OAKVILLE

North Oakville Creeks Subwatershed Study

MANAGEMENT REPORT

August 2006

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North Oakville Creeks Subwatershed Study

MANAGEMENT STRATEGY

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6.0 MANAGEMENT STRATEGY

6.1 INTRODUCTION

The management strategy is developed to provide guidance for the future management of the North Oakville Creeks Subwatershed and specifically to meet the goals and objectives within the context of future land use and other activities within the watersheds. The guidance provided, reflects the goals and objectives set for the area and the characteristics of the watershed.

Initially, the characterization (**Section 4.0**) of the watershed was carried out in such a way as to identify current conditions related to the goals and objectives (for example, characteristics of the natural environment including both terrestrial and aquatic, stream conditions, water quality, and hydrogeology) established for the area. The analysis (**Section 5.0**) of the watershed (including potential impacts related to land use change) focused on how the subwatershed functions. Also examined were processes as they relate to the goals and objectives (*e.g.,* Do current nutrient loadings to the stream lead to algae growth? Will urban land uses increase loadings? How can they be controlled if needed?). The subsequent steps involved in developing a management plan are presented in this section of the report and are as follows.

Section 6.1 Provides an overview of the approach to developing a management strategy and the factors associated with the North Oakville Subwatershed that led to the development of the management strategy.

Section 6.2 Provides a summary of issues (from the characterization and analysis portions of the Subwatershed Study) related to the goals and objectives that have led to the development of the strategy (*e.g.,* Is management intervention needed?) and outlines what targets are needed to meet the specific objectives.

Section 6.3 Provides a detailed discussion of all of the management elements by component, how they have been selected, and why they are needed.

Section 6.4 Presents the monitoring strategy which will enable the evaluation of the management strategy for effectiveness.

6.1.1 What is a Management Strategy?

Many management strategy approaches are based on the “carrying capacity” of the subwatershed as well as the goals and objectives set for the particular watershed. The application of the concept of carrying capacity requires an understanding of the limits of an ecosystem’s ability to support various life forms and land use activities. In any watershed, the existing habitats are generally operating at carrying capacity under the existing pressures of the human matrix within which they lie. As human activities/pressures increase, the carrying capacity of the habitats is reduced. The concept of carrying capacity is generally translated in watershed management into identifying a threshold beyond which the reduction in carrying capacity is not acceptable. In many traditional watershed studies this threshold is based on the survival of key indicator species or habitat types, usually rare species or sensitive habitats that are also protected by policies and regulations. Human activities are then managed in a way that does not exceed these natural limits. The ecosystem approach used in this watershed study used the concepts of carrying capacity and ecosystem health in evaluating land use scenarios and watershed management options. However, instead of focusing the identification of threshold(s) on significant species and/or habitats, the approach was to consider the current biodiversity of the system. In a subwatershed with a balanced carrying capacity, the land uses must be managed through specialized land use policies and stormwater management (SWM) techniques.

Using the public input obtained during the study, it was concluded that the watershed residents are concerned about existing conditions and potential changes to the watersheds in the future. Residents do not want to see conditions worsen and are encouraged about the potential to improve and enhance existing, particularly environmental, conditions.

The management strategy must recognize that human activities will continue, and that land use activities and changes are also a part of society's requirements. Watershed residents and landowners indicated that the strategy must incorporate environment, economics, and society. It is therefore, important that the management strategy is based on the premise that future changes do not exceed the present carrying capacity and that feasible and practical rehabilitation measures are used to enhance conditions and manage expected changes. These enhancements should result in improved resiliency of the system and overall health of the watershed.

The scope of a management strategy must be broad enough to include all of the technical and administrative tools that are involved in land use and resource management measures. The scope of the strategy includes:

- Land Use Management Measures – That guide land use in a manner that recognizes the natural environment which includes terrestrial resources, wildlife, wildlife habitat, ecological linkages and associated environmental corridors, stream and riparian corridors, and the subwatershed processes that influence these resources;
- SWM Measures – To preserve or enhance hydrologic functions/flow conditions related to surface water and groundwater flows and water quality;
- Terrestrial and Wetland Resource Management – To protect and enhance terrestrial and wetland resources;
- Riparian Corridor Management Plans – To protect and enhance riparian systems;
- Rehabilitation and Remediation Plans – For environmental (terrestrial and aquatic) features to increase the resiliency of the catchments and stream system;
- Monitoring Plan – Must be practical and focused to measure the environmental health of the catchments and to track the effectiveness of the watershed management strategy (**Section 6.0**);
- Implementation Plan – That describes how the strategy is to be put into place. Based on the mandates of the various agencies and stakeholders, identify the specific roles and responsibilities for each group (**Section 7.0**); and
- Contingency Plan – If needed, this plan provides modifications to the Strategy if objectives or targets change. The contingency plan allows for the implementation of the adaptive environmental management (AEM) approach.

6.2 GOALS, OBJECTIVES, TARGETS

A subwatershed management strategy is developed on the basis of the goals and objectives for the North Oakville Creeks Subwatershed which were discussed in **Section 1.0**. These objectives were used to guide the overall characterization of the catchements, the analysis carried out and the development of this management strategy. In addition, the strategy also reflects the input by the community through the Official Plan, public meetings, and concerns reflected by input through the Secondary Planning process. In this way the strategy that has been developed shows consideration for the three cornerstones of subwatershed planning: environmental objectives, social concerns, and economic considerations.

For North Oakville, the following steps led to the development of this management strategy:

- Goals and objectives were established resulting in the identification of the key subwatershed components or areas to be considered;
- Concerns and issues were identified;
- The information collected was analyzed, resulting in the development of a series of targets related to specific goals and objectives;
- The targets were used to develop a management approach and strategy. By setting targets within the strategy, the effectiveness of the approach and strategy can be monitored and evaluated; and
- The management approach includes monitoring and contingency plans that help determine whether targets are being met, and assists in modifying the strategy to help achieve the identified goals and objectives.

This section provides a summary of the management issues identified through the characterization and analysis phases of this Subwatershed Study (**Sections 1.0** through **5.0**), for each goal and objective. The targets related to these goals and objectives are then discussed and the management issues are presented. The overall goals, objectives, management issues, and targets are summarized in **Table 6.2.1**.

6.2.1 Goal #1

To minimize the threat to life and the destruction of property and natural resources from flooding, and preserve (or re-establish, where possible) natural floodplain hydrologic functions.

6.2.1.1 Goal #1, Objective 1.1

To ensure that runoff from developing and urbanizing areas is controlled such that it does not increase the frequency and intensity of flooding at the risk of threatening life and property.

Flood Protection

Flood protection goals include protecting the public and property from flood damages that could result from increased runoff rates and volumes due to new development. Also, downstream riparian landowners have the right to receive runoff quantity and quality in the current state. The targets will maintain runoff peak flow rates from new development to existing levels for the 2-year through 100-year return periods and the Regional Storm.

In order to protect existing and future development from flood potential, the floodlines that have been developed are used to delineate flood hazard lands. All development is to be excluded from within the Regional Storm or 1:100-year floodplain, whichever is greater. In areas where floodplains are not delineated, conveyance for flood events, (*i.e.,* the greater of the Regional

Storm or the 1:100-year storm) is to be provided for in the conveyance system, in accordance with Town of Oakville drainage standards.

In addition, floodplain storage plays a role in mitigating the potential for increase in flood flows downstream through the storage of runoff. This storage is currently provided by the "natural" storage of the current stream corridors or by the storage along modified streams that currently exist. This storage serves to store surface water during runoff events and control peak flows when the stream is at overbank conditions.

If the stage-storage conditions along stream reaches are reduced, peak flows will increase downstream. South of Dundas Street, the stream systems are experiencing varying levels of erosion conditions and flooding has been experienced in the past. Increases in peak flows or changes in flow regime conditions from current levels would result in an increased risk of flooding and erosion. To mitigate this, the target of maintaining the current stage-storage relationship along selected reaches has been adopted. In addition, peak flows after development must be controlled to current levels, including the use of threshold targets for erosion control.

Targets

- Maintain existing peak discharge rates for all design events, particularly high flows.
- Target discharge rates required for each subwatershed (unit area).
- Stream reach floodplain storage targets to protect existing floodplain storage.
- Remove flood potential at identified locations within the study area.
- Delineate floodplains to provide development limits.
- Restrict development in the floodplains as per Provincial and Conservation Authority (CA) policies.

6.2.1.2 Goal #1, Objective 1.2

To adopt appropriate land use controls and development standards to prevent development in natural flood hazard and erosion hazard areas.

Stream Corridor (meander belt width, access allowance, and erosion setback)

Erosion hazards exist primarily through channel migration and the resultant loss of property. In the case of a defined valley setting, this migration may result in toe erosion, causing a decrease in slope stability and subsequent failure of the valley wall. In order to address these concerns, stream corridors were identified for the study area on a reach basis. These corridors are meant to incorporate the meander belt width for each reach plus an additional safety factor or buffer to encompass any stable top of bank allowance, erosion or access allowance, and the Conservation Halton buffer. These requirements are consistent with *Provincial Policy Statements* and Conservation Halton Guidelines. Due to the scale of the study area, it was not feasible to perform a detailed meander belt width and hazard assessment on each reach. As such, the values presented in this report are larger approximations and should be refined in the detailed site plan stage before it is decided whether they are the constraining parameter for watercourse extent.

Flood Protection

(See discussion under **Objective 1.1**)

Targets

- Delineate floodplains to provide development limits.
- Restrict development in the floodplains as per Provincial and CA policies.
- Delineate meander belt and erosion setback to be applied on all streams designated to be left as open watercourse (providing erosion protection).
- Apply valley wall setback standard (slope plus top of valley setback).
- Develop SWM plan to replicate flow-frequency-duration from existing conditions.
- Meet threshold tractive force targets.
- Use Distributed Runoff Control (DRC) approach.

6.2.1.3 Goal #1, Objective 1.3

> *To ensure that new development incorporates the most appropriate development form and mitigation measures necessary to optimize compatibility with natural features and their associated functions.*

Terrestrial and Wetland

The overall goal relates to the sustainability of the natural resources in the area, based on maintenance and restoration of biodiversity at a series of levels (species and habitats). From a vegetation perspective, the goals and objectives of the Subwatershed Study focus on the protection of important naturally vegetated features in terms of both structure and function. For the purposes of this section, wetlands and woodlands and other upland features are considered.

The consideration of these features includes several aspects:

- The structure, function and conservation of vegetation communities of conservation concern (see further discussion under **Objectives 2.8** and **3.1**);
- The presence of plant species of conservation concern (including rare species) (see further discussion under **Objectives 2.8** and **3.1**);
- The provision of wildlife habitats (see further discussion under **Objectives 2.8**, **3.1** and **3.2**);
- Ecological linkage opportunities (see further discussion under **Objective 3.2**);
- The influence of vegetative cover on aquatic habitats (see further discussion under **Objective 2.3**), and
- The relationship of vegetative cover and type on hydrologic aspects of the subwatershed (see further discussion under **Objectives 2.1** to **2.6**).

Aquatic

Maintenance of a healthy aquatic ecosystem requires that predevelopment flows be maintained or enhanced to a level within the fluvial capacity of the streams. There are two main components that contribute to streamflow: surface runoff and infiltration, followed by groundwater discharge. In addition there may be groundwater discharge from deeper zones such as layers or lenses in the overburden or the shallow bedrock. In an urban setting, surface runoff is collected by a SWM system, treated and discharged. The method of SWM treatment can have considerable impact on the quality and quantity of the waters being discharged, as well as the timing of these discharges in relation to the natural setting. Land development can alter infiltration volumes which may affect subsurface flows and discharges to streams. Therefore, consideration of the degree to which surfaces are hardened is necessary since diverting too much infiltration flow to a surface treatment system can impact on fish and fish habitat by changing the hydrograph of the watercourse.

Targets

- Aquatic protection based upon resident fish community and existing aquatic habitat conditions.
- Achieve Ministry of the Environment (MOE) "enhanced" level of SWM protection (80% Total Suspended Solids (TSS) Removal) for all reaches supporting redside dace populations (Fourteen Mile and Morrison Creeks).
- For all other stream reaches, achieve a "normal" level of SWM protection (70% TSS Removal) to adequately protect aquatic habitat and resident fish. Note that "enhanced" protection of these streams may be required for reasons not directly related to aquatic habitat and resident fish. (See **Section 5.7** regarding Phosphorus loadings).

6.2.2 Goal #2

To restore, protect, and enhance water quality and associated aquatic resources and water supplies for watercourses, including their associated hydrologic and hydrogeologic functions, within the subwatershed areas.

6.2.2.1 Goal #2, Objective 2.1

Protect stream morphological and fluvial character; restore where appropriate and feasible, sinuosity; maintain physical habitat attributes (e.g., pools and riffles), diversity and fluvial processes (e.g., bedload transport and energy reduction through sinuosity); and prevent increase in erosion and deposition, through maintenance of hydrological regime.

To achieve this objective, morphological targets were established on a reach basis in the form of an overall geomorphic classification, which dictates the management approach for the stream network. The reaches identified north of Highway 407 did not fall within the study area limits. They do, however, have the potential to influence the downstream conditions of reaches within the study area. Consequently, these reaches were characterized to ensure a comprehensive understanding of the geomorphic system.

The overall geomorphic classification identified three categories of streams according to their relative sensitivity, rehabilitation potential, and geomorphic form and function. These three categories included:

- Streams that displayed a high sensitivity to change and have a well-developed geomorphic form and function;
- Streams that exhibited some sensitivity to change and geomorphic function with a moderate degree of form; and
- Streams that lacked a defined form but still had a geomorphic function such as sediment transport, flow conveyance, and connectivity to other features.

In order to prevent an increase in erosion and deposition within the study area, erosion threshold targets were developed to determine critical discharge for bed materials across the stream network. Furthermore, rehabilitation of existing reaches will restore morphology, increase diversity, and provide greater capacity to handle flows. These targets will provide guidance for the North Oakville SWM measures by outlining flow regime objectives.

<u>Targets</u>

- Preserve the stream network required to preserve function of stream network for a geomorphologic perspective;
- Meander belt targets specified to provide for natural meander;
- Identify stream corridors for protection;
- Threshold targets set by subwatershed to provide for flow regime target.

6.2.2.2 Goal #2, Objective 2.2

To prevent the accelerated enrichment of streams and contamination of waterways from runoff containing nutrients, pathogenic organisms, organic substances, and heavy metals and toxic substances.

Analysis carried out on existing conditions resulted in the identification of concerns regarding potential surface water quality impacts and the need for mitigation through the management strategy. These included:

- Current nutrient levels in the streams, the potential increases in nutrients and associated impacts on algae growth;
- The potential increase in suspended solids and associated urban pollutants;
- The level of chloride and potential increase; and
- The need to manage stream temperature for fisheries protection.

The management needs resulted in the selection of phosphorus, suspended solids, chloride, and temperature as the representative parameters for management targets and monitoring as outlined in **Table 6.2.2.** The selection of these parameters as a basis for targets was discussed in **Section 5.7 – Analysis of Water Quality Impacts** and summarized in the Rationale column in **Table 6.2.2.**

The MOE provides a listing of Provincial Water Quality Objectives (PWQO) that apply to surface waters including North Oakville Subwatershed. "The PWQO are numerical and narrative criteria which serve as chemical and physical indicators representing a satisfactory level for surface waters (*i.e.,* lakes and rivers) and, where it discharges to the surface, the ground water of the province. The PWQO are set at a level of water quality which is protective of all forms of aquatic life and all aspects of the aquatic life cycles during indefinite exposure to the water" (MOE, 1994). It is considered that the PWQO apply to all the watersheds and that monitoring be continued for parameters not specifically identified as targets for this study. Many of these parameters are discussed in detail in **Sections 4.0 and 5.0**, and are presented in **Appendix GG – Management Approach Criteria for Stream Systems**. No specific target is adopted for other parameters such as heavy metals. Use of TSS as a control parameter for design of SWM measures will result in a high level of control for contaminants associated with TSS, such as metals.

Table 6.2.2
Water Quality Targets

Target	Rationale
Total Phosphorus (TP) • No increase in loadings after development.	• Recommended to protect the Lake Ontario shoreline and to not contribute the shoreline algae problem. The Provincial Water Quality Objective (PWQO) for TP is exceeded in the watercourses draining North Oakville.
Total Suspended Solids (TSS) • Level 1 (enhanced protection) for some streams requiring 80% TSS removal • Level 2 (normal protection) for some streams requiring 70% TSS removal.	• Enhanced protection of Fourteen Mile and Morrison Creeks. • Normal protection for all other watercourses. • TSS – associated with many contaminants in urban runoff, such as heavy metals, petroleum hydrocarbons, PAHs (polynuclear aromatic hydrocarbons). • TSS used as a surrogate parameter for control in the MOE SWM manual. • No PWQO for TSS
Chloride • The Town of Oakville has formally adopted (approved by Town Council Feb 8, 2004) a *Salt Management Plan*. • The management plan recommends that the Town of Oakville review the Federal Code of Practice that was finalized in April 2004 to identify areas that are vulnerable to road salt and update the *Salt Management Plan*.	• Background from the mineral soils and from road salt. With urbanization and the addition of more roads and parking lots, additional applications can be expected. Chlorides are soluble and not removed by SWM ponds. • Road Salt declared toxic by Environment Canada (as defined by the Canadian Environmental Protection Act) because of its impact on aquatic organisms. • Areas identified as vulnerable to road salt such as the Redside dace in Fourteen Mile and Morrison Creeks should be considered for additional salt management measures. • No PWQO for chlorides, but the *Code of Practice* identifies *Environmental Risk Factors for Road Salts*.
Dissolved Oxygen • 6 mg/L should apply to Fourteen Mile and Morrison Creeks. • 5 mg/L for other streams in the North Oakville Creeks Subwatershed.	• The PWQO for coldwater fishery should protect redside dace, a coolwater fish, and the PWQO for warmwater fish would protect the biota in the other streams.
Temperature • A daily maximum mid-summer water temperature target of 18°C is recommended for Fourteen Mile and Morrison Creeks.	• Protection of redside dace populations. See details under **Objective 2.3** (**Section 6.2.2.3**).

<u>Aquatic Biota</u>

For redside dace streams, removal of suspended solids is considered important. Redside dace are sight feeders and as such require relatively clear, not turbid water to forage effectively. Accordingly a target of “enhanced (80% TSS removal)” level of SWM protection (as per MOE guidelines) for Fourteen Mile and Morrison Creeks will ensure that the maximum benefit of available and affordable stormwater technologies are provided to these streams.

Targets

- Targets will vary depending upon subwatershed (fishery condition for some items).
- Phosphorus – an overall target of "no increase in loading after development" is proposed based on protection of the Lake Ontario shoreline.
- Suspended Solids – SWM ponds are recommended to be designed for an enhanced level of protection requiring 80% removal of TSS, or a normal level of protection, requiring 70% removal of TSS.
- Chloride – no specific target recommended, but the Region of Halton and Town of Oakville should update the *Salt Management Plan*) to reflect requirements in the *Canada Gazette Road Salt Code of Practice* of April 2004, especially with respect to the application of Environmental Impact Indicators for road salt and identification of areas vulnerable to road salt effects.
- Dissolved oxygen – PWQO for cold and warmwater fisheries as outlined in **Table 6.2.2.**

6.2.2.3 Goal #2, Objective 2.3

> *To maintain or restore a natural vegetative canopy along streams where required to ensure that mid-summer stream temperatures do not exceed tolerance limits of desirable aquatic organisms.*

All watercourses within the study area have had riparian vegetation impacted to some degree by agricultural activities. The degree of impact varies from watercourse to watercourse and within watercourses by reach. Levels of impact range from the complete removal of vegetation, a reduction of the riparian vegetation to a narrow strip, or areas where the riparian corridor remains very much intact within a larger woodlot or wetland feature.

As mentioned under **Objectives 1.1**, **1.2** and **2.1**, the protection of designated floodplain and meander belt width will have positive implications for the thermal regime of the watercourses as vegetative succession occurs in these zones. In addition, these zones will positively influence other factors associated with aquatic habitat maintenance and enhancement. The vegetative buffers afforded by these zones limits the potential for impacts from human-dominated land uses on the stream channel, compared to the current conditions. These zones can also act as filters, effectively removing suspended sediment often contained in overland urban flow and stopping it before it enters the watercourses and negatively influencing aquatic communities.

Depending on the stream geometry and/or hydrology/hydraulics, it is expected that riparian zones of a minimum of 20m in width and a maximum of over 100m in some cases will be established. Provided that riparian cover can be maintained and or re-established in these zones, adequate riparian vegetative canopy to moderate stream temperatures is expected to develop. In essence, the establishment of riparian canopy will occur as a result of management for fluvial and floodplain aspects of these watercourses. Given that these zones will exist, the target for vegetative enhancement is dictated by the extent to which intervention should occur as part of the permitting process to accelerate vegetative succession. For habitats that have been identified as critical aquatic habitats, active planting may be used to accelerate riparian growth and associated temperature moderation. The exception is for redside dace habitat, where herbaceous grass cover is preferred over woody riparian vegetation. Redside dace are known to be closely associated with this habitat type (Parish, 2004) and temperature does not appear to be a controlling factor. It would appear that the benefit provided by insects (food base) growing in this type of vegetation is more important than the temperature moderation offered by woody vegetation. For habitats that have been designated as important or marginal aquatic habitat, establishing the fluvial/floodplain limits and then either letting vegetative succession proceed without intervention or rehabilitating the stream and its riparian corridor for enhancements is warranted. Environment Canada (2001) recommended that streams having 75% of their length surrounded by natural vegetation were usually healthy, especially if the width of the vegetation was greater than 30m.

<u>Target</u>

- Maintain existing riparian vegetation associated with watercourses where feasible.
- Active restoration of riparian zones with native plantings, in cases where watercourse modifications/alterations require permitting/authorization.

6.2.2.4 Goal #2, Objective 2.4

To minimize the disturbance of the streambed and prevent streambank erosion and, where practical, to restore eroding streambanks to a natural or stable condition.

Streams continually adjust their dimensions to accommodate fluctuations in their sediment transport and discharge regimes. Consequently, bank erosion is a natural process and exists even in channels that have achieved an equilibrium state. In order to prevent the exacerbation of erosion issues due to land use changes within the study area, erosion threshold targets were established. In addition to these targets, channel enhancement through management options can mitigate erosion issues and provide resilience to active channel processes.

<u>Target</u>

- Targets as outlined in **Objectives 2.1** and **2.2**.

6.2.2.5 Goal #2, Objective 2.5

To restore, rehabilitate, or enhance water quality and associated resources through the implementation of appropriate Best Management Practices on the land.

Surface Drainage

Water quality protection is needed to protect downstream receiving systems, including Lake Ontario. The primary focus is fisheries protection and nutrient control to mitigate impacts on algae growth. Consideration is needed to provide full SWM measures including at source conveyance and end-of-pipe works for the most effective approach in water quality control/

Groundwater Quality

The characterization and analysis of existing conditions within the study area resulted in the identification of concerns regarding potential groundwater quality impacts, particularly as they relate to preserving existing stream health. The analysis also indicated a need for mitigation through the management strategy. The groundwater quality issues of concern are the variable but generally mineralized quality of groundwater, particularly from the bedrock and the potential for increases in chloride concentrations, as well as the concentration of other contaminants, as a result of infiltrating urban runoff.

Based on these identified management needs, management and monitoring of general groundwater quality on a long-term basis to evaluate the effect of infiltration management is needed. Therefore the groundwater quality target for the area is to keep overall groundwater quality the same as it is currently.

Target

- Targets for surface water as outlined in **Objective 2.2**.
- For groundwater, target of no detrimental change in existing groundwater quality.

6.2.2.6 Goal #2, Objective 2.6

To ensure that hydrogeologic function is preserved and maintained and take full advantage of stream and groundwater discharge/baseflow enhancement opportunities.

Groundwater – Surface Water Interaction

Maintaining the relationship between the groundwater system and the surface water system is the focus of this objective. This can be done, in part, by managing infiltration which assists in sustaining groundwater discharge to surface water features and the elevation of the water table.

Groundwater discharge zones are often found immediately adjacent to the watercourses, usually within the floodplain or riparian corridor associated with watercourses. In North Oakville, groundwater discharges were observed in two locations along Joshua's Creek. In addition groundwater discharge zones were identified in the Shannon's Creek catchment (around Dundas Street), the area north of the closed Fourth Line Landfill (south of Burnhamthorpe Road), and the East Sixteen Mile Creek tributary just south of Burnhamthorpe road.

In addition, groundwater is being used to some degree by local residents as a drinking water supply source. As such, the ability to use groundwater for this purpose must be addressed until alternatives are readily available. As a result, the specific objectives related to hydrogeology include:

- Maintaining groundwater supplies for existing residents while development and servicing proceed.
- Keeping changes in the depth to the local water table to within the seasonal fluctuations normally experienced.
- Maintaining the groundwater contribution to stream health (groundwater quantity and quality), where it currently exists.

Since groundwater withdrawal from the subsurface in the future will not affect either groundwater supplies or the contribution of groundwater to stream flow, the targets for hydrogeology focus on the input of water to the subsurface (*i.e.,* infiltration and recharge). Accordingly targets must focus on maintaining sufficient infiltration so that current recharge/discharge processes are continued. Recognizing the difficulty presented by ground conditions in the area, primarily the low hydraulic conductivity of local surficial soils, the infiltration targets focus on the development and use of best management practices to ensure that as much infiltration as possible is added to the subsurface as possible.

<u>Target</u>

- Develop approaches to maximize infiltration using best efforts and best available technology (*i.e.,* most practical, feasible, sustainable and cost effective) to continue the existing recharge/discharge processes.
- Protect areas of potential groundwater discharge through preservation of associated streams.

6.2.2.7 Goal #2, Objective 2.7

To maintain and enhance the aquatic habitat.

Biodiversity is a measure of the number of species present in an ecosystem as well as the distribution of individuals among species. As ecosystem health improves, new and improved habitats can be expected to lead to an increase in the biodiversity of aquatic life.

The management approach to stream corridors for this study will ensure protection of the stream channel, as well as a vegetative buffer along the corridors. The re-establishment of vegetation along the stream channels, and in some cases the maintenance and improvement of stream geometry, is expected to result in improved habitat conditions and ultimately improved biodiversity. This includes consideration of existing wetlands associated with stream channels and riparian zones.

The diversity of the fish community in Fourteen Mile Creek is quite good. A review of data collected from all available sources (LGL, 2000; MNR, 2003) reveals that Fourteen Mile Creek supports at least 17 species of fish. Morrison and Joshua’s Creeks support five and six species respectively, and have the potential to support more as the benefits of habitat improvement are realized. The targets relating to biodiversity for these three creeks should be that the biodiversity of the fish community be, at a minimum, maintained at existing levels and increased if possible.

Water quality control and improvement is considered important for certain aquatic habitats (see **Objective 2.2** for additional detail).

Targets

- The targets relating to biodiversity for Fourteen Mile, Morrison, and Joshua's Creeks should be that the biodiversity of the fish community be, at a minimum, maintained at existing levels and increased if possible.
- Identify stream corridors for protection.
- Fluvial geomorphology/erosion control targets under **Objective 2.1**.
- Water quality targets under **Objective 2.2**.
- Designate reaches which support redside dace populations as "no touch" areas where stream sections cannot be relocated.
- Enhanced level of stormwater quality control for Fourteen Mile and Morrison Creeks.
- Retain wetlands within stream corridors if possible and incorporate into drainage system.

6.2.2.8 Goal #2, Objective 2.8

To minimize disturbance of wetlands, preserving and/or enhancing the habitat and functions they provide.

The overall goal of protecting wetlands within the study area has been expressed in the original Terms of Reference and subsequently during discussions with agency staff and interested individuals. This goal is reflected in the objective of maintaining the role of the wetlands despite urbanization. The approach used here focuses on the identification of the roles and functions of the wetlands.

The wetlands are not evenly distributed throughout the catchments in the study area. A number of rare plant species are known to be in the wetlands in the area, including numerous locally rare species (*i.e.,* within the Greater Toronto Area (GTA), Region and/or Site District). As well, the buttonbush swamp is described as a rare community type, and has been highlighted for protection in previous documents such as LGL (2000). Wetlands are also known to provide habitats for a number of wildlife species and play an important role in the hydrology of the watersheds.

A number of numeric thresholds have been cited in the literature with respect to wetlands. For example, Environment Canada recommends that at least 10% of watersheds should be comprised of wetlands, especially wooded swamps and a variety of marshes (Environment Canada, 2002; 2004).

Wetlands in the area consist of three general types:

1. Wetlands with no permanent inflow or outflow of water (isolated wetlands, as defined in the Wetland Evaluation System) – These are represented by small pockets of wetlands that are a result of accumulation of runoff in low areas with less permeable soils. Many of these are found as vernal components of woodland blocks, or in open field areas. Many have been plowed through, but some have retained or have established wetland vegetation.

2. Wetlands with a direct outflow (palustrine wetlands, as defined in the Wetland Evaluation System) – These wetlands are associated with a watercourse or other wetland feature and

may play an important hydrological role in addition to their ecological role. Key examples of these wetlands are the tree and shrub dominated systems that are found scattered throughout the study area. A number of larger swamp communities fall within this category, including several buttonbush stands (the largest stand is east of Trafalgar Road).

3. Wetlands associated with the channels of watercourses – These wetlands are generally online features that have established as a result of flow patterns in the channels (*e.g.,* low gradient systems and areas with impeded flows). In some locations, offline wetlands are found in close proximity to channels (in some cases direct connections are only found for short periods of time, in others more defined outflows exist).

<u>Targets:</u>

- Minimize the fragmentation of wetlands;
- Maintain the function of all wetlands associated with watercourses; and
- Maintain the function and structure of wetlands within woodlands.

6.2.2.9 Goal #2, Objective 2.9

Provide appropriate buffers to wetlands, watercourses, and valley lands to maintain or enhance their biological health and meet objectives of long-term sustainability of these features.

Although not specifically mentioned in the original objective, buffers from woodlands are also discussed here. The identification of buffers around wetlands and woodlands has received considerable research in the recent past. There are a number of similarities in the approaches typically used to delineate these buffers. From review of numerous past studies on buffers, general components/approaches have been used to identify the extent of buffers:

1. Cases where the immediate protection of the edge of the natural habitat is considered. For example, buffers for the protection of wetland vegetation and control of runoff to wetlands. These dimensions are typically smaller (a dimension of 30m is in common usage for provincially significant wetlands; Environment Canada, 2004; Ministry of Municipal Affairs and Housing, 2005).

2. In some cases the protection of woodlands considers arboricultural approaches in which the focus is on the physical protection of the outer trees based on root zone protection. This type of approach results in a modest buffer normally in the range of 5 to 10m from the dripline. However in the case of hazard prevention some outer tier trees may be over 25m tall, suggesting buffers of this dimension or greater.

3. A number of recent studies have identified substantial buffers around natural habitats based on specific species' habitat requirements (see **Section 6.3.3**).

4. In some cases the extent of buffers takes into account the relationship of neighbouring open vegetation types as possible foraging and/or movement habitats for wildlife that use the woodlands. This is generally determined on a site specific basis and considers the presence of pockets of habitats retained within as well as outside the woodland or wetland.

