# Rouge River Watershed

## Scenario Modelling and Analysis Report

## Chapter 5.0
## Summary and Recommendations

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5.0

# SUMMARY AND RECOMMENDATIONS

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To provide effective guidance for the protection and enhancement of the Rouge watershed, the TRCA and Rouge Park, in cooperation with the multi-stakeholder Rouge Watershed Task Force undertook an innovative modelling and analysis study, as one component of an overall watershed planning exercise. This study involved prediction of the watershed's response for a range of ecosystem indicators to scenarios of potential future watershed land use, climate and management strategies.

Section 5.1 provides an overview of the integrated study design. Section 5.2 summarizes the key findings of this work, which have contributed to an improved understanding of the interdependencies of watershed systems, their sensitivity to change and the relative effectiveness of various management actions. Section 5.3 describes the overall management strategies that appear to be the most effective at achieving goals and objectives for watershed health and Section 5.4 identifies how these study results were used.

## 5.1 Integrated Study Design

The modelling and analysis study design was guided by the following questions, which arose from a review of five primary watershed issues and opportunities identified in Phase 1 of the overall watershed planning study:

- **Urban growth:** How will different extents of urban growth affect watershed conditions? Can different forms of urban community design reduce the impacts? How would the protection of lands in the Greenbelt, Rouge Park, and as conceived in Markham's draft Small Streams study affect watershed conditions?
- **Natural cover:** What are the opportunities for expanding natural cover and how would expanded natural cover affect watershed conditions?
- **Stormwater management/retrofits:** How effective would retrofits of end-of-pipe stormwater management ponds be in addressing water management problems? What would be the cumulative effect of lot level, conveyance and end-of-pipe stormwater management practices in new greenfield developments and retrofits in existing urban communities?
- **Sustainable practices:** What would be the cumulative effect of a range of sustainable practices on watershed conditions, if implemented throughout the watershed?
- **Climate change:** How will climate change affect watershed conditions? Can the adoption of sustainable practices mitigate these effects?

A series of eight land use and management scenarios were formulated to depict the possible futures contemplated in the study questions. The scenarios were as follows:

1. Baseline conditions (2002)
2. Official plan (OP) build-out
3. End-of-pipe stormwater retrofit
4. Expanded natural cover
5. End-of-pipe stormwater retrofit and expanded natural cover
6. Full build-out
7. Sustainable community (includes programs in new and existing developments)
8. Climate change (two 2080 climate change predictions applied to scenarios 6 and 7)

The scenarios thereby provided a common basis from which to model/predict and evaluate the watershed's response for a range of ecosystem indicators. Predictive tools included a combination of computerized mathematical models, empirical relationships and professional judgement as follows:

- Surface water balance - WABAS (Water Balance Analysis System) – a distributed continuous water budget model;

- Surface water hydrology and water quality - HSP-F (Hydrological Simulation Program – Fortran) – a continuous hydrologic model with water quality simulation capabilities;

- Groundwater - MODFLOW (Modular Flow System – Fortran) – a three-dimensional finite difference numerical groundwater flow model;

- Aquatic system - LSAT (Landscape and Stream Assessment Tool) – an aquatic community predictive model based on established relationships between land cover and habitat/species;

- Terrestrial system – TRCA's Landscape Analysis Model and Terrestrial Natural Heritage System Design Tool - GIS based terrestrial natural heritage models based on principles of landscape ecology;

- Cultural Heritage – TRCA's probability model for archaeological potential and professional judgement;

- Nature-based Recreation - Professional judgement and literature.

Predicted effects of each scenario were evaluated in terms of acceptability with respect to established watershed goals and objectives and working targets. An overall watershed response model illustrated the pathways and linkages among the individual systems and was used to guide the integrated analysis. The individual models were linked in that often output from one model was required as input to another. Care was taken throughout the study to ensure the compatibility and comparability of study results.

## 5.2 Summary of Scenario Modelling Results

As illustrated in the Watershed Response Model shown in Chapter 1, changes in climate and land cover affect a series of changes in the watershed's surface water, groundwater and aquatic systems through hydrologic pathways, and impose related direct and indirect impacts to terrestrial natural heritage and cultural and nature-based recreational resources. This pattern of watershed responses also emerged from the analysis of scenarios addressing: conventional urban development, end of pipe stormwater management retrofit ponds, expanded natural cover, sustainable community design and climate change.

