DRAFT – June 2007

PART B: SENSITIVITY ANALYSIS REPORT
COMPREHENSIVE BROADER SCALE ENVIRONMENTAL STUDY:
CALEDON AGGREGATE RESOURCE AREA 9-A

VOLUME 1 - REPORT, TABLES, AND APPENDICES

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Dear Mr. Salter, Ms. Banz, Ms. Breton:

Re: James Dick Construction Limited (JDCL), Comprehensive Broader Scale Environmental Study (CBSES) - Part B Report

Please find enclosed a revised draft of the CBSES Part B Sensitivity Analysis Report. Prepared in consideration of the work plan and various discussions and agreements with your agencies. As you recall, JDCL has agreed to undertake the work outlined in the revised Work Plan at the request of the agencies. However, as previously advised and for the record, the undertaking of such work is on a without prejudice basis and is not to be interpreted as meaning that JDCL was or is in agreement with the agencies with respect to what constitutes an appropriate scale and scope of work to address the Official Plan policies.

We would appreciate any comments you may have on the Part B Report at your earliest opportunity as we are striving to catch-up to the overall timelines. The Project Team is continuing to move forward with Part C of the CBSES.

Thank you for your prompt attention to this matter.

Yours truly,

CONESTOGA-ROVERS & ASSOCIATES

J. Richard Murphy, M.A.Sc., P. Eng.

JRM/ev/2
Encl.

c.c.: See Distribution List

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1 INTRODUCTION

1.1 CBSES BACKGROUND

The Comprehensive Broader Scale Environmental Study (CBSES) for the Town of Caledon's High Potential Mineral Aggregate Resource Area (CHPMARA) 9-A is being completed for James Dick Construction Limited (JDCL) to address policies of the Caledon Official Plan. The CBSES is being completed in three phases or parts:

- Part A - Characterization;
- Part B – Sensitivity Analysis; and
- Part C – Implementation.

The Part A Characterization Report (Draft issued November 30, 2006) presents the Study Area characterization information and identified key features, functions, and linkages for the natural system. The Part A Report includes further information on the Study background, context, and Work Plan. The Part B Sensitivity Analysis Report presents the evaluation of the sensitivity and significance of the Study Area features and the assessment of the potential impacts that may result from development within the Study Area and particularly development of Aggregate Resource Area 9-A. Results of the sensitivity analysis and impact assessment assist with the following aspects of the CBSES:

- Identifying the relative significance and sensitivity of Study Area features;
- Assessing the potential impacts of select land use scenarios on the Study Area features, based on their significance/sensitivity;
- Identifying objectives for the Study Area that will provide the basis for the development of environmental management protection priorities and targets (Part C);
- Identifying appropriate alternative management solutions and mitigation strategies to avoid or minimize impacts;
- Establishing appropriate programs for monitoring baseline environmental conditions and monitoring the performance of recommended management/mitigation strategies (Part C);

- Identifying restoration/enhancement opportunities (Part C); and
- Assessing the potential implications of impacts to features / functions in relation to the various municipal, watershed and provincial landscapes and policy levels (Part C).

1.2 PART B APPROACH AND REPORT OUTLINE

Part B Approach

The Part B Sensitivity Analysis includes the assessment of both direct and indirect impacts from potential development within the Study Area. As described in the Part A Report (Section 4.8.2) and presented in Section 2.1 (below), the potential extraction of aggregate in Aggregate Resource Area 9-A is the focus of the Part B Sensitivity Analysis. Figure 1-1 illustrates the CBSES Study Area and Aggregate Resource Area 9-A.

Direct impacts describe the effects of the actual removal or alteration of environmental features. Direct impacts associated with the development of Resource Area 9-A are limited to the lands or features that are directly within or immediately adjacent to Resource Area 9-A. These impacts are relatively easy to identify and understand by simply examining the features within the potential development area and the interactions with surrounding areas. Examples of direct impacts include the removal of certain features (e.g., a field or pond) through a development process such as quarrying.

Indirect impacts describe the results of development beyond the physical limits of the development activity. The primary mechanisms for indirect impacts to occur from development of Resource Area 9-A are the groundwater and surface water pathways. Aggregate extraction activities have the potential to affect groundwater levels and flows in surrounding areas and may also interrupt, or otherwise alter, surface water flows downstream from the extraction area. Changes that may propagate along the groundwater and surface water pathways may then affect other aspects of the environment, including water supplies, aquatic systems/fisheries, wetlands, and even forests. The primary indirect environmental effects of such development would be on water resource features and associated natural features (e.g., streams and wetlands).

Part B of the CBSES uses hydrologic and hydrogeologic models to simulate the potential effects of hypothetical land use scenarios. This is done in order to demonstrate what features and functions within the Study Area are most susceptible to the effects of development within the Study Area due to indirect impacts.

The scope of Part B of the CBSES includes:

- Refining the resolution of the watershed-scale hydrologic and hydrogeologic models to the smaller scale of the CBSES;
- Identifying the types of potential influences on water resources, and in turn on associated environmental features, within the Study Area that may result from the land use scenarios;
- Evaluating the approximate nature and extent of the potential responses to hypothetical development in the absence of mitigation measures and the resultant effects on the water-dependant ecological features in the Study Area; and
- Providing a basis for identifying mitigation and planning requirements for potential future development.

The impact assessment modelling was completed using the CVC's Watershed Models (HSP-F and FEFLOW), which were refined for the Study Area in accordance with the CBSES Work Plan. The models were extensively refined based on the background and specific information developed as part of this Study to represent the Study Area at a smaller scale to support the impact assessment.

The impact assessment process utilizes a stress-response framework that uses hydrologic (surface water) and hydrogeologic (groundwater) models to identify the hypothetical impacts of land use changes on groundwater and surface water (*primary indicators*), and then to assess the impacts of those water-related changes on associated water-dependent features (*secondary indicators and end receptors*).

The potential changes are compared to existing (baseline) conditions that were previously established as part of the Part A Characterization.

The impact analysis process involves using the characterization information to assess the sensitivity of natural features/end receptors, which includes consideration of their relative significance and representation within the Study Area as well as their sensitivity to environmental change. The impact analysis then assesses the potential impact of the water-related changes as a result of the land use change (i.e., a land use scenario) on the receptors, based on their relative significance/sensitivity. This analysis is a multi-step process that first ranks the influence of the development (land use change) on key surface water and groundwater water-related indicators (e.g., baseflow, groundwater drawdown), and then ranks the anticipated response (or magnitude of the response) of these water-related changes on the natural feature or receptor, based on its relative significance/sensitivity.

The impact assessment approach is described further in Section 3. The results of the impact analysis are presented in Section 6 as a matrix evaluation table organized by local subcatchments within the Study Area. The results rank the overall relative magnitude/extent of the potential impacts based on the anticipated impacts to the most sensitive features/receptors identified within each catchment.

Seven (7) main end receptors were identified for detailed analysis as part of this impact analysis:

(a) Water Supply (groundwater/aquifer/well yield impacts);

(b) Property Damage/Flooding (surface water impacts);

(c) Creek Channel Form (in relation to fluvial geomorphologic impacts);

(d) Terrestrial (Upland Forest) Habitat;

(e) Non-Riverine Wetlands;

(f) Riverine Wetlands; and

(g) Fisheries.

The assessment of potential impacts to these receptors includes both water quantity and water quality considerations (as applicable).

Three (3) principal land use scenarios were considered for this analysis:

- Scenario A: Baseline Condition - Existing Conditions;

- Scenario B: Interim Condition - Full Active Extraction without Mitigation; and
- Scenario C: Long-Term Condition - Passive Rehabilitation.

The assessment also includes two additional evaluation components:

- Scenario D: Interim Condition – Partial Extraction without Mitigation; and
- Scenario E: Lake Filling Condition – Timing for Rehabilitation.

These scenarios generally reflect hypothetical worst-case scenarios to provide a conservative (i.e., negative or severe) basis for the sensitivity analysis. A detailed description of each scenario is provided in Section 3.2 below and in the Work Plan (Appendix E of the Work Plan).

The results of this analysis are then used to identify the features that are most susceptible to the potential land use change and applicable objectives for the development of the Study Area. The potential impacts of land use change and the identified objectives provide the basis for assessing the need for and general type of management/mitigation strategies for development of Resource Area 9-A.

The establishment of potential impacts, objectives, and management/mitigation options provides the basis for the Part C Implementation Plan. The Implementation Plan includes guidelines for site-specific development applications as well as identification of protection priorities and targets, an overall Comprehensive Adaptive Management Plan (CAMP), a monitoring program, and identification of restoration/enhancement opportunities in the Study Area. Part C also reviews the Policy conformity of the completed CBSES.

Report Outline

This Part B report is presented in the following sections:

Section 1 provides the introduction to this phase of the CBSES and outlines the general relationship of this phase provides the connection to the Part A Characterization and Part C Implementation reports.

Section 2 provides the context of the land use scenarios considered under the Part B Sensitivity Analysis, and outlines the general influences that aggregate extraction can have on a watershed.

Section 3 describes the impact analysis framework and the five (5) land use scenarios used to evaluate the impacts of potential development of Resource Area 9-A on Study Area features.

Section 4 describes the direct impacts from aggregate extraction of Resource Area 9-A.

Section 5 summarizes the development and application of the hydrologic and hydrogeologic impact assessments models used to simulate future conditions under the five land use scenarios and related changes to the water budget.

Section 6 presents an evaluation of the response of the Study Area features to the impacts of the development scenarios on a local subcatchment basis. That is, for each receptor, the relative magnitude of the impact of the water-related change on the local catchment features is assessed, based on their relative sensitivity. The overall or combined response (or impact) of each local catchment to the changes associated with a development scenario is then assessed by integrating all of the impacts on the various receptors

Section 7 presents the environmental management goals and objectives for the main Study Area components, i.e., groundwater, surface water, fluvial geomorphology/channel form, terrestrial features (e.g., wetlands, wildlife, and upland vegetation), and fisheries.

Section 8 provides a general introduction to management and mitigation requirements and alternatives.

Section 9 introduces the work to be conducted for completion of the CBSES (Part C).

1.3 AGENCY / PUBLIC CONSULTATION

Agency Involvement

The Town of Caledon, Region of Peel, and Credit Valley Conservation (CVC) have been and continue to be in direct consultation with JDCL regarding the CBSES. These lead agencies initially prepared a draft Terms of Reference for the CBSES, were involved in detailed discussions leading to the preparation of the CBSES Work Plan, and have been involved in extensive detailed discussions and consultation regarding the CBSES Study and Reports.

Many meetings have occurred between the lead agencies and JDCL to discuss all aspects of the CBSES, including those mentioned above. These meetings have occurred between 2003 and 2007 and have involved lead consultants and technical staff from JDCL and the agencies.

There continues to be ongoing technical discussions with Agency Staff regarding the CBSES work and reports, and additional meetings are planned as the CBSES progresses and is completed.

Landowner Contact

Private landowners own the majority of lands within the CBSES Study Area. Access to some of the properties was required for the purposes of collecting data for the CBSES, and the CCC helped JDCL to facilitate access. More than half of the landowners responded to the Study Team's requests to access their lands for data collection, and the access necessary to complete Part A of the CBSES was obtained. Some landowners did not wish to grant access to their properties, but most were quite cooperative.

Data was collected over the course of three summers for many components of the Study, and is now complete. A summary of the work conducted on these sites has been forwarded to the landowners.

Public Information Forums

To date, two Public Information Forums (Open Houses) have been held relating to the CBSES - June 28, 2005 and January 25, 2007.

JDCL and the CBSES Project Team held a Public Open House on June 28, 2005 at the Creditview Public School in the Town of Caledon. The Open House was well attended, with approximately 100 people signing in at the door. However, actual attendance was estimated at approximately 200 people as a large number of people arrived at once. The purpose of the Open House was to present some of the information collected to date for the Part A Report (Characterization) to the public and to provide an opportunity to collect potentially helpful information from individual landowners. The Open House format consisted of about 40 display panels arranged by discipline. Thirteen (13) members of the CBSES project team attended the Open House, and the public was provided with the opportunity to review information and maps, discuss information presented with the members of the project team, and provide any input with respect to the information presented or other aspects of the Study Area (and beyond). Information provided by the public was evaluated and incorporated into the CBSES, as appropriate.

Copies of the Draft Part A Report were provided to landowners in electronic format upon request. Hard copies and electronic copies of the Draft Part A Report was made available at the Town of Caledon, Coalition of Concerned Citizens (CCC), and CVC offices, and a copy was placed at the library in Belfountain.

A second Public Information Forum was held jointly by JDCL, the Town of Caledon, Region of Peel, and Credit Valley Conservation on January 25, 2007 at the Brampton Fair Grounds in Caledon. Attendance at the Open House was nearly 200 people. The CCC was involved in the organization of the Information Forum, and members were present as well. The purpose of the Information Forum was to provide an update on the progress of the CBSES to date, and to provide information regarding the next steps of the Study (including the Goals and Objectives). The format of the Information Session consisted of: an Open House with display boards; presentations by Robb Ogilvie (Facilitator), the Town of Caledon, and the CBSES Study Team; and a question and answer period. In addition, comment forms were distributed and attendees could indicate if they had additional questions. A detailed set of responses to the additional questions was compiled by JDCL and the Lead Agencies, and the responses were distributed to attendees at the February 27, 2007 Workshop.

CD copies of the updated Part A Report were made available at the Information Forum, and attendees were asked to indicate if they would be interested in attending a Workshop to further develop the Goals and Objectives. A summary of the Information Forum was prepared by Robb Ogilvie, and is attached as Appendix K.

Objectives Workshop

A public Workshop was held jointly by JDCL, the Town of Caledon, Region of Peel and Credit Valley Conservation on February 27, 2007 at the Caledon Ski Club in Caledon. There were 59 people that attended the Workshop. The CCC was involved in organizing the Workshop and representatives were in attendance as well. The purpose of the Workshop was to discuss the Study Area Objectives for the CBSES related to various topics (groundwater; surface water; fisheries; and woodland wetlands and wildlife). The format of the Workshop included a light dinner, presentations by the Facilitator, Town of Caledon and CVC, facilitated break-out sessions regarding the four topics, and a wrap-up discussion.

Sample objectives were developed for each of the four topics and these were discussed in detail within the smaller groups formed at the Workshop. The groups rotated between the various topics so that each group was able to discuss them, and scribes kept notes of the discussions for inclusion in the summary. The summary of the Workshop prepared by Robb Ogilvie is included as Appendix L.

The results of the Workshop were taken into account when developing the Goals and Objectives contained later in this Part B Report.

2 LAND USE SCENARIOS

2.1 DEVELOPMENT OF LAND USE SCENARIOS

A major component of the Part B Sensitivity Analysis is the evaluation of potential or hypothetical land use scenarios and assessing the associated potential for changes to surrounding water-dependant features. This exercise is important to the CBSES as it facilitates the assessment of potential impacts to the Study Area and allows recommendations to be developed regarding the protection of sensitive features in future development proposals. The sensitivity impact assessment, and associated modelling exercise, being undertaken for Part B of the CBSES is based on hypothetical aggregate extraction within Resource Area 9-A consistent with the Work Plan. The approach to the impact assessment and modelling was discussed with the lead agencies, and agreement was reached on the various scenarios to be modelled.

For the purposes of the Part B impact assessment and modelling exercise, aggregate extraction is the land use scenario being considered. This is based on the detailed review of applicable land use planning documents in Part A of the CBSES, and the determination that the most likely large scale land use within the Study Area would be the development of Resource Area 9-A for aggregate extraction.

As noted in the Part A Report, a portion of the CBSES Study Area is identified as a High Potential Mineral Aggregate Resource Area in both the Town of Caledon and Region of Peel Official Plans, which recognizes the high-quality aggregate present (Figure 2-1). As shown on Figure 2-1, much of the remainder of the Study Area is either used for agricultural, recreational, natural areas, or residential land uses, and major planning approvals would generally be required for other large-scale developments such as golf courses or estate residential subdivisions.

The Part A Report concludes that overall, the potential for urban development, significant numbers of new lots or other large-scale development proposals is low. Growth is directed to settlements outside of the Study Area such as Erin Village, Georgetown, or Caledon East. The Greenbelt Plan recently released by the Province restricts urban uses to designated areas, and placed further restrictions on permitted uses within the Protected Countryside area. A large portion of the Study Area is within the Niagara Escarpment Plan which, in conjunction with local and regional policies strictly limit and control opportunities for growth and development. The Greenlands Systems identified by the upper-tier municipalities generally follow the Niagara Escarpment landform and the features identified in the Provincial Greenbelt Plan (refer to Figure 4-3 in the Part A Report).

The Part A Report invested the potential for other land uses, and concludes that the most likely form of land use change in the Study Area is the development of mineral aggregate operations given the Resource Areas identified in the Regional Official Plan and Town of Caledon Official Plan. It could also reasonably be assumed that there is the potential for intensive agricultural operations within the Study Area, given the predominant agricultural designations (outside the Greenlands Systems). Any estate residential developments or large recreational uses such as golf courses generally require amendments to the respective Official Plans. The trend of increasing naturalized areas due to abandonment of farming operations is also expected to continue in the future.

Although other land uses are not being specifically evaluated or modelled for the purposes of the Part B Report scenarios, they will be discussed in the Part C report and recommendations made regarding their potential future development.

In order to streamline the models used in the impact assessment, Resource Area 9-A was simplified for the purposes of the modelling exercise (Figure 2-2). This simplification of the Resource Area does not compromise the results of the Part B assessment given the scale of the Study and the model used. The features not represented in the model are the small wetland (often referred to as the Northeast Wetland) located near the middle of the Resource Area (circular in shape), and the channel buffer on the southeast side of the Resource Area. However, these areas are actually excluded from Resource Area 9-A, and appropriate consideration for protection of these features should be incorporated through site-specific development proposals.

Additional details regarding the refinement of Resource Area 9-A can be found in Section 3.2.

2.2 GENERAL INFLUENCE OF AGGREGATE EXTRACTION

Any change in land use in a watershed can affect the water and ecological features in a variety of ways. This includes a change in land use from natural areas to urban or rural residential development, agricultural applications, or industrial development, including aggregate extraction. This section describes some of the cause and effect relationships that may be exhibited in a watershed (or subwatershed) in response to development of an aggregate extraction land use to provide context for this Sensitivity Analysis. This introductory discussion is not specific to the particular characteristics of the Study Area or Resource Area 9-A and is not intended to provide a comprehensive list of development responses and effects. The specific physical and biotic characteristic will influence how the natural environment will respond to changes in land use within a watershed; however, the trends and patterns outlined herein are generally relevant.

General types of land use change that can occur in the region of the Study Area include:

- natural areas to agricultural areas;
- agricultural areas to natural areas;
- agricultural or natural areas to settled (primarily rural residential) areas;
- agricultural or natural areas to aggregate extraction operations;
- agricultural or natural areas to recreational (e.g., golf course); and
- aggregate extraction areas to agricultural, settled, or natural areas (i.e., rehabilitation).

In addition to the direct removal and fragmentation of habitats and displaced species, larger scale development in particular has had significant effects on the local hydrologic cycle. The greatest changes to the hydrologic cycle and associated ecology of developed areas have occurred due to the historic transition from natural areas to agricultural land use and settled/urban development. These changes have been observed to generally result in marked decreases in infiltration and increases in runoff volumes and peak flow rates resulting in downstream damages (i.e., flooding and increased channel erosion).

The reduction in infiltrated surface water results in associated decreases in groundwater levels and sources of groundwater discharge to supply baseflow within creeks and streams. These alterations result in losses, shifts and reduced diversity in the natural flora and fauna species and communities due to direct loss of habitat(e.g., streams and wetlands) and degradation or alteration of these habitats.

The development of agricultural areas or natural areas for aggregate extraction operations will also result in direct loss of habitat for flora and fauna in the active area of operations. Aggregate operations typically result in changes to the water conditions that are very different from (and frequently the opposite of) agricultural or urban development.

Quarry extraction activities often result in the collection and/or retention of water, both surface water runoff as well as groundwater, depending on the local conditions. Although collection of surface water may result in reduced surface flow initially, it may also result in increased infiltration or 'exfiltration' to groundwater and associated increased baseflow, unless dewatering activities occur. Dewatering activities that transfer collected groundwater to surface water discharge may result in lower groundwater levels and higher and/or fluctuating stream flows (yet continued lower peak flows) depending upon how the dewatering flows are discharged. Release of water to surface water streams or wetlands can also result in erosion depending on the rate of release and sensitivity of the receiving feature. These changes typically vary depending on the location around the extraction zone (e.g., up or down gradient of it).

Further, the effects of active extraction are 'temporary', typically varying throughout the extraction cycle and ultimately changing significantly following the completion of extraction and rehabilitation. The rehabilitation of lands used for aggregate operations can have a variety of effects on the water conditions and ecology of an area, depending on the nature of the final rehabilitation.

If the end rehabilitation is a water body, which is typically the case where groundwater is present, any surface water runoff draining to or within the extraction area is captured and stored to be released slowly over time through infiltration, evaporation or release via an outlet system or structure. The peak storm runoff discharge to receiving creeks (downgradient of the extraction area) is therefore typically decreased as stormwater continues to be stored or buffered in the water body. However, once the extraction area fills with water, infiltration/exfiltration from the water body generally increases, resulting in increased infiltration, higher groundwater levels, and elevated baseflow discharge conditions. Open water areas generally result in an increase in evaporation rates; however, this may be more than offset from a groundwater level/baseflow perspective by the retention and infiltration of runoff. The increased baseflow may result in enhanced habitat conditions in downstream receiving creeks and streams. Overall habitat for flora and fauna may be restored or created depending on the rehabilitation plans.

As previously discussed, the focus of this impact assessment is the development and subsequent rehabilitation of Aggregate Resource Area 9-A for aggregate extraction. The potential effects of aggregate extraction and associated rehabilitation activities are described in further detail below. The following pertains to extraction of bedrock from below the current water table as this is the most relevant situation to Resource Area 9-A. This discussion, like the rest of the impact assessment, assumes that there are no mitigation measures employed during the active extraction process to address any negative effect of the potential development of the Resource Area. This situation is hypothetical only and would not be permitted to occur without mitigation if extraction occurs.

Changes in Hydrology

Aggregate extraction and associated rehabilitation changes can result in alterations to surface water flow processes and patterns. The resulting influences on the affected area can include:

- Decreased runoff to downstream receiving streams as a result of interception of overland flow and/or drainage channels by excavation for aggregate extraction activities;
- Increased infiltration of intercepted surface runoff water;
- Decreased flooding and flood flows resulting from interception of storm runoff and snow melt;

- Decreased evapotranspiration when existing soil and vegetation are removed for extraction operations and the floor is maintained in a dry condition;
- Increased evaporation rates if open water areas are created;
- Changes in flow patterns (including increased or decreased streamflow), such as enhanced baseflow if extraction is accompanied by pumping to the creek for dewatering;
- Decreased flows in areas where groundwater/baseflow levels drop; and
- Changes in water quality such as increased TDS or pH depending upon the material present in the extraction area and changes in temperature of baseflow discharged depending upon configuration of dewatering systems.

Changes in Hydrogeology

Aggregate extraction and associated rehabilitation changes can result in alterations to groundwater levels and flows as well as associated hydrologic functions such as baseflow. The resulting influences on the affected area can include:

- Decreased or increased groundwater levels. Groundwater levels may be decreased by dewatering operations if water is discharged "off-site". Groundwater levels may be increased if there is no significant dewatering and infiltration increases; and
- If a surface water body ('lake') is created by extraction below the groundwater level, the groundwater levels may decrease on the upgradient side of the lake and the groundwater levels may increase on the downgradient side of the lake.

The associated increases or decreases in groundwater can in turn result in:

- Decreased or increased availability of groundwater supplies associated with decreased or increased groundwater levels, respectively;
- Decreased or increased baseflow associated with decreased or increased groundwater levels, respectively;
- Decreased or increased pond and wetland water levels/areas associated with decreased or increased groundwater levels, respectively; and
- Changes in water quality such as increased TDS or pH depending upon the material present in the extraction area and management of discharge water.

<u>Changes in Fluvial Geomorphology</u>

Changes in flow patterns and sediment regimes influence the form and natural development of a stream. The volume and timing of the flow pattern and the manner in which the flow conveys both water and sediment, determines the form of the channel in combination with the physical (e.g., soil, slope) conditions. The flow pattern is constituted of its typical peak flow and flow duration as well as the infrequent storm flow and flooding events. These characteristics govern sediment transport principles that affect erosion and deposition patterns in the stream and how it will develop over time.

If the flow to a channel is interrupted such that the flow is reduced, then aggradation or deposition of sediment with the channel typically occurs, resulting in highly incised channels or excessive deposition. Conversely, if the changes to the flow pattern result in more flow or flow reaching the receiving channel faster, then excessive erosion may occur. These changes could result from straightening or removal of surface tributaries, dewatering activities that release more flow to the receiving channel reach than it typically receives, or construction of on-line ponds that remove the sediment naturally conveyed by the stream flow. The scale or magnitude of these impacts is directly related to the amount or extent of changes to the flow pattern.