The targets associated with buffers are based on the overall objectives of maintaining the biodiversity of the habitats in the area. Discussions of this are included under **Objectives 2.7**, **3.1** and **3.2**. The identification and use of appropriate buffers and consideration of edge effects and the ecological needs of species within the natural areas is recommended.

Targets

- Establish appropriate feature-specific buffers for protection of natural habitats.

6.2.3 Goal #3

To restore, protect, develop, and enhance the Natural Heritage, historic, cultural, recreational, and visual amenities of rural and urban stream corridors.

6.2.3.1 Goal #3, Objective 3.1

To ensure that environmental resource constraints are fully considered in establishing land use patterns in the subwatershed.

Terrestrial

From a terrestrial perspective, this objective of the Subwatershed Study focuses on the protection of important naturally vegetated features in terms of both structure and function. For the purposes of this section, wetlands and woodlands and other upland features are considered. Each of these is discussed below relative to: woodlands, wetlands, other vegetation communities, and wildlife.

Specific detailed discussion relative to wetlands is included under **Objective 2.8**.

Woodlands

The overall goal of protecting woodlands within the study area has been expressed in the original Terms of Reference and subsequently during discussions with agency staff and interested individuals. This goal is reflected in the objective of maintaining the role of the woodlands despite urbanization.

Woodland size and shape is a consideration in the analysis of the woodlands. This is discussed in **Section 5.0**.

Based on the character of the woodlands in the study area, the following targets were identified:

- Minimize the fragmentation of woodlands;
- Maintain the function of all woodlands that are >200m in width (*i.e.,* provide potential interior conditions);
- Maintain the function of woodlands associated with watercourses.

Wetlands

The goal of preserving wetlands within the study area is discussed in **Section 6.2.2.8** Goal #2,

Objective 2.8.

Other Vegetation Communities

For the purposes of establishing objectives and targets, these features are treated separately in this discussion. This allows an analysis of the specific roles of the early successional areas such as meadows, old fields, and open savannah-like or thicket habitats. These habitats play an important supporting role for woodlands and wetlands.

As discussed in **Section 5.0**, these areas were found to provide a number of functions and features of note. This includes the provision of habitat for species of conservation/management concern (including rare species), role as foraging/nesting habitat for species associated with woodlands and wetlands, as well as a possible linkage role.

These types of vegetation communities are often not specifically targeted for management or inclusion in Natural Heritage Systems in subwatershed or planning studies.

In increasingly developed landscapes, it is important to maintain habitat for all species. Natural grasslands in southern Ontario have largely been lost to agriculture and afforestation. Restoration of grasslands or maintenance of other open habitats at virtually any scale can provide habitat for grassland flora, providing habitat for grassland fauna is more challenging. Efforts on a regional scale to provide a greater number of smaller patches of differing habitat structure in conjunction with at least one larger patch should be pursued to maintain or increase numbers of grassland birds. In the increasingly fragmented landscape of North Oakville, the old landfill site (on Neyagawa Boulevard) (>35 ha) in conjunction with other grassland areas of varying sizes and vegetation structure will help to sustain populations of grassland birds.

Some early successional stands, such as meadows, are somewhat transitory as they are plowed in one-year, left fallow for some time, and then re-plowed. The locational benefit of these areas must be considered in this analysis. Recognizing the relationship of these habitat types to wetlands, woodlands, and stream corridors, and the provision of habitat for the species of conservation/management concern, the following targets are recommended:

- Maintenance of early successional stands in locations where they are found associated with existing wetlands, woodlands, and watercourses;
- Protection or creation of these habitat types (through natural succession) in large, strategically located blocks; and
- Minimize fragmentation of these stands.

Wildlife

For the most part, the goals for plants and wildlife species overlap with those noted above for wetlands, woodlands, and other habitat types. The key objective for plants and wildlife is the preservation of biodiversity. Given the character of the habitats and species known from the study area, and relationship of these habitats to others outside the study area, the management of plants and wildlife species must be considered at the metapopulation level. This translates to considering the specific habitat patches within the study area, as well as linkages between these habitats and beyond the limits of the study area. Many wildlife species use a range of habitat types for different aspects of their life history, and this range of habitats must be considered. For example, protection of forest interior stands (as discussed above) speaks to the nesting needs of certain sensitive forest interior species, but in many cases species forage and move outside these forested stands through other vegetation community types (see Wegner and Merriam, 1979). Amphibians provide a prime example on why metapopulations must be managed. Depending on their life cycle stage and season, amphibians require different habitats. Spring peepers (*Pseudacris crucifer*), for example, use marsh habitats for breeding, but then migrate to upland areas once breeding is complete or once tadpoles have transformed. In winter, this species hibernate under logs, bark, or fallen leaves (Harding, 2000). Semlitsch and Bodie (2003) list the terrestrial migration distances from aquatic sites for amphibians and reptiles, including some species found in North Oakville, where distances range up to 1115m.

The targets for the maintenance of plant and wildlife biodiversity are for the most part reflected in those cited for the habitat types listed above. Linkages are an important consideration for the maintenance of sustainable populations and are therefore discussed separately below under **Objective 3.2**.

<u>Targets</u>

- See targets listed for wetlands, woodlands, and other vegetation community types.
- Provide for linkages, see **Objective 3.2**.
- Provide buffers, see **Objective 2.9**.

6.2.3.2 Goal #3, Objective 3.2

To ensure that existing wildlife linkages are preserved and that opportunities for improving these linkages are considered/implemented as part of any future development.

As discussed in **Section 5.0**, a range of linkage types and opportunities currently exist within the study area. However, certain types of linkages are less well represented, for example wide, contiguous forested connections. In light of the objectives of maintaining sustainable woodlands, wetlands, watercourse corridors and wildlife populations, linkages are an important part of the subwatershed.

Linear habitats either associated with riparian habitats or other upland features may provide an intrinsic habitat function (Riley and Mohr, 1994). Ecological linkages must be designed with an understanding of the species that will use the connection.

Within the study area, Sixteen Mile Creek provides a broad wooded linkage to lands north of Highway 407 and south of Dundas Street. This is a key ecological corridor that should be focused on for the identification and/or creation of forested linkages. A diversity of linkage types and a measure of redundancy in the linkage network should be considered to provide a range of movement opportunities.

<u>Targets</u>

- Minimize the discontinuities in linkages (especially >20m).
- Linkages to be 100m wide.
- Allow for linkages to habitats or other linkages located outside the study area (for example Sixteen Mile Creek valley and Bronte Creek).

6.2.3.3 Goal #3, Objective 3.3

To retain, preserve or maintain Natural Heritage Features (i.e., open space and visual amenities) in urban and rural areas by establishing and maintaining greenbelts along stream corridors and adjacent natural areas and maintaining linkages between these areas.

(See discussions under **Objectives 2.8**, **3.1** and **3.2**).

6.2.3.4 Goal #3, Objective 3.4

To ensure that development in the stream corridor is consistent with the historical and cultural character of the surroundings and reflects the need to protect visual amenities.

The historical and cultural characteristics of the catchments have been considered primarily through the Secondary Planning Process but also in the subwatershed analysis and management strategy. Besides providing an environmental resource through vegetation and wildlife habitat, the terrestrial features, including stream corridors, provide a cultural and visual feature. The most significant of these are the larger features such as the Sixteen Mile Creek valley, Joshua's Creek valley system and the Neyagawa woodlot.

Targets

- Presence of visual and historic amenities through the subwatershed and Secondary Planning Processes.

6.2.3.5 Goal #3, Objective 3.5

To ensure that the recreational and fisheries potential of a stream corridor are developed to the fullest extent practicable.

The assessment of streams and stream corridors and development of a management strategy has included existing conditions and the potential for enhancement. In this way, the fisheries potential will be developed to the fullest extent practicable. Recreational potential will be provided through trails and park planning developed in conjunction with this and the Secondary Planning Process.

Information on the management related to fisheries is presented under **Objectives 1.3**, **2.3**, and **2.7**.

Targets

- See discussion under **Objectives 1.3**, **2.3**, and **2.7**.

6.3 MANAGEMENT STRATEGY

6.3.1 Overview

The management strategy has been developed to meet the goals, objectives, and related targets outlined in **Section 6.2**. The proposed management strategy addresses both the form and the function (or process) that support those characteristics. The characterization and analysis provide an understanding of the environmental conditions and related processes (as well as potential impacts) throughout North Oakville. Based on this understanding of form and function in the area, an ecosystem approach was used to develop a strategy that will protect and enhance the watershed features.

6.3.2 Overall Approach to Management Strategy

To adhere to the overall approach that protects and enhances the natural environment in a sustainable fashion, the management strategy must be comprehensive and address all of the key components and processes. These components include:

- Natural Heritage System
- Terrestrial and Wetland (**Section 6.3.3**) – The development of a management approach for terrestrial and wetland features that will protect and enhance overall biodiversity including the flora and fauna associated with terrestrial and wetland features in an environmentally sustainable fashion. This includes the provision of a corridor system to provide for any necessary linkages for wildlife and plant movement;
- Streams (**Section 6.3.4**) – The provision of a corridor system for streams that have been identified as having environmental characteristics or watershed functions that require protection and/or enhancement to meet the watershed goals and objectives. A riparian corridor approach is to be applied which will consider all of the stream functions including:
  - hydrologic;
  - hydrogeologic;
  - geomorphologic;
  - environmental; and
- SWM (**Section 6.3.6**) – The development of an approach that will protect and enhance environmental characteristics through managing related stormwater response and conveyance processes.

6.3.2.1 Management Implications in North Oakville

The text in the preceding section involved a generic description of management strategies that is applicable to most subwatershed studies. The challenge inherent in this subwatershed planning study is taking the general principles of a management strategy and applying them to a relatively diverse landscape and environmental conditions. For instance, the North Oakville area encompasses an assemblage of numerous catchements that sustain a varied natural heritage. Furthermore, the geology and topography across this area is varied from the area referred to as the Trafalgar Moraine along the north side, to the deeply incised Sixteen Mile Creek valley through the centre of the study area. This variability presents challenges in developing and implementing an effective management strategy. These challenges can, however, be overcome through the application of sound, comprehensive assessment and science. Before presenting the overall management strategy, a review and discussion regarding several of the physical issues and variability across the study area which influence the management strategy is warranted.

6.3.2.2 Physical Variability

The geological and hydrogeological character of the study area varies from east to west and north to south. This variation has influenced the development of existing conditions and will influence the management of the area for the future. Consequently the management of the area must address these variations in character and the features present in the area. Characteristics and features of note in the study area include:

- The low permeability silt and clay till soils throughout the entire study area,
- A buried bedrock valley in the vicinity of the existing Fourteen Mile Creek Valley;
- The Trafalgar Moraine located across the north part of the study area east of Sixteen Mile Creek and north of the study area (and Highway 407) west of Sixteen Mile creek;
- The localized pitted topography along the crest of the Trafalgar Moraine;
- The generally poor (mineralized) quality of groundwater throughout the area;

- The presence of localized and isolated groundwater discharges along some existing watercourses;
- The poor potential for well development throughout the area; and
- The limited contribution that groundwater makes to the perennial flow of water in the study area streams.

The land development process changes the physical characteristics of the land surface and land use, most notably increasing the degree of imperviousness which increases runoff and decreases infiltration. The water collected from urbanized areas has higher concentrations of some chemical constituents than natural water. This urban runoff is then channeled to water courses via the storm sewer system, delivering these constituents to the local watercourses. In evaluating ways and means of determining the highest and best use of the land, opportunities are available to meet water quality and other objectives at the source (the land use activity), in the drainage conveyance system, and at the end-of-pipe prior to discharge. The preference and focus for achieving the groundwater related objectives are those that can be done at the source (*e.g.,* at the local or lot level).

Based on the discussion in **Section 4.0**, it is apparent that the physical nature of the study area, as summarized above, manifests itself through the stream system, aquatics and, to a certain degree, the ecology of the area. Differentiation of some of the management approaches would greatly enhance the ability of a management strategy to be effective through the development of specific goals and targets that will ensure natural functions and processes are maintained throughout the development of the entire area.

To be realistic, too much differentiation could result in overly complex management recommendations and a strategy that may be cumbersome and unwieldy. Based on a thorough review of the physical elements within the study area, it is apparent that there are three distinct areas that should be treated somewhat differently when developing specific management strategies. These areas are the western portion of North Oakville (Fourteen Mile Creek to Glen Oak Creek), Sixteen Mile Creek, and the eastern portion of North Oakville (Shannon's Creek to Joshua's Creek). The west is dominated by linear drainage patterns (*i.e.,* trellis pattern) due to the underlying geology and fluted nature of the surface. Sixteen Mile Creek, with its deep valley, has numerous tributaries which are steep and actively eroding. These channels are unlike any others in the study area. The eastern side, by contrast, has a more typical drainage system (*i.e.*, dendritic) and is more influenced by the relatively low relief throughout the area rather than geologic controls.

6.3.2.3 Headwater Areas

The study area is comprised of the headwater areas of several catchments and, as a result, is more sensitive to land use change. While the importance of headwater channels is generally recognized, a quantitative analysis of their formative requirements, basin contributions, and the impacts of channel loss through development and land use change is lacking. First order streams (streams with no contributing upstream tributaries) are formed when the tractive force exerted by overland flow is sufficient to transport surface sediment (Rogers and Singh, 1986) (**Figure 6.3.1**). Several sources offer insight regarding the approximate drainage area required to produce such flows. Brummer (2004) states that for mountain stream systems, drainage areas of one to several kilometres will support headwater systems. Takashi *et al.* (2002) cite a smaller value of 0.01-1km^2 for the formation of headwater channels. This latter range of values is mirrored in work by Leopold (1994) and the Sierra Club (2004), who offer similar values of 0.23 and less than 1km^2

for first order streams and headwater streams respectively (headwater streams are defined as first and second order streams).

While the specific pattern of network development reflects the combined influence of topography, geology and climate, these first order channels eventually merge with other channels and erode the surface until a slope develops. At this point, alluvial streams reach a quasi-equilibrium form in which the surface runoff is sufficient to transport the sediment delivered by the headwater tributaries (Whiting *et al.*, 1999). This sediment is eventually deposited in the lowland tailwater system where the stream reaches its confluence with a receiving water body such as a lake or ocean (**Figure 6.3.2**).

From a management perspective, when facing development pressures and land use planning decisions in a headwater system, the question remains: to what extent can one manipulate the production aspect of this delicate equation and still maintain the overall function of the system? This becomes particularly challenging when the main stem and tail water portions of the network have already undergone drastic alterations through urbanization and many of the low-order streams in these downstream portions of the watershed have been lost. Additionally, development in the downstream portions of the watershed produce increased surface runoff that exacerbates erosional issues caused by the decrease in sediment supply from the missing headwater tributaries.

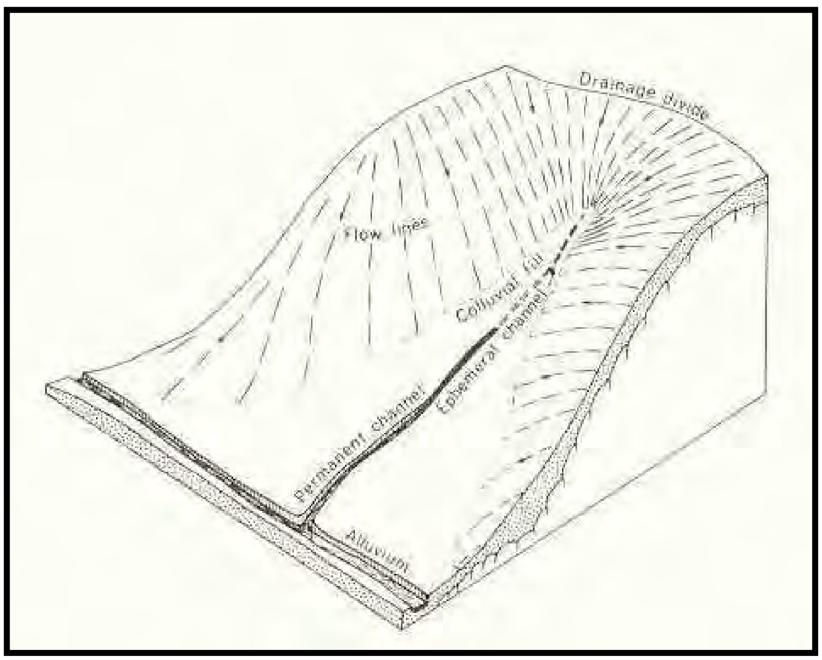


Figure 6.3.1: Headwater Stream Formation (Selby, 1982)

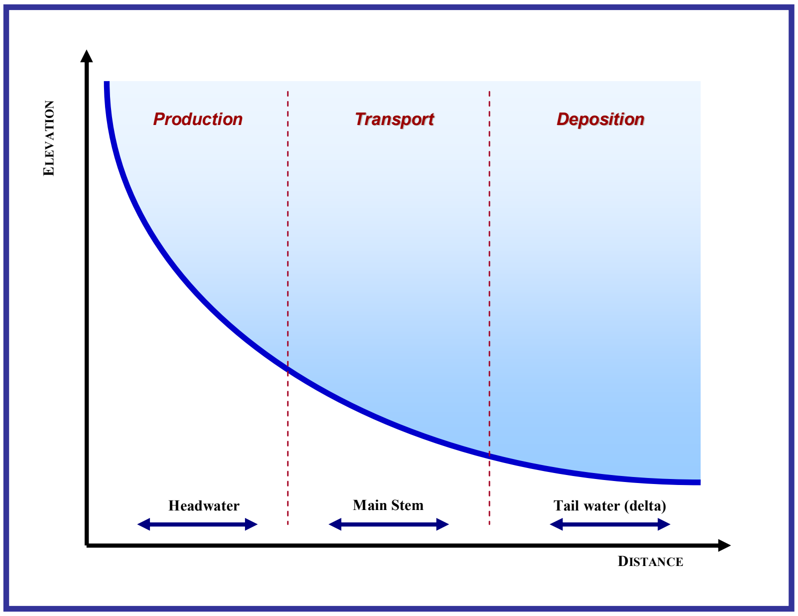


Figure 6.3.2: Transition Zones Along a Fluvial System (Schumm, 1977)

In a study of the Chattooga River watershed in the Blue Ridge Mountains area of the United States, Hansen (2001) reported that, of the total stream network, 55% of the contributing channels were ephemeral (undefined) channels, while 17% were intermittent and 28% were perennial. The majority of these ephemeral and intermittent channels were first and second order headwater tributaries. Based on these results, Hansen concluded that management decisions on a watershed basis should include the combined use of stream order and stream conditions based on field investigations.

To further emphasize the importance and difficulty of developing appropriate management for headwater areas, one only has to look at the drainage pattern and channels in the area. First, on an individual basis, most of the first order channels are ill-defined (*i.e.,* no bed or bank), are ephemeral (*i.e.,* flow for only a few weeks or months in the year), are often altered and could be actively farmed. It is often argued that the function of these channels can be replicated by SWM. A new management approach to headwater streams is to treat headwater channels in a more cummulative sense. That is to base stream length targets on catchment drainage densities which result in more "open" channels. These channels better maintain natural channel functions.

Another important element of true headwater areas is the greater proportion of first order streams. A headwater area is found at the subwatershed divide. In this area there are more first order streams than further downstream in the watershed. This is one reason why headwater areas are referred to as production areas (see **Figure 6.3.2**). Given these channels, this area produces the energy (from rainfall and corresponding runoff) and sediment to drive the downstream sections. For instance, in the Fourteen Mile Creek subwatershed, there are 54 first order streams north of Dundas Street, and only 24 south of Dundas Street. In contrast, there are 12 second order streams north of Dundas Street and 9 in the southern portion. In the eastern side of the study area, this ratio is even greater, due to the dentritic nature of the drainage pattern. Therefore, a management strategy that applies basin morphometrics in the form of stream order and regional drainage density values, in combination with field observations as the basis for subwatershed management decisions is necessary.

6.3.2.4 Terrestrial and Wetland Resources

The current pattern of terrestrial and wetland habitats through the study area has resulted from a number of human and natural influences. The resulting pattern varies across the study area and warrants comment in terms of focusing or varying the management of the features due to these patterns. A number of general patterns are noted:

- The Sixteen Mile Creek valley is the major vegetated feature in the area. It extends well to the north of the study area and as such only a small portion of this system is actually covered by this study. The valley provides a wide forested linkage to lands to the north and south of the study area. In addition, a number of tableland woodlands are contiguous with the forested valley. On the east side of the Sixteen Mile Creek valley a number of woodlands are found (east of Neyagawa Boulevard and along the south side of Highway 407) that are currently well-connected to the valley.
- To the west of Sixteen Mile Creek the remnant natural areas are associated with Fourteen Mile Creek and are fairly well removed from the Sixteen Mile Creek valley. Linkages between these two areas consist of broad agricultural areas with hedgerows.
- A cluster of woodlands is found in the north-central portion of the lands east of Sixteen Mile Creek. These consist of fairly rectilinear woodlands, retained along the backs of lots. They include numerous small wetland areas associated with depressions. Existing physical linkages between these woodlands are limited, but proximity with one another over intervening agricultural lands is likely to provide some functional connectivity.
- Although several of the remnant habitat areas are for the most part only woodlands, four areas were found to present a greater diversity of habitat types. These areas also have more irregular shapes with a number of habitat lobes. These areas include the habitats associated with Joshua's Creek, the woodlands and wetlands to the east of Trafalgar Road (associated with the buttonbush swamp), the habitats associated with the east side of Neyagawa Boulevard, and habitats associated with the main Fourteen Mile Creek.

The management strategy is recommended to consider some of these variations in patterns.

6.3.3 Natural Heritage System – Terrestrial and Wetland

<u>Background</u>

Management of natural habitats in an urbanizing landscape includes:

- Identification and delineation of the natural feature(s) in question;
- Management of the feature in question (*e.g.* subject woodland or wetland);
- Management of the interface between the feature and neighbouring development lands (generally by way of a buffer); and
- Management of the uses of the lands beyond the buffer that may influence the feature (*e.g.* grading, SWM, and servicing).

The latter three items are discussed below. In this section, specific management recommendations for wildlife are included under each of the habitat types below (*i.e.,* wetlands, woodlands, other habitats, and linkages).

6.3.3.1 Wetlands

Feature Management

The management of wetlands has undergone considerable research and study throughout North America. This has been triggered by policies that require the protection of the function and in many cases, the structure of wetlands. Structure and function are generally closely linked since the character of wetlands is directly related to the factors that drive the water regime and other aspects of wetlands (*e.g.*, Pearsell and Mulamoottil, 1996).

The approach to protection of wetlands has included extensive research into the buffers necessary to protect the wetland system and especially the species that use it. Castelle *et al.* (1994, p. 880) reported that "bird species diversity, richness, relative abundance, and breeding numbers were positively correlated with wetland buffer size". Environment Canada (2004) stated that literature increasingly indicates large buffer requirements based on wildlife attributes, especially around marshes. These distances have been found to extend over several hundred metres from the wetland (Environment Canada, 2004; Semlitsch and Bodie, 2003). The PPS (1997) requires that an assessment of environmental impacts be completed within 120m of provincially significant wetlands. As discussed in **Section 6.2**, two general components/approaches have been used to identify the extent of wetland buffers:

1. In cases where the immediate protection of the edge of the wetland is considered (*e.g.,* protection of wetland vegetation and control of runoff to wetlands), these dimensions are typically smaller and a dimension of 30m is in common usage around provincially significant wetlands (Castelle *et al.,* 1994; Provincial Policy Statement, 1997; Stephenson, 1999; Environment Canada, 2004); and

2. A number of recent studies have identified substantial buffers (*i.e.*, Environment Canada (2004) advocates 240m from wetlands, see below). In many cases the dimension of these buffers are driven by wildlife species habitat needs (*i.e.*, most waterfowl nest within 240m of a marsh, while most turtles nest and hibernate within 275m of a marsh (Environment Canada 2004)), that extend well beyond the typical 30m buffer.

How Much Habitat is Enough?: A Framework for Guiding Habitat Rehabilitation in Great Lakes Areas of Concern (*Framework*) is a document prepared by Environment Canada (2004) which "provides science-based information and general guidelines to assist government and non-government restoration practitioners, planners and others involved in natural heritage conservation and preservation in ensuring there is adequate wetland, riparian and forest habitat to sustain minimum viable wildlife populations and help maintain selected ecosystem functions and attributes. The *Framework* provides 18 wetland, riparian and forest habitat guidelines and accompanying rationales" (see **Table 6.3.1**). These guidelines have been applied in a number of catchments and have been used as input to municipal plans.

Table 6.3.1
Summary of Wetland, Riparian and Forest Habitat Restoration Guidelines
Source: Environment Canada, 2004

Wetland Habitat Guidelines	
Parameter	**Guideline**
Percent wetlands in watersheds and subwatersheds	Greater than 10% of each major watershed in wetland habitat; greater than 6% of each subwatershed in wetland habitat; or restore to original percentage of wetlands in the watershed.
Amount of natural vegetation adjacent to the wetland	For key wetland functions and attributes, the identification and maintenance of the Critical Function Zone (CFZ) and its protection, along with an appropriate Protection Zone, is the primary concern. Where this is not derived from site specific characteristics, the following are minimum guidelines: • Bog: the total catchment area • Fen: 100m or as determined by hydrogeological study, whichever is greater • Marsh: 100m • Swamp: 100m
Wetland type	The only two wetland types suitable for widespread rehabilitation are marshes and swamps.
Wetland location	Wetlands can provide benefits anywhere in a watershed, but particular wetland functions can be achieved by rehabilitating wetlands in key locations, such as headwater areas for groundwater discharge and recharge, flood plains for flood attenuation, and coastal wetlands for fish production. Special attention should be paid to historic wetland locations or the site and soil conditions.
Wetland size	Wetlands of a variety of sizes, types, and hydroperiods should be maintained across a landscape. Swamps and marshes of sufficient size to support habitat heterogeneity are particularly important.
Wetland shape	As with upland forests, in order to maximize habitat opportunities for edge intolerant species, and where the surrounding matrix is not natural habitat, swamps should be regularly shaped with minimum edge and maximum interior habitat.
Riparian Habitat Guidelines	
Parameter	**Guideline**
Percent of stream naturally vegetated	75% of stream length should be naturally vegetated.
Amount of natural vegetation adjacent to streams	Streams should have a minimum 30m wide naturally vegetated adjacent lands area on both sides, greater depending on site specific conditions.
Total suspended sediments	Where and when possible, suspended sediment concentrations should be below 25 mg/L or be consistent with Canadian Council of Ministers of the Environment (1999) guidelines.
Percent of an urbanizing watershed that is impervious	Less than 10% imperviousness in an urbanizing watershed should maintain stream water quality and quantity, and preserve aquatic species density and biodiversity. An upper limit of 30% represents a threshold for degraded systems.
Fish communities	Watershed guidelines for fish communities can be established based on knowledge of underlying characteristics of a watershed (*e.g.,* drainage area, surficial geology,

Table 6.3.1
Summary of Wetland, Riparian and Forest Habitat Restoration Guidelines
Source: Environment Canada, 2004

	and flow regime), historic and current fish communities, and factors (and their relative magnitudes) that currently impact the system.
Forest Habitat Guidelines	
Parameter	**Guideline**
Percent forest cover	At least 30% of the Area of Concern (AOC) watershed should be in forest cover.
Size of largest forest patch	A watershed or other land unit should have at least one 200 ha forest patch that is a minimum 500m in width.
Percent of watershed that is forest cover 100 and 200m from forest edge	The proportion of the watershed that is forest cover 100m or further from the forest edge should be greater than 10%. The proportion of the watershed that is forest cover 200m or further from the forest edge should be greater than 5%.
Forest shape	To be of maximum use to species such as forest-breeding birds that are intolerant of edge habitat, forest patches should be circular or square in shape.
Proximity to other forested patches	To be of maximum use to species such as forest-interior birds, forest patches should be within 2km of one another or other supporting habitat features.
Fragmented landscapes and the role of corridors	Connectivity width will vary depending on the objectives of the project and the attributes of the nodes that will be connected. Corridors designed to facilitate species movement should be a minimum of 50 to 100m in width. Corridors designed to accommodate breeding habitat for specialist species need to be designed to meet the habitat requirements of those target species.
Forest quality – species composition and age structure	Watershed forest cover should be representative of the full diversity of forest types found at that latitude

Environment Canada (2004) is currently recommending the identification of “Critical Function Zones” (CFZ) and “Protection Zones” (PZ) around wetlands. It is recommended in the literature that the dimensions of these areas be determined on a site specific basis, but minimum recommendations of 100m around marshes and swamps are recommended. Environment Canada (2004) recognized that wildlife attributes tended to have the greatest influence on the dimensions of the CFZ. Semlitsch and Bodie (2003) propose zones of protection of up to 400m surrounding wetlands and on either side of creeks, based on the habitat requirements of amphibians and reptiles. Similarly, Herrmann *et al.* (2005) state the significance of protecting upland habitat surrounding wetlands. They found that the area within one kilometer of a pond had to have a forest cover of more than 60% to support a thriving amphibian community. Ducks Unlimited recognizes the importance of protecting upland habitat by aiming to conserve three acres of upland for every acre of wetland they protect. This provides areas for wetland species to nest (Cicierski, 1998).

Wetlands serve a function from a watershed perspective in the hydrologic response to rainfall and snowmelt events. They act to retain or detain water to allow it to infiltrate, evaporate or evapotranspirate. This role is provided for by wetland features that are linked to a stream, as well as those that are isolated. In the North Oakville Creeks Subwatershed, there are a number of small wetlands and often wet pockets that are distributed throughout the watershed. The environmental characteristics of these vary substantially.

Land and Process Management

Perhaps the most important consideration for the maintenance of wetlands as features is the management of factors on lands that are located outside the wetland buffer that drive the functioning of the wetland system.

The key land and process management considerations for wetlands relate to the maintenance of the factors that drive the wetland. These factors include land management issues that affect the water regime within the wetland, including water quantity and delivery pattern, as well as water quality. In some cases, larger dimension buffers have been identified to deal with land management issues.

Research has shown in some cases that water level fluctuations created as a result of land development (*i.e.*, from the changes to land drainage, servicing, and especially related to impermeable surfaces) can lead to impacts on wetland biodiversity. A number of researchers were reviewed in a recent document compiled by the Centre for Watershed Protection (2003), with a series of impervious cover thresholds noted. Many cited 10%, above which a decline in wetland diversity was noted. Water level fluctuations as little as 8 inches (approximately 20 cm) have been cited to impact wetland vegetation and amphibian species (Center for Watershed Protection, 2003). Some of the marsh systems found within the study area, have established in locations where water level fluctuations beyond this threshold are anticipated to occur, and these marshes are typically simpler habitats with low vegetation species diversity. On the other hand, many of the woody wetlands are not currently subjected to these types of water level fluctuations and would be susceptible to changes in water level fluctuations due to land management.

Grading, drainage, and SWM are important processes and land management issues. For wetlands associated with watercourses, preservation of flow regime including the pattern of flows is key. The management of these is discussed in other sections of this report.