<u>Conventional urban development</u>

The build out scenarios assumed urbanization according to the existing official plans and potential full build out to the Greenbelt boundary, using conventional approaches to development and stormwater management. Much of the future development will occur in the watersheds of the Main Rouge and its tributaries. The analysis predicted the following changes in water budget, surface water flow, water quality and groundwater systems as a result of build out in the Rouge watershed:

- Altered water budget of the Rouge watershed as evapotranspiration and infiltration will be reduced and more precipitation will run off newly created impervious surfaces;
- Increases in total annual stream flow volumes due to increased runoff in proportion to the degree of upstream development and impervious cover, with the greatest increases in summer. This is particularly significant in the Upper Main Rouge where development will occur on sand and loam soils and result in larger decreases in infiltration and therefore greater increases in runoff. Stormwater management detention ponds designed according to conventional criteria (control of peak flows from synthetic design events to existing levels and extended detention for erosion control) will reduce the impact of increased runoff by providing storage and slower release of the greater volume of flows, but these may not be sufficient to completely mitigate flooding and erosion impacts, particularly when considering cumulative effects at the subwatershed and watershed scale. Further, the extended discharge from ponds, combined with a reduction in infiltration, will result in a greater proportion of low flows in streams between storm events being comprised of stormwater runoff rather than groundwater discharge, particularly in summer months.
- Increases of 5-45% in in-stream erosion potential, in proportion to the degree of upstream development and permeability of upstream soils, despite implementation

of extended detention stormwater ponds in new development. Anticipated increases in erosion potential on the Main Rouge and its tributaries are greater than on the Little Rouge, in large part because more of the upstream drainage area is assumed to be developed;

- Potential reduction in local recharge of silt/sand lenses overlying clay till in the projected growth area of north Markham. Discharge from these lenses may be important in sustaining baseflow and aquatic habitat in local streams;
- Decreases in recharge of the Oak Ridges Aquifer of up to 175 mm/yr locally (an approximate reduction of 7% in total annual watershed recharge) under the official plan scenario. These effects are particularly noticeable, because of the relatively permeable soils underlying the urban lands of the official plans. Smaller decreases in recharge of 10-25 mm/yr will likely occur under the full build out (additional 1% drop in total annual recharge), as a result of the limited existing infiltration capacity where development is projected to occur;
- Reduction in the Oak Ridges Aquifer water level of up to about 5 m, which is 2-5 times the current average annual water level fluctuation. Only an additional 0.5 m drop is predicted in response to the full build out. While not expected to have widespread impacts due to the presence of relatively few residential wells, reductions in aquifer levels may affect personal water supplies in the rural, headwater areas;
- Reductions in groundwater discharge (ranging from <1% to 33%) across the watershed, particularly under the official plan build-out where much of the development occurs in areas of higher recharge. Reductions are predicted to be most intense on Bruce Creek, Berczy Creek, and Little Rouge River relative to existing conditions;
- Reduction in baseflow and associated slight increase in the expected impact of existing surface water users. This predicted result may underestimate the potential impacts given the inability of the model to predict seasonal changes in groundwater discharge;
- Deterioration of water quality in streams and rivers, with increases in total phosphorus, nitrates, bacteria, some metals and chloride. There would be no significant changes in total suspended solid concentrations post-development, because stormwater management ponds are effective at removing them (increased sediment loads associated with the urban construction phase are an acknowledged concern). For all water quality parameters, loads would increase more than concentrations because flow volumes would also increase. Most of the increase in levels of nutrients and heavy metals was predicted to occur under build-out of the Official Plan. Traditional stormwater management practices were instrumental in reducing peak concentrations and limiting further water quality degradation in the full build-out scenario. Chloride was an exception because it is not effectively removed by stormwater ponds. Chlorides (primarily from road salt) would increase in watercourses downstream of development, potentially to levels that are toxic to aquatic life.

These hydrologic and water quality effects would be more significant in the Main Rouge River and its tributaries than the Little Rouge, because much less development is anticipated in the Little Rouge watershed. The most significant changes in water budget are expected to occur during implementation of current official plans, with full build-out having a comparatively smaller effect.

