge may reduce groundwater discharge that provides base flow to local streams and other surface water bodies during dry periods.	Groundwater Quantity	Groundwater elevations in the PRP footprint. An adverse effect would be groundwater elevations that decline below the natural baseline range of seasonal variation.
The use of de-icing solutions, herbicides, petroleum fuels or other chemicals for runaway operations and maintenance may adversely affect groundwater quality in the LSA.	Groundwater Quality	Groundwater concentrations for the Contaminants of Concern: glycol, herbicides, runway de-icing chemicals, and petroleum hydrocarbons (F1 to F4) in the PRP footprint (LSA). An adverse effect would be groundwater concentrations that exceed baseline groundwater quality and the relevant federal and provincial water quality criteria.

7.1.5 Interaction Matrices

The following interaction matrices were identified:

- groundwater discharge provides base flow during dry periods to local streams and other surface water bodies; and
- groundwater forms a pathway for subsurface contaminant movement to streams and aquatic receptors.

7.2 Spatial and Temporal Boundaries

7.2.1 Local Study Area

The baseline study focussed on groundwater quantity and quality in a discipline-specific LSA and provides regional context by also presenting available information within a larger RSA. The LSA consists of the proposed footprint of the PRP and associated infrastructure and immediately adjacent areas (Figure 7-1). The LSA includes all areas where the project could have a direct impact on groundwater quantity (flow) and quality.

7.2.2 Regional Study Area

The RSA was established to include the project area, upslope recharge areas and down slope areas, including inferred groundwater discharge zones along Nose Creek. The RSA includes all areas in which the PRP could potentially impact groundwater quantity (flow) or groundwater quality including the project area and down-gradient receiving waters (Figure 7-1). The RSA provides the context for cumulative effects assessment of groundwater.

7.2.3 Temporal Boundaries

The assessment compares present baseline conditions to predicted future groundwater conditions, with and without the PRP. Temporal boundaries for project-related effects are defined in terms of the following project phases:

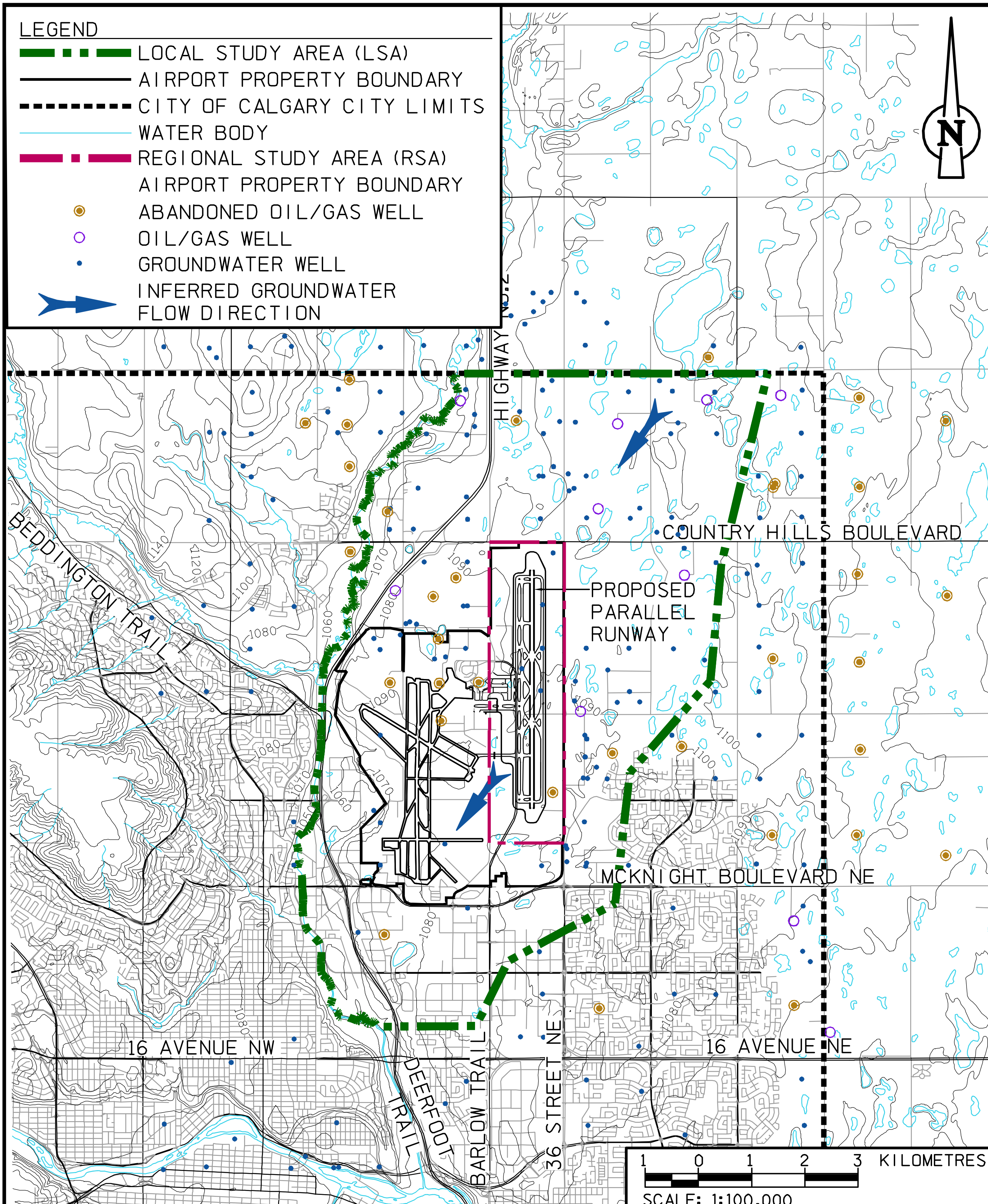
- Pre-construction/baseline;
- Construction; and
- Operations.

7.2.3.1 Pre-construction/Baseline

The baseline scenario was frozen at the end of 2009 before the commencement of construction. This was to allow for other airport project activities ongoing or expected to occur before that date. Seasonal variations in groundwater elevations are continuing to be monitored until the summer of 2010 to provide a full year of data to assess the extent of seasonal groundwater elevation variations.

7.2.3.2 Construction

The footprint for the construction of the PRP was frozen for the purposes of assessment as defined by the Project Description drawings of November 2009. Changes to the footprint after November 2009 will be accommodated by amendments to the final CS. The construction phase includes all activities associated with project construction and prior to commissioning of the PRP, including mobilization of equipment and supplies, topsoil stripping, filling and grading, site preparation, and PRP construction of the proposed runway, taxiways, maintenance facility, field electrical centre, and service underpasses.



The Calgary Airport Authority
Runway Development Program
Parallel Runway Project

YYC CALGARY AIRPORT AUTHORITY

AECOM

Groundwater Study Area

Figure - 7-1

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7.2.3.3 Operations

Operations include ongoing operation and maintenance of PRP and related infrastructure. The following four scenarios for operations were considered:

- 2015 Do-Nothing scenario (DN), which describes YYC and the proposed project area without the proposed runway in place in 2015, the proposed opening year;
- 2015 Do-Something scenario (DS), which describes YYC and the proposed project area with the proposed runway in place in 2015;
- 2025 Do-Nothing scenario (DN), which describes YYC and the proposed project area without the proposed runway in place in 2025; and
- 2025 Do-Something scenario (DS), which describes YYC and the proposed project area with the proposed runway in place in 2025.