In cases where smaller buffers are used, it is important to consider compatible land uses. This is further discussed below under Compatible Adjacent Land Uses (see **Section 6.3.4.6**).

As noted above, some wildlife species that use the wetlands require neighbouring habitats such as woods and open country. This includes species of birds, amphibians, and mammals (Castelle *et al.*, 1994; Semlitsch and Bodie, 2003; Environment Canada, 2004; Herrmann *et al.*, 2005). Including upland habitat can be dealt with as either a component of larger buffers around the wetlands, or by using an approach in which wetlands are clustered with other habitats (not necessarily equidistant around the entire perimeter of the wetland).

6.3.3.2 Woodlands

Feature Management

Like wetlands, the management of the wooded feature itself includes protection of the stable woodland edge, as well as a buffer. The stable edge provides protection for the sheltered interior microclimate from excess sunlight or winds that may affect the interior of the stand, as well as invasive edge species and predators. Burke and Nol (1998) report on how stable edges actually reduce edge effects in woodlands to the point where the size of the woodland is no longer significant. Matlack (1993) also discusses the difference between “recent”, “closed”, and “embedded” edges. The findings show that closed edges, which have intact side canopies act in a similar way as crown canopies. As discussed in **Section 6.2**, buffers from woodlands have also experienced considerable research, and like wetlands consist of two general approaches:

1. Arboricultural approaches to the protection of the edge vegetation. These are often based on root spread as well as possible hazard protection; and

2. Ecological approaches to woodland protection which consider the use of neighbouring lands by species that reside in the woods.

The matrix surrounding habitat patches and corridors is an integral component of landscapes and should be considered when designing a Natural Heritage System to increase dispersal in a fragmented landscape (Baum *et al.*, 2004).

Buffers in Rouge North Park (Rouge North Management Plan Committee, 2001) are delineated based on the tree species in the vegetation community. For white pine, buffer width is 53m, sugar maple, 40m; elm, 36m; and other species, 30m.

Numerous studies have been completed that have identified the value of larger blocks of woodland in terms of sustainability and provision of habitats. The larger blocks of woodland are necessary to provide the sheltered microclimate that is found within the interior of these woodland stands. Because certain edge effects (such as predation) can extend up to 600m into a forest, Riley and Mohr (1994) present the notion of “mega-woodlands” that are 400ha or larger. Such woodlands, they state, contain enough forest interior to sustain populations and landscape variability. Some other researches, however, such as Burke (1999), argue for even larger woodlands, reporting that Ovenbirds (*Seiurus aurocapillus*) require woodlands larger than 500ha in order to maintain their populations, and Environment Canada (2004) recommends that 30% of all watersheds should be in forest with some larger than 200ha. The MNR’s *Big Picture Project* also recommends the inclusion of 200ha woodland patches in Natural Heritage Systems (Jalava *et al.,* 2000).

The breeding bird information compiled for the habitat units was used to identify which bird species breed in the woodland areas and those that are considered to be forest interior species. The presence of these types of breeding birds was compared to rules of thumb in common usage for the identification of potential forest interior (*i.e.*, amount of interior habitats over 100, 200, and 300m from the forest edge). As part of the characterization and analysis of the woodlots in the study area (see **Section 5.9**), few of the habitats units were found to provide interior habitat over 200m from the forest edge. A limited number provide interior habitats over 100m inside the forest edge. This distance from the forest edge is commonly used to describe interior habitat (*e.g.,* Puric-Mladenovic *et al.*, 2000). As well, in many of these cases the amount of interior was found to be less than the 4ha, the minimum amount of forest required to have forest interior habitat 100m from the edge (Riley and Mohr, 1994; Region of Halton, 2002a). The Environment Canada (2004) guideline on habitat recommends at least one 200ha forest patch in each watershed. The Framework recommends 10% of the watershed should be interior forest habitat 10m from the edge, and 5% should be 200m from the edge. The guideline also suggests a forest cover of 30% for each watershed.

Despite these habitat patch metrics, a number of the forested stands have forest interior birds that displayed some evidence of breeding. This study did not allow for an assessment of actual breeding success, nest success or predation in the forested stands within the study area. Regardless, it was concluded that forested stands with interior >100m from the edge provide interior habitat. Interior habitat defined as 100m from the edge of the woodlot is standard practice in many studies and the use of this distance can allow for comparison with other studies (see Riley and Mohr, 1994; Cadman, 1999; Austen *et al.,* 2001). Cadman (1999) defines interior forest habitat as 100m from the forest edge, and deep forest interior as 200m or more from the woodland edge.

As noted above, some wildlife species that use the woodlands require neighbouring habitats such as open country. This can be dealt with as either a component of larger buffers around the woodlands, or by using an approach in which woodlands are clustered with other habitats (not necessarily equidistant around the entire perimeter of the woodland).

<u>Land and Process Management</u>

As noted above with respect to wetlands, in cases where smaller arboricultural-based buffers are used around woodlands, the ecological needs of species that reside within the woods may not be addressed, and these would need to be reflected in the identification of compatible adjacent land uses.

Research into the potential for urban lands to impact woodland systems has found that impacts can be detected in some cases where development occurs as far as 100m from the woodland (Friesen *et al.*, 1995). Friesen *et al.* (1998) reported that the number of houses surrounding a woodlot had a significant impact on the forest's neotropical bird community. Neotropical migrants decreased in diversity and abundance as development around the woodlot increased, regardless of the woodlot's size. A study done by Matlack (1993) revealed human impact up to 70m into a suburban forest. Much greater distances of intrusion are found where vehicle access is provided. Matlack (1993) stated that human impacts are worse than natural edge effects and do not decline in severity by distance into the woodland. Besides the nature of the surrounding landscape, the shape of a forest will impact how much interaction of biota there is between the forest and the matrix. The greater the edge to interior ratio (*i.e.,* the more convoluted the edge), the greater the interchange (Saunders *et al.*, 1991; Dramstad, 1996).

The characteristics of wooded linkages between wooded stands are an important land management issue. Connectivity between woodlands can be achieved where contiguous wooded corridors are provided. As well, certain wildlife and plant species will move between nearby wooded patches despite the lack of a direct connection (Saunders *et al.*, 1991; Taylor *et al.*, 1993).

6.3.3.3 Other Vegetation Communities

Feature Management

This section covers early successional stands that can be transitory in nature. These stands are a result of human influences that have triggered succession or have arrested natural succession. Many of these systems can re-establish in a short period of time (especially meadows), and many include a considerable number of non-native species.

These types of vegetation communities are often not specifically targeted for management or inclusion in Natural Heritage Systems in subwatershed or planning studies. These features and their ecological roles are usually relegated to buffers, and this has lead in some recent studies to recommendations of substantial buffer widths from some features (see **Sections 6.3.3.1** and **6.3.3.2**).

The ecological role of open country habitats are discussed in **Section 5.9**.

The management of these features must consider the ultimate goal for the stand, in some cases encouraging natural succession to habitats dominated by woody species, and in other cases maintenance of early successional characteristics with few woody species. The latter is likely to require intervention to control the establishment of woody species.

Breeding bird surveys completed as part of this study found abundant open country bird species in many of the larger meadows and field areas. This included the open habitats associated with the landfill as well as meadows and hayfields throughout the study area.

The locations of these features relative to other habitat patches is an important consideration (see **Sections 6.3.3.1** and **6.3.3.2**). As noted under the discussion of wetlands and woodlands, the early successional open country habitats can either be approached as occurring as bands or buffers around other features or as blocks strategically located in habitat clusters associated with other stand types.

Vegetated buffers outside the actual extent of these habitat types are not considered since these buffers (which are typically early successional vegetation communities) would simply occur as an extension of the habitat itself.

Land and Process Management

The implications of open country habitats on neighbouring lands is minimal, although some researchers have identified edge-effects associated with the interface of these habitat types with development (see Winter *et al.*, 2000).

6.3.3.4 Linkages

Feature Management

Linkages are linear pieces of land that differ from the matrix on either side, and connect larger habitat areas (patches) (Barnes, 2000). The current linkages within the study area are dominated by more diffuse corridors with a limited number of wider wooded linkages. Most of the linkages found in the Subwatershed are dominated by open country and/or agricultural features as well as hedgerows.

Linear habitats either associated with riparian habitats or other upland features may provide an intrinsic habitat function as well as other ecological and human values (see Riley and Mohr, 1994). In addition to providing intrinsic habitat, these features role in providing important avenues for the movement of plant and wildlife species is noted. The optimum design of the movement corridor must be a balance between ecological factors and realistic space and financial constraints (Adams and Dove, 1989).

Corridors function as conduits, habitat, filters, barriers, sources, and sinks (USDA, 1999; Hess and Fischer, 2001). Some researchers have recognized that some linkages may have disadvantages such as increased immigration of undesirable non-native species of plants and animals into previously isolated habitats, or increased edge and interior-edge effects such as predation (Simberloff *et al.*, 1992, reviewed in Dougan and Associates, 2005). However, most evidence shows that the benefits of connectivity in fragmented landscapes far outweigh the potential disadvantages (Naiman *et al.,* 1993; Beier and Noss, 1998; Environment Canada *et al.,* 1998; Soulé and Terborgh, 1999; Barnes 2000; Kirchner *et al.,* 2003; Dougan and Associates, 2005). Linkages have been shown to benefit those species most, whose survivorship is low when dispersing through unsuitable (matrix) habitat (Hudgens and Haddad, 2003). Throughout much of southern Ontario, the natural heritage landscape has been reduced so significantly, "that a natural landscape can be thought of only in terms of long-term restoration or replacement. On these landscapes, it will be necessary to restore and replace natural areas and linkages to allow landscapes to sustain minimum conservation functions. Connecting links can be considered as potential corridors on the landscape" (Riley and Mohr, 1994, p. 46).

Ecological linkages must be designed or identified with an understanding of the species that are anticipated to use the connection. Some species, called "passage species" use corridors for brief passage between habitat patches (Beier and Loe, 1992; Stephenson, 1999; Hess and Fischer, 2001). In this case, the connection must at least provide suitable conditions to motivate species to enter and use the area. "Corridor dwellers" may require several days or even generations to pass through the connection (Beier and Loe, 1992; Hess and Fischer, 2001), and individuals must therefore be able to live in the connection for extended periods.

The protection of the existing linkages is recommended. In most cases this must be accompanied by restoration of neighbouring lands to make these linkages wider and more continuous. The use of woody species (either naturally established or planted) is recommended for these areas. A structurally diverse linkage (with deciduous and coniferous trees, shrubs, especially those that produce berries, and herbaceous species), provides greater benefit to more species than a simple corridor (Fleury and Brown, 1997; Pearson and Manuwal, 2001).

Discontinuities in linkages are noted in background research to occur when breaks of over 20m are found (MNR, 2000), and in some cases discontinuities over 50m are seen as creating sufficient gaps to preclude significant movement of certain more sensitive wildlife species (Hounsell, 1982). Some authors, such as Noss (1987) and Hickman (1990) report that even narrow clearings such as roads, utility corridors, and nature trails can create breaks large enough to produce edge effects. However, connectivity between habitat patches can occur simply as a result of proximity (without a direct physical connection). In these cases plant and wildlife species that can tolerate gaps or use saltatory movements (*e.g.,* flying over gaps) are able to benefit from this type of connection. In effect, habitat units that are close to each other can be used as "stepping stones" (Dramstad *et al.,* 1996). The lands neighbouring the linkages have an impact on the potential use of these areas (*e.g.,* Knaapen *et al.*, 1992; Taylor *et al.,* 1993; Collinge, 1996).

The provision of suitable culverts and bridges should be considered on a site specific basis. As well, considerations to prevent wildlife and vehicular interactions should also be considered (Langton, 1989; Collinge, 1996). Measures described in literature include, but are not limited to:

- Selecting sizeable roadway and linkage alignments to avoid unsafe intersections (*e.g.,* at curves);
- Use of plantings and wing-walls to direct wildlife using the linkage to culvert/bridge crossings; and
- Design of culverts/bridges to accommodate wildlife movement.

The provision of a linked system of habitats can be based on a network with some redundancy in which multiple linkages are available, or networks in which key major linkages are identified.

<u>Land and Process Management</u>

The land uses through which the linkages traverse impact on which species use the corridor. Compatible land uses adjacent to the linkages must be balanced along with the number and size of discontinuities (see Saunders *et al.*, 1991; Knaapen *et al.,* 1992; Collinge, 1996).

Multiple use linkages, especially associated with trail systems, must be reviewed in light of the objectives of the specific linkage. In some stream corridor linkages, trail systems may be accommodated without affecting the functioning of the linkage. This is further discussed below under Compatible Adjacent Land Uses (**Section 6.3.4.6**).

6.3.3.5 Preferred Management Approach to Terrestrial Features

With respect to terrestrial and wetland resources in the study area, a preferred management approach was selected based on the goals, objectives, and targets listed in **Section 6.2**.

From the discussion in **Section 6.3.3.1** to **6.3.3.4**, two aspects of the management were highlighted:

1. The Treatment of Buffers as Part of the Management of the Feature – As discussed above, the consideration of the ecological needs of some species that reside within the wetlands and woodlands has implications on the extent of the buffer. Whereas the protection of the actual edge of the natural area may be accommodated by a modest buffer, the consideration

of some of the foraging and movement aspects of species must either be considered as factors leading to substantially larger buffers, or as blocks of suitable habitats strategically associated with the woodlands and wetlands; and

2. The Implications of Land and Process Management Issues and the Identification of Compatible Land Uses – In cases where small to modest sized buffers are used on individual natural features simply to protect the edge of the feature, the identification of compatible land uses becomes more important.

Feature level management and protection is embodied in many of the recent and current approaches to Natural Heritage and Land Use Planning (*e.g.,* the focus on significant features such as woodlands and wetlands in the *Provincial Policy Statement*). With this approach in mind, "selected" features, such as the larger mature woodlands and wetlands, were identified in **Section 5.0** of the Subwatershed Study. Inherent in these management and protection approaches is consideration of the function of the feature that in many cases requires an analysis of the context of the feature and the relationship of the feature to areas beyond its borders. One approach for conservation of the specific feature includes only the feature and its buffer, and may not include any linkages, especially if the feature has been isolated by historic clearing of surrounding lands.

In some recent examples, this approach has lead to the identification of large buffers and "complexes" or clusters of similar habitats (*e.g.*, wetland complexes under the MNR wetland evaluations system, and for woodlands see City of London, 2003). Conserving biodiversity encourages the consideration of a series of habitat types required for species metapopulations and linkages. In an urbanizing setting, achieving this latter approach is challenging especially considering the character of the land use matrix and in planning approaches with numerous human connections. Managing for clusters of habitats can be used to deal with a number of concerns created in the selected feature approach. Inherent in this approach is a balance between:

- The diversity and size of habitats within a specific cluster;
- The cluster's connectivity to other clusters; and
- The extent of buffering around the component of the habitat cluster.

This cluster management approach stems from approaches to protecting the diversity of habitats and species within an area, not just rarities. Connected to this approach is the realization that certain features located outside these clusters may be less viable than those inside the clusters under an urbanizing land use.

<u>Selected Features versus Core Areas</u>

The selected feature approach is premised on the delineation of natural features, the identification of suitable buffers around the feature and consideration of land and process management implications on the feature's structure and function. For example, in the case of wetlands, the use of a standard modest buffer of 30m and the identification of compatible land uses, grading and drainage constraints around the individual wetland leads to a "ripple effect" in which the protection of the individual wetland has a broad zone of influence on land use. This is similar with woodlands, although the zone of influence of an individual woodland may be less since water regime may be less of a concern. The consideration of the ecological linkages between these separate features may require an extensive network of linkages reflecting the relative locations of these individual pockets to each other. As well, the treatment of the ecological needs of certain wildlife species that require expanses of open country areas for foraging may require that each pocket of wetland or woodland have an associated concentric zone of habitats that further adds to the extent of the zone of influence on land management decisions.

Given the dispersed arrangement of the natural features in the study area, the additive influence of these protected features, their buffers and neighbouring compatible land uses and constraints would have a significant impact on the ability to develop much of the study area. In these types of cases the typical approach is to discount the need for connectivity, especially by stating that the features may already be isolated (although this tends to take a very short-term human perspective on the dynamics of theses systems), or discounting the need for other non-wooded habitats associated with the woodlands or wetlands.

In the Core Area approach the natural features are treated as clusters of habitats. This clustering has a number of effects:

- Linkages between habitats within the cluster are readily accommodated and linkages between clusters are fewer and can be more focused than in the selected features approach;
- Modest edge protection buffers can be used around the perimeter of features where they are at the outside of the cluster since diverse habitats are included within the cluster; and
- Compatible land use concerns would be less of an issue especially where open country habitats form the boundary of the cluster.

By clustering the habitats, the broad influence of concentric buffer and compatible land use zones around individual habitat patches can be avoided. This allows for reduced influences on land and process management. Associated with this approach are more focused linkages between the clusters. The habitat cluster, or core, approach has been used with considerable success in many locations (see Stantec *et al.,* 2000; Planning and Engineering Initiatives, 2003; MMM and LGL, 1993; TSH, 2000; NRSI, 2002; 2003; 2004; 2005).

The *Provincial Policy Statement*, which deals with Natural Heritage, supports the Core Area approach. The *Provincial Policy Statement* states that both “features” and “areas” will be protected from incompatible development. The *Provincial Policy Statement* specifically references fish and significant wildlife habitats, significant wetlands, significant woodlands, significant valleylands and significant Areas of Natural and Scientific Interest (ANSI). Development and site alteration may be permitted in these areas if it has been demonstrated that there “will not be ‘negative impacts’ on the natural feature or the ‘ecological function’ for which the area has been identified” (PPS, 1997). The Core Area approach focuses on protecting not only the features, but their ecological function as well. In addition, the *Provincial Policy Statement* calls for protection of lands that are “adjacent” to the features. Development and site alteration on adjacent lands are permitted only if it has been demonstrated that there will be no negative impacts on the features and their ecological function. Finally, the *Provincial Policy Statement* notes that “diversity” of natural features “in an area” and the “natural connections between them” should be “maintained and improved where possible.” The definition of “ecological function” is broadly defined and reflects the importance of the environment to support connections within or between species.

Using this approach, the terrestrial features which are outside the boundaries of the cores and linkages may be removed.

Core Areas

As part of the identification of opportunities and constraints, and emphasized through discussions in the process, the identification of cores was undertaken.

As noted in the *North Oakville Planning Authorities Interagency Review Phase 1 Report* (September 2003), Core Areas, when linked together, would create the basis for a Natural Heritage System for North Oakville. The criteria used to establish the Cores by the IAR were:

- Diversity – Areas with diverse habitats and/or supporting a rich assemblage of species given priority over areas with less diversity;
- Size – Sufficient size to protect interior habitat;
- Contiguous – Designed to create contiguous units;
- Connectivity – The unit can be linked with other units;
- Significance – Areas supporting significant species or habitats;
- Representativeness – Areas which include appropriate representational features associated with a life or earth science ANSI designation or a candidate life or earth science ANSI designation, including the Trafalgar Moraine candidate earth science ANSI; and
- Overall watershed functionality including hydrological processes which protect the flow regime of the receiving streams.

Core Areas were initially identified based on the constraints discussed above, with the focus being on:

- Large and sustainable units consisting of a diversity of continuous habitats; and
- Neighbouring areas (both natural and human dominated) that are deemed to be integral to the functioning of the core habitat(s).

The Core Areas consist of the following:
- Existing woodland/wetland areas;
- Adjacent areas either:

    1. Existing savannah, thicket, or meadow areas associated with the mature woodland/wetland;
    2. Pockets of savannah, thicket or meadow or agricultural lands that are integral to the woodland (*e.g.,* surrounded by woodland on three sides); and
    3. Active agricultural lands around the outside of the woodland.

The Core Areas are shown on **Figure 6.3.3**.

The actual delineation of the Core Areas is dependent on the features within the Core. However it is important to understand that although some features within specific Cores may warrant protection under current provincial policies, in this Subwatershed Study the identification of the Core is a management approach not a designation approach. The specific delineations of the Cores are discussed below.

The implications of these two approaches on the objectives, targets, and management of the natural features are discussed below.

Management Themes for Core Areas

Generally each Core provides one or more ecological "themes". These themes are based on the existing features and functions within the specific Core Area and not only speak to the rationale and factors for delineation of the Core, but also relate to the recommended management of the Core. The following general ecological themes and associated characteristics are represented in the study area.

Forest Interior

These are Cores, or portions of Cores, that currently provide forest interior habitat, or the potential for forest interior habitat. The breeding bird information compiled for the habitat units was used to identify which bird species breed in the areas and those that are considered to be forest interior species. The presence of these types of breeding birds was compared to rules of thumb in common usage for the identification of potential forest interior (*i.e.,* amount of interior habitats over 100, 200, and 300m from the forest edge). As part of the characterization of the woodlots in the study area, few of the habitats units were found to provide interior habitat over 200m from the forest edge. A limited number provide interior habitats over 100m inside the forest edge. As well, in many of these cases the amount of interior was found to be less than the 4ha, a rule of thumb used in conjunction with the distance inside the edge (Region of Halton, 2002a).

Despite these habitat patch metrics, a number of the forested stands have forest interior birds that displayed some evidence of breeding. It was concluded that forested stands with interior >100m from the edge provide interior habitat.

Associated with the Cores that provide forest interior habitat are a number of general ecological considerations for delineating the extent of the core. These include:

- Minimum width targets of 200m for forested areas within the Core;
- Habitat connectivity within wooded portions of Cores via connections of a minimum 200m width;
- Wooded linkages between forested Cores via connections 100m in width; and
- Open country habitats within the Core Area targeted for restoration/naturalization to woodland.

Open Country

The North Oakville study area provides a range of open country habitats including meadows/old fields, thickets, and savannahs. Even hay fields and pastures can provide open country habitat for a range of wildlife species (*e.g.,* nesting bird species). The open country habitats can be difficult to delineate in some cases where active agriculture may leave meadows fallow for some years, but plow them in other years. The mapping of early successional open country habitats was completed based on conditions in late May 2003. It showed some extensive open country habitats.

Breeding bird surveys of the area also identified a number of bird species of conservation concern that either nest or forage in open habitats. In many of these areas, these open country bird populations appeared to be thriving (based on variables such as numbers of breeding pairs and fledged young). As part of the subwatershed characterization, plant and wildlife species were recorded for lands outside habitat units in open fields and landscaped areas. In many of the catchments, species of some significance were found in these areas outside the habitat units. The literature on minimum habitat areas for open country birds is discussed in **Section 5.9**.

Open country habitats associated with the forested portions of candidate Cores were mapped and considered during the delineation of the Cores. As well, in a few instances active agriculture lands were included within Cores with the aim of providing a number of functions, including the provision of open country habitats.

Associated with the Cores that provide open country habitats, are a number of general ecological considerations for delineating the extent of the core. These include:

- Minimum habitat areas of 30 to 50ha have been identified in the literature to provide habitat areas required by most upland meadow nesting bird species. In some cases, larger open country habitats are preferred by some species (Mass Audubon, 2003);
- In many cases, buffers from features are anticipated to be open country habitats which would provide foraging, nesting, and dispersal habitats; and
- Large open country habitats be included in Cores where possible and targeted for restoration/naturalization to remain as open country habitat.

Habitat Connectivity within Cores

This Core Area theme differs from linkages between the Cores and focuses on cases where the Core consists of a number of distinct habitat patches that are recommended to be connected. This is the case in which current woodland stands within a specific Core may be connected to each other. One of the objectives of this type of habitat connectivity is to provide opportunities for forest interior species to reside within these connections. As well, this theme affects Cores which provide habitat connectivity to natural areas outside the study area.

Associated with the Cores that provide this function is a number of general ecological considerations for delineating the extent of the Core. These include:

- Minimum widths of the Core Area depend on the types of habitats that the Core Area links;
- In cases where wooded portions of a Core are connected, minimum widths of 200m are recommended; and

Special Considerations

In addition to these three general themes, a number of special consideration themes are found in the area. These include:

- Redside Dace Habitat – Cores that provide habitat for redside dace include special considerations stemming from the status and recovery of this rare fish species. The inclusion of habitat for this species within a Core Area triggers a number of considerations for the delineation (and management) of the Cores, including:
  - Consideration of the buffers as recommended by the draft *Redside Dace Recovery Strategy* (Dextrase *et al*., 2005);
  - Inclusion of small order tributaries within the Core;
  - Management of the areas within the Core Area and land management for lands outside the Core Area will be influenced by the recovery plan;

- Buttonbush Swamp – Small pockets of buttonbush swamp are found in a number of areas, but one large stand is included in Core 10. The inclusion of this rare habitat type triggers a number of considerations for the delineation of the Cores, including:
  - Consideration of the headwater location of the swamp; and
  - Management of the areas within the Core and land management for lands outside the Core will be influenced by this community.

Delineation of Core Areas

The Core Areas were delineated based on a series of broad general ecological principles in conjunction with a range of site specific factors. The factors are based on both features and functions and include the buffers from features within the Cores. The buffers have been identified based on buffers in common usage throughout southern Ontario, except in unique instances where site specific features/functions require specific buffer considerations.

Although the Cores identified by the IAR process are centered on terrestrial and wetland features, in some locations watercourses and enhancement areas were considered. The variation in pattern discussed above in **Section 6.3.2.4** was also considered.

The original delineation of the Cores (IAR, 2003) was superimposed over the most recent mapping of vegetation, watercourses, floodline, and stream corridor widths. The delineations were modified through the subwatershed analysis and management strategy process. The features included with the original Cores were reviewed and the applicability of the above themes was assessed. The species lists from habitats within the Cores were reviewed (especially lists of species of conservation concern/significance or habitat specialists), along with species lists from habitats in the catchments outside of the Cores. The specific delineation of each Core Area is depicted on the attached **Figures 6.3.4** to **6.3.12.** The themes and management practices that are related to the individual cores are listed in **Table 6.3.2** and described below. **Appendix MM** provides a comparison of the previous core and linkage boundaries with the final boundaries on a single base map.

The delineation of specific cores considered a number of standard factors, but these were applied at the site level based on specific site characteristics. In some cases, Core Area delineation considered the sustainability of small fingers of forest and often balanced the inclusion/exclusion of these features with an overall goal of creating a Core with a minimum edge to interior ratio. This lead to the identification of straight or gently curved boundaries for the Cores (Dramstad *et al.,* 1996). The objective was to avoid the creation of potential development areas "embedded" within the natural habitats of the Cores.

Site-specific factors considered in the delineation of the Cores include the following:

- Forest interior blocks are assumed to be >100m from the woodland edge. However, in order to provide a volume of habitat beyond 100m, the minimum width of some woodland areas was recommended to be 300m. In some cases, where existing forested blocks were found to be wider, this was taken into account in the delineation of the Core;
- In cases where there are more than one interior habitat node within a single Core, habitat connections between these units should be at least 200m wide;
- Buffers from typical features such as:
  - Mature forest: 10m (except in specific cases where other factors apply);

  - Wetlands: 30m (although this dimension is in common usage, the implications of 100 and 200m buffers around key wetlands has also been examined in some cases to reflect the recent literature on wetland buffers);
  - Watercourses: stream corridors and floodlines;
  - Redside dace survival habitat buffers from meander belt and/or top of bank: 30m, as per draft *Redside Dace Recovery Strategy* (Dextrase *et al.,* 2005); and
- Maximize area for open country habitat blocks.

As part of the review of the Core Area boundaries, existing residences, farm building complexes or other human-made structures in the vicinity of the Core Area were identified and not included in the Core. A Transitway is proposed for the lands immediately south of Highway 407, for the entire stretch of the study area. A width of 60m has been set aside for this purpose, which has been taken into consideration when delineating the Cores and linkages. In a few cases, additional land is set aside for the corridor, as for train stations and parking areas.

The analysis of Cores includes recommendations regarding the linkages between the Cores. Based on the identified Cores, the description of linkages (**Section 6.3.3.4**), linkages were identified associated with the Cores. Two main types of linkages are considered:

1. Primary linkages to provide connections of suitable habitat between Cores. Recommended habitat of the linkage is to be the same as the Cores it connects, which is forested in almost all cases. Linkage width is 100m, other than a few exceptions, which are discussed in the Core descriptions below; and

2. Secondary linkages where widths and habitat types are more variable and widths are driven by other factors especially stream corridor and floodline dimensions.

The second category is assumed to be managed from the perspective of aquatic, fluvial or other factors and these secondary linkages are not assessed further in this section.

From a location perspective the following factors were considered:
- Existing linkages (primarily associated with riparian habitats and hedgerows, but including some existing field linkages);
- Potential linkages which take advantage of some pockets of vegetation, hedgerows or other natural features; and
- General locations of potential linkages where no existing natural feature currently exists, generally associated with the shortest distance between end habitats.

Core #1: Fourteen Mile Creek (Main) (Figure 6.3.4)

Description

This Core Area includes a diversity of habitat types and themes. It is bordered on the west by the Zenon facility, and the smaller industrial facility at Dundas Street and Highway 407 to the north. It is separated from lands to the south by Dundas Street which would create a gap of approximately 30 to 40m and from lands to the north of Highway 407 by a larger gap. A number of small culverts are found under Highway 407 associated with the tributaries. The proposed Transitway is proposed for the lands immediately south of Highway 407 and would overlap with existing open areas and some creeks in this area.

The southern reaches of Fourteen Mile Creek within the Core provide in-situ "survival" habitat for redside dace. The recommendations for redside dace therefore influence the delineation and management of this portion of the Core. Key aspects of this include the 30m buffer from the top of bank, although along the western bank an existing industrial facility is found. As well, inclusion of smaller order tributaries near the northern limit of the Core have been included with their respective floodlines and/or stream corridor widths.

The forested portion of the Core was found to provide potential nesting habitat for a number of forest bird species of conservation concern. Most of these bird species are also considered to be area sensitive species, despite the limited amount of interior habitat beyond 100m of the edge (<1ha).

The habitat connectivity theme of this Core Area is noted since natural habitats are found outside the study area to the south, with connections to the north limited to existing culverts under the highway and proximity to habitats to the north of the highway right-of-way. A connection to the Bronte Creek system is found south of Dundas Road. The minimum width of the southern and central portions of the Core (*i.e.,* south of the woodlands) is affected by maintaining a minimum 200m width.

Several open country birds of conservation concern were noted from the Core Area.

Management Recommendations

- The existing woodlands and wetlands are recommended for retention.
- This theme suggests that linkages between the forested component of the Core and lands to the south should be connected with linkages approximately 200m in width. Significant gaps in these connections will be created by major roadways and highways in the area. As well, the connections should be wooded.
- The presence of the wooded and linkage themes in this Core override the management of the open habitats. The configuration of the Core would allow for minimal open country habitat. The majority of the Core should be wooded, including the open area in the centre of the main woodland towards the north of the Core.

Core #2: Fourteen Mile Creek East (ORC Lands) (Figure 6.3.5)

Description

The forest block in this Core supports several interior bird species. A small area of potential forest interior is found (<1 ha). Open country species and marsh birds are also reported from this Core.

The delineation of the Core Area is based on a combination of woodland setbacks and inclusion of tributaries.