As described previously, aggregate extraction and associated rehabilitation changes can result in alterations to geomorphologic processes by reducing peak flows and reducing sediment loading to receiving creeks. The resulting influences on the affected area can include:

- Decreased peak flows and peak flow durations to downstream receiving streams resulting in a loss of stream power to carry sediments and flush accumulated sediments in stream channels. This may result in excessive accumulation of sediments in reaches where sediments are deposited (i.e., roadside creeks). The reduced sediment load may result in cleaner water in downstream reaches that has the ability to carry more sediment resulting in erosion of reaches further downstream if flow conditions are appropriate; and
- Reduced peak flows may result in a reduction in flow during the annual spring melt and during the "channel forming" event (the flow during which the creek is filled to

the crest of the banks). The reduced flow may be conveyed entirely within the channel banks without any opportunity for the energy of the flow to disperse in the floodplain resulting in increased erosional rates within the channel cross section.

Changes in Water Quality/Benthics

Changes in the flow patterns in a watercourse can affect the water quality. Changes in water quality, as well as changes in habitat conditions related to changes in the flow regime and fluvial geomorphological conditions, in turn affect the benthic community. As outlined in the Part A report, the benthic community is a good indicator of water quality.

Possible influences include:

- Decreased flow can increase the amount of fines that accumulate on the stream bed substrates and eliminate habitat for invertebrates;
- Increased flow can decrease the amount of fine substrate on the streambed that provides habitat for larger invertebrates such as mayflies, stoneflies and caddisflies, typically classified as sensitive species;
- Sediments can accumulate in slow flows causing organic silts to deposit and creating a biological oxygen demand in the water;
- Reduced velocities have lower aeration levels, and therefore less oxygen. Potentially affecting many invertebrate species;
- Slow flows have increased opportunity for thermal loading (exposure to sunlight) and therefore increased water temperatures and decreased dissolved oxygen levels;
- Limited potential for groundwater or surface water contamination to occur given that discharge water quality of quarries in similar settings is generally good. However, some increased potential in migration of a contaminant if released due to the increased proximity of the water table to the land surface. Some increased mineralization of water collected in the quarry may occur (e.g., higher total dissolved solids), but the water quality changes are unlikely to affect ecological receptors; and
- Potential changes in groundwater temperature if groundwater temperatures are altered (e.g., raised in summer) in areas where the groundwater travel time to a surface water discharge area is short.

Changes in Terrestrial Habitats – Upland Forest, Riverine & Non-Riverine Wetlands and Associated Wildlife

A change in land use and water-related functions can affect the terrestrial features of a watershed. Potential influences include:

- Direct loss of terrestrial habitat from clearing and soil removal, which may result in reduced biodiversity;
- Increased fragmentation and isolation of habitats through the loss of connecting corridors;
- Reduction in species that are sensitive to human intrusion as habitats are modified or reduced in size;
- Loss or alteration of wetland habitat if groundwater levels decrease due to groundwater drawdown and associated drying of wetland substrates;
- Alteration of wetland habitat if groundwater levels rise and result in increased soil moisture content, increased or permanent root saturation or drowning;
- Alteration of riparian communities due to changes in groundwater or surface water levels or flows, including changes in the overbank flooding regime;
- Some species rely on regular flooding for moisture and nutrient input and to facilitate seed dispersal;
- Alteration of riparian buffer functions for their associated streams and wetlands (e.g., shading, nutrient, detritus, woody debris and food inputs, water quality filtration, bank stability) due to direct encroachment and reduction of buffer width, or to indirect changes associated with loss/shifts in species associated with water regime changes; and
- Habitat creation or enhancement associated with rehabilitation buffer plantings.

Changes in Fish Habitat and Associated Fish Communities

All of the various features within a watershed are inter-related to some extent, particularly through water-related pathways. In particular though, fisheries resources can be considered as an overall or integrative receptor. That is, fish habitat and the associated fish community 'integrates' the influence of and changes in all of the various primary and secondary indicators- surface and groundwater, water quality, macrobenthics, fluvial geomorphology and terrestrial features.

Therefore, the influences of aggregate extraction outlined above on all of the various other watershed features will in turn affect fish habitat and fish communities, including:

- A change in the macrobenthic community can influence fish biomass (addition, loss, or change of food source);
- A change in channel form (fluvial geomorphology) can alter fish habitat in areas where flows decrease and the channel bed accumulates finer materials (affecting the physical habitat conditions and the macrobenthic and fish communities) or flows increase and erosion of the channel bed and/or banks results;
- A decrease in baseflow or the water table can eliminate or reduce refuge areas during dry periods or winter months;
- A decrease in baseflow or the water table can cause summer water temperatures to warm, stressing intolerant fish species;
- A decrease in groundwater upwelling can reduce or eliminate spawning habitat and success for certain fish species, particularly brook trout;
- An increase in baseflow or water table can change fish habitat by providing more refuge areas during dry periods or winter months;
- An increase in water table or baseflow can cause river temperatures to cool providing more habitat for intolerant species;
- Decreased surface flow can result in lower oxygen levels, as there is less aeration, and can combine with organic silt deposition on the channel bed that uses more oxygen. This can stress fish species that require high oxygen levels;
- Decreased or increased surface flow can change (increase or decrease) the concentration of any chemical constituents;
- Decreased surface flow in permanent systems can create intermittent or discontinuous flow conditions, or can reduce the duration of flow in intermittent systems, affecting productivity of the fish and aquatic communities;
- Changes in flow permanence can isolate fish communities, increasing their susceptibility to other stressors;

- Increased flow where pumping occurs can provide fish habitat in areas that were intermittently dry;
- Alteration of riparian areas or wetlands associated with streams can affect buffering functions or inter-related flow and habitat functions; and
- Creation of new habitat through associated surface water features or rehabilitation/enhancement of existing features.

3 SENSITIVITY ANALYSIS AND IMPACT ASSESSMENT APPROACH

This section describes the approach and associated framework used to undertake the analysis of sensitivity/significance of features in the Study Area and to assess the potential impacts of development of Resource Area 9-A. As described in Section 1, both direct and indirect impacts are considered. While direct impacts are relatively simple to identify and are presented in Section 4, indirect impacts require considerably more analysis and their analysis represents the majority of the Part B efforts and report. The remainder of this section as well as Sections 5 and 6 of the report deal with the indirect impacts.

The overall assessment approach for indirect impacts is based on the inter-relationships among the physical water-related functions and the biotic features that depend on them. The underlying basis for this approach is that development within Resource Area 9-A can influence the hydrologic and hydrogeologic regimes within the Study Area, subsequently resulting in changes to the water-dependent features within the Study Area.

Changes in land use will trigger a sequence of responses within the hydrologic and hydrogeologic systems. Since the biotic composition, structure, and function of terrestrial (including riparian and wetland ecosystems) and aquatic ecosystems depend largely on the hydrologic and hydrogeologic regimes, modifications of the water regimes as a result of development can alter the composition, structure or function of these systems. The modified water regimes effect changes in physical habitat characteristics through changes in water levels, flow regimes, and water quality. The changes in the habitat conditions in turn affect the species that use these habitats, and their diversity and community structure.

Thus, changes in the hydrologic and hydrogeologic regimes are evaluated using indicator parameters that are relevant to water resources and biological functions for evaluating the degree to which aggregate extraction and rehabilitation land uses (i.e., development scenarios) differ from existing conditions.

To examine the potential impacts of the aggregate development on Study Area features, alternative land use scenarios were developed including three main scenarios and two supplementary scenarios, as discussed in Section 3.2. The effects of these land use scenarios on the surface water/hydrologic and groundwater/hydrogeologic conditions in the Study Area were then evaluated using the surface water (hydrology) and groundwater (hydrogeology) computer models, as described in Section 5. The output responses from these models were used to generate the *primary indicator* responses that were in turn used to assess the impacts on the *secondary indicators* and *receptors* as described in Section 6.

Specific water-related parameters (e.g., groundwater level, baseflow or groundwater discharge, 2-year flow, overbank flow), or primary indicator parameters, that are relevant to the receptor features, were developed as outputs from the computer modelling. The modelled outputs or changes in the primary water-related indicator parameters were then used to assess effects on the water-dependent receptor features.

Potential indirect pathways of effects on some of the receptor features are reflected using secondary indicators, which are affected by changes in the primary indicators, but also effect changes to the receptors. In particular, fish habitat and fish community receptors, and to some extent riverine and non-riverine wetlands, and can be affected by changes in the secondary indicators. The selected secondary indicators are water quality, the macrobenthic community, and fluvial geomorphology.

Since the Study Area and its features vary in character, and the proximity of the development to the features will influence the degree of anticipated effect, the Study Area was subdivided into a series of local assessment catchments (Figure 3-1) and the results of the analysis presented on the basis of these local catchments.

To summarize, the main components of the impact assessment approach are:

- Development of the land use (development) scenarios;
- Subdivision of the Study Area into smaller local assessment catchments;

- Modelling of the changes associated with the various land use scenarios to the hydrologic and hydrogeologic systems; and
- Identification of relevant end receptors that can be affected by changes in the primary indicators, and in some cases by changes in the secondary indicators.

Selection of relevant primary indicator parameters to measure changes in the hydrologic and hydrogeologic systems, such as changes in groundwater levels, baseflow, overbank flooding, and surface water flow (e.g., peak flow, etc.):

- Identification of relevant secondary indicators that can be affected by changes in the primary indicators but can in turn affect the receptor features (i.e., water quality, macrobenthics, and fluvial geomorphological processes);
- Evaluation of the sensitivity of the receptors to environmental changes, both generally and specifically to water-related changes; and
- The amalgamation of the impacts of the land use changes on the various receptors within the local subcatchment.

The stress-response assessment framework and land use (Resource Area 9-A development) scenarios used in the analysis are described further in Sections 3.1 and 3.2, below.

3.1 STRESS-RESPONSE ASSESSMENT FRAMEWORK

A comprehensive model for forecasting the effects of development on the natural environment does not exist. Thus, some imprecision is expected when predicting subwatershed response to change (CVC, May 2003). In this Study, a combination of computer models, empirical literature, and professional experience are used to complete the impact assessment within the CBSES Study Area.

In consultation with the CVC, a stress-response framework was adopted to conduct a comprehensive integrated impact assessment. Stress-response frameworks have been used in similar studies previously conducted by the CVC (e.g., Subwatershed Studies). The main activity of concern in the Study Area is development of Resource Area 9-A through below water table aggregate extraction and subsequent lake filling to a rehabilitated lake condition. This activity generates a series of stressors that cause a variety of responses or effects to a variety of features. As previously identified, the framework is primarily based on the water-related inter-relationships.

The response framework is a sequential set of cause-and-effect relationships that links the influence or stresses of development (land use change) to impacts on receiving water-dependent features and functions (*receptors*). The influence of development on the Study Area is represented by changes in water-related direct (primary) and indirect (secondary) indicator parameters.

As shown on Figure 3-2, these inter-relationships can be shown diagrammatically as pathways linking a change in the hydrologic and hydrogeologic *indicator*, or *primary indicator*, as a result of the land use scenario, such as a reduction in the groundwater level, to a response in a *receptor* feature, such as a groundwater dependant wetland. As noted, in some cases, the indicator change results in a response in a *secondary indicator* that in turn elicits a response in a *receptor*. For example, a decrease in surface water flow may cause an increase sediment deposition through altered fluvial geomorphological processes, in turn affecting fish habitat.

The influence or degree of effect of the change in the *indicator* parameter will vary depending on the *sensitivity* of the *receptor* to the change. Inherently, natural environmental features exhibit varying levels of sensitivity to environmental changes. An *overall sensitivity/significance* for the various Study Area features was derived based on the characterization information compiled in Part A of this Study. As discussed further in Section 6, this overall sensitivity/significance also considers the significance and representation of the various features in addition to the potential for it to be changed. The receptor features exhibit varying sensitivity specifically to water-related changes. That is, individual receptor features vary in their capacity to tolerate or withstand changes in the primary or secondary water-related indicators. The level of sensitivity of a receptor is to a change in an indicator will be reflected in the magnitude of the anticipated response or potential impact on that receptor feature.

These sensitivities are reflected in a range of levels (indicator parameter ranges) that were developed in consultation with CVC staff to summarize relative (low, moderate and high) sensitivity to water-related changes. For example, the effects of a decrease in groundwater level on riverine wetlands was ranked as low if the level decreased by less than 0.1 metres (m), moderate if it decreased by 0.1 0 to 0.5 m, or high if it decreased by more than 0.5 m.

The impact assessment classifies receptor response as low, moderate or high based on the significance/sensitivity of the environmental feature or function to a change in the indicator parameter(s). The overall impact assessment classifies impacts as low, moderate, or high on a per catchment basis based on the most sensitive receptor identified within each catchment.

The *overall impact* of a change as a result of development on a receptor ranks the anticipated level of impact of the modelled water-related change or indicator on the receptor considering its the overall sensitivity and significance, as well as its specific sensitivity to the water-related change or indicator. That is, the overall impact on the receptor is based on the combination of the indicator response and the receptor sensitivity/significance. The overall impact is also ranked on a relative scale of Low-Moderate-High.

The understanding of the Study Area features and the bio-physical and specifically water-related inter-relationships developed during the data collection and analysis undertaken throughout Parts A and B of this Study, professional experience, and input from CVC, including their experience with similar studies and their watershed, was used to and conduct the impact analysis.

<u>Methodology</u>

As outlined in the preceding sections, the impact assessment is a multi-staged analysis of the water-related impacts on end receptors by catchment for each of the primary development scenarios (Scenarios B and C). The assessment is premised on the basis of the overall sensitivity/significance of the receptor to water-related changes.

The primary steps taken to undertake the impact assessment are identified below.

Step 1. Model *primary indicators* - defined as the primary water-resource parameters that are directly influenced by unmitigated development of the Resource Area, i.e., below water table aggregate extraction and passive rehabilitation.

The selected primary indicators are:

Hydrogeological Primary Indicators:

1. change in groundwater level; and
2. change in groundwater discharge/baseflow.

Hydrological Primary Indicators:

1. change in 2-yr. peak flow regime; and
2. change in overbank flooding regime, including seasonal flow duration/hydroperiod.

Potential changes in flow duration will be evaluated for each receptor as described in Step 7 below. The changes in flow duration and hydroperiod will be primarily qualitative estimates based on the quantitative primary indicator results and characterization knowledge. Changes in average annual (base) flow and average annual runoff will be assessed in terms of overall changes in the water budget.

Step 2. Assess key features and functions within the Study Area to identify relevant *secondary indicators* (Step 3 below) and *end receptors* (Step 4 below) within each local assessment catchment (Section 3.3).

Step 3. Where appropriate, identify key secondary indicators that will be affected by changes in the primary water-resource indicators and changes in which may in turn affect a series of receptor features (and which may also effect changes in one another- e.g., water quality and fluvial geomorphology on benthics).

The selected secondary indicators are:

1. Water quality (chemistry and temperature);

2. Macrobenthics; and
3. Fluvial geomorphology.

Step 4. Identify end receptors or 'integrative indicators' that will be affected by primary indicators and in some cases by related secondary indicators.

The selected receptors are:

(a) Water supply (groundwater/aquifer yield);

(b) Property damage/flooding (surface water);

(c) Stream channel form (fluvial geomorphology);

(d) Terrestrial upland forest habitat;

(e) Riverine wetlands;

(f) Non-riverine wetlands; and

(g) Fisheries – warm, cool, and coldwater systems, encompassing both permanently and ephemerally/intermittently flowing habitat types.

Step 5. Identify *key* primary indicators and related secondary indicators that are relevant to a particular receptor. These key indicators will capture or integrate the influence of other indicators, so that the analysis is scoped to those indicators with the greatest influence on the receptor. The key indicators will also often capture several related secondary indicators. For example, changes in groundwater discharge will affect coldwater fisheries directly, as well as indirectly along secondary indicator pathways via changes in the thermal regime, and possibly changes to macrobenthics as prey items. The receptor-specific indicators are described in Section 6.

Step 6. Use the characterization information to assess the specific sensitivity of the receptor feature to changes in the water-related primary indicator, for example, assessing the sensitivity of fisheries to changes in baseflow/discharge or non-riverine wetlands to changes in groundwater level.

As noted in the preceding section, the *overall sensitivity* of the receptor features to environmental change was also derived from analysis of the feature characterization information. This overall sensitivity considers the resilience or tolerance of the feature to environmental changes generally, as well as the significance and representation of the feature.

The overall sensitivity is ranked qualitatively using a series of criteria as outlined for each receptor in Section 6. The specific sensitivity to changes in the water-related primary indicator is a component of overall sensitivity, but the relative Low-Moderate-High scale is derived using the modelled numerical values of the water-related indicator parameters for each relevant indicator-receptor pair.

To facilitate this analysis, the 'most sensitive' feature(s) for each individual receptor was identified and mapped within each sub-catchment, so that the specific modelling outputs for the relevant primary indicators specifically targeted these features. This approach is based on a worst-case analysis approach to ensure that the impacts on the most sensitive features were used to determine the overall impact for the individual receptor.

Step 7. Conduct receptor-specific analysis of the impacts, and associated relative scale/level of impact, of modelled change in primary indicator (and related secondary indicators) on receptor, based on its sensitivity, for each local assessment catchment.

This analysis is based on professional judgment, understanding of the Study Area and other similar studies, and in consultation with CVC. The overall impact is assessed qualitatively and ranked on a relative scale of magnitude (low-moderate-high) of impact derived for each specific receptor.

Step 8. Integrate the cumulative impacts of an individual indicator on all the receptor features (e.g., various types and sensitivities of wetlands, various types and sensitivities of fish communities, etc.) within each local catchment. As for the individual receptor, a worst-case approach was used such that the overall impact ranking for the local catchment reflects the worst-case impact on the most sensitive receptor. That is, the overall impact to a local catchment is based on the worst case impact to any receptor in the local catchment.

3.2 LAND USE SCENARIOS

Five scenarios have been developed to assess the potential influences of development to the environmental features, functions and linkages identified within the CBSES Study Area. The overall impact of the land use scenario on the Study Area was predicted based on the evaluated response of the system components (receptors) to the modelled changes in the hydrologic and hydrogeologic regimes (represented by direct and indirect indicator parameters) and related changes to the water budget for the Study Area.

The three (3) principal land use scenarios developed for this analysis are:

- Scenario A: Baseline Condition – Existing Conditions;
- Scenario B: Interim Condition – Full Active Extraction without Mitigation; and
- Scenario C: Long-Term Condition – Passive Rehabilitation.

The assessment also includes two additional evaluation components:

- Scenario D: Interim Condition – Partial Extraction without Mitigation; and
- Scenario E: Lake Filling Condition – Timing for Rehabilitation.

A detailed description of each of the five scenarios is provided in the Work Plan (Appendix E of the Work Plan), and summarized below in the following sections. The associated modelling evaluations were conducted by JDCL and the modelling consultants involved with other modelling studies for CVC, in cooperation with the Agencies as described in Section 5.

Scenario A: Baseline Condition – Existing Conditions

Scenario A represents existing conditions in the Study Area as established in the Part A Characterization Study, and provides the baseline for comparison to the remaining development scenarios. This condition is represented (simulated) using the calibrated steady-state groundwater and surface water models as refined from the CVC model for the CBSES.

Scenario B: Interim Condition – Full Active Extraction without Mitigation

Under Scenario B Resource Area 9-A is represented as fully extracted below the water table *without mitigation* in order to represent a hypothetical worst case scenario, consistent with the objectives of the CBSES and similar regional scale planning studies. The worst-case analysis provides a conservatively large depiction of the potential extent and magnitude of impacts associated with the development of Resource Area 9-A. The active extraction and dewatering of the entire Resource Area is simulated using the calibrated surface water and groundwater models developed under Scenario A, modified to represent quarrying of the entire Resource Area 9-A.

The groundwater evaluation is simulated using the steady-state groundwater model. To identify the worst case conditions for the impact analysis the surface water model evaluation includes two situations under Scenario B: Scenario B1 with quarry dewatering flows being routed to the creeks; and Scenario B2 with quarry dewatering flows not being routed to creeks (i.e., accumulating in the quarry or otherwise being removed to an off-site location). Some secondary indicators/receptors are most sensitive to low water conditions (e.g., fisheries) while others are most sensitive to high water conditions (e.g., property damage/flooding). The Part B impact assessment will consider the worst case conditions of these two variations for the evaluation of the full extraction conditions.

The groundwater model will conservatively assume dewatering flows are not available to creeks. The actual creek discharge patterns may vary so it is conservative (worst case) to not rely on dewatering flows to mitigate dewatering effects. Dewatering flows will, however, be incorporated into water budget calculations.

Under the development scenarios, the boundary of Resource Area 9-A was adjusted to reflect the current mapping of Second Creek alignment with 30-m offsets from roads (based on ARA License requirements of MNR) as well as from the Main and West Branches of Second Creek. Under Scenario B, all of the Resource Area is represented as extracted, excluding the affected Rogers Creek tributaries and Shaws Creek Road. Within the extraction footprint, the Second Creek tributaries remain in place on a 65-m wide pillar, which assumes a 5-m channel width plus twice the 30-m setback (i.e., 30 m on either side). Shaws Creek Road remains as an 80-m wide pillar between the adjacent extraction areas (80 m is sum of the standard 20-m road allowance plus the standard 30-m setback requirement on either side of road). This representation results in three separate extraction cells (or areas) as shown on Figure 3-3.

This scenario facilitates evaluation of the potential maximum nature and extent of the influence of extraction activities within the Study Area (without mitigation), and to identify those receptors that would be most impacted by the land use activity being evaluated.

Scenario C: Long-Term Condition – Passive Rehabilitation

Rehabilitation of the Resource Area will (in all likelihood) include the extraction cells being filled with water to create lakes in order to provide the maximum reasonable degree of passivity for the long-term condition. Therefore, under Scenario C, the Resource Area extraction footprint is represented as rehabilitated to a long-term passive lake condition in passive hydraulic equilibrium with the groundwater flow regime (i.e., no pumping).

Constructing quarry cells/lakes into a configuration that allows the lake levels to mimic the upgradient and downgradient groundwater levels under natural conditions can enhance the passivity of the rehabilitated state. Due to the practical benefits of leaving rock pillars in place to create lakes (rather than constructing large dykes/dams within a quarry cell), there is benefit in identifying a reasonable conceptual final lake configuration for the Resource Area as part of this Study (i.e., in advance of extraction). It is recognized that the precise configuration of mining can not be pre-determined and therefore full optimization of rehabilitation conditions, including lake configuration, is not feasible or appropriate.

Under Scenario C, numerous scenario simulations were run to determine an optimal or near optimal lake configuration. The "best case" scenario from these simulations (Scenario C15) was chosen to undertake the Part B impact assessment, including representation with the surface water model. Figure 3-4 presents the preferred lake configuration and hydraulic controls subsequently used in the impact analysis. The modelling results test the sensitivity of the Study Area under long-term passive rehabilitation conditions and identifies those receptors that will be most impacted by the proposed land use activity under evaluation.

The interim development scenario (Scenario B) represents a hypothetical worst-case scenario with dewatering of the entire extraction footprint to the base of the Amabel with no water-related mitigation measures in place. Under the rehabilitation scenario (Scenario C), the extracted Resource Area is flooded to a lake condition (each extraction cell becomes a lake). Although it is improbable that the interim and rehabilitation scenarios will ever be realized in the precise manner represented herein, they are proposed for the purpose of modelling and assessing ecosystem response.

Scenario D: Interim Conditions Partial Extraction

An interim extraction system scenario was run using the groundwater model to demonstrate to the agencies, and any future proponents, the immediacy of potential dewatering effects from quarry extraction in Resource Area 9-A – i.e., to assess the potential impact of even a small/limited amount of bedrock extraction with dewatering. Scenario D was simulated as steady-state dewatering of the upper weathered bedrock plus one-third of the underlying massive bedrock. The results of this scenario are presented as groundwater drawdown contours derived from the groundwater model since the primary influence beyond the quarry extraction area is via groundwater. Hence the groundwater levels are used to provide an overall surrogate for impacts. Corresponding surface water model simulations and full impact assessments are not necessary for the purposes of this analysis.

This scenario, along with physical testing results completed in support of the Rockfort Quarry Application (CRA, 2000), demonstrates that even limited extraction is likely to create a significant dewatering influence and hence a potentially significant impact on surrounding water resources.

Scenario E: Lake Filling Conditions – Timing For Rehabilitation

Under Scenario E, the potential water filling time for the rehabilitated quarry cells in Resource Area 9-A to passive lake conditions will be forecast. The objective of this analysis is to provide an overall demonstration of the potential filling time (expected to be long - decades or more), such that plans for appropriate mitigation measures can be established. Significant efforts to try and achieve precision in this prediction are not warranted due to the potential variability in mining methods (e.g., dry quarry or below water extraction), sequencing of extraction and filling, and timing that could result in decades or centuries of bedrock extraction and/or lake filling occurring in this area.

The objectives for analysis of the filling time are addressed by a water budget calculation for the filling time using the results of the above modelling scenarios as described in Section 5.

3.3 LOCAL CATCHMENT ASSESSMENTS

The CBSES Study Area is defined by CVC's Subcatchments 1203 (Rogers Creek) and 1202 (Second Creek) of the Credit River Valley Escarpment Tributaries Subwatershed 12, as well as a Supplemental Assessment Area (SA) to the east (portions of Third and Fourth Creeks) to account for functional linkages via groundwater flow. For the Part B analysis, these two subcatchments were further refined into 10 smaller tributary catchment areas in order to conduct a more detailed analysis of the potential effects of hypothetical development within Resource Area 9-A on a more local subcatchment basis (refer to Figure 3-1).

Land cover types represented within each catchment are based on the CVC's Ecological Land Classification (ELC) provided to the CBSES Team in 2006, and subsequently updated as part of the CBSES under the Part A Characterization report. Figure 3-5 shows the distribution of land cover types under baseline (existing) conditions, and includes intensive agriculture, non-intensive agriculture, rural residential areas, forest, open space, wetlands and open water. The following definitions are provided to define each of the modelled land cover types used in this analysis.

