



Don River Watershed Plan

Baseflow and Water Use Assessment – Report on Current Conditions

2009

Prepared by: Toronto and Region Conservation

TORONTO AND REGION Conservation for The Living City

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the Don

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1.0 Introduction

The Toronto and Region Conservation Authority (TRCA), in consultation with the multi-stakeholder Don Watershed Regeneration Council and watershed municipalities, is developing a watershed plan for the Don River. This watershed planning process has been initiated in response to a number of recent policy and planning developments, including the need to fulfill York Region's watershed planning requirements under the *Oak Ridges Moraine Conservation Plan* (ORMCP, Ontario Regulation 140/02) and to update the original management strategy outlined in *Forty Steps to a New Don* (Metropolitan Toronto and Region Conservation Authority [MTRCA], 1994).

The goal of the watershed planning study is to recommend updated management strategies that will guide land and water use decisions, such that the overall ecological health of the Don River watershed is protected and improved. The aim is to build on the *Forty Steps'* principles to protect what is healthy, regenerate what is degraded, and take responsibility for the Don. Recognizing the significant watershed planning work that has already been completed, and given that there are limited undeveloped lands remaining on the Oak Ridges Moraine within the watershed boundary, this study will focus mainly on filling information gaps, guiding land use planning and approval decisions and providing direction to advance implementation of regeneration priorities.

This report has been prepared as part of the scoping and characterization phase of the watershed planning process. This phase presents current watershed conditions in the form of technical reports covering a range of subject areas, including groundwater quality and quantity, surface water quantity, low flows and water use, fluvial geomorphology, surface water quality, aquatic systems, terrestrial systems, nature-based experiences, cultural heritage, land and resource use and air quality.

The purpose of this document is to report on current watershed conditions of baseflow and surface and groundwater use. This report presents indicators, measures and targets for evaluating the condition of baseflow and water use, as per sections 24 and 25 of the ORMCP. Also included in the report are comparisons with findings from the most up to date groundwater modeling (YPDT Regional Groundwater Model) of the Don River. Section 2.0 presents an overview of water budget modeling. Section 3.0 summarizes data sources and methods for evaluating current conditions. Section 4.0 presents current conditions of baseflow and water use and allocation. Sections 5.0 and 6.0 describe low flow management strategies as well as conclusions and management considerations for the Don River watershed.

2.0 Understanding Groundwater Recharge and Discharge

Developing a better understanding of groundwater recharge, or the quantity of rainfall and snowmelt that infiltrates over a watershed area, and at what rate it filters into and moves through the underlying geologic layers, is critical to improving our understanding of the interconnections between surface and groundwater systems. By combining this understanding of surface water balance with an understanding of the groundwater flow system, it is possible to predict where, and at what rates, groundwater is discharged to surface watercourses. This information helps to improve our understanding of the watershed's low flow regime. A good understanding of these complex processes, at watershed and subwatershed scales, is needed to develop effective programs and policies for protecting and managing low flow regimes.

2.1 Don River Watershed Water Budget Modeling

A common approach to developing a better understanding of the quantity of groundwater recharge that occurs over a watershed area is to develop a water budget model. A water budget model attempts to quantify on an average annual basis, what portion of annual precipitation becomes run-off, what portion is evaporated or transpired by plants, and what portion infiltrates and becomes groundwater recharge.

Groundwater recharge is an important water management parameter since it replenishes the groundwater reservoir and is the main source of baseflow in streams. The annual recharge capacity of an undeveloped area depends on the climate and the soil infiltration characteristics in the area. Urbanization results in more impervious areas (such as buildings, roads, etc), which leads to more storm runoff, and reduction in the natural recharge capacities of the area, unless mitigation is applied.

In 2005, the TRCA retained Marshall Macklin Monaghan Limited (MMM) to develop a database of the geographic distribution of groundwater recharge rates within the Don River Watershed through the HSPF model (Hydrologic Simulation Program Fortran) (MMM, 2005). The information will be used to implement stormwater management policies designed to maintain the existing recharge rates in future developments and areas of land use intensification. More information on the HSPF modeling of the Don watershed is presented in *Surface Water Hydrology/Hydraulics and Stormwater Management – Report on Current Conditions* (TRCA, 2009a). A water budget for the Don River watershed is presented in *Geology and Groundwater Resources – Report on Current Conditions* (TRCA, 2009b).

2.2 Regional Groundwater Modeling

A regional groundwater system model has been developed through a partnership between the Regions of York, Peel, and Durham; the City of Toronto and the Conservation Authorities Moraine Coalition (YPDT-CAMC) (AMEC *et al*., 1999). The groundwater model uses information on surface soils and underlying geology to define the aquifer and aquitard units which influence the movement of groundwater in the region. Water budget model outputs regarding average annual infiltration rates (recharge) are used as inputs to the groundwater flow model. The groundwater model allows predictions to be made regarding:

- direction of groundwater flow;
- water levels and rate of flow through aquifer units;
- important recharge and discharge areas; and,
- long-term affects of water takings on aquifer water levels.

Low flow monitoring data collected through the TRCA Low Flow Program were used to assist in the calibration and validation of this model. Further information regarding the YDPT Model can be found in Section 3.2.4.

2.3 TRCA Role/Interest in Low Flow

The Toronto and Region Conservation Authority is a watershed-based natural resource management agency with a key interest in understanding and working with its partners in managing aspects of the hydrologic cycle.

As the TRCA moves toward a more ecosystem-based approach to managing its watersheds, issues related to all aspects of the surface flow regime and interconnections among all aspects of the hydrologic cycle need to be addressed in watershed management strategies and policies. The flow regime within a watershed can be viewed as having stages of "high flow" and "low flow". When a rainfall or snowmelt event occurs, additional water is introduced into the surface watercourses resulting in higher flows, velocities, and water levels. These high flow conditions can result in erosion and flooding. However, most of the time, the flow sustained in our rivers and streams is supplied from groundwater or discharge from wetlands. This portion of the flow regime is referred to as low flow, or more commonly as "baseflow".

While designing new development projects and strategies to protect against flooding has and continues to be a primary consideration for the Authority, there is a need to develop a strategy to deal with low flows, as they represent a significant proportion of total stream discharge. An understanding of the range of fluctuation of these flows on a watershed basis is necessary, in order for the Authority to be in a position to fully manage our water resources. This involves a comprehensive understanding of the connections between the groundwater system and the surface system in order to implement an overall water management approach.

The main purpose of the TRCA Low Flow Program is to develop the data which allows for a better understanding of the interconnections between the groundwater and surface water systems. The program also helps to establish contacts and relationships with water users as a basis for promoting awareness and stewardship activities. The long term goal of the TRCA Low Flow Program is to guide the management and protection of baseflow levels to protect aquatic life and ensure sustainable human use of surface water.

The Program has the following objectives.

1. Monitor current baseflow levels in terms of volume, flow rates, seasonal fluctuations and spatial gains / losses of water along individual watercourses.
2. Identify key factors influencing observed baseflow patterns, including groundwater recharge / discharge zones and withdrawals for human use.
3. Review and field validate current and expired MOE Permits to Take Water through baseflow measurements and user surveys.
4. Determine "threshold" baseflow quantities for the protection of aquatic life in association with aquatic ecosystem biologists.
5. Identify options for managing sensitive recharge / discharge zones and other areas with baseflow quantities that currently pose a risk to aquatic life.
6. Develop a better understanding of groundwater / surface water interactions as part of a larger effort to refine watershed water budget estimates and hydraulic modeling.

In order to meet these objectives, information on the current status of baseflow within TRCA watersheds is required. With this information, the TRCA can begin to develop an understanding of the low flow regime to allow for sustainable future land use planning and management of water takings.

3.0 Data Sources and Methods

This report discusses the current conditions of the Don River watershed based on data collected in the summers of 2003 and 2006. Baseline low flow monitoring data were collected in two separate years due to time and weather constraints. Analysis of data collected from 2003 focus primarily on the upper subwatersheds, while data from 2006 focus on the lower subwatersheds of the Don River.

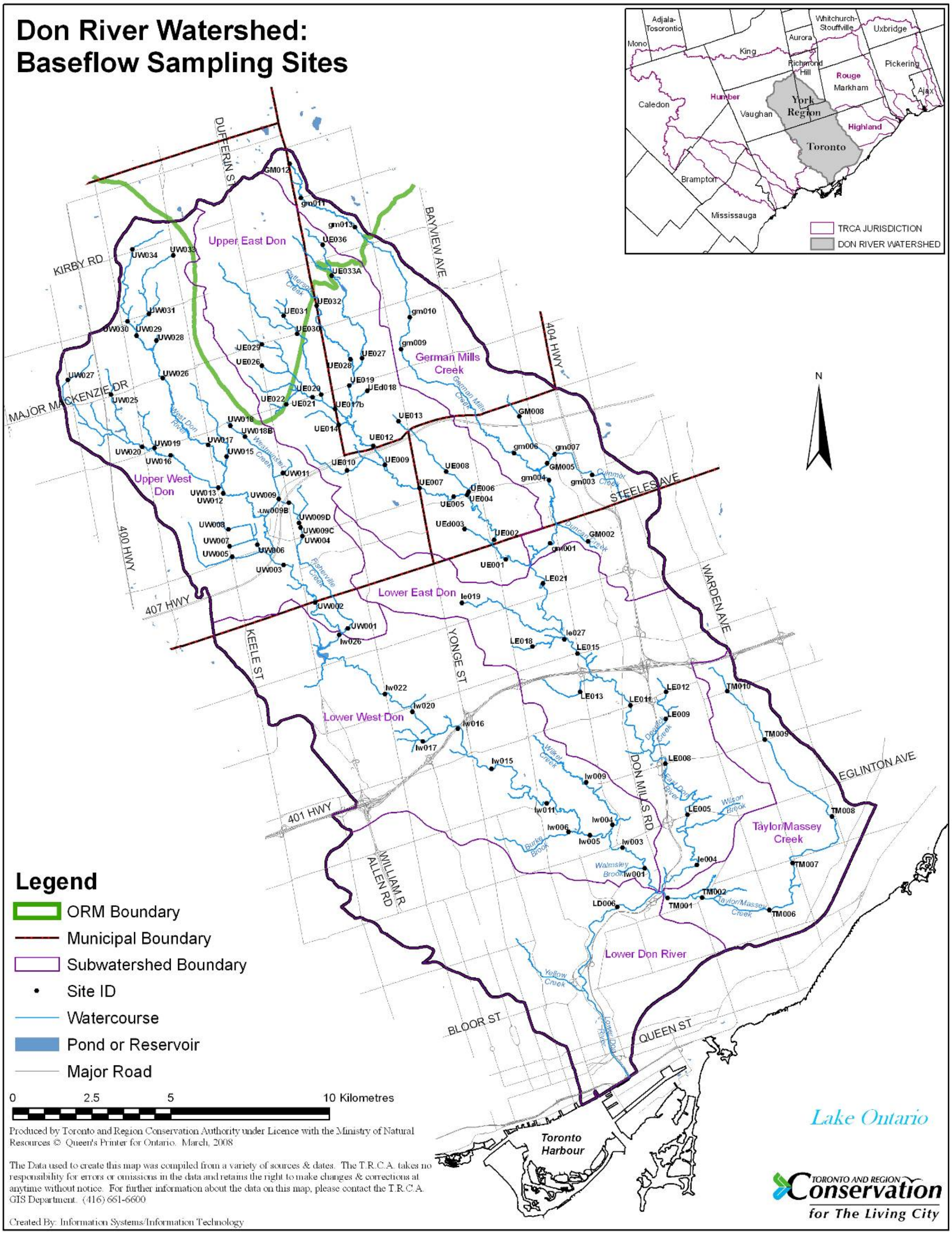
In order to characterize the Don River watershed in terms of baseflow conditions, historical stream gauge data and baseflow data collected at pre-established monitoring sites were used to determine the overall status of the baseflow system. Further analysis into the local changes in baseflow throughout the watershed was completed for all subwatersheds, in order to identify groundwater recharge/discharge areas and those in need of protection from further development. Water users located in the Don were also assessed in order to determine whether non-natural influences on the baseflow system exist. This analysis was then used to develop indicators, measures, targets and ratings for surface water flow and water use so that proper planning policies and management strategies can be implemented.

3.1 Baseflow Data Collection

Timing is a critical element in the measurement of baseflow, as it must be ensured that all overland runoff has ceased and river flows are comprised solely of baseflow before any sampling can be done. To account for this, data were collected based upon a sampling protocol originally developed by the Geological Survey of Canada (GSC) (see Appendix A). All sampling was completed using Water Survey of Canada flow measurement standards. The GSC sampling protocol was used by TRCA to ensure that a baseflow condition existed following any precipitation event. Given the hydrologic response of the TRCA watersheds, a 72 hour period was established as the minimum time to wait following any rainfall event prior to any baseflow measurement. Sampling sites were selected from topographic maps, with the final sampling location determined in the field.

Baseflow data were collected in the summer of 2003 for Upper East Don River, Upper West Don River, and German Mills Creek subwatersheds. Sampling within the upper subwatersheds took place during the mid to late summer, between July and September, at a total of 78 sampling sites (Figure 1). According to precipitation records from Pearson International Airport, the months of August and September had total accumulations of 53.4 and 114.2 mm respectively. Although total rainfall recorded for the month of August was low, the timing of events hindered sampling during the field season. Therefore, sampling was not completed for the Lower Don River subwatersheds in 2003, and was later completed during the summer of 2006.

Figure 1: Baseflow monitoring sites in the Don River watershed.



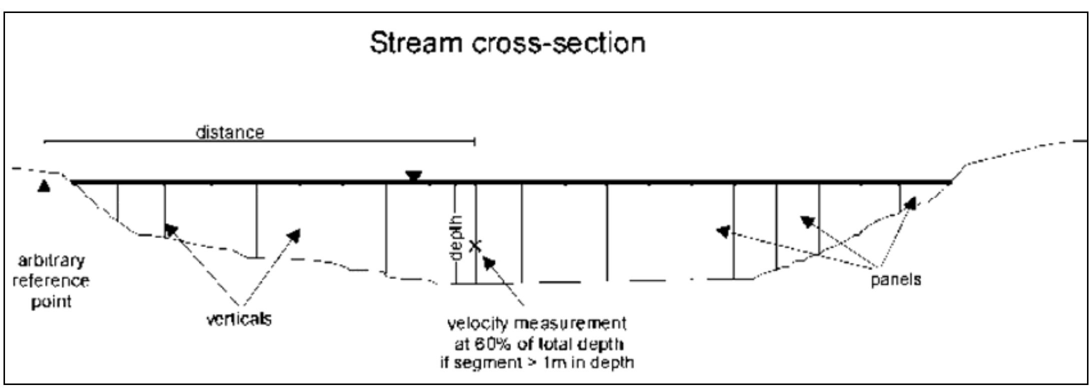
Sampling of 35 sites within the Lower West Don River, Lower East Don River, Taylor/Massey Creek and Lower Don River subwatersheds, took place in 2006 over a period of three weeks in the months of July and August (Figure 1). Precipitation totals from July and August were 105.2 and 40.2 mm respectively, as recorded at Pearson International Airport. Special considerations were taken for baseflow measurements sampled in the Lower West Don River subwatershed, due to the presence of the G. Ross Lord Dam located on the north-east corner of Finch Avenue and Dufferin Street. Daily reservoir levels were recorded for days where baseflow measurements were taken downstream of this structure. Therefore, this data set requires some caution as to accommodate for this outside influence on baseflow levels.

From Environment Canada's precipitation averages (as calculated from 1971-2000), the two months in which sampling occurred in 2003 and 2006 showed less than 10% deviation from the average rainfall amounts. However, total precipitation from August and September of 2003 was 6.7% above average, while the total from July and August of 2006 was 5.6% below average accumulations. For the purposes of this report, the 2003 and 2006 sampling years are not similar enough to make direct baseflow comparisons between the Upper and Lower Don subwatersheds.

At all TRCA baseflow sampling stations, the following parameters are measured (Figure 2):

- Baseflow discharge
- Date and time of sampling
- Water temperature
- Air Temperature
- Weather Conditions
- Site Photographs (*Upstream/Downstream*)
- Stage / Discharge measurements (*where applicable*)
    - o Culvert / Bridge heights
    - o Water depths
- Low Flow Channel cross sections
    - o Width and Depth
    - o Top of Bank Height and Width (*2003 sites only*)

Figure 2: Typical sampling stream cross-section.



3.1.1 Baseflow Spatial Analysis

To allow for a breakdown of baseflow contributions, a measured baseflow endpoint was selected at the outflow of each subwatershed (referred to as “indicator stations”). This end point was used to calculate the percentage of overall baseflow derived from each subwatershed. Data measured at indicator stations in 2005 and 2006 were used to determine subwatershed contributions for the entire watershed. Data collected in 2003 and 2006 at additional low flow monitoring stations were used to calculate the percentage of change in measured baseflow on a reach by reach basis.

Once the percentage of change in baseflow has been determined between each site, the natural and non-natural contributions of these changes were ascertained. Changes in baseflow of greater than 10% will be the focus of further investigation. The surficial geology, physiography, and YPDT data parameters along a particular reach were assessed as a potential cause of any major gains or losses in baseflow. For instance, a large increase in baseflow along a reach can be attributed to the presence of a positive hydraulic gradient and a potential groundwater discharge area identified by the York-Peel-Durham-Toronto Groundwater Model (Kassenaar and Wexler, 2006). Ministry of Environment (MOE) Permit to Take Water (PTTW) and TRCA water use data are also examined to determine the potential influence of withdrawals on any measured change in baseflow.

3.2 Water Use Data Collection

To assist with interpretation of spatial variations in baseflow volumes within TRCA’s watersheds, human influences on water needed to be addressed. These influences primarily include water entering and/or leaving the system due to urban or rural users. However, land use changes may also have a distinct impact to the baseflow system.

The Ministry of Environment (MOE) is the agency responsible for approving water withdrawals of more than 50,000 liters/day, through their Permit to Take Water (PTTW) Program. The 2002 PTTW database was obtained, edited, and updated using air photo reconnaissance. Expired PTTW records were removed from the database if the land use for that location did not match that of the permit. If the land use was found to be the same as the specific permit use, the expired permit was retained, and assumed active until it could be verified in the field.