The “Do-Nothing” scenarios assume that no runway would be developed. Pre-construction/baseline conditions are expected to be very similar to future 2015 or 2025 conditions without the new runway; therefore, the first and third scenarios are not discussed further with respect to groundwater. Groundwater effects were assessed for scenario 2 with the new runway in place in 2015. There is little difference in groundwater effects if the runway is built in 2015 or 2025. Therefore, the groundwater effects assessed for scenario 2 are considered to be identical to effects for scenario 4. Therefore, project effects only relate to construction and operation of the PRP.

7.3 Baseline Conditions

Groundwater quantity includes the amount of groundwater recharge that occurs in the LSA that flows to deeper bedrock aquifers used for water supply or laterally to Nose Creek. A layer of low permeability clay glacial till covers the LSA and overlies low permeability claystone. Groundwater moves slowly to the southwest through both of these strata. Groundwater also moves slowly downward in the LSA from the clay till to the claystone bedrock, and likely deeper to the Paskapoo Formation (sandstone/shale bedrock). Groundwater wells completed in the Paskapoo formation are used as local water supply wells for residences, farms and commercial facilities to the north and east of the LSA. However, the groundwater flow direction in the LSA is to the southwest towards Nose Creek and away from the area that relies on water supply wells. Groundwater discharge to Nose Creek is beneficial for maintaining stream flow in Nose Creek during dry periods when there is no surface runoff.

The volume of water that infiltrates per square metre of terrain in this dry area is difficult to measure or estimate. During the dry summer months, evapotranspiration exceeds the amount of precipitation and there is a moisture deficit. Periods in the winter when the temperature rises above freezing will result in snow melt, but if the ground remains frozen, then this melt water will runoff and will not infiltrate into the ground. Based on a review of the papers discussed in the baseline report (Section V, Item 5 of the CS), the average annual groundwater recharge rate for the LSA is 3 mm/yr or less. This refers to groundwater recharge that moves downward through the deeper clay till of the LSA and recharges the deeper bedrock. This recharge may then either be used by local water wells in the LSA or flow laterally to the southwest towards Nose Creek. Higher amounts of recharge may occur seasonally in the shallow fractured till (upper 2 m), but most of this additional water will be lost to evaporation and local vegetation transpiration during the year. A 3 mm/yr recharge rate over the 8,000,000 m^2 LSA would be equivalent to 24,000 m^3/yr or 0.76 l/s.

Baseline groundwater quality sampling indicates that the natural groundwater within the clay till in the upper 4 m to 10 m is mineralized; predominantly by sodium and sulphate ions. Water quality in the claystone bedrock below the till is also mineralized, but the level of total dissolved solids generally decreases with depth. At one location, shallow groundwater had elevated nitrate nitrogen concentrations that exceeded the Canadian Drinking Water Criteria, probably due to localized agricultural activities or local organic matter decay. Chloride concentrations were elevated above the Drinking Water Criteria in several monitoring wells screened in more permeable sand lenses within the clay till. These wells are located in close proximity to Barlow Trail and each other, and the elevated chloride levels may be related to use of de-icing salts on the road.

Baseline groundwater quality testing found no evidence of contamination with petroleum or other manmade organic chemicals. Due to the low permeability of the upper clay till soils, there is minimal potential for movement of contaminated groundwater from potential up-gradient sources to the LSA.

For more details on the groundwater baseline conditions, see Volume V, Item 5, Groundwater Baseline Report.

7.4 Effects Assessment

7.4.1 Effects Assessment Methodology

The purpose of this effects assessment is to identify and describe any potential environmental effects that may occur as a result of the construction and operation of the PRP.

Potential environmental effects on groundwater were identified and evaluated for each project phase. Effects were determined by predicting how project related activities will interact with the groundwater VCs. Factors used in the determination and analyses of potential environmental effects include:

- evaluation of project design and construction specifications;
- suitability of mitigation measures/Best Management Practices (BMPs) including the identification of project specific constraints;
- potential residual effects; and
- significance of potential residual effects.

Potential environmental effects for the groundwater VC are described in terms of relative or absolute significance, where possible, and were determined through an assessment of the following characteristics:

- magnitude;
- nature;
- direction;
- duration;
- timing;
- frequency;
- scope; and
- reversibility.

These characteristics were adapted from characteristics developed by the Canadian Environmental Assessment Agency (2006). Table 7-2 provides a definition of these, and other, terms applied in this report.

Table 7-2 Definition of Effects Assessment Terms

Term	Explanation
Project Phase	Refers to the phase of the project as construction, operation, or reclamation of the proposed PRP.
Potential Effect	Classification of the type of effects anticipated during a specific project phase.
Magnitude	Refers to the magnitude of groundwater elevation decline or groundwater contaminant concentration increases that may be caused by activities associated with the construction and operation of the PRP. Where the magnitude of an effect is within the range of baseline seasonal variations in groundwater elevations and concentrations within the LSA, then the effect is considered **negligible**. The following effects on groundwater are considered to be of **low magnitude**: • Groundwater Quantity – Water table elevation declines more than 1 m below the lowest baseline value within less than 10% of the LSA. • Groundwater Quality – Water quality exceeds the applicable CCME criteria within less than 10% of the LSA. The following effects on groundwater are considered to be of **moderate magnitude:** • Groundwater Quantity – Water table elevation declines more than 1 m below the lowest baseline value within 10% to 50% of the LSA. • Groundwater Quality – Water quality exceeds the applicable GWQG within 10% to 50% of the LSA. The following effects on groundwater are considered to be of **high magnitude:** • Groundwater Quantity – Water table elevation declines more than 1 m below the lowest baseline value within more than 50% of the LSA and extends into the RSA. • Groundwater Quality – Water quality exceeds the applicable GWQG within more than 50% of the LSA and extends into the RSA.
Nature	Refers to whether an effect is directly related or indirectly related to the action that caused the effect. It also refers to effects that will produce a cumulative effect by combining with another project, whether the project occurred in the past, present or future.
Direction	Refers to whether an effect on a resource is considered to be beneficial, adverse or neutral.
Duration	Refers to the time it takes a resource to recover from the effect. If quantitative information was lacking, duration was identified as short term (<5 years), moderate term (<20 years) and long term (>100 years).
Timing	Refers to when the effect occurs. The effect can occur during a life stage of the project, such as construction, operation, or reclamation. The effect can also be seasonal, while the effect could also occur immediately or could be delayed.
Frequency	Refers to the number of times an activity occurs over the project phase, and is identified as once, rare, intermittent, or continuous.
Scope	Refers to the geographical area potentially affected by the effect and was rated as local, regional and beyond regional. Where possible, quantitative estimates of the resource affected by the effect were provided.
Reversibility	Refers to the extent an adverse effect is reversible or irreversible over a 10 year period.
Residual Effect	A subjective estimate of the residual effect remaining after employing mitigation measures in reducing the magnitude and/or the duration of the identified effects on the environment.