Intensive Agriculture – row cropping and seasonally tilled land, and may include farm residences and buildings;

Non-Intensive Agriculture – pasture land used primarily for grazing or historically used for intensive agriculture but now lying fallow, and may include farm residences and buildings;

Rural Residential Areas – transportation networks and settled areas, which may include hamlets and areas of rural development where the primary use is a dwelling and associated yard area;

Forest Areas – coniferous/deciduous/mixed forest communities, and culturally influenced forest communities (e.g., coniferous plantation and cultural woodland), and may include residences associated with these areas;

Open Space – manicured open space, cultural meadow, cultural savanna, cultural thicket, major trails, and inactive aggregate; and

Wetlands/Open Water – swamp (coniferous, deciduous, thicket, and mixed), marsh, meadow marsh (a.k.a. wet meadow), and all open water areas not considered being part of the flowing stream network (e.g., off-line ponds).

Although the region has a history of mineral resource development (e.g., aggregate extraction and quarrying), there are presently no such active areas within the CBSES Study Area. Active mineral resource development does occur in areas located adjacent the Study Area within Subcatchment 1201 – Third Creek Subcatchment.

Table 3-1 summarizes the distribution of land cover types within each catchment under baseline (existing) conditions and subsequent development scenarios. All land cover types outside Resource Area 9-A were considered static through subsequent development scenarios. Settled areas were assumed to be less pervious than agricultural areas. Agricultural areas were assumed to be less pervious than natural areas. Soils in intensive agriculture areas were assumed to be less porous than soils present in non-intensive agriculture areas.

The Resource Area extraction footprint under Part B analysis represents approximately 248 ha or 7 percent of the Study Area. Under interim conditions (Scenario B), all areas inside the Resource Area extraction footprint are represented as Active Aggregate. For the rehabilitated (or long-term) condition, any of the above land use classes can be used to define the Resource Area, depending on the particular rehabilitation plan. For the purposes of this Study, it is assumed that Resource Area 9-A will be rehabilitated to a long-term passive lake condition, and is therefore represented as an open water reservoir.

The boundaries of some of the local surface water catchments shift with the development of the Resource Area due to the shift in surface water divides. These changes have a minor effect on the total area (and hence the land cover makeup) of the local assessment catchments, namely within R2, R3, R4, S1, and S2, as shown on Figure 3-6.

4 DIRECT IMPACTS OF DEVELOPMENT OF RESOURCE AREA 9-A

As described in Section 1, the Part B Sensitivity Analysis includes the assessment of both direct and indirect impacts from potential development within the Study Area. As described in the Part A Report (Section 4.8.2) and presented in Section 2.1 (above), the only identified larger scale development activity of significance in the Study Area is the potential development of Aggregate Resource Area 9-A for aggregate extraction.

The following section describes the direct impacts from the actual removal, fragmentation, or alteration of environmental features and habitats (both the terrestrial and aquatic systems) within the hypothetical development footprint of Resource Area 9-A. This hypothetical extraction footprint of the Resource Area (Cells 1, 2, and 3) represents approximately 248 ha or seven (7) percent of the Study Area.

<u>Terrestrial Features/Habitats</u>

The natural features within Resource Area 9-A that will be directly impacted by the potential development of the Resource Area are shown on Figure 4-1. The land cover types represented within the Resource Area extraction footprint are summarized in Table 4-1. The predominant land use within the Resource Area is agricultural, representing 48 percent of the total Resource Area.

Wetlands cover approximately 8 percent (19 ha) of the extraction footprint. Three small wetland patches covering 6.7 ha within Cell 1 were recently added to the Caledon Mountain Wetland Complex, a provincially significant wetland (PSW) complex; these would be removed if the entire Resource Area were extracted. The PSW patches to be removed cover approximately 3 percent of the Resource Area and comprise mainly thicket swamp and marsh communities. Other wetlands include 2.4 ha of other wetland in Cell 1 (thicket swamp and meadow marsh) and 5.5 ha of other wetland in Cells 2 and 3 (deciduous swamp – poplar).

Approximately 20 ha of the Resource Area are covered by natural forested areas (i.e., coniferous, deciduous, and mixed forest cover types). Cultural woodlands cover approximately 2 ha, and coniferous plantations another 21 ha.

As shown on Figure 4-1, approximately 32 ha (or 13 percent) of the Resource Area is identified as Core Woodland under the Peel Official Plan Greenlands System (30 ha or greater, minimum dimension of 100m), running in a northwest to southeast direction down the middle of Cell 1. In addition to natural (upland) forest types, this Core Woodland area includes treed swamp areas of the Northeast Wetland and Caledon Mountain Wetland Complex, and approximately 16 ha of coniferous plantation and cultural woodlands.

It is understood that the Northeast Wetland is not actually part of the designated Resource Area under CHPMARA. Obviously this feature would be significantly affected if all of the surrounding areas were extracted and site-specific consideration of any proposal to extract around the wetland would need to consider the potential impacts and the need for appropriate mitigation.

Extraction of Resource Area 9-A will remove natural areas that form part of north-south natural habitat connections/linkages in Cell 1 along the Hutchinson Swale (including wetlands, Core Woodland, etc.). Similarly, extraction in Cell 2 and Cell 3 would remove habitats connected to the West and Main Branches of Second Creek.

There are no Environmentally Sensitive Areas (ESAs) or Areas of Natural and Scientific Interest (ANSIs) within the extraction footprint of the Resource Area.

<u>Aquatic Features/Habitats</u>

Table 4-2 lists the reach lengths (and percent within the Resource Area) of the reaches that will be directly impacted/removed by the hypothetical extraction footprint within Resource Area 9-A by fish community. Figure 4-1 shows these various communities in relation to Resource Area 9-A. Figure 6-20 maps the overall sensitivity of these fish communities; the approach used to assess overall sensitivity of fish communities is outlined in detail in Section 6.7.

With respect to the aquatic system, the greatest impact on the creek features and their associated fisheries based on the hypothetical extraction of the entire area within the Resource Area boundary is in Cell 1. The Rockfort Drain and Hutchinson Swale do not provide direct fish habitat. This habitat type represents 52 percent of the removals within the Resource Area. However, a short section of cold water fish community, as well as longer sections of seasonal warm water, and seasonal cool/warm water fish communities have been identified along reaches of the East Branch of Rogers Creek, located along the eastern boundary of Cell 1, as shown on Figure 4-1.

The coldwater community is associated with a series of stocked fish ponds located in the upstream portion of Cell 1. The seasonal cool/warmwater community is located along the middle portion of the reach, up and downstream of two on-stream ponds which provide refuge habitat. These reaches are fragmented by these ponds and further isolated from permanent stream habitat by relatively long stretches of stream that convey only ephemeral flow. Therefore, local productivity is limited and survival of fish using the intermittent reaches is reliant on their successful retreat to the on-stream pond at the downstream end of the reach or the outlet pool of the upstream pond. The upper reach of the East Branch draining into the Resource Area and the lower reach draining out of the Resource Area support a localized seasonal warm water communities when flow is present in the spring.

The extraction of the Resource Area effectively removes the lower reaches of the longer tributaries, that is, the Hutchinson Swale and the East Branch, which drain into, through and then out of Cell 1. That is, the upper reaches of these tributaries drain into the hypothetical extraction area and the lower reaches drain out of it. The lower reach of Rockfort Drain also drains out of Cell 1. Since the upper and lower reaches beyond the Resource Area do not support direct fish use, their removal is primarily an issue in relation to removal of the localized downstream flow they convey seasonally to the main branch of Rogers Creek via the main East Branch, which also flows only seasonally.

The removal of aquatic habitat features in the two easterly cells is comprised primarily of small tributaries where the fish communities have not been defined.

5 SURFACE & GROUNDWATER IMPACT ASSESSMENT MODELS

This section discusses the development and results of the hydrologic (surface water) and hydrogeologic (groundwater) impact assessment models and the water-related primary indicator parameters used to quantify the influence of development within Resource Area 9-A on the CBSES Study Area. The computer modelling process, whether surface water or groundwater modelling, involves a process of constructing a computerized mathematical model of the key water flow processes and calibrating the model to existing (observed) conditions. The calibration process involves the adjustment of model construction assumptions and parameter values within reasonable ranges to result in a model that predicts the observed water flow characteristics (e.g., stream flow or groundwater elevations).

The hydrology and hydrogeology assessment models for this Study were developed through refinement of the existing CVC models for the Credit River Watershed to the scale of the Study Area. The refined CBSES models were developed consistent with the CBSES Modelling Work Plan and Part A Characterization. The modelling consultants presently involved with CVC in the ongoing development of the CVC hydrologic and hydrogeologic models were retained to perform the modelling for the CBSES on a cooperative basis with the support of the CVC, other agencies, and JDCL project teams. The hydrologic modelling consultant is EbnFlo and the hydrologic model is based on the computer program HSP-F. The hydrogeologic modelling consultant is AquaResource (previously the hydrogeologic modelling consultant was Waterloo Hydrogeologic Inc.) and the groundwater modelling program is FEFLOW. These refined models prepared for the CBSES maintain the underlying structure and the general calibration characteristics of the regional models consistent with CVC's modelling approach. This approach is appropriate for this Study and the relative comparison of development scenarios as presented herein. The approach does, however, limit the use of these models such that they are not suitable for site-specific assessments.

The following Sections 5.1 and 5.2 provide an overview of the development and calibration of the surface water and groundwater models, respectively. The calibration of the surface water and groundwater models was integrated through use of the surface water model's simulated recharge rates as the prescribed recharge in the groundwater model and calibration of both models to stream baseflow measurements.

Section 5.3 presents the modelling results for each development scenario. The water budget assessment is presented in Section 5.4. The assessment of the impacts of the hydrologic and hydrogeologic primary indicators derived from the models on the secondary indicators and receptor features is presented in Section 6. Further details on the development of the refined models are presented in Appendices M and N.

5.1 SURFACE WATER ASSESSMENT MODEL DEVELOPMENT

The hydrology model represents a refined version of the CVC model created by CVC and EbnFlo to represent the entire Credit River watershed. The relevant portion of the watershed model was extracted from the master model file and provided to the Study Team for use in the CBSES. The model was developed to run in the United States Geologic Service's Hydrologic Simulation Program – Fortran (HSP-F). HSP-F is a mathematical computer model capable of using existing meteorological and hydrologic data to yield a continuous simulation of watershed hydrology and water quality. HSPF Version 12 was used for all hydrologic simulations in this Study. Simulation of water quality variations using HSP-F was not within the scope of the CBSES.

The surface water hydrologic model represents the processes that affect precipitation that falls on the surface. HSP-F model inputs include data on climate (using measured historical data), surficial and subsurface soils, slope, land use and vegetation. Hydrologic parameters previously calibrated to represent the Credit River watershed on a macroscopic scale were used to represent conditions within the CBSES Study Area. Runoff and infiltration characteristics used to represent specific soils, slopes, and land use classes within the CBSES Study Area are therefore consistent with those used to describe other similar soils in the Credit River Watershed. Calibration of the CBSES HSP-F model to observed baseflow data within the Study Area was based on subsurface routing of water between local catchments within the Study Area to better represent observed baseflow rates. The HSP-F model is capable of calculating the distribution of precipitation into runoff, evapotranspiration, infiltration, and stream flow thereby representing all components of a surface water balance. The model does not fully account for all subsurface processes affecting groundwater flow and these processes are better represented using a hydrogeologic model such as FEFLOW as described in Section 5.2. The hydrologic model runs in a transient mode (i.e., climate data and outputs vary over time) and was developed and calibrated to best represent baseflow conditions in the Study Area.

As detailed in Part A Section 5.2.1, data from climate stations at Toronto Pearson Airport, Orangeville MOE, the Fergus Shand Dam, and the Guelph Turfgrass Institute were used to represent the meteorological characteristics of the Study Area in the CBSES hydrologic (HSP-F) model. Meteorological parameters analyzed in the model include precipitation (hourly), maximum and minimum temperature (daily), wind speed (hourly) and solar radiation (daily). Combined, climate data collected from these sources represent a continuous period from January 1, 1996 through November 22, 2006. The refinements to the model completed for Part B of the CBSES are summarized below and include the refinements identified in the Part A Report (Section 7.1) and the Modelling Work Plan (Appendix F of the Work Plan).

- The spatial features in the Study Area were refined, particularly the surface water network (creeks, ponds, and wetlands), and corresponding land use information was updated);
- The current topographic information provided by CVC (5-m resolution DEM) was utilized to delineate drainage areas and characterize slopes in the Study Area;
- The Study Area was subdivided into 34 catchment areas, as shown on Figure 5-1. Input data was defined with respect to these catchment areas and the local catchment outflows were calibrated to observed flow data;
- Hummocky areas such as occur on the Paris Moraine were identified to represent a significant portion of the headwater areas and represented in the model with a special land use that considers the limited runoff discharged from that area;
- Extensive streamflow/baseflow monitoring was undertaken with approximately monthly monitoring undertaken at 34 stations in and around the Study Area as described in the Part A Report. The watershed model was originally calibrated by the CVC and EbnFlo to continuous flow gauging stations on the Credit River. The

refined CBSES Study Area model was further calibrated to the streamflow/baseflow monitoring data collected as part of this Study.

Further information on the model refinements is presented in Appendix M, including a detailed discussion on development of the hydrologic model, summary input and output tables, as well as a detailed interpretation of the model results.

The calibration results for the refined model are presented herein for the stream flow monitoring period for this Study. As described previously, the model utilizes parameters that were previously calibrated by CVC to represent various soil types, land uses, and slopes within the watershed. The calibration was therefore limited to re-allocation / subsurface routing of flow between catchments to balance flows within each creek system to match those observed over the ten year monitoring period. This transfer flow within the model represents springs and/or baseflow upstream of the Credit River and/or groundwater flow to the Credit River.

The CBSES HSP-F model calibration provides a reasonable representation of the Study Area for the purpose of the CBSES. The fit of the calibrated model to the measured stream flow data is qualitatively presented on Figures 5-2 through 5-12. These figures illustrate the observed flows along with the precipitation record as well as the modelled continuous flow hydrograph in Catchment 12 from 1996 through 2006, respectively. Calibration plots for the remaining catchments have been prepared and are presented and discussed in detail in Appendix M.

From the figures it is apparent that the baseflow data is reasonably well represented by the model for the purposes of the CBSES. From the figures, it is reasonable to assume that the flows calculated for the periods in between the monitoring events during low flow and baseflow conditions may be considered reasonably representative of the actual conditions in the creek system, although there are limitations in the ability to represent the transient and spatially variable nature of the intermittent flow system in the Study Area. Based on this calibration, average monthly baseflows and average monthly streamflows were calculated for existing conditions and each development scenario. Figure 5-13 presents the monthly distribution of the average baseflow in Catchment 12 calculated using HSP-F. Figure 5-14 presents the monthly distribution of the average streamflow in Catchment 12 calculated using HSP-F. A complete set of the calculated monthly average baseflows and monthly average flows for all catchments is presented and discussed in detail in Appendix M. Figure 5-15 maps the average annual baseflow and average monthly streamflow calculated using the HSP-F model at each monitoring location under existing conditions (Scenario A).

In calculating the baseflow in the creek, HSP-F calculates a complete water balance for the system. The water balance includes infiltration and evapo-transpiration rates in addition to stream flow. A discussion on the water budget calculated using HSP-F is presented in Section 5.4 and a detailed analysis is presented in Appendix M.

Figure 5-16 presents the simulated distribution of the infiltration of precipitation to the groundwater from the hydrologic model subsequently used as the groundwater recharge distribution input into the hydrogeologic model described in Section 5.2. There was close coordination between the hydrologic and hydrogeologic models to ensure consistency.

The calibrated hydrologic model was then used in conjunction with the hydrogeologic model to conduct the sensitivity analysis simulations as presented in Section 5.3 (Scenarios B and C described above in Section 3.2) and the water budget assessment (described in Section 5.4).

5.2 GROUNDWATER ASSESSMENT MODEL DEVELOPMENT

The hydrogeologic, or groundwater flow, model represents the processes affecting the movement of water that infiltrates to the groundwater flow system and its interaction with the surface water features. The model inputs include the geology conditions, hydraulic properties of subsurface materials, infiltration distribution (as calculated by the hydrology model), representation of the surface water features, and large water takings. The model outputs include the hydraulic head (groundwater level) and groundwater flux throughout the three-dimensional model domain, and groundwater fluxes to/from surface water features (e.g., baseflow contribution), and other specified boundaries of the model. The hydrogeologic model represents average annual conditions consistent with the CVC groundwater modelling approach.

The refined hydrogeologic model was developed from the CVC regional model originally developed by Waterloo Hydrogeologic Inc. (WHI) with subsequent refinements by AquaResource. The CVC model represents the entire Credit River watershed. The CBSES subdomain model is a subset of the regional model that includes the CBSES Study Area and a considerable area beyond to minimize the influence of the model boundary conditions on the simulation results (particularly Scenario B that has a large zone of influence). The CBSES subdomain model boundary is presented on Figure 5-17. The model is based on the simulation program called Finite Element Flow (FEFLOW) developed by a WASY Ltd. of Germany and supported in North America by AquaResource.

The CVC model was based on a relatively coarse regional scale and required spatial refinement and further calibration to CBSES Study Area conditions for use in the Part B analysis. The refinements of the model completed for Part B of the CBSES are described below and include the required refinements identified in the Part A Report (Section 7.1) and the Modelling Work Plan (Appendix F of the Work Plan).

Some of the key model refinements that were completed include:

- Spatial refinement of features in the Study Area, particularly the surface water network (creeks and ponds);
- Incorporation of up-to-date topographic information provided by CVC (5-m resolution DEM) in the Study Area;
- Refinement of the finite element mesh to provide a higher spatial resolution in the Study Area and to better represent the surface water features, Resource Area 9-A boundaries, and local assessment catchment boundaries;
- Refinement of the net recharge distribution (i.e., water infiltrating to the groundwater flow system) across the Study Area using the simulated output from the calibrated CBSES hydrology model;

- Refinement of the representation of the surface water features (e.g., wetlands) to prevent excessive contributions of surface water to groundwater;
- Incorporation of additional geologic borehole information, including data available from studies conducted for the Rockfort Quarry application;
- Incorporation of up-to-date MOE water well record data for geology (hydrostratigraphic surfaces) and static water level information (calibration targets);
- Calibration to a network of refined calibration targets specific to the CBSES Study Area (based on observed groundwater levels measured in select residential wells and monitoring wells within the Study Area during representative high and low water level conditions in 2006); and
- Calibration to stream baseflow conditions based on calibration targets developed from monthly monitoring over a 3-year period from 34 stations across the Study Area and beyond, in addition to available longer term flow data.

The calibrated model is based on steady-state conditions. The hydraulic head data interpreted from the MOE water well records is considered to be generally representative of average annual groundwater levels. The CBSES 2006 well survey provides information on seasonal fluctuations in the water table and the results are quite consistent with the data available from the MOE well records (refer to Section 6.2 of the Part A report).

The simulated groundwater model results provide a reasonable representation of the observed groundwater elevation and baseflow data as illustrated on Figures 5-18 and 5-19, respectively. Further information on the model refinements and calibration is presented in Appendix N. The output of the calibrated model is summarized on Figures 5-20, 5-21, and 5-22, which depict the simulated baseline water table configuration for Scenario A, the groundwater elevations in the lower Amabel, and the vertical hydraulic gradients between the bedrock and overburden, respectively. These results illustrate the overall northwest to southeast flow direction from the Paris Moraine in the Upper Region to the Credit River Valley in the Lower Region. Consistent with the findings from the surface water model, the groundwater model represents a significant transfer of water out of the Study Area to the east, as well as transfers in/out of other areas. The flows represented by the groundwater flow model for the principal water budget components are presented in Section 5.4. The simulated gaining and losing stream reaches under the simulated average annual conditions generally reflect the pattern of observed baseflow conditions. In general, the simulated groundwater discharge flows for the local catchments are within the range of observed baseflow conditions, as shown on Figure 5-19. The calibrated hydrogeologic model was then used in conjunction with the hydrologic model to conduct the sensitivity analysis impact assessment simulations as presented in Section 5.3 (Scenarios B, C, D, and E described above in Section 3.2) and water budget assessment (described in Section 5.4).

5.3 SCENARIO ANALYSIS

The development scenarios were evaluated by simulating the hypothetical development scenarios (Section 3.2) with the hydrologic and hydrogeologic models and comparing the results to those for Scenario A (existing baseline conditions). The sections below present an overview of the implementation and results of the development scenarios for the hydrologic and hydrogeologic impact models.

Table 5-1 summarizes the average annual streamflow calculated from each catchment under the conditions described in the following sections for each scenario using the surface water model. The catchments are grouped in terms of their respective Local Assessment Catchments for ease of reference. Similarly Table 5-2 summarizes the average annual stream baseflow calculated for each scenario. Table 5-3 summarizes the change in the 2-Year Peak Flow, and Table 5-4 summarizes the Change in Overbank Flooding.

Each of these tables should be referenced in support of the discussions presented in the following sections. Detailed descriptions of the surface and groundwater models and scenario analysis results are provided in Appendices M and N, respectively.

Scenario A: Baseline Condition – Existing Conditions

Scenario A is reflective of the existing conditions identified through the CBSES and is used as the baseline for comparing the results of the other sensitivity analysis scenarios.

Scenario A is represented by the calibrated surface water and groundwater model results presented in Sections 5.1 and 5.2, respectively.

Scenario B: Interim Condition – Full Active Extraction without Mitigation

Scenario B represents the hypothetical worst case scenario of the active (working) extraction of the entire Resource Area in the absence of any water-related mitigation measures. Scenario B is simulated with both the surface water and groundwater models. Further information on the background for Scenario B is provided in Section 3.2 and the CBSES Work Plan (Appendix E).

The three cells of Resource Area 9-A shown on Figure 3-3 are used to represent active bedrock extraction zones. These cells are represented as being dewatered to the base of the Amabel to maintain a "dry" working condition.

The local catchment area and hydrologic inputs were modified to reflect the extraction area, as well as the changes in the hydrologic network resulting from the quarry excavation (i.e., some minor tributary reaches are intercepted by the quarry cells and hence streamflow would drain into the extraction cells. Precipitation falling on the Resource Area was assumed to be captured in the extraction area and a reduced rate of effective evapotranspiration was applied (300 mm/year) to represent a dewatered bedrock quarry floor condition.

The dewatering of the Resource Area cells to the base of the Amabel Formation is simulated, resulting in the inflow of groundwater from the surrounding area due to the dewatering effect. The simulated change in groundwater elevations in the water table and lower Amabel under Scenario B conditions are shown on Figures 5-23 and 5-24, respectively. The simulated changes in groundwater elevations in the lower Amabel are very similar to the water table elevations but generally exhibit slightly less influence of surface water interactions and a slightly larger zone of influence. In order to provide a conservative analysis of groundwater level changes for the impact assessment, the lower Amabel water levels are used for the impact assessment (Section 6).

The amount of captured surface water and groundwater in the quarry cells is calculated using the net surface water and groundwater inflow results. In order to be able to assess the worst case scenario for all receptors (Section 6), two alternatives are considered using the surface water model:

1. Scenario B1 – all water is discharged downstream of the cells in proportion to the intercepted surface water catchment contributing drainage area of each tributary on a monthly average flow basis, representing a potential logical operating basis for dewatering. Cell 1 is represented with three outlets: the Rockfort Drain, Hutchinson Swale, and the East Branch of Rogers Creek. Dewatering flow from Cell 1 was distributed proportionately between these three outlets based on their respective contributing drainage areas. Cells 2 and 3 each drain solely to Second Creek and no distribution of flow was necessary. These dewatering flows contributed to baseflows calculated in the downstream water courses.; and

2. Scenario B2 – dewatering water is not discharged downstream (i.e., is lost to the system), representing a worst case "dry" condition such as may temporarily occur due to a cessation of discharge operations (e.g., water temporarily stored on-site).

The surface water model was used to simulate both scenarios to assess the impact to flooding of having enhanced baseflow in the creeks due to the dewatering discharge and the local assessment catchment of water due to the absence of dewatering discharge. The groundwater model simulations only consider Scenario B2 as it is most conservative for assessing groundwater related impacts to all receptors. Any availability of the discharge water to the groundwater flow system would tend to minimize the dewatering drawdown effects (i.e., reduce dewatering influence) downgradient of the quarry cells.

Figure 5-25 presents the calculated average annual streamflow and stream baseflow at each monitoring location under Scenario B2 conditions and illustrates the enhanced average annual flow and baseflow resulting from the excess dewatering water being discharged to the receiving watercourses. Figure 5-26 presents the calculated average annual streamflow and baseflow at each monitoring location under Scenario B2 conditions and illustrates the lower average annual flow and baseflow resulting from the complete removal of the streamflow from reaches upstream of the Resource Area.

The model results illustrate that under the hypothetical worst-case scenario there would be a large influence on both the surface water and groundwater flow systems.

The simulated change in groundwater elevations demonstrate a large zone of dewatering influence, particularly to the north, east, and west of the Resource Area. The dewatering influence is somewhat less to the south as a result of various factors, such as: the smaller aquifer thickness, the natural dewatering influence of surface water features in this area, and the simulated average annual groundwater conditions. Under some conditions (e.g., dry conditions) the hypothetical dewatering influence would likely extend further south than shown by these results.