Unfortunately, individual water takings only recently have required monitoring after a permit has been issued. Hence, the relationship between actual and permitted water takings is difficult to verify. The MOE has developed and implemented a Water Taking Response System (WTRS) in which users are required to record and submit the actual amount of their water taking. Until this system is fully populated, calculations of total baseflow allocated for withdrawal are used to indicate potential rather than actual stresses to river segments.

Further investigations into water use within the TRCA jurisdiction were required to establish an accurate database of water use. In 2003 an initiative to locate and identify all water users within the TRCA jurisdiction was developed. This project involved the creation of a survey form with an attached newsletter promoting rural and commercial water conservation (Appendix B). The surveys were hand delivered by field technicians, and filled out on-site when contact with the landowner/proprietor was possible.

To facilitate user feedback and open communication between field staff and landowners, the Water Use Survey allowed for landowners to remain anonymous, and contact information to remain confidential within the TRCA.

Questions posed by the Water Use Survey included:
- Water source,
- Daily pumping rate,
- Days pumping per year,
- Hours pumping per day,
- Water use purpose, and
- Contact information (Confidential).

Surveying of all water users in the Don watershed was completed during the summer of 2003. The data collected from these water users were inputted into a database, and geo-referenced.

An initial analysis was carried out using the updated database and cross-referencing it with measured baseflow discharge of each watershed/subwatershed. This analysis provided estimates of the proportion of total baseflow that could be allocated for permitted withdrawals within a stream or river reach.

3.2.1 York Region Water Use Assessment

An overall assessment of MOE Permits to Take Water within York Region, on behalf of the regional municipality, was also conducted by Golder Associates and Marshall Macklin Monaghan in 2003. The main objective of this project was to compile data for ground and surface water users into a database which would be used as a tool for long-term resource management. This project involved developing queries in the MOE PTTW database, removing expired records, and confirming active users through air photo interpretation. Updates to the database were also made by correcting withdrawal coordinates through GIS. Information regarding water use not requiring a permit was also included in the report, including livestock use and self supply domestic use. This information was derived form various sources such as the Municipal User Database (MUD), Statistics Canada, and estimated coefficients. This revised version of the PTTW database was then reviewed and analyzed, in order to evaluate the quantity and distribution of water users within York Region by area municipality and subwatershed (Golder Associates and Marshall Macklin Monaghan Limited, 2003).

The final database from the York Region Water Use Assessment (Golder Associates and Marshall Macklin Monaghan Limited, 2003) was then amalgamated with the TRCA Water Use Assessment Database to provide a database of all users, major and minor, within York Region. Details of the merging of these databases can be found in Appendix C.

3.2.2 Surface Water Vulnerability Assessment

To account for the site specific impacts of individual surface water takers, a vulnerability assessment was developed by TRCA. This detailed analysis classifies surface water users into potential risk categories of high, medium and low impact (Table 1).

In determining these potential impacts, surface water users were separated from the data set and average withdrawals in liters per second (L/s) were calculated based on daily withdrawal amounts and durations. From these calculations, and utilizing TRCA baseflow measurements within the area of water taking, a percentage between the withdrawal amounts and the available baseflow volume can be determined. Estimates can be made of the approximate withdrawal rate from the Don River and its tributaries, and the potential impacts on the low flow system can be assessed. This classification system of low, medium, or high potential impact can be used as a tool to quickly prioritize areas for management. The selection of the impact thresholds is arbitrary, and based on a local knowledge of the Don River. These thresholds can be altered to better relate to thresholds (Environmental Flow Thresholds) when this information is available.

Table 1: Ratings for the potential impact of water users on baseflow.

Percent baseflow required for individual permitted withdrawal	Potential impact rating
0	No known impact
0 0.01 – 5	Low impact
5.01 – 25	Medium impact
>25	High impact

3.2.3 Study Limitations

The lack of historic baseline data available for the Don River watershed makes a full assessment of changes and trends to the baseflow system difficult. While baseline data collected for the Upper Don in the summer of 2003 and for the Lower Don in the summer of 2006 provide a good indication of the status of the low flow system, the data remain spot measurements at a specific point in time and do not allow for long term trend analysis to be performed. As a result, monthly monitoring of indicator stations situated at the outflow of each subwatershed was established for summer months, in order to perform this type of analysis.

When supplementing baseline data with long term stream gauge data to develop an historical interpretation of the watercourse, some limitations should be realized. Currently, there are three long term stream gauges in the Don River that provide data since the 1950s and 1960s. They are situated in the Lower portion of the Don River watershed. As a result, distinguishing subtle changes in baseflow in the headwaters is difficult.

In the analysis of water use data, several limitations were observed. This report contains analysis based on water use information contained solely in the TRCA York Region Water Use database. While this database has improved understanding of actual withdrawal rates of some individual users, some withdrawal rates remain unknown. As a result, when determining the potential impacts of water users on baseflow, those users whose withdrawal rates are unknown show no impact when in actuality their impact may be significant.

Currently, there is insufficient data to explore the effects of groundwater extractions on surface baseflow levels. Therefore an analysis of impacts to baseflow due to groundwater abstractions was not completed as a part of this report.

3.2.4 Groundwater Data Sources

Throughout this report, references are made to the YPDT Groundwater Model with regards to specific reaches modeled and identified as recharge and discharge areas. The YPDT

Groundwater Model is the main component of YPDT (York, Peel, Durham, Toronto)-CAMC (Conservation Authorities Moraine Coalition) Groundwater Management Strategy Study. A final report has been produced, providing specifics of the myriad of smaller data sources incorporated into the study (Kaseneer and Wexler, 2006). This study produced technical products which assisted in the analysis of the low flow data, including:

1. Data Compilation: A comprehensive relational database,
2. Data Interpretation: A regional hydrostratigraphic framework, and
3. Numerical Modeling: Regional and sub-regional numerical groundwater flow models.

The primary outputs utilized in this report were gridded surfaces (100m x 100m) of groundwater recharge and discharge estimates.

4.0 Existing Conditions in the Don River Watershed

4.1 Baseflow Conditions

In the Don River watershed, there are three continuous stream gauges which have available historic stream flow data, dating as early as the 1950s. Table 2 shows hydrological flow characteristics for the three long term stream gauges in the Don, which was used to calculate the Baseflow Index (BFI) at those gauging locations (Table 3). BFI represents the ratio between the average annual baseflow discharge and average annual streamflow discharge (Smakhtin, 2001). Table 3 shows that historically, the majority of flows in the West and East Don were comprised of runoff. Currently, over the last 10 years of gauge records, the amount of total flow comprised of baseflow is around 49%. This means that flow in the Don watershed is still predominantly comprised of runoff, showing only minor differences from historical values. BFI estimates can vary, depending on the methodology used to determine the groundwater discharge component. Both HSP-F and MODFLOW estimates of groundwater discharge have been developed for the Don watershed, with ranges of groundwater discharge between 158 and 174 mm/yr. Estimates reported in Table 3 were slightly higher, at approximately 200 mm/yr. These previous estimates are discussed in more detail in the *Geology and Groundwater Resources – Report on Current Conditions* (TRCA, 2009b).

A natural, less urbanized system, by comparison, can be found in the Main Humber (north of Palgrave) where 72% of the total flow is comprised of baseflow. The lower ratio of baseflow to total flow can be explained by the highly urbanized nature and different soil types of the Don watershed as well as the situation of these stream gauges. These gauges are located in the lower, mostly densely urbanized portion of the Don; therefore, the Baseflow Index has a tendency to be lower than that of more natural subwatersheds. The lack of stream gauges in the headwaters of the Don makes it difficult to determine the BFI and the effect that development has had on the low flow system.

The BFI is not solely an indicator of urban or impervious cover, and can be influenced by a number of additional factors. BFI values as an indicator of baseflow health can be misleading, as it is a non-dimensional ratio calculation. For example, if runoff decreases due to a lack of precipitation or a major improvement in stormwater management, the BFI value will increase. This increase however, has little to do with the baseflow. The inverse is also true, where anthropomorphic influences can create a higher BFI due to leaky storm / sanitary infrastructure, stormwater facilities with long (>72 hours) detention times or other non-natural inputs to the system. From an aquatics perspective, these inputs generally do not provide the same benefits as natural groundwater discharge, but would be classified as baseflow through hydrograph separation.

Table 2: Flow characteristics for Don River stream gauges.

WSC Gauge Information		Parameter	Annual (m^3/s)		Summer (m^3/s)*	
Gauge #	Location/Record Period		Mean Annual	Median Annual	Mean Summer	Median Summer
02HC005	West Don River @ York Mills (1945 – 2005)	Total Flow	0.858	0.866	0.545	0.479
		Baseflow	0.403	0.395	0.271	0.249
02HC024	Don River @ Todmorden (1962 – 2005)	Total Flow	3.944	4.068	3.291	3.130
		Baseflow	2.088	2.083	1.661	1.651
02HC029	Little (i.e., East) Don River @ York Mills (1964 – 1996)	Total Flow	1.523	1.597	1.164	1.150
		Baseflow	0.756	0.756	0.551	0.558

Flow data obtained from Water Survey Canada (WSC) Hydat database for entire record period.
* Summer = June-Sept

Table 3: Percentage of baseflow to total flow.

WSC Information		†BFI Index (Annual)	
Gauge #	Location, Record Period	*Historic (entire record period)	**Current (last 10 yrs of record)
02HC005	West Don River @ York Mills, 1945-1998	0.47	0.49
02HC024	Don River @ Todmorden, 1962-2004	0.53	0.51
02HC029	Little (i.e., East) Don River @ York Mills, 1964-1996	0.49	0.47

Flow data obtained from Water Survey Canada (WSC) Hydat database.
† Smakhtin, 2001.

Recently, the TRCA has adopted an interim instream flow requirement which is currently used by the MOE when reviewing surface water permit applications. This measure identifies the 40th percentile (60% durational) of mean daily summer flow. Where recent gauging data were available, the median summer total flow and median summer baseflow were calculated for the period of 1993 – 2003, as shown in Table 4. In the Don watershed, median summer flow and baseflow were only available for the gauge at Todmorden, as this was the only gauge where data were available beyond the 1990s. This ten year median total flow can then be compared to the 60% durational flow to determine areas within the Don River which are under stress. As shown in Table 4, the gauge at Todmorden shows a positive departure from the 60% durational flow. The median total flow for the 10 year period is roughly 30% higher than the 60% durational flow. Unfortunately, comparable data do not exist for the other gauges in order to see if this trend is experienced in other areas of the watershed. There is one operating sewage treatment facility in the Don River watershed, the North Toronto Wastewater Treatment Plant, which is located in the Lower Don. This facility treats sewage for approximately 55,000 people, and discharges into the Lower Don River. This discharge accounts for approximately 11% of the total annual flow of the Don River (CH2M Hill and MacViro, 2003). These discharges were not subtracted from the gauged annual flows.

Also displayed in Table 4 for comparison, is the 7Q10 flow for each gauge. The 7Q10 is a measure of the lowest 7 day low flow over a ten year period. This number represents extreme low flow conditions, and is usually used for assimilative capacity for sewage treatment plants and other operations discharging into watercourses.

An instream flow threshold methodology for Ontario watersheds is currently in development under the guidance of Conservation Ontario (Maunder and Hindley, 2005). The goal of this study is to avoid ecological impacts while accommodating water users.

Table 4: Measured and recommended flow for Don River gauges (cubic meters per second).

WSC Gauge Information		Measured Baseflow (Summer 2003)	Median (1993-2003)		60% Durational Flow Environmental Flow Threshold (Preliminary)	7Q10
Gauge #	Location		Total Flow	Baseflow		
02HC005	West Don River @ York Mills	0.279	0.971	0.420	0.387	0.086
02HC024	Don River @ Todmorden	1.458	4.075	2.066	2.844	1.204
02HC029	Little (i.e., East) Don @ York Mills	0.372	No Data		0.927	0.314

Flow data obtained from Water Survey Canada (WSC) Hydat database.
Note: Median Annual calculated for 1993-2003 and 60% durational flow calculated for 40th percentile for record period for summer months.

Historically, increased urbanization and development, and the establishment of G. Ross Lord Dam in the Lower West Don River subwatershed, have had an effect on both annual and summer baseflow volumes. The Don River gauge at Todmorden shows that prior to the construction of the dam in the 1970s, average annual baseflow volumes showed an increasing trend of approximately 2.5% per year. During the post-regulation years, particularly in the 1980s and onward, average annual baseflow began to level out, showing no significant trend. While G. Ross Lord Dam is not actively used to augment low flow, the fixed orifice outlet (which is the only outlet under low flow conditions) does have a reducing impact on the contribution from upstream baseflows. Similar to annual trends, average summer baseflow in the Don also increased by 2.5% until 1973; however, this increasing trend continues beyond the 1980s. These differing seasonal trends are likely due to the low flow operations of the dam. Annual average baseflows entering the dam are typically greater than the low level outlet, and are therefore detained. Summer low flows however, are at or below the low level outlet, and would not be detained.

In the absence of equally distributed long term monitoring data, a preliminary assessment of environmental flows was developed to ascertain if baseflow volumes were at acceptable levels (Table 5). A threshold value of the 40th percentile of summer flow was used as discussed previously. This statistic requires a long term, continuous data set and therefore is only attainable at long term gauging stations. The distribution of measured baseflow allows this value to be moved within watercourse, to an un-gauged location. Several measurements are required to develop such a relationship, and these preliminary values are based on 2 – 4 measurements, where a strong relationship was found. Further field data are required to refine these values and they are presented in Table 5 as preliminary thresholds only.

Table 5: Measured baseflow discharge as compared to preliminary environmental flows.

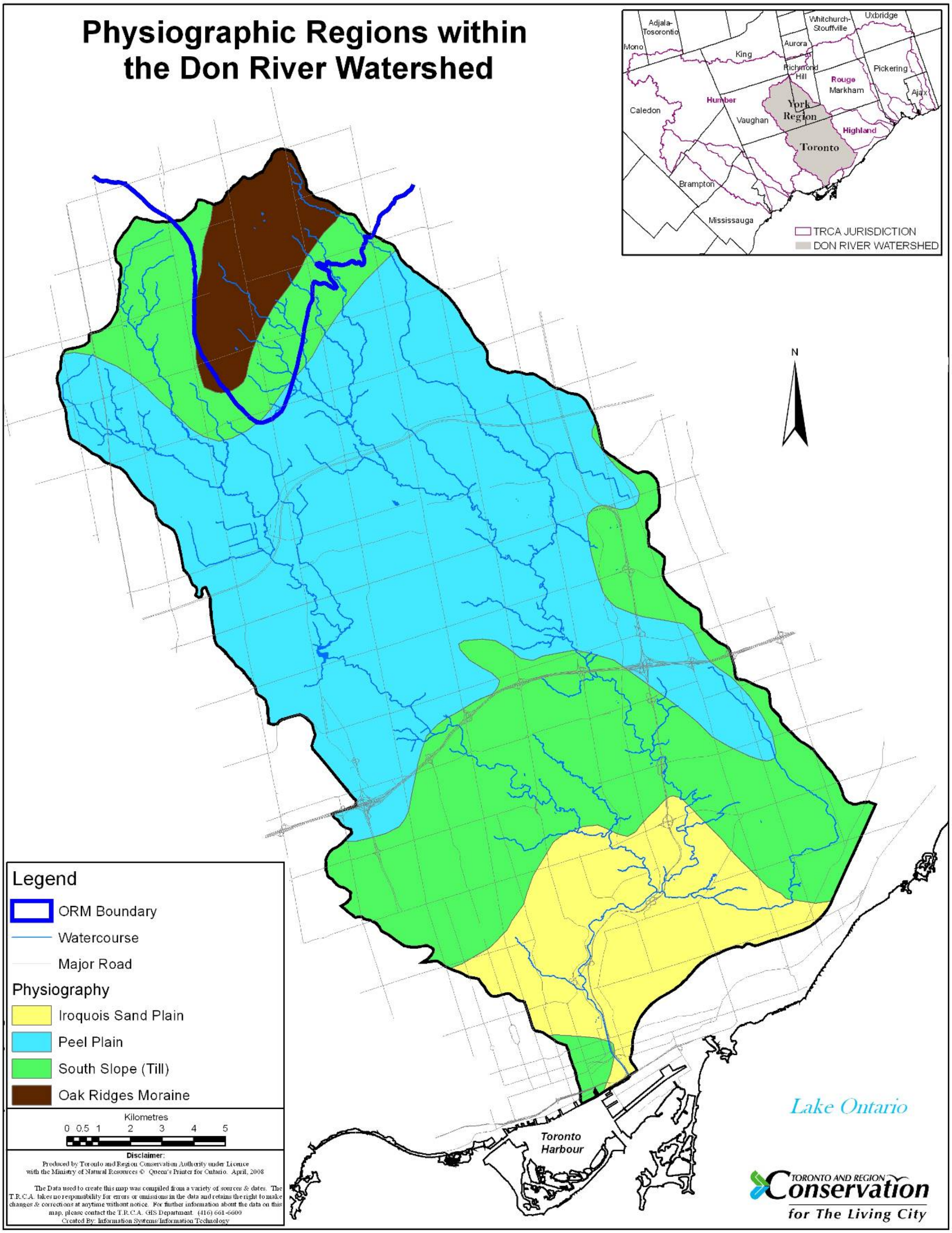
Subwatershed	2003 Summer BFQ (l/s)	2005 Summer BFQ (l/s)	2006 Summer BFQ (l/s)	Environmental Flow (Preliminary)
Upper West Don River	142	139	199	241
Upper East Don River	160	239	300	236
German Mills Creek	111	169	145	153
Lower West Don River	431	533	555	506
Lower East Don River	n/a	631	638	591
Taylor/Massey Creek	73	40	95	n/a
Lower Don River	n/a	1458	1763	n/a

Measured summer baseflow discharges (BFQ) from monitoring years are used for the comparisons where there is a significant difference between the majority of 2003, 2005 and 2006 field measurements (Table 5). It should be noted that summer rainfall totals from Toronto's Pearson International Airport between the months of June and August presented comparable values for the three years of monitoring, with an average of 187.3 mm. The years 2003, 2005 and 2006 all showed about 22% less precipitation than climate normals established from 1971-2000 data. Overall, the 2005 and 2006 data were shown to be higher than the Environmental Flows, while the 2003 data were uniformly below this threshold. With these Environmental Flow Targets being preliminary, it is difficult to determine if baseflows are below healthy levels, or if the targets require significant further refinements.