Not surprisingly, the predicted effects in the aquatic community mirror those in the water system. Analysis of potential aquatic communities showed that with official plan build-out, the overall aquatic ecosystem within and downstream of the urban boundary would experience moderate impact and shift to warm-water tolerant communities. The mid to lower portions of the Main Rouge and Lower Little Rouge are of primary concern for aquatic community composition and for the rainbow darter in particular (a key target warm-water species sensitive to flow and sediment regime changes). The rainbow darter will likely be significantly impacted or even lost from the watershed. The other two key target species, those of redside dace (cool-water community) and brook trout (cold-water community), will be less affected, because their populations are distributed relatively higher in the watershed, mainly upstream of urban areas. Local populations of redside dace will likely be directly and potentially severely affected by landscape change in the Upper Rouge, Lower Berczy and Bruce Creeks. With full build-out, the more sensitive cold- and cool-water communities would also disappear or be limited to fragmented headwater habitats. Overall biodiversity and long term viability of those isolated populations would be dramatically decreased, with only the most tolerant fish species remaining. Consideration of all available technical information suggests that the primary causes of these effects would be unmitigated changes to the water budget (more surface water, less groundwater recharge and less discharge to streams), loss of natural cover, increased water temperatures and fragmentation of habitats.

Terrestrial habitats are currently fragmented in the watershed and of a fair quality overall, although there are considerable blocks remaining in the upper main Rouge and in Rouge Park in the lower and Little Rouge watersheds. Urban growth will continue to negatively impact the system, either through direct loss of habitat or through urban matrix impacts on adjacent habitat, unless the system can be protected and expanded. Under a full urban growth scenario, overall habitat quality is expected to drop to a “poor” ranking, which will jeopardize its ability to support biodiversity and, in particular, species of concern (despite current best efforts for buffer protection).

Further urban development could result in loss of undiscovered cultural heritage sites, if proper advance investigation and protective actions are not undertaken. However, the settlement of more people in the watershed will continue to enrich the cultural diversity of the population.

The increasing population, changing demographics (aging population, immigration), and shifts in land use from rural to urban will have implications for the variety of nature-based recreational uses and experiences available in the watershed, and the adequacy, accessibility and condition of greenspace and the trails network. Rapid urban growth, particularly in Markham and Stouffville, is expected to result in rising demand for nature-based recreation and falling per capita greenspace resources. This will be felt most strongly in Rouge Park North/Little Rouge Corridor. As also noted in relation to the terrestrial natural heritage concerns, the increased proximity of urban land uses to natural areas and the increased intensity of recreational use could result in damage to sensitive natural areas (e.g. proliferation of informal trails, invasive species, dumping, litter) and associated impacts on the quality of the recreational experience. Changing demographics will be expressed in shifting demands for particular types of recreational uses (e.g. East Asian and South Asian immigrant population preference for social gatherings, such as picnics) and needs (e.g. better access for the elderly).

End of pipe stormwater retrofit ponds

This analysis considered the effects of improving existing stormwater management ponds or constructing new ones in all existing developed areas where there are opportunities as identified in studies by the Towns of Markham and Richmond Hill. These measures would result in local downstream benefits, but due to the limited numbers of opportunities for new or improved ponds in existing developed areas these measures alone would not be enough to provide significant hydrologic improvements in terms of surface run-off, erosion potential and water quality at a subwatershed scale.

Ponds are limited in the benefits they can provide for erosion control, and need to be augmented by source and conveyance control measures that address the total volume of runoff. Only the retrofit opportunities identified on Beaver Creek address an area of sufficient size to realize benefits to erosion control and water quality on a subwatershed basis. Retrofits at identified locations on the Upper Rouge, Robinson Creek and Eckardt Creek would have little hydrologic impact but could provide local water quality benefits.

Loading reductions for total suspended solids and total phosphorus were estimated to be modest (between 5-15%) with most of the reduction occurring during wet weather. The construction of end-of-pipe retrofit facilities would be of more benefit where undertaken in previously untreated urban areas, and their implementation should still be considered as opportunities arise on the basis of their local benefits.

Given the relatively limited and localized benefits of the assumed stormwater management pond retrofits in managing stream flows, erosion potential and water quality, the benefits to the aquatic ecosystem are also expected to be limited and result in no appreciable change from existing conditions.

The implementation of end-of-pipe stormwater retrofit measures is expected to have limited to no effect on the groundwater system, cultural heritage and nature-based recreation.

Expanded natural cover

Expanding natural cover from 24% to 31% of the watershed area, as shown in the targeted natural heritage system map (see Box 1, section 4.5.8), has the potential to provide significant hydrologic benefits with regards to stormwater management. The primary benefit would be the reduction of runoff and stream flow volumes and a corresponding reduction in erosion potential in downstream watercourses in proportion to the amount of additional vegetative cover provided within each sub-watershed. For example, changes will be greatest in the Little Rouge Corridor and some of the middle tributaries, where there are the most opportunities for new plantings. Annual flows, however, remain greater than the existing conditions volumes in most areas, indicating that the increase in runoff from the official plan build out (also part of the expanded natural cover scenario) is not fully offset by the reduction in volume resulting from reforestation.

