

RESEARCH REPORT



Don River Watershed Site Evaluation



CMHC—HOME TO CANADIANS

Canada Mortgage and Housing Corporation (CMHC) has been Canada's national housing agency for more than 60 years.

Together with other housing stakeholders, we help ensure that Canada maintains one of the best housing systems in the world. We are committed to helping Canadians access a wide choice of quality, affordable homes, while making vibrant, healthy communities and cities a reality across the country.

For more information, visit our website at www.cmhc.ca

You can also reach us by phone at 1-800-668-2642 or by fax at 1-800-245-9274.

Outside Canada call 613-748-2003 or fax to 613-748-2016.

Canada Mortgage and Housing Corporation supports the Government of Canada policy on access to information for people with disabilities. If you wish to obtain this publication in alternative formats, call 1-800-668-2642.

Toronto & Region Conservation Authority

Don River Watershed Site Evaluation

July 2009 • File 09103



Member of Conservation Ontario



The Municipal Infrastructure Group Ltd.
2300 Steeles Avenue West Suite 120
Vaughan ON CA L4K 5X6
Tel 905.738.5700 Fax 905.738.8075
www.tmig.ca



This study was funded by Canada Mortgage and Housing Corporation (CMHC). The contents, views and editorial quality of this report are the responsibility of the authors and CMHC accepts no responsibility for them or any consequences arising from the reader's use of the information, materials and techniques described herein.

RESEARCH HIGHLIGHT

October 2010

Technical Series 10-101

Don River Watershed Site Evaluation— Predicting Effectiveness of Stormwater Source Controls in Urban Watershed Revitalization

INTRODUCTION

The Don River flows through the heart of the Greater Toronto Area. From its headwaters on the Oak Ridges Moraine to its mouth in the heart of Toronto's industrial waterfront, the watershed is over 80 per cent urbanized. Fifteen years ago Toronto and Region Conservation and the Don Watershed Task Force released *Forty Steps to a New Don*, a call to action to restore this troubled river system. Since then, countless volunteers and agency staff have worked to implement that vision of a revitalized Don River.

In 2006, Toronto and Region Conservation began the process of updating the science on this watershed and developing a new *Don River Watershed Plan* for the next phase in its restoration. The need for innovative stormwater management practices emerged as a key component of the recommendations from the new Don plan. Much of the watershed is already built up so the emphasis is on retrofitting existing communities with enhanced stormwater management. Stormwater source controls (also called low impact development measures) such as permeable pavement, bioswales, rain gardens, rainwater harvesting and downspout disconnection are recommended for private and public lands. As space and capital dollars for stormwater work are limited, creative solutions that achieve multiple objectives and integrate well with existing communities are needed.

To illustrate possible scenarios for implementing the watershed plan's recommendations at a local scale, five concept site plans were developed. The sites were chosen to be representative of common challenges faced in many locations throughout the watershed. The plans illustrated a suite of actions that could be implemented to achieve gains in water quality, water balance, erosion control, natural heritage protection and

community engagement within the context of other sustainability elements. Three of the five site plans proposed significant stormwater source control activities.

As a part of a broader research initiative to support the development of a hydrologic modelling tool, CMHC provided research funding to apply the hydrologic model to the three sites to assess the outcomes of different residential developments and other measures on stormwater and how innovative practices can mitigate adverse environmental impacts of stormwater. The hydrologic modelling was used to estimate the potential reductions in peak flows (and associated flood risk and erosion potential) and overall flow volume that might result from implementing these measures.

HYDROLOGIC MODELLING METHODOLOGY

Three scenarios were modelled at each site:

- pre-development agricultural conditions;
- existing urban conditions;
- proposed conditions with the stormwater source control measures outlined in the concept site plans.

The analysis for each site was completed using the hydrologic modelling software Visual OTTHYMO version 2.0. Modifications were made to the model input values for each scenario based on the different land use and stormwater source control assumptions. Each of the three scenarios was run at a variety of storm intensities. The smallest storm event was five millimetres, a rainfall event that is very common in southern Ontario.

Research Highlight

Don River Watershed Site Evaluation—Predicting Effectiveness of Stormwater Source Controls in Urban Watershed Revitalization

The modelling was also completed for 25 mm, two-year, five-year, 10-year, 25-year, 50-year and 100-year return period storm events. The following sections describe the features of each concept site plan and the hydrologic model findings.

CONCEPT SITE 1

Building Sustainable Neighbourhoods – Warden Woods Residential Area, Toronto

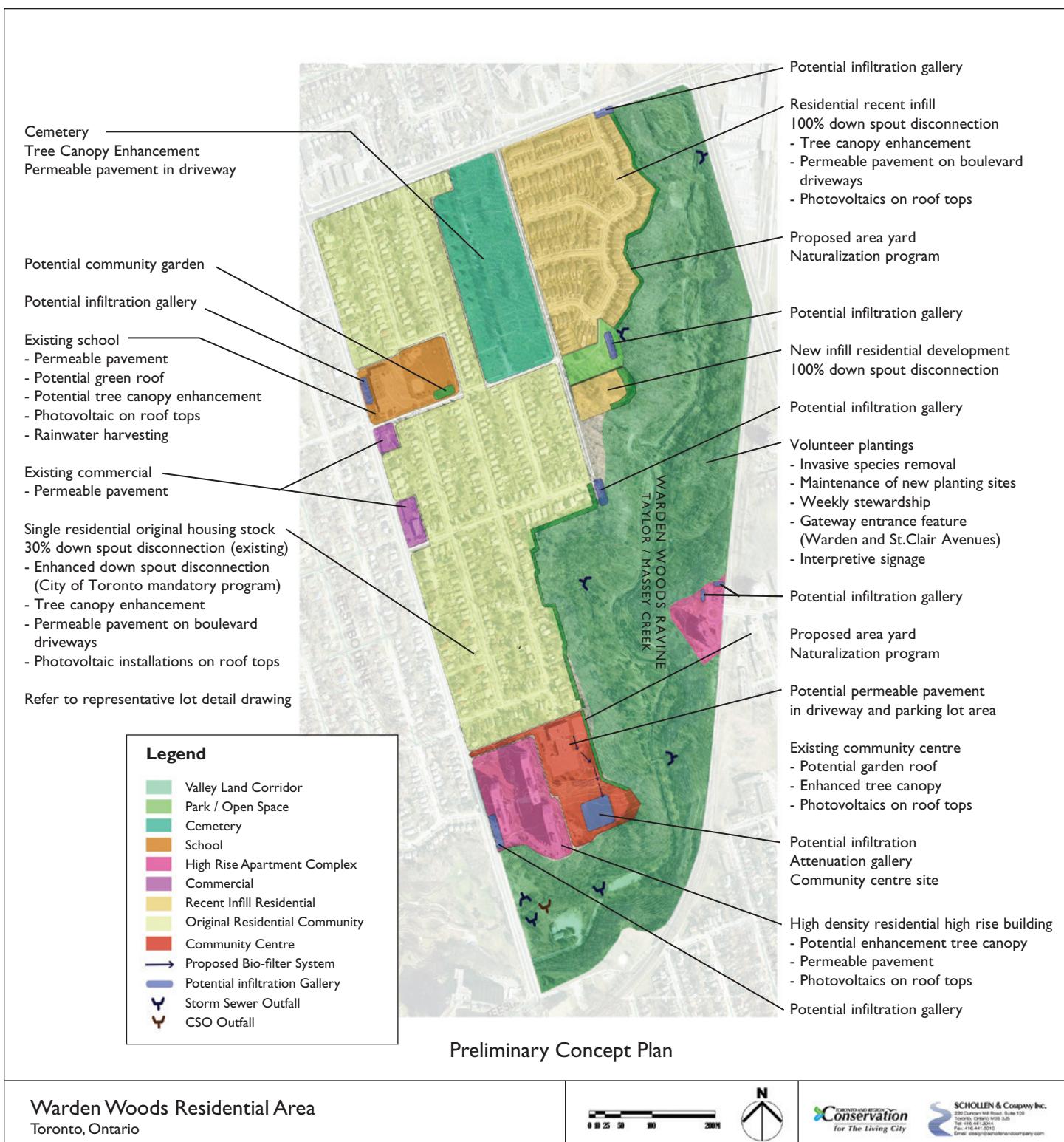


Figure 1 Warden Woods Concept Plan

Concept Site Features

The 1950s suburban single family housing that covers much of the Warden Woods area is typical of many older residential areas throughout the watershed. The concept site plan showcases how such older housing stock can be made more sustainable by improving energy efficiency and water conservation, and implementing other green retrofits.

Diverting stormwater from the combined sewer system will also reduce overflows into Taylor/Massey Creek, mitigate erosion and improve downstream water quality. Under the site plan, improved stormwater management and water infiltration/attenuation techniques would be implemented. The valley parks and other natural areas would be protected and regenerated to restore ecosystem functionality and improve community enjoyment. In addition to promoting a more sustainable community, the site plan would: restore vegetation and enhance the tree canopy; mitigate the urban heat island effect; enhance public awareness of environmental/conservation practices; and improve the streetscape and pedestrian realms.



Existing: The right-of-way bordering the Dawes Road Cemetery. Note, the roadside swale which enhances the potential for stormwater infiltration.

Modelling Results

The stormwater management components in the ‘proposed conditions’ scenario for Warden Woods reduced peak flows and flow volume for both the smaller storm events and the larger, less common storms in the modelling.

For the most frequent category of storms (resulting in 5-25 mm of precipitation), peak flows were reduced 40-45% and runoff volume is decreased by about 20-45%. This decrease in runoff would help to reduce many of the erosion and water quality concerns in this section of Taylor/Massey Creek.

Peak flows from larger storm events (i.e., those that would occur in the 5-100 year timeframe) would also be reduced by 20-35%. The concept site plan would improve the resiliency of the system and help mitigate the impacts of these events.



Prospective: A more attractive, pedestrian friendly streetscape. Additional native trees have been planted. Low-maintenance “rain gardens” are designed to encourage water infiltration. A new, more efficient biofilter system has replaced the swale.

Figure 2 Transforming a 1950s Suburban Community

Research Highlight

Don River Watershed Site Evaluation—Predicting Effectiveness of Stormwater Source Controls in Urban Watershed Revitalization

CONCEPT SITE 2

Ravine Challenges – Mud Creek, Toronto

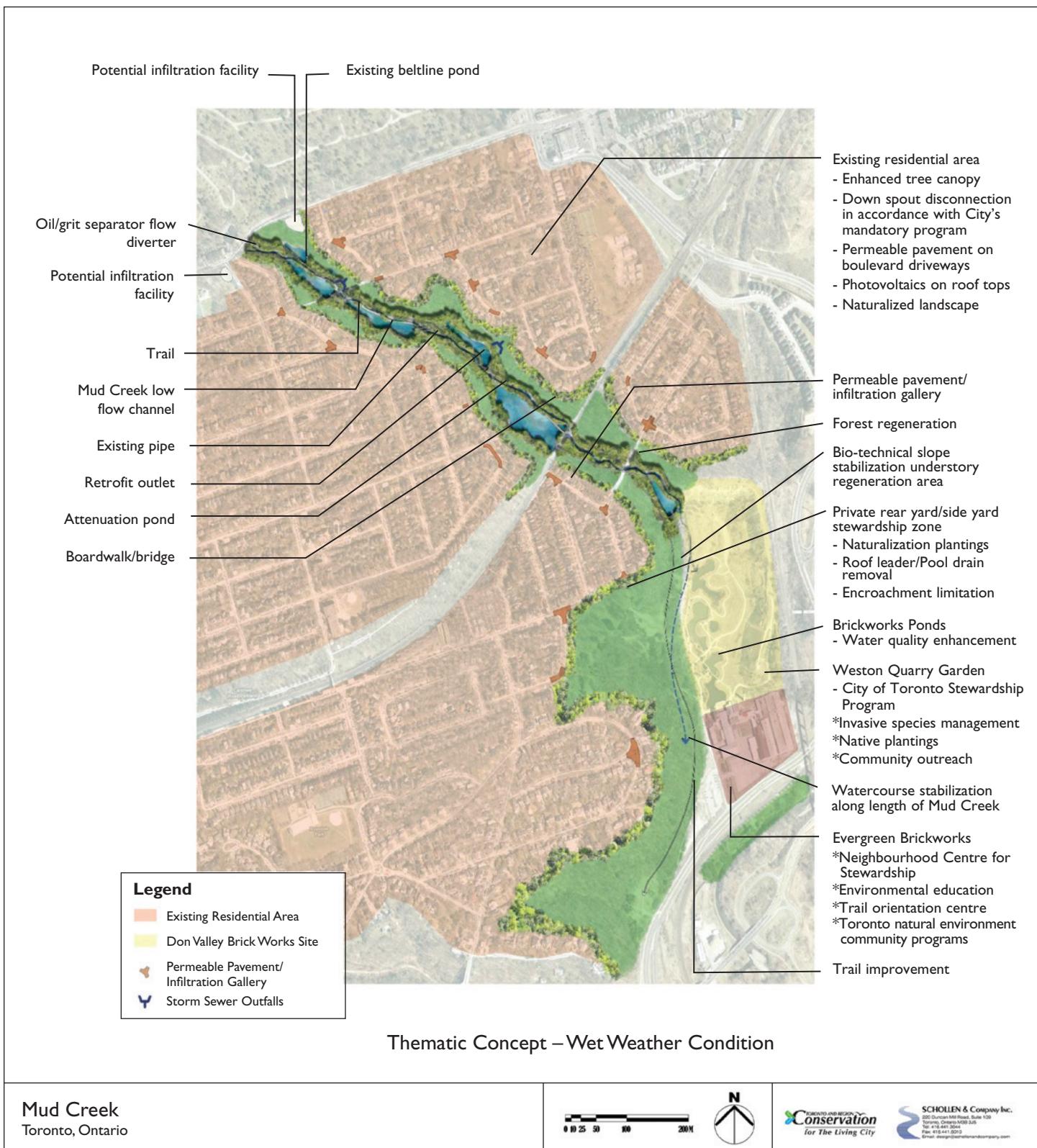


Figure 3 Concept Plan for Mud Creek

Concept Site Features

The erosion problems evident in Mud Creek are typical of those seen in many other ravines throughout the lower part of the watershed. The contributing causes are ineffective stormwater control, heavy pedestrian traffic on formal and informal trails and the actions of neighbouring homeowners. This concept site highlights community stewardship initiatives to manage stormwater at the lot level on neighbouring properties and eliminate encroachment. Suggested actions include: infiltration galleries, bioswales, permeable pavement on driveways, downspout disconnection and green roof technology.