4.1.1 Baseflow Findings

In every watershed, there are major influences on the baseflow regime that can largely be explained by the presence of certain physiographic regions (Chapman and Putman, 1984). It has been found that a chief contributor to the overall baseflow regime is the Oak Ridges Moraine (ORM), particularly the southern edge of this formation (TRCA 2007, 2008). The ORM is comprised of highly permeable materials allowing precipitation to infiltrate and be released as baseflow into local watercourses. As expected, groundwater modeling results showed that more than 80% of the lands in the 905 area generate higher groundwater recharge values (>150 mm/year), due to the greater extent of open spaces and undeveloped lands found in this area (MMM, 2005). Since the lands within 416 area are considerably more urbanized, more than 50% of the lands in these areas generate lower groundwater recharge values (<150 mm/year) (MMM, 2005). A large portion of the Don watershed lies in the Peel Plain, which consists largely of sandy silt till and glacial deposits of silt and clay, which are significantly less permeable (Figure **3**). The southern part of the watershed, near Lake Ontario, is dominated by lacustrine deposits laid down within Glacial Lake Iroquois.

Figure 3: Physiographic regions in the Don River watershed.



Overall, at a watershed scale, baseflow contributions in the Don differ from other TRCA watersheds, in which the Don appears to be a bottom-heavy system. That is, the northern (north of Steeles Avenue) subwatersheds appear to contribute less than the southern (south of Steeles Ave.) subwatersheds. From data collected at indicator stations in 2005, the total contribution calculated from the upper three subwatersheds was 38%, while the remaining 62% is contributed from the four lower subwatersheds (Figure 4). The same trend was calculated from 2006 indicator station data, where upper subwatersheds totaled 37%, and the lower subwatersheds contributed 63% (Figure 5). A similar assessment was completed using preliminary groundwater discharge data modeled in the YPDT Groundwater Model and the results were comparable, showing contributions of 45% and 55% from the upper and lower subwatersheds, respectively. Table 6 shows the total baseflow and groundwater discharge contributions by subwatershed based on both TRCA field data (2005 and 2006) and YPDT modeled data.

Table 6: Percent contribution to baseflow/groundwater discharge by subwatershed.

Subwatershed	Baseflow Contribution (%) (TRCA, 2005)	Baseflow Contribution (%) (TRCA, 2006)	Groundwater Discharge Contribution (%) (*YPDT, 2008)
Upper East Don	16.4	17.0	24.4
Upper West Don	9.6	11.3	7.7
German Mills	11.6	8.2	7.0
Lower East Don	9.0	10.9	25.7
Lower West Don	27.0	20.2	23.0
Taylor/Massey	5.0	5.4	0.2
Lower Don	21.4	26.9	12.1

* Based on Water Budget Modelling for the TRCA jurisdiction

The upper three subwatersheds of the Don River are primarily influenced by the Oak Ridges Moraine as shown in Figure 6. The Upper East Don shows the most significant contributions from the ORM, due to a portion of the Oak Ridges Moraine referred to as the Maple Spur, which provides much of the discharge to this subwatershed. The Maple Spur is a southern lobe of ORM deposits that extends down into the Upper Don, and can be seen in Figure **3**. As much as the ORM is a major contributor to baseflow volumes in the upper subwatersheds, the deeper aquifer formations (Thorncliffe and Scarborough) also play a large role in the total baseflow discharge of the Don River watershed. The average groundwater discharge component of the streamflow hydrograph is approximately 158 mm/year, or 40% of total streamflow, averaged over the drainage area. This estimate of groundwater discharge has been corrected for discharges emanating from the North Toronto Wastewater Treatment Plant into the Don River. The groundwater discharge estimate of approximately 173 mm/year from hydrograph separation for the period 1991 to 1996 is comparable to the groundwater recharge estimate of 175 mm/year obtained from the HSP-F model for the Don River study area (MMM, 2005). These estimates are slightly lower than TRCA calculations, which showed BFI ranging from 46% - 53%. The time period of data differs between the three methods, which can account for the subtle differences.

Figure 4: Don River subwatersheds – 2005 subwatershed percent contribution to baseflow.

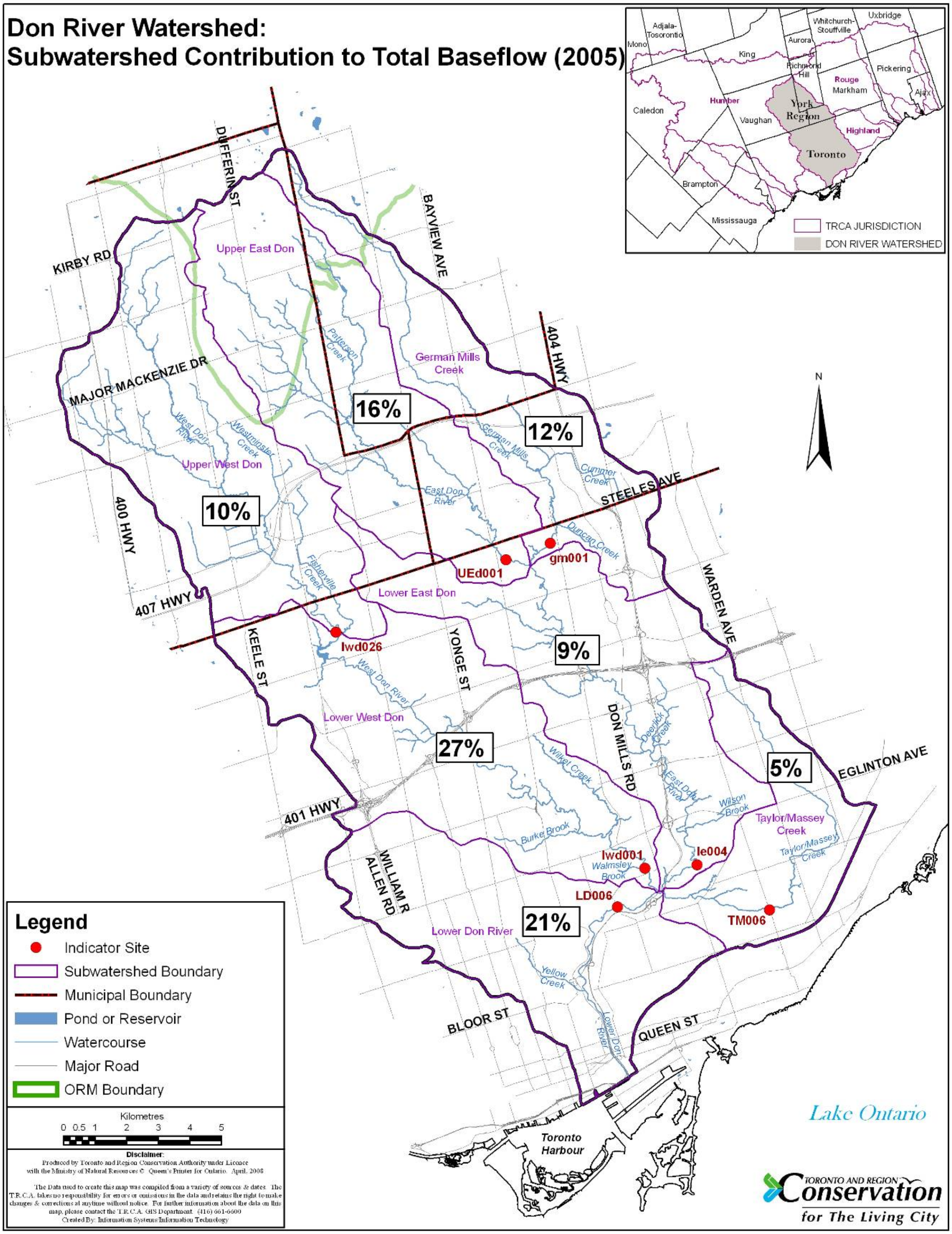


Figure 5: Don River subwatersheds – 2006 subwatershed percent contribution to baseflow.

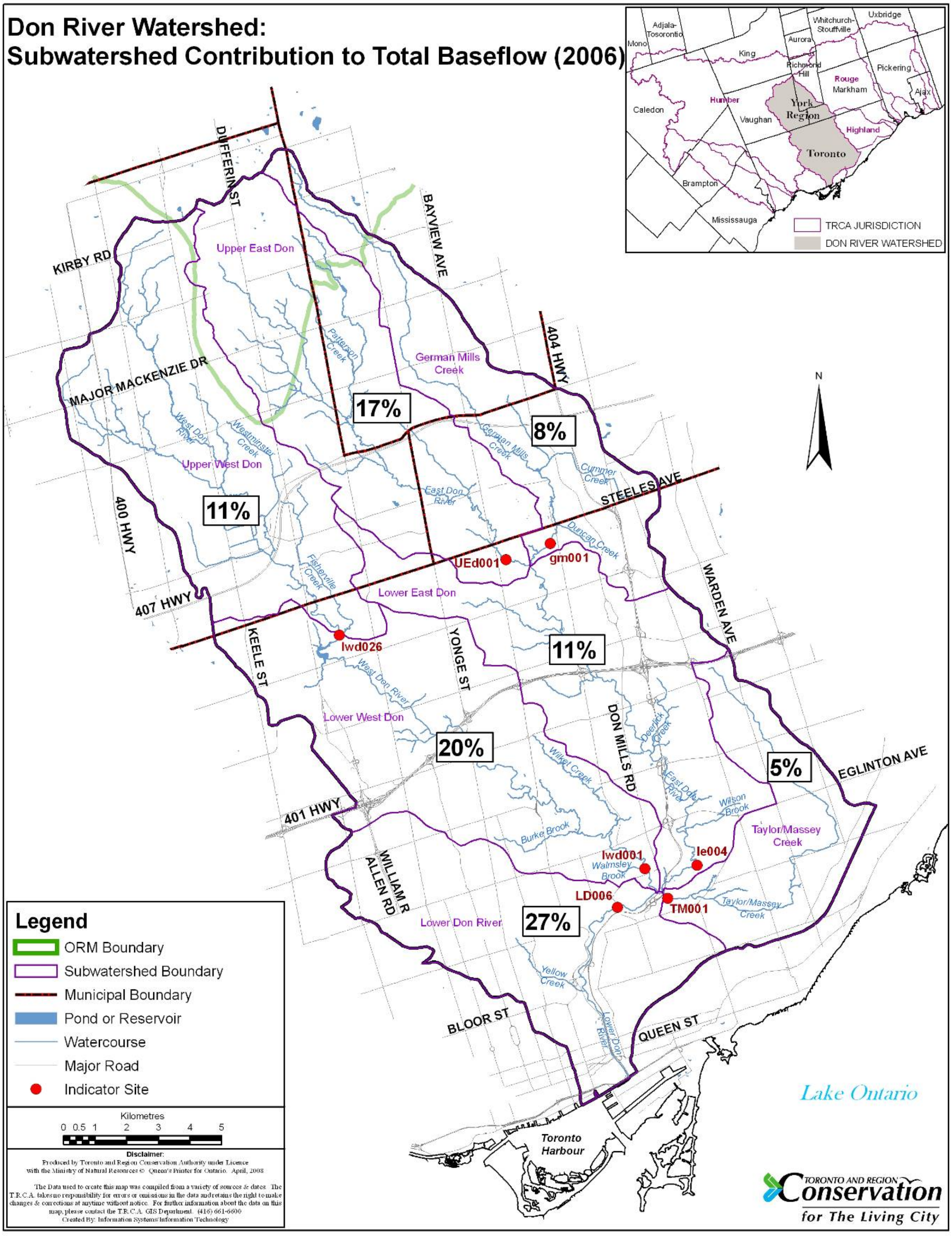
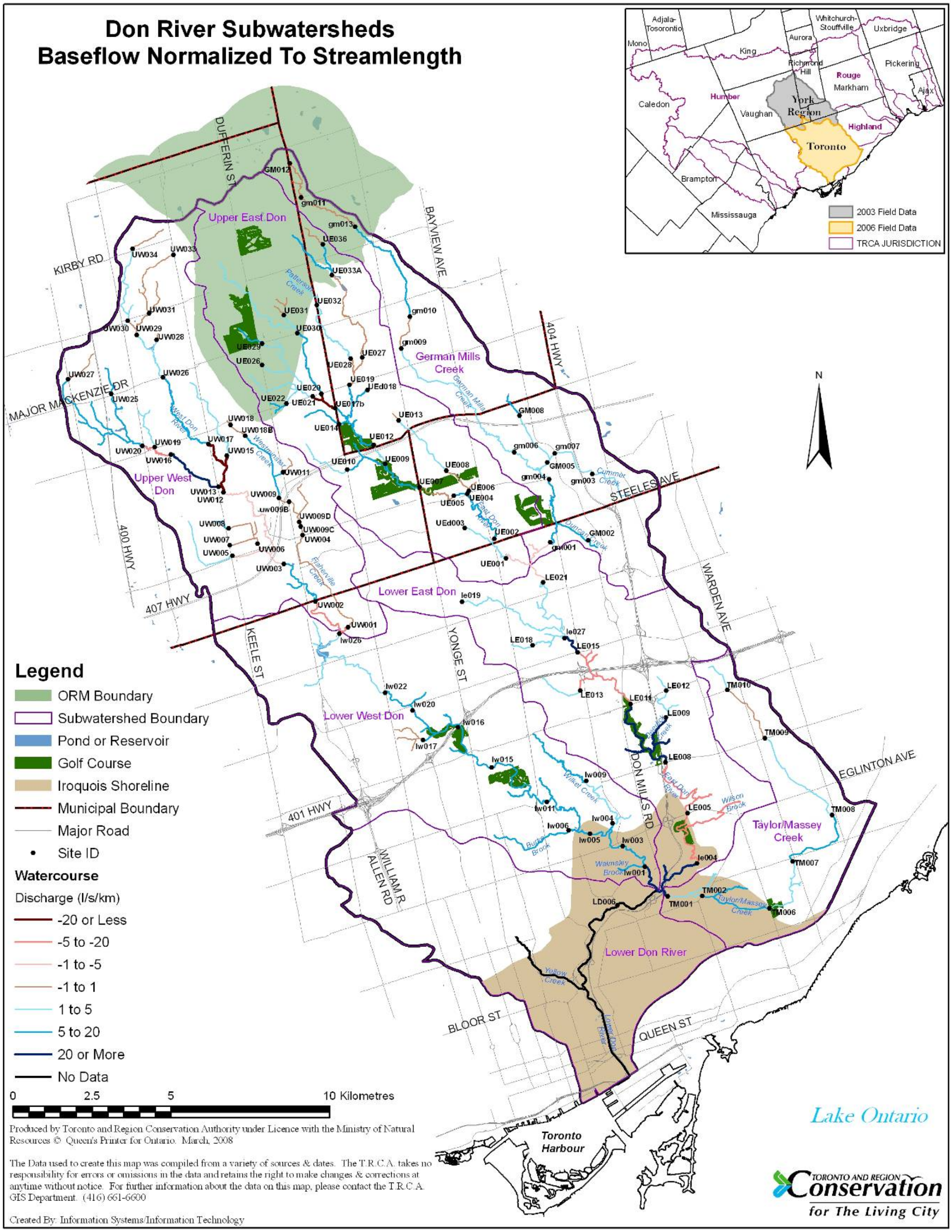


Figure 6: Normalized baseflow as calculated from 2003 and 2006 summer measurements.



The lower reaches of the Don River are located in relatively deep ravine systems, which increase the potential for the valley to incise upon the lower aquifer systems. The large contributions from the lower subwatersheds are likely emanating from both the Thorncilffe and Scarborough aquifer complexes. Another potential contributor to the increased baseflow contributions from the lower subwatersheds is that of groundwater being intercepted by sewer infrastructure. In the early 1990s, there were a total of 1,185 outfalls in the Don River, cited as comprising as much as 71% of the Don's total flow (MTRCA, 1994). There have been a number of studies which have found that groundwater infiltrates into sewer infrastructure and contributes to dry weather flow (Zimmerman, 2002; Meyer, 2002; Stormwater Assessment Monitoring and Performance (SWAMP) Program, 2002). With this increased knowledge of the baseflow and groundwater system, this 71% may be a high estimate. In 2006, the TRCA conducted a small study in the Town of Richmond Hill, in which the flow contributions of 29 storm sewer outfalls were measured during dry weather, to better understand the influence of sewer infrastructure. As expected, larger discharges were measured at outfalls draining larger sewershed areas. The study also included seven and ten outfall locations in the Upper East Don and German Mills Creek subwatersheds, respectively. The contributions from measured outfalls in these subwatersheds were calculated and ranged from 100-300 million litres per year. In comparison to Creek baseflow values measured in 2006, these discharges represent <10% of total annual baseflow. However, these values represent only a small percentage of the actual number of storm sewer outfalls that exist in Richmond Hill and the Don River watershed. Further studies of contributions of storm sewers in the Lower Don must be conducted as older sewer infrastructure in the City of Toronto is more of a concern than in the Town of Richmond Hill.

There is currently one active sewage treatment facility within the Don River watershed, located in the Lower Don near Millwood Rd. The North Toronto Wastewater Treatment Plant treats wastewater for approximately 55,000 people, and discharges treated water directly into the Don River. Discharges of the plant are reported to contribute 11% of the river's total flow (CH2M Hill and MacViro, 2003).

Upper West Don River Subwatershed

Very little of the Upper West Don River subwatershed lies within the Maple Spur formation in comparison to the Upper East Don; however, the Oak Ridges Aquifer still plays a large role in where groundwater discharge occurs. Like the Upper East Don, the headwaters of the Upper West Don can be broken down into two main branches, east and west, located just north-west of Langstaff Road and Keele Street. All of the tributaries for these two branches are formally unnamed. Downstream of the two main branches, just north of Highway 7, the Upper West Don is joined by an unnamed tributary that begins near Rutherford Road. Towards the outlet of the subwatershed Fisherville Creek is joined with the main Upper West channel, just before entering the G. Ross Lord Reservoir. In the headwaters, the upper eastern branch begins north of Kirby Road, with small inputs of baseflow occurring north of Teston Road. Inputs continue to occur in an increasing trend down to Rutherford Road and from feeder tributaries ranging from 5 – 20%.