The simulated changes in groundwater discharge to surface water (such as baseflow contribution) are all negative (i.e., a reduction) due to the lowered groundwater elevations in Scenario B. In some areas immediately adjacent to the Resource Area, there is a complete loss of groundwater discharge.

Rogers Creek Main Branch downstream of the Resource Area would the one of the more significantly impacted reaches in the system as a result of extraction activities in the Resource Area. This portion of the watercourse has an average stream baseflow of 63 l/s and an average annual streamflow of 100 l/s. The modelling indicates a 17 percent increase in stream baseflow and a 13 percent increase in average annual streamflow under Scenario B1 as a result of the discharge of dewatering water to the watercourses. Therefore, under Scenario B1, more water would be present in Rogers Creek Main Branch than under existing conditions and it maintains or increases its hydroperiod. Under Scenario B2, a 71 percent decrease in baseflow and a 63 percent decrease in average annual flow was calculated. Therefore, less water would be present in Rogers Creek Main Branch and its hydroperiod would be shortened.

Similar impacts to flow were calculated to occur throughout the system downstream of the resource area. In upstream reaches, the depressed water table resulted in general reductions in average annual streamflow and baseflow. Of note was that Rogers Creek South Branch showed no impacts resulting from the various development scenarios

The Scenario B simulation results that are used for the Primary Indicators in Section 6 are presented as identified below. Further information on the simulation results are presented in the modelling appendices as previously identified.

Primary Indicator #1: Change in Groundwater Level – Figure 5-24.

The change in groundwater elevation is conservatively represented by the change in the lower Amabel groundwater elevation as previously discussed.

Primary Indicator #2: Change in Baseflow/Discharge – Table 5-5

Table 5-5 presents the change in groundwater discharge to surface water features (creeks, riverine wetlands, and non-riverine wetlands) from the hydrogeologic model simulation results under Scenario B full active extraction conditions for each local assessment catchment.

Primary Indicator #3: Change in 2-Year Peak Flow – Table 5-6
Change in 2-Year Peak Flow Velocity – Table 5-7

The simulated change in 2-year peak streamflow and velocity determined from HSP-F simulation results is presented for both Scenarios B1 and B2.

Primary Indicator #4: Change in Overbank Depth – Table 5-8

The simulated change in Overbank Depth is presented for both Scenarios B1 and B2.

In addition to the Primary Indicators, the potential changes to the hydroperiod were assessed as presented in Table 5-9. Due to the practical limitations of the modelling results, the changes in hydroperiod can only be assessed in a qualitative manner. The change in hydroperiod was assessed using information from the surface water and groundwater model results (e.g., change in stream baseflow, loss of groundwater discharge, and change in groundwater elevation) as well as knowledge of the characterization.

Scenario C: Long-Term Condition – Passive Rehabilitation

Scenario C provides a reasonable representation of the rehabilitation scenario as described in Section 3.2. The rehabilitation scenario was developed through an iterative process, illustrating the need for certain development characteristics to minimize the influence on surrounding water resources.

Numerous modelling iterations were evaluated to arrive at the rehabilitation scenario selected for use in the impact assessment (Section 6). All rehabilitation scenarios were based on filling the quarry cells with water to minimize the drawdown to groundwater surrounding the Resource Area. Various combinations of subdividing the Resource Area (i.e., multiple quarry cells and lakes), varying the final lake level, and the use of hydraulic buffers such as earthen buttresses or grout curtains, were evaluated. The full range of scenarios represented through the modelling evaluation are presented in Appendix N and the selected scenario (Scenario C15) is presented herein and used for the impact assessment in Section 6.

Through the development of the rehabilitation scenario, a number of key considerations for quarry development and rehabilitation were demonstrated, including:

1. Rehabilitation should include creating lakes to restore water levels similar to natural levels, as opposed to maintaining "dry" conditions as in the active extraction scenario (Scenario B);

2. Resource Area should be subdivided into multiple cells/lakes for rehabilitation to allow variation of water levels as well as to allow progressive rehabilitation during extraction, and conservation (storage) of water;

3. Lower permeability hydraulic buffers (such as earthen buttresses or grout curtains) should be used to help vary water levels between quarry cells/lakes and the surrounding groundwater flow system;

4. In topographically low areas, it is beneficial to raise lake levels somewhat above existing ground surface by establishing hydraulic berms (as in common pond construction practices) or to avoid extraction of such areas; and

5. Transfer of water between quarry cells can help control lake levels and route excess water to appropriate discharge locations.

The rehabilitation scenario developed for the Part B impact assessment is depicted on Figure 3-4. The large part of the Resource Area, referred to as Cell 1, is subdivided into four individual cells/lakes. In this scenario the quarry cells are filled with water and hydraulic buffers around and between the quarry cells/lakes to control water levels through managing groundwater inflow and outflow to, from, and between the lakes. The modelled hydraulic buffer alignments and lake levels are also depicted on Figure 3-4.

The configuration of the rehabilitation scenario provides an illustration of a reasonable concept for subdivision and rehabilitation of the Resource Area to mitigate effects on water resources. As discussed in Section 3.2, it is not feasible or appropriate to establish the precise configuration or fully optimize the rehabilitation concept, due to the various site-specific considerations such as detailed hydrogeological characteristics, proposed development land holdings, and gradual progression of development of the Resource Area. The results of the rehabilitation scenario are, however, appropriate for the purposes of the CBSES and the Part B impact assessment (Section 6).

The combination of the rehabilitation quarry lake levels and hydraulic buffers allow the rehabilitation conditions to mimic pre-extraction groundwater level conditions. As shown on Figures 5-27 and 5-28, the simulated change in groundwater elevation of the water table and lower Amabel, respectively, are relatively small. These changes may be further reduced through optimization at the site-specific scale.

The local catchment area and hydrologic inputs were modified to reflect the extraction area, as well as the changes in the hydrologic network resulting from the quarry excavation (i.e., some minor ephemeral tributary reaches are intercepted by the quarry cells and hence any surface water flow drains into the extraction cells/lakes).

Precipitation falling on the Resource Area lakes is captured and a higher rate of effective evaporation consistent with a lake (630 mm/year) is applied. The quarry lakes have a net outflow of water that is discharged to the adjacent/downstream creek reaches by gravity outflow from the lakes.

Figure 5-29 presents the calculated average annual streamflow and stream baseflow at each monitoring location under Scenario C conditions and illustrates the average annual flow and baseflow in the receiving watercourses.

These results illustrate that under the rehabilitation scenario there would be little to no negative influence on both the surface water and groundwater flow systems.

The simulated change in groundwater elevations demonstrate the combination of individual lakes and water levels in combination with hydraulic buffers allows the pre-extraction groundwater levels to be a closely matched.

Under the modelled conditions there are a number of areas with slightly higher groundwater levels under rehabilitation conditions such as upgradient and downgradient of most of the Resource Area. A few small areas show somewhat lower groundwater levels such as the two areas extending west of Winston Churchill. Further optimization at the site-specific level may allow even further reduction in the modelled changes in groundwater levels than those considered herein.

Watercourses outside of the Resource Area extraction limits were calculated to be only mildly influenced (if at all) by the rehabilitation conditions showing less than a ten percent change in average annual streamflow and average stream baseflow rates. This change in flow rates represents a minimal impact that will not be noticeable in the stream flow rates or hydroperiod and is within the limit of error of a modelling exercise of this nature.

The Scenario C simulation results that are used for the Primary Indicators in Section 6 are presented as identified below. Further information on the simulation results are presented in the modelling appendices as previously identified.

Primary Indicator #1: Change in Groundwater Level – Figure 5-28

Figure 5-28 presents the change in groundwater elevation in the lower Amabel, resulting from the conditions presented in Scenario C when compared to existing conditions (Scenario A).

Primary Indicator #2: Change in Baseflow/Discharge – Table 5-10

Table 5-10 presents the change in groundwater discharge to surface water features (creeks, riverine wetlands, and non-riverine wetlands) from the hydrogeologic model simulation results under Scenario C rehabilitation conditions for each local assessment catchment.

Primary Indicator #3: Change in 2-Year Peak Flow – Table 5-6
Change in 2-Year Peak Flow Velocity – Table 5-7

The simulated change in 2-year peak streamflow and velocity calculated from the HSP-F simulation results is presented for Scenario C in Tables 5-6 and 5-7, respectively.

Primary Indicator #4: Change in Overbank Depth – Table 5-8

In addition to the Primary Indicators, the potential changes to the hydroperiod were assessed, as presented in Table 5-9. Overall changes to hydroperiod under rehabilitation conditions are anticipated to be minimal, with some increases in hydroperiod likely to result from the seasonal groundwater level buffering that will be provided by the large storage volume of the lakes.

<u>Scenario D: Interim Conditions Partial Extraction</u>

As described in Section 3.2, the Scenario D partial extraction scenario was run using the groundwater model to demonstrate to the agencies, and any future proponents, the immediacy of potential dewatering effects from quarry extraction in Resource Area 9-A – i.e., to assess the potential impact of even a small/limited amount of bedrock extraction with dewatering. Scenario D was simulated as steady-state dewatering of the upper weathered bedrock plus one-third of the underlying massive bedrock.

The results of this scenario are presented on Figures 5-30 and 5-31 as changes in groundwater elevations of the water table and lower Amabel, respectively. The groundwater results are indicative of the potential influence of partial extraction since the primary influence beyond the quarry extraction area is via groundwater.

The groundwater drawdown from Scenario D extends almost as far from the Resource Area as the full extraction simulated for Scenario B. The simulated drawdown along with the knowledge of the ecological dependence on groundwater levels and discharge, demonstrate that even partial depth extraction (with dewatering below the water table) in the Resource Area would result in a significant dewatering influence.

In addition to the CBSES simulation results, available hydrogeologic characterization information, including Site-specific hydrogeologic testing data from the Rockfort studies, provide valuable information on the extent and rate of influences from dewatering in the Resource Area. In particular, several pumping tests have been conducted as part of the Rockfort studies and these tests demonstrated that the zone of influence from temporary pumping of a groundwater well can extend over hundreds of metres within a matter of days (CRA, 2000, Section 6). Based on the pumping tests results, it is clear that even limited dewatering, whether to a limited depth over a broad area or to a deeper depth over a small area, will have an extensive zone of influence over time periods that are short (days, months, years) relative to the duration of quarry operations (decades).

Scenario E: Lake Filling Conditions – Timing For Rehabilitation

The potential water filling time for the rehabilitated quarry cells to passive lake conditions is forecast to demonstrate potential filling time such that plans for appropriate mitigation measures can be established. It is clearly evident that the potential effects of dewatering for a dewatered quarry operation as represented by Scenario B (or even Scenario D) do not cease with the completion of active bedrock extraction. The long-term rehabilitation conditions represented by Scenario C are not achieved until the rehabilitation lake filling is complete.

The rehabilitation lake filling time is estimated through water budget calculation for the filling time using the results of the above modelling scenarios. The water accumulation rate was linearly interpolated between the full extraction and rehabilitation scenarios (Scenarios B and C above).

The available dewatering/discharge flow at the end of active extraction (Scenario B) is calculated to be 12,925 m^3/day and reduces to 553 m^3/day under rehabilitation conditions (Scenario C). Based on a total volume of the rehabilitation lakes of 80,000,000 m^3 and an average filling rate of 6,739 m^3/day[1], it would take approximately 33 years to fill the lakes.

5.4 WATER BUDGET

Water budget calculations are used to help understand the amount and distribution of water in an area and also to help understand the potential changes that may occur as a result of various factors, including changes in land use. Water budgets are approximations due to the complexity and variability of climatic conditions as well as groundwater and surface water flow systems. Therefore water budgets are most useful when used on a comparative basis. For the CBSES, water budget calculations have been performed to look at both the relative distribution of water in the Study Area under existing conditions and to look at the differences that may result from land use development such as extraction of Resource Area 9-A.

The following presents water budget calculations from both a hydrologic (surface water) perspective and a hydrogeologic (groundwater) perspective. The infiltration results from the surface water calculations (model) is used as an input to the groundwater calculations (model) and both models are calibrated to surface water baseflow measurements so the two analyses are integrated. Further information on the surface water and groundwater budget calculations is provided in Appendices M and N.

[1] The available dewatering/discharge flow under the partial extraction conditions (Scenario D) is calculated to be 11,633 m^3/day which is only slightly below the value calculated for Scenario B.

EXISTING CONDITIONS

A water budget for the Study Area was presented in the Part A report based on an evaluation performed by the Meteorological Service of Canada on long-term data for the Study Area. This analysis calculated the following estimates of the average annual distribution of water based on records available from 1960 to 2004:

- Total Precipitation (P): 922 mm
- Evapotranspiration (ET): 517 mm
- Water Surplus (S=P-ET): 405 mm
- Infiltration (I): 222 mm
- Runoff (S-I): 183 mm

The hydrologic modelling conducted for CVC regional studies and refined for the CBSES as discussed previously (Section 5.1) provides more site-specific estimates of the water budget components based on the more recent precipitation records from 1996 to 2006. The more recent period of analysis is based on the available data record of surface water baseflow that provided the basis for calibration of the CBSES model. The average annual water budget estimates for the Study Area from the CBSES modelling study are summarized below and in Table 5-11 with further information provided in Appendix M:

- Total Precipitation (P): 827 mm
- Evapotranspiration (ET): 475 mm
- Water Surplus (S=P-ET): 352 mm
- Infiltration (I): 242 mm
- Runoff (S-I): 110 mm

The variations between the preliminary (Part A) water budget estimates and the above (Part B) estimates is due to the difference in the climate period (especially the lower annual precipitation experienced in more recent years) and differences in the method of estimation of the different water budget components.

Across the Study Area, the calculated average annual infiltration from the water budget estimate (as calculated in Part B) is approximately 8,500,000 m^3/year, which is more than the Part A water budget estimate of approximately 7,500,000 m^3/year. The calculated water budget infiltration values are somewhat less than the value of 10,300,000 m^3/year estimated from measurements of baseflow as described in the Part A report. The infiltration and baseflow estimates are reasonably comparable given the approximations inherent in water budget calculations and the variability of climate (and hence water flow) conditions.

The groundwater budget for the existing conditions (Scenario A) is presented in Table 5-12. These results represent the refined CBSES groundwater modelling analysis as compared to the comparable preliminary results included in the Part A Report. Table 5-12 reflects the refinement of the creek representation in the Part B groundwater model which generally represents ephemeral creeks as part of a grouping of riverine wetlands.

The following observations can be made regarding these groundwater budget results:

- There is a net outflow of groundwater from the Study Area;
- Upgradient areas in the Upper Region such as R1, R2, and S1 provide significant recharge to groundwater and overall catchment surpluses;
- Downgradient areas in the Middle and Lower Regions such as R4, R6, and S2 provide significant discharge of groundwater and overall catchment deficits;
- Not all recharge to the groundwater flow system discharges in the Study Area – i.e., some water flows beyond the Study Area (e.g., Third Creek) prior to discharge;
- Not all baseflow comes from areal recharge within the Study Area catchments – i.e., some groundwater flows into the Study Area, particularly from the west;
- Groundwater discharge to creeks (including riverine wetlands) is much greater than discharge to non-riverine wetlands, although the groundwater model does not represent the re-infiltration of surface water and hence may tend to overestimate the overall amount of groundwater discharge; and
- Represented wetlands have a net (overall) discharge of groundwater – i.e., on average wetlands are fed by groundwater more than they recharge groundwater.

SENSITIVITY ANALYSIS SCENARIOS

Water budget calculations were also completed for the sensitivity analysis Scenarios B and C. Surface water budget results are presented in Table 5-11 and groundwater budget results are presented in Tables 5-13 and 5-14 for Scenarios B and C, respectively.

Scenario B

Scenario B represents the full active extraction condition. The primary influences of **Scenario** B on the water budget pertain to the removal of part of the existing flow system. The extraction of the quarry cells intercepts the upstream flow, captures direct precipitation over the extraction area, reduces evapotranspiration over the extraction area, and draws in groundwater flow. The results of these effects are evident in reduced discharge to surface water features, and the generation of relatively large volumes of water in the quarry cells.

In general, the water balance indicated that development of Aggregate Resource Area 9-A will reduce the amount of direct groundwater infiltration and increase the surface runoff component in the Study Area due to the development of the quarry cells, as identified above. The overall effect on downstream systems depends on the handling of the quarry dewatering flow. Two sub-scenarios were considered for the surface water budget/analysis for **Scenario** B, representing the range in possible conditions at any time:

- **Scenario** B1 – all dewatering flow is discharged at rates similar to what may be expected from a continuous dewatering process; and

- **Scenario** B2 **–** no dewatering flow is discharged.

The overall surface water budgets developed for Scenarios B1 and B2 (Table 5-11) produced the same results since each scenario assumed that the quarry floor would be maintained in a dry condition. The surface runoff volume would therefore be the same in each scenario. The only difference being where the water was routed. **Scenario** B1 would result in enhanced stream baseflow downstream of Aggregate Resource Area 9-A as a result of continual dewatering flow from the extraction area being discharged to receiving watercourses. **Scenario** B2 would result in depressed stream baseflow conditions downstream of Aggregate Resource Area 9-A as a result of no dewatering flow being discharged downstream.

Under **Scenario** B1, there would be an overall increase in stream flow to the Credit River due to the reduction in evaporation from the Resource Area. Under **Scenario** B2, there would be an overall decrease in stream flow to the Credit River due to the loss of water collected by the quarry cells.

For each of Scenarios B1 and B2, the average infiltration component decreased by seven (7) percent relative to existing conditions as the floor of the extraction area was assumed to have a net inward flux of groundwater, effectively creating an area that would not infiltrate water. The average surface runoff increased by four (4) percent as a direct result of the development of the Aggregate Resource area with a dry quarry floor which collects all precipitation (minus evaporation) as surface runoff. The evapotranspiration component of the water balance was calculated to decrease by two (2) percent in the Study Area. This is a result of simulation of the active extraction area as a dry floor condition with no vegetation similar to typical operational characteristics.

The groundwater budget for **Scenario** B represented only the conditions equivalent to **Scenario** B2 (i.e., no discharge of water) as that is the worst case from the perspective of assessing potential impacts via the groundwater pathway.

The groundwater budget results for **Scenario** B are presented in Table 5-13. These results indicate that there is a substantial decrease in groundwater discharge to surface water features as represented by the creeks and wetlands. Approximately 4,700,000 m^3/year (12,925 m^3/day) of water is collected as a result of quarry dewatering which is equivalent to about one-half of the total groundwater infiltration (and baseflow) over the Study Area.

The water budget results demonstrate that disposition of the collected dewatering flow (e.g., discharge to surface water or recharge to groundwater) will have a major influence on the effects of quarry development. The increase in overall catchment surplus is due to the reduction of evapotranspiration and collection of upstream surface water flow in the quarry cells where it gets added to inflowing groundwater and direct precipitation.

Scenario C

Scenario C represents the rehabilitation to lake conditions. The primary influences of Scenario C on the water budget pertain to the removal of part of the existing flow system. The extraction of the quarry cells and conversion to lakes intercepts the upstream flow, captures direct precipitation over the extraction area, increases evaporation, and integrates as part of the groundwater flow system. Groundwater flows into and out of the lakes with a net outflow of water – i.e., a recharge of the downgradient groundwater flow system with water from the lakes.

Under conditions described in Scenario C the infiltration component continued to show a reduction of approximately seven (7) percent from existing conditions because precipitation on the open water body was assumed to behave as surface water runoff, effectively creating an area that would not infiltrate water. The average surface runoff increased by 26 percent resulting in runoff of precipitation to downstream receiving watercourses. Simple controls on the lakes could allow opportunities for the managed retention and release of such water. The evapo-transpiration component of the water balance was calculated to increase by three (3) percent in the Study Area. This is also a result of simulation of the active extraction area as an open water body with no transpiration potential and an annual open water evaporation rate of 630 mm/year in the area of the rehabilitated extraction area. The overall streamflow to the Credit River is approximately equal to the existing conditions scenario.

The resultant discharge to surface water features (creeks and wetlands) is very similar to existing conditions with some declines evident in comparison of Table 5-14 (Scenario C) to Table 5-12 (Scenario A) as result of the direct removal of some of these features within the Resources Area itself. The calculated surface water discharge from the quarry lakes under average annual conditions is approximately 200,000 m^3/year (553 m^3/day).

The water budget results demonstrate that rehabilitation of the quarry cells to lakes can restore the water budget conditions similar to those under existing conditions.

6 IMPACT ASSESSMENT

As previously stated, the CBSES Study Area is defined by CVC's Subcatchments 1203 (Rogers Creek) and 1202 (Second Creek) of the Credit River Valley Escarpment Tributaries Subwatershed 12, as well as a supplemental assessment area to the east (portions of Third and Fourth Creeks) to account for functional linkages via groundwater flow. For the Part B analysis, the two subcatchments were further refined into ten (10) local assessment catchment areas in order to conduct a more detailed analysis of the potential effects of hypothetical development within Resource Area 9-A on a more local subcatchment basis (Figure 3-1).

Hydrogeologic and hydrologic models were used to simulate the response of the hydrologic system to the development scenarios for Resource Area 9-A as described in the Section 5. A sensitivity and impact analysis was completed for each receptor within each local assessment catchment using the modelled results to assess what features and functions of the natural environment within the Study Area are most susceptible to the effects of potential development within the Resource Area. The general environmental impact assessment model is illustrated on Figure 6-1.

The impact assessment was undertaken for six (6) end receptors: water supply (groundwater/aquifer yield), property damage/flooding, stream channel form (fluvial geomorphologic impacts), terrestrial (upland) forest habitat, non-riverine wetlands, riverine wetlands, and fisheries (including cold, cool and warm water communities, in permanent, intermittent and ephemeral flow aquatic habitats). The anticipated impact to each receptor from development within the Resource Area under interim and rehabilitation conditions (Scenarios B and C, respectively) was evaluated based on simulated changes in key water-related indicators using pre-defined indicator parameter ranges specific to each receptor. The indicator parameter ranges specific to each receptor is provided in Table 6-1.

The potential (or anticipated) impact to receptors is ranked as high, medium or low based on the pre-defined indicator parameter ranges. The indicator parameter ranges determined for each receptor was based on the receptor specific sensitivity to the respective water related change. These ranges were determined in consultation with the CVC's technical staff based on the receptor's significance and overall capacity to be subject to change (i.e., sensitivity). Thus, the overall impact to the end receptor is derived based on consideration of the overall sensitivity of the receptor in combination with modelled change in the indicator that is ranked based on the indicator-specific sensitivity as reflected in the indicator parameter range.

The results of the analysis are presented in matrix evaluation tables that summarize the overall impact of each land use scenario within each local assessment catchment, based on the relative level of change in the primary indicators from the modelled results and the relative sensitivity/significance of the receptor. The impact assessment summary matrix evaluation tables for each local assessment catchment are presented as Appendix O. The response of each local assessment catchment to changes associated with the development scenarios were compared against existing baseline conditions. The effect of these responses is evaluated on the basis of the local subcatchment and the entire Study Area. The overall impact to the local catchment area is based on the worst-case ranking of the most sensitive feature in the local assessment catchment. The overall assessment of Study Area sensitivity is established by integrating the various discipline components.

The impact assessment and sensitivity analysis for each receptor is presented in the following Sections: Sections 6.1 through 6.7. The overall assessment of the Study Area (i.e., integration) is presented in Section 6.8 and summarized in Table 6-2.

6.1 WATER SUPPLY (GROUNDWATER/AQUIFER YIELD)

Groundwater is a valuable resource and the primary source of water supply within the Study Area (Part A Section 6.3), particularly above the Escarpment. Figure 6-1 graphically shows the key components of the impact assessment undertaken for water supply. Each component of the assessment is described below.

<u>Sensitivity</u>

Water supplies within the Study Area are primarily obtained from groundwater from individual private supply wells. The principal uses of private water supplies are for domestic and agricultural use although a variety of other uses may occur. The water yield of a well is dependent upon the nature and hydraulic properties of the aquifer in which the well is completed. The well yield is also heavily influenced by the construction of the well, including such factors as the depth of the constructed well and depth of the well surface (i.e., the screened or open seal interval of the well), the depth of the pump intake inside the well, the diameter of the well, the construction and maintenance condition of the well, and the hydraulic connection of the well to the aquifer.

Changes in groundwater levels have the potential to affect water supply wells. The primary consideration for aggregate extraction is the potential quarry dewatering influence and the effect that drawdown may have on the yield of wells. However under rehabilitation conditions some minor increases in groundwater levels may occur that would tend to increase well yields, particularly during dry periods.

The potential impact from unmitigated development of the Resource Area on water supplies is a function of many factors including: proximity to the aggregate operation; scale and depth of the extraction operation; location of quarry within the groundwater flow system (i.e., recharge or discharge area); and sensitivity of the aquifer to changes in groundwater elevations i.e., size/thickness of the aquifer (storage capacity) and hydraulic characteristics (ability to transmit water).