The concept site plan also addresses wet weather flow control by creating a series of flow regulating structures and water holding ponds (attenuation areas) upstream of each piped segment of the creek. In addition, a new surface baseflow channel would be created along the entire length of the ravine. The currently deteriorating gabions along the exposed stream banks would be replaced with biotechnical

stabilization works such as stone in-laid with vegetation, and the failed grade control structures near the Don Valley Brick Works site would be replaced and upgraded. A number of additional initiatives would be undertaken to increase the ravine's biodiversity, improve the trail system, protect at-risk environmental components, and expand public outreach through interpretive signage.

Modelling Results

The 'proposed conditions' scenario for the Mud Creek site plan modelled the potential effects of the source control measures on the tablelands on peak flow and flow volume. Results showed reductions in peak flows (22-52%) and flow volume (6-53%) from the existing conditions. The greatest reductions in both peak flows and flow volume are seen in the smallest storm events. This supports the case for implementing these measures as the smaller (<20mm) storms are the most common type of event in this area and have a significant cumulative impact on erosion in the creek.



Existing: the trail traveling north towards the Governors Road bridge. The hard-packed trail has encroached into the surrounding forest and a number of dead limbs and fallen trunks pose a threat to trail users.



Prospective: The trail has been narrowed, surfaced and repositioned alongside the new surface channel which carries the baseflow of Mud Creek. The channel banks are protected by stone interspersed with native vegetative plantings.

Figure 4 Transforming a Buried Creek

Research Highlight

Don River Watershed Site Evaluation—Predicting Effectiveness of Stormwater Source Controls in Urban Watershed Revitalization

CONCEPT SITE 3 –

A Sustainability Makeover: Generic Commercial/Industrial Example



Figure 5 Generic Commercial/Industrial Concept Plan

Concept Site Features

The generic commercial / industrial site is representative of many sites throughout the watershed built prior to the establishment of current standards for sustainability. Many of these aging sites are due for redevelopment, presenting an excellent opportunity to work with private sector and municipal partners to give these sites a sustainability makeover. TRCA will continue to search for a suitable demonstration site to implement the concept site plan in partnership with local business groups and the municipality.

The concept plan is focused on rebuilding/retrofitting the study area to restore water balance, mitigate flooding, improve water quality and enhance overall environmental sustainability. The plan addresses the needs of a generic industrial park, typical of many across the watershed, that were built in the 1960s without consideration of modern stormwater management or energy efficiency standards. Many of these areas are currently in transition, with facilities being upgraded and retrofitted to meet modern business requirements. The remaking of an aged, inefficient industrial area will demonstrate the feasibility and benefits of both modest retrofits and bold planning moves in achieving water balance and environmental sustainability objectives.



Existing: Typical of many low rise industrial areas across the watershed, hard and impermeable surfaces predominate which encourages rapid runoff and potential flooding. The tree canopy is largely absent, the streetscape bleak, and there are few alternatives to truck and car transport.

Modelling Results

This site showed the greatest potential reduction in peak flow rates (ranges from 30% for a 100 year storm event to 80% for a 5 mm storm) and total runoff volumes (20-85% reductions) of all the concept sites under the ‘proposed conditions’. Much of the site is currently blanketed by hard and impervious surfaces—roadways, roofs, parking lots and storage areas. The modelling results suggest significant benefits that can result from retrofitting existing industrial developments with source control projects.

A water budget analysis evaluated the impact of the conceptual source control measures on stormwater runoff volumes and potable water usage. City of Toronto design criteria were used to estimate average annual potable water use and calculate an estimated reduction based on the rainwater harvesting proposals in the concept plan. The modelling predicted a 30% reduction in potable water use if the rainwater harvesting assumptions are implemented. This reduction in water use also saves energy costs associated with pumping and treating water.



Prospective: Trees and low maintenance native vegetation have been planted along the right-of-way, while a public transit route and bike lanes are added. Solar panels have been installed on the large flat roof of the closest facility. Where feasible, parking lots and driveways are retrofitted with semi-permeable surfaces.

Figure 6 Transforming an Industrial Enclave

CONCLUSIONS

The implementation of low impact development measures in existing areas has a significant impact on the reduction of both peak stormwater release rates and runoff volumes. However, it should be noted that the types of low impact development measures that can be implemented for a subject location depend highly on the existing site conditions and constraints and the type of land use. As a result, it is difficult to generalize the effects of the measures as they will be different on a site by site basis.

IMPLICATIONS FOR THE HOUSING INDUSTRY

The results of the modelling indicate that implementation of innovative stormwater control practices and low impact development strategies can result in more resilient stormwater management systems and, by extension, better protection of watersheds and surface water quality. The stormwater modelling of the watershed revitalization scenarios provided a quantitative estimate of potential impacts associated with the stormwater control measures. This information can help to support the development of business cases for implementing such practices at the sites studied and similar locations throughout the watershed. The research project provides useful examples of innovative stormwater measures for those considering similar measures elsewhere.

CMHC Project Manager: Cate Soroczan

Housing Research at CMHC

Under Part IX of the *National Housing Act*, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This fact sheet is one of a series intended to inform you of the nature and scope of CMHC's research.

To find more *Research Highlights* plus a wide variety of information products, visit our website at

www.cmhc.ca

or contact:

Canada Mortgage and Housing Corporation
700 Montreal Road
Ottawa, Ontario
K1A 0P7

Phone: 1-800-668-2642
Fax: 1-800-245-9274

©2010, Canada Mortgage and Housing Corporation
Printed in Canada
Produced by CMHC

15-10-10

Évaluation du bassin hydrologique de la rivière Don – Prévoir l'efficacité des mesures de gestion des eaux pluviales dans le cadre de la revitalisation d'un bassin hydrologique en milieu urbain

INTRODUCTION

La rivière Don traverse la région du Grand Toronto en son centre. De son cours supérieur dans la moraine d'Oak Ridges, jusqu'à son embouchure au cœur du secteur riverain industriel de Toronto, le bassin hydrologique est urbanisé à plus de 80 %. Il y a quinze ans, l'Office de protection de la nature de Toronto et de la région (TRCA), ainsi que la commission d'étude du bassin hydrologique de la rivière Don (*Don Watershed Task Force*) ont publié *Forty Steps to a New Don*, un appel à l'action pour la restauration de ce réseau hydrographique perturbé. Depuis, d'innombrables volontaires et membres du personnel des organismes ont travaillé à la concrétisation de cette vision d'une rivière Don revitalisée.

En 2006, le TRCA a entamé le processus d'actualisation de l'information scientifique entourant ce bassin hydrologique, tout en élaborant un nouveau plan pour la phase de restauration du bassin hydrologique de la rivière Don. Le besoin d'innover dans la façon de gérer les eaux pluviales était un élément clé des recommandations du nouveau plan. Étant donné qu'une grande partie du bassin hydrologique est déjà aménagée, il faut mettre l'accent sur l'amélioration des mesures déployées pour gérer les eaux pluviales dans les quartiers établis. Pour les terrains privés et publics, on recommande de prendre des mesures de gestion des eaux pluviales ayant peu d'impact sur l'environnement, telles que les revêtements perméables, les rigoles de drainage

écologiques, les jardins pluviaux, la collecte des eaux de pluie ainsi que le débranchement des descentes pluviales. Comme l'espace et les fonds pour des travaux de gestion des eaux pluviales sont limités, il importe de trouver des solutions créatives qui atteignent plusieurs objectifs à la fois et qui s'intègrent bien au sein des quartiers.

Afin de démontrer comment les recommandations du plan de revitalisation du bassin hydrologique pourraient être mises en œuvre à l'échelle locale, cinq plans de situation ont été élaborés. Les sites choisis ont été retenus parce qu'ils présentaient des défis communs à de nombreux endroits du bassin hydrologique. Les plans illustrent aussi une série d'actions qui peuvent être prises en vue d'assurer l'amélioration de la qualité de l'eau, l'équilibre hydrologique, la lutte contre l'érosion, la protection du patrimoine naturel, ainsi que la mobilisation de la communauté dans le contexte d'autres mesures de durabilité. Trois des cinq plans de situation suggèrent d'importantes méthodes de gestion des eaux pluviales.

Dans le cadre d'une initiative de recherche plus vaste destinée à mettre au point un outil de modélisation hydrologique, la SCHL a fourni des fonds de recherche pour l'application du modèle hydrologique à ces trois sites afin d'évaluer l'effet de différents aménagements résidentiels et d'autres mesures sur les eaux pluviales et de démontrer comment des pratiques innovatrices peuvent atténuer les dommages environnementaux causés par les eaux pluviales.

La modélisation hydrologique a été utilisée afin d'évaluer les réductions potentielles de débit de pointe (et les risques d'inondation et d'érosion potentiels qui y sont associés) et le volume d'écoulement général que pourrait entraîner le recours à ces mesures.

MÉTHODE DE LA MODÉLISATION HYDROLOGIQUE

Trois scénarios ont été modélisés pour chaque site :

- état initial des lieux, aspect agricole;
- état actuel du milieu urbanisé;
- état des lieux projeté après la mise en œuvre des mesures de gestion des eaux pluviales proposées dans les plans de situation.

L'analyse de chaque site a été effectuée à l'aide du logiciel de modélisation hydrologique Visual OTTHYMO, version 2.0. Les variables d'entrée ont été modifiées pour chaque scénario selon l'utilisation du territoire et les hypothèses formulées pour la gestion des eaux pluviales. Chacun des trois scénarios a été analysé à différentes intensités d'averse. La plus petite averse était de cinq millimètres, une intensité très courante dans le sud de l'Ontario. La modélisation a aussi été effectuée dans le cas d'une averse de 25 mm, ainsi que pour des périodes de récurrence des pluies de 2 ans, 5 ans, 10 ans, 25 ans, 50 ans et 100 ans. Les sections suivantes décrivent les caractéristiques de chaque plan de situation et les résultats obtenus avec le modèle hydrologique.

SITE N° 1

Développement durable des voisinages – Quartier résidentiel Warden Woods, à Toronto

Caractéristiques du site

Les maisons individuelles de banlieue datant des années 1950 qui constituent la majeure partie du quartier Warden Woods sont typiques d'un bon nombre des vieux quartiers de ce bassin hydrologique. Le plan de situation illustre de quelle manière un parc résidentiel de cet âge peut devenir plus viable si l'on améliore l'efficacité énergétique et la conservation des eaux, et si on procède à d'autres améliorations écologiques.

En détournant les eaux pluviales du réseau d'assainissement mixte, il est possible de réduire aussi les débordements dans le ruisseau Taylor-Massey, d'atténuer l'érosion et d'améliorer la qualité de l'eau en aval. Ce plan de situation se distingue par le recours à des techniques visant à mieux gérer les eaux pluviales, à atténuer leur écoulement et à favoriser leur infiltration. Les parcs de la vallée et autres espaces naturels seraient protégés et régénérés afin de restaurer la dynamique de l'écosystème et d'embellir le milieu pour le plaisir des citoyens. En plus de rendre le quartier plus durable, le plan de situation permettrait de restaurer la végétation et d'étendre le couvert des arbres, de diminuer l'effet d'ilot thermique, de sensibiliser le public aux pratiques environnementales et de conservation et d'embellir les paysages de rue et le réseau piétonnier.

Évaluation du bassin hydrologique de la rivière Don – Prévoir l'efficacité des mesures de gestion des eaux pluviales dans le cadre de la revitalisation d'un bassin hydrologique en milieu urbain

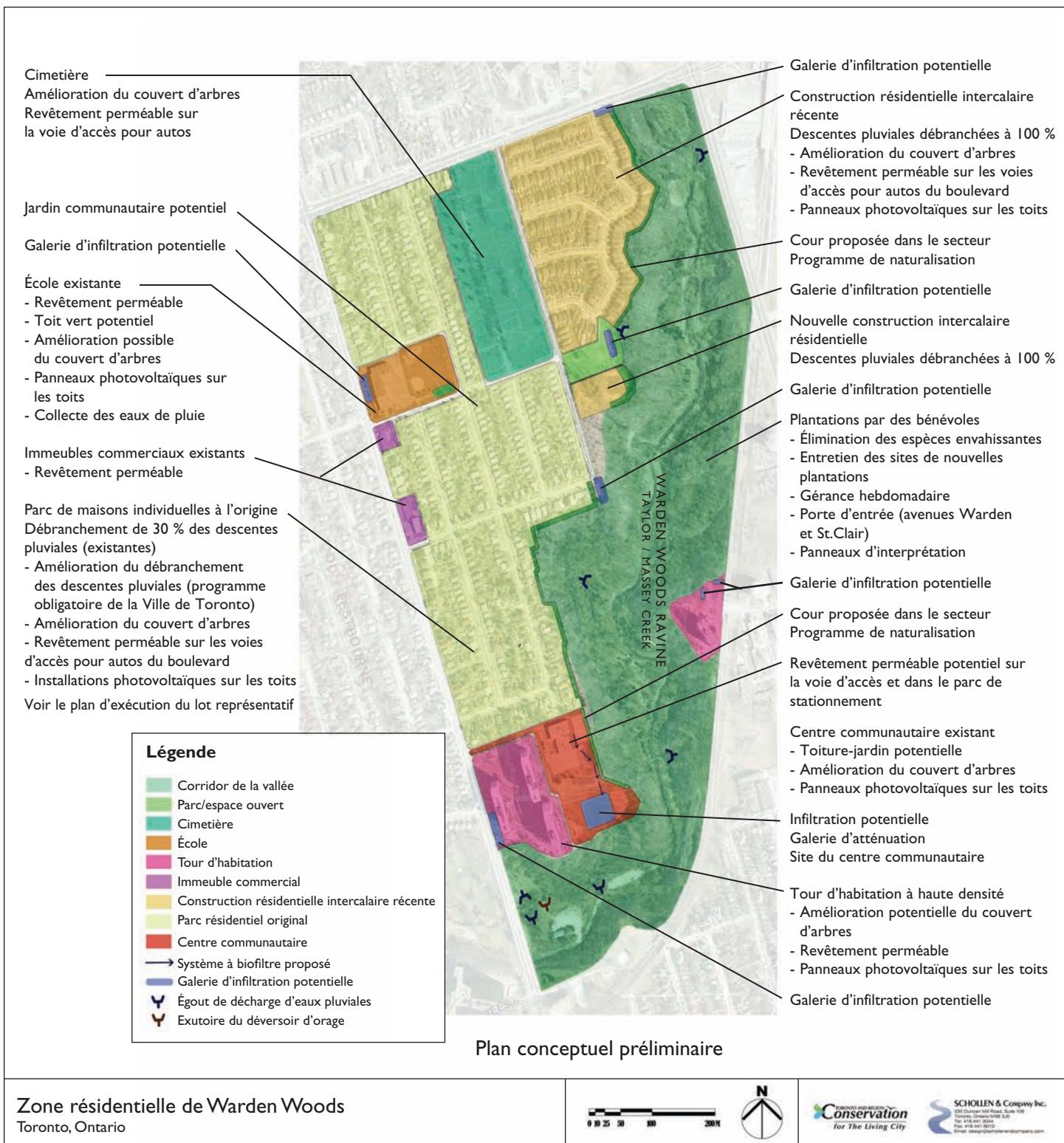


Figure 1 Plan de situation de Warden Woods

Évaluation du bassin hydrologique de la rivière Don – Prévoir l'efficacité des mesures de gestion des eaux pluviales dans le cadre de la revitalisation d'un bassin hydrologique en milieu urbain



État initial des lieux : Emprise longeant le cimetière du chemin Dawes. La rigole bordant le chemin augmente le potentiel d'infiltration des eaux pluviales.