The western branch begins south of Teston Road, and also starts to show perennial flow north of Major Mackenzie with the same volumes as that of the east (~5% of subwatershed discharge). Larger increases were measured in 2003 south of Major Mackenzie Drive, where several first and second order streams converge. At this confluence, a significant contribution of 37% was measured. This increase was measured downstream of Canada's Wonderland, which is a leisure centre with considerable on-line water reservoirs. Measurements taken further downstream as the east and west branches merge also show significant increases and decreases. One considerable input was measured upstream of Keele Street, which totaled more than 50% of the total outflow of the Upper West Don subwatershed (in 2003). In 2005, TRCA staff conducted piezometer and seepage metering in these reaches to ascertain the cause of the seemingly anomalous measurements. All tests conducted in these reaches did not correspond with the measured baseflow data, so it is possible that the detention facilities associated with Canada's Wonderland may have influenced field sampling, and further measurements are required along this entire reach.

At the confluence of the east and west branches a large decrease of 45% was measured, with losses continuing downstream to Highway 7. The magnitude of the changes to baseflow along these reaches is likely exaggerated due to the timing of the sampling as well as the above noted potential influences of Canada's Wonderland. The three measurements taken at this confluence were taken on separate days, and short term water uses may influence flow during sampling at one location, but not at others. This measured increase of 50% and a similar downstream decrease of 45% are similar in amount, and are more than likely not natural changes to baseflow.

The Westminster tributary which flows along the west side of Dufferin Street also converges with the main branch north of Highway 7 under baseflow conditions. This tributary once flowed south of Highway 407 (and Highway 7) and joined the main branch south of Steeles Ave. Due to residential development this tributary was piped in a westerly direction, to flow directly into the main branch of the Upper West Don River. Approximately 13% of the baseflow output of the Upper West Don subwatershed emanates from this tributary. The channel of this tributary still exists south of Highway 407 and is called Fisherville Creek. However the bulk of flow within is derived from stormwater ponds collecting runoff from Highway 407 and surrounding area.

Just downstream of Highway 7, several small tributaries flow from an industrial area and the CN Rail yard located north-west of Highway 7 and west of Keele Street respectively. While no indication of groundwater discharge is predicted by the YPDT Groundwater Model in this area, baseflow was measured in all three major tributaries, cumulatively inputting approximately 12% of the total baseflow.

The lowest reach of the Upper West Don River, south of Highway 7, begins to show some larger groundwater inputs. Increases in discharge were measured down to the outflow of the Upper West Don River subwatershed totaling 30% of total baseflow discharge. While this large input of baseflow was measured along this reach, the YPDT Groundwater Model does not predict this area to have significant groundwater discharge.

The total baseflow output of the Upper West Don River subwatershed was measured at approximately 4.4 million m^3 / year, and contributed 10% of the total baseflow output of the Don River watershed from measurements conducted in 2005.

Upper East Don River Subwatershed

The northern portion of the Upper East Don River lies on a lobe of the Oak Ridges Moraine known as the Maple Spur. The headwaters of the Upper East Don divide into two main branches just north of Highway 407. The tributaries in the main western branch are all formally unnamed. In the eastern main branch, the west tributary is known as Patterson Creek, while the east tributary is also formally unnamed.

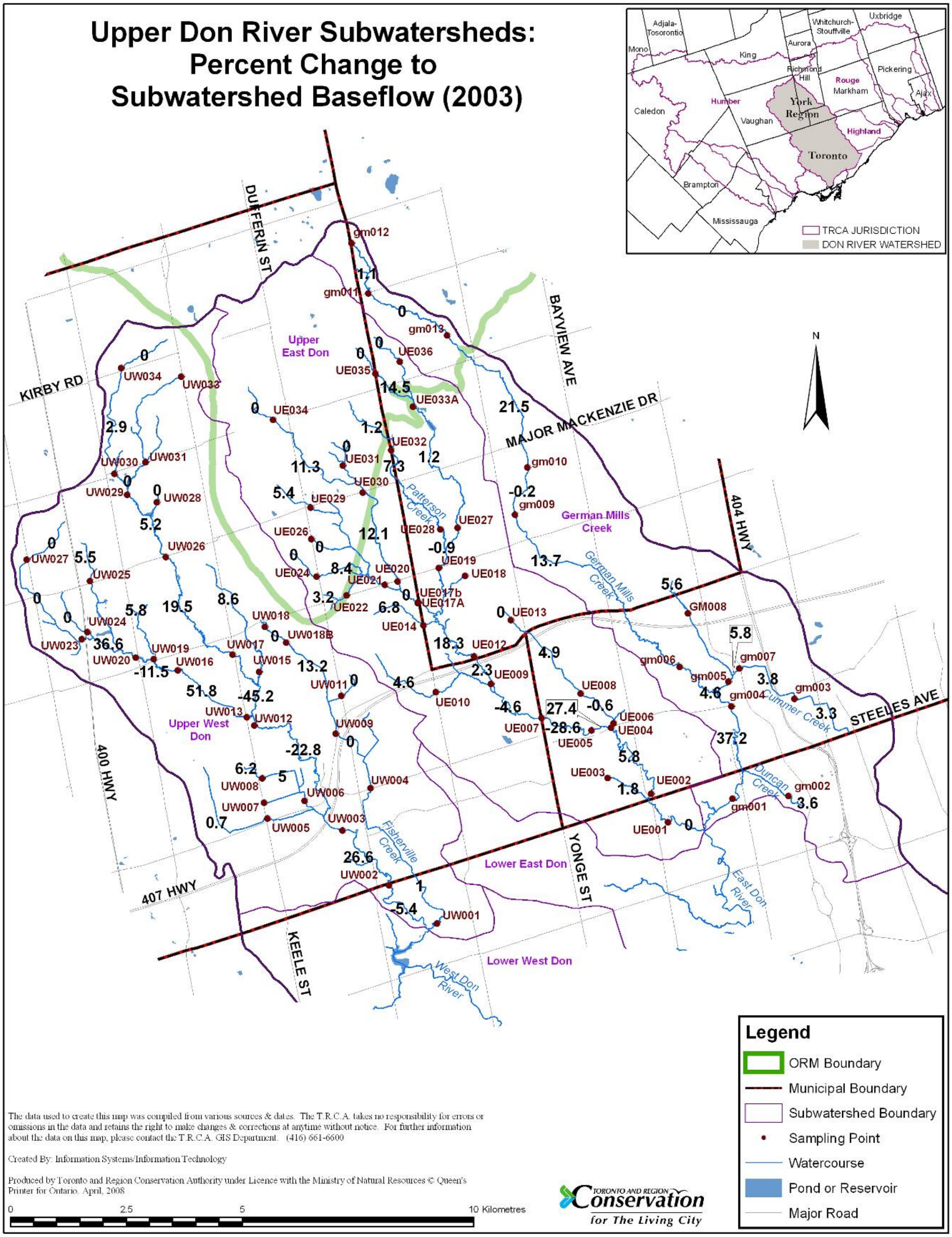
In the main eastern branch, baseflow measurements taken in the summer of 2003, found both Patterson Creek and the east tributary to be dry north of Elgin Mills Road, with some initial inputs occurring south of Teston, towards Major Mackenzie. As Patterson Creek flows off the Moraine, discharge occurs along its reaches totaling approximately 25% of the Upper East Don's total baseflow output (Figure 7). These inputs, located between Elgin Mills Road and Major Mackenzie Drive, are generally echoed across the Don watershed where all three headwater subwatersheds begin flowing at or just below Elgin Mills and Teston Road.

The main western branch also shows the same pattern of groundwater inputs south of Teston Road, with increased inputs ranging from 8 – 12 % as this branch flows off the Moraine. The Maple Spur of the Oak Ridges Moraine is a significant feature in the Upper East Don subwatershed. The western branch and Patterson Creek are directly influenced by the Moraine; 40% of the total baseflow output for this subwatershed emanates from the western branch and 25% is contributed from Patterson Creek and its feeder tributaries. Therefore the Upper East Don has the largest baseflow contribution from the ORM at 65% of the total subwatershed baseflow output. All the headwater tributaries are shown to have some groundwater discharge occurring according to the YPDT Groundwater Model (Kassenaar and Wexler, 2006), and this, for the most part, agrees with the TRCA field data. One discrepancy found was that the YPDT Model shows groundwater discharge occurring to the highest degree in the tributaries north of Elgin Mills andTeston Road; however, as discussed above, the majority of inputs were found to occur south of Elgin Mills and Teston Road.

Upstream of where the west branch and Patterson Creek merge, there is little change to baseflow volumes. However, at the confluence of these two branches a large increase of 18% was measured. This area is not modelled as a groundwater discharge zone, although downstream of this location, at and below the 407, an area of medium to high groundwater levels is shown in the YPDT Groundwater Model. This area of the Upper East Don showed mixed results in the 2003 field data, showing mixed gains and losses along the tributary. This pattern continues downstream to Highway 7, however measured data show substantially larger increases and decreases upstream of site UE005 (Figure 7). A large decrease of 28.6% measured at Highway 7 is coincident with a modeled groundwater recharge area in the YPDT Groundwater Model (Kassenaar and Wexler, 2006), however this segment of the Don River also has two known surface water abstractions for golf course irrigation, and was found to have a relatively high vulnerability due to water use (Section 4.2.1). Active pumping during sampling may have skewed measured data, and further field measurements are required in this reach.

As the Upper East Don flows into the Lower East Don, small inputs occur within the main tributary as well as some smaller first order streams. These inputs range from approximately 2% in the west and 5% in the main tributary and the smaller watercourse to the north.

Figure 7: Upper Don River subwatersheds – 2003 percent change to baseflow discharge.



The total baseflow output of the subwatershed was measured at approximately 7.5 million m^3 / year, which is equivalent to 16% of the total baseflow output of the Don River watershed in 2005. The Upper East subwatershed, which is largely influenced by the Oak Ridges Moraine, is the largest contributor to overall baseflow discharge among the upper three subwatersheds.

German Mills Creek Subwatershed

The headwaters of German Mills Creek begin within the Oak Ridges Moraine, and appear to have continual flow north of Kirby Road. Flows measured in 2003 in the headwater reach of German Mills Creek were found to be quite low, at approximately 1 liter / second. Large increases to baseflow of approximately 22% were measured just south of Major Mackenzie. The increases along this reach correspond with findings from the YPDT Model, which shows this reach to be a groundwater discharge zone (Kassenaar and Wexler, 2006). This increase to baseflow is also similar to findings elsewhere in the Don and other TRCA watersheds, where the bulk of inputs from the moraine are found on the southern slope of this feature.

Flows remain relatively stable downstream of Major Mackenzie Drive; however, another significant increase of 14% was measured north of John Street (site GM006). This too corresponds with the above noted discharge area, as predicted in the YPDT model.

At this point, several smaller reaches, including Cummer Creek, converge into German Mills Creek. These tributaries are not designated as discharge areas within the YPDT Model; however, TRCA field measurements show these tributaries to be contributing approximately 4 - 6 % of total outflow of the German Mills Creek subwatershed.

Another significant increase was measured towards the bottom of German Mills Creek, where increases of 37% were found. A portion of this flow is contributed by Duncan Creek, a smaller tributary which flows into German Mills Creek. Data from the YPDT Groundwater Model show this portion of German Mills to be a medium to high groundwater discharge zone (Kassenaar and Wexler, 2006). The groundwater discharge areas occurring in the German Mills Creek subwatershed is coincident with areas where the depth to the Oak Ridges Aquifer (or equivalent) is minimal.

The total baseflow output of the subwatershed was measured at approximately 5.3 million m^3 / year, and contributed 12% of the total baseflow output of the Don River watershed in 2005. German Mills Creek is one of the few subwatersheds within the TRCA jurisdiction in which no significant in-stream groundwater recharge was found.

Lower West Don River Subwatershed

The Lower West Don River has the largest subwatershed area in the Don River system. It includes the main West Don River branch and Wilket Creek, as well as Burke and Walmsley brooks in the lower reaches. The top of the subwatershed begins downstream of the confluence between the main Upper West Don River and Fisherville Creek. Downstream of this confluence is the main Lower West Don River branch which flows into the reservoir at the G. Ross Lord Dam. The dam structure was built in 1973 for flood protection and it is located at the northeast corner of Finch Avenue and Dufferin Street.

When the Lower West Don River was sampled in 2006, reservoir water level was checked prior to measuring sites downstream, so that baseflow conditions would not be compromised. The YPDT Groundwater Discharge Model shows no significant discharge zones in the vicinity of the dam; however, measured baseflow showed a 6% increase downstream of the dam (Kassenaar and Wexler, 2006).

The majority of the surficial geology in the Lower West Don subwatershed includes sandy silt and sand, with pockets of less permeable silt and clay. Permeable sand and gravel occur along the lower reaches, south of the 401. Average annual groundwater recharge typically varies between 100-200 mm/yr (MMM, 2005). Measurements taken in 2006 at 13 locations show a steady increase in baseflow moving downstream (Figure 6).

The largest increase in baseflow in the Lower West Don was measured just south of Sheppard Avenue (site lwd016), at 23%, where groundwater inputs also pick up according to the YPDT Discharge Model data. The next largest increase to occur is downstream of Bayview and Lawrence Avenues where discharge increases by 22%. This increase was measured downstream of the confluence with the Burke Brook tributary. Results from the YPDT Model also suggest inputs of groundwater discharge both upstream and downstream of this area, until Eglinton Avenue (Kassenaar and Wexler, 2006). Surficial geology downstream of this increase changes to more permeable deposits from the ancient Iroquois Shoreline and baseflow increases by only 7-10%.

The total baseflow output of the Lower West Don in 2006 was approximately 11.2 million m^3 / year, with a subwatershed contribution of 20% (Figure 5). In 2005 however, the Lower West Don River subwatershed contribution was calculated to be 27% (Figure 4).

Lower East Don River Subwatershed

The Lower East Don River is composed of the main East Don River branch and three second order streams: Newtonbrook Creek, Deerlick Creek and Wilson Brook. Another tribuatary, Tyler Creek, also joins the Lower East Don just north of Eglintion Avenue.The main branch begins south of Steeles Avenue, downstream of the confluence with the Upper East Don River and German Mills Creek subwatersheds.

Groundwater recharge is similar to the Lower West Don subwatershed in which average annual recharge varies between 100-200 mm/yr (MMM, 2005). Surficial geology is also similar to the Lower West Don, with predominantly sandy silt and sand coverage. The areas surrounding the main East branch show a pattern of alternating sand/gravel and silt/clay deposits when traveling downstream. This pattern is reflected by 2006 measurements taken at 12 sites, which showed a general gain and loss pattern in baseflow, particularly in the downstream reaches south of Sheppard Avenue.

Baseflow measurements showed small increases in discharge occurring south-west of Finch Avenue and Leslie Street after a series of small tributaries join the main branch. These small first and second order streams had measurable flows and corresponding low to medium inputs of groundwater at their outlets as shown by the YPDT Groundwater Model (Kassenaar and Wexler, 2006). This increase to baseflow may be aided by less permeable silt and clay deposits that reduce infiltration into the ground.

The most significant increase of baseflow occurs in the area of Leslie Street and Sheppard Avenue (site LE015), at which a 98 L/s gain was measured in less than one kilometer of stream length (Figure 6). This gain can be explained by surficial geology in that vicinity, and no known water user is recorded to be taking water in that area. However, due to the large increase in baseflow over a short distance of stream, further investigation should be conducted as to the interactions between surface and groundwater at this location.

Downstream of this large increase in baseflow, a 5% loss was measured in 2006 between Sheppard Avenue and York Mills Road. This can also be explained by geology; however, results from the YPDT Model show many low to medium inputs of groundwater south of Sheppard Ave, which contradict the measured loss in baseflow (Kassenaar and Wexler, 2006). In this case, a known surface water user is located near the measuring sites, and may possibly account for the 5% loss in flow.

After this reach, another large gain in flow of 28% was measured between York Mills Road and Lawrence Avenue (site LE008). A gain in baseflow in this area can be explained by surrounding silt and clay which are unfavourable for infiltration, and by the groundwater contributions shown in the Groundwater Model. Measured baseflow losses of 6% in the lower reaches of the Lower East Don were expected due to the presence of the Glacial Lake Iroquois deposits. However, an upstream water user is also noted here.

From measurements collected in 2006, the Lower East Don subwatershed showed a baseflow contribution of 11% (Figure 5), with a total baseflow output of approximately 6.1 million m^3 / year. This is an increase from 2005, where measurements showed only a 9% contribution (Figure 4).

Taylor/Massey Creek Subwatershed

Taylor/Massey Creek is the smallest subwatershed in the Don River watershed. It is situated entirely within the City of Toronto, just east of the Don Valley Parkway, and its headwaters begin just south of Highway 401. The surficial geology of Taylor/Massey Creek consists of sand and silt glacier deposits, shifting to more permeable sand and gravel at the Iroquois Shoreline boundary. Average annual groundwater recharge in Taylor/Massey Creek varies throughout its smaller catchment area ranging from 50-250 mm/yr (MMM, 2005).

Seven monitoring sites were sampled in the summer months of 2006. Measured baseflows showed increasingly larger contributions from its headwaters and along its primary branch until the creek crosses St. Clair at site TM007. The large increases can be partly explained by the occurrence of sandy-silt till material. In addition to the natural inputs to baseflow, there are known to be a number of storm and combined sewer outfalls along this reach. These outfalls may be contributing some shallow groundwater through sewer wicking or other discharges. As previously discussed, sewer outfalls studied in the upper subwatersheds were found to be contributing to annual baseflow discharge.

Lesser gains are then found downstream of St. Clair where the Creek enters a deep valley and crosses the permeable deposits of the Iroquois Shoreline. The remainder of the Creek passes over sand and gravel deposits and is directly connected to the Scarborough Formation aquifer. Groundwater recharge is highest in this lower portion with an average annual rate of 200mm/yr (MMM, 2005).