Figure 6-2 presents the sensitivity of water supplies across the Study Area, based upon the principal bedrock aquifers from which water supply wells draw their water. The Amabel Aquifer and Queenston Shale are the principal sources of groundwater supplies in the Study Area located above and below the Escarpment, respectively. The dolostone bedrock of the Amabel Formation is considerably more permeable than the Queenston shale, and has a much higher water bearing capacity (i.e., water yielding capability) than the Queenston Aquifer. Below the Escarpment, wells are generally completed in the upper weather portion of the Queenston shale (approximately the upper 3 to 5 m), which may have somewhat enhanced permeability to provide sufficient (but modest) water yields for domestic uses. On the other hand, wells completed within the Amabel Aquifer generally yield substantially greater water yields if they are completed to a sufficient depth. Thus wells completed in the Queenston Aquifer are typically shallower, and have less available drawdown to sustain an adequate water supply for domestic uses. As a result, water supply wells completed above the Escarpment (within the Amabel Aquifer) are not as sensitive to changes in groundwater levels (or can be readily modified - e.g., deepened) compared to wells completed below the Escarpment (e.g., the Queenston Formation). Water wells completed in the transitional area along the Escarpment have variable yields based on local conditions and are therefore also categorized as more sensitive. Wells completed in buried valley deposits along the Credit River would also have a low sensitivity to water level changes; however, these wells have been conservatively grouped into the higher sensitivity group for the purpose of this assessment.

The foregoing describes the sensitivity of water supply wells to changes in groundwater elevations and this is incorporated into the indicator parameter ranges as described below. From an overall sensitivity/significance perspective, all water supply wells are considered to have a high overall sensitivity/significance due to the importance of water supplies.

Primary Indicators

Given the anticipated extent and magnitude of impacts on groundwater levels due to unmitigated development of the Resource Area (i.e., the extent and magnitude of the groundwater drawdown zone of influence), the change in groundwater level (Indicator #1) is the primary indicator to assess potential impacts to ground water supplies.

Table 6-1 presents the indicator parameter ranges used to classify impacts to water supply as high, moderate or low, based on the simulated change in average annual groundwater levels under the development scenarios. The higher parameter ranges selected for the Amabel Aquifer reflect its generally higher yield and the range of seasonal groundwater level variations. The lower parameter ranges selected for the area beyond the Amabel Aquifer reflect the generally limited groundwater supply and hence higher sensitivity to potential changes.

Secondary Indicators

It is important to consider the water quality for water supplies in addition to the water quantity. In general it is unlikely that there will be direct effects on groundwater quality due to the inflow of groundwater to the quarry as discussed in Section 2.2. Some increased mineralization of water may occur with large drawdowns and this is considered in the impact assessment through the use of Primary Indicator #1 (as above). Other potential water quality effects that may arise under rehabilitation conditions or through site-specific mitigation measures should be dealt with through monitoring and management/mitigation measures based on site-specific conditions.

Potential Impact to Receptor

The potential extent of the area that may be influenced by unmitigated quarry dewatering from below water table aggregate extraction (Scenario B) and subsequent lake filling of the quarry cells (Scenario C) was assessed using the groundwater flow model (Section 5).

Water supply sensitivity overlain by the simulated change in average annual groundwater elevations due to active dewatering of Resource Area 9-A (Scenario B) and the long-term rehabilitation of the quarry cells to a passive lake condition (Scenario C) is shown on Figure 6-3. Under both development scenarios, the zone of influence occurs above the Escarpment, within the area of low water supply sensitivity. Therefore, changes are not anticipated for water yields of wells completed below the Escarpment (e.g., within the local assessment catchments R5, S3, S4, and the lower portion of R6).

Above the Escarpment, changes in groundwater elevations decrease with distance from the Resource Area, with the greatest lowering of the groundwater levels occurring adjacent the Resource Area. Under Scenario B, the overall impact to water supply within each local assessment catchment above the Escarpment (R1, R2, R3, S1, S2, and the top portion of R6) is moderate, based on the response (change in Indicator #1 - groundwater elevation) and sensitivity of the receptor (water supply) to the simulated lowering of the groundwater level. Under Scenario C, a lowering of the groundwater level occurs in some areas adjacent the Resource Area; however, the average annual drawdown is less than 2 m, within the range of observed seasonal and long-term groundwater fluctuations. Thus, the overall impact to water supply under the rehabilitation condition is low.

6.2 PROPERTY DAMAGE/FLOODING

This component of the impact assessment considers the potential changes and results of impacts associated with damages to property (or life). Two impact pathways are considered in this assessment, including changes in groundwater elevations and changes in surface water flows, which may affect features such as ponds, and changes in surface water flows which may affect flooding.

Changes in groundwater levels have the potential to affect properties. Decreases in groundwater levels may lower pond levels (or even cause them to dry out). Increases in groundwater levels may raise pond levels and/or saturate or flood low-lying areas.

The potential for loss of life and property damage to occur directly as a result of flooding represents a direct impact on the quality of life for residents within any watershed. The Credit Valley conservation Authority has identified that no increase in the potential for flooding to occur may be considered acceptable as a result of any proposed developments. Any increase in flood flows were therefore considered to be a high impact.

Figure 6-4 graphically shows the key components of the impact assessment undertaken for property damage/flooding. Each component of the assessment is described below.

Sensitivity

All areas were considered to have equivalent overall sensitivity/significant level of moderate to groundwater elevation changes due to the variability of features, their responsiveness to changes in groundwater elevations, and the subjective nature of the perceived impact of changes to property value.

The overall sensitivity/significance of the various creek reaches to flooding was assessed based on the proximity of structures to the watercourses and their respective floodplains.

Based on this assessment, reaches of watercourses were identified as having a low, medium, or high sensitivity to flooding. Overall sensitivity/significance was characterized in accordance with the following definitions:

- *Low Sensitivity*: the floodplain runs through open landscape.
- *Moderate Sensitivity*: the floodplain is within 100m of a structure.
- *High Sensitivity*: there is a structure inside the floodplain.

Figure 6-5 illustrates creek reaches of low, moderate, and high overall sensitivity to an increase in the potential for flooding within the Study Area.

<u>Primary Indicators</u>

As listed on Figure 6-4, the primary indicators used to assess the potential for flooding and property damage within the Study Area are groundwater levels (Primary Indicator #1) and the 2-year peak flow (Primary Indicator #3).

The parameter ranges selected for Indicator #1 (change in groundwater elevation) are shown in Table 6-1. The natural range of variation in groundwater elevations in the area potentially influenced by quarrying is generally in the range of (1 to 3 m) and this is used as the range for defining a moderate change. A change of less than 1 m is defined as low and a change of more than 3 m is defined as high. While a change in groundwater elevation is not likely to result in the same degree of change in pond (or flooding) elevation, and the perceived influence of a change is subjective, the above provides a reasonable basis for assessing the potential impacts for the CBSES.

An increase in the 2-year peak flow was considered to be the primary indicator in assessing if an increase in the potential for flooding would occur. The 2-year storm event represents the storm event during which the banks of most creeks are full or have overtopped. At this point, inundation of the floodplain begins to occur. Analysis of the 2-year storm peak flow is also considered to be reasonably close to the calibration range of the hydrologic model which was calibrated to baseflow conditions. While not permitted, many structures have been constructed in the floodplain over time and the potential for those structures to be damaged is immediately increased. Based on observations made during the course of this Study, many culverts within the Study Area also begin to be surcharged during storms of a 2-year storm magnitude. The potential for damage to the roadways and culverts therefore may be increased if these flows are increased. Simultaneously, the potential for flooding of the roadways increases and the potential for loss of life resulting from either drowning or restricted emergency vehicle access is increased.

Potential Impact to Receptor

The potential extent of the area that may be influenced by unmitigated quarry dewatering from below water table aggregate extraction (Scenario B) and subsequent lake filling of the quarry cells (Scenario C) was assessed using the groundwater and surface water flow models (Section 5).

The changes in groundwater elevations are presented on Figure 6-6, as previously discussed under Section 5.

The impacts associated with groundwater level changes for the local assessment catchments under Scenario B are low for catchments R1, R5, R6, and S4, moderate for the supplemental assessment area (SA), and high for catchments R2, R3, R4, S1, S2, and S3. Under Scenario C, the associated impacts for all catchments are indicated to be low. Although some very limited areas have the potential for changes in groundwater levels that are slightly above the moderate threshold, consideration of the nature of the features and hydrogeologic conditions in these areas and the intention for site-specific optimization of the rehabilitation plans indicates the likelihood that any changes will have only a low impact.

Table 6-3 presents a summary of the flooding sensitivity on a local assessment catchment basis for each scenario. Flow rates were calculated at each monitoring location the Study Area over the period of record. A 2-year storm in the area of the Town of Caledon is considered to have a total accumulation of 54 mm over a 24-hour period. The precipitation record was evaluated between 1996 and 2006 and two storms were identified that occurred on November 1, 1997 and November 2, 1999. Each of these storms represented a total accumulation of 42.5 mm over a 24-hour period and were used as approximations for a 2-year storm event. The resultant peak flows at each monitoring location were calculated using the calibrated models for existing conditions and each scenario.

Under development Scenario B1, watercourses that were modelled to receive discharge directly from the Resource Area dewatering systems were calculated to have an increase in the potential for flooding to occur. The affected reaches include local assessment catchments R3, S1, S2, S3, and S4. These reaches showed an increase in the potential for flooding because the de-watering flow was consuming some of the existing capacity in the stream and it was conservatively assumed that any dewatering systems would operate continuously over the course of the entire year.

The remaining local assessment catchment's were calculated to either have a reduction in peak flows or show no impact as a result of the development scenario. These reaches were either not influenced by the dewatering activities, resulting in no change in channel conveyance capacity, or the dewatering activities resulted in decreased baseflows, and an increased channel conveyance capacity resulted.

Under development Scenario B2, no dewatering discharge to receiving watercourses from the Resource Area was simulated. This resulted in a lowering of the groundwater table in the area above the Escarpment and either a reduction in flow or equivalent flow in all of the watercourses in the system. This resulted in a net gain in channel conveyance capacity and therefore, a decrease in the flooding potential throughout the system. This scenario is considered to have no potential to adversely impact the potential for flooding in the Study Area.

The impact assessment was based on the worst case result from Scenarios B1 and B2.

Under development Scenario C, discharge was simulated to occur from the rehabilitated quarry via a gravity outlet to the receiving watercourses. This resulted in either a reduction in flow or equivalent flow in all of the watercourses in the system due to an increase in the evaporation rate and a slight depression in the water table upstream of the

Resource Area. This resulted in a net gain in channel conveyance capacity and therefore, a decrease in the flooding potential throughout the system. This scenario is considered to have no potential to adversely impact the potential for flooding in the Study Area.

The overall property damage/flooding impact assessment is based on the worst case impact associated with the two indicator parameters. As stated above, these overall results are summarized in Table 6-2 and detailed in Appendix O for each local assessment catchment.

6.3 CHANNEL FORM

Channel form is a function of all forces of surface and groundwater flow incident on surface water systems. The existing channel form in undisturbed landscapes reflects the balance between flow inputs and outputs; this form becomes important for the use of the surface water feature by aquatic organisms and fishes. Alterations to the channel form can affect the overall health of the system for those organisms which rely on a stable, yet variable, system.

As land use change occurs, there is the potential for alterations within the balance between inputs and outputs to the surface water system. These alterations may serve to create a change in the overall channel form which then plays a role in alteration of the aquatic habitat, either as a positive (net gain) in sedimented reaches or a negative (net loss) in erosional reaches.

Figure 6-7 graphically shows the key components of the impact assessment undertaken for channel form. Each component of the assessment is described below.

Sensitivity

The surface watercourses in the CBSES Aggregate Resource Area 9-A are sensitive to two potential types of changes: loss of water due to groundwater tables lowering (resulting in decreased shear and velocity under base flow and higher flow conditions—resulting in sediment accumulation on the bed); or excess water under base flow conditions due to persistent flows from stormwater management facilities or other flow-enhancing measures (resulting in increased potential for erosion).

Figure 6-8 shows the results of the sensitivity analysis for all surface watercourses in the CBSES Study Area. The sensitivities are classified as being either low, moderate or high, and there is no distinction between sensitivity to erosion or deposition. Reaches sensitive to deposition are those where flat gradients upstream of ponded areas or wetlands exist; reaches sensitive to erosion occur in areas where persistent baseflow discharge is anticipated or where slopes are great enough to increase velocities during persistent flow periods. Classification of high, moderate or low sensitivity is based on field evidence as indicated in the Part A Report.

In most cases, moderate sensitivity occurs in reaches that are cross-classified as intermittent or ephemeral. This sensitivity class is based on the assumption that during periods of no flow, other forces are acting on the channels to make them sensitive to erosion (drying out and desiccation fracturing of banks; vegetating in creating depositional zones for sediment).

The overall determination of sensitivity is also dependent on the scale of impact of development of the Resource Area, including scenarios where extracted water is either lost to the downstream systems or where it is discharged at a constant rate downstream of the Resource Area.

Primary Indicators

Given the sensitivity to erosion and deposition in the channels, there are three primary indicators of impact: decrease in baseflow; increase/decrease in 2-year peak flow (as expressed in a change in velocity based on discharge as velocity is an indicator of sediment mobility); and overbank flow depth.

Decreases in baseflow discharge from a fluvial process perspective are relatively sensitive—baseflow is used by streams to maintain bed form, and even minor decreases in baseflow discharge can result in sedimentation of fine materials which affect fish and benthic habitat. Through consultation with CVC, it was agreed that the demarcation between low and moderate is set at 5 percent reduction, and between moderate and high is set at 10 percent.

Similar assumptions are made for changes in 2-year peak flow. Because the record drawn upon for the modelling exercise has a high degree of variability, and because the assumptions relating to velocity in a modelled channel are less than perfect, the boundaries between low (<15 percent) and high (>30 percent) are somewhat wider than for baseflow. However, the boundaries, which are based on sediment characteristics of the watercourses, are reflective of current research in sediment transport. The boundaries for changes in 2-year peak flow operate in both the positive (increase) and negative (decrease) manner.

Overbank flow is an indication of the concentration of shear stresses within a channel. Access to floodplains is important for a number of reasons, but from a fluvial perspective access decreases the concentration of flow energy and allows for an upper limit to erosional forces due to shear stress. When overbank flow frequency is altered in a negative manner (decreased frequency), more flow is concentrated in the channels and erosion of the bed occurs. This leads to incision, which as a positive feedback loop creates less overbank flow opportunity, which in turn concentrates more energy, and so on. The anticipated overbank flow discharge in unaltered systems is statistically determined as the 1.2 to 1.7 year return flow; in extreme situations the 1:10 year flow has been concentrated in a channel, creating excess erosion and instability (though this is not evident in the Study Area).

There are three stream types in the CBSES Aggregate Resource Area 9-A: ephemeral, intermittent, and permanent. The frequency of overbank flow for each of these stream types, in order to maintain channel stability, differs. Therefore the thresholds distinguishing low, moderate and high must be different for each stream type.

Ephemeral streams flow very infrequently and usually under conditions of high flow input. This means that overbank flow in ephemeral channels (which tend to be ill-defined) is common. Therefore the boundaries between low impact (<30 percent decrease) and high impact (>60 percent decrease) appear rather significant.

Intermittent streams flow more frequently than ephemeral streams, and while they tend to flow during periods of high flow input (and common overbank flow), they tend to be more persistent during drawdown and are therefore susceptible to multiple flow events, particularly during the spring freshet. Therefore decreases in overbank flow must be less frequent than ephemeral streams, or incision could result. Therefore the thresholds between low (<15 percent decrease) and high (>30 percent decrease) are reflective of these more persistent flows.

Permanent streams require frequent connection to their floodplains. Because these streams are not dependent on high flow inputs (they reflect constant baseflow discharge whereas ephemeral and intermittent streams do not), shear and velocity processes are more significant and therefore the thresholds between low (<10 percent decrease) and high (>20 percent decrease) are more sensitive.

While there are three primary indicators for channel form, there are no secondary indicators. However, it is important to indicate that channel form becomes one of a series of secondary indicators for fisheries, and is a part of the larger fisheries impact assessment. That said, channel form is important for reasons other than fish and aquatic habitat (sedimentation and erosion can result in significant change to planform and vertical stability), and should be considered in and of itself with respect to impacts of land development.

<u>Potential Impact to Receptor</u>

The potential extent of impact that may be influenced by unmitigated quarry dewatering from below water table aggregate extraction (Scenario B) and subsequent lake filling of the quarry cells (Scenario C) was assessed through both the groundwater and surface water models. The spatial extent of impact should be considered to be beyond the drawdown isobars found in other sections of this report, as flowing water is cumulative and impacts require a greater distance in surface water flow to dissipate.

Tables 6-4, 6-5, and 6-6 summarize the results of the model analysis for the primary indicators (change in Primary Indicator #2, #3, and #4, respectively) under each development Scenario. Note that in local catchment R3, Indicators #3 and #4 were not assessed, as this scenario requires the removal of the surface watercourses in this reach as part of the aggregate extraction process. Local catchment S2 has two results for Indicator #4, reflecting the two branches of Second Creek.

The analysis of groundwater and surface water simulation results on channel form are summarized in Table 6-7. Overall impacts for each reach reflect the worst-case scenario (for instance R1 results indicate high impact for Indicator #2 and low for Indicators #3 and #4, yet the overall impact is high). This is consistent through all reaches, and is indicative of a desire to be conservative in our assessment of overall impact in an effort to provide maximum protection of the surface water features. This procedure also considers the nature of modelling inputs and outputs, which, while very detailed in this Study, cannot perfectly reflect natural conditions.

For catchment S1, the highest sensitivity feature (east of Mississauga Road as shown on Figure 6.8) has zero change in baseflow/discharge. Therefore, the impact was selected based on other moderate sensitivity reaches where changes were identified. The resultant impact for catchment S1 is moderate.

Overall impacts are considerably lower under Scenario C compared to Scenario B, with the main impact being overbank flow in R4. This indicates that Scenario C results in significantly less impact on surface watercourses (channel form) than Scenario B.

6.4 TERRESTRIAL HABITAT (UPLAND FOREST)

Upland forest communities can be sensitive to changes in moisture regime. This is particularly so for 'wet-mesic' or 'moist' forest community types, which represent the wetland-upland interface. Many of the ELC forest types with a "fresh-moist" moisture regime have the greatest potential to be impacted. Increases in the water table elevation may result in drowning of existing trees and other vegetation and selection towards plant species that favour wetter ground conditions. Decreases in water table elevation would favour plant species that prefer drier conditions and have deeper rooting systems. The moisture regime is estimated based on soil pore pattern, depth of mineral soil material, topographic position and soil profile characteristics (Ontario Centre for Soil Resource Evaluation 1993).

Determining the impact of a change in water table elevation is site specific and rather complex, depending on community composition and structure, soil characteristics and other site conditions. The rooting depth of trees may vary from one to several metres depending on the species and soil/site type. Consequently, this impact assessment is generalized, given that most of the ELC vegetation mapping available for the Study area is at the more general, community series level (e.g., deciduous forest – FOD, mixed forest – FOM, coniferous forest – FOC).

Impacts were assessed for areas mapped as upland forest (FOD, FOM, FOC) where the existing groundwater level is 2 m or less below the ground surface.

The general approach to impact assessment for upland forest habitats is shown on Figure 6-9.

Sensitivity – Upland Forest

Where forest communities occur in areas with the groundwater elevation no more than 2 m below the ground surface, generalized sensitivity ratings were assigned as follows:

High Sensitivity	-	core forest (30 ha in Peel, 10 ha in Wellington and Halton)
High Sensitivity	-	non-core forest with springs or species at risk
Moderate Sensitivity	-	all other forest blocks (0.5 ha or larger)

Forest sensitivity mapping is shown on Figure 6-10.

Primary Indicators – Upland Forest

The groundwater level was the primary indicator used to assess the impact of any predicted changes, as follows:

Low:	< 0.5 m decrease in groundwater level
Moderate:	0.5 – 1.0 m decrease in groundwater level
High:	>1.0 m decrease in groundwater level

Potential Impact to Receptor – Upland Forest

Impacts were assessed for the most sensitive upland forest features within each subcatchment, giving a conservative assessment of impacts, since not all upland forest features in the subcatchment are necessarily *highly sensitive*. Figure 6-11 shows the anticipated change in groundwater elevation under Scenarios B and C. Table 6-8 summarizes the impact to Riverine and Non-Riverine wetlands due to changes in Indicator #2 - groundwater discharge to surface water features.

Scenario B (Interim Condition – Full Active Extraction)

Potential impacts upon upland forest (where groundwater level is within 2 m of ground surface) are:

- LOW for Roger's Creek subcatchments R1, R2, R3 and R4 (above escarpment)
- LOW for Roger's Creek subcatchments R5 and R6 (below escarpment)
- HIGH for Second Creek subcatchments S1 and S2 (above escarpment)
- LOW for Second Creek subcatchments S3 and S4 (below escarpment)
- HIGH for the Supplemental Assessment Area

Scenario C (Long-term Condition – Passive Rehabilitation)

Potential impacts upon upland forest (where groundwater level is within 2 m of ground surface) are:

- LOW for Roger's Creek subcatchment R3 (immediately downgradient of Resource Area)
- LOW for Roger's Creek subcatchments R1, R2, R4, R5 and R6
- LOW for Second Creek subcatchments S1 and S2 (above escarpment)
- LOW for Second Creek subcatchments S3 and S4 (below escarpment)
- LOW for the Supplemental Assessment Area

Table 6-2 summarizes the overall catchment impacts for each receptors, including upland forest. Appendix O summarizes the anticipated response (change in indicator), overall significance/sensitivity, and overall impact on receptors.

6.5 NON-RIVERINE WETLANDS

Non-riverine wetlands include isolated and palustrine wetlands. Isolated wetlands have no surface water inflow or outflow. Palustrine wetlands have an outflow, but usually no inflow. Riverine wetlands have both an inflow and outflow based on the mapped stream network. Non-riverine and riverine wetlands were treated separately, to allow for the consideration of channel form impacts on riverine wetlands.

The general approach to impact assessment for non-riverine wetlands is shown on Figure 6-12.

<u>Sensitivity – Non-riverine Wetlands</u>

Generalized sensitivity ratings for non-riverine wetlands were assigned as follows:

High Sensitivity	-	PSW – treed swamps
Moderate to High Sensitivity	-	PSW - thicket swamps and marshes (marsh and meadow marsh)
Moderate to High Sensitivity	-	LSW – treed swamps
Moderate Sensitivity	-	LSW - thicket swamps and marshes (marsh and meadow marsh)
Moderate Sensitivity	-	"Other" wetlands greater than 0.5 ha in area

In general, treed swamp communities were considered more sensitive than thicket swamp and marsh communities. Sensitivity mapping for non-riverine wetlands is shown on Figure 6-13.

<u>Primary Indicators – Non-riverine Wetlands</u>

Two primary indicators were used to assess impacts upon non-riverine wetlands, groundwater level and baseflow/discharge, in accordance with the following impact ranking levels:

<u>Groundwater Level</u>

Low:	<0.1 m decrease
Moderate:	0.1 – 0.5 m decrease

High: >0.5 m decrease

<u>Baseflow/Discharge</u>

Low: < 10 percent decrease

Moderate: 10 percent – 25 percent decrease

High: > 25 percent decrease

<u>Potential Impact to Receptor – Non-riverine Wetlands</u>

Impacts were assessed for the most sensitive non-riverine wetland feature within each subcatchment, giving a conservative assessment of impacts, since not all non-riverine wetlands in the subcatchment are necessarily *highly sensitive*. Figure 6-4 shows the anticipated change in groundwater elevation under Scenarios B and C. Figure 6-11 shows the anticipated change in groundwater elevation under Scenarios B and C. Table 6-8 summarizes the impact to Riverine and Non-Riverine wetlands due to changes in Indicator #2 - groundwater discharge to surface water features.

Scenario B (Interim Condition – Full Active Extraction)

Potential impacts upon non-riverine wetlands are:

- HIGH for Roger's Creek subcatchments R1, R2, R3, and R4
- MODERATE for Roger's Creek subcatchment R5
- LOW for Roger's Creek subcatchments R6
- HIGH for Second Creek subcatchments S1, S2, and S4
- LOW for Second Creek subcatchment S3
- LOW for the Supplemental Assessment Area (SA)

Scenario C (Long-term Condition – Passive Rehabilitation)

Potential impacts upon non-riverine wetlands are:

- LOW for ALL Roger's Creek subcatchments
- LOW for ALL Second Creek subcatchments

- LOW for the Supplemental Assessment Area (SA)

Table 6-2 summarizes the overall catchment impacts for each receptors, including non-riverine wetlands. Appendix O summarizes the anticipated response (change in indicator), overall significance/sensitivity, and overall impact on receptors.

6.6 RIVERINE WETLANDS

Riverine wetlands have both an inflow and outflow based on the mapped stream network. All contiguous wetland polygons in the GIS mapping were treated as riverine if any portion had an inflow and outflow. Riverine wetlands were treated separately from non-riverine wetlands (isolated or palustrine), to allow for the consideration of channel form impacts on riverine wetlands.

The general approach to impact assessment for riverine wetlands is shown on Figure 6-15.

Sensitivity – Riverine Wetlands

Generalized sensitivity ratings for riverine wetlands were assigned as follows:

High Sensitivity	- PSW – treed swamps
Moderate to High Sensitivity	- PSW - thicket swamps and marshes (marsh and meadow marsh)
Moderate to High Sensitivity	- LSW – treed swamps
Moderate Sensitivity	- LSW - thicket swamps and marshes (marsh and meadow marsh)
Moderate Sensitivity	- "Other" wetlands greater than 0.5 ha in area

In general, treed swamp communities were considered more sensitive than thicket swamp and marsh communities. Sensitivity mapping for riverine wetlands is shown on Figure 6-16.