État des lieux projeté : Un paysage de rue plus attrayant, un aménagement convivial pour les piétons. Des arbres indigènes ont été plantés. Des « jardins pluviaux » requérant peu d'entretien favorisent l'infiltration de l'eau. Un nouveau biofiltre plus efficace a remplacé la rigole.

Figure 2 Transformation d'une communauté suburbaine des années 1950

Résultats de la modélisation

Les éléments de gestion des eaux pluviales prévus dans le scénario de « l'état des lieux projeté » pour Warden Woods permettent d'envisager une réduction des débits de pointe ainsi que du volume d'écoulement tant pour les petites pluies que pour les gros orages plus rares dans la modélisation.

En ce qui a trait aux averses les plus fréquentes (donnant lieu à des précipitations de 5 à 25 mm), les débits de pointe ont été réduits de 40 à 45 % et le volume de ruissellement a diminué d'à peu près 20 à 45 %. Cette atténuation du ruissellement aiderait à surmonter de nombreux problèmes d'érosion et de qualité de l'eau dans ce secteur du ruisseau Taylor Massey.

Les débits de pointe des plus gros orages (c.-à-d. ceux qui se produisent tous les 5 à 100 ans) seraient aussi réduits de 20 à 35 %. Ce plan de situation améliorerait la résilience du réseau et contribuerait à atténuer l'impact de ces événements.

SITE CONCEPTUEL N° 2

Les défis que pose un ravin – le ruisseau Mud, à Toronto

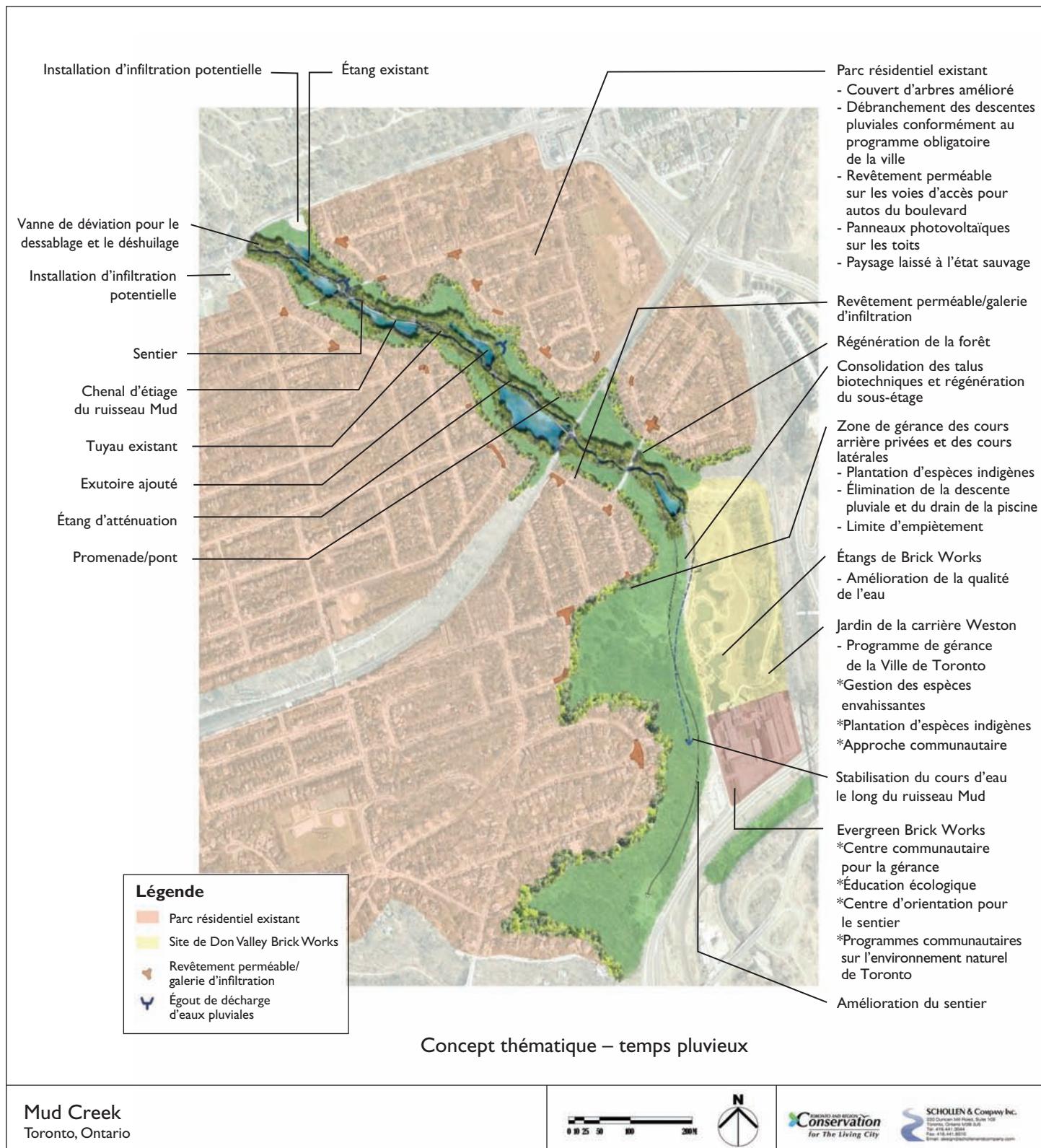


Figure 3 Plan de situation du ruisseau Mud

Évaluation du bassin hydrologique de la rivière Don – Prévoir l'efficacité des mesures de gestion des eaux pluviales dans le cadre de la revitalisation d'un bassin hydrologique en milieu urbain



État initial des lieux : Le sentier va vers le nord, vers le pont du chemin Governors. Le sentier dont le sol est très compacté a empiété sur les boisés avoisinants et des branches mortes ainsi que des troncs d'arbre tombés représentent un danger pour les usagers du sentier.



État des lieux projeté : Le sentier a été rétréci, revêtu et réaménagé le long du nouveau chenal qui transporte les basses eaux du ruisseau Mud. Les berges du chenal ont été protégées par des roches parmi lesquelles on a planté des végétaux indigènes.

Figure 4 Transformation d'un ruisseau enseveli

Caractéristiques du site

Les problèmes d'érosion évidents dans le secteur du ruisseau Mud sont typiques de ce qu'on constate pour de nombreux autres ravins dans la partie inférieure du bassin hydrologique. Cette érosion est causée par une gestion inefficace des eaux pluviales, une circulation dense de piétons sur les sentiers prévus, ou non, à cette fin, et les actions des propriétaires des résidences avoisinantes. Le concept proposé mise essentiellement sur la participation des citoyens du secteur pour gérer les eaux pluviales sur les propriétés privées qui jouxtent le ruisseau et pour éliminer l'empietement. Les actions proposées comprennent l'aménagement de galeries d'infiltration et de rigoles de drainage écologiques, l'emploi de revêtements perméables pour les voies d'accès pour automobile, le débranchement des descentes pluviales et le recours à la technique des toits verts.

Le plan de situation traite aussi de la gestion de l'écoulement par temps de pluie au moyen de dispositifs de réglage des débit et d'étangs de retenue d'eau (zones d'atténuation) réalisés en amont de chaque section canalisée du ruisseau. De plus, un nouveau chenal d'étiage serait aménagé tout le long du ravin. Le mur de gabions en voie de détérioration le

long des berges exposées serait remplacé par des ouvrages de stabilisation biotechniques tels que des roches parmi lesquelles pousserait de la végétation, et les structures anti-érosion défaillantes qui se trouvent près du site de Don Valley Brick Works feraient place à des ouvrages renforcés. Un certain nombre d'autres initiatives seraient mises en œuvre pour augmenter la biodiversité du ravin, et améliorer le réseau des sentiers, ainsi que pour protéger les éléments environnementaux à risque et accroître la sensibilisation du public au moyen de panneaux d'interprétation.

Résultats de la modélisation

Le scénario sur l'« état des lieux projeté » du plan de situation du ruisseau Mud a modélisé les effets potentiels des mesures de gestion à la source dans les hauts plateaux sur les débits de pointe et les volumes d'écoulement. Les résultats font état de réductions des débits de pointe (de 22 à 52 %) et du volume d'écoulement (de 6 à 53 %) comparativement aux conditions présentes. Les plus grandes réductions du débit de pointe et du volume d'écoulement ont été enregistrées lors des averses de moindre importance. Ces résultats appuient la mise en œuvre de ces mesures, puisque les plus petites averses (moins de 20 mm) sont les plus fréquentes dans cette région et qu'elles ont une incidence cumulative importante sur l'érosion du ruisseau.

SITE CONCEPTUEL N° 3 –

Une métamorphose vers la durabilité : un exemple commercial/industriel générique



Figure 5 Plan de situation générique d'aménagement commercial/industriel

Caractéristiques du site

Ce site commercial/industriel générique est représentatif de nombreux sites du bassin hydrologique construits avant l'établissement des normes de durabilité contemporaines. Beaucoup de ces sites vieillissants ont grand besoin d'être réaménagés; ils présentent donc d'excellentes possibilités de partenariat avec le secteur privé et la municipalité afin de les remettre au goût du jour dans le respect des principes du développement durable. Le TRCA continuera de chercher un site de démonstration convenable pour la mise en application du plan de situation, avec la collaboration des gens d'affaires locaux et de la municipalité.

Le plan conceptuel met l'accent sur le réaménagement du secteur à l'étude afin de restaurer l'équilibre hydrologique, de réduire le risque d'inondation, d'améliorer la qualité de l'eau et d'accroître la durabilité de l'environnement en général. Les concepteurs du plan ont étudié les besoins d'un parc industriel générique, typique de nombreux parcs industriels que l'on retrouve dans le bassin hydrologique à l'étude et qui ont été construits dans les années 1960, donc avant l'adoption des méthodes de gestion des eaux pluviales et des normes d'efficacité énergétique actuelles. Bon nombre de ces secteurs sont actuellement en transition, les installations étant modernisées et mises en conformité afin de satisfaire aux besoins fonctionnels contemporains. La transformation d'un secteur industriel âgé et inefficace démontrera qu'il est faisable et avantageux de procéder à de modestes travaux de mise aux normes et d'adopter des méthodes de planification novatrices dans le but d'atteindre les objectifs d'équilibre hydrologique et de durabilité de l'environnement.

Résultats de la modélisation

Ce site laisse entrevoir les meilleures possibilités de réduction des débits de pointe (de 30 % pour un orage centenaire à 80 % pour une averse de 5 mm) et des volumes de ruissellement totaux (réductions de 20 à 85 %) pour ce qui est de tous les « états des lieux projetés » à l'égard des sites à l'étude. Ce site est en grande partie recouvert de surfaces dures et imperméables : chaussées, toits, parcs de stationnement et lieux d'entreposage. Selon les résultats de la modélisation, il serait très avantageux de mettre aux normes un parc industriel existant grâce à des projets de gestion à la source.

Une analyse du bilan hydrologique a permis d'évaluer l'impact des mesures de gestion à la source envisagées sur les volumes d'eaux de ruissellement et sur l'utilisation de l'eau potable. Les critères de conception de la Ville de Toronto ont été utilisés pour estimer la consommation d'eau potable moyenne durant une année et pour calculer une réduction estimative basée sur la collecte des eaux de pluie proposée dans le plan conceptuel. La modélisation prévoit une réduction de 30 % de l'utilisation de l'eau potable, si les hypothèses de collecte d'eau de pluie se concrétisent. Cette réduction de l'utilisation de l'eau potable représente aussi une économie de coûts énergétiques associés au pompage et à l'épuration de l'eau.



État initial des lieux : On y trouve des bâtiments de faible hauteur typiques des parcs industriels situés dans le bassin hydrologique à l'étude : les surfaces y sont surtout dures et imperméables et favorisent le ruissellement rapide des eaux, ce qui augmente le risque d'inondation. Le couvert d'arbres est pratiquement inexistant et le paysage de rue est morne. Les voies de circulation n'offrent aucune autre solution pour le transport que le camion et l'automobile.



État des lieux projeté : Des arbres et de la végétation indigène requérant peu d'entretien ont été plantés le long des emprises routières, et des voies de transport en commun ainsi que des bandes cyclables ont été ajoutées. Des panneaux solaires ont été installés sur le grand toit plat du bâtiment le plus proche. Là où c'était possible, des parcs de stationnement et des voies d'accès pour automobiles ont été dotés de surfaces semi-perméables.