There were no baseflow losses measured in the 2006 data set. Taylor/Massey Creek is not largely dependent on groundwater as the YPDT model shows only low inputs of groundwater west of O'Connor Drive, near the confluence with the Lower East Don River (Kassenaar and Wexler, 2006). Due to its completely urbanized location, this Don subwatershed has no known water users catalogued in the TRCA Water Use Assessment database (2005).

Overall, total baseflow output calculated from 2006 measurement was approximately 3.0 million m^3 / year. Taylor/Massey Creek contributed 5% of baseflow to the Don watershed, which was consistent with contribution measurements collected in 2005 (Figures 4 and 5).

Lower Don River subwatershed

The Lower Don River subwatershed begins downstream of the confluences with the Upper West, Upper East and Taylor/Massey Creek branches, located at Don Valley Parkway and Don Mills Road. One small tributary, Yellow Creek, joins the Lower Don River at Bayview and the Prince Edward (Bloor-Danforth) Viaduct, before discharging into the Keating Channel and the Toronto Harbour about four kilometers downstream.

Surficial geology in this area is a mixture of glacial deposits ranging from less permeable silt and clay to the north, and a sand and gravel mixture associated with the pre-historic Glacial Lake Iroquois deposits to the south of the channel. Some sections of the Lower Don have been engineered or channelized, therefore influencing the natural rate of flow and groundwater discharge. Models show that average annual groundwater recharge in this subwatershed ranges between 100-200 mm/yr (MMM, 2005). The YPDT Groundwater Discharge Model also shows a large number of inputs downstream from the confluences with the three lower subwatersheds, until Queen Street (Kassenaar and Wexler, 2006).

Baseflow discharge in August 2006 was measured at one location approximately 6.5 kilometers from the mouth of the Don River. This measurement showed a very large increase (37%) in baseflow largely due to the significant contributions from the three subwatersheds upstream (Lower West, Lower East and Taylor/Massey). Total discharge at the site was measured to be 1,763 litres per second, with a calculated total baseflow output of approximately 15.0 million m3 / year. The North Toronto Wastewater Treatment Plant was located just downstream of this site and therefore the contribution to baseflow from this facility could not be determined at the time of monitoring.

Baseflow contributions for the Lower Don subwatershed was calculated to be 27% of total baseflow in 2006, which is 6% higher than in contributions calculated in 2005 (Figures 4 and 5). Annual discharge for the entire Don watershed was calculated to be approximately 55.6 million m^3 / year.

4.1.2 Baseflow Issues in the Don

- Further investigation and resampling of areas where baseflow data showed significant discrepancies such as contradicting data or inconclusive findings. In particular, significant discharge areas that were measured in the Upper East Don near Teston Road as well as in the Lower East Don near Leslie Street and Sheppard Avenue. Resampling of reaches downstream of the Canada's Wonderland facility is also needed.

- Long term monitoring in the Don River watershed to quantify baseflow discharge is under development in order to ascertain a trend in baseflow contributions by subwatershed. Long term monitoring at pre-established indicator stations and the re-sampling of monitoring sites in all of the Don subwatersheds to obtain a complete, continuous and up-to-date data set, must be established.

- Stormwater management can play a large role in maintaining baseflow volumes in highly urbanized watersheds like the Don. By reducing the amount of run-off generated from precipitation events, and converting it into infiltration through various existing stormwater management techniques, baseflow contributions can be better maintained.

- Much of the flow regime in the Upper Don is unknown due to the lack of active gauges in the Don River watershed. Long term monitoring through stream gauges should be explored at the outflow locations of the three upper watersheds. This is especially true for the Upper East Don subwatershed which was the largest contributor to baseflow among the upper subwatersheds in 2005 and 2006, as well as having a distinct connection to the Oak Ridges Moraine. New gauging locations have been recently set-up in the Don watershed as part of the Real-Time Gauging Network. Although these were installed at strategic locations within the Don River for flood warning purposes, they could still provide long-term monitoring in the future.

4.2 Water Use and Allocation Conditions

Analysis of water users residing in the Don watershed was carried out using the updated database mentioned in Section 3.2. Water use within the Don can be broken down into two major groups by source: surface water and groundwater use. There are some users that withdraw from both sources and they will be discussed as groundwater use for this report, as this is usually the predominant source.

There are a total of 51 water users within the Don River watershed, the majority (59%) relying of groundwater sources (Table 7). This is predominantly due to the specific types of water use in the watershed, where the larger volume abstractions are for varying industrial uses and groundwater remediation in the now closed Keele Valley Landfill. There are currently no active municipal wells for potable supply in the Don River watershed, and lake based supplies from Lake Ontario are the primary source for potable water.

Spatially speaking, the majority (84%) of water users are located in the northern portion of the watershed in the three upper subwatersheds: Upper West Don, Upper East Don, and German Mills. Among these, the Upper East Don contains the largest number of users with 31, which is more than half of all known users in the Don watershed. There are no known water users within Taylor/Massey Creek subwatershed.

Table 7: Water Withdrawals by Subwatershed – Don River Watershed, 2003.

					Annual Withdrawals (millions of L/year)			
Subwatershed[1]	Purpose	# Users	% Users	% Usage	Surface	Ground	Both	Total
Upper West Don River								
	Agricultural	1	13%	0%	0	0	0	0
	Commercial	1	13%	17%	0	246	0	246
	Industrial	1	13%	55%	0	796	0	796
	Recreational	2	25%	28%	403	0	0	403
	Unknown	3	38%	0%	n/a	n/a	n/a	0
		8			403	1,042	0	1,445
Upper East Don River								
	Agricultural	3	10%	0%	0	6	0	6
	Commercial	6	19%	16%	73	99	30	202
	Recreational	4	13%	2%	21	10	0	31
	Remediation *	16	52%	81%	0	1,052	0	1,052
	Unknown	2	6%	0%	n/a	n/a	n/a	0
		31			94	1,167	30	1,291
German Mills Creek								
	Commercial	1	25%	92%	0	19	0	19
	Dewatering	1	25%	0%	0	0	0	0
	Livestock Watering	1	25%	8%	0	2	0	2
	Recreational	1	25%	0%	0	0	0	0
		4			0	20	0	20
Lower West Don River								
	Commercial	2	50%	100%	30	142	0	172
	Miscellaneous	2	50%	0%	1	0	0	1
		4			31	142	0	173
Lower East Don River								
	Commercial	2	100%	100%	151	0	0	151
		2			151	0	0	151
Lower Don River								
	Industrial	2	100%	100%	0	134	0	134
		2			0	134	0	134
WATERSHED TOTALS		51			678	2,506	30	3,214

[1] No known water users in the Taylor/Massey Creek Subwatershed have been identified in the combined database
* Groundwater Remediation in the Upper East Don River Subwatershed includes water abstractions from 16 active groundwater wells located within the Keele Valley Landfill

Overall, approximately 3.2 million cubic meters of water are extracted from surface and groundwater sources annually in the Don watershed. The majority of users in the Don watershed withdraw for groundwater remediation, golf course operations and aesthetics purposes, at 31%, 24% and 14% of total users, respectively (Figure 8). Although groundwater remediation purposes make up the largest portion of water takers, in reality it is only one permit taking from 16 groundwater wells that are located within the Keele Valley Landfill. But for the purposes of this report, each well is treated as a separate abstraction due to the large spatial distribution of the wells. The remedial works extract groundwater from the 16 wells to filter leachate, after which the water is then conveyed to a sanitary sewer. The withdrawals for these remediation works potentially withdraw the largest percentage of total annual withdrawals within the Don. The Industrial sector is second with potentially extracting approximately 29% of total annual withdrawals. Other significant withdrawals come from golf course irrigation and aesthetic users, taking approximately 24% and 14% of withdrawals in the Don watershed, respectively (Figure 9). All of these withdrawals represent a worst case scenario, should all the users be withdrawing at the same time.

Figure 8: Percent of water users by sector.

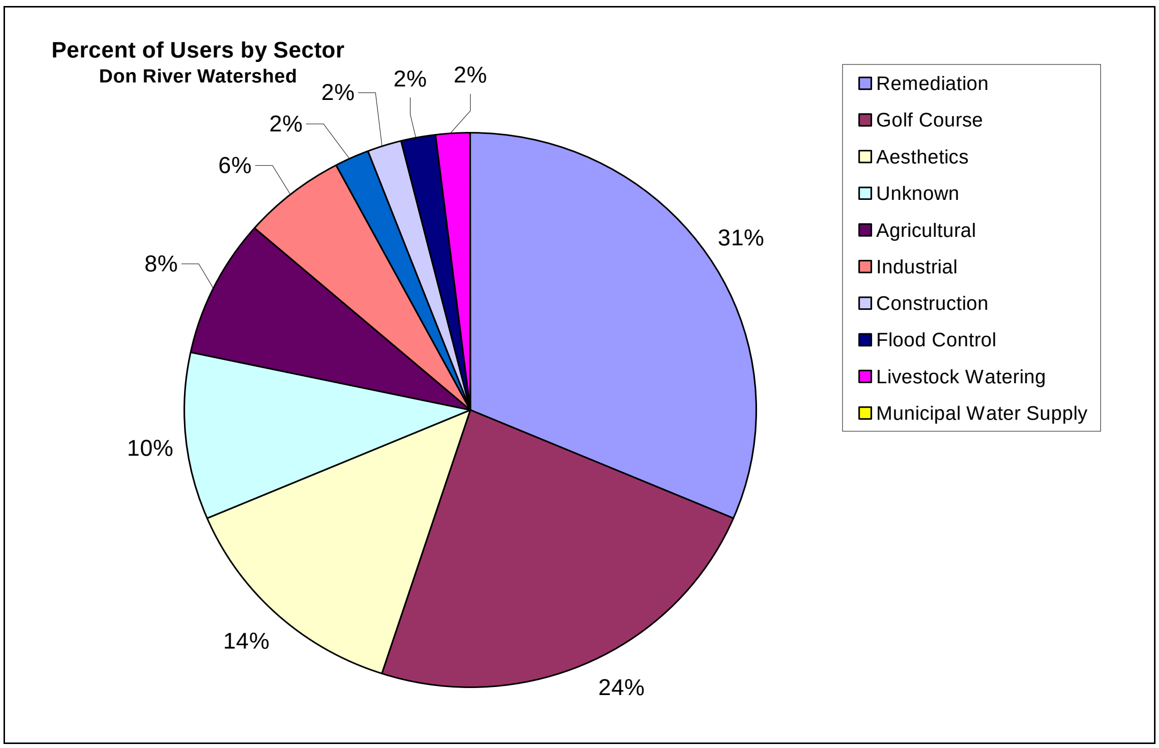
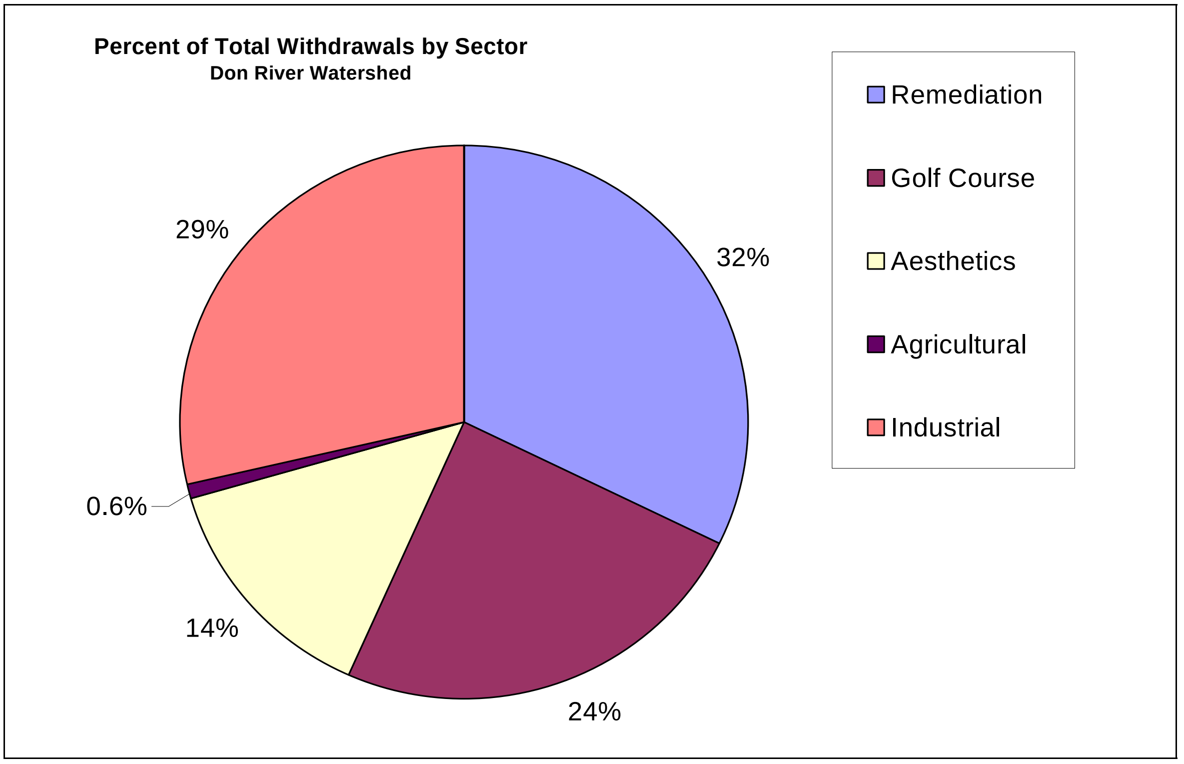


Figure 9: Percent of total withdrawal by sector.



4.2.1 Surface Water Use Assessment

Of the 12 surface water users in the Don watershed, half of them are extracting for golf course irrigation, while the others are for the purposes of aesthetics (33%), wildlife conservation (8%) and flood control (8%). Although golf course operations make up the majority of surface water users in the Don, aesthetic use has the highest annual withdrawal percentage (63%) in comparison to the other sectors. Surface water withdrawals for aesthetic use are concentrated in the Upper Don, within the Upper West Don and Upper East Don subwatersheds, with four users in total. Withdrawals for aesthetic purposes are generally for filling off-line ponds on private properties, although in some cases, these ponds are filled using rain/runoff water, and water is not taken directly from the nearby stream. There is often little record keeping of these types of withdrawals, and little is known regarding the actual withdrawal volumes and the timing thereof.

Within the three upper subwatersheds of the Don, seven of the 12 surface water users are removing from surface water sources. Collectively, the total annual surface withdrawals within the Upper Don was calculated to be 0.5 million m^3 / year, which potentially removes a total of approximately 11% of available baseflow within these upper subwatersheds. The main purposes for surface water takings in these subwatersheds are for aesthetics (57%) and golf course irrigation (43%). Five users are located within the Upper East Don and 2 are within the Upper West Don. German Mills Creek subwatershed has no known surface water users. The Upper West Don users are potentially removing as much as 9% of available baseflow, mostly due to one aesthetic user that is potentially removing as much as 0.4 million cubic meters annually. Furthermore, the Upper West Don has one of the smallest baseflow outputs in the

Don River watershed. These removals from the Upper Don are concerning to baseflow levels since the Upper Don subwatersheds contribute 36% to total baseflow volumes.

Of the seven surface water users in the Upper Don subwatersheds, all four aesthetic users have a high impact rating (Table 9), which means the user requires more than 25% of the available baseflow at their location in the subwatershed. However, as mentioned previously about this type of user, there is little record keeping of withdrawals for off-line ponds. The remaining three users are golf courses. Two of these also have a high impact rating and the third has no known impact. The latter golf course has no impact because they have recently installed a water intake system, which limits the amount of water they can pump directly from the stream, especially under low flow conditions. One reason for the high vulnerability ratings in the Upper Don is because they are based on estimated withdrawal rates and baseflow spot measurements. Since baseflow levels are generally lower than the subwatersheds located downstream, users in the upper sections of the watershed have a greater chance of impacting the flow in the area, even if their withdrawal rates are considered to be low.

The Lower Don subwatersheds contain a total of eight water users of which five are drawing from surface water sources. The Taylor/Massey Creek and Lower Don River subwatersheds have no known water users extracting from surface water sources.

The Lower West Don water users possibly remove 1% of the available baseflow and collectively withdraw approximately 0.2 million cubic meters of water annually. This is the lowest percentage of baseflow removed in the subwatersheds containing surface users. However, aside from one user extracting for golf course irrigation, the other two users are withdrawing for purposes of flood control and wildlife conservation. Therefore, since the majority of the users have very low withdrawal rates due to their low consumptive uses, their impact is minimal.

There are two surface users within the Lower East Don. On an annual basis, they potentially withdraw about 0.3 million cubic meters of water from surface water sources. These two users take for purposes of operating a golf course and potentially remove 1.7% of available baseflow, cumulatively.

Sixty percent of users in the Lower Don subwatersheds are golf courses. Two have a medium impact rating, which means they require between 5 and 25% of baseflow (maximum) to conduct their operations. The third golf course, as well as one flood control user, both fall under the low impact rating and require less than 5% of baseflow volumes. The remaining user is deemed a non-consumptive user (returns >90% of water extractions) for wildlife conservation purposes. This refers to natural habitat creation by building dams or weirs on a watercourse by agencies such as Ducks Unlimited, and therefore has been categorized to have no known impact on baseflow levels.