A number of small tributaries are found within the Core, but the eastern tributary is the dominant drainage feature. The Core Area has been delineated to include this tributary, as well as its floodlines and stream corridor width. This captures an open area between the tributary and the main portion of the Core.

Like Core #1, this Core is bordered by major roadways and by residential developments along its western and southern faces. The Core Area is potentially linked to lands south of Dundas Street (noting the gap created by the major roadway of 30 to 40m). Connections to the west towards Core #1 can be made, but again a roadway acts as a major barrier. To the east, Sixteen Mile Creek is a considerable distance. A linkage is proposed as part of the ORC land decision. The distance and current lack of intervening natural features limits the feasibility of creating a continuous forested connection between this Core and others. The linkages associated with Fourteen Mile Creek to the south are anticipated to be fairly wide based on floodlines and stream corridor widths. However substantial wooded blocks are not found south of Dundas Street in this area and the gap created by Dundas Street is substantial.

Management Recommendations

- The existing woodlands and wetlands are recommended for retention.
- It is recommended that the focus of long-term management of this Core Area is to allow the majority of it to reforest to maximize the extent of forest habitat.

Core #3: Sixteen Mile Creek Valley (Figure 6.3.6)

Description

The main valley of Sixteen Mile Creek was not studied as part of the Subwatershed Study. Some background information on this area was available and it has been summarized and included in the characterization portions of this report. Limited original detailed vegetation mapping of species inventories were conducted as part of the Subwatershed Study.

The delineation of the Core for this area was overlain by the limit of natural vegetation associated with the valley based on aerial photographs. For the most part, the boundary corresponds to the dripline of the woodlands (plus 10m). However, in a number of areas existing residences and portions of the cemetery influenced the boundary of this Core.

This Core Area provides key linkages to lands north of Highway 407 and south of Dundas Street. It is the only Core that provides interior forest habitat beyond 300m from the edge.

Management Recommendations

- The existing woodlands and wetlands are recommended for retention.
- Forested linkages to Core #4 and #5 are recommended.

Core #4: Highway 407 - East of Sixteen Mile Creek (Figure 6.3.7)

Description

The main theme that this Core Area appears to provide is the provision of forest interior habitat. Although the forested block that comprises this Core is relatively small with little interior habitat (less than 3ha), a substantial number of forest bird species of conservation concern were reported from this area (of which most are considered area sensitive species). On the other hand, few open country species of conservation concern were reported.

The delineation of the Core Area includes the woodland with a 10m buffer. In light of the connectivity to the Sixteen Mile Creek valley, a 100m linkage along the south side of Highway 407 is recommended. This linkage would correspond to existing woodland and open meadow habitats.

A second linkage towards the Neyagawa Woodlot Core (#5) is another potential forest connection. The location of the linkage has been selected to coincide with a reported groundwater discharge location, as well as a woodlot. The linkage is 100m wide north of Burnhamthorpe Rd., but widens south of the road to encompass the entire woodland. It should be noted that this linkage will be crossed by a major roadway to be determined by the Burnhamthorpe Road Environmental Assessment.

Management Recommendations

- The existing woodlands and wetlands are recommended for retention.
- Forested linkages to Core #3 and #5.

Core #5: Neyagawa Woodlot (Figure 6.3.8)

<u>Description</u>

This is one of the largest and most diverse Cores in the area, measuring approximately 2.5 km in length with a maximum width of 600m. The central portion of the Core Area is the large woodlot that provides forest interior habitat beyond 100m from the edge as well as beyond 200m from the edge. Many forest birds of conservation concern were reported from this Core, with most considered sensitive interior species.

The presence of this forest interior theme has been noted to influence the delineation of the Core, as well as its connections to other habitats. The woodland is approximately 600m wide at Neyagawa Boulevard. Between Neyagawa Boulevard and the first road crossing location proposed in the Secondary Plan, the woodland width tapers to 300m in width. In order to achieve this width, a portion of agricultural lands in the north would be recommended to be forested. Beyond this point, the width of the Core Area tapers to 200m in the eastern section.

The abandoned landfill plays an important part in this Core. It provides an opportunity to create a forested linkage between Sixteen Mile Creek valley and the woodlands east of Neyagawa Boulevard. As well, it currently offers one of the largest areas of open country habitat (approximately 50ha) in the study area (and the largest area of open country in any Core). The provision of open country habitats is reflected in a large number of open country birds of conservation concern.

Some of the largest forested wetlands are found in this Core. This is also reflected in a fair number of wetland birds of conservation concern and a fair number of significant wetland plant and bird species. The delineation of the Core provides buffers to the main wetlands associated with the central "spine" of the Core, which allow for distances of 30 to 100m from the Core boundary to the wetland.

<u>Management Recommendations</u>

- The existing woodlands and wetlands are recommended for retention.
- The provision of a forested linkage between this large woodlot and the Sixteen Mile Creek valley is seen as a key management feature. A minimum width connection of 200m has been recommended.
- A connection to the south of Dundas Street via Shannon's Creek is secondary and anticipated to be fairly narrow.
- The eastern linkage is recommended to be substantial to connect to Morrison Creek to the east.
- The north linkage associated with West Morrison Creek directly connect this Core Area to other Cores (*i.e.,* #7).
- Management of the landfill portion of the Core is recommended to be continued open country habitat with a created forested connection along the south margin if possible.

Core #6: Northwest of Burnhamthorpe & 6th Line (Figure 6.3.9)
Core #7: Southwest of Burnhamthorpe & 6th Line (Figure 6.3.9)

Description

These two Core Areas have similar characteristics and themes. Core #7 is larger and provides some small forest interior habitat (<1ha). It supports a considerable number of forest birds of conservation concern, whereas few were reported from Core #6 (north of Burnhamthorpe). A limited number of open country and virtually no wetland bird species of conservation concern were reported from these Cores.

Management Recommendations

- The existing woodlands and wetlands are recommended for retention.
- These two Cores are proposed to be linked to each other over a fairly short span (approximately 100m), although this includes residences and a major roadway.
- Connections of the southern Core to West Morrison Creek links to Core #5 and is anticipated to be associated with the creek
- The northern Core is proposed to be linked to Core #8 to the north, again across a major roadway, and includes the regional reservoir.
- The connectivity of these two Cores will likely be more a function of proximity. This may help to explain the presence of some forest interior bird species in the smaller northern Core, despite it being only 200 by 200m large.

Core #8: Earth Science Woodlots (Figure 6.3.9)

Description

This Core Area is comprised of two rectangular woodlots roughly 200m apart. The small hummocks and pits found in the area have resulted in the development of numerous small wetland pockets, many of which contain locally significant vegetation communities, as well as one provincially significant community (bur oak swamp).

Like Cores #6 & #7, these two woodlots are fairly narrow and provide little potential forest interior (<1ha). Despite this, a number of forest birds of conservation concern were reported from the two woodlots (especially the southern one). Few open country birds and wetland birds were reported from the woodlots. On the other hand, a fair number of significant plant species were reported from the wetlands in these stands, as well as a diversity of amphibians.

The delineation of the Core considered the forest interior conditions as well as the presence of the rarity and diversity associated with the wetlands. The Core is defined by the woodlands with a 10m buffer from the dripline. A linkage between the two woodlots of 100m in width is recommended.

Management Recommendations

- The existing woodlands and wetlands are recommended for retention.
- The proximity of the Cores #6 and 7 is seen as a potential connectivity opportunity for some species in these Cores. Direct forested linkages beyond the Core Area itself are limited.

Core #9: Trafalgar Woodlot (Figure 6.3.10)

Description

The delineation of this Core Area includes the woodland. This portion of the Core was found to provide 1.6 ha of potential forest interior habitat and a fair number of forest birds of conservation concern were reported from the stand.

The delineation of the Core is based on the limit of the forested area including 10m from the dripline or 30m from the small buttonbush pockets found in the woods.

The linkage to the south of this Core is associated with the west branch of East Morrison Creek, which historically sustained a downstream population of redside dace. As such, the width of this linkage is recommended to be based on the *Redside Dace Recovery Strategy* (Dextrase *et al.,* 2005) that includes a 30m buffer from meander belt. This is approximately 120m in width. Due to the presence of open country bird species, as well as recommendations for the maintenance of herbaceous vegetation next to redside dace habitats, the linkage is recommended to be maintained primarily as open habitat.

Management Recommendations

- The existing woodland and wetlands are recommended for retention.
- Linkage to the south associated with the creek is seen as providing possible connectivity to habitats south of Dundas Street. The open country species that are targeted in this Core Area may use this linkage which is recommended to be 120m in width
- The focus on management of this Core Area is anticipated to be on continued provision of forest habitat with open country habitats recommended for the linkage.

Core # 10: Buttonbush (Figure 6.3.11)

Description

Numerous forest birds of conservation concern were reported from this area, including many that are considered area sensitive forest species. Considerable open country bird species and several wetland bird species were also reported from this area.

The Core Area is comprised of three main nodes. The western node is associated with East Morrison Creek and is fairly low and dominated by a broad floodplain with wetlands. The eastern node is a mix of wetland and forest, while the central node contains some of the largest wetland areas in the study area. Within these wetlands is the large buttonbush (*Cephalanthus occidentalis*) community.

A southern finger of forest extends from the Core, but only a small portion has been included where a small stand of wetland containing high amphibian breeding and rare swamp white oaks (*Quercus bicolor*) are located. Beyond this, the narrow finger has been excluded.

The southern limit of the Core Area has been delineated to include the southern extreme of the western woodland node (including the floodplain and wetlands along East Morrison Creek) and eastern woodland node, as well as the central finger of woods.

The drainage divide between Joshua's Creek and East Morrison Creek is found roughly in the centre of this Core. Key to this is the location of the large buttonbush swamp near the headwaters. Substantial buffers around this wetland have been considered with a minimum of 100m along the northwest side of the Core (otherwise buffers of >200m are provided).

The delineation of the Core Area considers the abundance of forest, open country, and wetland birds. As well, a long list of significant plants is known from this Core, many of which are wetland species, but some are upland species.

This Core is linked to Joshua's Creek to the east by a 100m wide link associated with the floodplain of Joshua's Creek.

<u>Management Recommendations</u>

- The existing woodlands and wetlands are recommended for retention.
- Within the Core, connectivity between the forested blocks of a minimum 200m width can readily be accommodated and is recommended.

Core # 11: Joshua's Creek (Figure 6.3.12)

<u>Description</u>

This Core Area includes a range of habitat types associated with Joshua's Creek at the confluence of a number of tributaries. A portion of the Core is wooded, but the majority of it is dominated by thicket communities. Based on the extent of woodland, potential forest interior habitats are limited (< 2 ha). However, numerous forest birds of conservation concern were reported from this area, many of which are area sensitive species. The proximity of some of the thicket stands to the more mature forest may increase the potential for interior habitats. Many open country species were also reported from the area.

The delineation of the Core Area is based on the limit of the forest with adjoining buffer. In the northwest corner, the limit of the Core has been extended to include a mature forested slope and stretch of critical aquatic habitat (associated with groundwater discharge).

The Core Area extends out in the northeast corner to include a series of wetlands and a forest stand. A number of significant plant species were reported from this area.

Within this Core Area groundwater discharges have been observed, particularly in reach JC-5. Preservation of these discharges will help maintain the current habitat in Joshua's Creek associated with the discharge.

<u>Management Recommendations</u>

- The existing woodlands and wetlands are recommended for retention.
- A linkage for this Core is a potential connection west to Core #10. The proposed location is associated with the western branch of Joshua's Creek.
- A second linkage along the main creek to the south of Dundas Street is also proposed. The natural habitats to the south of Dundas are quite wide (approximately 150m), but the 30 to 40m gap created by Dundas Street is noted.

- Reforestation of open portions of this Core Area is recommended and will substantially increase the amount of forest interior.

Terrestrial Natural Heritage System

The terrestrial and wetland component of the Natural Heritage System (NHS) includes Cores and Linkages as described above. The NHS also includes the high and medium constraint stream corridors as discussed below in **Section 6.3.4**. The stream corridors include some terrestrial habitats in the form of riparian corridors.

The extent of this NHS was compared to the analysis of significant woodlands as discussed in **Section 5.9.1**. Out of 21 significant woodlands (based on Halton Region's significant woodland criteria) 5 do not fall within the NHS. This represents 11.42 ha out of a total of 215.77 ha of significant woodland. The significant woodlands not included in the NHS are as follows (see also **Tables 5.9.2** and **6.3.3** for a more complete description):

Unit 1.1	A small (1.27 ha) forest located immediately south of Highway 407 between Tremaine Road and Bronte Road (Regional Road 25) with significance based on proximity (< 50m) to a medium constraint creek.
Unit 2.1	A forest located immediately south of Highway 407 between Bronte Road (Regional Road 25) and Sixteen Mile Creek with significance based on its size greater than 2ha (2.08ha).
Unit 14.0	A woodland just west of Trafalgar Road, adjacent to the linkage area south of Core 9 with significance based on its size greater than 2ha (2.83ha).
Unit 18.0	A woodland located in the northeast of the study area, east of Trafalgar Road and north of Burnhamthorpe Road, with significance based on its size greater than 2ha (2.28ha).
Unit 19.0	Asecond woodland located in the northeast of the study area, east of Trafalgar Road and immediately south of Highway 407, with significance based on its size greater than 2ha (2.96 ha).

The five significant woodlands that fall outside the NHS are relatively small (vary in size between 1.27 and 2.96 ha) and they make up 5.3% of the total significant woodland area. Three of these five significant woodlands are within the Transitway right-of-way and as such may be impacted by future development. Should the Transitway development proceed, it is estimated that 2 significant woodlands would fall below the 2 ha size criteria threshold to be considered significant with one of the woodlands no longer having the area required to be considered for evaluation as a woodland, (*i.e.*, 0.5 ha). This would suggest that 3 significant woodlands totaling 7.71 ha or 3.6% of the existing significant woodland area are excluded from the NHS.
The intent of the NHS is to capture the majority of significant woodlands (96.4%), while also creating a system of protected areas with long term ecological integrity. The NHS includes areas which currently are classified as agricultural fields, meadows and thickets, with the intent that these areas will become wooded over time, thereby reversing the effects of forest fragmentation. As woodlands develop within these areas the total area of significant woodlands will increase, possibly by up to 160 ha or 42.6%.

Table 6.3.3
Natural Heritage System and Significant Woodlands

ID	Found Within Habitat Unit	Location	Connection to Other Natural Areas?	Part of Natural Heritage System?	Comments
1.0	1	Part of Core 1	Yes	Yes, Core 1.	
1.1	N/A	Between Tremaine Rd and Bronte Rd, adjacent to Hwy 407	Lies adjacent to Core 1 and medium constraint stream	No	Lies almost entirely in path of transitway
2.0	2	Part of Core 2	Yes	Yes, Core 2.	
2.1	N/A	Between Bronte Rd and 16 Mile Creek, adjacent to Hwy 407	No	No	Lies almost entirely in path of transitway
4.0	4	Adjacent to Hwy 407, just east of 16 Mile Creek	Yes	Yes, linkage between Cores 3 and 4.	Part of it lies in direct path of transitway
5.0	5	Between 16 Mile Creek and Neyagawa Blvd, north of Burnhamthorpe Rd	Yes	Yes, Core 4.	Part of woodland effected by transitway
6.0	6	Adjacent to north edge of landfill, west of Neyagawa Blvd	Yes	Yes, Core 5.	
7.0	7	South of Burnhamthorpe Rd, west of Neyagawa Blvd	Yes	Yes, linkage between Cores 4 and 5.	Linkage width widens to incorporate entire woodland.
8.0	8	East of and adjacent to Neyagawa Blvd	Yes	Yes, Core 5.	
8.1	8	Between Neyagawa Blvd and Sixth Line	Yes	Yes, Core 5.	Separated from Woodland 8 by 94m
9.0	9	Adjacent to Hwy 407, just west of Trafalgar Rd	Yes	Yes, Core 8	Partly affected by transitway
10.0	10	Between Neyagawa Blvd and Sixth Line, north of Burnhamthorpe Rd	Yes	Yes, Core 7	

Table 6.3.3
Natural Heritage System and Significant Woodlands

11.0	11	West and adjacent to Sixth Line, south of Burnhamthorpe Rd	Yes	Yes, Core 6	
12.0	12	Between Sixth Line and Trafalgar Rd, north of Burnhamthorpe Rd	Yes	Yes, Core 8	Woodlands are connected by 23m, therefore considered as one contiguous forest.
ID	**Found Within Habitat Unit**	**Location**	**Connection to Other Natural Areas?**	**Part of Natural Heritage System?**	**Comments**
13.0	13	Between Sixth Line and Trafalgar Rd, south of Burnhamthorpe Rd	Yes	Yes, Core 9	
14.0	14	Between Sixth Line and Trafalgar Rd, south of Burnhamthorpe Rd	Lies just east of the linkage south of Core 9	No	
16.0	16	Between Trafalgar Rd and Ninth Line, south of Burnhamthorpe Rd	Yes	Yes, Core 10	Woodland is somewhat dissected, but narrow corridors are >20m wide, therefore considered one contiguous forest.
18.0	18	Between Trafalgar Rd and Ninth Line, north of Burnhamthorpe Rd	No	No	
19.0	19	Between Trafalgar Rd and Ninth Line, north of Burnhamthorpe Rd	No	No	Partially impacted by transitway
20.0	20	Between Trafalgar Rd and Ninth Line, just north of Dundas St	Yes, through stream corridor	Yes, part of high constraint stream corridor	
21.0	21	Between Trafalgar Rd and Ninth Line	Yes	Yes, Core 11	

A similar approach was taken with the provincially and locally rare wetland communities listed in **Table 4E.9.7**. 64 significant wetland communities are found within the study area. Of these, 17 communities (27%) are not protected in the NHS. 11 of these are impacted by the Transitway, and only 6 fall outside the NHS away from the Transitway. All provincially significant communities are protected in the NHS. Of the 19 significant wetland community types identified by the MNR (2003c) within the North Oakville – Milton West & East Wetland Complexes, 17 types are found within the study area. All but 3 of these are represented in the NHS. The exceptions are River Bulrush Graminoid Shallow Marsh (located just west of the Sixteen Mile

Creek valley, labelled as MAS2-2 on **Figure 6.3.6**), Watermeal Herbaceous Shallow Marsh (located northwest of Neyagawa Blvd. and Burnhamthorpe Rd., labelled as SAF1-3 on **Figure 6.3.8**), and Star Duckweed Herbaceous Shallow Marsh (located northwest of Core 10, labelled as SAF1-3 on **Figure 6.3.11**). The Duckweed community is represented elsewhere in the Wetland Complexes, outside the study area.

6.3.4 Natural Heritage System - Streams

In developing a management approach the form and function of the stream system by reach was considered using a riparian corridor approach. This approach considers the broad scope of characteristics and processes that affect the health of the stream system throughout it watershed including:

- Environmental – both aquatic and terrestrial conditions are included, such as the type of aquatic habitat, species (fish and benthic), the condition of riparian vegetation, linkage to other terrestrial features, and ability to provide nutrients to life in the stream;
- Geomorphologic – the overall condition of stream form including structural aquatic habitat, severity of erosion, bedload condition and source of bedload for downstream reaches;
- Hydrologic – influence on hydrologic response of stream, primarily through the floodplain adjacent to the stream and hydraulic characteristics (*i.e.,* ability to detain flows), influence of vegetation and storage on base flows; and
- Hydrogeologic – the presence of recharge and discharge functions either locally or regionally, and the associated contribution to base flow and flow detection.

6.3.4.1 Fluvial Geomorphology

The role of the stream corridors is multipurpose from a geomorphic standpoint. It not only provides flow and sediment storage during high flow events, it also acts as a filter to prevent sediment and particulate inputs from surface water runoff from embedding coarse substrates within the streams. The maintenance of riparian vegetation within the stream corridor acts to stabilize banks and also provides inputs of organic materials and debris which aid in creating a diverse morphology. The meander belt width incorporated into the corridor allows the channel to migrate naturally within its floodplain without the loss of property or structural integrity. As discussed in **Section 5.8** the streams were evaluated from a fluvial geomorphologic standpoint, which is summarized in **Appendix X .** The overall categorization is outlined as follows:

<u>Streams Corridors – Conveyance Corridors</u>

1. High Geomorphic Classification: These reaches have been identified as high quality resource, based on their form and function. Management options for these reaches include the following:
    a. Do nothing: If the reach is unlikely to be affected by future development, leave the corridors in their present condition and develop outside of their boundaries; and
    b. Enhance existing conditions: If the reach is likely to be affected by future development, maintain the present location of the corridor but enhance both the geomorphic and aquatic habitat conditions (*e.g.,* bank stabilization, re-establish a meandering planform, and connect channel to functioning floodplain).

2. Medium Geomorphic Classification: These reaches may or may not have a well-defined morphology but do maintain geomorphic functions and have potential for rehabilitation. Management options for these reaches include the following:
    a. Do nothing: leave the corridors in their present condition and develop outside of their boundaries;
    b. Enhance existing conditions: maintain the present location of the corridor but enhance the existing conditions (*e.g.*, bank stabilization, re-establish a meandering planform, and connect channel to functioning floodplain); and
    c. Relocate and enhance existing conditions: many of the reaches within the study area have undergone extensive straightening and modification for agricultural drainage purposes. As such they are not as sensitive to relocation and would benefit from enhancements such as the reestablishment of a meandering planform with functioning floodplain and development of a riffle-pool morphology.

3. Low Geomorphic Classification: In general, these reaches consist of ephemeral headwater swales that lack defined bed and banks but do perform a geomorphic function through the conveyance of flow and sediment. Although many of the minor swales were given a low rating from a geomorphic standpoint, the cumulative impact of these features should not be overlooked. Management options for these reaches include the following:
    a. Do nothing: leave the channels/swales in place (no corridor required) and develop the surrounding lands;
    b. Combination of SWM and open conveyance techniques: the function of headwater streams can be mimicked through the implementation of SWM techniques and;
    c. Open conveyance techniques: the function of the ephemeral swales is replicated entirely through a system of open conveyance techniques (*e.g.*, backyard swales).

<u>Development of Regional Drainage Density Targets</u>

Drainage densities were calculated for the study area and two other neighbouring headwater systems with comparable climates and geology (Sheldon Creek and Sawmill Creek). Results for North Oakville were derived based on dividing the total stream length for each subcatchment (mapping provided by the Town of Oakville) by its respective drainage area. Drainage densities for Sheldon Creek and Sawmill Creek were established based on the subcatchment areas delineated in the Sheldon Creek Watershed Master Plan (Philips Planning and Engineering, 1993) and Sawmill Creek Natural Channel Design Study (Gore and Storrie, 1995). Total stream lengths were determined from 1:10,000 OBMs for Sawmill Creek and the most recent series of aerial photography available (1983, 1:20,000) for Sheldon Creek.

Preliminary calculations of drainage density based on stream length per unit area of subcatchment within the study area utilized 1:10,000 Ontario Base Maps (OBMs). To place these results in a regional context, drainage densities were also calculated for the headwater portions of Sheldon Creek and Sawmill Creek also using 1:10,000 OBMs. These two systems share a climate and geology similar to those in North Oakville to provide an appropriate comparison.

In order to calculate a regional average drainage density and develop targets, the drainage densities for all of the North Oakville, Sheldon Creek and Sawmill Creek subwatersheds based on the 1:10,000 OBMs were averaged. The standard deviation for this data set was also determined. Minimum drainage density targets were designated for each of the catchments by subtracting one standard deviation from the designated density, to a lower limit of 1.29km/km^2. This lower limit represents the regional average drainage density minus one standard deviation.

The new minimum allowable drainage density was compared to the existing drainage densities based on medium and high constraint streams. Those subcatchments that met or exceeded the minimum density target based solely on the protected red and blue streams were identified and their "surplus stream length" was calculated. For those subcatchments that did not meet the minimum density target based solely on the protected red and blue streams, a second drainage density was calculated, this time incorporating swales or SWM facility length. Within the North Oakville Creeks Subwatershed, the majority of the subcatchments meet and/or exceed the established regional drainage density targets based on their respective red, blue, and green streams.

That being said, there were a few isolated cases where the density target could not be met through existing conditions on a subcatchment basis. For these cases, consideration was given to whether surplus stream length from an adjacent subcatchment could be employed such that, within the overall subwatershed, the cumulative drainage density target at Dundas Street was met. In essence, subcatchments with a drainage "deficit" could be allowed as long as this deficit was recovered by a drainage surplus in a neighbouring subcatchment within the subwatershed.

In the case of North Oakville, the catchments more than meet the stream length requirements of the imposed drainage density targets based only on the red and blue streams. Despite individual basins having a deficit, there is an overall surplus indicating that the incorporation of the green streams is not necessary. If only adjacent basins are used to meet steam length requirements, stormwater management ponds can be established to address this deficit.

6.3.4.2 Environmental/Fisheries

Streams must be provided with a riparian buffer to protect them from the impacts of urban development and associated human activity. According to a review article by Castelle *et al.* (1994), buffer widths in the 15 to 30m range are required to maintain the biological components of many wetlands and streams. Castelle *et al.* (1994) also indicate that the need for larger buffers increases in some situations, for example, where a wetland or stream is highly valuable or the adjacent land use is intense. Environment Canada (2004) recommends a minimum buffer of 30m for streams and recognizes that vegetating the riparian areas associated with lower order streams is very important (see **Table 6.3.1** Riparian Habitat Guidelines). MNR (1994) *Fish Habitat Protection Guidelines for Developing Areas* recommended buffers of 15m from important fisheries habitats. This latter dimension is in common use by Conservation Authorities in southern Ontario.

For the redside dace streams, the buffer requirements of the draft *Redside Dace Recovery Strategy* (Dextrase *et al.,* 2005) are recommended. This would result in buffer widths, for survival habitat, of 30m from top of bank for incised channels and 30m on either side of meander belt width if no defined valley is present. The definition of survival habitat in the recovery strategy is as follows:

> "*All reaches currently occupied by Redside Dace including wetted stream width and associated riparian habitat.*"

For the purposes of this Subwatershed Plan, only reaches which contain redside dace and have been designated as critical aquatic habitat (14W-12, 14W-1 and 14W-1A), are considered as survival habitat requiring this 30m setback.

For non-redside dace streams, a minimum buffer width is recommended that would provide some level of protection for the stream. Review of the literature and of current practice in southern Ontario suggests that a minimum width of 15m would be appropriate and this width is recommended.

There is support in the literature for the use of fluvial driven stream corridors to protect aquatic habitat (Brosofske *et al.,* 1997; Naiman and Decamps, 1997; Naiman *et al.,* 1993; Gregory *et al.,* 1991). Because the habitat value and vegetation composition of a riparian zone is largely driven by floodplain and fluvial processes, it is sensible to use the stream corridor widths developed for this study as a result of floodplain and fluvial characteristics as a minimum measure to protect fish communities and aquatic habitat within the watercourses. The buffers created by the fluvial and floodplain management strategies developed for this Subwatershed Plan are generally sufficient to achieve the target buffer width for survival habitat of 30m described in the draft *Redside Dace Recovery Strategy* (Dextrase *et al*., 2005) and certainly achieve the recommended minimum width of 15m (see above) for all aquatic habitat. In some cases, these fluvial/floodplain buffers far exceed these recommended buffer widths. Wherever the recommended buffer widths are not met by floodplain and fluvial corridors requirements, it will be necessary to include upland habitat outside this zone to maintain the recommended buffer width along all watercourses.

Limiting the use of these riparian buffers for trails and other urban intrusions increases their effectiveness in terms of the functions described above. However, the desire to achieve aquatic habitat benefits must be balanced with the need for recreational opportunities within the urban environment. If intrusion into the redside dace stream buffers can be limited in return for placement of trail features in the buffers of less sensitive streams, this is desirable.

<u>Reach Specific Management Recommendations</u>

Broad Level Management Recommendations have been discussed above to achieve certain targets on a system wide basis. **Table 6.3.4** lists reach specific management practices which, if implemented, should aid in achieving broad level targets related to enhancing riparian canopy and moderating stream temperatures. These reach specific recommendations fall into the following broad categories. Each reach has one of these recommendations associated with it or, in some cases, a combination of more than one recommendation.

- Plant woody vegetation to supplement existing herbaceous vegetation where an herbaceous cover is well established.
- Allow vegetative succession of woody vegetation to continue undisturbed. In these cases woody vegetation is far enough advanced that natural succession should be left alone.
- Encourage herbaceous vegetation and discourage woody vegetation within the first 2 to 3m from top of bank for redside dace survival habitat.
- Remove online ponds. These ponds are considered detrimental from a temperature moderation perspective and should be removed. Furthermore, they interrupt sediment transport and can lead to downstream channel instability.
- Bank revetment required to repair bank erosion problems. Very site specific areas where advanced erosion is evident.
- Movement of channel recommended to remove it from negative land use practices. For example, moving a channel out of a road ditch.

- If existing vegetation community is doing well, it should not be disturbed. This applies mainly to heavily wooded reaches or reaches where shrubs and herbaceous vegetation is very well established.
- Do not modify channel form if redside dace are supported in reach. Riparian plantings and vegetation enhancement can occur but the channel is stable and should not be modified in any way.
- No management required if reaches have been designated as supporting no in-situ aquatic habitat.

<u>Stream Corridors</u>

Many of the aspects of the management of linkages are discussed in **Section 6.3.3.4**. In many cases, the existing riparian vegetation found within stream corridors is limited or not existent. Therefore, the issue of protecting the riparian vegetation is not as important as encouraging the establishment of vegetation in these areas.

The stream corridors are a composite of a number of factors that result in many cases in widths of 50m (+/-). The preferred management of the corridors from a linkage perspective would be to retain existing woody and wetland vegetation associated with the corridors, and allow for the establishment of woody vegetation within the stream corridors. This is consistent with the management recommendations from an aquatic perspective (see above).

Table 6.3.4 includes recommendations to the management of the stream reaches within the study area from a stream corridor and riparian vegetation perspective. A number of the reaches fall within Core Areas and as such, are covered by the overall management of the Core Area.

In some cases pockets of woodland and wetland are found associated with these stream corridors and these existing vegetation features should be incorporated into the corridor where possible.

The maintenance of existing vegetation associated with the stream corridors is related to the flow within the channels or in the case of wetlands, the factors that drive the water regime within them.

See **Section 6.3.3.4** for a discussion of the issues associated with the lands through which the stream corridor linkage traverses.

6.3.4.3 Flood Protection

As part of the stream corridor management strategy, the stream corridors that require protection, and the associated level of protection is summarized in **Section 6.3.4.5** and illustrated in **Figure 6.3.13**. **Figure 6.3.13** shows stream reaches that have been classified as being either those that require form and function to be maintained (red), those that are required to remain as open watercourses but whose form can be altered (blue), or those whose geomorphic function can be duplicated through the use of backyard swales or SWM ponds (green).

The red streams do not have any management options that may be used to increase their protection from flood. For those streams that must remain as they exist today, development will not be permitted within the floodlines that are registered by Conservation Halton.