Figure 6 Transformation d'un parc industriel

CONCLUSIONS

Les mesures de gestion à faible impact dans les régions urbaines existantes réduisent considérablement le débit de pointe des eaux pluviales ainsi que les volumes d'écoulement. Cependant, les mesures qui peuvent être mises en œuvre pour une région dépendent largement des conditions et des contraintes du site en question et du type d'utilisation du territoire. En conséquence, il est difficile de généraliser les effets de ces mesures, car ils seront différents d'un endroit à l'autre.

CONSÉQUENCES POUR LE SECTEUR DE L'HABITATION

Les résultats de la modélisation démontrent que l'emploi de mesures de gestion des eaux pluviales innovatrices et de stratégies d'aménagement écologiques peut accroître la résilience des systèmes de gestion des eaux pluviales et, par le fait même, la protection des bassins hydrologiques ainsi que la qualité de l'eau de surface. La modélisation des eaux pluviales pour chaque scénario de revitalisation du bassin hydrologique a fourni une estimation quantitative des impacts potentiels associés aux mesures de gestion des eaux pluviales. Cette information peut servir à élaborer des analyses de rentabilisation en vue d'utiliser ces pratiques dans les sites à l'étude et des sites semblables situés ailleurs dans le bassin hydrologique. L'étude fournit des exemples pratiques de mesures de gestion des eaux pluviales innovatrices pour quiconque envisagerait de les appliquer dans d'autres régions.

Directrice de projet à la SCHL : Cate Soroczan

Recherche sur le logement à la SCHL

Aux termes de la partie IX de la *Loi nationale sur l'habitation*, le gouvernement du Canada verse des fonds à la SCHL afin de lui permettre de faire de la recherche sur les aspects socio-économiques et techniques du logement et des domaines connexes, et d'en publier et d'en diffuser les résultats.

Le présent feuillet documentaire fait partie d'une série visant à vous informer sur la nature et la portée du programme de recherche de la SCHL.

Pour consulter d'autres feuillets *Le Point en recherche* et pour prendre connaissance d'un large éventail de produits d'information, visitez notre site Web au

www.schl.ca

ou communiquez avec la

Société canadienne d'hypothèques et de logement
700, chemin de Montréal
Ottawa (Ontario)
K1A 0P7

Téléphone : 1-800-668-2642
Télécopieur : 1-800-245-9274



National Office

Bureau national

700 Montreal Road
Ottawa ON K1A 0P7
Telephone: (613) 748-2000

700 chemin de Montréal
Ottawa ON K1A 0P7
Téléphone : (613) 748-2000

Puisqu'on prévoit une demande restreinte pour ce document de recherche, seul le résumé a été traduit.

La SCHL fera traduire le document si la demande le justifie.

Pour nous aider à déterminer si la demande justifie que ce rapport soit traduit en français, veuillez remplir la partie ci-dessous et la retourner à l'adresse suivante :

Centre canadien de documentation sur l'habitation
Société canadienne d'hypothèques et de logement
700, chemin Montréal, bureau C1-200
Ottawa (Ontario)
K1A 0P7

Titre du rapport: _____

Je préférerais que ce rapport soit disponible en français.

NOM _____

ADRESSE _____

rue

App.

ville

province

Code postal

No de téléphone () _____

Contents

1	INTRODUCTION	1
2	EVALUATION OF DON RIVER WATERSHED SITES.....	1
2.1	LID CONCEPT EVALUATION.....	1
2.1.1	Warden Woods	1
2.1.1.1	Existing Condition.....	1
2.1.1.2	Proposed Condition	1
2.1.1.3	Evaluation Method and Assumption	5
2.1.1.4	Summary of Results	7
2.1.2	Mud Creek.....	10
2.1.2.1	Existing Condition.....	10
2.1.2.2	Proposed Condition	10
2.1.2.3	Evaluation Method and Assumption	14
2.1.2.4	Summary of Results	14
2.1.2.5	Future Mud Creek Enhancement.....	17
2.1.3	Industrial Park	17
2.1.3.1	Existing Condition.....	17
2.1.3.2	Proposed Condition	17
2.1.3.3	Evaluation Method and Assumption	20
2.1.3.4	Summary of Results	21
2.2	WATER BUDGET ANALYSIS.....	24
3	CONCLUSION	25
4	REFERENCES	25

Appendices

Appendix A:	Site Evaluation – Warden Woods
Appendix B:	Site Evaluation – Mud Creek
Appendix C:	Site Evaluation – Industrial Park
Appendix D:	Water Budget Analysis

List of Figures

Figure 2-1: Warden Woods Site Plan	3
Figure 2-2: Warden Woods Preliminary LID Concept Plan	4
Figure 2-3: Mud Creek Site Plan	11
Figure 2-4: Mud Creek Preliminary LID Concept Plan (Dry Weather)	12
Figure 2-5: Mud Creek Preliminary LID Concept Plan (Wet Weather)	13
Figure 2-6: Industrial Park Site Plan.....	19
Figure 2-7: Industrial Park Preliminary Concept Plan.....	20
Figure 2-8: Impact of LID Measures on the Water Cycle.....	24

List of Tables

Table 2-1: Warden Woods Peak Release Rates Comparison.....	8
Table 2-2: Warden Woods Runoff Volumes Comparison.....	8
Table 2-3: Warden Woods Percentage Reduction Summary (Between Existing and Proposed Conditions)	9
Table 2-4: Mud Creek Peak Release Rates Comparison.....	15
Table 2-5: Mud Creek Runoff Volumes Comparison	15
Table 2-6: Mud Creek Percentage Reduction Summary (Between Existing and Proposed Conditions)	16
Table 2-7: Industrial Park Peak Release Rates Comparison	22
Table 2-8: Industrial Park Runoff Volume Comparison	22
Table 2-9: Industrial Park Percentage Reduction Summary (Between Existing and Proposed Conditions)	23

1 Introduction

The Municipal Infrastructure Group Ltd. (TMIG) was retained by the Toronto and Region Conservation Authority (TRCA) to evaluate the Low Impact Development (LID) measures proposed in three areas within the Don River watershed. The tasks include the evaluation of the implementation potential and impact of different LID measures; and to carry out a water budget analysis. The results of the evaluation will provide TRCA with a methodology for comparison against future models that are compiled for other development areas.

2 Evaluation of Don River Watershed Sites

In order to evaluate the implementation potential and the impact of different Low Impact Development (LID) measures on existing communities, site evaluation has been performed on three areas within the Don River watershed. The three potential sites selected by TRCA have been labelled as Warden Woods, Mud Creek, and an unnamed Industrial Park; all of which are located within the City of Toronto.

The site evaluation determines the reduction in stormwater runoff volumes and peak release rates from the subject sites through the implementation of LID measures. The analysis is performed using the hydrologic modelling software Visual OTTHYMO version 2.0 (VO2).

2.1 LID Concept Evaluation

2.1.1 Warden Woods

2.1.1.1 Existing Condition

Warden Woods is an existing residential area which is located adjacent to Massey Creek within the Don River watershed. The study area is approximately 53.35ha in size, which consists of single residential in a recent infill area (9.88ha), single residential lots in the original community (25.92ha), a high rise apartment complex (3.84ha), a high school (2.04ha), a commercial building block (0.51ha), a community centre (2.90ha), a cemetery (5.60ha), a park (1.02ha) and the road (1.64ha) (see **Figure 2-1**).

2.1.1.2 Proposed Condition

Several LID measures are proposed to be implemented throughout the site (see **Figure 2-2**) as detailed by the following:

- Down spout disconnection: this measure will be implemented in 100% of the single residential lots which are located within the recent infill area and 30% of those located within the original community.
- Enhanced tree canopy: this measure will be implemented in all landscape area.
- Permeable Pavement: this measure will be implemented in the boulevard driveway (ie. portion of driveways in the municipal right-of-way) and the parking lot areas.
- Green roofs: this measure will be implemented on the community centre and the high school building roof tops.
- Rainwater harvesting: this measure will be implemented in the high school building
- Biofilter system: this measure will be implemented in various locations to increase landscape areas and promote infiltration.

- Infiltration gallery: this measure will be implemented in several locations to increase landscaping, detain runoff and promote infiltration.
- Yard naturalization program: this measure will be implemented in a portion of the rear yard area along the Massey Creek ravine to increase green areas.
- Photovoltaics on roof tops: this measure will be implemented on the roof tops. Please note that this LID measure has no effect on the reduction in storm runoff volume and peak flow, as its main purpose is to reduce energy consumption.