Primary Indicators – Riverine Wetlands

Two primary indicators were used to assess impacts upon riverine wetlands, groundwater level and baseflow/discharge, in accordance with the following impact ranking levels:

Groundwater Level

Low: <0.1 m decrease

Moderate: 0.1 – 0.5 m decrease

High: >0.5 m decrease

Baseflow/Discharge

Low: <10 percent decrease

Moderate: 10 percent – 25 percent decrease

High: >25 percent decrease

Secondary Indicators – Riverine Wetlands

One secondary indicator, channel form, was used to assess impacts upon riverine wetlands in cases where the impacts based on channel form were higher than for groundwater level and baseflow/discharge as they relate to riverine wetlands: The impacts to channel from are presented in Section 6.3.

Potential Impact to Receptor – Riverine Wetlands

Impacts were assessed for the most sensitive riverine wetland feature within each subcatchment, giving a conservative assessment of impacts, since not all non-riverine wetlands in the subcatchment are necessarily *highly sensitive*. Figure 6-17 shows the anticipated change in groundwater elevation under Scenarios B and C. Table 6-8 summarizes the impact to Riverine and Non-Riverine wetlands due to changes in Indicator #2 - groundwater discharge to surface water features.

Scenario B (Interim Condition – Full Active Extraction)

Potential impacts upon riverine wetlands are:

- HIGH for Roger's Creek subcatchments R1, R2, R3, and R4
- MODERATE for Roger's Creek subcatchment R5 and R6
- HIGH for Second Creek subcatchments S1 and S2
- MODERATE for Second Creek subcatchment S3

- LOW for Second Creek subcatchment S4
- HIGH for the Supplemental Assessment Area (SA)

Table 6-2 summarizes the overall catchment impacts for each receptors, including riverine wetlands. Appendix O summarizes the anticipated response (change in indicator), overall significance/sensitivity, and overall impact on receptors.

The impact upon riverine wetlands in R6 and S3 was low based on change in groundwater elevation and baseflow/discharge. This ranking was changed from LOW to MODERATE for Riverine Wetlands due to the HIGH impact rating under Channel Form,

Scenario C (Long-term Condition – Passive Rehabilitation)

Potential impacts upon non-riverine wetlands are:

- LOW for Roger's Creek subcatchments R3
- MODERATE for Roger's Creek subcatchment R4
- LOW for Roger's Creek subcatchments R1, R2, R5, and R6
- MODERATE for Second Creek subcatchment S1
- LOW for Second Creek subcatchment S2, S3, and S4
- LOW for the Supplemental Assessment Area (SA)

6.7 HIGH FOR THE SUPPLEMENTAL ASSESSMENT AREA FISHERIES

Fisheries are an excellent indicator of watershed health, as they are dependent on a wide variety of inter-related biotic and abiotic components of the surrounding environment. Fish community structure, including abundance and richness, are directly or indirectly influenced by a number of these biophysical components. As defined under the federal Fisheries Act, fish habitat includes habitat components … *on which fish depend directly or indirectly in order to carry out their life processes*. The specific arrangement and inter-relationships of the biophysical components essentially determines the underlying form and function of the fish habitat.

The fish community is also influenced by other biotic variables such as macrobenthics (as a food item) and riparian wetlands and other vegetation, which are also influenced by biophysical factors.

Given these biophysical inter-relationships, changes to the natural environmental conditions within a watershed, either natural or anthropogenic, can result in 'cascading' effects on these ecological components. These cascading effects manifest themselves in end receptors, such as fish communities, which rely on the integrated or cumulative influence of many other watershed components. Therefore, studying the composition and health of a fish community provides a good measure of overall watershed health, and also provides a useful tool to monitor changes within the watershed.

Since fish are a key ultimate or cumulative end receptor in a watershed, a great deal of effort was placed on understanding and characterizing the existing fish community within the Study Area during Part A of the CBSES. Given their aquatic dependencies, fish communities are a particularly useful 'end receptor' for the Part B impact analysis, since the changes associated with the development scenarios under review for Resource Area 9-A are primarily water-related. Furthermore, given the integrative or cumulative aspect of fisheries, the analysis of potential impacts to fisheries can also be used to assess overall or cumulative environmental changes.

Although the inter-relationships among fish communities and bio-physical parameters are highly varied and complex, they have been summarized for the purposes of the impact analysis into a simplified framework that identifies the key water-related inter-relationships. These key inter-relationships or linkages with the various receptor features are shown on Figure 3-2. As outlined in Section 3.1, these linkages form the basis of the 'stress-response' framework that is used to structure the Part B impact analysis.

Of the various receptors identified for the CBSES, the fisheries receptor integrates the influences of the largest variety of the biophysical variables defined for this Study. Some of these factors have a direct linear relationship to fish, such as groundwater discharge. Some factors, such as benthic invertebrates, are first dependent on underlying biophysical factors prior to their influence on fish. The primary or secondary nature of the pathway of influence from the water impact to fish is used to describe the indicators as either primary (direct) or secondary (water via the indicator such as benthics to fish).

As shown in this framework, fisheries are influenced directly by surface water and groundwater primary indicators. The surface water and groundwater changes also impact the three secondary indicators, fluvial geomorphology, water quality (water chemistry and macrobenthics) and riverine wetlands, which in turn also influence fisheries.

Figure 6-18 graphically shows the key components of the impact assessment undertaken for fish communities. Each component of the assessment is described below.

Primary Indicators

The primary indicators are directly related to groundwater and surface water. The development of Resource Area 9-A would be expected to elicit changes to these indicators. As outlined in Section 3.1, changes to these indicators are modeled for the various land use scenarios.

Primary fisheries indicators are those parameters/factors which have a direct, linear influence on fish. Although fish communities are influenced by a range of direct water-related variables, two key indicators were identified. Of the various primary indicators that were modeled or derived for the Part B analysis (see Section 3.1.1), these two variables were considered to have the greatest direct influence on the fish communities and habitat in the Study Area.

As summarized in Table 6-1, the two variables used for the Part B impact analysis on fish communities, as primary indicators are:

- change in groundwater/baseflow discharge (Indicator #2); and
- change in surface flow, as it pertains to hydroperiod, or duration of flow.

The groundwater discharge/baseflow indicator was modelled directly. It is the change in groundwater 'flux'/discharge directly into the creek bed at a point along the channel (It is not cumulative in relation to combining groundwater or related surface water inputs from upstream reaches). Therefore, this output is important in assessing potential impacts to fish communities/habitats that are dependent on direct groundwater discharge for thermal moderation and other habitat functions (e.g., coldwater Brook Trout habitats).

Hydroperiod refers to the duration of surface flow (or standing water), or the length of time flow persists throughout the year, or more specifically, the length of time it persists through the spring into the summer period. The changes in the volume of flow over time progressing through spring runoff and rain events into the dry period of the year are a closely related consideration.

Given the predominance of intermittent flow and seasonal fisheries within this Study Area, hydroperiod or the duration of flow was derived as a surface flow indicator. It should be noted that other surface water indicators such as 2-year peak flow velocity and overbank flow are assessed in relation to fish through the secondary indicator assessment (e.g., fluvial geomorphology/channel form).

Hydroperiod changes are of specific interest where they change the surface flow regime and associated habitat from permanent to seasonal or from intermittent to ephemeral. These changes are most important where they directly affect productivity of the habitat. For example, in intermittent reaches, the success and ultimate recruitment of many fish depend on the duration of flow in the spring. If surface flow is decreased significantly during the spawning and development period, loss of eggs or juvenile fish can result as the watercourses dry out prior to completion of these activities. Successful recruitment in an intermittent system depends on the length of time water is in the system allowing juvenile fish to develop and ultimately retreat successfully to seasonal refuge habitat.

In perennial habitats, a significant reduction in the hydroperiod may not have a commensurate effect on direct productivity, since most fish will not be spawning during the driest period of the year when this would occur. However, if the affected permanent habitat provides seasonal refugia, a reduction of the hydroperiod could have a significant effect. This effect is magnified when the affected habitat is isolated. For example, loss of the perennial reach within a stretch of the watercourse that is isolated by dams would result in the loss of the fishery along this reach, as well as in adjacent intermittent reaches that use this reach as refuge habitat.

Secondary Indicators

Secondary indicators influence fish and/or their habitat directly, however they are features or functions that are also directly influenced by the primary water-related indicators. That is, they act along secondary pathways between surface water or groundwater, and fish. A change in the primary water indicator causes a change in the secondary indicator, which in turn affects fish. All three of the key secondary indicators identified for the purposes of the CBSES analysis are relevant for fisheries.

These secondary indicators are:

- fluvial geomorphology (channel form);
- water quality (water chemistry and benthic macroinvertebrates); and,
- riparian wetlands.

Sensitivity

As outlined in Section 3.1, sensitivity for fisheries was assessed on two scales, first at a broad overall scale that considered a number of criteria determinant to *overall sensitivity* of fish communities, and at a project-specific scale of *water-related sensitivity* directly relevant to the key impacts of potential development of Resource Area 9-A.

The fish community distribution identified within the Study Area, as presented in the CBSES Part A Characterization Report and mapped on Figure 6-19, was the basis for establishing the sensitivity. Overall fisheries sensitivity is presented on Figure 6-20. Fisheries sensitivity was assessed in further detail by considering sensitive habitat functions, such as spawning, refugia and isolation. A more detailed discussion of the approach to assigning i) overall sensitivity and ii) water-related sensitivity follows:

***i)* Overall Sensitivity**

'Overall sensitivity' encompasses:

- Consideration of the 'functional' aspects of habitat, or the dependencies of a particular type of habitat on underlying functional processes and characteristics such as groundwater discharge, flow and sediment transport and water quality in assessing the resilience of a habitat type to change;
- Consideration of the tolerance or resilience of individual fish species and communities to changes in environmental parameters such as water temperature, suspended sediment or salinity;
- Integration of habitat type with species use; the level of dependence of a species on specific habitat functions; and
- Integration of both site specific and broader ecosystem considerations in considering rarity/representation and importance.

For the purposes of this assessment, the criteria developed by Fisheries and Oceans Canada (DFO) in their *Practitioners Guide to the Risk Management Framework for DFO Habitat Management Staff* (DFO 2006), which embody the above noted principles, were used to assess overall sensitivity. DFO (2006) identifies four main sensitivity attributes for use in determining sensitivity of fish and fish habitat. These attributes are: 1) species sensitivity; 2) species dependence on habitat; 3) rarity; and 4) habitat resiliency. These elements are further described in Table 6-9.

Using these criteria, the various fish community types and underlying habitats identified in the Study Area during the Part A characterization were assessed to develop an overall sensitivity ranking for each community type. Key considerations used in identifying the various fish communities/habitat were the underlying flow and thermal regimes, which influence habitat function and fish sensitivity, and the species composition of the community.

Thermal regimes are important in establishing the sensitivity of a system, functionally and in turn determine the species that use the habitat. Warmwater, cool water and coldwater systems are represented in the Study Area. A warmwater system is ranked as having low sensitivity since it can undergo large fluctuations in temperature and tolerant fish species are dominant (DFO 2006). A cool water system is ranked as having a moderate sensitivity because it can still buffer temperature changes, but some species are linked to the cooler thermal regime. A coldwater system is ranked as having high sensitivity because these systems cannot easily buffer temperature changes (DFO 2006). Overall, tolerant species and habitats have a lower sensitivity ranking due to their resilience to impacts relative to those species and habitats that are more specialized.

'Isolation' and habitat refugia were also used as key considerations in this analysis based specifically on the nature of the habitat conditions in the CBSES Study Area. The natural and man-made barriers that occur along the stream reaches, in combination with the variable flow conditions that change back and forth from permanent-intermittent-ephemeral along many stream reaches, can function to isolate particular stream reaches or habitats. This isolation increases vulnerability to potential impacts, since fish cannot easily re-colonize an isolated reach if an impact results in extirpation of the fish community locally.

Particularly given the isolation aspects, seasonal refugia are critical to maintaining local fish communities. Refugia or refuge habitats are areas that fish retreat to and depend upon seasonally during periods of relative stress (e.g., summer, winter). Flow and/or thermal components (and related water quality aspects) are typically key determinants. For example, in an intermittent system, fish are dependent on successful retreat from a drying stream reach to a permanently flowing or pooled/ponded area. In a coldwater system, groundwater discharge areas are often critical refugia for coldwater species, such as brook trout, in order to survive periods of elevated stream temperature. Deeper pools can also provide important refuge habitat.

Key considerations in assessing habitat resiliency were their functional dependence on groundwater, as well as the relationship of intermittent habitats to flow duration. The duration of flow in intermittent habitats is important in relation to spawning and recruitment; if the flow duration is reduced such that a reach no longer flows long enough in the late spring early summer to support successful spawning and recruitment of young fish, the overall productivity of the reach and watercourse is reduced. Small intermittent stream systems are also typically dependent on seasonal groundwater influx to sustain flows into the summer period.

Generalized perennial flowing habitats are generally considered to be less sensitive. These habitats, particularly warm water, are generally not strongly influenced or dependent on groundwater conditions and can therefore tolerate some loss in groundwater inputs without negatively impacting the fish community. Perennial warm water is assigned a 'low sensitivity.' Perennial cool water habitat is assigned a 'low-moderate sensitivity' given the greater relative dependence on groundwater.

Ephemerally flowing reaches exhibit inherently lower sensitivity since they typically do not flow long enough to sustain any spawning or recruitment of fish. Where these habitats are used directly by fish, this use is highly seasonal and generally limited to movement through the reach and potentially localized, temporary feeding or shelter.

Fish habitats that are not used directly by fish, or indirect or contributing habitats, were included in the analysis, since they do provide contributing functions such as flow conveyance and allocthonous input to downstream habitats. However they were assigned a 'very low sensitivity', on a relative basis. The small number of reaches that were not field-verified during the Part A field work have been identified as undefined.

These sensitivity rankings were applied to each creek in the Study area on a reach basis based on the documented flow regime, fish habitat and fish community. For the purposes of the overall sensitivity assessment and to provide differentiation among the various habitat and fish community types, a relative scale using six levels was used: 1) High; 2) Moderate-High; 3) Moderate; 4) Low-Moderate; 5) Low and 6) Very Low.

The matrix presented in Table 6-10 summarizes the overall sensitivity of the various habitat/fish community types based on the DFO (2006) criteria. As indicated, overall sensitivity is mapped on Figure 6-20.

The stream reaches and their sensitivities are examined further in the following sections.

Rogers Creek - Overall Sensitivity

The headwater zone of Rogers Creek is associated with wetlands, forests and cultural vegetation located on the Paris Moraine. Surface water tends to 'recharge'/infiltrate through this area, limiting the formation of defined channels with continuous flow. Flow conditions within the Main Branch alternates between perennial and intermittent. Rogers Creek is perennial as it flows toward the Credit River.

For the purposes of the main components of the analysis, six local catchment areas were identified along with Rogers Creek. These areas are: R1, R2, R3, R4, R5, and R6.

R1

This catchment includes Rogers Creek West Branch, which is located north and south of 5th Sideroad and east and west of 10th Line.

Catchment R1 is dominated by low and very low sensitivity intermittent and ephemeral flowing watercourses, which when they do support fish, support simple, tolerant seasonal warm water forage and bait fish communities. There is one small perennial reach, where flow appears to be maintained through groundwater discharge, however based on the fish sampling conducted for the characterization, its fish community is still limited to a single species of warm water forage fish. Therefore, the fisheries are not particularly sensitive overall nor are they specifically sensitive to water-related changes

R2

Catchment R2, located upstream and downstream of 5th Sideroad is comprised of Rogers Creek Main Branch.

Catchment R2 is comprised of an almost even mix of very low, low and moderate sensitivity intermittent warm and cool water fish communities. Therefore, there is some influence of groundwater evident in the cool water reaches. One small perennial cool water reach located downstream of 5th Sideroad is identified as moderate to high sensitivity due to its refugia function.

R3

This catchment is located east of Winston Churchill Boulevard encompassing the area north and south of Olde Baseline Road. This area is comprised of Rogers Creek East Branch, Rockfort Drain and Hutchinson Swale.

Catchment R3 is dominated by very low and low sensitivity intermittent and ephemeral watercourse reaches. The majority do not support direct fish habitat, with the exception of a small reach of intermittent cool water and seasonal warm water. The isolated intermittent cool water reach would be ranked as moderate sensitivity and the small areas of associated refugia would be ranked as moderate to high sensitivity. These reaches are located within Resource Area 9-A. The reaches outside of the Resource Area are ranked as very low or low-moderate sensitivity.

R4

Catchment R4 is located west of Winston Churchill Boulevard north of Erin-Halton Hills Townline. Catchment R4 encompasses moderate to high sensitivity intermittent cool and perennial cold water fish communities. Many of these features are isolated and refuge habitats are therefore important particularly in the context of the isolation.

R5

This catchment is located north and south of Erin-Halton Hills Townline west of 9th Line to east of 10th Line, encompassing either very low sensitivity ephemeral watercourses or high sensitivity brook trout spawning habitat.

R6

Catchment R6 is located north of Erin-Halton Hills Townline, west of 9th Line and east of 10th Line. This catchment is composed of the Lower Region reaches of Rogers Creek that flow into the Credit River. Overall, the main branches of Rogers Creek are high sensitivity cold water brook trout spawning habitat. The only anomaly is a portion of Rogers Creek downstream of Erin-Halton Hills Townline where flow is intermittent;

since it is still part of the coldwater reach, it was assigned a moderate sensitivity even though direct fish use was not confirmed.

Second Creek - Overall Sensitivity

S1

Catchment S1 encompasses the area west of Shaw's Creek Road to east of Creditview Road, north of Olde Baseline Road. Catchment S1 is comprised primarily of very low sensitivity perennial warm water, moderate sensitivity perennial cool water and low to moderate sensitivity intermittent cool water.

S2

Catchment S2 is located north and south of Olde Baseline Road, east of Rockside Road and east of Winston Churchill Boulevard. Catchment S2 is comprised primarily of low to moderate sensitivity intermittent warm water, however there is an area of high sensitivity brook trout spawning habitat located at it extreme downstream end.

S3

Catchment S3 is located south of Ballinafad Road east and west of Winston Churchill Boulevard. The catchment is comprised of perennial cold, cool and warm water habitats ranging from high to low sensitivity. The high sensitivity reaches are associated with cold water brook trout spawning habitat.

S4

Catchment S4 is located east of Winston Churchill Boulevard, west of Heritage Road and south of Olde Baseline Road. S4 is comprised predominantly of low sensitivity intermittent warm water habitats associated with the escarpment slope.

Supplemental Assessment Area (SA) - Overall Sensitivity

The headwaters of Third Creek, comprised of two main branches, are located south of Olde Baseline Road between Rockside Road and Mississauga Road. These two branches coalesce just downstream of Ballinafad Road. Third creek then flows into the Credit River. There are relatively few tributaries associated with Third Creek.

Fourth Creek associated with this area encompasses a short reach, which outfalls to the longer South Branch Reach downstream of Mississauga Road. The supplementary area has been combined as one area - SA- for the purposes of the analysis

The SA is comprised of low sensitivity intermittent warm water, moderate sensitivity perennial cool water, and moderate-high sensitivity isolated cold water habitat. The cool water habitats are associated with Third Creek, while the cold water habitat is associated with Fourth Creek.

<u>Most Sensitive Reach</u>

To facilitate the analysis and focus the model outputs, a 'most sensitive reach' was identified for each local catchment. The most sensitive reach is also identified on Figure 6-20. Consistent with the worst-case approach adopted for the impact analysis, the underlying assumption is that for any given water-based impact, the most sensitive reach/habitat(s) is going to be the most highly impacted. The identification of the 'most sensitive' reach enabled the quantitative modeling output (e.g., groundwater flux and percent change in groundwater discharge) to be focused on the most sensitive reach(es) to ensure that impact analysis addressed these areas.

It is important to emphasize however that the identification of the most sensitive reach did not restrict the impact analysis to just that specific reach. A holistic impact analysis was undertaken for all of the watercourse reaches within each of the local catchments to ensure an overall conservative assessment.

Further, a specific 'check' of the analysis was conducted to confirm that the focus of the impact analysis on the most sensitive reach did determine the 'worst case' impact result for each local catchment. The drawdown modeling results (Figure 6-21) were used to identify those catchments where there was a wide variation in the simulated degree of groundwater related impact across the catchment, and specifically, to identify situations where the most sensitive reach was not the reach where the highest impacts occurred.

Based on the review of Figure 6-21, in two local catchments, R4 and S2, there were nominal impacts on the most sensitive reach, but high impacts on less sensitive reaches. Therefore, for these two catchments, the second most sensitive reach, which occurs through the zone where Figure 6-21 shows much greater drawdown potential, was also identified and the impact assessed.

Table 6-11 outlines the most sensitive reach for each of the catchments and the corresponding justification.

Sensitivity to Water-related Parameters

The second component of sensitivity specific to the impact analysis being conducted for the CBSES is the sensitivity of the fish community/habitat to water-related changes. For the key groundwater primary indicator that was modeled (percent change in Indicator #1 - groundwater discharge/baseflow), specific 'parameter ranges' were assigned to assess the relative impact of the water-related change on fisheries. As summarized in Table 6-1, different sensitivity ranges were based on the fishery type and its specific sensitivity to change in groundwater discharge/baseflow. A qualitative scale of high-moderate-low was assigned to the numerical scale.

For the derived surface water related indicator (change in seasonal hydroperiod) there was no direct modeling output; various water-related information components were assessed to provide a qualitative assessment of the relative change in hydroperiod. For this indicator, the relative qualitative scale was provided based on the water resources analysis. The fisheries impact was assessed based on this relative change, in combination with an assessment of the related modeling outputs such as groundwater level. For the small stream reaches prominent in the Study area where there is little upstream surface flow, changes in groundwater level will have a significant effect on surface flow during the lower flow periods that are generally of most interest in relation to fisheries.

More detail regarding the ranking of water-related sensitivity for the modeled groundwater discharge indicator and the derived hydroperiod indicator is provided in the following sections.

Groundwater Discharge

For the purposes of the analysis, the various habitat/fish community types were assessed in relation to their specific functional sensitivity to water-related changes. For example, brook trout spawning habitat, the quality of which is directly dependent on groundwater discharge, was considered to be highly sensitive to small changes in groundwater discharge. Therefore, the scale of Low-High impact is very tight (Low to High all <5 percent decrease in groundwater discharge). Similarly, coldwater groundwater dependent refugia and isolated coldwater habitats were also considered to exhibit a narrow range of tolerance to decreases in groundwater discharge.

At the tolerant end of the scale are the ephemeral reaches, which do not support direct fish use and have essentially no dependence on groundwater by nature. That is, although groundwater discharge may occur to the stream, it occurs seasonally, coincident with the spring runoff period when abundant surface water is present; any groundwater discharge does not persist long enough to extend the flow duration into the later spring/early summer.

The various fish community and habitat types were grouped into six categories of relative sensitivity to groundwater related changes. The relevant parameter ranges were developed based on the relative sensitivities of the fish communities and habitats to changes in groundwater discharge, as outlined in Table 6-1.

As outlined, the groundwater discharge impact analysis was conducted primarily using the 'most sensitive fisheries reach' in each catchment. In the two cases where the most sensitive reach was not highly impacted by the change in groundwater discharge relative to other reaches in the local catchment, secondary reaches that were in the highly impacted portion of the subcatchment were also assessed (Catchments R4 and S2).

Hydroperiod

Hydroperiod refers to the duration of surface flow (or standing water), or the length of time flow persists throughout the year, or more specifically, the length of time it persists through the spring into the summer period.

Hydroperiod changes are relevant to assessment of the Study Area fish communities since many are seasonal and dependent on extended flow into the early summer period. Significant reduction in hydroperiod can result in loss or reduction in successful recruitment or direct productivity. Reduction of hydroperiod large enough to change flow conditions from permanent to seasonal flow can also be critical in reaches or habitat areas that provide refugia, particularly where the habitat is isolated.

The change in hydroperiod was determined generally by evaluating the surface water model outputs, groundwater model results (changes in groundwater level and groundwater discharge), and characterization information (e.g., the documented existing flow regimes, stream size and size and flow character of their upstream drainage area, and associated relative dependence on groundwater to sustain flow during dry periods) and applying professional judgment to arrive at a qualitative ranking.

This information was considered in combination to predict an overall change in hydroperiod, which was expressed on the qualitative scale outlined below:

- LOW - Within expected normal variation. Hydroperiod increases or is not reduced more than the amount expected under normal climate variations. Generally change in flow duration of less than 1/5.
- MODERATE - Readily observable change. Hydroperiod changes noticeably but maintains the majority of its previous duration. Generally change in flow duration of more than 1/5 but less than 1/2.
- HIGH - Substantially changed. Majority of hydroperiod is lost. Generally change in flow duration of 1/2 or more.

To assess the impact to fisheries, the relative scale of hydroperiod impact within a given catchment was then evaluated in relation to the specific type(s) of fish community and habitat types within that catchment. Similar to the groundwater discharge impact assessment, the overall sensitivity of the fish community as well as the specific sensitivity to reduction in hydroperiod was considered. The most sensitive fisheries/habitat types were again used in this analysis to predict the 'worst case' overall impact on each local catchment.

In general, the general concepts used in categorizing hydroperiod sensitivities of the various fish habitat types/communities can be summarized as follows:

High Sensitivity to Hydroperiod Change/Reduction

- Cold water refugia and cool water refugia, since reduction in the hydroperiod that results in the loss of refugia could have a major effect on the fish community that relies on the refugia for survival during stressful low flow periods

- Cold water spawning habitat if the hydroperiod reduction extends into the fall period, limiting access to or direct use of spawning areas.

- The sensitivity of the habitat types in the moderate sensitivity category to hydroperiod reduction will be elevated when these habitats are isolated.