The selection of mitigation measures was based on the magnitude of the effect, as well as the direction, duration, frequency, and timing of the effect. Effects that were considered to be negligible were considered sufficiently mitigated and no further mitigation measures were proposed. For all other effects, mitigation measures were selected such that the effect will be avoided or minimized to the greatest extent possible taking into account the unique nature of the PRP and without compromising the safe operation of YYC.

After mitigation measures were applied, remaining effects were classified as residual effects. The likelihood of an adverse significant residual effect occurring was evaluated following the Reference Guide: Determining Whether a Project is Likely to Cause Significant Adverse Environmental Effects (Canadian Environmental Assessment Agency 2003). Following this guide, the significance of the adversity of the effect was determined based on the characteristics described in Table 7-3, including magnitude, duration, scope, and reversibility. The likelihood of the effect occurring was then determined by the probability of the effect occurring and the level of scientific uncertainty, where possible. If there was a high likelihood of the effect occurring, then the effect was considered significant. If there was no likelihood of the effect occurring, the effect was not considered significant. For the remaining effects, professional judgment was used to determine if the effect will be considered significant or not.

Table 7-3 Residual Effects Rating Criteria

Criteria	Rating	Definition
Direction	Beneficial	Beneficial change.
	Neutral	No change.
	Adverse	Adverse change.
Geographic Extent	Local	Effect is limited to the LSA.
	Regional	Effect extends beyond the boundaries of the LSA.
	Beyond Regional	Effect extends beyond the boundaries of the RSA.
Duration	Short Term	Effects are reversible at the end of project construction.
	Medium Term	Effects are reversible at project closure.
	Long Term	Effects are reversible within a defined time beyond project closure.
Frequency	Once	Effect occurs once during construction, operations or closure.
	Intermittent	Effect occurs occasionally or periodically during construction, operations or closure.
	Continuous	Effect occurs continuously during construction, operations or closure.
Reversibility	Reversible	Effect is reversed after the activity ceases.
	Partially Reversible	Effect is partially reserved after the activity ceases.
	Non-Reversible	Effect will not be reversed when activity ceases.
Magnitude	Negligible	No measurable effects.
	Low	Effect results in the following changes of the groundwater resource. • Groundwater Quantity – Water table elevation declines more than 1 m below the lowest baseline value within less than 10% of the LSA. • Groundwater Quality – Water quality exceeds the applicable GWQG within less than 10% of the LSA.
	Moderate	Effect results in the following changes of the groundwater resource. • Groundwater Quantity – Water table elevation declines more than 1 m below the lowest baseline value within 10% to 50% of the LSA. • Groundwater Quality – Water quality exceeds the applicable GWQG within 10% to 50% of the LSA.
	High	Effect results in the following changes of the groundwater resource. • Groundwater Quantity – Water table elevation declines more than 1 m below the lowest baseline value within more than 50% of the LSA and extends into the RSA. • Groundwater Quality – Water quality exceeds the applicable GWQG within more than 50% of the LSA and extends into the RSA.

Significance of residual effects was determined using the significance rating criteria in Table 7-4. The likelihood and degree of confidence in the data were also taken into account in determining the significance of the residual effects.

Table 7-4 Significance Rating Criteria

Effect Magnitude	Geographic Extent	Duration	Significance
Negligible	Any geographic extent	Any duration	Not Significant
Low	Any geographic extent	Any duration	Not Significant
Moderate	Local	Any duration	Not Significant
	Regional	Short term	Not Significant
	Regional	Medium term	Significant
	Regional	Long term	Significant
	Beyond Regional	Short term	Not Significant
	Beyond Regional	Medium term	Significant
	Beyond Regional	Long term	Significant
High	Local	Short term	Not Significant
	Local	Medium term	Not Significant
	Local	Long term	Significant
	Regional	Any duration	Significant
	Beyond Regional	Any duration	Significant

The effects of the PRP on the two identified VCs (Groundwater Quantity and Groundwater Quality) are assessed below by project phase (construction and operations).

7.4.2 Construction Phase Effects Assessment by VC

7.4.2.1 Groundwater Quantity During Construction

The main indicators for groundwater flow and infiltration (recharge) are groundwater elevations.

The construction of the project has the potential to adversely affect groundwater quantity by increasing the volume of surface runoff and thereby reducing the volume of runoff that infiltrates into the ground (i.e., groundwater recharge). Construction activities including grading and hard surfacing, subsurface drainage, subsurface utility corridors, stormwater drainage, and the taxiway underpasses could reduce groundwater recharge, affect groundwater elevations, and modify groundwater flow and recharge/discharge relationships. A reduction in groundwater recharge may reduce the amount of groundwater available for local water wells or for groundwater discharge (base flow) in Nose Creek during dry periods.

Less downward groundwater flow (recharge) to the Paskapoo sandstone bedrock could result in declining groundwater elevations in this aquifer, which is utilized by water supply wells in the area to the north and east of the PRP. This adverse effect is counterbalanced by the beneficial effect of reduced water well withdrawals from the bedrock aquifer when the existing water wells in the LSA are decommissioned. This beneficial effect will likely increase over time as City water is provided to areas to the east of the PRP which currently rely on groundwater wells.

The stormwater subdrains are expected to be approximately 2.0 m below the finished pavement grade. In most areas, the subdrains will be above the groundwater table and groundwater will not discharge into the storm subdrains. There may be a few areas of deeper excavation for the PRP where the subdrains may intersect the water table.

The steepest declines in the water table elevation will occur during construction and operations near the proposed taxiway underpasses. The Taxiway J Underpass is planned as an airside road link intended to allow free movement of aviation related support equipment and materials within the restricted area of the airfield and is not intended for public use. The Taxiway J Underpass will consist of a reinforced concrete structure approximately 200 m long, 5.5 m deep and 14.2 m wide. The underpass will accommodate one lane of traffic flow in each direction along with paved shoulders and concrete sidewalks. The structural engineering design for the Taxiway J Underpass takes into account existing geotechnical information, including the presence of claystone bedrock approximately 8 m below existing grade and the presence of groundwater at approximately 2 m to 4 m below existing grade. The tunnel cut and cover construction will require dewatering below the water table. It is expected that the underpasses will have a drainage system that will draw down the water table to the base of the tunnel. This will create a drawdown cone in the water table near the tunnel. Groundwater levels will decline more than 1 m below baseline levels in the vicinity of the tunnel. This will continue during the operational life of the PRP. However, the extent of the drawdown cone will be limited to much less than 10% of the LSA area due to the low permeability of the clay till and the underlying claystone bedrock.