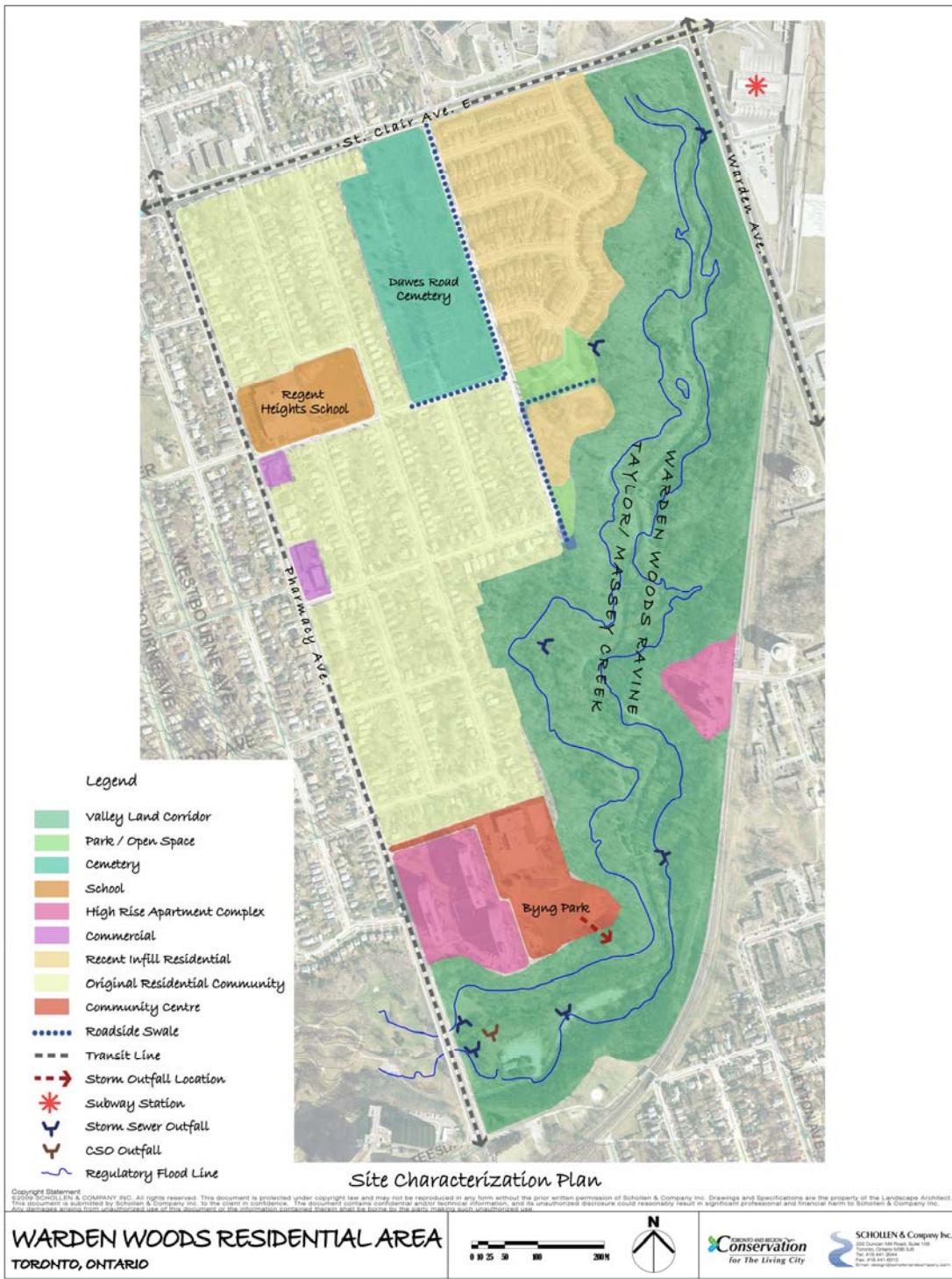


Figure 2-1: Warden Woods Site Plan

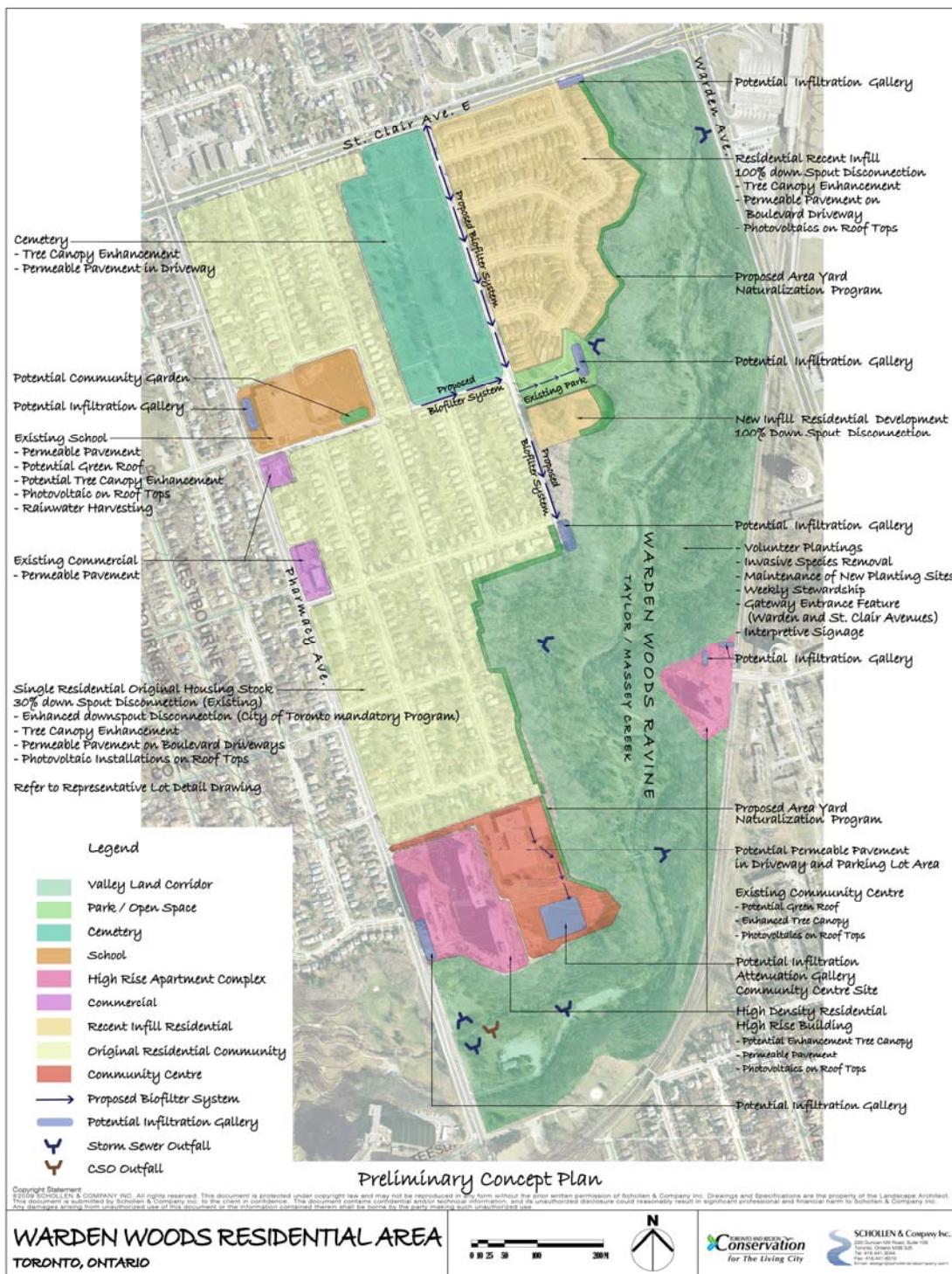


Figure 2-2: Warden Woods Preliminary LID Concept Plan

2.1.1.3 Evaluation Method and Assumption

In order to evaluate the impact of the different LID measures, a VO2 model has been set up for the pre-urban condition, the existing condition and the proposed condition. The methods used to simulate the different LID measures implemented under the proposed condition are summarized as follows. The areas used in the model were obtained by direct measurement from the site plan provided by TRCA.

Recent Infill Residential:

- 100% down spout disconnection: this measure is modelled by reducing the XIMP value for all the roof area which increases the amount of flow routed across pervious surfaces.
- Enhanced tree canopy: this measure is modelled by doubling the default initial abstraction (IA) value in the VO2 model which increases stormwater retention on site.
- Permeable Pavement: this measure is modelled by adjusting the runoff coefficient of the pavement area from 0.95 to 0.40 which reduces overall runoff from the areas. The permeable pavement runoff coefficient value of 0.40 is determined based on MTO design Chart 1.07 for gravel roads and shoulders.
- Infiltration gallery: this measure is modelled by setting a runoff coefficient value of 0.25 for the “infiltration gallery” area, therefore reducing runoff, and by doubling the default initial abstraction (IA) value in the VO2 model, which retains increased stormwater volumes on site.

Original Community Residential:

- 30% down spout disconnection: this measure is modelled by reducing the XIMP value for 30% of the roof area.
- Enhanced tree canopy: this measure is modelled by doubling the default initial abstraction (IA) value in the VO2 model.
- Permeable Pavement: this measure is modelled by adjusting the runoff coefficient of the pavement area from 0.95 to 0.40. The permeable pavement runoff coefficient value of 0.40 is determined based on MTO design Chart 1.07 for gravel roads and shoulder.

High School:

- Enhanced tree canopy: this measure is modelled by doubling the default initial abstraction (IA) value in the VO2 model.
- Permeable Pavement: this measure is modelled by adjusting the runoff coefficient of the pavement area from 0.95 to 0.40. The permeable pavement runoff coefficient value of 0.40 is determined based on MTO design Chart 1.07 for gravel roads and shoulder.
- Green roof and rainwater harvesting: this measure is modelled by adjusting the runoff coefficient of the roof area by assuming that the green roof and the rainwater harvesting measures will capture 15mm (LEED Gold criteria) of the rainfall. The reduction in the runoff coefficient varies under different return period storm events. This is due to the fact that the rainfall depth of each return period storm will be reduced by the amount captured by the roof. The base runoff coefficient will then be prorated based on the adjusted runoff value. Details of the method used to adjust the runoff coefficient are provided in **Appendix A**.
- Infiltration gallery: this measure is modelled by setting a runoff coefficient value of 0.25 for the “infiltration gallery” area and by doubling the default initial abstraction (IA) value in the VO2 model.

Community Centre:

- Enhanced tree canopy: this measure is modelled by doubling the default initial abstraction (IA) value in the VO2 model.
- Permeable Pavement: this measure is modelled by adjusting the runoff coefficient of the pavement area from 0.95 to 0.40. The permeable pavement runoff coefficient value of 0.40 is determined based on MTO design Chart 1.07 for gravel roads and shoulder.
- Green roof: this measure is modelled by adjusting the runoff coefficient of the roof area by assuming that the green roof will capture 6mm of the rainfall. According to Table 3.1 of the *Ministry of the Environment Stormwater Management Planning and Design Manual (March 2003)*, green roofs are considered to have low runoff potential and fall within Hydrologic Soil Group A under the Urban Lawns/Shallow Rooted Crops category. By analyzing the rainfall data from Toronto-Lester B. Pearson International Airport, with an annual average precipitation of 783.7 mm, the green roof can capture 429.4 mm of the rainfall through evapo-transpiration. This 429.4 mm of annual precipitation represents a capture of 6 mm of rainfall. The reduction in the runoff coefficient varies under different return period storm events. The rainfall depth of each return period storm will be reduced by the rainfall depth captured by the green roof. The base runoff coefficient will then be prorated based on the adjusted runoff value. Details of the green roof capture calculations and the method used to adjust the runoff coefficient are provided in **Appendix A**.
- Infiltration gallery: this measure is modelled by setting a runoff coefficient value of 0.25 for the “infiltration gallery” area and by doubling the default initial abstraction (IA) value in the VO2 model.

Commercial:

- Permeable Pavement: this measure is modelled by adjusting the runoff coefficient of the pavement area from 0.95 to 0.40. The permeable pavement runoff coefficient value of 0.40 is determined based on MTO design Chart 1.07 for gravel roads and shoulder.

High Rise Residential:

- Permeable Pavement: this measure is modelled by adjusting the runoff coefficient of the pavement area from 0.95 to 0.40. The permeable pavement runoff coefficient value of 0.40 is determined based on MTO design Chart 1.07 for gravel roads and shoulder.
- Infiltration gallery: this measure is modelled by setting a runoff coefficient value of 0.25 for the “infiltration gallery” area and by doubling the default initial abstraction (IA) value in the VO2 model.

Park:

- Infiltration gallery: this measure is modelled by setting a runoff coefficient value of 0.25 for the “infiltration gallery” area and by doubling the default initial abstraction (IA) value in the VO2 model.

Cemetery:

- Enhanced tree canopy: this measure is modelled by doubling the default initial abstraction (IA) value in the VO2 model.
- Permeable Pavement: this measure is modelled by adjusting the runoff coefficient of the pavement area from 0.95 to 0.40. The permeable pavement runoff coefficient value of 0.40 is determined based on MTO design Chart 1.07 for gravel roads and shoulder.

Road:

- Biofilter System: this measure is modelled by setting a runoff coefficient value of 0.25 for the "Biofilter System" area and by doubling the default initial abstraction (IA) value in the VO2 model.

In setting up the VO2 model, the following assumptions have been made:

- The Wet Weather Flow management Guidelines (WWFMG) design storm events applied.
- The runoff coefficient values obtained from the WWFMG.
- The residential lot break down is considered to have 64% landscape area, 30% roof area and 6% driveway area. This percentage break down corresponds to a weighted runoff coefficient of 0.50 for single residential lots as specified under the WWFMG.
- The high school and community block break down are considered to have 29% landscape area and 71% roof and driveway area. This percentage break down corresponds to a weighted runoff coefficient of 0.75 for the institutional block as specified under the WWFMG.
- The permeable pavement measure is implemented for all the boulevard driveway and parking lot areas.

2.1.1.4 Summary of Results

The results of the analysis are summarized in **Tables 2-1 to 2-3**. Depending on the storm event, the implementation of the LID measures resulted in peak release rate reductions in the range of 20% to 46% approximately; and reduction to total runoff volumes of between 9% and 43% approximately. It should be noted that the reduction in both the peak release rate and the runoff volume decrease under larger storm events. Detailed results of the analysis are provided in **Appendix A**.

Please note that the method used in modelling the biofilter and the infiltration gallery system is quite conservative, as the release rate and runoff reductions could be much higher than just doubling the default IA value within the VO2 model. If the tributary area to the infiltration system and the actual configuration of the infiltration facility (e.g. dimension, storage medium volume, existing soil permeability and etc) were available, a continuous analysis can be performed to determine the percentage runoff reduction on an annual basis which can then be prorated to determine the effect under different design storm events.

Table 2-1: Warden Woods Peak Release Rates Comparison

	5mm		25mm		2-year		5-year		10-year		25-year		50-year		100-year		
	Pre-urban Existing (m³/s)	Post (m³/s)															
Recent Infill Residential	0.00	0.075	0.035	0.102	0.61	0.297	0.202	1.132	0.609	0.461	1.856	1.068	2.36	1.803	0.916	2.833	2.283
Original Residential	0.00	0.13	0.095	0.266	1.252	0.973	0.53	2.701	2.079	1.21	4.503	3.614	5.77	4.694	2.403	6.965	5.733
High school	0.00	0.035	0.006	0.021	0.215	0.055	0.042	0.403	0.124	0.095	0.623	0.26	0.141	0.779	0.36	1.089	0.922
Community Centre	0.00	0.042	0.011	0.03	0.30	0.091	0.059	0.565	0.173	0.135	0.877	0.321	0.20	1.099	0.422	1.269	1.302
Commercial	0.00	0.013	0.006	0.005	0.07	0.036	0.01	0.124	0.067	0.024	0.185	0.105	0.035	0.229	0.143	0.047	0.267
High Rise	0.00	0.053	0.022	0.039	0.391	0.164	0.078	0.739	0.308	0.179	1.151	0.529	0.265	1.444	0.684	0.356	1.713
Park	0.00	0.00	0.00	0.01	0.01	0.004	0.021	0.021	0.011	0.011	0.048	0.048	0.07	0.07	0.053	0.095	0.074
Cemetery	0.00	0.006	0.002	0.058	0.074	0.026	0.114	0.159	0.066	0.261	0.331	0.196	0.396	0.47	0.317	0.519	0.614
Road	0.00	0.036	0.035	0.017	0.217	0.211	0.034	0.39	0.379	0.077	0.59	0.573	0.113	0.729	0.71	0.152	0.854
Total	0.00	0.39	0.21	0.55	3.14	1.36	1.09	6.23	3.82	2.49	10.16	6.70	3.68	12.95	9.19	4.95	15.57
															11.65	6.71	19.37
															8.11	23.25	18.50

Table 2-2: Warden Woods Runoff Volumes Comparison

	5mm		25mm		2-year		5-year		10-year		25-year		50-year		100-year			
	Pre-urban (m)	Existing (m)	Post (m)	Pre-urban (m)	Existing (m)	Post (m)	Pre-urban (m)											
Recent Infill Residential	0	203	93	461	1559	1189	659	1917	1521	1357	3008	2564	1863	3719	3257	2431	4476	
Original Residential	0	526	383	1209	4052	3512	1730	4985	4388	3561	7839	7156	4887	9699	8976	6377	11680	4000
High school	0	65	11	95	421	205	136	507	279	280	758	502	305	918	652	502	1085	805
Community Centre	0	92	20	135	589	299	194	720	384	398	1073	664	547	1305	851	714	1543	941
Commercial	0	20	10	24	122	82	34	145	100	70	212	157	96	254	194	125	238	233
High Rise	0	123	50	179	793	476	256	954	600	528	1423	989	724	1728	1249	945	2013	1529
Park	0	0	0	48	48	28	68	46	40	140	111	192	192	160	251	216	331	331
Cemetery	0	9	2	261	295	177	374	414	275	769	818	641	1056	1109	915	1378	1433	1227
Road	0	65	63	76	391	380	109	466	453	225	682	666	309	817	800	404	957	938
Total	0	1103	633	2488	8279	5348	3561	10775	8057	7330	15964	13451	10058	19741	17054	13126	23767	20927
															28019	26033	20594	
															33004	29329	28904	

Table 2-3: Warden Woods Percentage Reduction Summary (Between Existing and Proposed Conditions)

	5mm		25mm		2-year		5-year		10-year		25-year		50-year		100-year	
	Release Rate	Runoff Vol.														
Recent Infill Residential	53%	54%	51%	24%	46%	21%	42%	15%	24%	12%	19%	11%	23%	9%	21%	8%
Original Residential	27%	27%	22%	13%	23%	12%	20%	9%	19%	7%	18%	6%	17%	6%	11%	5%
High school	83%	83%	74%	51%	69%	45%	58%	34%	54%	29%	44%	26%	40%	22%	40%	21%
Community Centre	74%	78%	70%	50%	69%	47%	63%	38%	62%	35%	52%	32%	49%	28%	46%	26%
Commercial	54%	48%	33%	46%	31%	43%	26%	38%	24%	35%	22%	33%	20%	30%	18%	
High Rise	58%	59%	40%	58%	37%	54%	31%	53%	28%	44%	25%	41%	23%	39%	21%	
Park	0%	0%	60%	40%	48%	33%	29%	21%	24%	17%	22%	14%	17%	11%	15%	10%
Cemetery	67%	74%	65%	40%	58%	34%	41%	22%	33%	17%	27%	14%	23%	12%	20%	10%
Road	3%	3%	3%	3%	3%	3%	2%	3%	2%	3%	2%	3%	2%	2%	2%	2%
Total	46%	43%	41%	23%	39%	21%	34%	16%	29%	14%	25%	12%	24%	10%	20%	9%

2.1.2 Mud Creek

2.1.2.1 Existing Condition

The portion of Mud Creek being studied is located between Moore Avenue and Bayview Avenue and is bounded by existing residential development on both the east and west sides. The subject site locates within the Mud Creek watershed and is approximately 159.85ha in size. **Figure 2-3** shows the boundary of the proposed study area.