4.2.2 Vulnerability Assessment

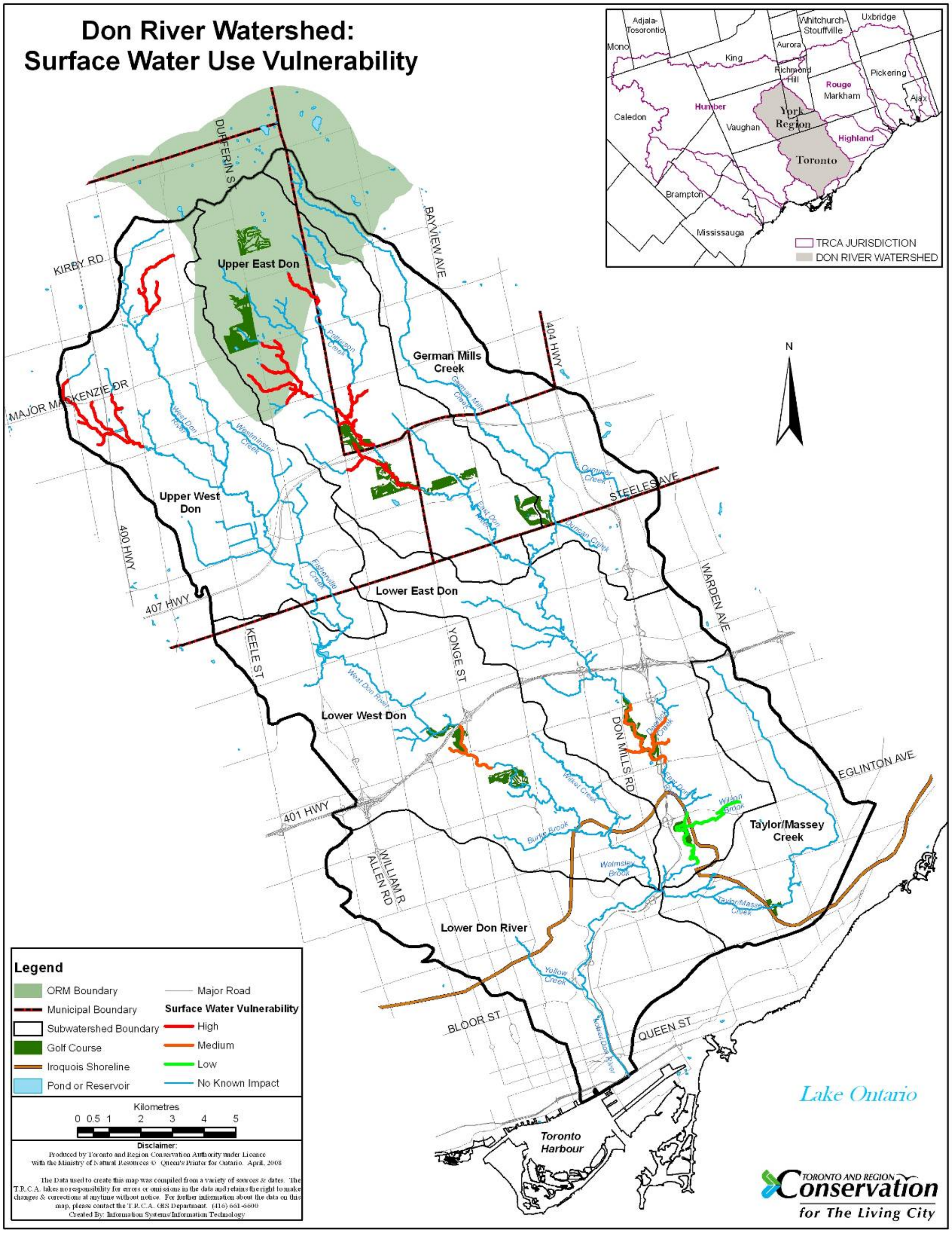
The potential impact of individual surface water withdrawals on baseflow varies across the watershed. These potential impacts are shown in Figure 10.

After assessment of the 12 surface water users in the Don watershed, it was not surprising to find that parts of the Upper Don subwatersheds were classified as potential high vulnerability areas. In the Upper Don, there are six main areas that were found to have high potential impacts due to surface water use, as shown by the red sections of watercourse in Figure 10. Specifically, these areas are found in the upper reaches of the Upper West Don and throughout the Upper East Don subwatershed. Although the locations of these water takings do not all reflect decreases in the measured baseflow, based on this assessment, the potential for high impacts on the low flow system exists. One golf course user in the Upper East Don was found to have no known impact due to the facility switching to a fixed intake system. A fixed intake system is sensitive to water level, so that when water in the stream is low no water is pumped from the stream. This allows for some regulation of water takings under drought or low flow conditions, especially during summer months.

The Lower Don subwatersheds had no surface water users that had potential high impacts on baseflow. This is expected as flows in the lower reaches of the watershed are significantly higher than in the upper subwatersheds. From the five identified users, two had a potential medium impact; two had a low impact; and one was classified to have no known impact.

From this assessment, it is clear that the Upper Don subwatersheds have the highest potential for negative effects on the low flow system. The Upper East Don contains the highest number of surface water users, and the Upper West Don has both of its users classified as a high potential impact to baseflow. Users in the Upper East Don include three golf course operations. Fortunately, through the Ministry of Environment's (MOE) Permit to Take Water (PTTW) Program, these users are regulated, and impacts to low flows can be mitigated through the permit process. Other users within the Upper East Don and Upper West Don subwatersheds are not regulated through the MOE PTTW process; these would include small farms and private aesthetic ponds withdrawing less than 50,000 liters / day. While the volume removed by these users in quite low, they are primarily withdrawing from first and second order streams where there is little baseflow to support withdrawals.

Figure 10: Don River surface water use reach vulnerability assessment.



4.2.3 Water Use and Allocation Issues in the Don

Water use can impact the baseflow system on both a watershed/subwatershed basis and locally on a reach by reach basis. On a watershed scale, managing the impacts of water use can involve the use of Best Management Practices for particular sectors. On a local scale, managing the impacts of water use by individual users may involve altering the way in which water is withdrawn or the source of the water taking. For example, an individual water user may withdraw water from multiple sources, or implement a fixed intake system (see Section 6.1). In the Don and other urbanized watersheds, water can be taken from stormwater sources rather than relying solely on baseflow or groundwater as single sources.

- To address the individual impacts of water users on a local scale, the MOE, in partnership with the TRCA, continues to work to alter on-line surface water takings by installing fixed intake systems. This allows users to better manage their water supplies and rely primarily on storm flows or multiple sources.
- Groundwater users and their cumulative effects should be taken into consideration when developing management strategies to protect baseflow. Rather than moving surface water users to groundwater to protect the baseflow system, water budgets should be developed to ensure sustainable rates of water withdrawal.
- Recently, an assessment of instream flow methods has been initiated by the MOE as part of the review of the PTTW process (Maunder and Hindley, 2005). The purpose of the assessment is to establish minimum flow requirements for different watersheds across the province and to better manage water taking activities. This type of assessment should be considered for TRCA watersheds so that sustainable rates of water use will be established to protect the baseflow system in the Don.
- For water budget purposes, it is necessary to be able to quantify the amount of water being withdrawn from the groundwater system, and from where within that system it is withdrawn from (shallow, medium or deep aquifers). To ascertain this, the withdrawal rates of Permit to Take Water holders should be linked back to known MOE Water Well Records as part of the PTTW review and data management process.

4.3 Ratings for the Baseflow and Water Demand Indicators

In evaluating current conditions in the Don River watershed, a rating system was adopted based on standard letter grades. Each of these categories corresponds with “poor”, “fair”, “good” and “excellent” levels of condition as shown in the table below. Where the measures and targets were quantitative and data permitted, ratings were assigned, in part, to reflect the percent satisfaction of the target. The baseflow and water demand ratings were assigned using the modified approaches described below. Comparisons to conditions in other watersheds under TRCA jurisdiction were made and informed evaluations where data were available, to reflect relative conditions. Where measures and targets were qualitative, or data were lacking, evaluations were based on professional judgment.

Grade	Rank	Percent of Target Achieved
A	Excellent	Better than 80
B	Good	Between 70 and 79
C	Fair	Between 60 and 69
D	Poor	Between 50 and 59
F	Fail	Below 50
TBD	To be determined	Further study required; baseline data not available

The management objectives, indicators, measures, targets, and current conditions ratings for baseflow and water demand are presented below. Current conditions have been compared to previous assessments of condition undertaken as part of report cards prepared after *Forty Steps*, where detailed assessments were available (Don Watershed Regeneration Council (DWRC) and MTRCA, 1997; TRCA, 2000, 2003).

4.3.1 Rating for the Baseflow Indicator

The management objective for baseflow is to maintain and restore natural levels of baseflow. The associated indicator, measure and target are presented below.

Objective: Maintain and restore natural levels of baseflow		Overall Rating
		C
Indicator	Measure	Target
Stream flow	Median daily baseflow rate (m^3/s, May to August, over most recent 10 year period at stream gauge locations)	No negative (i.e., decreasing) trend in median daily May – August baseflow rate

Rating Rationale

Changes in baseflow discharge can often mean a change in the groundwater system. A reduction in groundwater levels can decrease baseflow, and can be attributed to increased water withdrawals or an increase in impervious cover. Table 8 and Figure 11 show the change in median daily baseflow discharges (May – August, 1995 – 2005) from stream gauging data in the Lower West Don River and the Lower Don River (Main branch).

Table 8: Percent change in median daily baseflow discharges (May - August) from 1995 - 2005 in the Lower West Don River and Lower Don River.

Subwatershed	1995 – 2005 Percent Change	Rating*
Lower West Don River	-1.55%	D
Lower Main Don River	-0.94%	D
Lower East Don River	N/A	N/A

*Rating:

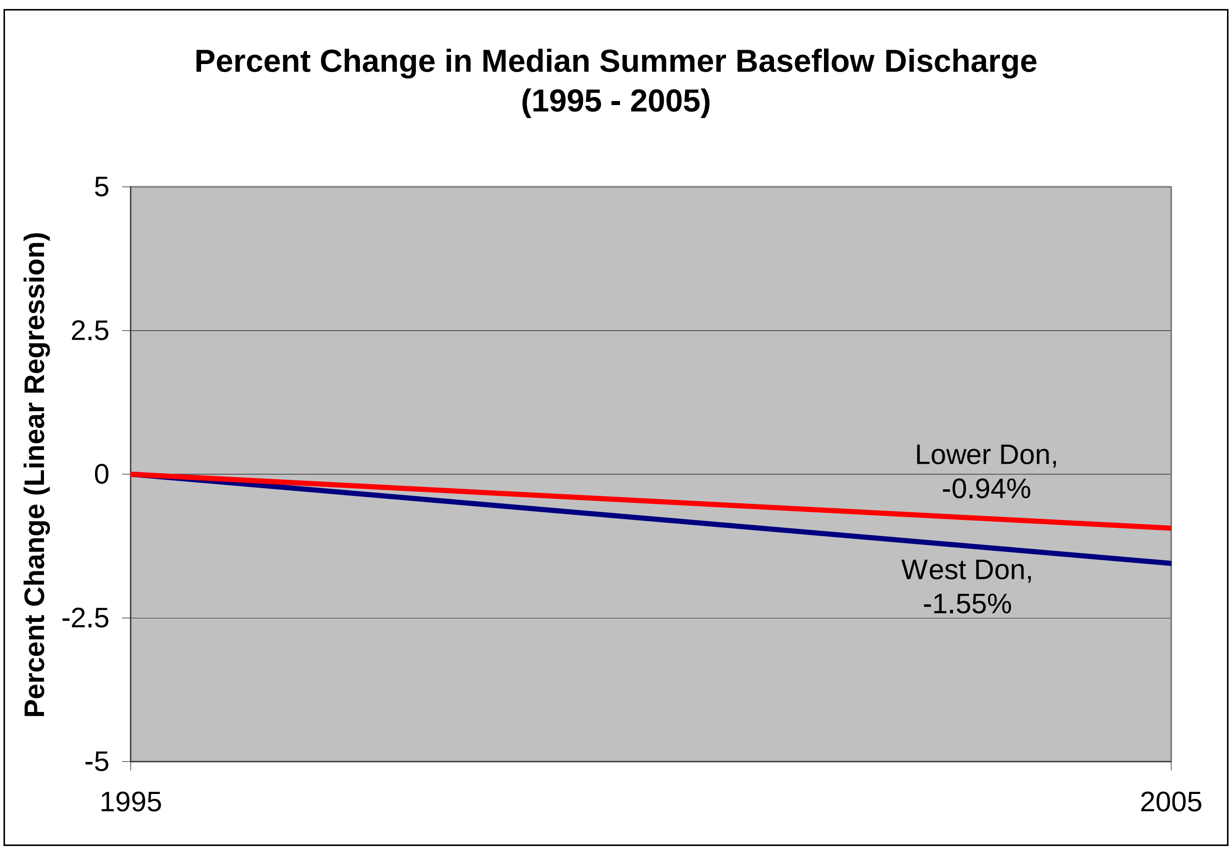
A/Excellent	Significant Increase in Baseflow (>10%)
B/Good	Increase in Baseflow
C /Fair	No change
D/Poor	Decrease in Baseflow
F/Fail	Significant Decrease in Baseflow (>10%)

The decreasing trends observed in summer median baseflow discharge from the West and Lower Don could be a potential reflection of many factors including increased water withdrawal practices, increased impervious cover, or short-term trends in precipitation (Figure 11). Effects from groundwater discharges from the ORM aquifers cannot be deduced due to the lack of long term data in the upper reaches of the Don, in particular the Upper East Don River, where flows are highly influenced by the Moraine.

The Lower West and Lower Don were both assigned a rating of “D/Poor” due to the decreasing trend in summer median flows between 1995 and 2005. The decreases were calculated to be <2%, with the Lower West Don having the higher decrease at 1.6%. However, these decreasing trends were also found to be within their normal range of variance. The Lower East Don could not be rated as data were only available up to 1996 and was insufficient to perform trend analysis for the desired timeline.

In the future, monitoring data from the recently launched Real-Time Gauging Network will be available for analysis, including several locations within the Don watershed. This network was initially developed for Flood Warning purposes but will also provide a continuous data set for streamflow, discharge and other parameters. Over time, baseflow trend analysis can be performed on this growing data set and will supplement existing gauging data.

Figure 11: Percent change in median daily baseflow discharges (May – August) from 1995 – 2005 in the Lower West Don River and the Lower Don River.



An overall watershed rating of "Fair" (C) has been assigned based on the data that was available.. It is difficult to determine whether contributions have increased or decreased in the Don River as a whole, given the few locations within the watershed with long term baseline and monthly monitoring data. However, from the analysis performed on the existing data, it was deduced that there was no major changes in baseflow from 1995 to 2005. Further monitoring and data analysis will have to be conducted in the future to allow for a more defined overall rating.

4.3.2 Rating for Water Demand Indicator

The water use management objective is to practice sustainable resource use by individuals, households, businesses, institutions and governments in the Don River watershed. Moving all surface water users off-line from the watercourse will help to mitigate potential and actual impacts on baseflow from surface water use. The indicator, measures and targets associated with water takings are presented below.

Objective: Practice sustainable resource use by individuals, households, businesses, institutions and governments		Overall Rating C/Fair
Indicator	Measure	Target
Water sources and demand*	Proportion of mean annual baseflow discharge allocated for withdrawal (under provincial Permits to Take Water) by subwatershed	Proportion of mean annual baseflow discharge allocated for withdrawal is less than 10% RATING: B
	Number of surface water takings representing low, medium and hight risk of downstream impacts by subwatershed	No known risk of downstream impacts from surface water takings exist (i.e., all surface takings are off-line and/or have intakes fixed at an elevation above baseflow water level) RATING: C

* See the *Geology and Groundwater Resources – Report on Current Conditions* (TRCA, 2009b) for an evaluation of the impact of groundwater withdrawals on aquifers. *See the Land and Resource Use – Report on Current Conditions* (TRCA, 2009) for an evaluation of municipal water use.

Rating Rationale

The number of high, medium, and low impact water takers, the percent of baseflow allocated, and ratings for Don River subwatersheds are shown in Table 9 and Figure 12. The cumulative impacts of withdrawals, based on the annual usage, are low, representing between 0.01 % and 1 % of total annual baseflow discharge. Although withdrawal amounts on a subwatershed scale are low, the potential for local impacts from individual users remains high. For example, in the Upper East Don subwatershed there are 4 high impact water users and 2 medium impacts users.

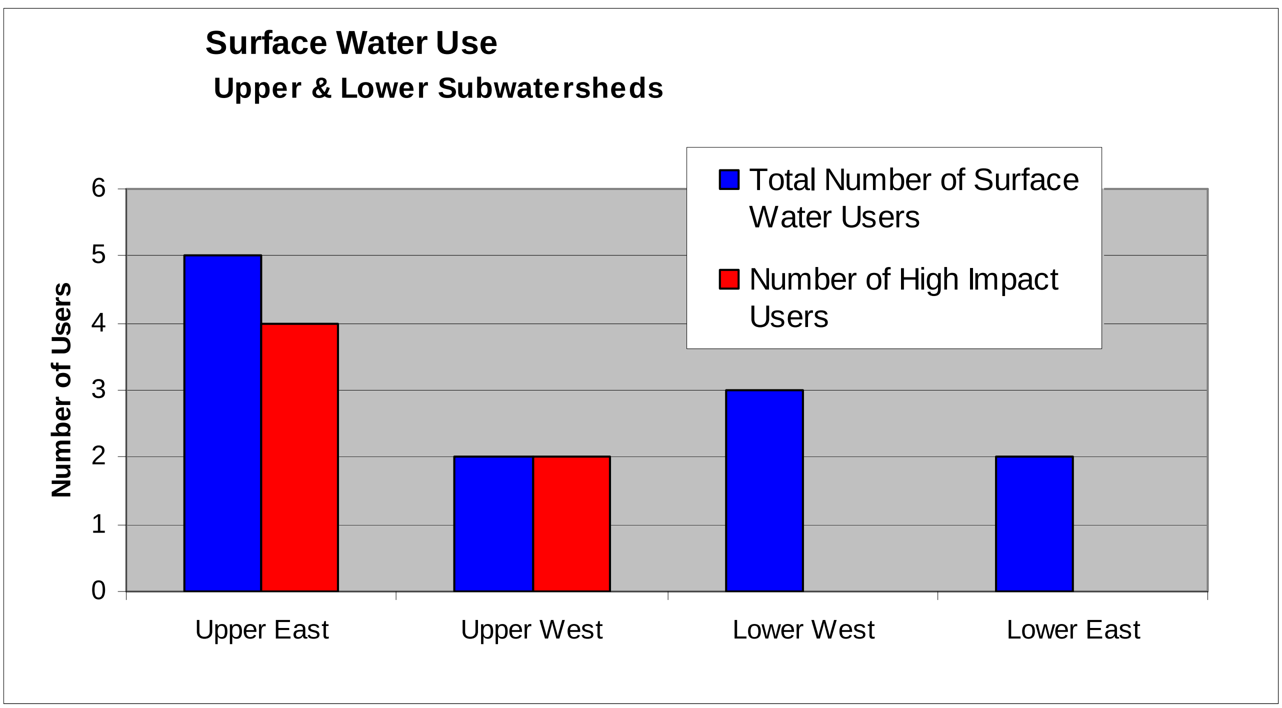
Table 9: Surface water users, high impact water users, and baseflow allocated in Don River watershed subwatersheds.