For those stream reaches that have been classified as being blue or green, there may be some opportunities to deepen the streams, combine adjacent streams or reroute the streams to a more desirable location. Any of these options will change the preliminary floodlines shown on **Figure 6.3.14,** and perhaps allow for development in areas that may not currently allow development due to the presence of floodlines. In any event, each of these potential opportunities should be explored at the Environmental Implementation Report (EIR) (see **Section 7.0**) stage and be completed under the authority of Conservation Halton. It is important to note that any of the changes proposed to the cross-section of the "blue streams" must also maintain the storage requirements discussed in **Section 6.2.1.1.**

Joshua's Creek Floodplain

As shown on **Figure 6.3.14**, there is a fairly significant floodplain located south of existing Burnhamthorpe Road to the east of Trafalgar Road. There may be some opportunity to refine the areal extent of this floodplain through the use of dynamic hydrologic modelling rather than the standard method of modelling used in this study. Any changes to the areal extent of this floodplain would be subject to approval and registration by Conservation Halton.

There may be opportunities to provide appropriate land uses adjacent to the floodplains registered by Conservation Halton. The EIR stage will provide the opportunity to study and identify land uses appropriate for lands adjacent to or within the floodplains. The compatible land uses must comply with current Conservation Halton and *Provincial Policy Statement* regulations.

Floodlines Outside Stream Corridors

Where floodlines extend beyond the stream corridor, the opportunity exists to tuck the floodlines into the stream corridors, specifically, within medium constraint stream corridors. Modifications are permitted subject to Conservation Halton approval and preservation of the stage storage function of the floodplain. **Figure 6.3.14** identifies the locations where floodlines extend beyond the Natural Heritage System.

6.3.4.4 Hydrogeology

In North Oakville there are specific geological, physiographic and hydrogeological features that have both created existing conditions and will contribute to the overall health of the watercourses in the future. These must be taken into account in developing an effective management strategy for the area.

There are also no municipal or large groundwater takings in North Oakville. Since there are no large water takings in the study area and future water taking will be virtually eliminated with the eventual provision of municipal servicing, little is needed to reduce future water taking.

Groundwater resource management in the urban setting has two main components. The first component involves managing infiltration in an urban environment. The second component is management of groundwater discharges.

<u>Infiltration</u>

Management of the groundwater resources in the study area for the future focuses on management of the hydrologic cycle. Given that urbanization will change components of the cycle, including a decrease in infiltration, the overall goal will be to maintain infiltration as close to current levels as possible. Within areas that will be preserved, the hydrologic function will remain the same. This includes the amount of recharge entering the system. In areas where development will occur, the increase in impervious areas will decrease infiltration and measures are needed that will help offset the predicted infiltration decrease.

Taking this approach will reduce the impact to the groundwater system, including limiting changes in depths to groundwater, limiting changes to groundwater quality, and ensuring the continuity of discharge to local watercourses. At the local level, preserving existing discharge areas serves to maintain the local component of the recharge/discharge cycle.

<u>Groundwater Discharge</u>

The discharge component is also present and contributes to the overall health of several watercourses in the study area. Thus, consideration must be given to the management of these groundwater discharge areas.

For groundwater discharge management the focus is the protection of groundwater discharge areas. There were only two areas where evidence supporting direct groundwater discharge was observed and two areas identified where modelling suggested a potential for groundwater discharge. These areas are in the Joshua's Creek, Shannon's Creek, Fourteen Mile Creek and Sixteen Mile Creek (east side) watersheds. In the Joshua's Creek and Fourteen Mile Creek valleys, small discharges were observed as isolated discharges from the banks or base of the watercourses or were interpolated from either the water temperature data collected or the vegetation observed.

In the Shannon's Creek and Sixteen Mile Creek watersheds two areas were identified as potential discharge zones in the Halton Region Aquifer Management model. These areas play a role in providing potential groundwater discharge to the surface water environment in the headwater zones for some of intermittent streams in the area.

Thus preservation of the riparian corridors is the most effective means of maintaining the identified groundwater discharges to the surface water system. Along with these discharge areas are their associated recharge zones. Considering the limited extent of the zones of influence that these small discharges have, the recharge that they receive is interpreted to occur close by. Thus the Riparian corridors likely capture much of the recharge area for these discharge zones.

The protection and incorporation of groundwater related functions that play a role in the hydrologic response of a watershed role can be used as a management tool to assist in mitigating peak flow increases and erosion increase related to land use changes (*i.e.,* urbanization and agricultural uses). These features primarily include wetlands, woodlands and the storage contained in riparian corridors along a stream system.

<u>Geological, Physiographic and Hydrogeological Features</u>

In the case of North Oakville Creeks Subwatershed, the role of the geological features, soil conditions and their relationship within stream riparian corridors have been taken into consideration in the characterization and analysis. This includes a number of relatively small depressions located within and/or between hummocks along the crest of the Trafalgar Moraine. These depressions are typically only wet on an event or seasonal basis. Some deeper or larger features retain water year-round and some smaller features are dry.

Some of these depressions are in areas that are currently used for other purposes (*i.e.,* recreational ponds and agriculture) and have been significantly modified from their original form and function. On occasion, these depressions are part of a drainage network; however, many do not have a direct connection (unless the water storage volume of the feature is exceeded and overflow takes place) to the overall drainage network. The influence of depression storage on the overall hydrogeologic and hydrologic system was discussed in **Section 5.4** and **5.5,** and the locations of the pitted topography is highlighted on **Figure 6.3.15.**

The hydrologic role of the larger features can be preserved through the protection and management of the Natural Heritage System as well as stormwater management. The development of this approach is also discussed through the environmental objectives and geomorphologic objectives of the stream system.

6.3.4.5 Riparian Corridor Management

The selection, evaluation and analysis of the stream corridor system are outlined in the preceding sections of this management strategy for the North Oakville Subwatershed. In the development of a management approach an overall evaluation of the reaches was carried out.

The stream reaches that are included in the evaluation are illustrated on **Figure 6.3.13.** The selection and evaluation of these reaches from an environmental, geomorphologic, hydrologic, and hydrogeologic standpoint are discussed in the preceding sections of this management strategy.

The stream corridor widths of the reaches (**Table 6.3.4a**) encompass three components, the meander belt width (defined in **Table 5.8.3**), the environmental setback allowance, and the erosion setback. The three components are illustrated in **Figure 6.3.15a**. **Figure 6.3.15b** provides a decision making flowchart that outlines the riparian corridor width determination protocol.

The stream corridor widths of the reaches (**Table 6.3.4a**) encompass three components, the meander belt width (defined in **Table 5.8.3**), a 7.5m or 15m setback allowance for minor and major streams respectively, and the factor of safety. The factor of safety is defined as either 10% of the belt width or 6m, whichever is larger. An erosion allowance component would be coincident with the top of bank setback. The three components are illustrated in **Figure 6.3.15a**. Additionally, when dealing with confined systems the setback should be based on the "stable top of bank" which may or may not coincide with the physical top of bank. The "stable top of bank" is determined based on the technical requirements set out in the Provincial Guidelines for Natural Hazards management (MNR, 2001). **Figure 6.3.15b** provides a decision making flowchart that outlines the riparian corridor width determination protocol.

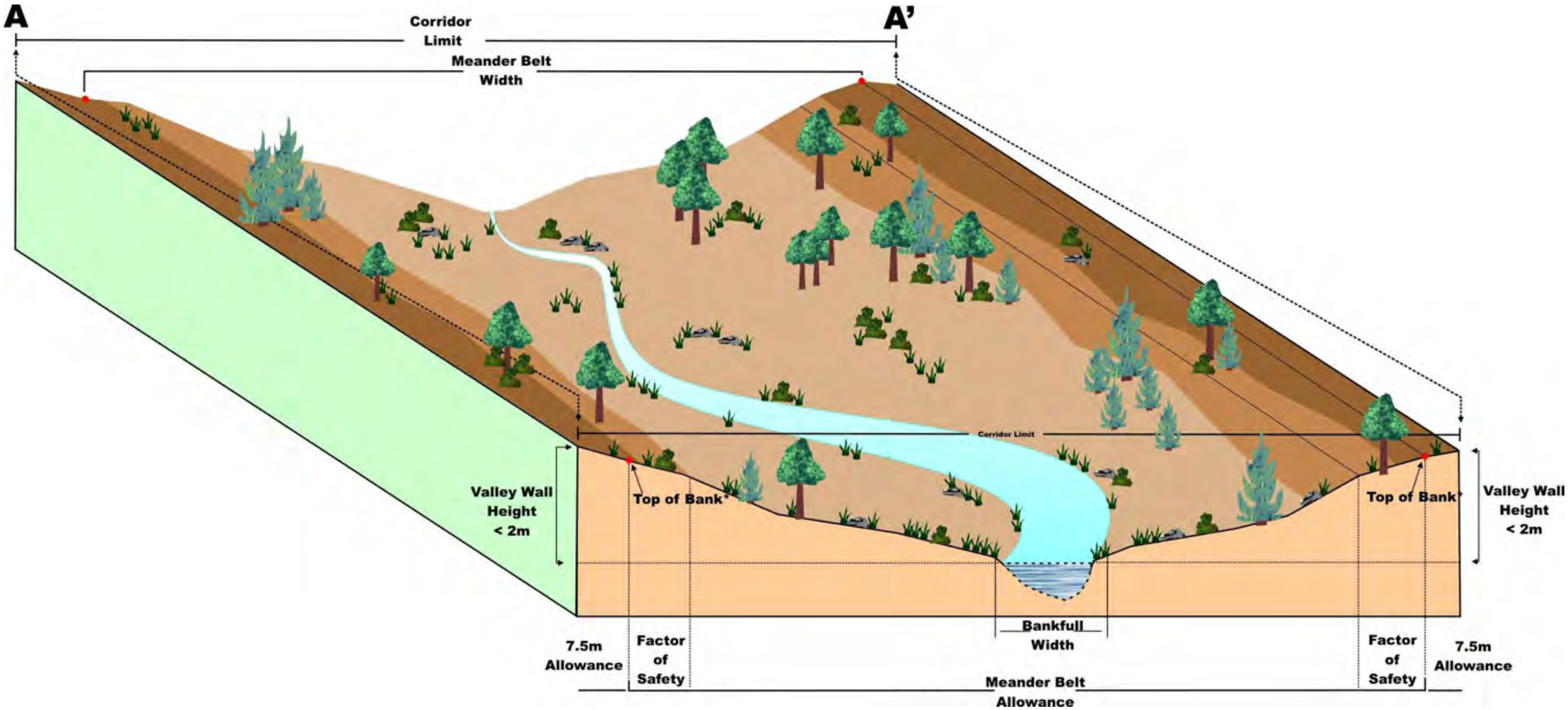


Figure 6.3.15a: Conceptual Belt Width.

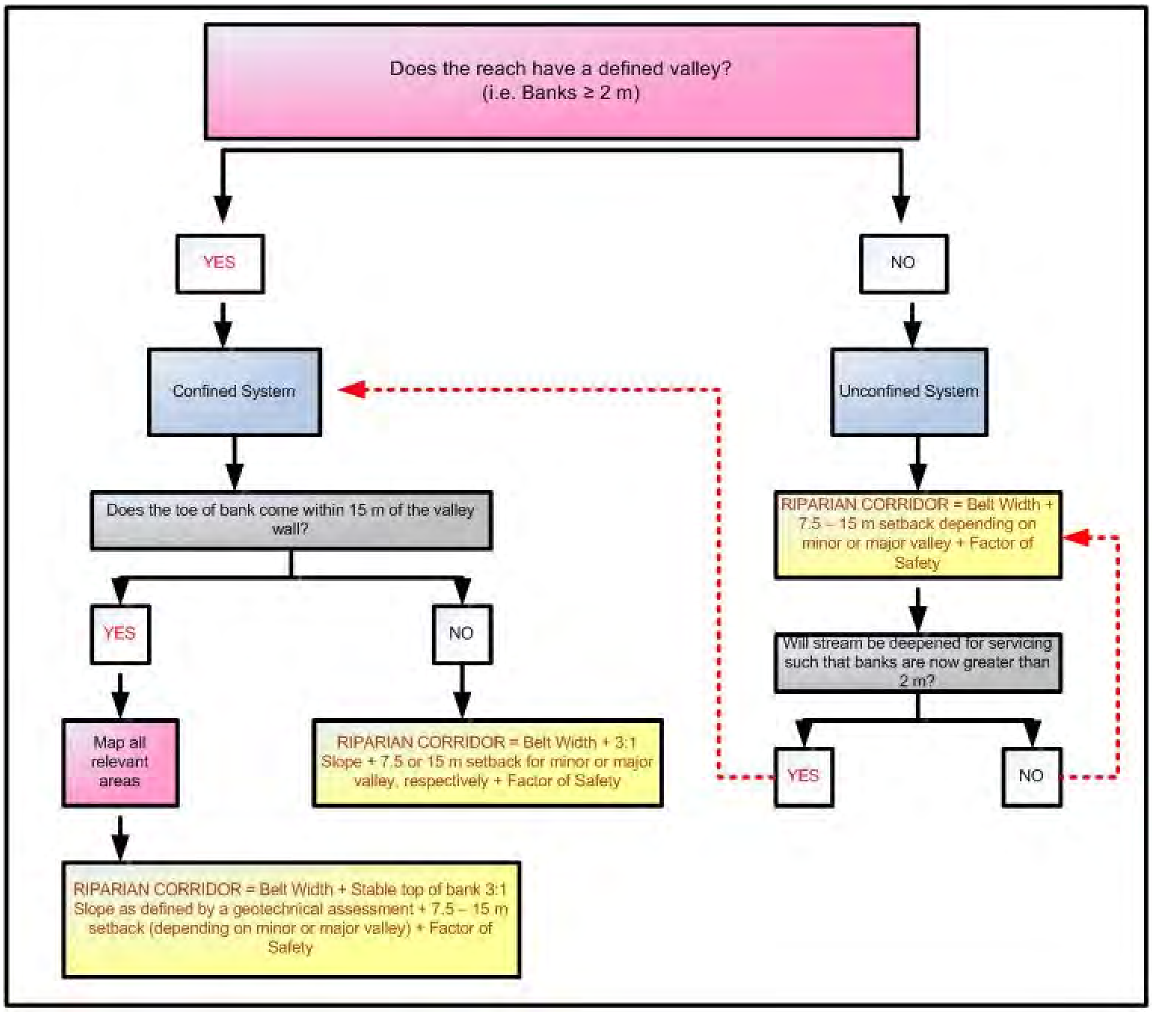


Figure 6.3.15b Belt Width Flowchart

Table 6.3.4a
Stream Corridor Widths for the Study Area

North Oakville Creek		***Reach***	***Corridor Width (m)*** Belt Width + 15m Setback + Factor of Safety
Sixteen Mile Creek	***A***	SMA-1	25+15+6
		SMA-2	45+15+9
		SMA-3	25+15+6
		SMA-4	40+15+8
		SMA-5	20+15+6
		SMA-6	45+15+9
		SMA-7	35+15+7
		SMA-8	15+15+6
		SMA-9	15+15+6
	B	SMB-1	30+15+6
		SMB-2	35+15+7
		SMB-3	45+15+15
		SMB-4	35+15+7
	C	SMC-1	35+15+7

Table 6.3.4a
Stream Corridor Widths for the Study Area

North Oakville Creek		***Reach***	***Corridor Width (m)*** Belt Width + 15m Setback + Factor of Safety
		SMC-2	35+15+7
		SMC-3	25+15+5
Shannon's Creek		SCH-1	25+15+6
		SCH-2	25+15+6
Munn's Creek		MUN-2	35+15+6
		MUN-3	25+15+6
Morrison Creek	***West***	MOC-W1	45+15+9
		MOC-W2	35+15+7
		MOC-W3	30+15+6
		MOC-W5	30+15+6
	Main	MOC-2	20+15+6
		MOC-4	45+15+9
		MOC-6	35+15+7
Joshua's Creek		JC-1	45+15+9
		JC-2	45+15+9
		JC-3	35+15+7
		JC-4	35+15+7
		JC-5	35+15+7
		JC-6	30+15+6
		JC-7	20+15+6
		JC-8	25+15+6
		JC-9	25+15+6
		JC-12	20+15+6
		JC-13	30+15+6
		JC-14	25+15+6
		JC-19	30+15+6
		JC-20	20+15+6
		JC-20a	20+15+6
		JC-22	40+15+8
		JC-27a	30+15+6
		JC-36	30+15+6
Fourteen Mile Creek	***West***	14W-1	40+15+8
		14W-1a	40+15+8
		14W-2	40+15+8
		14W-3	40+15+8
		14W-4	30+15+6
		14W-9	30+15+6
		14W-9a	20+15+6
		14W-10	20+15+6
		14W-11	20+15+6
		14W-11a	20+15+6
		14W-12	25+15+6
		14W-14	15+15+6
		14W-16	15+15+6
		14W-17	15+15+6
	East	14E-1	40+15+8
		14E-2	40+15+8
		14E-2a	30+15+6

Table 6.3.4a Stream Corridor Widths for the Study Area			
North Oakville Creek		***Reach***	***Corridor Width (m)*** Belt Width + 15m Setback + Factor of Safety
		14E-3	40+15+8
		14E-3a	40+15+8
		14E-6	40+15+8
		14E-7	40+15+8
		14E-8	20+15+6
Sixteen Mile Creek	***West***	16W-1	30+15+6
		16W-2	40+15+8
		16W-3	40+15+8
		16WA-1	45+15+9
		16WA-8A	20+15+6
McCraney Creek		MC-1	55+15+11
		MC-4a	20+15+6
Sixteen Mile Creek	***A***	SMA-1	25+15+6
		SMA-2	45+15+9
		SMA-3	25+15+6
		SMA-4	40+15+8
		SMA-5	20+15+6
		SMA-6	45+15+9
		SMA-7	35+15+7
		SMA-8	15+15+6
		SMA-9	15+15+6
	B	SMB-1	30+15+6
		SMB-2	35+15+7
		SMB-3	45+15+15
		SMB-4	35+15+7
	C	SMC-1	35+15+7
		SMC-2	35+15+7
		SMC-3	25+15+5
Shannon's Creek		SCH-1	25+15+6
		SCH-2	25+15+6
Munn's Creek		MUN-2	35+15+6
		MUN-3	25+15+6
Morrison Creek	***West***	MOC-W1	45+15+9
		MOC-W2	35+15+7
		MOC-W3	30+15+6
		MOC-W5	30+15+6
	Main	MOC-2	20+15+6
		MOC-4	45+15+9
		MOC-6	35+15+7
Joshua's Creek		JC-1	45+15+9
		JC-2	45+15+9
		JC-3	35+15+7
		JC-4	35+15+7
		JC-5	35+15+7
		JC-6	30+15+6
		JC-7	20+15+6
		JC-8	25+15+6
		JC-9	25+15+6
		JC-12	20+15+6

Table 6.3.4a
Stream Corridor Widths for the Study Area

North Oakville Creek		***Reach***	***Corridor Width (m)*** Belt Width + 15m Setback + Factor of Safety
		JC-13	30+15+6
		JC-14	25+15+6
		JC-19	30+15+6
		JC-20	20+15+6
		JC-20a	20+15+6
		JC-22	40+15+8
		JC-27a	30+15+6
		JC-36	30+15+6
Fourteen Mile Creek	***West***	14W-1	40+15+8
		14W-1a	40+15+8
		14W-2	40+15+8
		14W-3	40+15+8
		14W-4	30+15+6
		14W-9	30+15+6
		14W-9a	20+15+6
		14W-10	20+15+6
		14W-11	20+15+6
		14W-11a	20+15+6
		14W-12	25+15+6
		14W-14	15+15+6
		14W-16	15+15+6
		14W-17	15+15+6
	East	14E-1	40+15+8
		14E-2	40+15+8
		14E-2a	30+15+6
		14E-3	40+15+8
		14E-3a	40+15+8
		14E-6	40+15+8
		14E-7	40+15+8
		14E-8	20+15+6
Sixteen Mile Creek	***West***	16W-1	30+15+6
		16W-2	40+15+8
		16W-3	40+15+8
		16WA-1	45+15+9
		16WA-8A	20+15+6
McCraney Creek		MC-1	55+15+11
		MC-4a	20+15+6

Table 6.3.4a
Stream Corridor Widths for the Study Area

North Oakville Creek		**Reach**	**Corridor Width (m)** Belt Width + 15m Setback + Erosion Setback
Sixteen Mile Creek	**A**	SMA-1	25+15+6
		SMA-2	45+15+9
		SMA-3	25+15+6
		SMA-4	40+15+8
		SMA-5	20+15+6
		SMA-6	45+15+9
		SMA-7	35+15+7

Table 6.3.4a
Stream Corridor Widths for the Study Area

North Oakville Creek		***Reach***	***Corridor Width (m)*** Belt Width + 15m Setback + Factor of Safety
		SMA-8	15+15+6
		SMA-9	15+15+6
	B	SMB-1	30+15+6
		SMB-2	35+15+7
		SMB-3	45+15+15
		SMB-4	35+15+7
	C	SMC-1	35+15+7
		SMC-2	35+15+7
		SMC-3	25+15+5
Shannon's Creek		SCH-1	25+15+6
		SCH-2	25+15+6
Munn's Creek		MUN-2	35+15+6
		MUN-3	25+15+6
Morrison Creek	**West**	MOC-W1	45+15+9
		MOC-W2	35+15+7
		MOC-W3	30+15+6
		MOC-W5	30+15+6
	Main	MOC-2	20+15+6
		MOC-4	45+15+9
		MOC-5	20+15+6
		MOC-6	35+15+7
		JC-4	35+15+7
		JC-5	35+15+7
		JC-6	30+15+6
		JC-7	20+15+6
		JC-8	25+15+6
		JC-9	25+15+6
		JC-12	20+15+6
		JC-13	30+15+6
		JC-14	25+15+6
		JC-19	30+15+6
		JC-20	20+15+6
		JC-20a	20+15+6
		JC-22	40+15+8
		JC-27a	30+15+6
		JC-36	30+15+6
Fourteen Mile Creek	**West**	14W-1	40+15+8
		14W-1a	40+15+8
		14W-2	40+15+8
		14W-3	40+15+8
		14W-4	30+15+6
		14W-9	30+15+6
		14W-9a	20+15+6
		14W-10	20+15+6
		14W-11	20+15+6
		14W-11a	20+15+6
		14W-12	25+15+6
		14W-13	15+15+6

Table 6.3.4a Stream Corridor Widths for the Study Area			
North Oakville Creek		***Reach***	***Corridor Width (m)*** Belt Width + 15m Setback + Factor of Safety
		14W-14	15+15+6
		14W-16	15+15+6
		14W-17	15+15+6
		14W-17a	15+15+6
	East	14E-1	40+15+8
		14E-2	40+15+8
		14E-2a	30+15+6
		14E-3	40+15+8
		14E-3a	40+15+8
		14E-4	20+15+6
		14E-6	40+15+8
		14E-7	40+15+8
		14E-8	20+15+6
Sixteen Mile Creek	***West***	16W-1	30+15+6
		16W-2	40+15+8
		16W-3	40+15+8
		16WA-1	45+15+9
		16WA-8A	20+15+6
McCraney Creek		MC-1	55+15+11
		MC-4a	20+15+6
Taplow Creek		TC-1	30+15+6
Glen Oak Creek		GO-1	15+15+6

An overall evaluation and development of a classification of the riparian corridor by reach was carried out and is summarized in **Table 6.3.5** and illustrated on **Figure 6.3.13.** This evaluation has led to the development of four categories of streams for management.

1. <u>High Constraint Streams where current form and function are to be preserved (red streams)</u>
   These are streams that must be protected (and/or enhanced) in their current location. The only modifications permitted would be through local enhancement or rehabilitation works. The streams included in this group typically have conditions that are unique to the stream that lend to a high value from an environmental, geomorphologic, hydrologic, or hydrogeologic standpoint (*i.e.,* significant aquatic or vegetative condition, defined valley or steam definition, significant discharge/base flow function that would be disrupted by any changes to the stream).

2. <u>High Constraint Streams with Rehabilitation Opportunities (red hatched streams)</u>
   These are high constraint and must also be maintained in their current location but provide enhancement opportunity to provide for effective protection and their functional role. They typically display a well defined morphology, aquatic and hydrologic role but display signs of instability or past impacts that could be mitigated.

3. <u>Medium Constraint Streams where the current function is to be preserved (blue streams)</u>
   These streams still require preservation as a riparian corridor considering their environmental, geomorphologic, hydrologic, and hydrogeologic functions. It is judged, however that their function can still be preserved if the current stream is either relocated or deepened, and, in most cases enhancements can be provided to improve the overall

resiliency of the stream network and subwatershed. Any alteration, including lowering of the channel and channel crossing, is of course subject to acquiring approval (DFO, HRCA, MNR, and Oakville).

4. Low Constraint Streams (green streams)
   Can be replaced through infrastructure or SWM.

Enhancement should be carried out on both High Constraint Streams where enhancement is required (red-dashed Streams) and Medium Constraint Streams. The enhancement recommendations include the following.

a) Re-establish a functioning floodplain

   - Creating a bankfull channel with better connectivity to a wider floodplain, or terrace, would allow the flows to overtop the banks during periods of high water levels. This excess water would then travel across the floodplain, dissipating energy across a much larger surface area. Vegetation would also decrease velocity, thus reducing erosion issues downstream

b) Provide a low-flow channel

   - Creating a low-flow channel will provide storage and refuge for aquatic organisms during drought conditions

c) Re-establish a 'natural' meander planform

   - Using reference reaches as an indication of channel planform prior to agricultural influences, it is obvious that historical ditching and straightening removed the natural meander planform of many reaches within the study area. This channelization effectively increased stream gradient and, consequently, the stream energy available to erode bed and banks. Where possible, the restoration of a more 'natural' meandering planform would decrease gradient and stream energy, thus facilitating a reduction in erosional processes along the network.

d) Re-establish riparian vegetation

   - Re-establishing a healthy riparian vegetation community would increase bank stability in addition to creating shading and improving fish habitat along the creek. The provision of bank vegetation also provides a source of woody debris and organic matter for the stream which aids in creating a more diverse morphology.

The approach taken in stream corridor management is to address the functions outlined in this strategy. As part of this, drainage of flows within the corridors, must be maintained (hydraulic function). Similarly, conveyance of flows outside the stream corridors must be maintained as well for both frequent and infrequent events. A major and minor drainage approach is to be followed with any future land use considerations to ensure that flows are conveyed safely during flood events without danger to life or property.

6.3.4.6 Considerations for Stream Relocation

Some recognition of the importance of the existing stream geometry and morphology must be incorporated in the management strategy as modifications to these factors can negatively affect aquatic habitat and overall ecosystem health. Two management options were considered:

- A very conservative approach in which all streams remain where they are and no modification or relocation is considered; and
- An approach that considers the relative quality of aquatic habitats and the sensitivity of different habitats to modification and/or relocation.

The results of this study show that there are distinct differences in the quality of aquatic habitats throughout the site. High quality aquatic habitats and important fish communities are supported by relatively undisturbed corridors with good riparian cover. It is essential that these features remain undisturbed to maintain the quality of the aquatic ecosystem. Therefore, it is recommended that any watercourse reach designated a critical or important habitat (**Section 5.0**) remain in place and not be considered for relocation. Marginal habitats may be relocated provided that enhancement opportunities are considered in the design to reverse degradation and achieve a net gain in fish habitat. It will also be important to demonstrate no net loss of aquatic habitat productivity as a result of the relocation as this is a requirement of Section 35(2) of the Federal Fisheries Act and an authorization from the Department of Fisheries and Oceans will be required for the relocations.

6.3.5 Compatible Land Uses Adjacent and Within the NHS

6.3.5.1 Compatible Land Uses Adjacent to the NHS

Generally, the issue of compatible land uses is addressed in planning and development studies through identification of a suitable buffer in conjunction with structural setbacks from selected features. When smaller buffers are used, compatible land uses become more of an issue.

In conjunction with the Core area approach suitable buffers have been recommended and included within the Cores to allow considerable flexibility in siting land uses adjacent to these natural areas.

6.3.5.2 Compatible Land Uses within the NHS

Permitted Locations for SWM Facilities

SWM facilities have received considerable current research into their potential for accumulation of contaminants and the suitability of locating these features adjacent to natural features. In the past, the SWM feature has been touted as a wildlife enhancement opportunity, but more current thinking suggests that the facilities may be integrated with local natural features if they are designed in such a way as to allow for frequent monitoring and possible clean-out. SWM facilities could only be included in the corridor if compatible with the corridor function (*i.e.,* only if the characteristics of the stream corridor are not impacted by these facilities). If fully wooded, for example, this would not be compatible. SWM facilities shall not be permitted in high constraint stream corridors and Core areas other than Core 11 as set out below.

I. Core 11

There is a minimal amount of table lands remaining in the Core areas and as such there is only one location where SWM ponds may be permitted. It has been determined that a SWM facility would be permitted within Core 11 since it will not conflict with the overall health of natural resources form and function within the core.

II. High Constraint Streams (Requiring Rehabilitation) and Medium Constraint Streams (Blue Streams)

Grading will be permitted outside of the:

- 100-year floodline;
- Meander belt allowance (Including the factor of safety);
- 6m erosion allowance;
- Confined valley (deeper than 2m); and
- 10% maximum cross slope on erosion access.

Construction and associated grading of the SWM facility shall not reduce flood storage or conveyance within the floodplain.

Grading of slopes that can be fully restored and remain undisturbed are permitted into the 7.5m Conservation Halton buffer. Slopes are to be fully restored as per management plan. Grading is only permitted to the dripline, see **Section 6.3.4.6.** for more details.

For a SWM pond adjacent to Red and Blue Streams it is important to:

- Take into account Geotechnical considerations;
- Keep out of red side dace corridors (East Morrision and Fourteen Mile Creeks);
- Understand valleys greater than 2m are considered confined; and
- Result in no negative disturbance to the form and function.

III. SWM Facilities In Linkages at Road Crossings

SWM ponds are permitted to be constructed in linkages when the opportunity exists such that a facility may outlet into an existing watercourse. The intent is to allow SWM facilities within linkages where they can be used to help direct wildlife towards the designated crossings. Opportunities for diverting wildlife towards the crossings must be considered in the grading plan for the portion of the SWM facility located within the linkage in order for the SWM facility to be compatible. Careful consideration must be taken such that wildlife is not directed away from the crossing as a result of the SWM pond and grading. Wildlife includes small, medium and large mammals, reptiles, and amphibians. Refer to **Section 7.4.2.7** for more details on wildlife crossing criteria.

The following will apply:

- Only one SWM pond will be permitted within the linkage at each road crossing;
- The intrusion of the facility cannot exceed 25m in width and 75m in length from the outmost limit of the facility, including the access area, with the exception of stream corridors which are a minimum of 120m in width where the intrusion of the facility cannot exceed 30m in width and 90m in length;
- Some minor grading will be required from the SWM facility to the outlet in the linkage beyond the 25m limit;
- Consideration will need to be given as to lowering the outlet within the linkage to secure an outlet for the SWM facility and appropriate freeboard; and
- Consideration needs to be given to providing a maintenance easement from the SWM facility to the stream.