2.1.2.2 Proposed Condition

Several LID measures are proposed to be implemented throughout the site (see **Figure 2-4 and 2-5**) as detailed by the following:

- Down spout disconnection: this measure will be implemented on all single residential lots in accordance with the City's Mandatory Program.
- Enhanced tree canopy: this measure will be implemented in all landscape areas.
- Permeable Pavement: this measure will be implemented in the boulevard driveway of the residential area and on part of the existing road area.
- Infiltration gallery: this measure will be implemented in the permeable pavement locations along the road.
- Photovoltaics on roof tops: this measure will be implemented on the roof tops. Please note that this LID measure has no effect on the reduction in storm runoff volume and peak flow, as its main purpose is to reduce energy consumption.

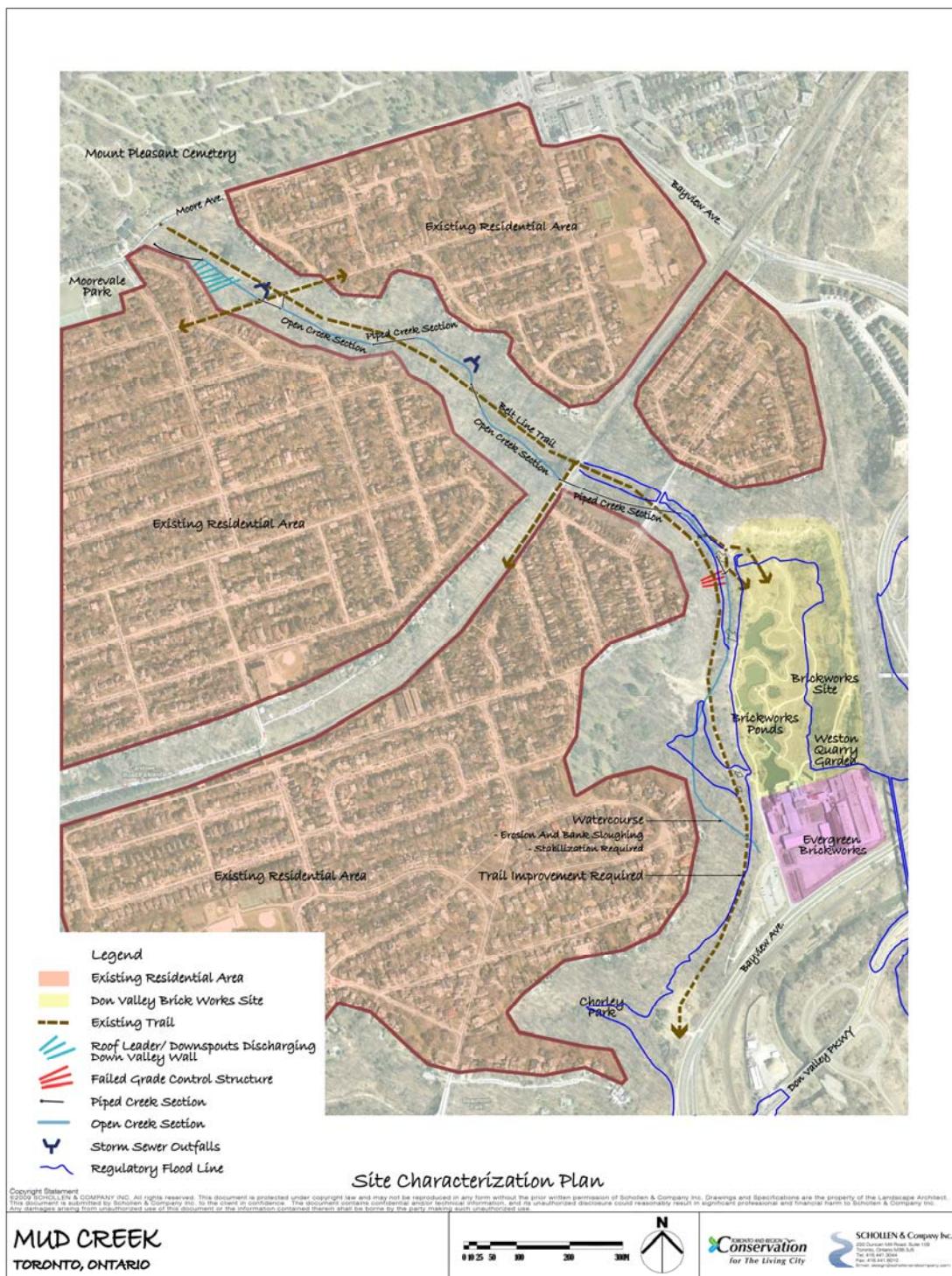


Figure 2-3: Mud Creek Site Plan

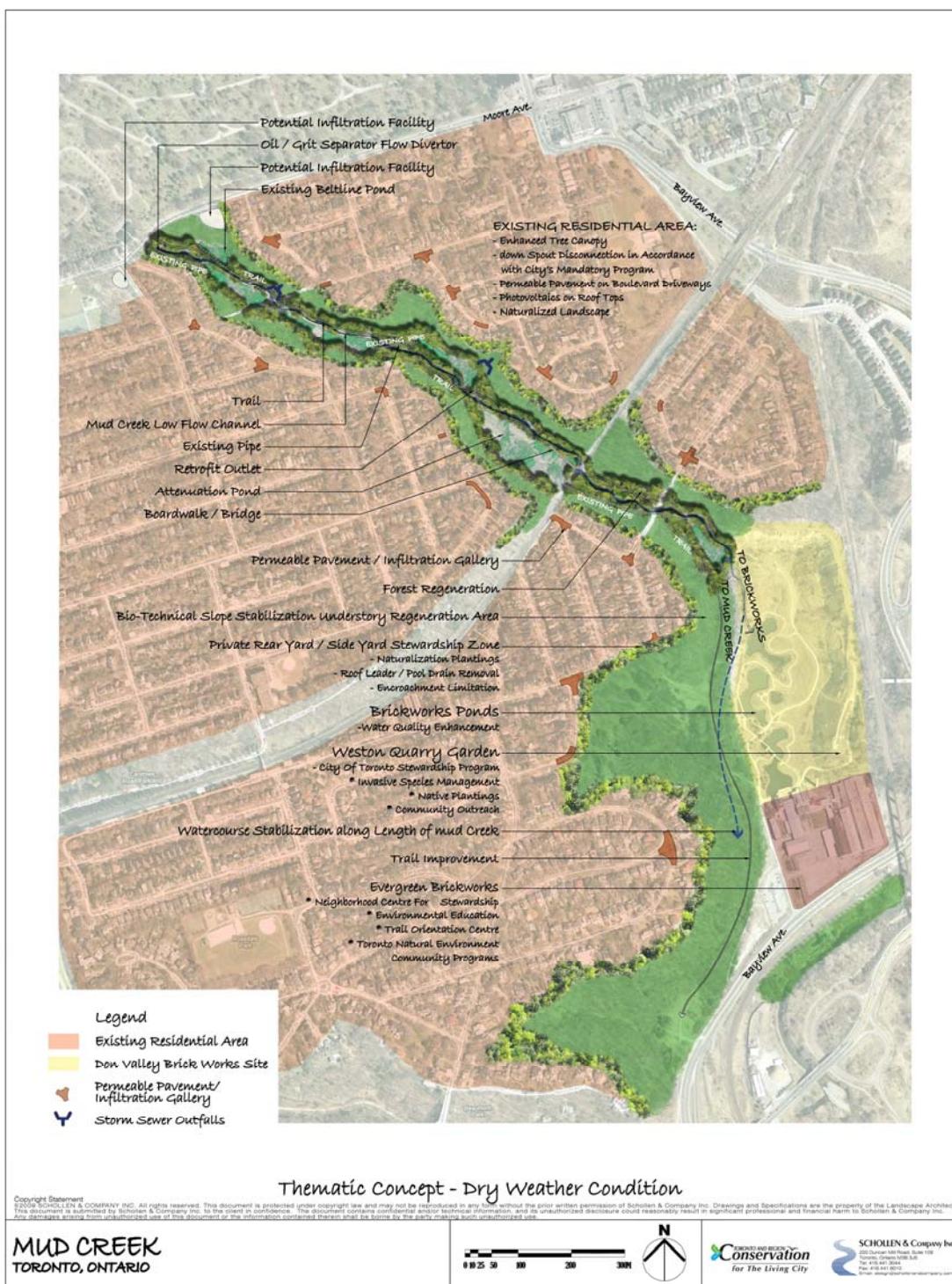


Figure 2-4: Mud Creek Preliminary LID Concept Plan (Dry Weather)

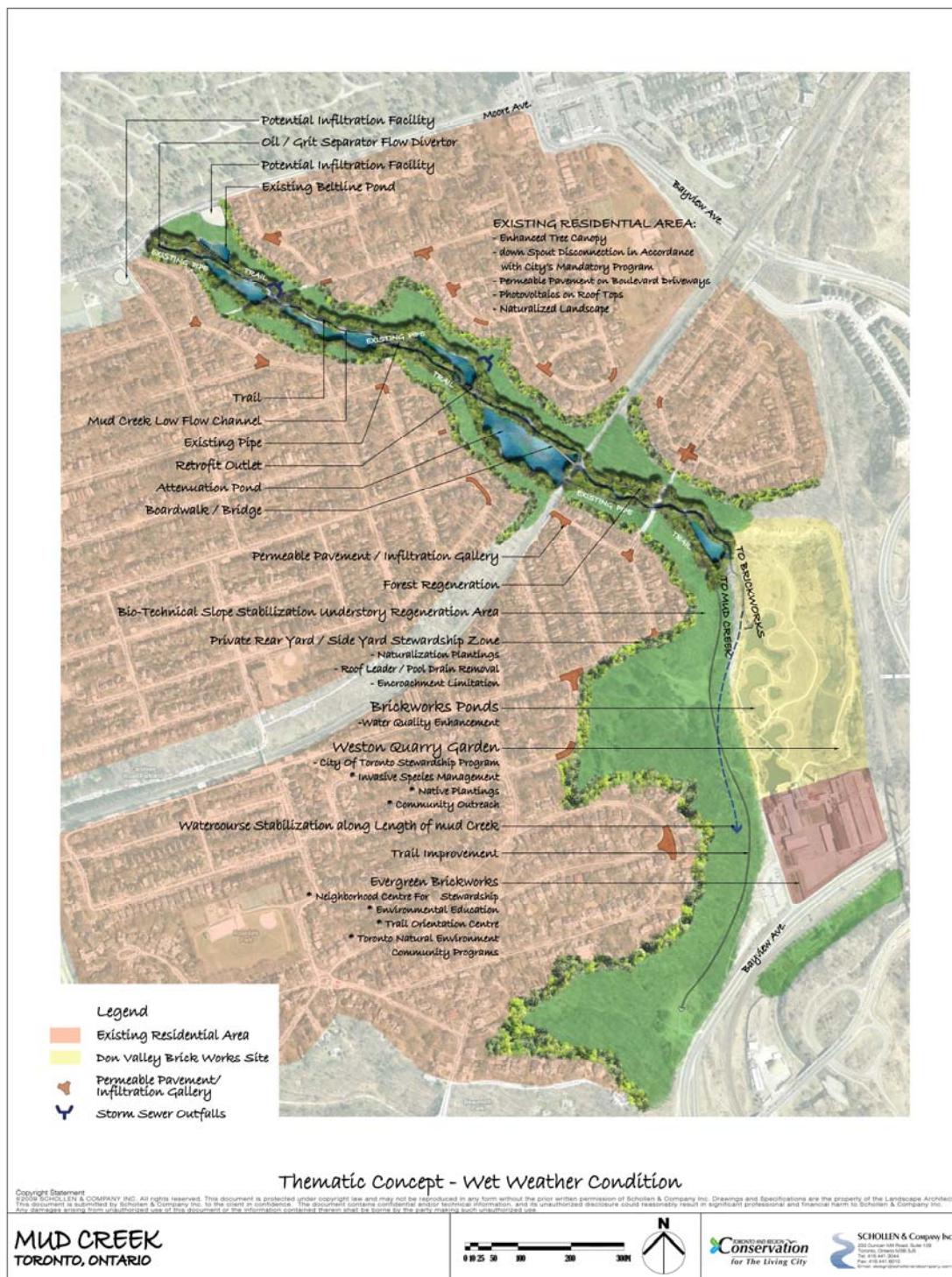


Figure 2-5: Mud Creek Preliminary LID Concept Plan (Wet Weather)

2.1.2.3 Evaluation Method and Assumption

In order to evaluate the impact of the different LID measures, a VO2 model has been set up for the pre-urban condition, the existing condition and the proposed condition. The methods used to simulate the different LID measures implemented under the proposed condition are summarized as follows. The existing residential area is generally broken down into four quadrants which are, namely, the NE, SE, SW and NW; and the areas used in the model have been obtained by direct measurement from the site plan provided by TRCA.

- Down spout disconnection: this measure is modelled by reducing the XIMP value for all the roof area.
- Enhanced tree canopy: this measure is modelled by doubling the default initial abstraction (IA) value in the VO2 model.
- Permeable Pavement: this measure is modelled by adjusting the runoff coefficient of the pavement area from 0.95 to 0.40. The permeable pavement runoff coefficient value of 0.40 is determined based on MTO design Chart 1.07 for gravel roads and shoulder.
- Infiltration gallery under the permeable pavement: this measure is modelled by doubling the default initial abstraction (IA) value in the VO2 model in order to incorporate the increase in infiltration volume.