Subwatershed	Total # of Surface Users	# of High Impact Users	% Baseflow Allocation	RATING*
Upper East Don	5	4	1.2	D
Upper West Don	2	2	9.2	D
Lower West Don	3	0	1.6	A
Lower East Don	2	0	5.6	B

*Rating:

A/Excellent	No Impact on Baseflow
B/Good	Low Impact on Baseflow
C/Fair	Medium Impact on Baseflow
D/Poor	High Impact on Baseflow
F/Fail	High Impact and Allocation

Figure 12: Total numbers of surface water users and high impact surface water users in Don River watershed subwatersheds.



Overall, the Upper Don subwatersheds show a high potential impact on baseflow. In the Upper East Don, <2% of baseflow has been allocated for surface water use; however, it has five surface water users, four of which are classified as high impact users. As a result, the impact of individual users on the overall baseflow system in the Upper East Don is high and receives a rating of “D”. Conversely, the Upper West Don has only two surface water users, but both of them have been classified as high impact users. Although this is a lower number of high impact users, it was observed that roughly 9% of the baseflow in the Upper West Don is allocated for water use by these two users. This shows that the withdrawal amount is equally as important, if not more so, as the number of users. Subwatersheds with a large number of surface users withdrawing small amounts can have very little impact on the baseflow system, whereas a small number of water users can have a considerable impact on baseflow. As a result, the Upper West Don also receives a rating of "D" since a potential for these two water users to have a high impact on baseflow exists. The German Mills Creek subwatershed has no known water users, and therefore was not rated.

Surface water users also have the potential to impact the baseflow system if they are located on-line to the watercourse. A secondary target for water use is to remove all on-line surface water takings from the Don River. Baseflow measurements have shown considerable losses due to on-line dams and ponds that are used for large volume water withdrawals. Of the seven surface water users that are located in the Upper Don there are currently four that take from ponds that are on-line with the watercourse.

On the contrary, water users in the Lower West Don and Lower East Don subwatersheds were deemed to have low to no impact on baseflow. The Lower West Don subwatershed contains no high impact water users and allocation of baseflow for surface water withdrawals is less than 2%. Since the objective is to reduce or eliminate high impacts on baseflow from surface water use, the Lower West Don receives a rating of "A". The Lower East Don also has no high impact users and even fewer surface water users than the Lower West Don; however, its allocation of baseflow is >5% and receives a rating of "B" for low impact to baseflow.

The overall rating of the Don River watershed was a "C", based on surface water use withdrawals and the number of high impact users. Water use in the Don River watershed has a medium impact on the baseflow system, with greater potential effects occurring in the Upper subwatersheds.

5.0 Low Flow Management Strategies

5.1 Climate Change

Climate change is anticipated to cause significant changes to the hydrological cycle. For example, a warmer climate will bring a shift in the timing for winter freeze-up and for the onset of spring melt. Milder winter temperatures will result in an increased potential for more midwinter melts and ice break-up. Furthermore, with a warmer air mass, more water vapour can be stored in the atmosphere, creating a higher risk of droughts. The same phenomena is anticipated to shift rainfall patterns with a higher proportion of precipitation being attributed to severe weather events creating a greater risk of flooding and increased erosion. These changes will also impact natural flora and fauna as well as human life and property.

With regard to baseflow volumes and surface water use, the predictions of climate change are not encouraging. Ultimately, what feeds natural baseflow is groundwater recharge. If the groundwater balance is in a deficit (outflow > inflow) then aquifers and the related water table will lower. With a lowered water table there is a high potential for many first and second order streams to dry up as they are no longer hydrologically connected to the groundwater system. This deficit due to climate change can occur in a two fold manner. With rainfall patterns showing longer dry periods, water use would likely increase and extended dry periods would not allow recharge to occur, resulting in an increased strain on the baseflow system. Added to this are the short duration and high intensity rainfall events. In a rain event with these characteristics the majority of the precipitation runs off with a reduced potential for infiltration into the groundwater system.

Maintaining groundwater recharge is of primary importance for preserving baseflow levels. Detention of storm flows for flooding, erosion and water quality management is already promoted by TRCA, and new technologies for promoting infiltration are currently being evaluated and implemented. The additional stressor that climate change represents will need to be integrated into these management techniques.

5.2 Drought Management

In keeping with the Provincial Low Water Response Plan, Conservation Authorities within the Greater Toronto Area have recognized the need to develop a process to respond to drought events and have set up Low Water Response Teams (LWRT) (Ontario Ministry of Natural Resources *et al.*, 2001).

While initially envisioned at the watershed scale, the number of watersheds involved within the GTA Conservation Authorities and the obvious overlap of municipal involvement warranted a different approach within GTA watersheds. The GTA Authorities agreed to establish LWRTs based upon a procedure developed as part of a flood forecasting and warning working group to streamline communications and response procedures with municipalities. In doing this, GTA teams were set up based upon Regional Municipal boundaries, with some minor additions of peripheral Municipalities. The current process and the teams developed represent a program in its initial stages, and based upon feedback from these groups across the Province, the role and expectations of these teams will undoubtedly be revised over time. At present, LWRT teams are organized as follows;

- Durham – TRCA, CLOCA and other stakeholders
- York – TRCA, LSRCA and other stakeholders
- Peel – TRCA (have not developed a LWRT with CVC)
- Toronto has no designated LWRT but TRCA monitors conditions

These teams are set up to respond in the event of a drought defined by a predefined set of conditions based upon precipitation and stream flow. There are three condition levels: Level I (conservation), Level II (conservation and restriction), and Level III (conservation, restriction, and regulation). Precipitation data are used to advise of any future water shortages by comparing monthly precipitation data with the average monthly precipitation for the previous 18 months, 3 months, or previous month for level I condition. To determine if there is enough water in the stream to meet the basic needs of the ecosystem, monthly stream flow at stream gauges is compared with the lowest average summer flow. LWRTs function by attempting to build consensus on voluntary actions to be taken by water users, such as watering restrictions, and Press Releases. Under the existing legislation for water takings, only the Province through MOE can order a reduction or elimination of water takings under a valid Permit to Take Water.

5.3 Integrated Water Management

While the flow data collected and the mapping products prepared through the Low Flow Management Program provide valuable information and direction on their own, some of the key uses of the information come from identifying and integrating the information into the development of other water management strategies.

To ensure that the data are effectively integrated into other land and water management planning activities, individual program assessments need to be undertaken to identify how low flow data or low flow mapping products can be of use. One such use is in the development of the YPDT Groundwater Model. The low flow or baseflow information reflects the location and amounts of groundwater discharge to the surface system and as such the data are instrumental in the calibration or verification of the YPDT groundwater model. Additional areas of integration exist with respect to the aquatic ecosystem. A direct relationship exists between the amounts of baseflow, whether the reach is a discharge zone, and the quality and productivity of a stream reach in terms of its fishery. Understanding the distribution of baseflow within a watershed integrated with known fishery data, can be used in the development and monitoring of Fish Management Plans.

Integration with stormwater management programs can also be useful in assessing impacts on the baseflow system, by determining the effects that storm sewers have on the natural flow regime of the Don River. Storm sewer contributions need to be quantified in order to determine an accurate rate of baseflow and ensure the quality of data that have been collected throughout the watershed. By identifying the number and location of storm sewer outfalls, non-natural influences to the baseflow system can be explained. In doing so, Low Flow Management Strategies can take into consideration not only the effects of water users on the system, but the impacts that pre-existing municipal infrastructure might have on low flows.

6.0 Conclusions and Management Considerations

6.1 Surface Water Use

Overall, surface water use in the Don is not significantly affecting baseflow at the watershed scale. However, the potential for impact by individual water users is high, as local impacts on baseflow were noted in several areas. In particular, the Upper East Don and Upper West Don subwatersheds contain a number of surface water users whose local and cumulative impacts are considerable. The majority of these users are located south of the ORM and more than 10% of baseflow along these reaches is allocated for their use. Coincident with one particular water user, is the presence of a groundwater recharge area in the Upper Don. These particular reaches need to be protected so that the rate of infiltration that naturally occurs in these areas is maintained and the discharge to local watercourses is not disturbed. In an effort to reduce or eliminate potential and direct impacts of water users, new guidelines for surface water withdrawal methods are being developed. The implementation of fixed, threshold-based withdrawal structures is one way to mitigate impacts. Currently, some golf course operations have adopted a fixed intake system in which the protection of environmental flow is achieved through the reliance on high flows. Similarly, the reliance on groundwater for water use needs is increasing among large operations, which could potentially alleviate direct impacts on the baseflow system. It should be noted, however, that the potential for increased groundwater use to have an indirect long term impact on a watershed is increased through this approach. Storm flows in the Don should also be considered as a source of water for irrigation purposes and steps to create storage facilities for this purpose should be considered by both surface and groundwater sourced abstractions.

6.2 Baseflow

Within the Upper Don River, it is clear that the Oak Ridges Moraine (ORM) is the primary influence on the spatial distribution of baseflow discharge. The Maple Spur formation of the ORM influences the Upper East Don subwatershed most strongly. In order to protect / manage baseflow in the Upper Don River subwatersheds, this is a key area in which to focus. Baseflow is not the only benefactor of the ORM influences in the Upper East Don subwatershed. Aquatics studies of fish species and habitat availability show that the Upper East Don has some of the most thermally stable habitat within the entire watershed. These cold water reaches were found to provide habitat for both redside dace and mottled sculpin, which have for the most part been extirpated from elsewhere in the Don River due to habitat loss. Currently, the Oak Ridges Moraine Conservation Plan and Greenbelt Plan protect some, but not all, of the natural system from further development. Development approved on the ORM prior to the ORMCP taking affect may alter the baseflow regime.

Similar to the Upper East Don, the headwaters of German Mills Creek are located on the ORM and may be partially protected from further land use changes. Just south of the Oak Ridges Moraine, a baseflow contribution of 22% was identified, so it is apparent that this area should be protected from further development. Along the main reach, at Steeles Avenue, a substantial increase in baseflow was also measured. Stream temperature logging by the TRCA has also found these to be some of the key cold water areas in the Don watershed, primarily due to these inputs. These important existing coldwater discharge areas require protection as well as the preservation of infiltration functions in recharge areas associated with these habitats since they are a source of a large amount of baseflow.

Baseflow measurements from 2005 and 2006 show that the Don River is a bottom heavy system, in which more than 60% of measured discharges are being contributed by the four lower subwatersheds (Lower West Don, Lower East Don, Taylor/Massey Creek and Lower Don River). Groundwater inputs are still influencing baseflow discharge in more urbanized locations south of Steeles Avenue. Gains in baseflow discharge of over 20% were measured in the Lower West Don and Lower East Don in some reaches. Losses in baseflow were also measured in the Lower East Don subwatershed. Reasons for these losses in baseflow discharge should be investigated, especially with regards to contributions from combined sewer outlets and influence on baseflow volumes by water users present within these areas.

As baseflow monitoring and water use assessment in the Don watershed continues, areas of concern can be identified in higher resolution. Through the various baseflow mapping products, these areas of ground and surface water interactions can be quickly identified and prioritized for planning / management decisions.

The following monitoring and management strategy is proposed for the Don River watershed:

- Monitoring at selected locations within the Don River, integrated with TRCA's Watershed Monitoring Program to further investigate some of the considerable gains and losses in baseflow that were observed.
- Continue to conduct monthly monitoring at indicator stations during summer months every year, to better understand and identify baseflow trends within the watershed.
- Based on considerable changes in baseflow and the identification of discharge/recharge areas, develop priority areas to protect the sustainability of baseflows in the Don River.

- Resurvey specific water users and integrate updated water use information to ensure that the latest data are used to assess potential stressors on the baseflow system in the Upper Don subwatersheds.
- Work with MOE through the renewal process of PTTWs to modify on-line water takings in order to mitigate disruptions to baseflow from these activities.
- With respect to recently expired PTTWs and known non-permitted water users, stricter enforcement is recommended. The onus should fall upon the MOE to contact landowners to ensure expired PTTWs are renewed. This will allow for the creation of an up-to-date database and contribute to the accuracy of the data possessed by the MOE.

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Appendix A – TRCA Low Flow Monitoring Protocol

Over the last three years the TRCA's baseflow monitoring methodology has been refined to accommodate greater accuracy and ground coverage in the data collection process. Watersheds are divided into drainage basins and then broken down to reaches within that basin. This division ensures that an entire basin can be sampled within a single dry period, and any precipitation events will not skew the collected data. Should a precipitation event occur, a period of 72 hours is allowed for surface runoff and groundwater infiltration to occur. If all the sites in a drainage basin are not completed within the same dry period, the entire basin may require re-measuring.

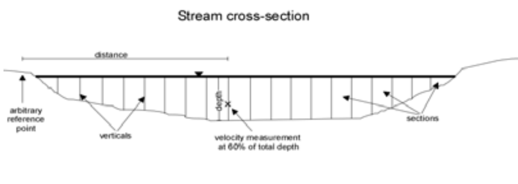


Figure 1. Velocity-Area method of stream flow measurement. Stream velocity, depth and distance are recorded for each vertical. The stream discharge is calculated for each section and summed across the stream.

Sampling sites are chosen starting from the headwaters down to the mouth from topographic maps prior to any field reconnaissance, exact transects are then chosen in the field to find the best suited segment for baseflow measurements. The sampling locations are chosen at major and minor road crossings for two main reasons, easier access for field staff, and road crossings provide an opportunity to form a Stage/Discharge relationship.

Upon arrival at the mapped sampling location, a suitable transect must be found. For accuracy of measurements the stream segment should have a uniform bed, free of debris such as logs and rocks. The transect should be well up or downstream from any bends or meanders, and the riverbanks should not be undercut. Transects must be at a 90° angle to the stream flow.

Once a suitable transect has been located the channel is broken into 20 panels (or 5% of river per panel). Panels do not have to be uniform width along the transect, if an area of the river is moving significantly faster than the rest, the panels could be narrowed, if there is a slow pocket the opposite is true. In certain situations it is not possible to fit 20 panels, it may be possible to dam up a small uniform channel and take a measurement within. If damming is not possible, less than 20 panels must be used. In this situation, as many panels that will fit should be used, while panel widths should not be less than 40mm. These panels are measured for depth, width and water velocity (Figure 1). This is the velocity-area method of stream gauging. Depth and velocity are measured using a Marsh McBirney portable flow meter and depth rod, velocity measurements must be taken at 60% of the depth from the waters surface. If the water is greater than .75 meters, velocity measurements shall be taken at 20% and 80% of the depth from the surface. The width is acquired from a graduated tape spanning the transect. The collected measurements are recorded into an Excel spreadsheet where the panels are calculated and the total discharge of that stream segment is given. This final discharge figure is referenced with the closest upstream discharge and compared for accuracy and continuity. Should the figures show a discrepancy the site is re-assessed, and another sampling may be required. Field crews are also required to record any comments regarding that segment of the river. Permitted and non-permitted water takers are noted, as well as any land use that may be

The Basis of a sound Low Flow Management Plan is the knowledge and understanding of a watershed's baseflow distribution. A complete mapping of baseflow discharge requires stream flow measurements on all tributaries, throughout the watershed. However, there are many factors that influence baseflow and may skew the results of the measurements. These inaccuracies may incorrectly influence management decisions regarding low water and aquatic issues. Therefore, to obtain a reading of baseflow that is as unaffected by outside influences as possible, the following is a list of procedures to follow when measuring baseflow.

1. Stream flow discharge measurements will be carried out according to TRCA accepted "General Metering Criteria". Refer to Guide provided by JDE Ventures, and Environment Canada's "Hydrometric Field Manual - Measurement of Stream flow".

2. Flow Meters will be calibrated at least once per year, as close to the beginning of the summer low flow period as possible. Calibrations are done by National Calibration Service of Environment Canada.

3. For consistency of results, the same meter should be used throughout the measurement of a watershed. Each meter has different correction factors, and each too, have differing degrees of error. Therefore, meters are assigned to a watershed, as opposed to a crew.

4. Site locations and general knowledge of the watershed will be obtained before field work commences. Site locations are chosen at major and minor road/river crossings, additional sites are to be added as need be, in order to integrate with other departments or related studies. These sites are labeled from headwaters to mouth (North to South), as shall be sampled as such. General knowledge of the watershed should be attained from such sources as the Permit To Take Water database, surficial geology and land use maps.

5. Sampling sites will be separated into sub-watersheds, and then into drainage basins. Each drainage basin should be sampled in the same dry period or if possible the same day. If a precipitation event should occur to disrupt this time line, the drainage basin shall be re-measured. To achieve true baseflow measurements, sampling must take place at least 72 hours after a precipitation event. Upon the re-start of sampling, water clarity shall be used to judge if runoff is affecting the flow.

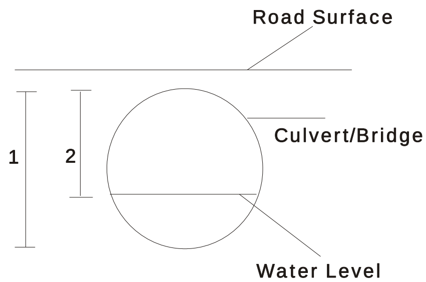
6. Upon the commencement of a new day of sampling, the closest site upstream shall be re-measured to ensure continuity and consistency. If the new site falls below a confluence, both contributing reaches shall be re-measured. If compared results show a significant difference (>10%), then the entire reach may have to be re-measured.

7. With the addition of iPAQ hand held computers to our equipment, on-the-spot calculations can be made, and a final "total discharge" can be attained from the iPAQ software. As well as calculations, the iPAQ unit is used to geo-reference each site, and record various data regarding river conditions, site observations, and measurements as requested (See Appendix 1). Once a final discharge number is calculated and added to the database, it should also be written on your field maps. With accessibility to on-site results, quality control is attained by comparing visual observations, and upstream records with the calculated result.