Road Crossings

As discussed above under management options for natural features, in some cases, linkages or other natural areas may be crossed by roadways and this will create a gap in the linkage or natural feature. The provision of suitable culverts and bridges should be considered on a site specific basis. As well, considerations to prevent wildlife-vehicular interactions should also be considered (Langton, 1989; Collinge, 1996). These measures include, but are not limited to:

- Selecting roadway and linkage alignments to avoid unsafe intersections (*e.g.,* at curves)
- Use of plantings and wing-walls to direct wildlife using the linkage to culvert/bridge crossings;
- Design of culverts/bridges to accommodate wildlife movement;
- Consideration of alternative road designs to minimize the width of the gap created by the roadway (in either linkages or other natural areas);
- Locating services under the roadway is recommended to minimize roadway right-of-way; and
- Road alignments through Core Areas should be selected to avoid woodland and wetland features.

Trails

Recreational trails for pedestrian and bicycle use will require special consideration and evaluation when planning their location within the NHS. A designated trail systems associated with the NHS will be the best strategy to discourage informal trail creation (*i.e.,* trail blazing) for the public wishing to gain access to the NHS.

The following should be considered when planning the location of future trail systems:

- Trails should cross the NHS (cores, linkages and stream corridors) with existing and proposed road crossings;
- Locations where roads are flanking core areas, trails should be substituted for side walks provided winter maintenance is feasible;
- Where trail systems are proposed to cross the NHS at locations other than where a road crossing is proposed, an impact assessment will be required to ensure no negative impacts to the NHS (*i.e.*, species migration, impacts to drainage);
- Trail systems requiring winter maintenance will need to be located outside the NHS to minimize disturbance (*i.e.,* ploughing, sand and salt); and
- Trail systems are not permitted in stream valleys.

The Ministry of Natural Resources and Conservation Halton will need to be consulted as part of the evaluation of placement of trails within the NHS.

6.3.5.3 Grading and the Natural Heritage System

It is recommended that the toe of slope for any grading on lands neighbouring the Natural Heritage System match the existing grade at the outer boundary of the Natural Heritage System. The extent of grading would be detailed as part of the EIR studies.

Some grading may extend into the Natural Heritage System, as associated with:

- Re-configuration of medium constraint (blue) streams (see **Section 6.3.2.1**);
- Construction of SWM ponds where allowed into the Natural Heritage System (see **Section 7.4.2.8**);
- Cases where current tilled and furrowed lands are levelled prior to any seeding/re-vegetation;
- Roads, sidewalks and roadside services that cross the Natural Heritage System (see **Sections 6.3.4.7** and **7.4.2.3**); and
- Trails as laid out in the trails master plan.

In some cases re-grading required for development outside of, but adjacent to, the Natural Heritage System may extend into the Natural Heritage System. In these cases the following recommendations are provided.

1. For the entire Natural Heritage System:

- Grading must not negatively impact existing natural features within the Natural Heritage System, drainage or hydrogeological functions;
- Grading can only extend into agricultural lands, around the perimeter of Cores and within linkages;

- In accordance with stream corridor management recommendations (see **Section 6.3.4.6**); and
- Slopes not to exceed 3:1.

2. Specific to Cores:

- No touch areas around existing natural features of 10m around wetlands and 1m from the dripline of woodlands
- In cases where woodlands are found adjacent to the outer margin of a Core, the application of the no touch area will allow for a maximum intrusion of 9m. This maximum intrusion is to apply to all portions of Cores
- A maximum of half the slope length can occur within the Core (*i.e.*, the fill slope would be "shared" between the Natural Heritage System and neighbouring development area).

3. Specific to linkages:

- No touch areas around existing natural features of 10m around wetlands and 1m from the dripline of woodlands
- In cases where there are no existing features, grading can extend into the linkage as long as the recommendations provided in Recommendation 1 above are applied.

Grading will be subject to an EIS to demonstrate no negative impacts. The grading shall not impact existing Natural Heritage System, due to erosive flows and consideration should include cross slope drainage and spreader swales. The exact controls will need to be determined at the design stage in consultation with the Conservation Authority.

Topsoil stripping will be required and is permitted to existing driplines. Newly graded slopes will be topsoiled, planted, and stabilized immediately after construction.

6.3.6 Stormwater Management

6.3.6.1 Hydrology

The protection and incorporation of features that play a role in the hydrologic response function of a watershed role is a management tool that will assist in mitigating peak flow increases and erosion increase related to land use changes (*i.e.,* urbanization and agricultural uses). These features primarily include wetlands, woodlands and the storage contained in riparian corridors along a stream system.

In the case of North Oakville subwatershed, the hydrologic role of the terrestrial features (woodlands, wetlands) and stream riparian corridors have been taken into consideration in the characterization and analysis. As well as the identified wetland features there are a number of relatively small depressional features, some of which exhibit typical wetland characteristics and some which are seasonally wet but are also used for other purposes (*i.e.,* recreational ponds, agriculture). Some of these areas are part of the overall subwatershed drainage network system whereas others do not have a direct connection (unless the storage of the feature is exceeded and overflow takes place). This section of depressional storage areas has been discussed in **Section 5.5** and is illustrated in **Figure 6.3.15**.

The hydrologic role of the larger features can be preserved through the protection and management of these features. The development of this approach is also discussed through the environmental objectives and geomorphologic objectives of the stream system.

With the smaller features, protection of the hydrologic function of these features can be provided through either preserving all of these features or a combined approach of replacing their function through stormwater management and/or preserving selected features. Given the facts that many of these features have currently been disturbed by current land use, the lack of practicality of preserving these features over the long term and the variability in their environmental role the best approach is judged to include selective preservation/rehabilitation of features and the use of stormwater management to duplicate the role of the features in their hydrologic response function.

Management of the groundwater resources in the study area for the future focuses on management of the hydrologic cycle. Given that urbanization will change components of the cycle, the overall goal will be to maintain infiltration as close to current levels as possible. Within areas that will be preserved, the hydrologic function will remain the same. This includes the amount of recharge entering the system. In areas where development will occur, the increase in impervious areas will decrease infiltration and measures are needed to create infiltration opportunities that will offset the predicted infiltration decrease.

Taking this approach will reduce the impact to the groundwater system, including limiting changes in depths to groundwater, limiting changes to groundwater quality, and ensuring the continuity of discharge to local watercourses.

Peak Flow Control

Maintaining peak flow rates at existing levels will require infiltrating or detaining new development runoff. If stormwater detention facilities are utilized then outflow rates from a development will be determined for each return period using unit area flow rates.

Unit area peak flow rates are shown in **Table 6.3.6** for each return period and the Regional Storm. The values were developed for each watercourse that flows under Dundas Street and for the Tributary of Sixteen Mile Creek at the confluence. The unit area peak flow rates are based on GAWSER simulated peak flow rates.

These were developed to provide targets for SWM quantity control that would be refined during the development application phase. Control to existing condition peak flows is required to mitigate increases in flood potential in the receiving watercourses.

This is necessary to protect private property along the receiving watercourses. In the case of a significant valley system such as Sixteen Mile Creek, where it consists of public property, consideration can be given to not requiring control to existing condition level for the Regional Storm, as long as flood potential to private property does not exist.

The unit area peak flow rates will be used to calculate peak flow rates for each development under existing land use conditions. If the development proposes to modify the topography of depressions (shown in **Table 6.3.7** and **Figure 6.3.15**) or the drainage to the depressions, then a detailed hydrologic analysis will be conducted for the stormwater management component of the EIR. Results from the detailed hydrologic analysis will be approved by the Town and Conservation Halton. The results will include revised unit area peak flow rates for the watershed.

SWM techniques have the potential to mitigate issues associated with the change in land use (*i.e.,* increased surface runoff). Open conveyance systems such as backyard swales increase flow detention and evapotranspiration, creating a less flashy hydrograph by decreasing peak flows. SWM ponds also act to attenuate and moderate flows within the stream network. The erosion thresholds derived for the study area provide targets for the drainage network, as they were determined for the system's most sensitive reaches.

6.3.6.2 Hydrogeology

Management of the groundwater resources in the study area for the future focuses on management of the hydrologic cycle. For groundwater, the overall goal will be to maintain infiltration as close to current levels as possible. Within areas that will be preserved, the infiltration and the associated hydrogeologic function will remain the same. This includes the amount of recharge.

In areas where development will occur, the increase in impervious areas will decrease infiltration. Best efforts and the use of best available technology is needed to generate as much infiltration of precipitation as possible to offset the predicted infiltration decrease. Taking this approach will reduce the impact to the groundwater system, including limiting changes in depths to groundwater, limiting changes to groundwater quality.

<u>Management Opportunities</u>

The preferred approach to managing groundwater resources has two components. The first is managing groundwater taking and the second is managing changes to infiltration. Since there are no large water takings in the study area and future groundwater taking will be virtually eliminated with the eventual provision of municipal servicing, little needs to be done to manage future water taking.

As noted, development of the land will change the physical characteristics of the area, resulting in changes to the way and amount of water that infiltrates into the ground. Taking advantage of natural features that are opportunities for infiltration, such as topography and subsurface soil conditions, can reduce the potential for both local and regional changes in groundwater conditions.

It is known that there are occasional more localized granular zones (lenses) in the subsurface and that the water table is at a slightly greater depth at the north end of the study area than in the vicinity of Dundas Street to the south. Taking advantage of these physical conditions to create infiltration opportunities will help alleviate the infiltration deficit. Examples include the use of infiltration trenches or basins as part of the storm water management system or the discharge of clean storm runoff (*e.g.*, roof runoff) to open spaces such as front/rear yards. These can be built in either topographically higher areas or associated with more granular subsurface soils. This infiltration water enters the groundwater flow system, eventually contributing to either stream flow.

The preferred approach to managing groundwater resources has two components. The first is managing groundwater taking and the second is managing changes to infiltration. Since there are no large water takings in the study area and future groundwater taking will be virtually eliminated

with the eventual provision of municipal servicing, little needs to be done to manage future water taking.

With regard to infiltration, the overall strategy is to provide as many opportunities for infiltration as possible in the developed areas. This can be achieved by various techniques that take advantage of physical setting (*i.e.,* soil conditions and topography) as well as best available technology and management practices. By taking this approach, it is expected that infiltration will be maximized in a feasible, sustainable manner.

In addition, current discharge features along existing watercourses that provide cool water for aquatic habitat must be protected. Since these occur along stream banks and channels, the protection of stream/riparian corridors will assist in sustaining these discharge areas so that they continue to function as they do currently.

6.3.6.3 Water Quality

The watercourses in the North Oakville study area will act as receivers for discharge from SWM facilities. These facilities typically treat for a certain efficiency of suspended solids removal which in turns controls Phosphorus as this nutrient is typically bound to suspended particles. Two options for the level to which suspended solids are controlled were considered:

- For all watercourses, MOE "enhanced" level of protection could be employed (80 % removal of suspended solids); and
- Protection levels for individual facilities could be set based on the sensitivity of the aquatic community in the receiving watercourse to suspended sediment.

The water quality control approach for SWM is recommended to focus on phosphorus, suspended solids, chloride, and temperature. These are intended to provide controls to meet the objective of not permitting further enrichment of the streams (*i.e.*, nutrient control), fisheries protection and overall water quality protection. SWM is to be designed to meet the targets specified in **Section 6.2** under goals and objectives as outlined in **Table 6.2.1.**

<u>Fisheries</u>

Fourteen Mile and Morrison Creeks will be managed to protect redside dace populations. Turbidity and sedimentation associated with agricultural activity and urban developments has been cited as a limiting factor for redside dace populations (Parker *et al*., 1988; Mckee *et al*., 1982; Becker, 1983). It is recommended that SWM facilities discharging to these watercourses be designed for an "enhanced" level of protection as per the MOE guidelines. This level would not be required for other watercourses, in terms of protection for fish communities. Other factors (see water quality section) will drive the recommendation for these watercourses.

The other consideration with respect to SWM is the control of temperature with respect to the thermal regime of the creek. Temperature control at outlets can be provided through rock filtration measures combined with shading.

Temperature controlling mechanisms are recommended for Fourteen Mile and Morrison Creeks, which will require an aggressive approach to protection of temperature moderating features, both within the stream corridor and in adjacent SWM facilities. For these three creeks, stormwater discharges should be routed to a sub-surface rock filtration system, prior to discharge to the creek to ensure maximum temperature benefit to the receiving watercourse.

Control of the amount of salt being discharged from SWM facilities is also very important. Environment Canada has released a notice with respect to the *Code of Practice for the Environmental Management of Road Salts* (Environment Canada, 2004). Presently, there is no technology for removal of salts in stormwater treatment.

Annex A of the Environment Canada notice indicates that concentrations of chloride of approximately 140 mg/L should be protective of freshwater organisms for short-term exposure; concentrations less than 35 mg/L are likely protective during long-term exposures.

Annex B of that same notice identifies two situations, applicable to North Oakville, where the habitats are considered to be particularly vulnerable to the effects of road salt:

> "Areas where the addition of road salts has the potential to harm a habitat necessary for the survival or recovery of a wildlife species listed on the List of Wildlife Species at Risk (Schedule 1 of the Species at Risk Act) where the area is identified as the species' critical habitat in the recovery strategy or in the action plan for the species established under that Act"

> "Areas where the addition of road salts has the potential to raise the chloride concentration, after mixing, to levels that could harm local fish or fish habitat"

Water quality sampling for this study (**Section 4.10**) showed chloride levels in the watercourses west of Sixteen Mile creek that exceeded the 140 mg/l short-term exposure guideline in all cases and in November and December of 2002, levels were an order of magnitude higher than the criteria (Maximum concentration measured was 2740 mg/l in Sixteen Mile Creek). Although samples were not collected for watercourses east of Sixteen mile creek, it is anticipated that similar concentrations would be found as land use activities are similar to the west side.

Currently, there is no viable technology for the removal of chlorides from stormwater. Therefore, the only possibility of controlling chloride levels in stormwater discharges to natural watercourses is to consider management of chloride application during road maintenance activities. The Environment Canada notice dictates that in an area where vulnerable areas have been identified, that the municipality should:

> "…prepare and implement a salt management plan that contains best management practices to protect the environment from the negative impacts of road salts".

It is recommended that the Town of Oakville develop a salt management plan that recognizes the vulnerable areas in the North Oakville Planning area. The creeks containing redside dace survival habitat are of paramount concern due to the fact that the redside dace is listed under Schedule 1 of the Species at Risk Act as an endangered species. However, in using the criteria of the Environment Canada notice, all streams identified as having resident fish populations and/or providing aquatic habitat should be considered as vulnerable to road salt, as the application of road salt has the potential to raise concentrations in these streams to toxic levels. It is therefore recommended that the Town's salt management plan consider the entire North Oakville planning area as vulnerable, and that the most up to date Best Management Practices be prescribed for this area within the salt management plan.

6.3.6.4 Stormwater Management Applications

Most features are to be protected and remain in their natural state with vegetation preserved or enhanced. As such the features contribute to water quality improvement in several ways:

- Maintain water balance, including maintaining infiltration to groundwater and natural runoff at low rates;
- Vegetation prevents erosion of soil; and
- Vegetation intercepts nutrients and pollutants in natural flow.

The land development process changes the land use and the physical characteristics of the surface, most notably increasing the degree of imperviousness increasing runoff and decreasing infiltration. The impervious surfaces collect pollutants from traffic, urban activities on the land and aerial fallout. The drainage system delivers these pollutants to the local watercourses. In developing the land, opportunities are available to meet water quality and other objectives at the source (the land use activity), the drainage conveyance system, and at the end-of-pipe prior to discharge. A treatment train approach, which utilizes more than one measure in series to achieve objectives, is preferable to expecting the end-of-pipe facility to perform all functions to meet targets.

Master Drainage Plans and SWM Plans that are prepared as part of the development process will include consideration of management measures to meet different objectives. Many of the measures usually built for one purpose or objective can contribute to meeting more than one target of other objectives. In choosing measures it is preferable to consider source control methods first and methods such as infiltration that satisfy multiple objectives. In sizing end-of-pipe elements, consideration should be given to reductions in flow volume or pollutant loadings that occur upstream in the drainage system. This "treatment train" approach will result in cost savings for the structural end-of-pipe measures such as SWM ponds. **Table 6.3.8** illustrates this approach.

Each type of measure is discussed below, with emphasis on phosphorus control.

Low-impact Development (LID)

The *National Guide to Sustainable Municipal Infrastructure* (2003) describes LID as a site design strategy that aims to maintain or replicate the predevelopment hydrologic regime by creating a functionally equivalent hydrologic landscape. **Figure 2.1.1** illustrates the components of the hydrologic cycle of a watershed ecosystem, and the interrelationships between the various components. In a relatively natural watershed, the flow of water is controlled by topography, soil type and vegetation. Urbanization typically involves the clearing of vegetation and large-scale earth grading that alters the topography and soil characteristics. The topography is often sculptured to create a smooth surface. For example, lawns that efficiently drain water to a drainage system and convey the runoff to a SWM facility where it is stored and treated before being released from the site.

The LID approach looks at using a variety of micro-scale controls that help to restore or replicate some of these natural hydrologic pathways. Typical LID measures include:

Conservation of Natural Features (*i.e.,* Hydrologic Feature "B");
Reducing impervious areas;
Bioretention areas;
Rain gardens;
Green roofs;
Rain barrels;

Cisterns;
Vegetated filter strips; and
Porous pavements or permeable pavements.

LID attempts to replicate components of the hydrologic cycle to restore rainfall back to the hydrologic pathways. Retaining native vegetation or planting vegetation maintains interception and evapotranspiration. Rain gardens and bioretention areas may act as depressional storage areas and can aid in promoting infiltration. Rainbarrels, cisterns and green roofs may act as the interception component. When applying these micro-scale controls across a drainage area, the cumulative impacts could potentially reduce the required SWM pond size.

Many of these practices are identified as stormwater BMP's in the MOE's *Stormwater Management Planning and Design Manual*. Micro-scale controls can be integrated into the infrastructure and located throughout a site making LID an effective means of reducing runoff volume and for treating stormwater runoff by filtering out the pollutants.

The main difference between the LID approach and past approaches is that the current approach focuses on conveying, storing and treating stormwater runoff at the base of the drainage area with emphasis on end of pipe facilities. LID practices on the other hand can be integrated into infrastructure throughout the site, and are more cost effective and aesthetically pleasing than traditional stormwater conveyance systems (EPA, 2000).

Accordingly, maximizing opportunities for stormwater management at the site level using the LID approach is recommended for all future land uses.

<u>Source Pollution Prevention</u>

Source pollution prevention measures such as reduced fertilizer and pesticide use, or road salt reduction programs are addressed at specific pollutants and often do not meet other objectives. It should be noted that some pollutants, such as road salt, are not removed well by other measures, and that pollution prevention may be the only effective means of reducing the effect of the pollutant.

Additional ways to remove phosphorus include source control or pollution prevention. This involves reducing the amount of chemicals used and thus reducing the amount available for discharge to the environment. Since this type of measure can involve changing behaviour of individual residents or commercial workers, education and community action programs can play a large part of any pollution prevention program. Many measures for controlling pollutants at source are outlined in a Stormwater Pollution Prevention Handbook, (MOE, 2001). Some measures are outlined below.

- Reduced Fertilizer And Pesticide Use – Education is required for residents to apply only needed amounts to lawns. Many municipalities are reducing the area of cultivated grassed areas and allowing more natural areas to prevail in parks and other public spaces.
- Alternate Lawn Practices – Naturescaping promotes natural lawn care techniques and encourages lawn replacement with alternatives, including drought-tolerant plants. Xeriscape landscaping is an alternative landscape method that emphasizes water conservation. Replacement of lawns with meadow grasses or rock gardens with low maintenance requirements will reduce water usage and reduce the need for fertilizers and pesticides and herbicides.

- Pet Litter Control – Pet feces (often called pet litter) are deposited primarily by dogs and left uncollected by owners. This material ends up in storm drainage and causes problems of oxygen depletion, aesthetic nuisance, bacterial contamination and nutrient enrichment from phosphorus and nitrogen. Control programs involve changing individual behaviour by preventing the littering action. Public education to prevent the littering activities by individuals and their pets has the most promise. Several municipalities have dog litter control "Stoop and Scoop" bylaws.
- Municipal Operations – Some reduction in the discharge of pollutants to stormwater from street surfaces can be accomplished by conducting street cleaning on a regular basis. The primary and historical role of street cleaning is for sediment and litter control. Catch basin and stormwater inlet maintenance should be done on a regular basis to remove pollutants, reduce high pollutant concentrations during the first flush of storms, prevent clogging of the downstream conveyance system and restore the catch basin's sediment-trapping capacity.
- Salt Management Plan – Environment Canada has released a Code of Practice for the Environmental Management of Road Salts (Canada Gazette, April 3, 2004). The Salt Management Plan adopted by the Town of Oakville in Feb., 2004 predated the Gazette Notice. Accordingly the Salt Management Plan should be updated in respect to the following: "The environmental impact indicators listed in Annex A, the guidance for identifying vulnerable areas provided in Annex B and the data gathering and reporting provisions in Annex C of this Code should be considered during the development and implementation of the salt management plan." (Section 10). In particular, streams identified as vulnerable areas should receive consideration and possibly increased application of best management practices to reduce the salt impact on those areas.
- Sewer Use By-law enforcement – The Sewer Use By-law is a useful tool for the Town to control discharges to storm sewers, especially from industrial, commercial and institutional sites. By-laws in most Ontario municipalities have allowable limits on water quality parameters that may be discharged to storm sewers. They also prohibit cross connections of sanitary sewage to storm sewers. Oakville's By-law needs to be reviewed to see if it has the necessary measures and powers to provide for control of dischargers after the development process is completed.

Source and Lot-Level Quantity Controls

Source quantity controls, such as rain barrels, backyard ponds, rain gardens, rooftop storage, downspout disconnection, pervious pavements, reduced lot grading, rooftop gardens, retaining existing vegetation canopy and planting vegetation reduce the quantity of runoff. Some of the water may percolate into the ground and contribute to infiltration and baseflow targets, however much of this water evapotranspires into the atmosphere. The reduction in the volume of water aids in meeting erosion and flood protection objectives. The pollutant load in the water leaves the runoff system and remains on the surface or is filtered in the soil matrix, helping to meet water quality objectives.

- Rain Barrel Program - This provides for the reduction in runoff volume as well as reducing wash off from lawns for water quality control.
- Rain gardens (absorptive landscaping) - Designed to capture storm runoff from roof areas and infiltrate a portion directly into the ground. These depressions are planted with a variety of native wetland and terrestrial plant species and the soils can be conditioned to enhance infiltration and water storage. Enriching the soils with organic substrate store and hold water that can be used for evaoptranspiration by plants.

- Retain existing vegetation wherever possible and plant tree and shrub species that will mature to create canopy cover.

<u>Conveyance System Controls</u>

- Infiltration trenches or basins - designed to percolate surface runoff into the ground below the root zone. The water enters the groundwater flow system and contributes to meeting baseflow targets. The reduction in the volume of water aids in meeting erosion and flood protection objectives. The pollutant load in the water leaves the runoff system and is filtered in the soil matrix, helping to meet water quality objectives. The trenches or basins can be located at the source, or in the conveyance system (or at the end of the drainage system discussed below).

- Exfiltration/Filtration System - The system was installed in the former City of Etobicoke as part of a road reconstruction project. The road and sewer replacement costs would be borne in any event, so the exfiltration system need only consider additional costs of the exfiltration trench and permeable pipe. The system is suitable where soils are permeable (gravel, sand, and sandy loam). Benefits and limitations are similar to infiltration ponds. No additional space is required for the method since it is built in the road right-of-way (ROW). In industrial and commercial areas and arterial roads, the exfiltration elements should be preceded by an oil/grit separator to provide pre-treatment and additional protection for groundwater. The system can be modified for use where soils are not very permeable to provide retention and filtration as well as some infiltration.

- Natural surface Drainage - allows runoff to flow over vegetated swales and open ditches. Some of the water may percolate into the ground and contribute to infiltration and baseflow targets, however much of this water evapotranspires into the atmosphere. The reduction in the volume of water aids in meeting erosion and flood protection objectives. The pollutant load in the water that percolates leaves the runoff system and the water also is filtered by the vegetation and remains on the surface or and in the soil matrix, helping to meet water quality objectives.

- Open Ditch Enhancement - Existing ditch systems with driveway culverts provide reasonable environmental benefits. Systems that avoid curb and gutter, and also avoid deep ditches and culverts can be installed. These also improve infiltration and filtering action and enhance TSS removal by 80% or more. In areas with existing ditches, a conversion to standard curb and gutter draining with conventional storm sewers would increase the solids load by 80% if no other control measures were added.

- Bioinfiltration and Bioretention Systems – Typically have multiple components that perform different functions in storing stormwater runoff and pollutant removal. The typical components of the system include vegetation, granular drainage layers, vegetated buffer strips, topsoil, ponding or storage areas and organic layers. The diversity of different substrate types provide habitat for a diversity of microrganisms capable of removing different containments and nutrients in the stormwater runoff. These systems also have features that help to filter and promote sedimentation of larger discrete particles in the stormwater runoff.

Suitability Criteria is where space is available, soils are permeable and groundwater is not vulnerable to stormwater contaminants.

End-of-Pipe Facilities

- Wet Ponds - Typically at the end of the drainage system as part of the SWM pond. The wet pond portion serves a water quality improvement function primarily by sedimentation, to remove total suspended solids and associated pollutants such as total phosphorus and metals.

- Infiltration Ponds - Infiltration systems remove pollutants from the runoff system, increase base flow and help control temperature. Soil permeability must be suitable to allow rapid draining of water into the soil. Concern about contamination of drinking water aquifers will limit the application to residential areas and roof drains from other types of land uses. They have a space requirement similar to SWM ponds with higher benefits. The are suitable where space is available, soils are permeable and groundwater is not vulnerable to stormwater contaminants.

- Outlet Filter - Addition of an under-drained filter following a pond will increase performance. High flows will be bypassed. Since the pond attenuates flow, smaller outlet filters are economical. There must be additional head to allow for the water to pool 1m above the filter and for the under-drain to function under gravity flow. There is an additional area requirement of approximately 50% increase in the conventional pond size. If space is limited, underground filters as described below may be used. For phosphorus control specifically, special media can be used to increase performance at a higher capital and operating cost.

- Extended Detention - Usually included in a SWM pond and is that portion of runoff that is allowed to fill the pond during a rain event and drain out slowly over 48 or 72 hours. This slow release of water contributes to meeting baseflow, erosion and flood protection targets. Sedimentation of this water also occurs contributing to water quality targets.

Treatment Train Evaluation of Performance

A procedure for calculating the efficiency of several measures applied in series or treatment train is provided in *A Stormwater Retrofit Plan for the Centennial Creek Subwatershed* by James Li, Don Weatherbe, Derek Mack-Mumford, and Michael D'Andrea, (1998 W. James ed.).

> "A multi-efficiency model is used to estimate the cumulative volume (N_v) and solids loading (N_s) reduction efficiencies of a series of RSWMPs

$$N_v = \left[1 - \prod_{i}^{n} (1 - \eta_v) \right] * 100\%$$

$$N_s = \left[1 - \prod_{i}^{n} (1 - \eta_v)(1 - \eta_s) \right] * 100\%$$

where i is the i^{th} RSWMP, n is the total number of RSWMPs, η_v is the runoff volume reduction efficiency of a RSWMP, and η_s is the solids concentration reduction efficiency of a RSWMP. For a RSWMP which reduces solids concentration only (*e.g.*, oil/grit separators, ponds), η_v is zero (the large *pi* is the symbol for product summation). For a RSWMP which reduces runoff volume only (*e.g.*, downspout disconnection, stormwater exfiltration systems), η_s is zero. This procedure was incorporated into the water quality loading model discussed earlier in the analysis component of the report (**Section 5.7.2**) when calculating performance of multiple methods in meeting targets for TSS removal or TP control in new developments**.** In the Oakville Loading Model the following assumptions are made:

- Source control measures are implemented first, primarily consisting of measures to control phosphorus;
- Infiltration measures are implemented secondly, with a reduced load of TP and/or TSS. Loadings of TP and TSS are reduced in proportion to the amount of water infiltrated. The amount of infiltrated water is compared to infiltration targets. Since infiltration maybe limited by site/soil characteristics, retention was considered as a similar means of TP and TSS removal; and
- End-of-pipe measures are implemented last in the treatment train, and remove a portion of the remaining pollutants after source control and/or infiltration measures are applied.

Additional control strategy scenarios were set-up and tested to see if targets for TSS and TP could be met.

Results

Infiltration/Retention Controls

Different measures discussed above can be applied in various configurations to reduce runoff. Typically, infiltration can be either deep in to the ground where it replenishes aquifers, or into surface soils where most of the water will either evaporate or transpire through the action of vegetation into the atmosphere (evapotranspiration). The measures consist of specific infiltration measures such as infiltration ponds and galleries or exfiltration systems in the right-of-way, or surface retention in ponds and flow over vegetated surfaces such as swales and open ditches. The different cases modelled are described in **Table 6.3.9.**

Table 6.3.9 **Infiltration/Retention Cases and Results**							
					Increase		Total
	Residential		Commercial /Industrial		m^3x1000	mm over the watershed	mm
Assumed Infiltration					697.14	17	40
	Infiltration – Runoff Volume reduction %	Area Applied - %	Infiltration - Runoff Volume reduction %	Area Applied - %			
Case 1	10	80	5	60	670.65	16	39
Case 2	10	80	10	80	971.16	24	47
Case 3	25	80	25	80	2427.91	59	82

Source Controls

Source controls were applied in the scenarios for phosphorus only, since the TSS targets were met or exceeded without addressing additional controls for TSS.

Two levels were considered (see **Table 6.3.10**).

Table 6.3.10 **Levels of Source Control applied in Scenarios for Phosphorous**			
	% reduction of TP	Area applied %*	Comment
Source control	5	100	Fertilizer reduction
Enhanced source control	20	100	Limited fertilizer use and /or end-of-pipe filters

* Residential and Commercial /Industrial land uses only

The enhanced level of control would be difficult to achieve in practice, so it may be substituted for by end-of-pipe specific media filters designed to remove TP.

Scenario Description and Results

Scenarios for management of stormwater runoff were introduced in the Analysis Section (**Section 5.7.6)**. Some discussion from the Base Scenario, and Future Scenario's 1 and 2 is repeated here for completeness.

Base Scenario. Existing Development. This scenario is provided for comparison purposes. Loadings and runoff volume for all scenarios are provided in **Appendix HH - Water Quality Loading Model Results.** Summary results are given below in **Table 6.3.11.**

Scenario 1. Future Development Uncontrolled. This shows the change in land use effect in increasing runoff volumes by 76%. Note that runoff volume increases from 7% of rainfall to 36%

as a result of increased imperviousness of roadways, parking lots and roof surfaces. The total suspended solids load and total phosphorus loads increase by 53% and 141% respectively due to the increase in runoff and the change in concentration of the runoff.

Scenario 2. Future Development Controlled to Level 2. This gives results with the same land uses as shown for Scenario 1, but with stormwater management ponds included for the new urban developments to Level 1 control (80% TSS removal and 65% TP removal). This is considered appropriate for possible consideration as a control level to be implemented in these catchments, given the type of fisheries present and the objective for nutrient control. Note that with controls, the total suspended solids levels are not increased over the predevelopment condition, while the total phosphorus levels are 10% above the predevelopment condition.