Moderate Sensitivity to Hydroperiod Change/Reduction

- General perennial cold and cool water habitats.

- Intermittent cool water, since the duration of the flow regime is typically sustained by groundwater into the early summer period and reduction of the hydroperiod can result in the loss of recruitment if the flow dries up too early.

- Warmwater refugia, since these habitats typically also have some surface water support in addition to potential groundwater support.

- Intermittent warm water, which is typically less sensitive than intermittent coolwater habitat since it is less dependent on groundwater flow. However the duration of the hydroperiod is still important to successful recruitment seasonally.

Low Sensitivity to Hydroperiod Change/Reduction

- General perennial warm water, which by nature has some surface water support as well as groundwater support.

- Ephemeral warmwater systems that support direct fish use seasonally for fish movement.

Very Low Sensitivity to Hydroperiod Change/Reduction

- Ephemeral systems that provide only contributing functions and do not directly support fish use.

Potential Impact to Receptor

Overall Approach

The impact analysis completed for fisheries receptor was completed in two stages, which involved integrating various sub-components of the analysis. Given the integrative nature of fisheries, a holistic approach was used to assess the overall impact of the potential land use change. The results of the primary fisheries analyses were used in combination with an assessment of inter-related secondary indicator and receptor analyses to develop the overall fisheries impact ranking for each catchment.

Specifically, the fisheries analysis involved:

- The direct evaluation of the specific impacts related to changes in the primary indicator – percent change in groundwater discharge, as well as the derived hydroperiod indicator;
- Integration of the potential impacts of the secondary indicators and receptors which also influence fisheries, specifically:
    - the evaluation of the results of the direct analysis of the *Fluvial Geomorphology* secondary indicator and its related receptor (i.e., *channel form*)
    - the evaluation of a related receptor- i.e., *Riverine Wetlands*, which by nature provide riparian habitat functions, and

- a qualitative assessment of the *Water Quality* and *Macrobenthics* secondary indicators .

The results of the various primary and secondary indicator analyses were then combined to determine an overall qualitative impact ranking for fisheries, within each local catchment. The overall fisheries impact analysis was based on specific consideration of the potential impact on the most sensitive reach, but also evaluated the fisheries features within the rest of the catchment in relation to the indicator or related receptor impact, to help refine the impact analysis for each individual catchment.

Indicators and Related Receptors Used in the Fisheries Impact Analysis

Fluvial Geomorphology/Channel Form The channel form indicator reflects the combined influences of baseflow/discharge, 2-year peak flow and overbank flow through fluvial geomorphologic processes. Channel form affects fish habitat.

Water Quality A qualitative assessment approach that assumed a simple linear relationship between changes in groundwater discharge or surface water flow on water quality was used to assess the potential fisheries related impact. This relationship is based on the principle of 'dilution', in that if either groundwater or surface water flow is reduced measureably in volume, the capacity of the water to dilute potential contaminants is reduced. That is, if the volume of water is decreased, it was assumed the water quality of the system would degrade through the increased concentration of the existing potential contaminants in the remaining water.

Macrobenthic invertebrates Macrobenthic invertebrates, like fish, are affected by various bio-physical components of aquatic habitat; they are directly affected by changes in water quality, and are also affected by changes in their habitat and flow regime. In addition to being an indicator of water and physical habitat quality, macrobenthic invertebrates are also an important food source for many fish species. Like water quality, a simple linear relationship between the losses of groundwater discharge or surface flow assumes a decline in the macrobenthic invertebrate community.

Riverine Wetlands The results of the riverine wetland impact analysis were also considered in the fish impact analysis since they function as important riparian habitats that are also directly influenced by water related changes. Like riparian vegetation generally, they provide bank slope stability, shading (especially in the Study Area where many are treed swamps), organic inputs, a source of terrestrial insects as food, a source of woody debris and detritus, and can influence local hydrological conditions. They are, unlike 'upland' riparian systems, more directly influenced by the changes in the water-related functions that are the primary component of this analysis.

Integration of the Analysis Results to Develop the Overall Fish Impact Ranking

As outlined, the overall fish impact ranking assigned to each catchment involved the integration of the results of the analyses of individual primary indicators and secondary indicators, as well as key receptors. Use of qualitative assessment tools was an important component of this analysis. Professional judgment, grounded on a sound understanding of the character and sensitivity of the Study Area features and their inter-relationships, was key to both the analyses of the individual components and the process of integrating the individual analyses into the overall fisheries impact ranking for each catchment. The qualitative analyses allowed the team to broaden the analysis of the quantitative modeled outputs, providing the ability to reflect a broader range of impacts.

As noted, an overall conservative or worst case approach was implemented throughout the analyses, by assessing the fisheries indicator at it most sensitive reach within each catchment. The various secondary and receptor indicators used to assess the overall fisheries impact often used different reaches as their most sensitive, thereby broadening the overall integrated fisheries assessment within the catchment.

Although the overall impact ranking was based on consideration of the relative impact and the overall sensitivity of the affected fisheries, use of the conservative approach placed greater emphasis on the magnitude of the relative impact compared to the sensitivity. That is, even where the sensitivity of the affected features is low, if the impacts on all of the indicators was high, the overall impact was not necessarily assessed as low. In using only three levels of overall impact (i.e., high, moderate, low), conservatism was also applied in using the higher category for the overall impact.

Overall Fisheries Impact Analysis

The results of the primary indicator impact analysis are presented in Table 6-12 and the overall impact analysis is presented in Table 6-13.

Scenario B

Scenario B models the full extraction of the Resource 9-A Area, without any mitigation, as described in Section 5.3.2.

R1

The overall ranking of the potential impact of full extraction on fisheries in catchment R1 is **Moderate.**

The impacts on groundwater discharge/baseflow and hydroperiod were ranked as moderate. The related analyses rank the impacts on the riverine wetlands and channel form receptors within this catchment as high. Water quality impacts were assessed as moderate.

Although the overall sensitivity of the majority of the fish communities within this catchment is low intermittent warmwater habitat, the highest sensitivity reach is ranked as low-moderate since it provides potential permanent warmwater refuge habitat. Therefore, the moderate impact on hydroperiod is relevant to fish habitat function and ultimately to the fish community within this catchment.

The potential reduction of the hydroperiod of up to half, if occurring in the spring, could result in the loss of the productive capacity in the intermittent reaches, and potential loss of the permanent flowing reach. However, the overall degree of potential impact is moderated based on the low-moderate sensitivity of the existing systems and their warmwater nature. As a result, the overall ranking for the catchment is moderate.

R2

The overall impact ranking for catchment R2 is **High.**

The impacts on all of the components (percent groundwater discharge, hydroperiod, riverine wetland, water quality and channel form) were ranked as high. The catchment is dominated by intermittent flowing watercourses and fish communities, which are again generally sensitive to flow duration to support the productivity of the seasonal fish habitats. The high impacts on groundwater discharge and hydroperiod would be expected to result in high impacts on direct fisheries productivity across the catchment. Therefore, although the fisheries in this catchment are only moderately sensitive overall, the overall impact ranking assigned to the catchment was high.

R3

The overall impact ranking for catchment R3 is **Moderate**.

The majority of catchment R3 is comprised of the Resource 9-A Area. As a result, under *Scenario* B, the features within Resource 9-A will be removed, as outlined in Section 4. The 'most sensitive' fisheries reaches within the catchment are located within Resource 9-A and therefore removed by the hypothetical extraction scenario, as outlined in Section 4. The water-related impact analysis for catchment R3 addresses the remaining watercourse reaches upstream and downstream of Resource Area 9-A.

The impacts on the riparian wetland, water quality and channel form indicators were all ranked as high. Groundwater discharge/base flow impacts and hydroperiod impacts for the areas outside of Resource 9-A were ranked as high. Therefore, although the overall sensitivity of the fisheries in these portions of the catchment is very low and low sensitivity, using a conservative approach in assessing the most sensitive reach and considering the range of related receptor impacts across the catchment, the overall impact ranking assigned to the catchment was assessed as moderate.

R4

The overall fisheries impact ranking for catchment R4 is **High**.

The R4 catchment is one of the two cases where the range of impacts modeled for the primary indicators varied widely across the local catchment. In the most sensitive (downgradient) fisheries areas (cold water brook trout spawning areas and refugia) the changes in groundwater baseflow/discharge, and hence hydroperiod, are low. However, the moderately sensitive reaches are located in the portion of the catchment where a high impact is simulated (e.g., refer to supplementary assessment reach in Table 6-12). Therefore the primary indicator impact is ranked as high. Additionally, channel form, water quality and riverine wetlands also all ranked as high impacts. Therefore, a high overall impact ranking was assigned to catchment R4.

R5

The overall fisheries impact ranking for catchment R5 is **Low**.

The impacts of all of the sub-analyses of all of the indicators and receptors within the catchment were ranked as low, with the exception of riverine wetlands where the impact was ranked as moderate. However the impact zone related to riparian wetlands is within an area of the catchment that does not support direct fish habitat.

Therefore, although the sensitivity of the fisheries in the lower portions of this catchment is high, the modeled outputs do not show any influence on groundwater at this distance from the resource area

Therefore, the overall impact for fisheries was still ranked as Low.

R6

The overall fisheries impact ranking for catchment 6A is **Moderate**.

Modeling does not predict impacts to groundwater discharge within catchment R6 is low; however, there is a moderate impact to hydroperiod. The related impact on water quality was moderate and on channel form was high. The sensitivity of the fish community present is predominantly high (cold water brook trout spawning). Flows within catchment R6 are generally groundwater dependent.

Since there are no changes in groundwater levels and groundwater discharge, the moderate change in the hydroperiod would not necessarily result in a significant change to overall habitat conditions. However, if duration of flow is reduced, an impact could occur, given the high sensitivity of the fish community present. Therefore, taking a conservative approach, an overall, a moderate impact ranking was assigned to the catchment.

S1

The overall fisheries impact ranking for catchment S1 is **High**.

The impacts of the primary water-related impacts as well as the impacts on the related secondary indicators and receptors were all ranked as high within this catchment.

The overall sensitivity of the fisheries in this catchment varies from low to moderate. Watercourses supporting perennial cool water conditions, as well as many of the intermittent reaches and seasonal warm and cool water fish communities are located within high impact areas. Using a conservative approach in assessing the most sensitive reach and considering the range of related receptor impacts across the catchment, the overall impact ranking assigned to the catchment was high.

S2

The overall fisheries impact ranking for catchment S2 is **High**.

Catchment S2 is similar to Catchment R4 in that, over the length of the catchment, there is a large variation in the water-related changes. The primary indicator outputs for the upstream end of the catchment that is immediately adjacent to the Resource 9-A Area predict high levels of impact, however the downstream extent of these impacts is shown to end near the downstream end of the catchment.

As in R4, the most sensitive fish community (cold water brook trout spawning and refuge habitat) is located at the downstream end of the catchment where the impact on groundwater is low. However, the moderately sensitive reaches are located in the portion of the catchment where there is a high impact (e.g., refer to supplementary assessment area in Table 6-12). As well, impacts to all of the related secondary indicators and receptors were also ranked as high.

Therefore, applying the conservative and worst-case analysis approach, and integrating the results of the other indicator and receptor analyses, the overall fisheries impact for this catchment is high.

S3

The overall fisheries impact ranking for catchment S3 is **Low**.

The modelled impact on groundwater discharge is low and the hydroperiod impact is moderate. The catchment includes a mix of perennial and groundwater influenced habitats that support high sensitivity fisheries; however, there are no simulated changes in groundwater levels and discharge in these areas. The impacts of the component analyses of all of the indicators and receptors were ranked low.

Therefore, the overall impact on fisheries in this catchment was ranked as low based on the modeling results.

S4

The overall fisheries impact ranking for catchment S4 is **Low**.

The modeled groundwater water-related impacts are not shown as extending into S4. The impacts of the component analyses on all of the indicators and related receptors are ranked low.

Therefore, the overall impact ranking on fisheries in this catchment is Low.

SA

The overall fisheries impact ranking for catchment SA is **High**.

SA covers the headwater areas of both Third and Fourth Creeks. Within a large portion of the remaining area of this local catchment, there are no simulated changes in groundwater levels. However, Fourth Creek is the 'controlling' feature as the most sensitive reach within the SA. These reaches are located within the portion of the catchment that have a high impact on the groundwater discharge/baseflow.

Therefore, using the worst-case scenario approach. The impact on fisheries from changes in groundwater discharge/baseflow was ranked high. As well, the impacts of the analyses on all the related secondary indicators and receptors were ranked high. The impact on fisheries of the change in hydroperiod was ranked as moderate.

Using the overall conservative approach to determine the combined impact on fisheries, an overall ranking of high impact was assigned to the entire SA.

Scenario C

Scenario C models the rehabilitated conditions of Resource Area 9-A, as outlined in Section 5.3.3.

R1

The overall fisheries impact ranking for catchment R1 is **Low**.

There is no change on the groundwater condition within the catchment and the impact for hydroperiod as well as all of the other water dependent indicators is low, giving an overall fisheries impact of low in catchment R1.

R2

The overall fisheries impact ranking for catchment R2 is **Low**.

All indicators both primary and secondary show a low impact under Scenario C. Simulated changes in groundwater conditions are restricted to two small area adjacent to Resource 9-A, one of which shows an increase in groundwater elevations and one showing a decrease. Overall, impacts throughout the catchment are negligible to fisheries. Therefore, an overall ranking of low was assigned for catchment R2.

R3

The overall fisheries impact ranking for catchment R3 is **Low**.

The majority of catchment R3 will be rehabilitated into a lake condition in Scenario C. Under this condition the Resource 9-A area function as direct fish habitat and will also result in increased downstream flow within Rogers Creek. Both of these factors will increase the quantity of fish habitat, and also the quality of fish habitat, albeit in an altered form within Resource 9-A. As a result the overall impact to fisheries within catchment R3 will be positive and as a result a low impact ranking has been assigned.

R4

The overall fisheries impact ranking for catchment R4 is **Low**.

Channel form was ranked as a high impact, and groundwater, hydroperiod, water quality, and riparian wetlands were ranked as a low impact. Groundwater and surface water flow conditions will not change within the catchment. Therefore, the overall potential impacts on the fish community within the catchment are low.

R5

The overall fisheries impact ranking for catchment R5 is **Low**.

There is no change in the groundwater condition within the catchment and the impact of the hydroperiod as well as all of the other water dependent indicators is low. Therefore, an overall ranking of low was assigned to the catchment.

R6

The overall fisheries impact ranking for catchment R6 is **Low**.

All indicators were ranked as a low impact. There is a positive change within R6 due to increased flow associated with an increase in discharge to Rogers Creek as a result of the lake rehabilitation condition in Resource 9-A. As a result the overall impact to fisheries is low (and possibly positive).

S1

The overall fisheries impact ranking for catchment S1 is **Low**.

Channel form is ranked as a moderate impact, groundwater, water quality, and riparian wetlands were ranked as a moderate impact, and hydroperiod was ranked as a low impact.

The majority of the catchment shows an increase in groundwater levels as a result of the lake condition within Resource 9-A. The groundwater model results show changes to some intermittent cool and perennial cool fish communities that are likely over-estimated due to model construction and Scenario C15 refinement limitations. It is considered most reasonable to rank the overall impact as low on the basis that actual rehabilitation planning would provide sufficient protection of these fish communities.

S2

The overall fisheries impact ranking for catchment S2 is **Low**.

All primary and secondary indicator and related receptor impacts were ranked as a low, therefore the overall ranking for the catchment is low.

S3

The overall fisheries impact ranking for catchment S3 is **Low**.

All primary and secondary indicator and related receptor impacts were ranked as a low, therefore the overall ranking for the catchment is low.

S4

The overall fisheries impact ranking for catchment S4 is **Low**.

All primary and secondary indicator and related receptor impacts were ranked as a low, therefore the overall ranking for the catchment is low.

SA

The overall fisheries impact ranking for catchment SA is **Low**.

All primary and secondary indicator and related receptor impacts were ranked as a low, therefore the overall ranking for the catchment is low.

6.8 CUMULATIVE IMPACTS (INTEGRATION)

The fisheries assessment (Section 6.7) provides a high degree of integration of the various changes and impacts that may result from land use change in the Study Area as described in Section 6.7 and earlier portions of the CBSES due to the interdependencies of the fisheries impact flowpath. It is possible however, to conduct an even broader assessment of the cumulative or integrated impacts by combining the impacts of all the receptors considered in Section 6, as presented below.

The overall cumulative impact assessment integrates the findings of the impact assessments completed for the individual receptors located outside the Resource Area as presented in the preceding sections (Sections 6.1 to 6.7). The combined overall sensitivities/significance for the various receptors is presented and the combined results of the impact analyses for each catchment are assessed. The direct impacts by removal of the features within the Resouce Area itself have been previously presented in Section 4.

The overall sensitivity/significance map for the Study Area is developed by integrating the sensitivities for individual receptors. The resultant integrated sensitivity map is presented on Figure 6-22. The map illustrates the location and degree of sensitivity of features over the Study Area.

The overall cumulative impacts for the development scenarios are integrated into an overall assessment by combining the impacts associated with the individual receptors for each of the ten local assessment catchments within the CBSES Study Area as summarized in Table 6-2. The individual receptors are combined in a highly conservative worst-case scenario manner, whereby the worst-case impact associated with any receptor is used as the overall impact for the catchment.

Figure 6-23 maps the overall impact ranking for conditions under the hypothetical Scenario B which represents the worst-case scenario for active extraction of the full resource area without the use of mitigation. It is clearly evident from examination of Figure 6-23 that the majority of the Study Area would be impacted if this unrealistic scenario were to occur. The only areas that are not impacted to a high ranking, are in the western subcatchment (catchment R5) and downstream on Rogers Creek (catchment R6) and these two areas still have a moderate impact ranking. Each of the receptors considered is impacted to a high level in at least several catchments.

Figure 6-24 maps the overall impact ranking for the conditions under the approximation of Scenario C to a reasonable long-term rehabilitation situation. The majority of the Study Area, outside the Resource Area itself has an impact that is ranked as low which varies from a low negative impact, to no impact, to a positive impact for some areas and features. The only high impact ranking originates from calculated overbank flow impacts on fluvial geomorphology (channel form) west of the Resource Area which may be conservatively over-estimating the impacts that may be expected under an actual reasonable site-specific development implementation of rehabilitation conditions.

7 STUDY AREA OBJECTIVES

7.1 INTRODUCTION

Municipal planning documents, such as Official Plans, establish Goals and Objectives for a wide range of land use planning matters, including environmental protection and resource management. Goals are fairly broad statements intended to indicate a long term vision or direction for the municipality and objectives are more specific statements that indicate particular desired outcomes that will assist in achieving the overall vision established by the Goals.

For example, an environmental Goal could be: "To protect and steward ecosystems in the Town" and an Objective related to this Goal could be: "To protect, maintain, and, as appropriate, enhance and restore the quality and quantity of groundwater".

The Town of Caledon Official Plan contains wording regarding the balancing of goals, and states the following in Section 2.2.3:

> *"These Goals are to be read in their totality and in conjunction with each other. In preparing new policy and in reviewing specific proposals, it is the Town of Caledon's intent to balance all of the goals set out above, taking into account specific circumstances, and natural heritage, cultural heritage, social, community, natural resource and economic factors."*

The Town of Caledon Official Plan currently contains Town-wide goals and objectives. Through the CBSES, environmental objectives are being reviewed and developed in relation to the Study Area. This component of the CBSES will serve a number of purposes:

- Assess the completeness of the existing Town-wide environmental management objectives based on the ecosystem characterization work undertaken in Part A of the CBSES and supplement and add detail to these objectives if necessary;
- The objectives for the Study Area features will provide the basis for the development of quantitative environmental recommendations and management targets that are developed in Part C of the Study;

- The objectives and targets are used in Parts B and C to assist in evaluating various resource management alternatives within the Study Area and the selection of preferred management approaches;
- Once any additional supplemental objectives and targets are incorporated into the Caledon Official Plan, they will be used to guide the review of site-specific development applications.

Once completed, the CBSES will contain a range of recommendations, including potential policy changes to address and implement the findings of the Study. To be given formal effect, such policy changes are to be incorporated into the Official Plan or other approved agency documents. When considering potential policy changes and reviewing specific development proposals, municipalities must balance all the various goals and objectives set out in the Official Plan.

The following points summarize the considerations that have guided the development of objectives for the CBSES Study Area:

- The characterization of the Study Area completed in Part A has been considered, and objectives developed to reflect the understanding of significant features, functions and interrelationships identified in the Part A Report.
- Extensive consultation regarding the development of the objectives with the lead Agencies has occurred during the commencement of the Part B work.
- Sample objectives were developed by JDCL and the lead Agencies for discussion at the February 27th Public Workshop.
- Input from the public consultation program, in particular the February 27th Public Workshop which was designed to obtain public input on the Study Area objectives was integrated.
- Comprehensive review and consideration of existing goals and objectives from the upper tier and lower tier Official Plans was undertaken. These existing goals and objectives apply across the Study Area and are taken as the starting point for consideration of any more specific objectives for the Study Area arising from the CBSES.

  In considering these objectives, the specific policies and performance measures that apply to mineral aggregate operations as outlined in Section 5.11.2.2.6 of the Caledon

Official Plan must also be referenced. As stated in the Official Plan, satisfying the performance measures of Section 5.11.2.2.6 satisfies the Ecosystem Objectives of Section 3.1.2.

The following sections present the objectives that have been considered and developed through the CBSES. There is overlap between the goals, objectives and Official Plan policies, and some policies incorporate or elaborate on objectives. This section of the CBSES provides key objectives for reference, but should be read in the context of the entire documents to ensure all matters are taken into account.

Other Official Plans applicable within the Study Area have been consulted as part of the goals and objectives exercise in order to determine if additional goals and objectives should be referenced for the purposes of the CBSES. The goals and objectives in the Official Plans for Wellington County, the Town of Erin, Halton Region, and the Town of Halton Hills that are applicable to the CBSES are generally covered in the Region of Peel and Town of Caledon Official Plans and have not been repeated here.