In setting up the VO2 model, the following assumptions have been made:

- The Wet Weather Flow management Guidelines (WWFMG) design storm events applied.
- The runoff coefficient values obtained from the WWFMG.
- The residential lot break down is considered to have 64% landscape area, 30% roof area and 6% driveway area. This percentage break down corresponds to a weighted runoff coefficient of 0.50 for single residential lots as specified under the WWFMG.
- The permeable pavement for the boulevard driveway implemented in all residential lots.
- For each quadrant of existing residential area, the area break down is 10% road and 90% residential.

2.1.2.4 Summary of Results

The results of the analysis are summarized in **Tables 2-4 to 2-6**. Depending on the storm event, the implementation of the LID measures resulted in peak release rate reductions in the range of 22% to 52% approximately; and reduction to total runoff volumes of between 6% and 53% approximately. It should be noted that significant reductions in both the peak release rate and the runoff volume are observed under the 5mm, 25mm, and 2-year design storm events. This signifies that, with the implementation of the LID measure, erosion issues could be significantly eased within Mud Creek. Detailed results of the analysis are provided in **Appendix B**.

Please note that the method used in modelling the biofilter and the infiltration gallery system is quite conservative, as the release rate and runoff reductions could be much higher than just doubling the default IA value within the VO2 model. If the tributary area to the infiltration system and the actual configuration of the infiltration facility (e.g. dimension, storage medium volume, existing soil permeability and etc) were available, a continuous analysis can be applied to determine the percentage runoff reduction on an annual basis which can then be prorated to determine the effect under different design storm events.

Table 2-4: Mud Creek Peak Release Rates Comparison

	5mm		25mm		2-year		5-year		10-year		25-year		50-year		100-year									
	Pre-urban (m/s)	Existing (m/s)	Post (m/s)	Pre-urban (m/s)	Existing (m/s)	Post (m/s)	Pre-urban (m/s)	Existing (m/s)	Post (m/s)	Pre-urban (m/s)	Existing (m/s)	Post (m/s)	Pre-urban (m/s)	Existing (m/s)	Post (m/s)	Pre-urban (m/s)	Existing (m/s)	Post (m/s)						
NE Corner (Area = 27.24ha)	0.00	0.144	0.067	0.28	1.357	0.638	0.557	2.906	1.469	1.272	4.828	2.854	1.879	6.18	3.796	2.525	7.453	4.731	3.426	9.126	7.858	4.143	11.57	9.237
SE Corner (Area = 9.33ha)	0.00	0.073	0.034	0.097	0.587	0.289	0.193	1.088	0.595	0.44	1.782	1.043	0.65	2.265	1.77	0.874	2.718	2.241	1.186	3.668	2.882	1.434	4.203	3.384
SW Corner (Area = 70.45ha)	0.00	0.288	0.142	0.724	3.134	1.674	1.44	5.837	3.326	3.29	11.105	6.912	4.859	14.8	9.236	6.531	17.942	11.537	8.86	22.094	14.644	10.715	25.28	17.066
NW Corner (Area = 52.73ha)	0.00	0.231	0.112	0.542	2.43	1.296	1.078	4.528	2.568	2.462	8.549	5.316	3.637	11.371	7.081	4.888	13.762	8.834	6.631	16.916	11.197	8.02	19.334	17.132
Total	0.00	0.75	0.36	1.64	7.51	3.96	3.27	14.36	7.36	7.46	26.26	16.13	11.03	34.62	21.88	14.82	41.88	27.34	20.10	51.80	36.58	24.31	60.39	46.82

Table 2-5: Mud Creek Runoff Volumes Comparison

	5mm		25mm		2-year		5-year		10-year		25-year		50-year		100-year									
	Pre-urban (m)	Existing (m)	Post (m)	Pre-urban (m)	Existing (m)	Post (m)	Pre-urban (m)	Existing (m)	Post (m)	Pre-urban (m)	Existing (m)	Post (m)	Pre-urban (m)	Existing (m)	Post (m)	Pre-urban (m)	Existing (m)	Post (m)						
NE Corner (Area = 27.24ha)	0	564	264	1270	4307	3388	1818	5294	4323	3743	8306	7254	5136	10268	9194	6702	12356	11270	8839	15075	13987	10515	17138	16051
SE Corner (Area = 9.33ha)	0	195	90	440	1491	1171	629	1833	1495	1296	2875	2509	1778	3554	3180	2320	4277	3899	3060	5219	4839	3640	5932	5553
SW Corner (Area = 70.45ha)	0	1460	682	3286	11142	8799	4702	13694	11223	9679	21484	18813	13283	26557	23833	17334	31987	29208	22860	38991	36237	27194	44324	41577
NW Corner (Area = 52.73ha)	0	1093	519	2459	8339	6594	3519	10249	8409	7245	16079	14092	9942	19876	17851	12974	23918	21875	17110	29183	27137	20354	33175	31134
Total	0	3312	1565	7455	25220	19951	10668	31070	25449	21952	48744	42668	30138	60255	54057	33329	72507	66251	51870	88468	82220	61704	100569	94316

Table 2-6: Mud Creek Percentage Reduction Summary (Between Existing and Proposed Conditions)

	5mm		25mm		2-year		5-year		10-year		25-year		50-year		100-year	
	Release Rate	Runoff Vol.														
NE Corner (Area = 27.24ha)	53%	49%	21%	49%	18%	41%	13%	39%	10%	37%	9%	14%	7%	20%	6%	
SE Corner (Area = 9.43ha)	53%	54%	21%	45%	18%	41%	13%	22%	11%	18%	9%	21%	7%	19%	6%	
SW Corner (Area = 70.45ha)	52%	53%	47%	21%	43%	18%	38%	12%	38%	10%	36%	9%	34%	7%	32%	6%
NW Corner (Area = 52.33ha)	52%	52%	47%	21%	43%	18%	38%	12%	38%	10%	36%	9%	34%	7%	11%	6%
Total	52%	53%	47%	21%	45%	18%	39%	12%	37%	10%	35%	9%	29%	7%	22%	6%

2.1.2.5 Future Mud Creek Enhancement

Future enhancement is also proposed for the subject portion of Mud Creek itself. According to the preliminary conceptual plan as indicated in **Figure 2-4 and 2-5**, the following enhancement works are proposed:

- Water course stabilization along the length of Mud Creek.
- Construction of several attenuation ponds.
- Construction of an infiltration facility.
- Provide oil/grit separator on existing outlet pipe.
- Retrofit existing outlet.
- Forest regeneration within the creek.
- Bio-technical slope stabilization.
- Naturalization planting

Prior to implementing the above captioned enhancement works, the following detailed design and analysis should be carried out.

- Finalize the extent of different LID measures that are going to be implemented within the tributary area to the Mud Creek including dimensions, configuration and the tributary areas to each of the measures.
- Based on the proposed condition information, stormwater management analysis will be performed to ensure that the subject site optimize the relevant erosion and water quantity control requirements.
- According to the existing topographic information of Mud Creek and the results from the stormwater management analysis, sizing of the attenuation pond will need to be performed to utilize the available storage area within the creek. The purpose of the detention ponds is to further reduce the peak release rate from the contributing area and hence improve erosion control within the creek system.
- Finally, an update of the HEC-RAS model will be required based on the updated release rate from the creek's tributary area and to confirm that the floodlines are within the allowable limits.

2.1.3 Industrial Park

2.1.3.1 Existing Condition

The Industrial Park is an existing industrial area which is located within the Don River watershed. The subject site consists mainly of industrial building with some undeveloped areas and an existing water course crossing the site (see **Figure 2-6**). The exact location is not provided as this analysis is intended to provide insight into LID measures that could be implemented in any industrial area rather than a specific neighbourhood.

2.1.3.2 Proposed Condition

Several LID measures and SWM facilities are proposed to be implemented throughout the site (see **Figure 2-7**) as detailed by the following:

- Enhanced tree canopy: this measure will be implemented in all landscape areas.
- Permeable Pavement: this measure will be implemented in all driveway and parking lot areas.

- Green roofs and rainwater harvesting: this measure will be implemented on both the existing and future industrial buildings.
- Biofilter and landscape infiltration system: this measure will be implemented in various locations to increase landscape areas and promote infiltration.
- Enhanced swale SWM corridor: this measure will be implemented in several locations to increase landscape areas and for conveyance of flow.
- SWM Pond: this measure will be implemented in several areas within the site to increase landscape areas and for flow detention.
- Photovoltaics on roof tops: this measure will be implemented on the roof tops. Please note that this LID measure has no effect on the reduction in storm runoff volume and peak flow, as its main purpose is to reduce energy consumption.

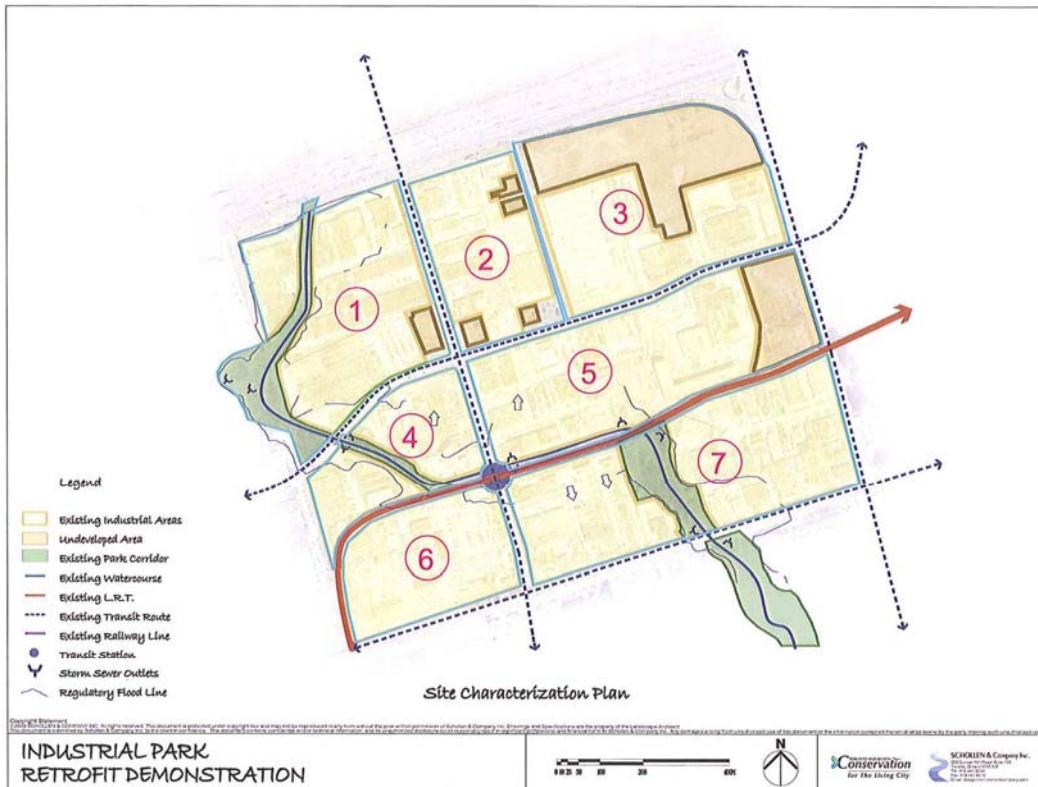


Figure 2-6: Industrial Park Site Plan

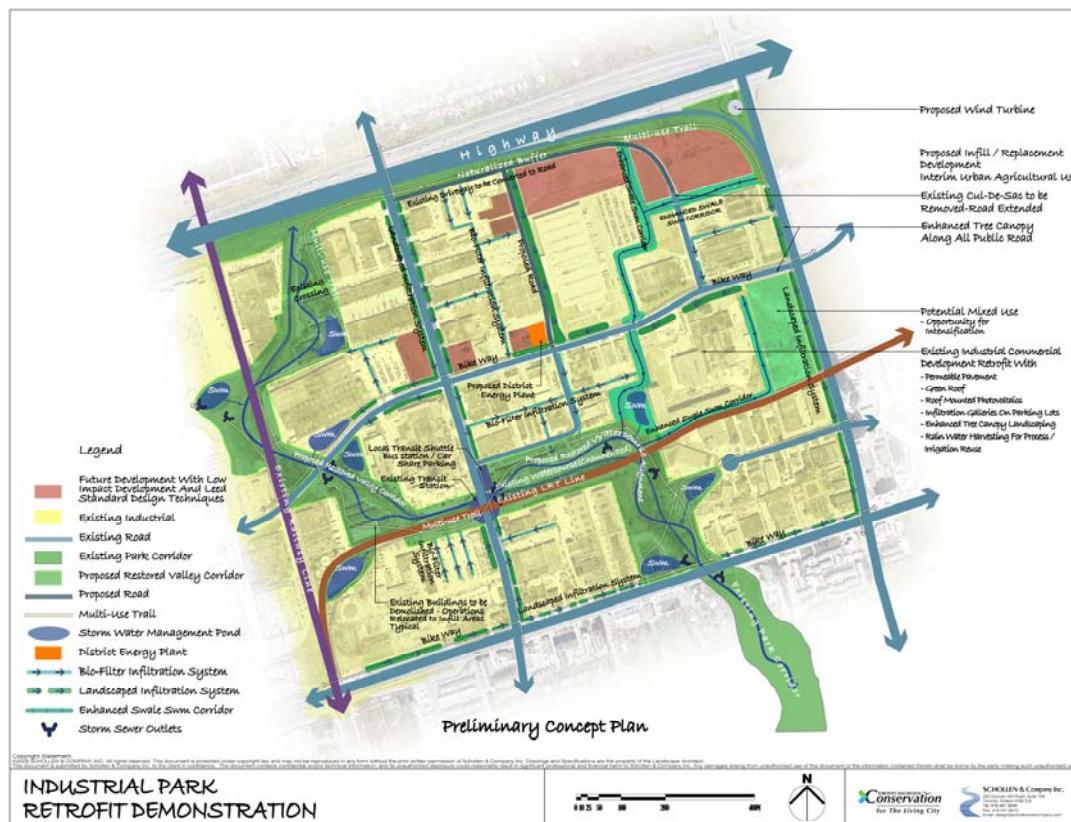


Figure 2-7: Industrial Park Preliminary Concept Plan

2.1.3.3 Evaluation Method and Assumption

In order to evaluate the impact of the different LID measures, a VO2 model has been set up for the pre-urban condition, the existing condition and the proposed conditions. The methods used to simulate the different LID measures implemented under the proposed condition are summarized as follows. The existing industrial area has been divided into seven areas for the analysis (see **Figure 2-6**) with the areas used in the model obtained by direct measurement from the site plan provided by TRCA. The method used to model the different LID measures are summarized as follows:

- Enhanced tree canopy: this measure is modelled by doubling the default initial abstraction (IA) value in the VO2 model.
- Green roof and rainwater harvesting: this measure is modelled by adjusting the runoff coefficient of the roof area by assuming that the green roof and the rainwater harvesting measures will capture 15mm (LEED Gold criteria) of the rainfall. The reduction in the runoff coefficient varies under different return period storm events. This is due to the fact that the rainfall depth of each return period storm will be reduced by the amount captured by the roof. The base runoff coefficient will then be prorated based on the adjusted runoff value. Details of the method used to adjust the runoff coefficient are provided in **Appendix C**.
- Permeable Pavement: this measure is modelled by adjusting the runoff coefficient of the pavement area from 0.95 to 0.40. The permeable pavement runoff coefficient value of 0.40 is determined based on MTO design Chart 1.07 for gravel roads and shoulders.