Preliminary airfield modelling analysis has revealed that a second cross-field taxiway is required in addition to Taxiway J in order to ease congestion in the vicinity of the terminal complex. It would create one-way taxi paths to eliminate head-to-head conflicts as aircraft move between the eastern and western sides of the airfield. In order to address the potential air traffic congestion problem, an extension of the existing Taxiway F to the east is proposed to connect the existing airfield to the new parallel runway system. The extension of Taxiway F will require the construction of a roadway underpass to allow continued public access to the McCall North Trade Park area via McCall Way. The Taxiway F Underpass will be a taxiway bridge structure approximately 60 m wide and 20 m long. Clearance between the new McCall Way road surface and the underside of the taxiway bridge will be 4.5 m. Bedrock and water table elevations are known to be high in the vicinity of the underpass and, therefore, dewatering will be required for construction which will result in a decline in groundwater levels in this area during construction. It is expected that the underpass will require some type of drainage system so it is likely that the water table elevation will decline more than 1 m below baseline levels in the vicinity of the tunnel. This will continue during the operational life of the PRP. However, the extent of the drawdown cone will be limited to much less than 10% of the LSA area due to the low permeability of the clay till and the underlying claystone bedrock.

The direction of this effect (reduced recharge and locally lowered groundwater elevations) is assessed to be adverse and the nature is assessed to be direct.

The timing of this effect would commence during construction as the LSA is graded, low wet areas are filled in, hard surfaces are constructed, storm drainage is installed, and the two service tunnels are excavated.

The frequency is assessed as continuous.

The duration will continue as long as the runway and associated grading, hard surfaces, stormwater conveyance systems, and service tunnels remain in place.

The scope of the effect is assessed to be local (i.e., within the LSA).

The effect would be reversible if the PRP was removed and the original topography was reconstructed, although this does not appear to be a likely scenario.

It is probable that the reduced infiltration effect and locally lowered water table elevation would occur if the PRP proceeds.

Magnitude is the amount of change in a measurable parameter or variable relative to the baseline case. Of all of the criteria used to rate potential residual effects after mitigation, magnitude most accurately reflects the degree of an effect. Magnitude refers to the intensity or severity of an effect and is the best indicator of the amount of change in a measurable parameter compared with baseline conditions. The following paragraphs describe how the magnitude of PRP effects on groundwater quantity, specifically groundwater recharge/discharge, was assessed.

The poorly drained hummocky terrain within the LSA is expected to focus recharge to groundwater beneath closed depressions in the ground surface, rather than being evenly distributed over the entire area. Van Dijk and Hayashi (2006) investigated groundwater infiltration mechanisms in the Calgary area and note that most groundwater recharge occurs in low areas and wetlands that collect surface runoff. Due to the poorly developed drainage systems throughout most of the LSA, most runoff collects in closed depressions and either evaporates or locally recharges the groundwater system. Where the water table is not close to ground surface, closed depressions can function as groundwater recharge areas.

Based on a review of the papers discussed in the baseline report (Section V, Item 5 of the CS), the average annual groundwater recharge rate for the LSA is 3 mm/yr or less. This refers to groundwater recharge that moves downward through the deeper clay till of the LSA and recharges the deeper bedrock. This recharge may then either be used by local water wells in the LSA or flow laterally to the southwest towards Nose Creek. Higher amounts of recharge may occur seasonally in the shallow fractured till (upper 2 m), but most of this additional water will be lost to evaporation and local vegetation transpiration during the year. A 3 mm/yr recharge rate over the 8,000,000 m^2 (3.1 square miles) LSA would be equivalent to 24,000 m^3/yr (equivalent to 65.7 m^3/day or 0.76 l/s).

This rate of recharge can be compared to typical well water use for a similar rural area in Rocky View County. A Regional Groundwater Assessment for Rocky View County was commissioned by Agriculture and Agri-Food Canada and Prairie Farm Rehabilitation Administration (Hydrogeological Consultants Limited 2002). This report estimates that the average well water use per section in Rocky View County is 20.5 m^3/day and notes that higher rates of more than 30 m^3/day per section exist in some areas near Calgary. The 20.5 m^3/day per section well water usage rate is equivalent to a metric unit recharge rate of 0.0029 m/yr or about 3 mm/yr.

Specific information on groundwater use within the LSA is not available, but Figure 2 of the groundwater baseline report shows that at least five water wells were drilled within the LSA. However, based on our understanding of current land use, the baseline groundwater use in the LSA would be less than the average well water use per section provided above.

For the purposes of assessing magnitude of the effect of the PRP on groundwater recharge, a theoretical quantitative recharge/discharge water balance was developed for the LSA. We have used the following conservative assumptions in this calculation:

- baseline well water use is only 50% of the average well water use per section in Rocky View; and
- recharge within the LSA is reduced by 50% from baseline conditions due to PRP grading, hard surfaces, improved runoff drainage, and service underpass dewatering.

Baseline Conditions			
Water Inputs	-	Baseline groundwater recharge in LSA	+ 3 mm/yr
Water Outputs	-	Baseline well water use in LSA (assume 50% of Rocky View average	- 1.5 mm/yr
	-	LSA Baseline groundwater discharge to Nose Creek	- 1.5 mm/yr
Net water balance			0.0 mm/yr

PRP Construction and Operation			
Water Inputs	-	PRP groundwater recharge in LSA during construction and operations	+ 1.5 mm/yr
Water Outputs	-	PRP well water use in LSA (all water wells removed)	+ 0.0 mm/yr
	-	LSA Baseline groundwater discharge to Nose Creek	- 1.5 mm/yr
Net water balance			0.0 mm/yr

Positive values in the above assessment indicate groundwater recharge and negative numbers indicate groundwater discharge to surface water or extraction by water wells. Based on this theoretical calculation, using what are considered to be conservative assumptions, it appears that a 50% reduction in groundwater recharge within the LSA caused by the PRP grading, hard surfacing, improved stormwater drainage, and service underpass dewatering will be counter balanced by the removal of all existing water wells and groundwater takings in the LSA. The magnitude of the PRP effects on groundwater quantity under this scenario is, therefore, assessed to be low.

A second way of assessing the magnitude of effect on flows in Nose Creek caused by reduced groundwater recharge in the LSA is to compare the watershed areas that are contributing to groundwater discharge to Nose Creek. The Nose Creek watershed drains a gross area of 989 km^2 (Nose Creek Watershed Management Plan 2007). The 8 km^2 LSA constitutes only 0.8% of the gross Nose Creek watershed and, therefore, could potentially contribute a maximum of 0.8% of the groundwater discharge to Nose Creek. However, the actual contribution of groundwater flow from the LSA is probably less as described below.

Groundwater studies conducted in the West Nose Creek watershed (Hayashi et al 2004) showed that infiltration capacity/groundwater recharge is a function of biophysical conditions including topography, soil, vegetation, and geology.). They recorded change in base flow during one month in 2003. With no significant precipitation events occurring during the course of their study, they found that Big Spring Creek contributed 64% of the flow in West Nose Creek, while occupying only 15% of the area. The headwaters of Big Spring Creek are comprised of a group of springs apparently discharging from the contact zone between the Paskapoo Formation and the overlying gravel layer. Based on this nearby study, it would appear that localized geological conditions such as highly permeable granular material over the permeable Paskapoo bedrock aquifer can result in high rates of recharge and specific geological areas that provide the majority of groundwater discharge to creeks during dry periods.

The LSA does not have these high recharge geological conditions and, therefore, will contribute less water to Nose Creek than the 0.8% suggested by the LSA's share of the catchment. The low permeability clay till that overlies the LSA restricts the amount of recharge that occurs and the claystone bedrock below the till also has a low permeability. Based on this evaluation, which considers the percentage of the drainage basin and local geological conditions, the magnitude of the PRP effect on groundwater quantity flowing from the LSA to Nose Creek is assessed to be low.