7.2 GENERAL GOALS AND OBJECTIVES

General goals and objectives applicable to all disciplines are summarized as follows and will be considered in reviewing all disciplines:

- *"To recognize, respect, preserve and enhance the importance of ecosystem features and functions and enhance the environmental well-being of air, water, land resources and living organisms."* (1.3.6.2 - Peel OP).
- *"To create and maintain a system of viable, well-functioning environmental features to ensure a healthy, resilient and self-sustaining natural environment within Peel Region."* (2.1.2 - Peel OP).
- *"To recognize and promote the connections between local ecosystem functions and large environmental systems and contribute to the protection of these larger non-localized systems."* (2.2.1.1 - Peel OP).
- *"To conserve and maintain the integrity of Peel's air, water and land resources."* (2.2.1.2 - Peel OP).
- *"To identify, protect and support the restoration and rehabilitation of the Greenlands System in Peel."* (2.3.1 - Peel OP).
- *"To protect and steward ecosystems in the Town"* (2.2.3 - Town OP)

- *"That the Town will seek to preserve, protect and enhance natural physical features and biological communities and cultural heritage resources".* (2.2.1.a - Town OP)
- *"To protect, maintain, and, as appropriate, enhance and restore ecosystem functions and processes vital to the integrity of communities (both natural and cultural), particularly in relation to:*
  - *air quality;*
  - *groundwater quality and quantity, recharge and discharge;*
  - *surface water quality and quantity;*
  - *soil fertility; and,*
  - *biota.*" (3.1.2.1.1 - Town OP)
- *"To protect, maintain, and, as appropriate, enhance and restore ecosystem attributes and values, including:*
  - *connectivity;*
  - *viability / self sustainability;*
  - *biological diversity;*
  - *dynamics; and,*
  - *aesthetics (natural scenery)." (3.1.2.1.2 - Town OP)*
- *"To protect, maintain, and, as appropriate, enhance and restore physical and biological systems and features that support ecosystem integrity and associated functions, processes, attributes and values, including:*
  - *bedrock and surficial geology;*
  - *landforms, topography and soils;*
  - *groundwater and aquifers;*
  - *surface water systems including: watersheds and subwatersheds; rivers and streams (permanent and intermittent); valley and stream corridors; and, lakes and ponds;*
  - *fisheries and wildlife;*
  - *wetlands and woodlands; and,*
  - *ANSI's and ESA's." (3.1.2.1.3 - Town OP)*

7.3 VARIOUS DISCIPLINES

Groundwater

a) *"To protect, maintain and enhance the quantity and quality of water resources for the supply of potable water and maintenance of ecosystem integrity in Peel".* (3.4.1.1 - Peel OP).

b) *"To eliminate or minimize negative potential land use impacts on headwater recharge and discharge areas, groundwater aquifers, producing wells, stream base flow, surface water, downstream aquatic systems and related natural systems."* (3.4.1.2 - Peel OP).

c) *"To increase the collective knowledge of water resources in and adjacent to Peel through the study, analysis and monitoring of these resources."* (3.4.1.3 - Peel OP).

d) *"New development must ensure that the quality and quantity of groundwater recharge and discharge and the flow distribution of groundwater (including groundwater - surface water interconnections and contributions to stream baseflow) are protected, maintained, and, where appropriate, enhanced and restored".* (3.1.5.12.1 - Town OP)

e) *"Areas of groundwater recharge capability, and groundwater discharge zones, as identified through broader scale studies, shall be subject to further detailed hydrogeological study requirements. Critical recharge and discharge areas, as identified through such studies, shall be excluded from development and placed in an appropriate restrictive land use designation such as EPA."* (3.1.5.12.2 - Town OP)[1]

f) *"The restoration of degraded groundwater recharge and discharge zones, and the establishment of appropriate ecosystem linkages utilizing groundwater recharge discharge zones is strongly encouraged, and may be required as a condition of development approval".* (3.1.5.12.4 - Town OP)

g) *"New development shall not negatively impact the quality and quantity of groundwater aquifers."* (3.1.5.12.5 - Town OP).

h) *"The establishment of new water taking uses such as municipal water supply production wells, golf course irrigation systems and commercial water suppliers shall adhere to the Town's ecosystem principle, goal, objectives, policies and performance measures, as well as those of applicable agencies."* (3.1.5.12.6 - Town OP).

i) *"The management and use of groundwater must adhere to the Town's ecosystem principle, goal, objectives, policies and performance measures, as well as any applicable policies and guidelines established by other relevant agencies".* (3.2.5.12.9 - Town OP)

j) Groundwater transfers between catchments should be maintained. (CBSES recommendation)

k) Planning for the Study Area should address the current scientific community 's understanding of the impact of climate change on future weather patterns and compensate for the changes by protecting and / or enhancing current surface and ground water conditions as appropriate. (CBSES recommendation)

l) Changes to features and / or land uses should recognize and mitigate, as appropriate, the potential effects of long-term global climate change (e.g., increased severity of storm events and drought conditions). (CBSES recommendation)

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1 See policy 5.11.2.2.6.f, which includes performance measures for mineral aggregate operations.

m) To protect, maintain, and enhance the quantity and quality of water resources for the supply of water for potable and other uses. (CBSES recommendation)

Surface Water

a) *"To eliminate or minimize negative potential land use impacts on headwater recharge and discharge areas, groundwater aquifers, producing wells, stream base flow, surface water, downstream aquatic systems and related natural systems."* (3.4.1.2 - Peel OP).

b) *"To increase the collective knowledge of water resources in and adjacent to Peel through the study, analysis and monitoring of these resources."* (3.4.1.3 - Peel OP).

c) *"The quality and quantity of surface water entering Wetland Core Areas shall be maintained and, where appropriate, enhanced and restored, to the satisfaction of the Town, the relevant Conservation Authority, the Niagara Escarpment Commission, where applicable, and the Ministry of Natural Resources".* (3.1.5.4.5 - Town OP)

d) *"The quality and quantity of surface water entering Core Fishery Resource Areas shall be maintained and, where appropriate, enhanced and restored, to the satisfaction of the Town, the relevant Conservation Authority, the Niagara Escarpment Commission, where applicable, and the Ministry of Natural Resources".* (3.1.5.10.4 - Town OP)

e) *"The quality and quantity of surface water entering Valley and Stream Corridors shall be maintained and, where appropriate, enhanced and restored, to the satisfaction of the Town, the relevant Conservation Authority, the Niagara Escarpment Commission, where applicable, and the Ministry of Natural Resources".* (3.1.5.11.4 - Town OP)

f) *"Restoration and enhancement of Valley and Stream Corridors is encouraged. Where appropriate, a riparian habitat zone shall be maintained or established on lands abutting watercourses and waterbodies to the satisfaction of the Town, the relevant Conservation Authority, the Niagara Escarpment Commission, where applicable, and the Ministry of Natural Resources".* (3.1.5.11.5 - Town OP)

g) *"Management and restoration of Valley and Stream Corridors shall adhere to the Town's ecosystem principle, goal, objectives, policies and performance measures, as well as any applicable policies or guidelines established by the relevant Conservation Authority, the Niagara Escarpment Commission, where applicable, and the Ministry of Natural Resources, and the Niagara Escarpment Plan, where applicable."* (3.1.5.5.3 - Town OP)

h) Maintain and/or enhance the hydrologic system including peak flows, low flows and baseflow discharge to intermittent and permanent streams. (CBSES recommendation)

i) As appropriate, maintain the existing flow and sediment conditions in watercourses and provide for enhancements in sensitive reaches. (CBSES recommendation)

j) Protect and/or enhance water quality (including temperature) conditions to protect or enhance the structure and diversity of the aquatic life. (CBSES recommendation)

k) It should be noted that the objectives related to climate change listed in 3.1.l and 3.1.m are also applicable to surface water.

Fisheries

a) *"To create and maintain a system of viable, well-functioning environmental features to ensure a healthy, resilient and self-sustaining natural environment within Peel Region."* (2.1.2 - Peel OP).

b) *"Restoration and enhancement of Fishery Resource Areas is encouraged. Where appropriate, a riparian habitat zone shall be maintained or established on lands abutting Fishery Resource Areas to the satisfaction of the Town, the Ministry of Natural Resources, the relevant Conservation Authority, and the Niagara Escarpment Commission, where applicable".* (3.1.5.10.6 - Town OP)

c) All fish communities and habitats, including contributing habitats and their associated functions, should be protected, maintained and, as appropriate (that is, subject to natural and practical limitations), enhanced and restored. Harmful alteration, disruption or destruction of fish habitat (HADD) is not permitted unless authorized by Fisheries and Oceans Canada. (CBSES recommendation - variance of Town Official Plan policies 3.1.5.10.1, 3.1.5.10.2, and 3.1.5.10.3)[2]

d) As appropriate (that is, subject to natural and practical limitations), man-made barriers should be mitigated or removed and flow regimes of intermittent reaches maintained or restored to improve aquatic connectivity. (CBSES recommendation)

e) It should be noted that the surface and groundwater objectives that pertain to protection of surface and groundwater resources, and specifically listed in 3.1.a, 3.1.b, 3.1.d, 3.1.f, 3.2.a, 3.2.c, 3.2.d, 3.2.e, 3.2.g, 3.2.h, 3.2.i, 3.2.j and 3.2.k are also applicable to fisheries.

Woodlands, Wetlands and Wildlife

a) *"Protect, maintain and enhance the quality and integrity of ecosystems, including air, water, land and biota jointly with the area municipalities, conservation authorities and provincial agencies."* (2.1.3.2 - Peel OP).

b) *"To recognize and promote the connections between local ecosystem functions and large environmental systems and contribute to the protection of these larger non-localized systems."* (2.2.1.1 - Peel OP).

[2] See policy 5.11.2.2.6.e, which includes performance measures for mineral aggregate operations.

c) *"To identify, protect, maintain, and, as appropriate, enhance and restore ecosystem forms, functions and integrity within Caledon through the implementation of appropriate designations, policies and programs."* (3.1.2.2.2 - Town OP).

d) *"The re-establishment of native forest ecosystems in currently non-wooded areas is strongly encouraged. Such reforestation initiatives should be guided by the ecosystem principle, goal and objectives of this Plan and should be implemented through an approved EIS & MP, Forest Management Plan, Environmental Management Plan, or comparable document".* (3.1.5.3.4 - Town OP).[3]

e) *"Management and restoration of ANSI's shall adhere to the Town's ecosystem principle, goal, objectives, policies and performance measures, as well as any relevant policies or guidelines established by the Ministry of Natural Resources, and the Niagara Escarpment Plan, where applicable."* (3.1.5.5.3 - Town OP)

f) *"Management and restoration of ESA's shall adhere to the Town's ecosystem principle, goal, objectives, policies and performance measures, as well as any relevant policies or guidelines established by the Ministry of Natural Resources, and the Niagara Escarpment Plan, where applicable."* (3.1.5.6.3 - Town OP)

g) Maintain a diversity of wildlife habitat types, with particular emphasis on native species and natural, native communities. (CBSES recommendation)

h) Protect, maintain and, as appropriate (that is, subject to natural and practical limitations), enhance and restore, the functions and connectivity of wildlife habitats, with particular emphasis on key habitats. (CBSES recommendation)

i) Protect, maintain and, as appropriate (that is, subject to natural and practical limitations), enhance and restore, natural vegetation and associated connectivity of regional corridors and local linkages. (CBSES recommendation)

j) As appropriate (that is, subject to natural and practical limitations), reduce habitat fragmentation by restoring native natural habitats between existing natural features to encourage habitat linkages and wildlife movement. (CBSES recommendation)

k) It should be noted that many of the surface and groundwater objectives, and specifically objectives 3.1.a, 3.1.b, 3.1.f, 3.2.a, 3.2.c, are also applicable to wetlands (and their associated wildlife).

[3] See policy 5.11.2.2.6.h, which includes performance measures for mineral aggregate operations.

Community Objectives

The public consultation program associated with the CBSES identified a desire for community objectives related to social conditions in the Study Area.

The Part A Report discusses the interrelationship between social conditions and the natural environment. Section 4.1 of the Part A Report recognizes that land uses within the Study Area are dependant on well water supplies, and notes that the quality of life in the Study Area is connected to the rural setting and the natural features in the area.

Accordingly, many of the objectives related to groundwater, surface water, fisheries, and woodlands, wetlands and wildlife also address and protect community values identified through the CBSES and the public consultation program.

In addition, the existing Official Plans for the Study Area municipalities include goals and objectives intended to address community values. These are not being reviewed as part of the CBSES, but a selection of objectives are listed below for the Town of Caledon in order to illustrate what is in place to ensure community values are taken into account in planning processes.

a) *"To create a healthy regional community of communities for those living and working in Peel which is characterized by physical, mental, economic and social well-being; minimized crime, hunger and homelessness; a recognition and preservation of the region's natural and cultural heritage; and an emphasis on the importance of Peel's future as a caring community."* (1.3.6.1 - Peel OP)

b) *"To promote healthy rural communities that contain living, working and recreational opportunities, and respect the natural environment and resources."* (5.4.1.3 - Peel OP)

c) *"To maintain and enhance the quality of the Rural System while allowing choices in alternative rural lifestyles."* (5.4.1.4 - Peel OP)

d) *"To preserve and enhance the distinct character, cultural attributes and historical heritage of the rural area."* (5.4.6.1.1 - Peel OP)

e) *"That the Town will seek to improve the health and well-being of residents, employees, landowners and businesses by fostering the development of communities where individuals can pursue diverse goals for personal development and where individual needs for employment, learning, culture, recreation, physical and social well-being can be satisfied."* (2.2.1.b - Town OP)

f) *"As a municipality with a strong rural character, adjacent to a large urban area where urban activities are intensifying rapidly, the responsibility for conserving the resources and related rural ambiance of the Town is a major basis for the policies of this Plan."* (2.2.2.a - Town OP)

g) *"To conserve and promote cultural heritage resources in recognition of the non-replaceable nature of cultural heritage, as well as the contribution it makes to the character, civic pride, tourism potential, economic benefits and historical appreciation of the community."* (2.2.3 - Town OP)

h) *"To provide residents with a quality of community life that provides access to community based services in a manner that best responds to the need for employment, learning, shopping, culture, recreation and social opportunities".* (2.2.3 - Town OP)

i) *"To provide residents with an open space system which promotes a diversity of recreational and leisure opportunities".* (2.2.3 - Town OP)

j) *"To prevent undue property damage and reduce the potential for injury and loss of life as a result of naturally occurring hazards".* (2.2.3 - Town OP)

k) *"To encourage the preservation of present and future recreational linear trail systems in their present conditions for the benefit of citizens within the Town and beyond".* (5.2.2.e - Town OP)

l) *"To preserve the unique rural character of the landscape and in particular, the Oak Ridges Moraine Complex and the Niagara Escarpment."* (5.2.2.f - Town OP)

m) *"To maximize the development or preservation of the natural resources of the Town for recreation and conservation purposes."* (5.2.2.g - Town OP)

n) *"To develop and maintain a system of parks and publicly accessible open spaces, which provide for a diversity of recreational and leisure opportunities for a range of age and interest groups."* (5.8.2.1 - Town OP)

o) *"The Town shall ensure that all natural environment based recreational activities are consistent with the environmental policies and performance measures of this Plan."* (5.8.3.2 - Town OP)

With regard to impacts on land uses and residents associated with aggregate extraction, the Town of Caledon Official Plan includes current and comprehensive policies addressing issues such as noise, dust, vibration, traffic, and visual impacts. These policies should also be referred to in order to understand how impacts on Study Area residents are addressed.

Aggregate Resource Objectives

The emphasis of the CBSES is on aggregate development within Resource Area 9-A9-A, given the triggering application and the fact that a portion of the Study Area is identified as High Potential Mineral Aggregate Resource Area in both the Town of Caledon and Region of Peel Official Plans. The Town of Caledon Official Plan was recently updated and contains detailed aggregate policies and specific objectives related to aggregate resource development.

The following objectives from the aggregate policies section in the Town of Caledon Official Plan are not being reviewed through the CBSES but are listed below in order to reference the relevant objectives applicable to the Study Area. These objectives have to be taken into account in reviewing development applications and during other planning processes.

a) *"To identify high potential mineral aggregate resource areas, to protect them for possible use and to establish policies that allow as much of the resource as is realistically possible to be made available for use to supply resource needs, in a manner consistent with this Plan, the Niagara Escarpment Plan, where applicable, and the area municipal official plans."* (3.3.1.1 - Peel OP)

b) *"To recognize the Region's mineral aggregate resource industry as an important component of the Region's economic base."* (3.3.1.2 - Peel OP)

c) *"To achieve a balance between the demand for, and economic benefits of resource extraction activity and the protection of Peel's communities, natural environment, cultural heritage and other resources."* (3.3.1.3 - Peel OP)

d) *"To support initiatives for the rehabilitation of abandoned pits and quarries and to require the progressive rehabilitation of operating pits and quarries."* (3.3.1.4 - Peel OP)

e) *"To balance the protection and use of mineral aggregate resources now and in the future with other goals of the Town of Caledon as expressed in the Official Plan, including, but not limited to, maintenance of the local community/social values; protection and stewardship of the Town of Caledon's natural ecosystems and cultural/human heritage resources; and strengthening the local economy and tax base".* (2.2.3 - Town OP)

f) *"To recognize the Town of Caledon's mineral aggregate resource industry as an important component of the Town of Caledon's economic base and to provide for the continuation of presently licensed mineral extraction operations; to protect existing licensed facilities from new adjacent land* *uses which may hinder their operation; and to stress the need for progressive rehabilitation in existing facilities, as well as rehabilitation of abandoned pits and quarries".* (2.2.3 - Town OP)

g) *"To identify high potential mineral aggregate resource areas in Caledon, to protect them for possible use and to establish policies that allow as much of the resource as is realistically possible to be made available for use, to supply resource needs, in a manner consistent with this Plan and the Niagara Escarpment Plan where applicable".* (2.2.3 - Town OP)

h) *"To ensure that the extraction of aggregate resources is undertaken in a balanced manner which adheres to the Ecosystem Planing and Management Objectives contained in Section 3.1 of the Plan and which will recognize Caledon's community character and social values over the short and long term."* (5.11.1.1 - Town OP)

i) *"To provide a framework for orderly extraction of aggregate resources that provides for a greater degree of certainty to both the aggregate industry and the community, ensures the efficient use of infrastructure, minimizes impacts, and encourages timely rehabilitation."* (5.11.1.2 - Town OP)

j) *"To provide a framework to allow as much of the aggregate resource as is realistically possible to be made available for use."* (5.11.1.3 - Town OP)

k) *"To protect aggregate resources identified as Caledon High Potential Mineral Aggregate Resource Areas (CHPMARA) as identified on Schedule L for possible future extraction. Development within or adjacent to the protected areas that would preclude or hinder extraction or access to the aggregate resources will be restricted."* (5.11.1.4 - Town OP)

l) *"To minimize the impact of aggregate related traffic on the community."* (5.11.1.5 - Town OP)

m) *"To establish a set of clear, balanced, and standard criteria for evaluating applications for new or expanded aggregate operations that will contribute to achieving the goals and objectives of this Plan."* (5.11.1.6 - Town OP)

n) *"To minimize the disturbed area and achieve beneficial end uses by encouraging and promoting the speedy, progressive and final rehabilitation of both new and older aggregate operations and the preparation of a Rehabilitation Master Plan for each of the ten aggregate resource areas."* (5.11.1.7 - Town OP)

o) *"To improve aggregate resource management in Caledon through co-operation with the aggregate industry and other stakeholders in joint sponsorship or ventures."* (5.11.1.8 - Town OP)

Other Land Use Objectives

It should also be recognized that the Study Area contains other land uses such as Agriculture, Transportation, and Public Uses, and that there are objectives related to these land uses in the Official Plan.

These objectives are not being reviewed as part of the CBSES, but reference can be made to Sections 2.2.1, 2.2.3, 5.1, 5.8, 5.9, and 5.15 of the Town of Caledon Official Plan for applicable goals and objectives related to these uses.

In addition, Sections 3.2.1, 3.5.1, 5.6.1, 5.6.3.1, 5.6.4.1, 5.6.5.1, and 5.6.7.1 of the Region of Peel Official Plan contain similar objectives related to these other land uses.

8 INTRODUCTION TO MANAGEMENT SOLUTIONS

The previous sections of this Part B report have set out the sensitivity analysis impact assessment for the potential (worst case) effects of the development of Resource Area 9-A and the identified environmental protection objectives for the Study Area. This Section of the report considers the management options in respect of the impact assessment and objectives.

8.1 TYPES OF OPTIONS

There are a variety of options available for managing the development of Resource Area 9-A. These options include:

Do Nothing Approach

This approach acknowledges that there will be future land use changes and chooses not to intervene with offsetting mitigative actions. It is clearly evident from the Scenario B impact assessment (Section 6) that this approach is not consistent with the vision, goals, and objectives for the Study Area, as well as municipal, provincial, and federal policies and legislation.

Structural Measures

This approach acknowledges that there will be future land use changes and allows the potential effects of any land use change to be managed and mitigated to prevent or offset impacts that may occur.

Non-Structural Measures

This approach acknowledges that there will be future land use changes and allows for changes while utilizing management solutions that call for changes to human behaviours and management practices.

Avoidance

This approach does not acknowledge that there will be future land use changes and therefore supports the status quo conditions. This approach is not realistic given the potential for land use change in the Study Area, Provincial Policy, and particularly the Provincial, Regional, and Municipal commitment to the Caledon High Potential Mineral Aggregate Resource Area (CHPMARA) 9-A.

Upon review of the above options, it becomes clear that the implementation of structural and non-structural measures is the most viable approach. Large-scale development that addresses the objectives for the Study Area is not feasible in the absence of structural measures. The following Section 8.2 identifies a number of available measures based on the primary study disciplines. It must be recognized that there is significant overlap between the study disciplines given their functional inter-relationships, particularly with the hydrogeology aspects. The selection and implementation of appropriate measures will also depend upon various site-specific considerations.

While the CBSES is focused on managing potential development within the Study Area and particularly the development of Resource Area 9-A, the evaluation of any actions within the Study Area (including evaluation of development plans) should consider the potential effects of climate change to ascertain the likely effects and implement measures to manage or mitigate as appropriate. The potential effects of climate change are beyond the scope of the CBSES; however, CVC is currently undertaking assessment of the potential effects of climate change and these/future findings should be considered in conjunction with the findings, and application of the findings, of the CBSES.

8.2 MANAGEMENT MEASURES

Hydrogeology

The principal consideration for managing the potential effects of aggregate development within the Study Area is to minimize changes to the groundwater levels. Changes in groundwater levels have the potential to affect all of the receptors and secondary indicators, that is, water supplies, streamflow, fisheries and benthic invertebrates, and wetlands, as well as water quality and fluvial geomorphology.

There are a number of measures available to manage groundwater levels and flows, including those described below:

- Extraction of Resource Area in multiple cells to allow rehabilitation conditions to utilize lakes to restore water levels similar to natural levels. Planning must include consideration of the overall Resource Area development as illustrated by Scenario C and, in particular, any existing or approved adjacent development;
- Ongoing storage and management of water collected from quarry dewatering to maximize available water available for mitigation and minimize lake filling time post-extraction. This may include transfers of water between active extraction and rehabilitation areas;
- Sub-aqueous extraction of bedrock to allow rock extraction with minimal lowering of groundwater levels;
- Groundwater recharge to maintain groundwater levels around the quarry excavation when dewatering is occurring. Groundwater recharge methods can include recharge through ponds, trenches, and/or wells;
- Controlling groundwater inflow/outflow from quarry cells (or rehabilitation lakes) using hydraulic buffers such as earthen buttresses, grout curtains, or other means;
- In topographically low areas, it may be beneficial to raise lake levels somewhat above existing ground surface by establishing hydraulic berms (as is commonly used in pond construction) or to avoid extraction of such areas; and
- Transfer of water between quarry cells to help control lake levels as well as route excess water to appropriate discharge locations.

Related measures to manage groundwater implications on water quality and quantity include:

- Management of water quality through storm water management (e.g., settling ponds), management of fuel, hydraulics fluids, and maintenance chemicals, and careful selection and use of explosives; and

- Protection of potable water quantity and quality through measures identified above in addition to regular monitoring and further actions if necessary (e.g., deepen wells, local treatment, communal water supply solutions).

Monitoring and related response to monitoring findings by adjusting the protection/management measures is a key element to managing groundwater levels:

- Adaptive Management principles should be applied at both the site-specific and Study Area scales to ensure appropriate ongoing monitoring, evaluation, and management of individual activities and the overall development of the Study Area.

Groundwater levels can also be affected by other activities in the Study Area. Therefore, broader management measures include:

- Develop programs to encourage environmental understanding and stewardship within the Study Area in relation to management of increased recreational use of the area, agricultural activities, and rural residential activities.

Hydrology

The implementation of the hydrogeologic protection measures also address many of the hydrologic aspects, since the groundwater and surface water systems are highly inter-related. In addition to the measures identified above, measures that can provide further hydrologic management/mitigation, include:

- Maintaining/enhancing natural infiltration of precipitation and surface water where appropriate;
- "Stormwater" management measures to store, manage, and release water to downstream surface water systems to minimize effects on flooding, water quality, fluvial geomorphological processes, and aquatic and wetland habitats;
- Drainage improvements to reduce overall erosion and effects of runoff;
- Review of opportunities to modify existing drainage systems to enhance baseflow; and
- Application of monitoring and adaptive management principles at both the site-specific and Study Area scales are again relevant to ensure appropriate ongoing monitoring, evaluation, and management of individual activities and the overall development of the Study Area.

It is noted that the overall effects of aggregate extraction can counteract the effects of other forms of development and/or climate change through the capture and storage of storm event precipitation and surface water flows. Many forms of development (e.g., urbanization, road improvements, etc.) limit infiltration and increase runoff and flooding. The generally anticipated effects of climate change include increased temperatures and severity of storm events and droughts which will also tend to limit infiltration and increase runoff and flooding. The effects of aggregate extraction and related management features can serve to counteract these changes by capturing runoff and enhancing infiltration.

Terrestrial

The implementation of the water-related protection measures also address the majority of the terrestrial needs, particularly for wetlands that are directly dependent on groundwater and/or surface. Stewardship initiatives are also an important aspect of managing terrestrial features. In addition to the measures identified above, measures that can provide further terrestrial management/mitigation and enhancement, include:

- Identification and protection of key terrestrial habitat features and functions;
- Restoring and enhancing vegetative communities and habitats in both upland and wetland environments;
- Enhancing the main corridor systems as well as local linkages to improve connectivity among the natural areas;
- Enhancing 'buffers' around more sensitive natural areas;
- Promoting the use of wetlands in aggregate extraction rehabilitation to increase the amount and diversity of wetland communities within the Study Area;
- Promoting the creation of natural areas and habitats within the aggregate rehabilitation plans; and
- Ensuring that the water-resource related monitoring and adaptive management principles integrate consideration of the specific wetland sensitivities and functions.

Aquatic

The implementation of the water-related protection measures also address the majority of the aquatic needs, again, given the direct dependence of fish habitat, fish and benthic invertebrates on groundwater and/or surface water. The inter-related protection of water quality and fluvial geomorphological processes through management of groundwater and surface water also in turn protects fish and aquatic habitat, and the associated aquatic biota. Stewardship initiatives are again an important aspect of managing aquatic features.

In addition to the measures identified above, measures that can provide further aquatic management/mitigation and enhancement, include:

- Stream corridor improvements such as re-vegetation of riparian areas and enhancement of associated stream buffering functions. This measure can also be closely linked to enhancing terrestrial connectivity;
- Assessment of opportunities to remove of man-made (or other) 'barriers' along streams that affect movement of fish, as well as movement of sediment and fluvial processes, and increase thermal loading. It is noted that a number of considerations are relevant to the assessment of barrier removal;
- Re-vegetation of headwater areas generally, to benefit natural recharge of groundwater and stream baseflow processes. Again this measure can be closely integrated with terrestrial benefits;
- Promoting the creation of a diversity of aquatic habitats within aggregate rehabilitation plans. Other opportunities to enhance aquatic features in the rehabilitation design may include such aspects as improving coldwater baseflow to coldwater stream habitats;
- Ensuring that the water-resource related monitoring and adaptive management principles integrate consideration of the specific aquatic sensitivities and functions.
- Managing access of cattle and other pastured animals to streams; and
- Employing a variety of measures to re-naturalize modified reaches of streams, particularly through the upper portion of the Study Area, and site specific measures to enhance habitat diversity and quality generally.

9 FUTURE WORK

This concludes the work carried out under Part B of the CBSES. Future work regarding the CBSES includes the production of the Part C Report (Implementation), which will occur later in Summer 2007. The Part C Report will synthesize the results of Parts A & B of the CBSES, and provide direction and recommendations that will guide future work related to Site-specific applications for aggregate extraction. Part C of the CBSES will also include an analysis of the natural heritage systems included in the existing Official Plans for the Study Area, and the recommendations for future mapping refinement where applicable.