- Biofilter and landscape infiltration system: this measure is modelled by setting a runoff coefficient value of 0.25 for the "infiltration gallery" area and by doubling the default initial abstraction (IA) value in the VO2 model.
- Enhanced swale corridor: this measure is modelled by setting a runoff coefficient value of 0.25 for the "enhanced swale" area
- SWM Pond: this measure is modelled by setting a runoff coefficient value of 0.25 for the "SWM Pond" area

In setting up the VO2 model, the following assumptions have been made:

- The Wet Weather Flow management Guidelines (WWFMG) design storm events applied.
- The runoff coefficient values obtained from the WWFMG.
- The industrial lot break down is considered to have 14% landscape area, 52% roof area and 34% driveway area. This percentage break down corresponds to a weighted runoff coefficient of 0.85 for industrial lots as specified under the WWFMG.
- The permeable pavement measure is implemented for all the driveway and parking lot areas.
- Future development with LID and LEED design techniques will achieve the LEED Gold criteria of capturing 15mm of rainfall on site.

2.1.3.4 Summary of Results

The results of the analysis are summarized in **Tables 2-7 to 2-9**. Depending on the storm event, the implementation of the LID measures resulted in peak release rate reductions in the range of 28% to 82% approximately; and reductions to total runoff volumes of between 17% and 86% approximately.

It should be noted that the reduction in both the peak release rate and the runoff volume is lower under larger storm events. For Area 3, the peak release rates and the runoff volumes increase under the 50-year and 100-year storm events. This increase is due to the fact that 45% of the undeveloped area within Area 3 is being converted to industrial building under the proposed condition. Detailed results of the analysis are provided in **Appendix C**.

Please note that the method used in modelling the biofilter and the infiltration gallery system is quite conservative, as the release rate and runoff reductions could be much higher than just doubling the default IA value within the VO2 model.. If the tributary area to the infiltration system and the actual configuration of the infiltration facility (e.g. dimension, storage medium volume, existing soil permeability and etc) were available, a continuous analysis can be applied to determine the percentage runoff reduction on an annual basis which can then be prorated to determine the effect under different design storm events. Additionally, the proposed SWM pond will also further reduce the peak release rate by attenuation of the storm runoff generated from the site.

Table 2-7: Industrial Park Peak Release Rates Comparison

	5mm			25mm			2-year			5-year			10-year			25-year			50-year			100-year				
	Pre-urban (m/s)	Existing (m/s)	Post (m/s)																							
Area 1 (19.4ha)	0.00	0.185	0.029	1.673	0.395	0.403	3.141	0.979	0.922	5.002	2.235	1.362	6.34	3.202	1.83	2.328	0.95	4.29	2.939	1.289	5.22	3.989	1.559	5.887	6.768	
Area 2 (11.25ha)	0.00	0.127	0.03	0.987	0.327	0.209	1.827	0.769	0.479	2.869	1.664	0.707	3.612	2.328	1.927	4.38	5.285	1.424	3.101	5.749	6.336	2.615	7.784	3.162	8.883	9.151
Area 3 (20.5ha)	0.00	0.144	0.037	0.214	1.355	0.495	0.425	2.545	1.304	0.971	4.412	1.412	1.434	5.285	1.927	1.927	1.927	1.927	1.927	1.927	1.927	1.927	1.927	1.927	1.927	1.927
Area 4 (6.95ha)	0.00	0.121	0.013	0.933	0.188	0.183	1.722	0.461	0.418	2.689	1.043	0.617	3.375	1.482	0.83	3.375	1.482	1.482	1.482	1.482	1.482	1.482	1.482	1.482	1.482	
Area 5 (20.4ha)	0.00	0.193	0.031	0.207	1.766	0.396	0.412	3.309	1.01	0.94	5.256	2.367	1.389	6.653	3.367	1.867	7.937	4.398	2.533	9.6	6.017	3.063	10.855	7.119		
Area 6 (9.71ha)	0.00	0.125	0.019	0.1	1.088	0.273	0.198	2.008	0.654	0.453	3.13	1.444	0.67	3.925	2.03	0.9	4.645	2.567	1.221	5.57	3.573	1.477	6.336	4.224		
Area 7 (21.53ha)	0.00	0.218	0.04	0.221	1.991	0.512	0.44	3.73	1.242	1.005	5.913	2.746	1.485	7.477	3.877	1.996	8.911	4.835	2.708	10.765	6.344	3.275	12.163	8.117		
Total	0.00	1.11	0.20	1.14	9.79	2.59	2.27	18.28	6.42	5.19	28.98	14.60	7.66	36.35	20.67	10.30	42.69	26.59	13.97	52.92	36.06	16.90	59.37	43.21		

Table 2-8: Industrial Park Runoff Volume Comparison

	5mm			25mm			2-year			5-year			10-year			25-year			50-year			100-year		
	Pre-urban (m)	Post (m)	Pre-urban (m)	Post (m)	Pre-urban (m)	Post (m)	Pre-urban (m)	Post (m)	Pre-urban (m)	Post (m)	Pre-urban (m)	Post (m)	Pre-urban (m)	Post (m)	Pre-urban (m)	Post (m)	Pre-urban (m)	Post (m)	Pre-urban (m)	Post (m)	Pre-urban (m)	Post (m)	Pre-urban (m)	Post (m)
Area 1 (19.4ha)	0	573	68	921	3717	1595	1317	4487	2273	2712	6753	4307	3722	8252	5699	4857	9802	7124	6405	11807	9050	7620	13319	10439
Area 2 (11.25ha)	0	321	60	478	2042	1102	654	2458	1556	1408	3685	2798	1933	4466	3620	2522	5287	4459	3326	6345	5551	5957	7142	6346
Area 3 (20.5ha)	0	429	83	970	3051	1999	1388	3750	2878	2856	5448	3920	7288	7110	5115	8787	8309	6746	10752	11028	8025	12248	12840	
Area 4 (8.95ha)	0	304	28	417	1900	729	597	2278	1038	1230	3388	1963	1687	4090	2597	2202	4824	3244	2904	5768	4119	3455	6477	4750
Area 5 (20.4ha)	0	606	66	939	3896	1594	1344	4685	2286	2767	7071	4419	3797	8586	4956	10183	7323	6535	12245	9233	7774	13799	10736	
Area 6 (9.71ha)	0	362	45	453	2222	1009	648	2653	1409	1334	3909	2576	1831	4696	3345	2389	5517	4129	3151	6568	5151	3748	7353	5895
Area 7 (21.53ha)	0	698	95	1004	4409	1992	1437	5296	2795	2958	7915	5170	4059	9575	6768	5297	11318	8400	6986	13653	10572	8311	15250	12144
Total	0	3292	445	5182	21238	10119	7415	25617	14226	15265	38637	26682	20949	469153	34979	27338	55717	43487	36054	67047	54755	42890	75588	62951

Table 2-9: Industrial Park Percentage Reduction Summary (Between Existing and Proposed Conditions)

	5mm			25mm			2-year			5-year			10-year			25-year			50-year			100-year		
	Release Rate	Runoff Vol.																						
Area 1 (19.7ha)	84%	88%	76%	57%	69%	49%	55%	36%	49%	31%	46%	27%	38%	23%	35%	22%								
Area 2 (10.25ha)	76%	81%	67%	46%	58%	38%	42%	24%	36%	19%	31%	16%	23%	13%	20%	11%								
Area 3 (20.7ha)	74%	81%	63%	34%	49%	23%	25%	7%	17%	2%	9%	0%	-1%	-3%	-3%	-3%								
Area 4 (8.95ha)	89%	91%	80%	62%	73%	54%	61%	42%	56%	37%	53%	33%	46%	29%	43%	27%								
Area 5 (20.14ha)	84%	89%	78%	59%	69%	51%	55%	37%	49%	32%	45%	28%	37%	24%	34%	22%								
Area 6 (9.71ha)	85%	88%	75%	55%	67%	47%	54%	34%	48%	29%	45%	25%	36%	22%	33%	20%								
Area 7 (21.53ha)	82%	86%	74%	55%	67%	47%	54%	35%	48%	29%	45%	26%	41%	22%	33%	20%								
Total	82%	86%	74%	53%	65%	44%	50%	31%	44%	26%	39%	22%	32%	18%	28%	17%								

2.2 Water Budget Analysis

A Water Budget Analysis has been performed for the Industrial Park to evaluate the impact of the conceptual LID measures on stormwater runoff volumes and potable water usage. **Figure 2-8** illustrates the impact of the LID measures to the water cycle. It should be noted that the LID measures that would have impact on the sanitary flows would be dependent on reductions of water usage through societal changes only, which include installation of low flow toilets, running dishwashers only when full etc. Therefore, the proposed LID measures shown in the conceptual plan (**Figure 2-7**) will not provide a reduction in sanitary flows.

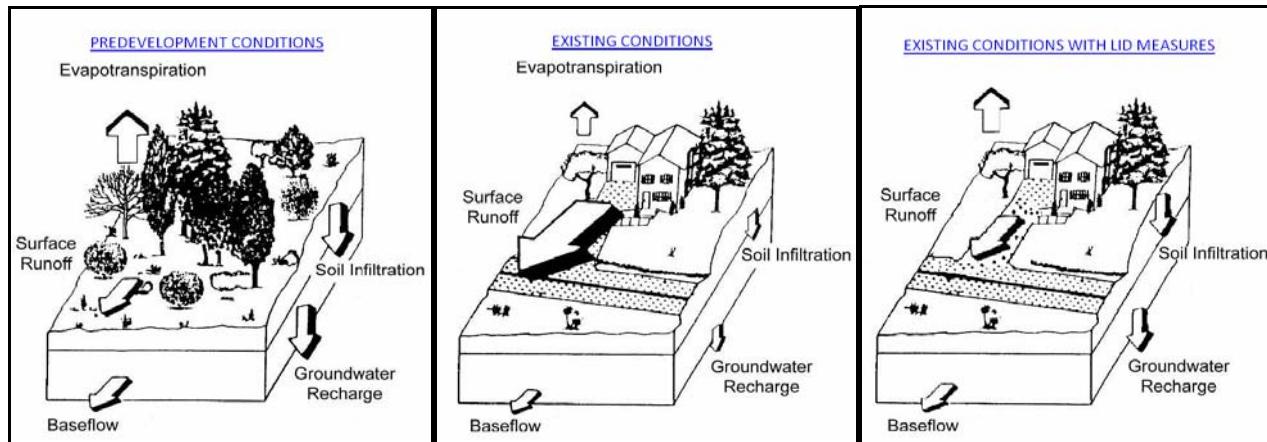


Figure 2-8: Impact of LID Measures on the Water Cycle

Referring to **Section 2.1.3.4**, reductions to stormwater runoff volumes with the implementation of the proposed LID measures will range between 17% and 86% approximately, depending on the storm event. As for the potable water usage, an analysis has been performed based on the City of Toronto design criteria to compare the pre and post-condition annual water demand. In the analysis, the annual water demand of the subject site is determined based on a population density of 136 persons/ha and a per capita demand of 191 l/capita/day. Under the proposed condition, potable water demand is reduced through capturing rainwater for re-use. By assuming that all the roof areas will consist of 20% green roof in the post-condition, rainwater will be captured in the cistern for re-use in order to achieve the LEED Gold 15mm retention criteria. From the results, it is noted that under the proposed condition the annual potable water demand of the site will be reduced by approximately 31%. For details of the analysis please refer to **Appendix D**.

3 Conclusion

In conclusion, the implementation of Low Impact Development (LID) measures in existing areas has significant impact on the reduction of both the peak stormwater release rates and the runoff volumes. However, it should be noted that the types of LID measures that can be implemented for a subject location depend highly on the existing site conditions / constraints and the type of land use. As a result, it is difficult to generalize the effects of LID measures as they will be different on a site by site basis. Based on the VO2 modelling results, it is evident that the effect of LID measures are more significant under smaller storm events while their impact reduces under larger rainfalls.

In regards to the water budget, it is noted that the LID measure of rainwater reuse is the major component in reducing the potable water consumption. The impact of rainwater re-use is most significant for high rise residential/commercial building, while for single residential lots, rainwater reuse can be implemented through the use of rain barrel however the effect will be much smaller. Moreover, reduction of potable water usage and sanitary flow can be achieved through societal change like the installation of low flow toilets, running dishwashers only when full etc. In order to quantify the effect of the measures resulted from societal changes, further studies are required.

4 References

Stormwater Management Planning and Design Manual, Ministry of the Environment, March 2003.

Wet Weather Flow Management Guidelines, City of Toronto, November 2006.

Sincerely,

The Municipal Infrastructure Group Ltd.

(Final Report– Signed & Sealed)

John Lau, P.Eng.
Water Resources Engineer

David F. Ashfield, P.Eng.
Partner