The proposed taxiway underpasses will decrease shallow groundwater elevations in the upper soils by more than 1 m near the underpasses. However, the underpasses are not deep enough to intersect the Paskapoo Sandstone Bedrock utilized by local groundwater wells. The underpasses are located on the west side of the PRP more than 1 km from the existing water wells located east and north of the PRP. The underpass drawdown will have negligible effect on groundwater quantities in the regional bedrock aquifer tapped by water wells to the north and east of the LSA.

If the underpasses intersect the silty sand lens encountered in boreholes MW09-217 and MW09-363, then greater inflows may occur for a short period during construction until this localized silty sand lens is dewatered, but this will have negligible effect on the bedrock aquifer or long term flow volumes to Nose Creek. Based on the baseline borehole data, this sand lens is not extensive and is only moderately permeable.

In summary, the PRP construction may reduce groundwater recharge in the LSA and groundwater elevations will be depressed near taxiway underpasses. The effect on local groundwater elevations in the LSA is assessed to be low. The effects on the regional bedrock aquifer used by water supply wells to the north and east, and the effects on groundwater flows to the southwest to Nose Creek, are assessed to be negligible.

7.4.2.2 Groundwater Quality During Construction

Groundwater quality may be affected by leakage, accidents and malfunctions during construction equipment fuelling and maintenance in the LSA. Fuel storage and fuelling and maintenance practices will follow industry accepted BMPs and will meet all applicable provincial and federal regulations. Equipment storage will be primarily on-site and dependent on the construction operations in progress. Servicing of equipment and fuelling operations, which are a necessary part of construction activities, will occur in accordance with the Authority's environmental policies and the ECO Plan developed specifically for the PRP (see Volume V, Item 14).

An all-weather driving surface, drainage and dust abatement are necessary for operation of the lay-down area. Gravel surfacing with dust suppressing stabilizers, such as calcium chloride or magnesium lignosulphonate will be used. These stabilizers are commonly used on most construction projects where dust is a concern and their use during construction is not considered to constitute a measureable risk to groundwater quality in the LSA or RSA.

Due to the low permeability clay till and claystone bedrock in the PRP, the only mechanism for rapid movement of chemical contaminants in the subsurface would be if there are unsealed wells that form a pathway for rapid downward movement. All existing wells will be identified and sealed with grout as soon as possible to prevent this possibility.

The direction of this effect is assessed to be adverse and the nature is assessed to be direct.

The timing of this effect would be for the duration of construction activities in the LSA.

The frequency is assessed as intermittent, although by following the BMPs, it is likely to be a rare event.

The duration will be short term as any spills or leakages will be promptly reported and cleaned up as required by the ECO Plan.

The scope of the effect is assessed to be local (i.e., within the LSA) and the effect is reversible if spills and leakages are cleaned up promptly.

The main indicators for groundwater quality during construction are concentrations of petroleum hydrocarbons (F1 to F3) in groundwater relative to the CWS. The thresholds would be the Canada Wide Standards for petroleum hydrocarbons (CWS-PH).

7.4.3 Operational Phase Effects Assessment

7.4.3.1 Groundwater Quantity During Operations

The operational phase of the project has the potential to adversely affect groundwater quantity similarly to the construction phase by increasing the volume of surface runoff and thereby reducing the volume of runoff that infiltrates into the ground (i.e., reducing groundwater recharge). Operational facilities including hard surfaces, subsurface drainage, subsurface utility corridors, stormwater drainage, and taxiway underpasses could reduce groundwater recharge, affect groundwater elevations and modify groundwater flow and recharge/discharge relationships. This may reduce the amount of groundwater available for local water wells or for groundwater discharge (base flow) in Nose Creek during dry periods. In areas of proposed taxiway underpasses that extend below the water table, the groundwater elevation decline will be greater in localized areas. The effects on groundwater quantity during operations are predicted to be similar to the effects described above for the construction phase.

Less downward groundwater flow (recharge) to the Paskapoo sandstone bedrock would result in declining groundwater elevations in this aquifer, which is utilized by water supply wells in the area to the north and east of the LSA. This adverse effect is counterbalanced by the beneficial effect of reduced water well withdrawals from the bedrock aquifer when the existing water wells in the LSA are decommissioned. This beneficial effect will likely increase over time as City water is provided to areas to the east of the PRP which currently rely on groundwater wells.

The direction of this effect is assessed to be adverse and the nature is assessed to be direct.

The timing of this effect would commence prior to the commencement of operations when hard surfaces, underpasses and storm drainage are installed in the LSA.

The frequency is assessed as continuous.

The duration will continue as long as the runway and associated grading, hard surfaces and stormwater conveyance systems remain in place.

The scope of the effect is assessed to be local (i.e., within the LSA) and the effect would be reversible if the PRP was removed and the original topography was reconstructed, although this does not appear to be a likely scenario.

It is highly probable that the reduced infiltration effect would occur if the PRP proceeds.

Magnitude is the amount of change in a measurable parameter or variable relative to the baseline case. Of all of the criteria used to rate potential residual effects after mitigation, magnitude most accurately reflects the degree of an effect. Magnitude refers to the intensity or severity of an effect and is the best indicator of the amount of change in a measurable parameter compared with baseline conditions. The technical rationale and assessment of the magnitude of this effect is the same as described above under the Construction Phase Assessment – Groundwater Quantity and, therefore, is not repeated here. Groundwater elevation declines on average below the entire LSA are predicted to be less than 1 m with no declines of greater than 1 m over more than 10% of the LSA. Based on this assessment, the magnitude of effects on groundwater quantity is assessed to be low.

In summary, the PRP operations phase will reduce groundwater recharge in the LSA and locally lower groundwater elevations near the two taxiway service underpasses. However, the effects on the bedrock aquifer used by water supply wells to the north and east, and the effects on groundwater flows to the southwest to Nose Creek, are assessed to be negligible.

7.4.3.2 Groundwater Quality During Operations

Groundwater recharged in the LSA is expected to move slowly downward and laterally to the southwest and eventually discharge into Nose Creek. Any contamination from runway operation that infiltrates the ground in the LSA will not move rapidly due to the low permeability of the clay till and underlying claystone bedrock. The average linear lateral groundwater flow velocity in the fractured claystone was calculated in the groundwater baseline report (Volume V, Item 5) to be about 0.5 m/yr. The distance from the LSA to Nose Creek is 3 km, therefore, the groundwater travel time to Nose Creek is estimated to be about 600 years. During this long travel path, natural renovation processes in the subsurface will reduce and attenuate any potential contaminant concentrations.

Although there is a downward component of groundwater flow to the underlying Paskapoo sandstone, groundwater contamination from the LSA will not move to the north or east to existing water supply wells because the direction of groundwater flow is to the southwest. During PRP operations, use of groundwater for drinking or other purposes in the LSA or in the down gradient areas to the southwest that are serviced with municipal water is unlikely.