Some water quality benefit is expected to accrue from converting significant agricultural land areas to forest, although it would not likely be sufficient to reverse the adverse impacts of conventional development on total suspended solids and nutrients.

Increased natural cover would benefit fish habitats and associated communities, at least under official plan build-out. These benefits would be most pronounced in the headwaters of the watershed, where there is assumed to be more opportunity for expanded natural cover. In contrast, the lower Main Rouge, Beaver Creek and central Main Rouge would experience continued degradation, because there are limited opportunities to expand natural cover in these areas. These are some of the areas slated for the most intense development in the watershed, suggesting that the effects of urbanization would overwhelm the benefits from the limited planting opportunities there.

Implementation of the targeted natural heritage system would increase terrestrial habitats to a large measure and improve the quality and connectivity of habitats and corridors. Improvements in the overall habitat quality throughout the watershed will increase the potential for these habitats to support a more diverse range of species, including species of concern. The presence of trees along riparian corridors, as required in the *Rouge North Management Plan*, will improve water temperature for aquatic communities via shading.

Most archaeological sites are found within 250 m of a watercourse or water body, and similarly much of the target terrestrial system within the Rouge watershed is oriented along watercourses. While the protection of natural cover can be mutually beneficial to the protection of cultural heritage resources *in situ*, more active regeneration projects involving land disturbance may impact archaeological sites, unless proactive planning and mitigative measures are employed.

Expanded natural cover may enhance some nature-based recreation experiences (e.g. hiking, bird watching) and may provide a large enough greenspace land base to protect more sensitive natural areas from incompatible uses (e.g. mountain biking). These improvements would be most noticeable in the Rouge Park areas and to a lesser extent in the Northern Countryside.

Sustainable community design

This scenario comprised four main sets of assumptions:

- An increase in natural cover (as in the expanded natural cover scenario) and additional natural cover associated with Rouge Park and Markham Small Streams policies;
- Sustainable community designs in greenfield developments that reduce overall percent imperviousness and emphasize lot level and other stormwater management practices aimed at maintaining pre-development water balance to the extent possible;
- Naturalized landscaping and stormwater retrofit practices at the lot level, along conveyance systems and at end of pipe in existing urban areas; and
- Shift toward more sustainable, conserving behaviours.

The combination of sustainable community initiatives assumed in this scenario would reduce the negative effects of conventional urban development, but are generally not expected to fully offset them, particularly from a water management perspective. There are, however, many positive effects of this scenario predicted for other natural and cultural heritage objectives and for Rouge watershed communities.

Modelling suggests that the incorporation of sustainable community design, including innovative stormwater management measures in new development, as well as the retrofit of such measures on existing developed areas, would help maintain a more natural hydrologic regime. Existing erosion impacts may be reduced in many parts of the watershed and, while there is still predicted to be up to a 25% increase in erosion potential in the Upper Main Rouge, Beaver Creek and Berczy Creek, this impact is much reduced as compared to the potential impact of conventional urban development. Groundwater modelling indicated that maintenance or restoration of recharge through infiltration measures could substantially mitigate the effects of development, and even improve upon existing conditions in some areas.

Pollution prevention and other sustainable community practices would not only prevent water quality impacts but often improve water quality relative to current conditions. Chloride is the only variable that would probably continue to rise with development, even if aggressive salt management practices were applied, as this constituent is not removed by structural stormwater management controls.

If sustainable community initiatives and increased natural cover were applied, it would likely be possible to maintain and perhaps achieve improvements to existing aquatic systems in most areas of the watershed, although there are limitations to this analysis. There is a need for further study into the cumulative benefits of innovative measures on the aquatic ecosystem. The targeted terrestrial natural heritage system, coupled with sustainable community design and practices, offers the opportunity to achieve better quality habitat overall, with greater likelihood of increasing biodiversity and supporting species of conservation concern.

The expanded natural cover inherent in the sustainable community assumptions will enhance opportunities for nature-based recreational experiences and protect sensitive natural areas, as in the expanded natural cover scenario. The assumed features of sustainable community designs (e.g. more urban open spaces, linked community trails, etc) will further contribute to improved quality of life.