Table 6.3.11:
Results of Management Scenarios Water Quality Loading Model

	Total Phosphorus	Total Suspended Solids	Infiltration/ Retention
Approach for Scenario	0% Increase from Base	Level 1/ Level 2	40 mm (17 mm more after development)
Scenario			
Base Condition	Base	Base	40
Future Scenario 1 – Development Uncontrolled	141%	No control	23
Future Scenario 2 – Development Controlled to Level 1	10%	Level 1	23
Future Scenario 3 – Development Controlled to Level 1 with infiltration/retention controls (case 1)	6%	Level 1	39
Future Scenario 4 – Development Controlled to Level 1 with infiltration/retention controls (case 2)	4%	Level 1	47
Future Scenario 5 - Level 1 with infiltration/retention controls (case 2) Plus Source Control	1%	Level 1	47
Future Scenario 6 - Level 1/2 with infiltration/retention controls (case 2) + enhanced Source Control	- 1.5%	Level 1/2	47
Future Scenario 7 - Level 1/2 with enhanced infiltration/retention controls (case 3) + Source Control	-0.2%	Level 1/2	82

Future Scenario 3 - Development Controlled to Level 1 with infiltration/retention controls (case 1). This results in improved TP control, with loadings reduced to 6% above the base level with measures to retain or infiltrate water. Infiltration to provide for water balance would be achieved as well, if specific infiltration devices are employed extensively.

Future Scenario 4 - Development Controlled to Level 1 with infiltration/retention controls (case 2). This scenario assumes increased infiltration retention controls that effectively double the water losses to the ground and atmosphere compared to case 1. This causes further reductions in TP loads to 4% above the base level.

Future Scenario 5 - Level 1 with infiltration/retention controls (case 2) Plus Source Control.

With Source control consisting of fertilizer reductions, the TP target is met (marginal increase of 1% compared to the base level).

Future Scenario 6 - Level 1/2 with infiltration/retention controls (case 2) + enhanced Source Control. With this scenario watershed management areas that have level 1 targets for TSS control based on the need for enhanced fishery protection are given level 1 TSS control (Morrison Creek and 16 Mile Creek). The other management areas are allowed to have Level 2 controls. This has the effect of reducing the TP treatment level at the end-of-pipe stormwater management pond. In order to meet TP targets additional controls were assumed by enhancing the source control to 20%. This may be difficult to achieve with source controls alone, so additional measures may be substituted such as end-of-pipe filters designed to remove TP. This had the result of slightly exceeding the TP objective and meeting all others.

Future Scenario 7 - Level 1/2 with enhanced infiltration/retention controls (case 3) + Source Control. As Scenario 6 some watersheds are given level 1 TSS control while other management areas are allowed to have Level 2 controls. In order to meet TP targets additional controls were assumed by enhancing the infiltration/retention measures even further. This may be difficult to achieve with infiltration/retention controls alone, so additional measures may be substituted such as end-of-pipe filters designed to remove TP.

Other combinations of enhanced source control and enhanced infiltration/retention controls would also achieve the TP, TSS, and infiltration goals.

<u>Conclusion</u>

- Application of Stormwater management at the end-of-pipe to Level 1 of control meets TSS control targets, while controlling TP loads to 10% above the base load.
- Application of infiltration/retention methods (in addition to the end-of-pipe controls to Level 1) can provide for infiltration and TSS targets and further reduces TP loads to 4% to 6% above the base loading level.
- With the addition of source controls for phosphorus reduction (in addition to infiltration/retention methods and the end-of-pipe for to Level 1) TP and TSS targets are met.
- Alternate scenarios were tested with reduced end-of-pipe controls to allow Level 2 of control for areas not requiring Level 1 on the basis of fishery targets. Since this reduces the phosphorus control, the loading model shows the enhanced source control or enhanced infiltration/retention controls can meet TP targets. These scenarios would be difficult to achieve in practice, so additional end-of-pipe controls may be necessary (end-of-pipe filters).

<u>Discussion of Phosphorus Removal</u>

Phosphorus is a naturally occurring element, which is necessary for life functions of plants and animals, since it performs a unique function of transferring energy in the life processes. In order to promote growth of plants, it is added as a fertilizer to agricultural crops and residential lawns and gardens. It is present in soluble and sediment bound fractions, with a common ratio of 2/3 sediment bound and 1/3 soluble. Phosphorus in the sediment forms can consist of plant and animal material, or bound to inorganic sediments. The targets for phosphorus control are in units of load or mass over time (kg/day or kg/year) of total phosphorus, which measures both the soluble and sediment forms.

A variety of processes are used to control phosphorus in treatment plants including sedimentation, uptake by biological organisms, adsorption of soluble phosphorus to particles (such as clay), and chemical precipitation with iron salts or lime. In stormwater runoff treatment, sedimentation and uptake by plants is the most common method, along with infiltration. Any method that reduces runoff also reduces the load of phosphorus. Many methods involve more than one process. Stormwater management ponds that retain a wet pool (called wet ponds) provide for both sedimentation and uptake by biological organisms such as plants and bacteria. The biological uptake can be enhanced by the addition of aquatic plants in artificial wetlands. Wetlands may require harvesting of plant tissue to continue to absorb phosphorus, since some have shown that they can be saturated with the nutrient.

This points out the significance of the phosphorus cycle. As a nutrient involved in biological growth it will cycle in the environment. Available in water or sediment, it is taken up by plants only to be released as the plant material decays and becomes available for other plants to use. It is preferable to infiltrate the phosphorus into the ground, where it remains attached to sediment that filters out in the soil or adsorbed to soil particles. **Table 6.3.12** summarizes the capability of different types of control practices to remove phosphorus.

Table 6.3.12
Phosphorus Removal Capability of Stormwater Management Measures

Process	Measures	Phosphorus with Sediment	Soluble Phosphorus
Sedimentation	Sediment forebays; ponds; oil grit separators	Yes	No
Infiltration	Infiltration ponds and trenches; grassed swales; downspout disconnection	Yes	Yes
Filtration with sand	Sand filters	Yes	No
Filtration with special media	Sand peat mixed media filters; iron salts media; zeolite media.	Yes	Yes
Municipal operational source control	Street sweeping; catch basin cleaning	Yes	No
Residential source control	Reduced fertilizer use; alternate lawn practices	Yes	Yes

6.3.7 Conclusions

The proposed management strategy provides an approach that will meet the subwatershed goals and objectives set. This will be accomplished through both the targets set and management elements proposed. The overall management strategy for the Natural Heritage System, which includes both terrestrial features and the riparian corridors, is depicted on **Figure 6.3.16**. The Natural Heritage System is composed of the Cores, Linkages, red and blue streams. Outside the NHS natural habitats are limited and less likely to be sustained.

The management elements have been described in this section and are summarized in **Table 6.3.13.**

6.4 MONITORING STRATEGY

6.4.1 Principles of Monitoring Program

Traditional master drainage planning has evolved since the 1970's into the comprehensive subwatershed planning now practised. The concerns addressed have increased the complexity and scope of the studies from quantity control for flood and erosion protection, with the addition of many issues such as water quality, aquatic biota and habitat, and geomorphology. Monitoring has been included in the more recent studies as an integral part of implementation. The Subwatershed Planning Report (MOE, MNR, 1993) stated the following:

> *"A subwatershed plan cannot be considered complete until its monitoring program is established. Monitoring programs should be designed to assess environmental changes in the subwatershed, to evaluate compliance with the plans, goals and objectives, and to provide information which will assist custodians of the plan to implement it and update it. The monitoring program should be presented as part of the subwatershed implementation plan."*

Monitoring is now considered as a necessary continuation of the subwatershed plan, designed to evaluate the need to review or update subwatershed plans, or to trigger the implementation of contingency plans that may include remedial measures needed to achieve the subwatershed goals and objectives.

The following principles are proposed as the basis of the monitoring framework.

1. Monitoring must be directed at fulfilling one or more objective sets, be subject to analysis and lead to potential actions.
2. Monitoring of receiving streams should be for identifying problems, establishing a background reference, and evaluating the effectiveness of controls.
3. Technology performance monitoring should be to confirm that the facility operates as designed, if not, determine if remedial design improvements are needed, or if it needs maintenance. This will assist in improving future designs.
4. An ideal monitoring program should be directed at connecting receiving stream impact analysis with technology performance assessment in a watershed context.
5. The strategy should recognize and incorporate existing monitoring programs.
6. Reporting on results and taking appropriate follow-up action is a key component that fulfils due diligence expectations.

6.4.2 Erosion and Sediment Control (ESC) Planning

Future construction activities taking place in North Oakville will require clearing of vegetation, topsoil stripping and earth grading that leaves exposed soils vulnerable to wind and water erosion. Stringent sediment and erosion control measures will need to be implemented to ensure that the adjacent natural heritage system is not negatively impacted by construction practices. Sediment release due to construction activities is not only detrimental to the health of the receiving NHS but will also result in costly future maintenance work of the existing downstream drainage infrastructure.

Prior to construction, comprehensive erosion and sediment control (ESC) plans must be submitted to the Town and Conservation Authority detailing the methods that will be used to prevent the release of sediment laden runoff from the construction site. There are extensive sediment and erosion control guidelines available that describe the design considerations, application and function, implementation procedures, maintenance procedures and removal procedures for a wide variety of sediment and erosion control measures for construction sites. The following is a list of existing guidelines currently used in Ontario:

- *MNR Technical Guideline: Erosion and Sediment Control;*
- *MTO Drainage Management Manual (1995 – 1997); and*
- *Erosion and Sediment Control Guidelines for Urban Construction from Source to Solution.*

The *Erosion and Sediment Control Guidelines for Urban Construction from Source to Solution* has been written specifically for the GTA area. In order to develop the most effective ESC plans for North Oakville, these guidelines must be consulted before submission of an ESC plan. The comprehensive checklists provided in these guidelines are specifically designed to assist developers, contractors and inspectors with developing and implementing effective ESC plans.

Typical sediment and erosion control best management practices currently in use today include but are not limited to:

- Sediment traps, dewatering traps;
- Sediment control fencing;
- Check dams;
- Inceptor swales and ditches;
- Temporary stabilization measures of exposed soils (*e.g.,* erosion control matting, seeding, hydro seeding, and mulches);
- Construction mud matts; and
- Protecting surface inlets with filter cloth.

In order for these measures to be truly effective, they will need to be monitored regularly by the contractor to ensure that theses measures are maintained in proper working order throughout the construction phase and until the site has become fully stabilized.

6.4.2.1 ESC Inspection

Approved sediment and erosion control plans are to be monitored at the start of construction and throughout the construction phase until the site has become fully stabilized. The contractor will be required to perform routine (minimum once a week) sediment and erosion control inspections to ensure that the sediment and erosion control measures are maintained and functioning as intended. Sediment and erosion control measures shall be inspected:

- Prior to forecasted rainfall events to ensure that the measures are in proper working condition;
- During rainfall events to observe in-situ performance; and
- After rainfall events to identify measures that may require immediate repair or maintenance.

The following provides examples of thresholds for when maintenance work is required:

- Once sediment accumulation in sediment traps, sedimentation basins, dewatering traps, catchbasins among others occupies 60% of the available volume a cleanout will be required;

- If sediment accumulation depths behind silt control fencing, granular berms, etc. exceeds 300mm the sediment must be removed; and
- Filter fabric protection of surface inlets and discharge points to be checked and replaced regularly (*i.e.,* after heavy rainfall events).

The inspection reports will verify that the sediment and erosion control measures are in place and properly maintained. In the event that the proposed ESC plans are not operating as intended corrective measures shall be taken immediately.

Appendix II provides a generic sample checklist style report that the contractor can fill out and submit the Town of Oakville and Conservation Halton as part of the inspection program. The checklist should be developed based on templates provided in the Erosion and Sediment Control Guidelines for Urban Construction Guidelines and modified accordingly for North Oakville.

6.4.2.2 ESC Monitoring

In addition to weekly inspections the contractor shall also be responsible for submitting regular water quality monitoring reports. As explained above, the inspections will verify and ensure that sediment and erosion control measures are in place and maintained. The water quality testing will ensure that the sediment and erosion control measures are performing and preventing the release of sediment laden water into the receiving watercourses and NHS.

The water quality parameter to be measured is Total Suspended Solids (TSS) and samples shall be required during and after rainfall events applying the following criteria:

- Stormfall events greater than 10mm (verify rainfall volume with on-site rain gauges); and
- Take discrete water quality samples of stormwater runoff leaving the site at all outlets regardless of where they outlet during and after rainfall events.

The measured TSS concentrations will provide Town staff with an indication of how the concentrations compare to typical TSS concentrations for construction sites with similar soil types. Threshold concentrations will be established to trigger when town staff need to perform independent inspections. Through site inspections it can be determined whether the sediment and erosion control measures are in need of maintenance, are improperly installed or whether additional measures need to be added to the existing treatment train to lower TSS concentrations to acceptable levels.

6.4.3 Monitoring Parameters

A major component of a subwatershed plan is SWM. It usually results in the construction and operation of built works such as stormwater ponds, conveyance features and infiltration facilities. These facilities are typically designed to meet some receiving water objectives such as: flood control, channel erosion control, water quality protection/improvement, habitat protection, and protection of biota, including fish. Thus, monitoring may involve both water quality and quantity monitoring that may be in stream or at other locations.

In-stream monitoring parameters can be both specific constituents or surrogates. The specific parameters are typically related directly to the objective or use being protected, whereas, for stormwater facilities, indirect parameters or surrogates are often used as indicators when monitoring system performance. In other words, different parameters will have to be identified and monitored to evaluate the system effectiveness in-stream and performance in the facility. The effectiveness is measured by comparing the monitoring results to the targets established for the parameters for each objective. **Table 6.4.1** illustrates this point. Monitoring in a watershed for the facility and watercourse elements will take advantage of the common elements for all objectives (*i.e.,* rain, flow, water quality, and toxicity data). Objective specific data will have to be collected for erosion control, and aquatic habitat and biota.

Table 6.4.1
Monitoring Parameters for SWM Objectives

Objectives	**Flood Control**	**Channel Erosion Control**	**Water Quality Improvement**	**Habitat/Biota Protection**
System Element				
SWM Facility	Rainfall, peak flow rate, water level, flood flow routing, draw down time	Rainfall, flow rate and duration, water level	Pollutant removal efficiency, sediment accumulation	Discharge water quality, toxicity
Watercourse	Peak flow rate, water level, property damage	Flow rate and duration, water level, bank erosion, channel modifications stable, velocity, bed substrate, bank recession, down cutting of channel, bank vegetation	Water quality improved? PWQO met? Subwatershed targets met?	Habitat parameters /indices (including physical parameters), toxicity, macro invertebrate indices/fish health indices, biomonitoring

For the North Oakville Subwatershed, two types of monitoring programs are proposed:

i) performance assessments of stormwater facilities, and
ii) watershed effectiveness assessment to ensure targets are met.

6.4.4 Performance Assessment Monitoring for Stormwater Facilities

Objectives:

- Determine whether performance of control facility meets design objective
- Can facility be assumed from developer?
- What level of continued monitoring and maintenance are needed?

Following construction, each facility should be inspected and compared to the design by municipal staff to ensure compliance and a monitoring policy should be implemented. The facility should be monitored for compliance for a minimum period of two years under the ownership of the developer starting once the development has been assumed by the Town. A monitoring report should be provided to the Town, Region, and Conservation Halton twice per year for the two year period. Responsibility for and ownership of facilities would be assumed by the agencies after a period of three consecutive years of monitoring that confirms the targets and objectives have been met. Should the monitoring show non-compliance, the developer would be responsible for implementing the contingency plan/remedial measures and continued monitoring until the monitoring confirms compliance for three consecutive years.

Analysis:

- Operations Monitoring
  - Compare infiltration, flood control and quality control pond hydraulics to design specifications for flow splitting, volume controlled, drawdown time and released flow rates. Compare total capture to expected volumetric control level. Compare quantity control hydrology to what was expected as the modelled performance. May need to apply models for some analysis steps. Calculate removal rate efficiency of parameters and compare to established targets.

- Maintenance Monitoring
  - Observe or measure sedimentation in channels, sediment build-up in ponds, berm erosion, litter build-up, clogging of inlet and outlet structures, free operation of moveable control elements, health of wetland plants, pond security and gratings, etc.

Action Plan/ Remedial Action:

- Facility functioning as designed – Town assumes facility from developer;
- Modify pond hydraulics – continue monitoring until facility meets targets and can be assumed from developer;
- Maintain pond;
- Replant aquatic plants;
- Remove sediment buildup; retrofit additional controls in pond or upstream in drainage area – continue monitoring until facility meets targets and can be assumed from the developer;
- Modify design and/or targets for future similar cases.

6.4.5 Effectiveness Assessment Monitoring

Proposed Program:

Following construction, each stream course should be inspected by municipal staff to determine whether targets are being met. The stream should be monitored by the developer for compliance for a minimum period as specified by the Town of Oakville. A monitoring report should be provided to the Town, Region, and Conservation Halton twice per year for period specified by the Town of Oakville. Responsibility for future monitoring will be discussed with the agencies after the monitoring confirms the targets and objectives have been met. Should the monitoring show non-compliance, the developer would be responsible for implementing the contingency plan/remedial measures and continued monitoring until the monitoring confirms compliance for three consecutive years.

Objectives

- Determine effectiveness of measures (upstream control facilities) in-stream.

- Flow rates not increased over pre-development (flood and erosion objective).
- Flow velocities (impulse) not increased (erosion control objective).
- Maintenance of base flows.
- Channel and bank erosion not increased.
- Water quality improved.
- Aquatic habitat conditions acceptable.
- Biota diverse and healthy.
- Lack of toxicity.

Analysis:

- Compare observed conditions to Subwatershed Study results. Reference can be to upstream control, pre-development conditions at the same site or to a parallel site. Also compare to published standards, (*i.e.,* PWQO), or acute lethality criteria. Compare to subwatershed targets.

Contingency Plan/Remedial Action

- Remedial measures in stream.
- Additional controls upstream.
- Retrofit control within existing facilities.
- Modify control requirements for future sites.

6.4.6 Monitoring Program

6.4.6.1 Terrestrial

The focus of the terrestrial monitoring program is to detect potential changes in habitats and populations in the study area.

<u>Vegetation Communities</u>

Monitoring changes in vegetation community composition and boundaries will assist in detecting changes as a result of natural succession, plantings (see below), and potential impacts as a result of development.

The use of the standardized Ecological Land Classification (ELC) system allows for the review and monitoring of vegetation community composition and boundaries over time. This approach has been used in a number of similar studies in which the extent of vegetation communities has been monitored using field surveys and/or aerial photography.

- **Woodlands**

  Woodland monitoring should consist of a series of standard permanent monitoring plots following a standard protocol (for example, see City of Waterloo 1998). The monitoring should include evaluations of the various strata within the woodlands (canopy tree, regeneration, herbaceous vegetation). This monitoring should be conducted in concert with wildlife monitoring (see below).

- **Wetlands**

  The treed and shrub dominated swamps should be monitored as per the woodlands (see above). Marsh wetlands should also be monitored for vegetation composition as well as limits. This monitoring should also be conducted in concert with wildlife monitoring (see below).

- **Restoration and Natural Succession**

  In a number of locations recommendations are provided for the establishment of native woody species (for example along stream corridors and in portions of Cores). Much of this is anticipated to occur by natural regeneration. Monitoring the establishment of these plantings is recommended.

Wildlife

Wildlife monitoring is recommended to consist of breeding bird surveys, as well as amphibian monitoring. These two groups of species are fairly readily monitored and are sensitive to changes in habitats and potential impacts of development. Standard monitoring protocols are in use throughout southern Ontario and can be used to track changes in species overtime.

- Birds **-** The Ontario Breeding Bird Atlas protocols should be used to monitor breeding birds at strategic locations in the study area.
- Amphibians - Early spring call surveys following the standard Marsh Monitoring protocol should be conducted at strategic wetland areas.

6.4.6.2 Streams

Stream Morphology

With respect to stream morphology, there are several monitoring program recommendations that can be made. First, some high quality baseline monitoring data has already been collected over the duration of this study, including control cross-sections and monitoring pins at JC-2, JC-13, SMA-4, MOC-4, 14W-1, 14W-7 and GO-1 that were established as part of the detailed field assessment. Consistent efforts to re-measure these control points should be continued and reviewed on an annual basis. Key to this effort will be landowner permission to access all of the monitoring sites. This data will prove invaluable in assessing the effects of urbanization on the stream network. Planform measurements from air photos or field surveys should be completed once every five years to assess channel migration and planform adjustment on a larger scale.

Performance targets from the monitoring should include minimal reduction in the entrenchment ratio, to ensure the channel does not become incised and functionally removed from its floodplain. Bank erosion or migration should not exceed a rate of 10 cm/year and cross-sectional areas should experience no more than a 10% increase over the annual monitoring period. Additionally, substrate sizes should not vary more than half a standard deviation from the current D50.

<u>Fisheries</u>

Riparian Vegetation

Ecological Land Use vegetation mapping as well as site specific monitoring of success of planting is proposed. This program is considered adequate to determine if the desired increase in riparian vegetation is occurring.

Stream Temperature

Stream temperature monitoring should occur for 14 Mile and Morrison Creek to determine success in moving towards the target water temperature of 18^{o}C. The methodology used should be that described by Stoneman and Jones, 1999. Stoneman and Jones propose periodic sampling on days when maximum air temperatures reach 24.5^{o}C or higher. It is recommended that continuous data logging temperature monitors be installed on these systems. These units are now very affordable and easily installed. The monitors should be in place and recording data during the months of July and August each year. Continuous data allows trends to be detected which, in combination with multiple sampling locations can help to pin down source problems in terms of stream warming. At a minimum, three stations should be established between the upstream on site limits of the stream and Dundas Street. A monitoring system as described above will allow measurement of the success of control measures (riparian vegetation and stormwater management) in moderating summer stream temperatures.

Suspended Sediment

A monitoring program is required to confirm the success of SWM initiatives to control suspended solids to the intended levels. See **Section 6.4** for details on this monitoring program.

Biodiversity

Biodiversity monitoring is recommended for fish communities on Fourteen Mile, Morrison and Joshua's Creeks and for invertebrate communities in the other watercourses. Both species richness (number of species) and evenness (distribution of individuals across species) must be incorporated in the measure of Biodiversity. Simple but well established Biodiversity indices such as those developed by Shannon and Weaver and Simpson are recommended or site specific indices can be developed as long as they are scientifically defendable. The number of sampling stations for the biodiversity program must be determined by some presampling followed by statistical review (power analysis) of the pre-sampling data.

Stream Corridors

As noted above, recommendations are provided for the establishment of native woody species along stream corridors. Much of this is anticipated to occur by natural regeneration. Monitoring the establishment of these plantings is recommended.

6.4.6.3 Hydrology

Flood Protection

The monitoring strategy is to measure streamflow on a continuous basis at a minimum of three locations within the study area. The streamflow measurements will be located along the main branch of Joshua's Creek at Dundas Street East, East Morrison Creek at Dundas Street East, and Fourteen Mile Creek at Dundas Street West.

Streamflow measurements will allow the calculation of annual peak flow rates as development progresses within the study area. Peak flow rates will determine if the Implementation Strategy has been successful. If peak flow rates increase, modifications may be required to the outlet works of the stormwater management facilities. In addition, continuous streamflow measurements will allow the determination of flow duration curves, baseflows, and annual runoff volumes.

Table 6.3.6 provides the target unit area peak flow rates for the existing land use.

6.4.6.4 Hydrogeology – Groundwater Monitoring

Changes to the groundwater regime are usually difficult to observe and quantify. Since the focus for managing changes to the groundwater system are founded in managing infiltration, the monitoring program should also have a similar focus. Future development will also result in changes to run off and other components of the hydrologic cycle. Thus, monitoring precipitation and stream flows will provide the data needed to determine the various components of the hydrologic cycle. The data can then be used to track the various components and compare the results to the original predictions. Although year to year variations are expected, and may be relatively large, the tracking and comparison of long term trends to both historical trends and predicted changes will enable a determination of the overall success of the management plan. Should significant variations in the long-term trend occur that affect the overall study area, opportunities for implementing alternative mitigation measures can then be explored.

To confirm that the management measures are working, changes in depth to the water table should also be monitored. To complete this monitoring, a series of permanent monitoring wells could be established and monitored. One such monitoring nest has already been installed and is monitored by Conservation Halton (Moore Reservoir well). The monitoring would begin immediately to establish a track record for the wells and would continue into the future. It should be noted that, since there are relatively large seasonal and year to year fluctuations in the water table, many years of monitoring would be needed before conclusions could be made regarding long term water level impacts.

For stream reaches where there is currently an observed or interpreted groundwater discharge, future monitoring would also be done as an overall measure of stream health. This would focus on the aquatic habitat function of the reach. No specific groundwater monitoring is proposed.

6.4.6.5 Hydrogeologic Features Monitoring

The constraint mapping will have identified hydrogeologic features within the study area and will have described the overall hydrologic system. The hydrogeological components of the system to be addressed will include:

- A Water Balance evaluation, including the determination of the infiltration and groundwater discharge relationship;
- A characterization of all hydrologic features illustrated on the constraint mapping and their functions;
  A description of the relationship and interdependence of these features and functions.
- Site-specific soil and groundwater investigations to assess the potential for groundwater recharge and infiltration. This will assist in identifying appropriate Best Management practices, and

- Define other lot level measures that could be implemented and their relative benefits and assess impacts to the water table.

Documentation in the EIR should address pre and post development conditions, proposed major and minor system patterns, selected storm water management technique(s), locations of ponds, preliminary design including outlet characteristics and controls to reduce thermal impacts, outfall locations and relationship to the stream and riparian habitats, erosion and channel stability with proposed release rates.

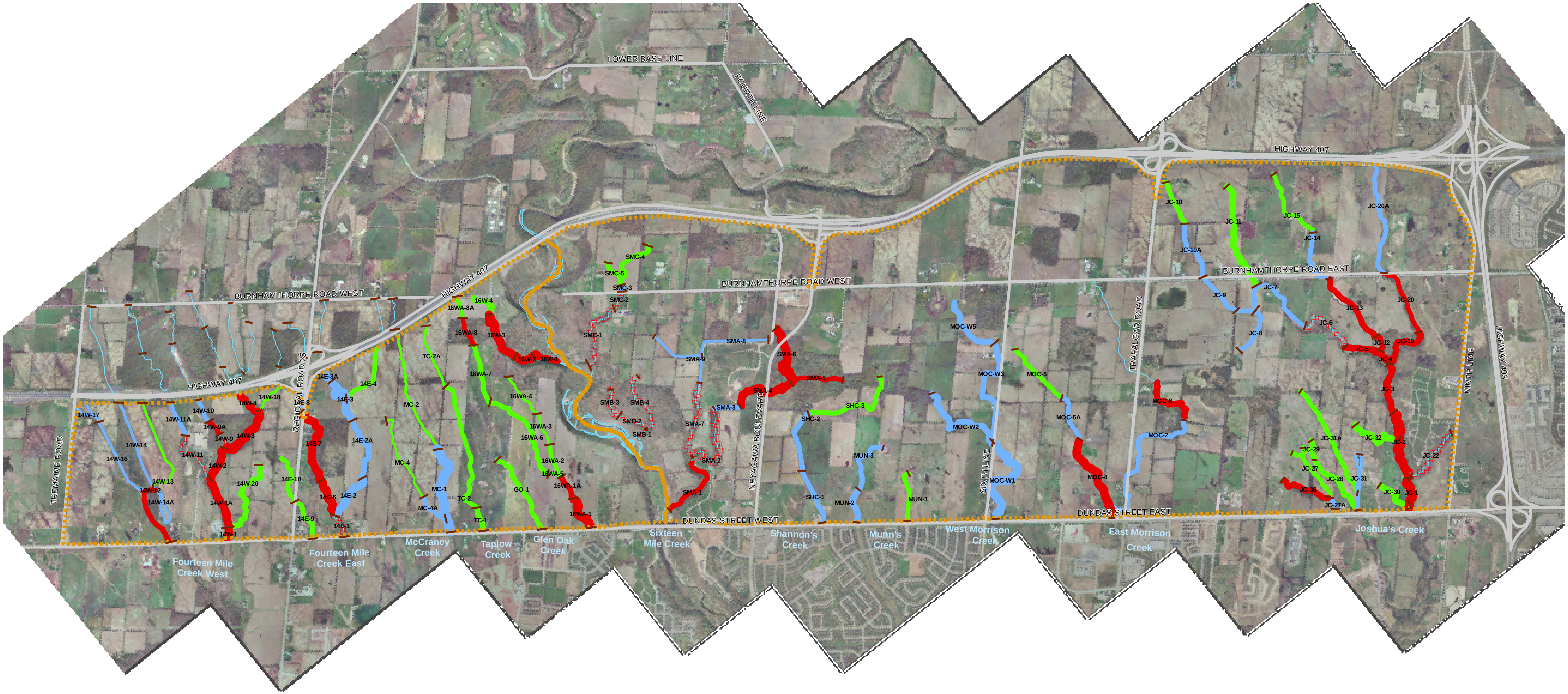
6.4.6.6 Water Quality Monitoring

The water quality monitoring program is to be based upon the objectives and targets established and management approach for water quality conditions as outlined in **Sections 6.2** and **6.3.** The parameters to be included are:

- Total Phosphorus;
- Total Suspended Solids;
- Chloride; and
- Temperature.

The monitoring of temperature is based primarily upon fisheries protection and is outlined in **Section 6.4.6.2.**

The remaining water quality parameters are to be monitored in-stream and can be linked to streamflow monitoring to provide a representation of overall effectiveness of the management strategy. It is recommended that water quality be monitored at the proposed streamflow monitoring sites (*i.e.,* main branch of Joshua's Creek at Dundas Street, East Morrison Creek at Dundas Street, and Fourteen Mile Creek at Dundas Street). The monitoring program should include continuous monitoring for nine rainfall events for the first year (to collect additional base information), followed by three rainfall events per year for each consecutive year.



NORTH OAKVILLE CREEKS SUBWATERSHED STUDY

TSH engineers architects planners

PARISH geomorphic

NATURAL RESOURCE SOLUTIONS INC. Aquatic, Terrestrial and Wetland Biologists

Donald G. Weatherbe Associates

Morrison Environmental Limited Groundwater Consultants

EWRG Environmental Water Resources Group Ltd.