The operational PRP activities that have been identified that have the potential to effect groundwater quality include the following:

- use of de-icing chemicals (potassium acetate or sodium formate) on runways;
- use of herbicides during airfield maintenance;
- use of de-icing chemicals (glycol) on planes; and
- potential spills or accidents of petroleum fuels from airplanes or other runway maintenance equipment.

YYC has an operational goal of minimizing the use of chemicals at the airport, which is balanced with safety considerations (personal communication Gary Kindrat March 2010). The following points discuss these activities and potential effects. The discussion also includes information about YYC's current initiatives to reduce the amount of chemicals/pesticides applied to runways and airside turf areas, while still meeting aviation safety requirements.

Runway De-icing Chemicals
YYC has recently improved runway de-icing methods by changing the category of chemicals from a urea based de-icer to potassium acetate and sodium formate. This change was adopted widely in the aviation industry and was meant to address the impacts urea de-icers were having on surface water quality (personal communication Gary Kindrat March 2010). Potassium acetate can be used as a de-icer instead of chloride salts like calcium chloride or magnesium chloride. It offers the advantage of being less aggressive on soils and much less corrosive, and for this reason is preferred for airport runways.

Potassium acetate is considered to be environmentally responsible because it does not contain urea or glycol, has a lower Biological Oxygen Demand (BOD) than glycol-based runway de-icers, biodegrades at low temperatures, and biodegrades to carbon dioxide and water. It is, however, more expensive (USEPA 2002). Sodium formate (or Formic Acid) is a similar de-icing compound that is less corrosive than chloride salts and undergoes faster melting action relative to other de-icing chemicals (Corsi et al 2008).

Herbicides

Broad-leaf herbicides will be applied selectively to control weeds in turf areas of the PRP, as is currently done on the remainder of the airport property. YYC uses Provincially Certified Applicators for spraying herbicides to control weeds in grassed areas (airside turf) along runways and taxiways. YYC has acquired a sophisticated chemical applicator that does double duty (herbicides in summer and runway de-icing applicators in the winter). With this equipment, the operator has better control of the product being applied through better nozzles and controls in the operator's cab. In 2011, an optional GPS package will be purchased and installed on the applicator. This option will further improve YCC's ability to document chemical use, define problem areas and reduce the amount of chemicals used (personal communication Gary Kindrat March 2010).

YYC currently uses and historically used a limited number of herbicides such as Tordon 101 to control the growth of noxious weeds and other vegetation on lands surrounding the airfields and taxiways. The areal extent of lands that might occasionally be subject to herbicide application will increase as a result of the PRP. No known or suspected impacts have been attributed to current herbicide/pesticide uses at the airport. If herbicide residues dissolve and migrate to aquifers or surface water receptors, it would be a concern. However, the potential for contaminant movement in the LSA groundwater system is considered to be low due to the low permeability clay till and claystone bedrock.

Airplane De-icing Chemicals

De-icing on the ground is usually done by spraying aircraft with a de-icing fluid (ethylene glycol or propylene glycol). The airlines and service providers such as ATS or Servicair apply the glycol. Glycol must be used with a containment system to capture the used liquid so that it cannot seep into the ground and/or surface water streams.

YYC has an existing environmental management system for managing and containing de-icing glycol. YYC provides the glycol management facility and monitors implementation of the Glycol Mitigation Plan.

A new Central De-Icing Facility (CDF) is planned for YYC, but it is not a component of the PRP. The size and location of the proposed CDF has not yet been determined; however, the general concept is to permit safe and efficient de-icing and anti-icing of aircraft in a centralized, controlled area so that de-icing fluids may be controlled and not permitted to impact local waterways. Initially the CDF will be used to de-ice aircraft departing from gates at the proposed IFP East Concourse and will eventually be used to de-ice all commercial aircraft originating from the main terminal building. Two potential CDF locations are being considered: one near the intersection of Taxiways J and B, and the other located east of the existing Runway 16/34, approximately 200 m north of existing Runway 10/28 (Volume II, Chapter 7 of the CS).

No de-icing of aircraft within the PRP is planned. The proposed de-icing facility will be down gradient to the west of the PRP. Therefore, the effects of aircraft de-icing activities are not expected to have a detectable effect on the LSA. Minor drips of glycol from aircraft taxiing to the PRP may occur and may enter the groundwater system below the LSA, but the amounts of de-icing fluid introduced into the LSA this way are likely to be so small that they will have negligible effect on groundwater quality. The low permeability of the clay till and claystone bedrock will restrict movement of this small amount of glycol in the subsurface.

Spills or Accidents of Petroleum Fuels from Airplanes or Other Runway Maintenance Equipment
Aircraft and runway maintenance equipment traffic are highly controlled for safety purposes and, therefore, accidents and related fuel or chemical spills are likely to be rare events. Measures to prevent accidents and spills will be implemented and appropriate emergency response plans will be developed and used as part of the standard operating practice for the PRP, similar to the other YYC airside areas. These are covered in more detail in the Airport Emergency Response Procedures and Volume III, Chapter 19.

Based on the information provided above, potential effects on groundwater quality during operations are assessed as follows:

The direction of this effect is assessed to be adverse and the nature is assessed to be direct.

The timing of this effect would commence with the commencement of runway operations.

The frequency is assessed as intermittent as de-icing and herbicide and pesticide applications will be seasonal and weather related events. The frequency of spills or accidents will be rare.

The duration will continue as long as the runway is operating.

The scope of the effect is assessed to be local (i.e., within the LSA) and the effect is considered to be reversible because the runway de-icing chemicals and herbicides applied during operations are biodegradable. Remediation activities will be implemented promptly in the case of spills or accidents.

Magnitude is the amount of change in a measurable parameter or variable relative to the baseline case. Of all of the criteria used to rate potential residual effects after mitigation, magnitude most accurately reflects the degree of an effect. Magnitude refers to the intensity or severity of an effect and is the best indicator of the amount of change in a measurable parameter compared with baseline conditions. There are a number of reasons why groundwater quality is not expected to exceed the Health Canada Drinking Water Quality Guidelines (GDWQ) in more than 10% of the LSA, including:

- The chemicals used are biodegradable and YYC has a policy to reduce chemical use to the minimum required for aviation safety.
- The low permeability clay till and the underlying low permeability claystone bedrock prevents rapid or extensive subsurface movement of contaminants in groundwater and attenuates contaminant movement.
- The existing water supply wells (area not serviced with City water) are up-gradient to the north and east, the down gradient area to the south and west is serviced with municipal water.
- The distance from the LSA to Nose Creek is 3 km and the time for groundwater to travel to Nose Creek is estimated to be about 600 years.
- Water quality in the sandstone aquifer used by rural water wells to the north and east will be affected by down gradient activities in the PRP and will not exceed current baseline water quality or applicable GDWQ criteria.

Therefore, the magnitude of the PRP effects on groundwater quality during operations is assessed to be low.

7.5 Mitigation Measures

The CS for the proposed parallel runway at YYC is using a mitigation-by-design approach. This approach systematically considers measures that could be used to reduce the potential effects of the PRP at the earliest possible stage in the assessment. The process of refining the project description and identifying new mitigation measures continued throughout the process of assembling the CS.