If a discrepancy is found, the site shall be re-measured fully. If a discrepancy persists, site location may be a factor, and a new site should be located. When protocol is followed, and proper methodology is used for the velocity-area method of stream gauging, it should be necessary to measure flow only once per site visit.

8. Once finished sampling, the site (if altered) will be restored to its previous condition, and all equipment, garbage, etc. shall be removed.

9. All crews are issued a cellular telephone which must remain charged and be kept on during all field work.



Specific Issues

The following are specific issues that have come up in past projects by previous baseflow monitoring crews. These issues must be dealt with in a consistent manner to ensure data integrity and accuracy.

1. Site Location: Accuracy can be greatly reduced if an improper sampling site is chosen. To ensure accuracy of your site look for the following parameters;
   A. Flat uniform riverbed
   B. Free from obstructions (weed masses, log jams, large rocks...)
   C. Sloped riverbanks, no undercutting.
   D. Moving water (no pooling or back eddies)
   E. Marshes adversely affect flow, do not sample in a marsh.

When choosing your sampling site, remember, a little time spent looking around the site location can save you a lot of time sampling.

2. Confluences: A confluence shall be treated as a trio of sites, all recorded in a single dry period. The two reaches above the confluence, and the post-union site downstream should be sampled as close to the confluence as possible.

3. Trespassing: You do not have the right to enter any privately owned property. If the site location falls on private property you must get landowner contact before proceeding. If the landowner refuses, a new site location shall be determined.

4. Data Backup: The “Compaq iPAQ” should have battery life for 2-3 days without charging. If the battery dies, all information on the iPAQ is lost. So as not to lose any data, the iPAQ should be brought into the office to be charged and backed up every 2-3 days.

Recording Additional Data from Baseflow Sites

Temperature - Air temperatures should be taken first, in the shade, away from your body. Water temperatures shall be measured mid-depth in the river thalweg. The thermometer shall not be in direct sunlight, and should be kept submerged for at least 60 seconds.

Stage/Discharge - A stage/discharge relationship shall be attained through 3 measurements over a given time. Measurement 1 is the height of culvert/bridge, from top to riverbed or culvert bottom. Measurement 2 is the water height. This shall be measured top down, from culvert/bridge top, down to top of water surface. Measurement 3 is the total flow for that site. An important note is to comment on where these measurements were taken. e.g.: South side of road, East culvert.

Photographs - Two photographs should be taken at each site; photo 1- upstream of location, photo 2 - site location and downstream.

Comments - The comment field is one of the most important recordings. Comments should include suspected baseflow altering land uses, landowner issues, site problems, in stream barriers, and any other observations made by the crew. Crews should get used to filling in comments for every site; a seemingly unimportant observation may be quite pertinent during baseflow analysis.

Appendix B – TRCA Water Use Assessment User Surveys

TORONTO AND REGION Conservation for The Living City

Water Use Assessment - Public Response Form

This information will remain anonymous, and is strictly for T.R.C.A Watershed Management use.
It is not intended to be shared with outside government bodies

If you are currently *NOT* on municipally supplied water, please find the time to fill out this response form and drop it in the mail. We thank you for your time, and assure you, this information will solely be used for calculating water budgets to better make future management strategies in <u>your</u> watershed.

1. Are you currently using non-municipal water? ☐ Yes ☐ No

2. What is the source of your water withdrawals? ☐ Surface ☐ Ground ☐ Both

3. What is your *approximate* daily pumping rate? Amount Units

4. On average, how many days a year are you actively pumping? Days / Yr

4b. On average, how many hours/day is pumping active? Hours / Day

5. What is the purpose of this water withdrawal? (Ie: Irrigation, Fish Ponds, Potable, etc..)

6. May we contact you if we have further questions regarding your water use?
(If yes, please provide your contact information)

☐ Yes ☐ No

Contact Information:

While this information is being collected solely for TRCA internal use, other agencies would be interested in this data.

7. Would you allow the TRCA to share this information with outside agencies? ☐ Yes ☐ No

TORONTO AND REGION Conservation for The Living City

TO: Whom it May Concern
RE: Toronto and Region Conservation Authority Water Use Assessment

The Toronto and Region Conservation Authority is currently undertaking base flow studies throughout the greater Toronto area watersheds. This study began in 2000, and after an initial 4 year study, annual monitoring of the watersheds is expected to be an ongoing process. The goal of this study is to develop an understanding of the connection between the ground water system and the surface water system, and effects of water user withdrawals. This understanding will inform future management strategies and decisions to ensure the healthy continuation of the aquatic and terrestrial aspects of our rivers and streams.

As part of this study, it is essential to determine water use statistics in as much detail as possible. Water use is a large component of calculating Water Budgets / Balances, and these Water Budgets are an integral part of Watershed Management Strategies.
During the spring/summer of 2003, Toronto and Region Conservation Authority field staff will be attempting to quantify water use within our watersheds. To do so, we are requesting your co-operation in developing this key information. The information you provide will be used in developing and managing overall watershed water activities.

If you have any questions or comments regarding this issue feel free to contact either Don Haley 416-661-6600 (ext. 5226), or Jamie Duncan 416-661-6600 (ext. 5286).

We thank you for your cooperation,

Don Haley
Resource Science Section
Toronto and Region Conservation Authority

Water Use in Ontario

Toronto and Region Conservation May, 2003

Water: A Fleeting Resource?

Low, Low H_20

Freshwater is a natural resource crucial to the economic and environmental well being of Ontario. Water supports almost all aspects of human activity, including health, industry, and recreation. Unfortunately, since 1998, southern Ontario has experienced several years of low rainfall, and high temperatures.

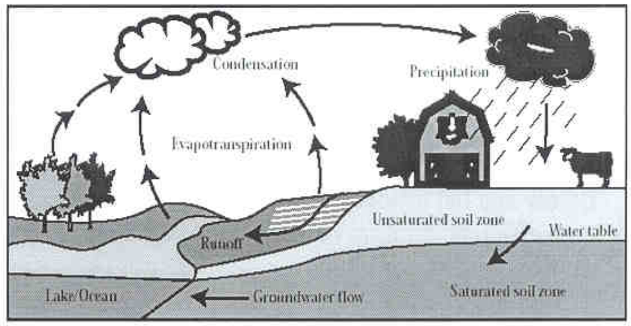
> How you use water affects the quality and quantity of water on your property – and that of your neighbours and community

These weather conditions resulted in some of the lowest surface water levels and driest soils recorded for several **decades**!

In fact, some great lake water levels have been significantly lower than they have been for many years, and tributary flows and groundwater levels appear to be decreasing.

Historically, periods of dry weather and low water levels (or drought) are relatively uncommon in Ontario (about every 10-15 years). However, recent studies indicate that low water levels may become more common, potentially compounded by the steadily increasing demands for water in Southern Ontario.

Source: Ontario Low Water Response Project 2002



The Hydrologic Cycle Image care of Agriculture & Agri-food Canada

Consumptive Use Targeted

In central Canada, 94% of all water use is derived from surface water sources. This large demand for surface water is making itself visible through degradation of our rivers and streams, and the aquatic habitat therein.

Farmers depend on water for livestock and crop production, in fact, agriculture was the fourth largest water user in 1996, accounting for 9% of total withdrawals. Of this 9%, water is withdrawn mainly for irrigation (85%) and livestock watering (15%). Since so much of the withdrawn water evaporates, or is consumed, only a small fraction is returned to its source. This is a highly consumptive use.

Source: Agriculture & Argi-food Canada

> Of the total world's freshwater supply, about one third is found underground

TORONTO AND REGION Conservation for The Living City

What You Can Do

Chances are, you've thought "Sure water is a valuable resource, but what can I do to protect it?". Simply being aware of the problem is half the battle. Once you are aware, the rest falls into place. Take a look at your daily operations and focus on water conservation. Can you see opportunities to re-use otherwise wasted water? Perhaps it's time to replace that leaky pump.

Below is a list of ideas that can help you increase efficiency, improve operations, and help the environment as well.

Responsible Irrigation

Over the years, large scale irrigators have increased efficiency, and reduced wasted water on golf courses, sod farms, and field crops. Irrigation is a highly consumptive water use, where 60% of the water removed does not return to the natural system. Through evapotranspiration and infiltration, this water can end up returning to the system miles from where it was removed.

Here are some ideas to reduce water consumption that you can apply in your industry:

- Ensure irrigation equipment applies water uniformly to reduce wasted water
- Replace worn out equipment with water saving models
- Ensure watering is done in the early morning or late evening to reduce evaporation
- Investigate the advantages of installing a Drip Irrigation System
- Try not to water on windy days
- Avoid landscape fertilizing and pruning that promotes excessive growth
- Install soil moisture overides or timers on your sprinkler system

Source: MOE Green Tips: Water Conservation Tips for Industry

Changes to the Permit To Take Water Program

In light of recent studies that show Ontario's water resources are under a great deal of stress due to the combined effects of overuse, climate change, and pollution, the Ministry of Environment is undertaking some changes to the Permit To Take Water program (PTTW).

The Ministry of the Environment has posted a draft regulation on the Environmental Bill of Rights Web site for public consultation. The draft regulation lays out proposed amendments to O.Reg. 285/99 that will:

- Require new permit applicants to notify municipalities, conservation authorities, and adjacent landowners about proposed water takings
- Require reporting of water use by permit holders
- Define potential impacts that will be considered when reviewing permit applications
- The ministry will also consult on the development of a fee structure to recover costs associated with the PTTW program

For more information contact:

Ministry of Environment
Public Information Centre 416-325-4000

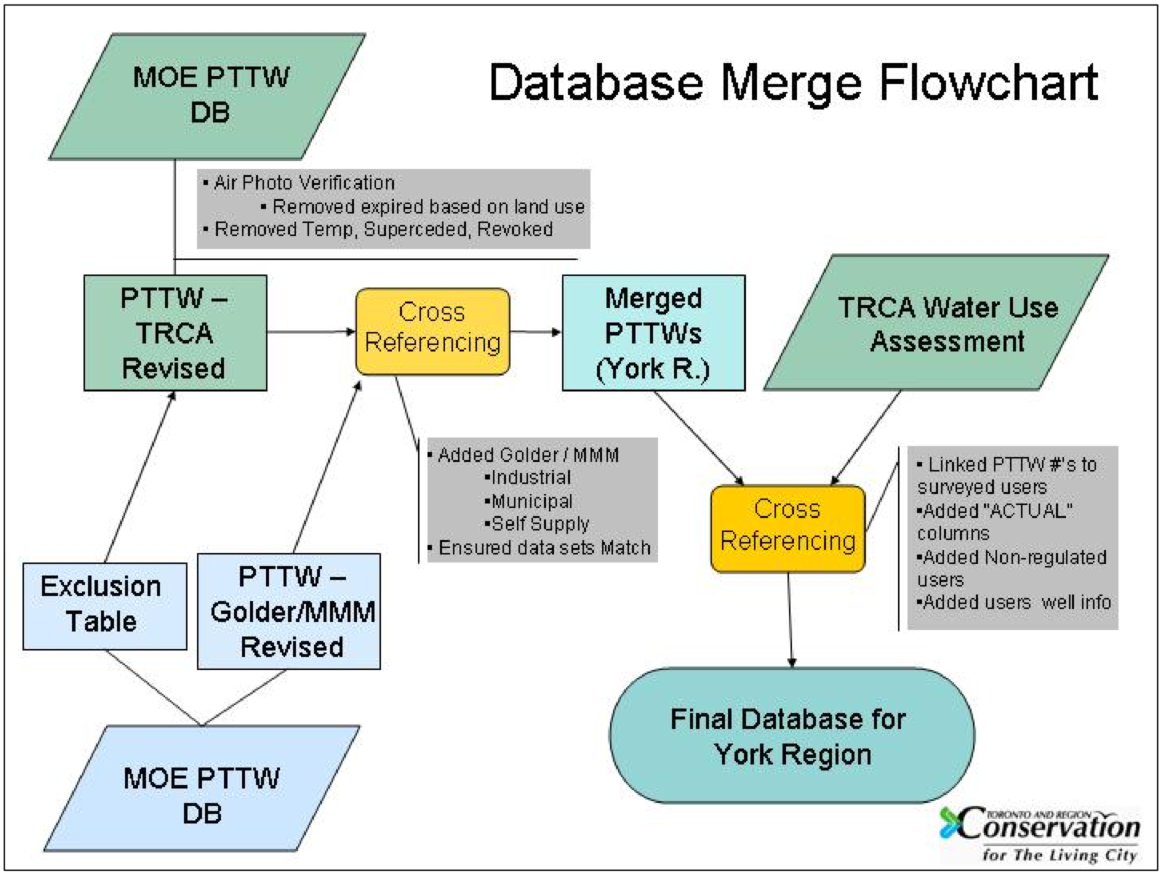
Ministry of Agriculture, Food & Rural Affairs
Common Services 1-888-466-2372

Agriculture & Agri-Food Canada
Public Information 613-759-1000

Toronto and Region Conservation 416-661-6600

Appendix C – Methodology for the Merging of Three Water Use Databases

The following is a brief breakdown of what steps were taken in order to collaborate efforts by York Region, through Golder Associates and Marshal Macklin Monaghan (MMM) and the Toronto and Region Conservation Authority (TRCA) to create a complete database of water users (regulated and unregulated) within York Region boundaries. Below is a flowchart outlining the different components which were brought together.



Data from two separate sources were amalgamated to create a single database; however the core data, which are the root of both data sets, are the MOE Central Region Permit To Take Water Database. This was received by both *Golder / M.M.M and the TRCA in late 2002. This is where the analysis took different directions. '

Golder / M.M.M were primarily interested in groundwater use within York Region, and the edits and revisions made to the original PTTW database reflect this. Surface water permits were for the most part left as is, removing only permits which were revoked, temporary, or superceded by a newer PTTW. Groundwater permits were removed under the same criteria; however phone calls and information from several data sources were also utilized to remove inactive permits. More information on the steps taken can be found in the draft report released by Golder in May 2003. A list of these removed permits was compiled and will be referred to as the Golder Exclusion Table.

* Golder Associates and Marshall Maclkin Monaghan York Region Water Use Assessment
This final database of active users was then presented to York Region with the Water Use Report. For the sake of this document it will be referred to as the EFX Database.
The TRCA conducted similar revisions to the original database, focusing both on surface and groundwater permits. Similarly, temporary, revoked and superceded permits were removed from the database, and air photo reconnaissance was used to match land use with permitted users. It was found that 83% of the permits in the TRCA watersheds were expired, and it was felt that this was not representative of what was actually happening on the ground. For this reason, expired permits were retained if the current land use matched that of the permitted use for an expired permit. This database was finalized by the TRCA and kept on-hand to be utilized in house. For the sake of this document this database will be referred to as the TRCA Revised Database.

The third and final dataset which was to be included in the amalgamation was the TRCA's field surveys of water users, or the WUA Database. The LSRCA undertook similar studies as the TRCA in this respect, so the specifics of this data collection will be omitted from this document.

The first step completed was bringing together both the EFX database and the TRCA Revised database. This was done as follows:

- GIS software was utilized to clip TRCA Revised records to the York Region Boundaries
- Through the same means, records in the EFX Database were clipped to the TRCA jurisdiction.
- A query was designed in MS ACCESS to remove all users from the TRCA Revised database that appear in the Golder Exclusion Table.
- A second query was designed which added any records from the TRCA Revised database that did not appear in either the EFX database or Golder Exclusion Table
- Industrial and Municipal users were taken 1directly from the EFX database and added to the final dataset. (See footnote)

At this point the final dataset contained all permits deemed active by both Golder and the TRCA based on the best information available.

The second step was to link PTTW records to the TRCA WUA database. During these field studies, landowners were not asked to confirm PTTW numbers. In hindsight this would have expedited this next step dramatically.

1. It was later found that the EFX Database did not have accurate information regarding municipal wells, and data included in the final database were derived from the YPDT Database (Kassenaar and Wexler, 2006)

Individual water users from the WUA Database were plotted using GIS and clipped to York Region boundary. Overlaid with this data was the final dataset derived from step one. Users taking for purposes and amounts not regulated by the PTTW program were removed from the view frame, and what were left should be all users requiring a PTTW.

Through spatial analysis, and using all data available (land use, landowner names, addresses, business names, specific purpose etc.) each record in the WUA Database was eventually linked to a permit record where possible. This was a tedious process which involved manually looking at the water user survey from the WUA Database, and then comparing that to all records in the vicinity from the final dataset. If no link could be made for a specific user, a query of all PTTW records needed to be completed based on landowner / business name. A query was developed in MS ACCESS for both the original EFX Database and the TRCA Revised database which searches for the landowner / business name in the contents of the MOE Client table(s). At the end of this step, all surveyed users who historically or currently have a permit were included in the dataset, with the permit number being added to the PTTW # column.

A third step was then completed to reduce each water user to a single record in the database. Through data contained in the WUA Database users with multiple instances of permit records could be reduced down to the actual taking from the watercourse / well, removing the 'transfer' permits (Permits for moving water from one off-line pond to the next). These were placed in a separate table labeled 'Transfer Permits'.

The final step was appending all non-regulated users. As no cross-referencing was needed for these users they could be imported directly into the final dataset.

This final table of users was imported into MS ACCESS as the 'main table' and broken down relationally by using ACCESS table analyzer. Once this was completed, several fields were added to the database to reflect the various data sources. The following fields were added to the final dataset:

Field Name	Description
TRCA_VERIF	User was field verified and confirmed by TRCA
TRCA_ID	A unique ID number assigned to each user surveyed by TRCA
TRCA_REPLA	If MOE data were insufficient to determine withdrawal activities/locations data were replaced by TRCA surveyed data (PTTW # , MAX L/D were retained)
TRCA_EST	Average daily withdrawal amount based on TRCA field surveys
AVGDAYSPER	Average days per year that withdrawal is active based on TRCA field surveys
TRCA_HRSDAY	Average hours per day that withdrawal is active based on TRCA field surveys
REGULATED_	Weather user falls under PTTW regulations
DATA_SOURCE	Defines the source of the record

With this main table of users and withdrawal information, supplementary data can be integrated into the database by adding tables linked relationally to the main table. The TRCA is looking to include well information for these users, including number, depth, type and diameter of wells where this information is available. Importing TRCA baseflow data is currently being explored to assess baseflow water use vulnerability.