With development will come the potential for increased traffic, resource use (e.g. water and energy), air emissions, and loss of farmland and local food production capacity. However, if development is undertaken on the basis of sustainability principles, the new communities will facilitate sustainable choices (e.g. reduced vehicle use, water re-use, and alternative energy use), foster awareness and appreciation of cultural and natural heritage, and create improved environments for human health. The outcome of these choices will contribute to overall watershed health.

Climate change

This study evaluated two climate change scenarios: 1) "CGCM2" is 5°C warmer and 6% wetter than recent average annual conditions; and 2) "British Hadley" is 7°C warmer and 10% wetter than recent average annual conditions. Seasonal differences in temperature and precipitation defined in these scenarios are described in Appendix A and in Section 4.1. Each climate change scenario was applied separately to the conventional full build out and sustainable community design scenarios.

The effect of future climate change on surface water quantity and groundwater systems of the Rouge River watershed is largely uncertain. While increases in temperature and precipitation are likely, the response of the watershed could vary substantially depending on the interrelationship and proportionality of changes in different meteorological parameters. Further, there is uncertainty regarding future changes in the frequency and intensity of storm events in Southern Ontario and the Rouge River watershed, as current climate change prediction models do not provide sufficient temporal or spatial resolution to predict such changes. Therefore, the effect of climate change on larger flows that result in flooding and/or erosion is difficult to predict at this time. Similarly, effects on low flows and baseflows are also difficult to predict as these are determined by a complex interaction of the magnitude, intensity and seasonality of both temperature and precipitation changes which cannot yet be predicted.

Notwithstanding the uncertainty there is the potential for significant changes to the surface water flow regime as a result of climate change that should be considered in management and planning. It is believed that the most precautionary approach would be to follow a course of action that attempts to maintain or restore a more natural hydrology to the extent possible, to maximize the watershed's resilience to change. The practices embodied in the sustainable community scenario appear to be the most effective at achieving this objective.

Concentrations and loads of most water quality variables cannot be predicted definitively, due to uncertainties in the hydrologic response. It is expected that chloride levels may decrease as winter temperatures become warmer and reduce the need for road salting.

Increased air temperatures expected with climate change will likely cause aquatic ecosystems to change from their current composition and form in favour of warmwater water habitat. It is therefore very important that aquatic ecosystem retain high species diversity to allow for flexibility, and to allow for adaptation and change as the local climate changes over time. Critical to this line of thinking is that healthy and diverse aquatic communities will only be maintained by decreasing impervious cover across the watershed with the primary objectives of maintaining water balance and reducing the storm-related erosion potential. The first negative response of aquatic communities will likely be the population decline of rainbow darter. Tracking the population status of this species may provide an early indication that greater aquatic ecosystem degradation will soon follow.

The increased temperature and precipitation expected under climate change scenarios will likely change the growing season and life cycle conditions for plants and wildlife. These conditions may favour more southern species and provide conditions suitable for invasive species. The latter will be exacerbated with an increase in the urban matrix and ongoing human impacts. An expanded natural heritage system with greater bio-diversity and connectivity would provide greater resiliency to these effects.

The potential impacts on nature-based recreation are broad and far reaching, as changes in hydrology, water quality, and air temperatures may affect the extent and composition of flora, fauna, and agricultural crops across the watershed. These altered conditions would affect the quality of a range of recreational experiences, including hiking, canoeing, bird watching, and swimming. The expanded natural cover associated with the sustainable community scenario could help to offset some of these climate change impacts.

Summary of Future Conditions

This analysis of potential future conditions provided valuable insights that can help to guide future activities towards a healthier, more sustainable watershed.

With respect to water management in the Main Rouge it may be possible to “hold the line” (i.e. avoid further degradation), providing that extensive work is undertaken to increase terrestrial natural heritage and implement new approaches to community design and stormwater management in new developments and retrofits of existing urban areas *in a timely manner*. Continued efforts at innovation beyond the assumptions of this study will also be necessary to fully maintain and potentially improve current conditions. There are opportunities to protect the Little Rouge by adopting new approaches to prevent and effectively mitigate negative impacts from additional growth, because there is a significant amount of protected land in the Little Rouge watershed relative to the amount of existing development and future growth areas.

With respect to natural heritage, there are excellent opportunities for protection, restoration and expansion of natural cover based on the policies applying to the Greenbelt, Oak Ridges Moraine and Rouge Park, combined with the potential of private landowner stewardship. In the aquatic systems, the key requirement will be to protect and maintain the water budget, especially with respect to surface flow regimes, groundwater discharges and water temperature.