7.5.1 Groundwater Quantity

Potential adverse effects on groundwater quantity that may warrant mitigation include potential reductions in the amount of groundwater infiltration (recharge) to deeper aquifers and associated reductions in groundwater discharge to surface streams. One of the design objectives of the stormwater drainage system is to secure compliance with the discharge criteria to Nose Creek established in the Nose Creek Watershed Management Agreement. The Nose Creek Watershed Management Agreement is endorsed by Alberta Environment. The stormwater management system includes stormwater retention ponds that will result in increased infiltration and groundwater recharge in these areas. Stormwater systems can also be designed with infiltration galleries and other features to allow leakage and groundwater recharge to occur along their length. There are a number of BMPs for runoff volume control such as porous pavement and other infiltration structures that could be implemented to maintain groundwater and base flows in this region. Infiltration will be encouraged below stormwater detention facilities. However, the low permeability clay soils within the LSA and much of the RSA may reduce the effectiveness of these BMPs in some areas.

The PRP will add large impervious areas and yield higher volumes of runoff compared to pre-development conditions. The natural soil surface available for water storage and infiltration will decrease. To manage the impacts from the large impervious areas, drainage systems will include storm sewer pipes (minor systems), overland flow paths (major systems) and storage facilities. Generally, storage facilities are a combination of parking lot storage, rooftop storage and dry or wet detention ponds. These storage facilities are designed to retain the surface runoff and to control the release rate from the new developments in order to protect downstream areas. Wet and dry detention ponds can be designed to allow groundwater recharge to occur to mitigate the loss of infiltration/groundwater recharge within the PRP due to hard surfacing. Due to aircraft safety consideration (i.e., bird strikes), it is expected that mainly dry ponds will be utilized in the PRP.

7.5.2 Groundwater Quality

Abandoned water wells, monitoring wells, and oil and gas wells can provide a pathway for rapid downward movement of contamination to deeper aquifers if they are not properly sealed and reclaimed. All existing water wells, monitoring wells, oil and gas wells, and boreholes on the PRP area that cannot be preserved will be identified, inspected and effectively sealed with grout to comply with standard BMPs and to prevent movement of potential contaminants to the deeper bedrock aquifer. This will be done prior to building the runway.

Groundwater quality within the PRP will be protected by the current plans to not allow aircraft fuelling, de-icing or maintenance within the PRP area. Groundwater quality impacts will also be minimized by the judicious use of types and quantities of herbicides and runway de-icing chemicals used in runway operations.

7.6 Sustainability

The consideration of sustainability goes beyond basic mitigation. While many mitigation measures may also qualify as sustainability measures, there are often additional measures that can be applied that go beyond the intention to simply reduce potential effects. These additional measures stem from an attitude or an approach towards potential development that actively seeks out smarter and better ways to do things that often increase the net sustainability of a project.

As the assessment and design of the PRP has unfolded, such measures have been actively sought and recorded in a sustainability framework. The process and results are described in more detail in Volume III, Chapter 2.

The main sustainability measure for groundwater quality is the use of BMPs for stormwater management to maximize the amount of groundwater recharge below stormwater retention facilities in areas where geologic conditions and land use allow beneficial infiltration of runoff. The implementation of site specific BMPs for promoting stormwater infiltration will help sustain groundwater elevations and groundwater recharge to deeper aquifers and will contribute to sustainability.

The main sustainability measure for groundwater quality is the use of low impact, biodegradable herbicides and runway de-icing chemicals that reduce the potential for groundwater quality degradation while maintaining appropriate safety standards for the PRP. A policy will be implemented that promotes the use of biodegradable runway de-icing compounds and biodegradable herbicides to protect groundwater quality and contribute to sustainability.

Further sustainability measures are outlined in Volume III, Chapter 2 of the CS.

7.7 Residual Effects after Mitigation

The assessment has determined that there is a negligible or low adverse effect on groundwater quantity due to the effect of grading, hard surfacing, underpasses, and surface water drainage improvements within the LSA. During construction and operations, these effects will be mitigated using BMPs for stormwater management to promote infiltration below stormwater retention facilities where geologic conditions and land use allow. A small reduction in the amount of groundwater recharge may persist within the LSA despite mitigation. However, this negligible or low magnitude effect will not extend beyond the LSA. Residual effects on groundwater quantity are predicted to be negligible in the RSA. Residual effects on groundwater quantity are assessed to be low in magnitude and local in extent; therefore, the residual effects of the PRP on groundwater quantity are assessed to be not significant.

The assessment has determined that there is a negligible or low adverse impact on groundwater quality in the LSA area due to the fuelling and maintenance of mechanized equipment during construction. The identified effects during construction and operations will be mitigated using BMPs for fuel and chemical handling. Similarly a negligible or low adverse impact on groundwater quality in the LSA is predicted with respect to the use of runway de-icing compounds and herbicides during runway operations. BMPs for de-icing compounds and herbicide types and applications will be utilized by YYC.

A small reduction in groundwater quality may occur within the LSA despite mitigation. However, this low magnitude effect will not extend beyond the LSA. No residual effects on groundwater quality are predicted in the RSA. Residual effects on groundwater quality are assessed to be negligible or low in magnitude and local in extent; therefore, the residual effects of the PRP on groundwater quality are assessed to be not significant.

7.8 Significance of Residual Effects

No significant residual effects on groundwater quantity are predicted as a result of the PRP construction or operations as outlined in the above discussion. Although the PRP may reduce the amount of runoff that infiltrates the ground and recharges the groundwater flow system, the effects are expected to be small and/or localized within the LSA. The predicted residual effects are assessed to be negligible in the RSA. No detectable effects are predicted for local water wells or Nose Creek. The existing water wells are located to the north and east, up-gradient of the PRP, and will not be affected. Existing wells within the LSA will be decommissioned and sealed prior to PRP construction. The area down gradient to the south and west is serviced with municipal water. Due to the low permeability of the soils and bedrock in the LSA and the long flow path to Nose Creek, the predicted reduction in recharge within the LSA is expected to have a negligible effect on stream flows in Nose Creek.

Similarly, no significant residual effects on groundwater quality are predicted as a result of the PRP construction or operations as outlined above. No permanent facilities for fuelling, equipment maintenance or de-icing are proposed for the PRP area. The surface soils are low permeability clay till underlain by low permeability claystone bedrock. Contaminant movement in the subsurface would be very slow.

7.9 Cumulative Effects

Cumulative effects are “changes in the environment that are caused by an action in combination with other past, present and future human actions” (Hegmann et al 1999). Cumulative effects are assessed by first determining if a project is likely to have an effect on a VC and then determining if other projects or activities potentially affect the same VC. When the effects of a project act in combination with the effects of other projects or activities, a cumulative effect might result. A cumulative effects assessment (CEA) determines how much of the change is attributable to the project under consideration, how much of the change occurs or has occurred because of other projects or activities, and whether the combined effects are significant for the VC under consideration.

7.9.1 Groundwater Quantity

The trend of increasing urbanization with more hard surfaced areas and more storm drainage systems will tend to have a cumulative effect on reducing the amount of recharge which occurs in this area of northeast Calgary. However, the PRP is unlikely to result in significant adverse cumulative effects, particularly if BMPs for stormwater management are implemented by YCC and the City of Calgary. As the area is urbanized and serviced with municipal water, groundwater extractions from wells in the area will decrease, potentially counteracting the effect of reduced infiltration due to hard surfacing and storm drainage. There is a proposal being considered to construct a road access tunnel under the PRP to facilitate public access to the airport from the east. This project is not part of the PRP and is not part of the CS. However, a large east-west tunnel under the PRP would likely involve groundwater dewatering during construction and during future operations. This could lower groundwater levels in the vicinity of the tunnel and reduce groundwater recharge. However, due to the low permeability of the clay till and the claystone bedrock, this cumulative effect is likely to be local in extent and is unlikely to be significant.

7.9.2 Groundwater Quality

Similarly, the trend of increasing urbanization, with commercial and industrial usage of fuel and other chemicals, will tend to have a cumulative effect on reducing the quality of groundwater in this area of northeast Calgary. However, the PRP is unlikely to result in significant adverse cumulative effects on groundwater quality as long as BMPs for fuel and chemical usage are implemented by YCC and the City of Calgary.

7.10 Follow-up and Monitoring

The main indicators for groundwater flow and infiltration (recharge) are groundwater elevations. A follow-up and monitoring program will be established for the PRP. Additional monitoring of groundwater elevations in select wells within the LSA is recommended to better define seasonal groundwater elevation trends. Groundwater elevations have been measured several times a day in three monitoring wells in the LSA since the summer of 2009, using transducers and dataloggers. This monitoring will continue along with quarterly manual groundwater level measurement in all available monitoring wells on the LSA until the summer of 2010 when a full year of data has been collected. This data will be plotted with precipitation data from the YYC weather station to provide a set of baseline groundwater level data for all seasons.

The PRP is predicted to not have any significant effects on groundwater quantity during construction or operations phases so further routine groundwater level monitoring is only required near the tunnel excavations and a few other representative locations within the PRP where transducers and datalogger stations have been installed in monitoring wells. Groundwater level monitoring near tunnel excavations should be completed to measure the effects of tunnel dewatering, before, during and after tunnel construction.

The construction of the PRP will necessitate the sealing of many of the existing water wells and groundwater monitoring wells that are located in areas of active excavation or filling. A memo will be prepared to document the work completed to identify and seal existing water wells within the PRP area.

An extensive amount of groundwater quality samples were collected in 2009 to establish baseline groundwater quality. No further groundwater monitoring is required for baseline or CS purposes. If spills of fuel or chemicals occur during construction or operations, then additional groundwater quality monitoring may be required in localized portions of the LSA to assess compliance with applicable water quality criteria.

7.11 Conclusions

The PRP will not have any significant residual effects on groundwater quantity after mitigation. Infiltration of runoff (i.e., groundwater recharge) will decrease in the PRP area due to the increased hard surfaces, improved stormwater drainage and two underpasses that intersect the water table. However, due to the low permeability clay till and claystone bedrock and the relatively dry climate, only a small amount of groundwater recharge occurs in the LSA. The decrease in groundwater recharge caused by PRP construction and operations will be partly offset because groundwater extraction from existing residential and agricultural wells in the PRP area will cease. Stormwater management BMPs will be used to increase groundwater recharge below the proposed stormwater retention facilities. The net reduction in groundwater recharge is predicted to be low in the LSA and have a negligible (i.e., not measureable) effect in the RSA on water quantities available to water supply wells or for discharge to Nose Creek.

The PRP will not have any significant residual effects on groundwater quality, after mitigation. The identified effects during construction and operations will be mitigated using BMPs for fuel and chemical handling. During operations, BMPs for de-icing practices and herbicide applications will mitigate impacts. A small reduction in groundwater quality may occur within the LSA despite mitigation. However, this low magnitude effect will not extend beyond the LSA. No detectable residual effects on groundwater quality are predicted in the RSA. Residual effects on groundwater quality are assessed to be negligible or small in magnitude and local in extent; therefore, the residual effects of the PRP on groundwater quality are assessed to not be significant.

7.12 Response to Issues Raised by the Public and the Stakeholders

Issue: Potential effects of glycol on groundwater.

Response: YYC currently applies glycol to de-ice aircraft at the main terminal gates. YYC has an existing environmental management system for managing and containing de-icing glycol. The existing on gate de-icing will not be sufficient when all concourses are integrated. A new Central De-Icing Facility (CDF) is planned for YYC, but it is not a component of the PRP. De-icing of aircraft with glycol will not occur on the PRP and no adverse effects from glycol are assessed (see Section 7.4.3.2).

Issue: Potential effects on airfield drainage and its effects on groundwater.

Response: The PRP has the potential to adversely affect groundwater quantity by increasing the volume of surface runoff and thereby reducing the volume of runoff that infiltrates into the ground (i.e., groundwater recharge). Operational facilities including hard surfaces, subsurface drainage, subsurface utility corridors, stormwater drainage, and the taxiway underpasses could reduce groundwater recharge, affect groundwater elevations and modify groundwater flow and recharge/discharge relationships. Potential effects on the amount of groundwater available for local water wells or for groundwater discharge (base flow) in Nose Creek was assessed. This adverse effect is counterbalanced by the beneficial effect of reduced water well withdrawals from the bedrock aquifer when the existing water wells in the LSA are decommissioned. This beneficial effect will likely increase over time as City water is provided to areas east of the PRP which currently rely on groundwater wells. In areas near proposed taxiway underpasses that extend below the water table, the reduction in groundwater elevations and recharge will be greatest. However, the existing water supply wells are located to the north and east of the PRP from the proposed taxiway underpasses, which are near the existing airport facilities to the west of the PRP.

Groundwater flow in the PRP area is to the southwest, away from the existing farmland wells and towards Nose Creek so no effects on local water supply wells are predicted. Groundwater recharge volumes in the PRP area are low because of the low permeability clay till and claystone bedrock. Due to the low permeability soils and bedrock, and very long calculated groundwater flow travel times to Nose Creek, the effects of the PRP are predicted to be low with respect to both groundwater flow and quality (see Section 7.4).

Issue: Potential effects on water quality within riparian habitats with consequences for groundwater.

Response: The PRP will have negligible effects on groundwater quality in riparian areas along Nose Creek. Only minor, local groundwater quality effects are predicted in the LSA due to PRP construction and operation. Groundwater flow travel times to Nose Creek are estimated to be in the order of 300 years due to the slow permeability of the clay till and claystone bedrock in the PRP area (see Section 7.4).

Issue: Potential effects on farmland groundwater (non-airport lands).

Response: See responses above.

Issue: Potential effects of groundwater displacement into storm sewers.

Response: See above discussion on groundwater recharge (see Section 7.4).

Issue: Potential subsurface movement of contaminants to Nose Creek.

Response: Groundwater flow travel times to Nose Creek are estimated to be in the order of 300 years due to the slow permeability of the clay till and claystone bedrock in the PRP area. Only minimal groundwater quality degradation is predicted as a result of the PRP and water quality will be adequately attenuated and renovated along this long slow flow path so that the PRP will have negligible effect on water quality in Nose Creek (see Section 7.4).