Climate change may exacerbate the negative impacts of stresses already at work in the watershed. This highlights the need to take actions that will increase the resilience of natural systems (e.g. maintain or restore water balance, increase size and connectivity of natural cover patches, increase biodiversity) and reduce the potential future costs of addressing environmental issues.

### 5.3 Recommendations for Watershed Management

The study found that the sustainable community design scenario provided the most effective means of achieving multiple objectives for watershed health. The practices assumed as part of that scenario are summarized in Appendix A of this report and are more fully described in the companion report, *Development of a Sustainable Community Scenario for the Rouge River Watershed.*

Three management strategies encompass many of the assumed practices embodied in the sustainable community scenario:

1. *Expand and enhance terrestrial natural cover in the watershed.*

The targeted terrestrial natural heritage system for the Rouge watershed, as shown in section 4.5 (See Box 1 in section 4.5.8), illustrates the configuration of this system and represents a target natural cover of approximately 31% of watershed area. Management actions should address the securement of existing features and the land base for expansion of the the system, restoration of the system, and management of surrounding land use impacts on the system. Initial implementation of increased natural cover should focus on areas upstream of existing and future urban growth to achieve improvements in water management, erosion control, and associated aquatic habitat functions in a timely manner. Strategic reforestation/wetland creation programs should therefore focus work in the upper Main Rouge and middle tributaries, and in the headwaters of the Little Rouge tributary that flows through the Town of Whitchurch-Stouffville. These improvements will contribute to the mitigation and management of anticipated impacts from urban growth.

2. *Build more sustainable new communities and retrofit older ones to improve their sustainability.*

   Key actions involve improvement of water management and promotion of sustainable practices overall.

   a) *Improve water management*
   Future development should utilize innovative stormwater management techniques and existing development should be retrofitted with innovative measures, in order to maintain a natural water budget to the maximum extent possible, mitigate erosion impacts to watercourses, and maintain or restore groundwater recharge and baseflows in streams. Development designs should employ an integrated stormwater management approach that uses both conventional end-of-pipe facilities and source control approaches (e.g. naturalized landscapes, infiltration techniques, rain harvesting) to minimize the increase in runoff volume from new

development. Pilot testing of innovative technologies should begin as soon as possible to determine performance in Rouge River watershed conditions. Once incorporated into new and existing development, representative installations should be monitored and measures put in place to track the cumulative benefits of these technologies at a subwatershed and watershed scale.

b) *Promote sustainable practices overall*
Facilitate the use of these innovative water management approaches by promoting improved urban form, green buildings and sustainable behaviour, and at the same time address a broad range of other objectives for the sustainable community. Of particular interest is the need to accelerate the shift to the adoption of more sustainable practices and the need for testing and demonstrating new technologies, particularly those described above for water management.

3. *Create a regional open space system for nature-based recreation*

Securement of the targeted terrestrial natural heritage system will not only contribute to water and natural heritage management objectives, but will provide an expanded greenspace system needed to meet the increased demand for nature-based recreation associated with population growth. Careful planning and management of the greenspace and trails system will be needed to balance public use with the protection of sensitive natural areas, realize opportunities to interpret and celebrate the cultural and natural heritage, and protect the distinctive urban wilderness and countryside experiences of the Rouge watershed. Access to natural areas contributes social well-being and thereby is an integral component of overall sustainability.

Although the analysis which demonstrates the effectiveness of these three management strategies was conducted at the watershed and subwatershed scale, many of the inherent assumptions will affect decisions at multiple scales. Therefore, implementation of these strategies must be considered at all levels of decision making: watershed, community, lot, building and individual behaviour.

Additional specific management recommendations pertaining to each of the theme areas are provided in each section of Chapter 4 of this report.

## 5.4 Use of the Study Results

This scenario modelling and analysis study largely constituted the second phase of the watershed planning study, and as such contributed findings and recommendations that were considered by the Rouge Watershed Task Force in the development of the Rouge River Watershed Plan, during the third study phase. Other input to the plan arose from a series of management summit workshops with experts on key issues and a review of emerging practices and literature from other jurisdictions.

As a supporting document to the Rouge Watershed Plan, this report will serve as a technical reference during the plan's implementation. In addition, the scenario modelling results can be used as a guide to comment on the likely relative effects of future scenarios that may contain different assumptions from the ones used in this study. Finally, this study contributes to the continued evolution of the field of integrated watershed planning, and in this regard will help to inform similar studies in other jurisdictions.