OAKVILLE

August 2006

N

0 500 1,000

Meters

Legend

Secondary Plan Boundary

Road

Reach Break

Stream Corridor

High Constraint

High Constraint - Requiring Rehabilitation

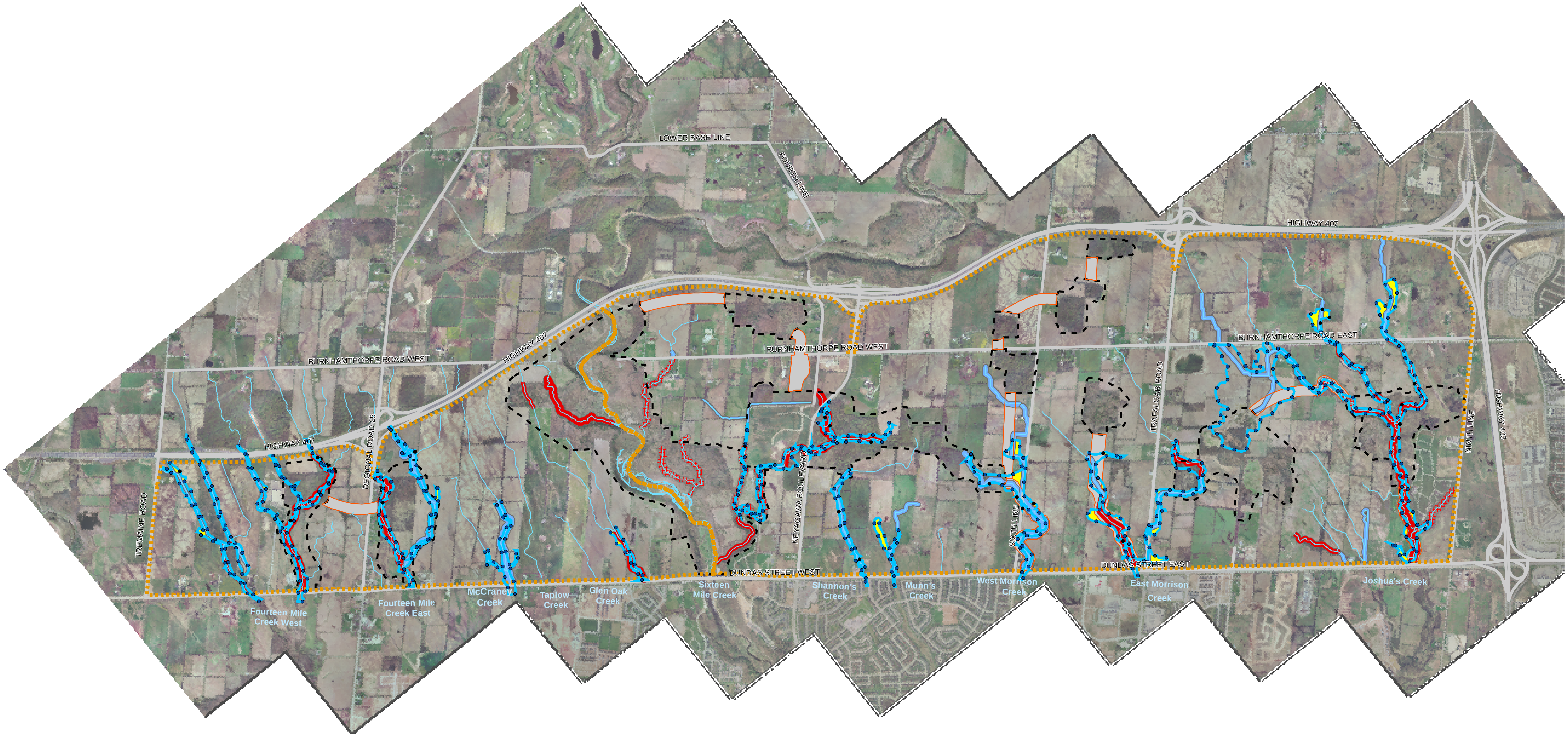
Medium Constraint

Low Constraint

Watercourse

Riparian Corridor Classification

Figure 6.3.13



NORTH OAKVILLE CREEKS SUBWATERSHED STUDY

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PARISH geomorphic
Natural Resource Solutions Inc. Aquatic, Terrestrial and Wetland Biologists
Donald G. Weatherbe Associates
Morrison Environmental Limited Groundwater Consultants
Environmental Water Resources Group Ltd.
Oakville

0 500 1,000
Meters

August 2006

Legend

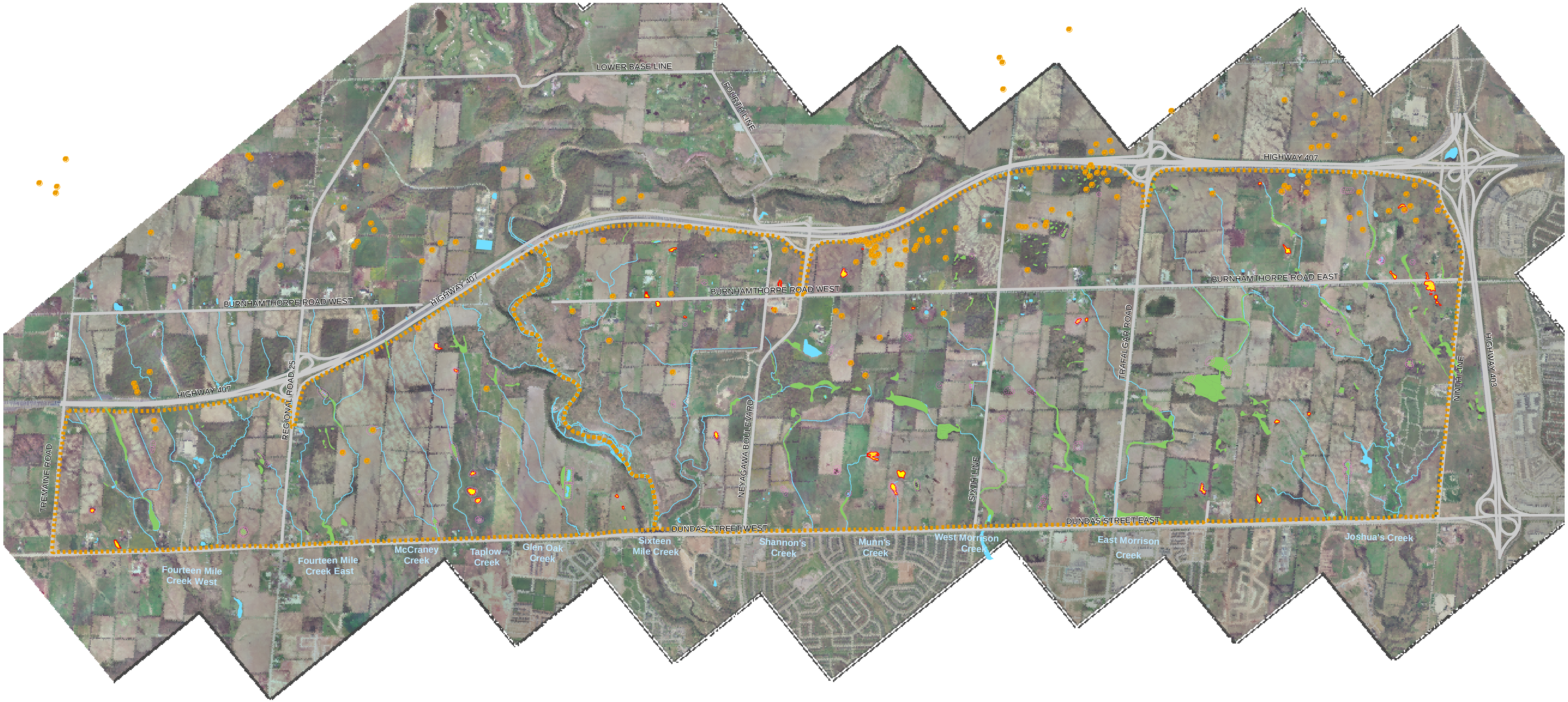
- Secondary Plan Boundary
- Core
- Linkage
- Additional Floodline Area (outside of NHS)

Stream Corridor

- High Constraint
- High Constraint - Requiring Rehabilitation
- Medium Constraint
- Floodline_Red_Blue

Floodlines Extending Beyond Natural Heritage System Boundaries

Figure 6.3.14



NORTH OAKVILLE CREEKS SUBWATERSHED STUDY

August 2006

N

0 500 1,000

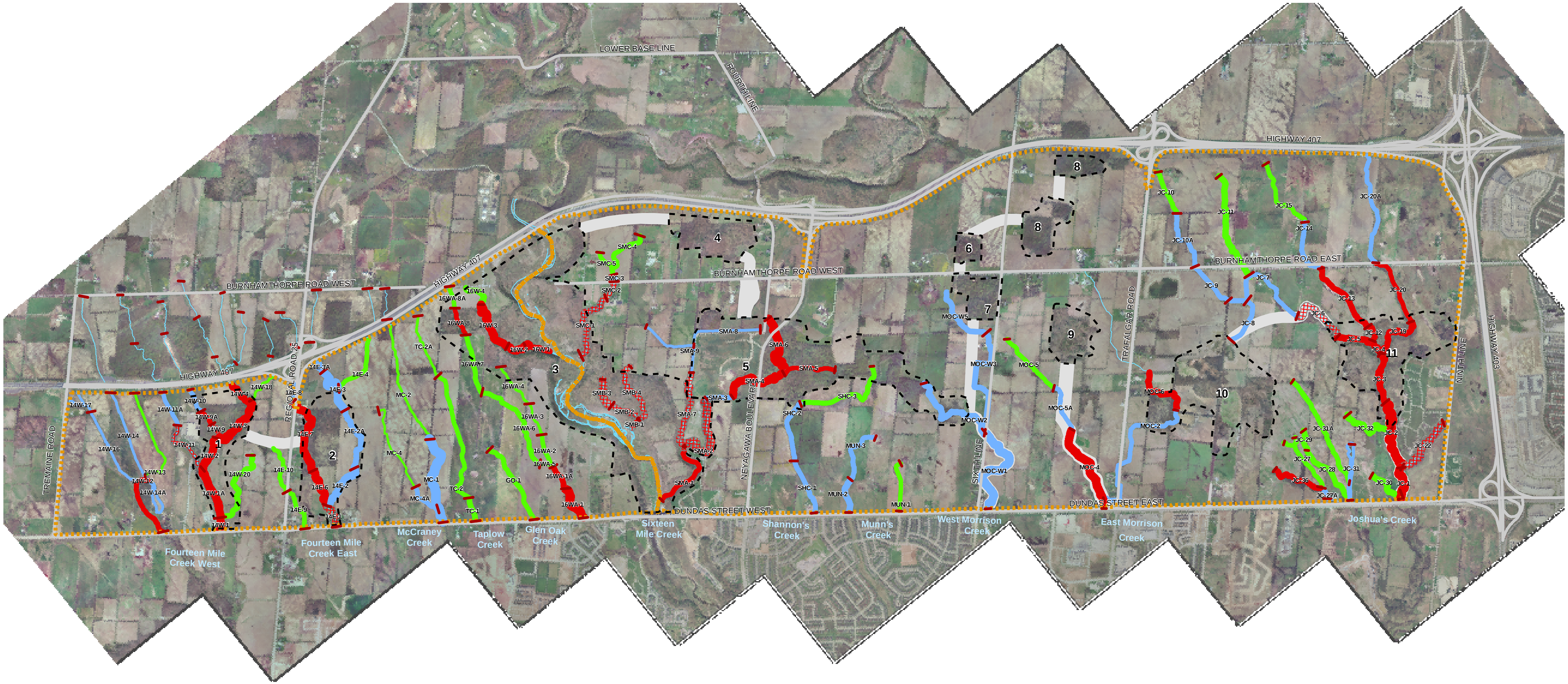
Meters

Legend

- Secondary Plan Boundary
- Road
- Watercourse
- MNR Wetlands
- Artificial Ponds
- Wetlands contributing to Hydrologic Function
- Depressional Storage Areas
- Pits

Wet Features and Depressions

Figure 6.3.15



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Morrison Environmental Limited

Environmental Water Resources Group Ltd.

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N

0 500 1,000

Meters

Legend

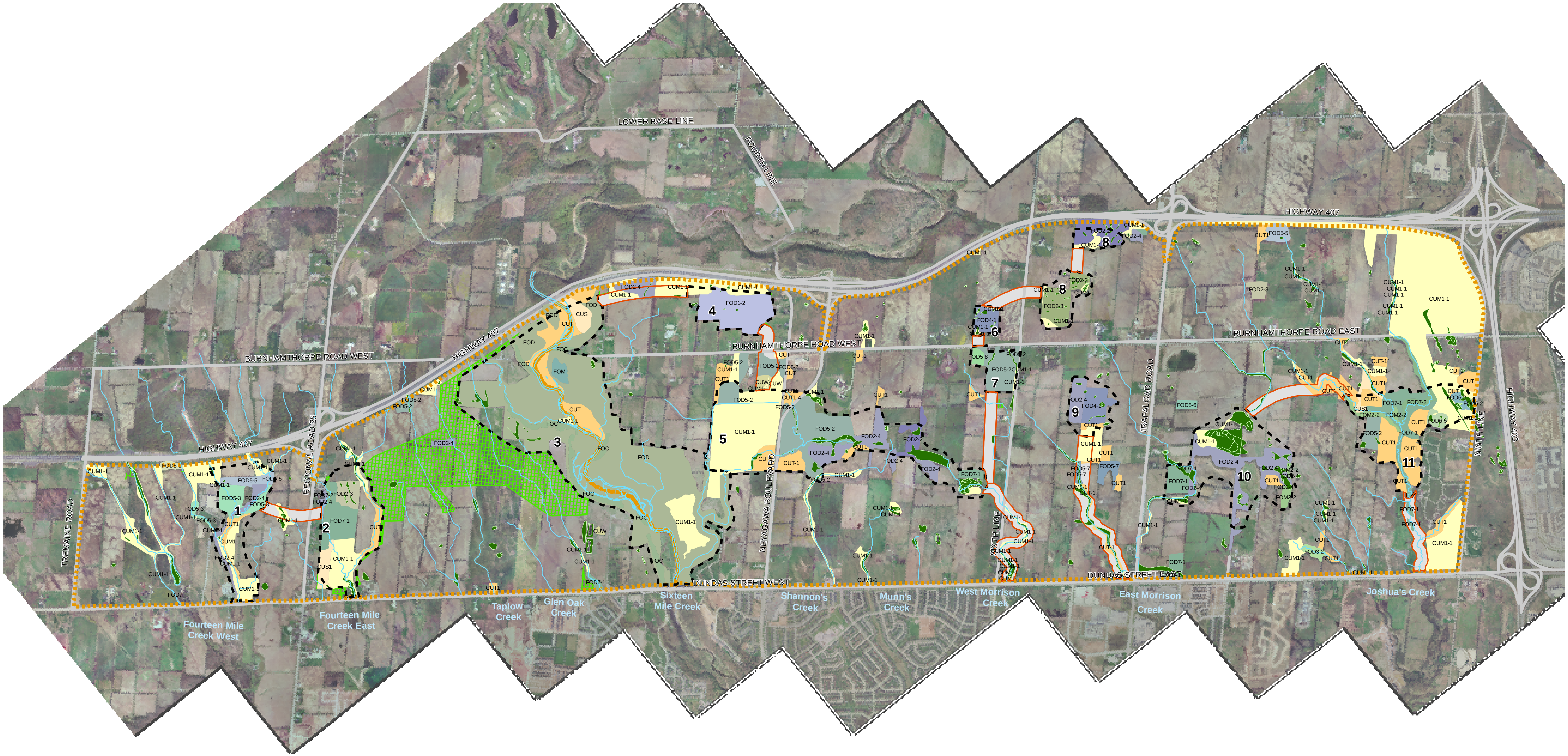
- Secondary Plan Boundary
- Road
- Reach Break
- Core
- Linkage

Stream Corridor

- High Constraint
- High Constraint - Requiring Rehabilitation
- Medium Constraint
- Low Constraint
- Watercourse

Management Strategy for the Natural Heritage System

Figure 6.3.16



NORTH OAKVILLE CREEKS SUBWATERSHED STUDY

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Morrison Environmental Limited Groundwater Consultants
EWRG Environmental Water Resources Group Ltd.
OAKVILLE

N

0 500
Meters

August 2006

Legend

- Road
- Secondary Plan Boundary
- Watercourse
- Core
- Linkage
- Wetland
- ORC Lands

ELC Descriptions

- CUM1-1, Cultural Meadow
- CUS1-1, Cultural Savannah; CUS1, Cultural Savannah
- CUT1-1, Cultural Thicket
- CUW, Cultural Woodlot
- FOC, Coniferous Forerst
- FOD, Deciduous Forest
- FOD1-2, Dry-Fresh White Oak Deciduous Forest
- FOD2-2, Dry-Fresh Oak Hickory Deciduous Forest
- FOD2-3, Dry-Fresh Hickory Deciduous Forest
- FOD2-3, Dry-Fresh Hickory Deciduous Forest
- FOD2-4, Dry-Fresh Oak Hardwood Deciduous Forest
- FOD3-2, Dry-Fresh White Birch Deciduous Forest
- FOD4-1, Dry-Fresh Beech Deciduous Forest
- FOD5-1, Dry-Fresh Sugar Maple Deciduous Forest
- FOD5-2, Dry-Fresh Sugar Maple-Beech Deciduous Forest
- FOD5-3, Dry-Fresh Sugar Maple-Oak Deciduous Forest
- FOD5-5, Dry-Fresh Sugar Maple-Hickory Deciduous Forest
- FOD5-6, Dry-Fresh Sugar Maple - Basswood Deciduous Forest
- FOD5-7, Dry-Fresh Sugar Maple - Black Cherry Deciduous Forest
- FOD5-8, Dry-Fresh Sugar Maple - White Ash Deciduous Forest
- FOD6-2, Fresh-Moist Sugar Maple - Black Maple Deciduous Forest
- FOD6-5, Fresh-Moist Sugar Maple-Hardwood Deciduous Forest
- FOD7, Fresh-Moist Lowland Deciduous Forest
- FOD7-1, Fresh Moist White Elm Lowland Deciduous Forest
- FOD7-2, Fresh-Moist Ash Lowland Deciduous Forest
- FOM, Mixed Forest
- FOM2-2, Dry-Fresh White Pine - Sugar Maple Mixed Forest
- ORC Lands

Core Area Index

Figure 6.3.3

NORTH OAKVILLE CREEKS SUBWATERSHED STUDY

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N

0 50 100 150 200
Meters

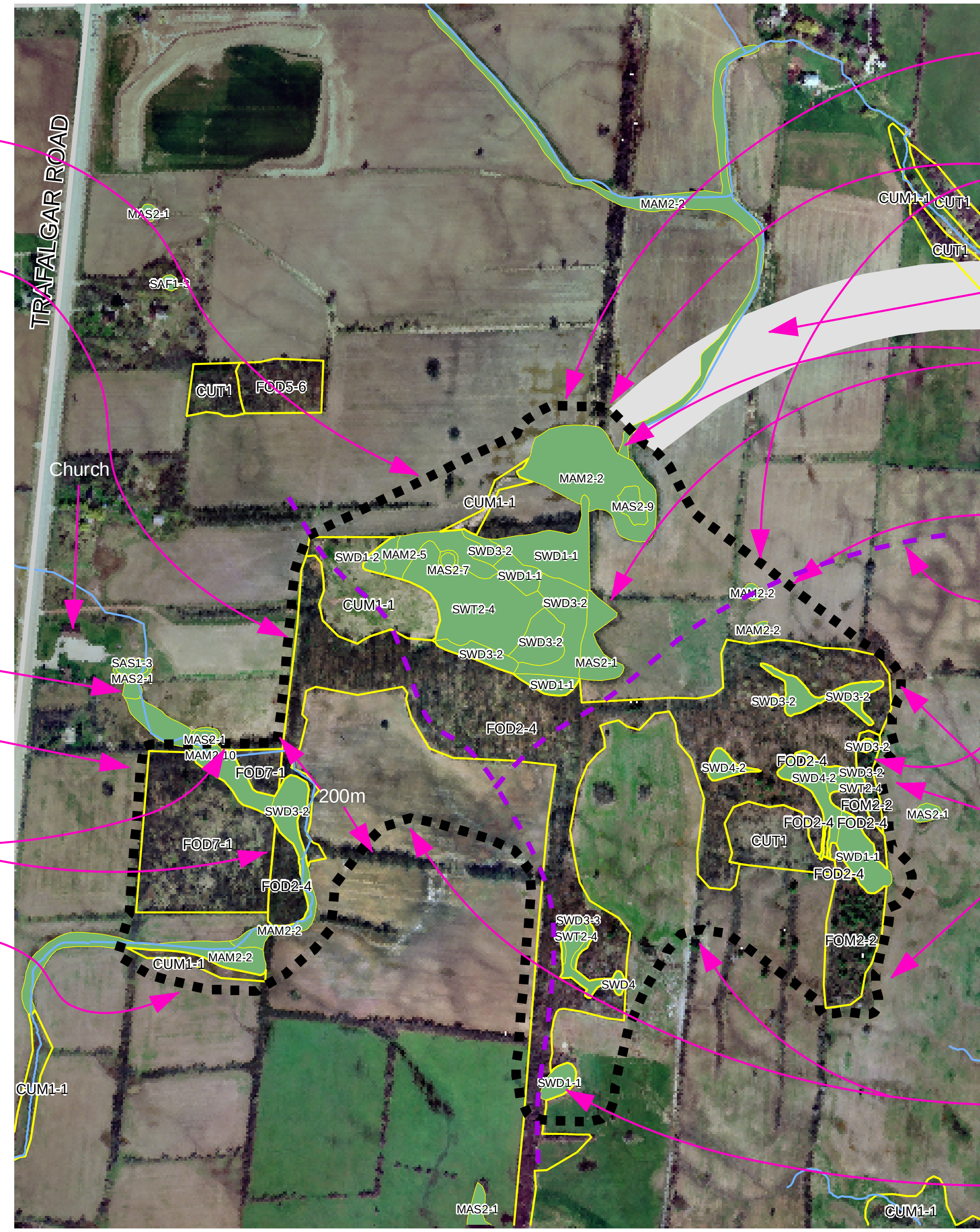
Legend
- Study Area Boundary
- Core Area 2006
- Linkage
- ELC
- Wetland
- Watercourse
- Road

Core Area #1
14 Mile Creek (Main)

Scale: 1:7,500

August 2006

Figure 6.3.4



NORTH OAKVILLE CREEKS SUBWATERSHED STUDY

0 100 200 300

Meters

Legend

- Study Area Boundary
- Core Area 2006
- Linkage
- ELC
- Wetland
- Watercourse
- Road

Core Area #10 Buttonbush

Scale: 1:10,000

August 2006

Figure 6.3.11

Streams and associated vegetation to be protected in riparian corridors

Core boundary includes forested slope and critical aquatic habitat (groundwater)

100m wide linkage between Core #11 and Core #10 associated with floodplain and creek corridor (possible realignment of creek)

Top of bank setback and floodline correspond to dripline

Forest edge with 10m buffer

Core boundary 30m from wetland

Note: Dundas Street road allowances creates a linkage of 30-40 m

Core boundary includes wetland with 30m buffer

Existing residence

Right of way to remain as open country

Borders on cemetary.
Core boundary at limit of cultural thicket (CUT)

Golf course ponds

Linkage to south: minimum width of 100m.
Note good forested valley south of Dundas Street (aproximately 150m wide).
Floodplain varies between 100m and 150m wide

NORTH OAKVILLE CREEKS SUBWATERSHED STUDY

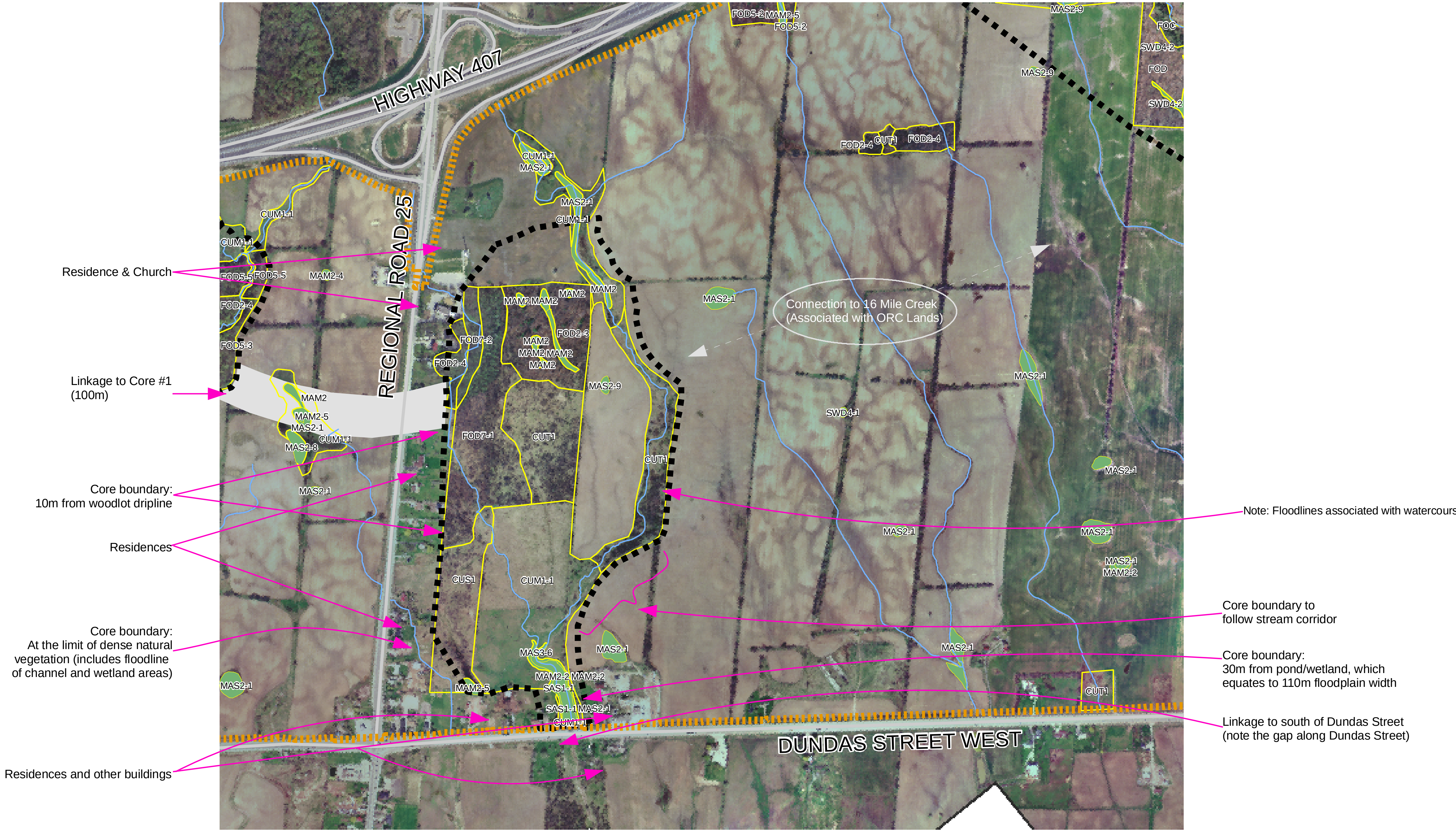
0 100
Meters

Legend
- Study Area Boundary
- Core Area 2006
- Linkage
- ELC
- Wetland
- Watercourse
- Road

Core Area #11
Joshua's Creek Core

Scale: 1:10,000
August 2006

Figure 6.3.12



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N

0 100

Meters

Legend

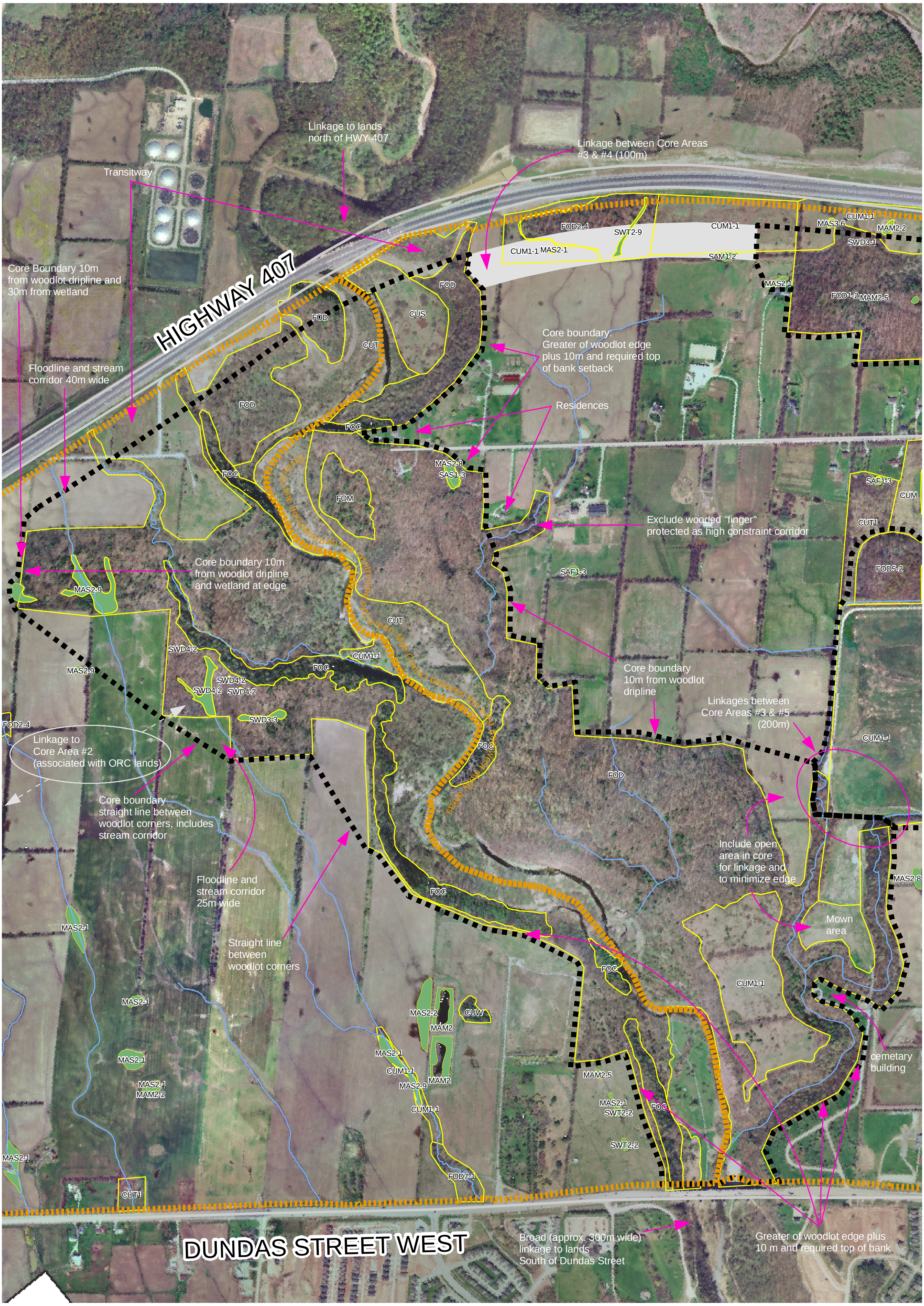
- Study Area Boundary
- Core Area 2006
- Linkage
- ELC
- Wetland
- Watercourse
- Road

Core Area #2
14 Mile Creek East (ORC Lands)

Scale: 1:10,000

August 2006

Figure 6.3.5



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0 50
Meters

Legend

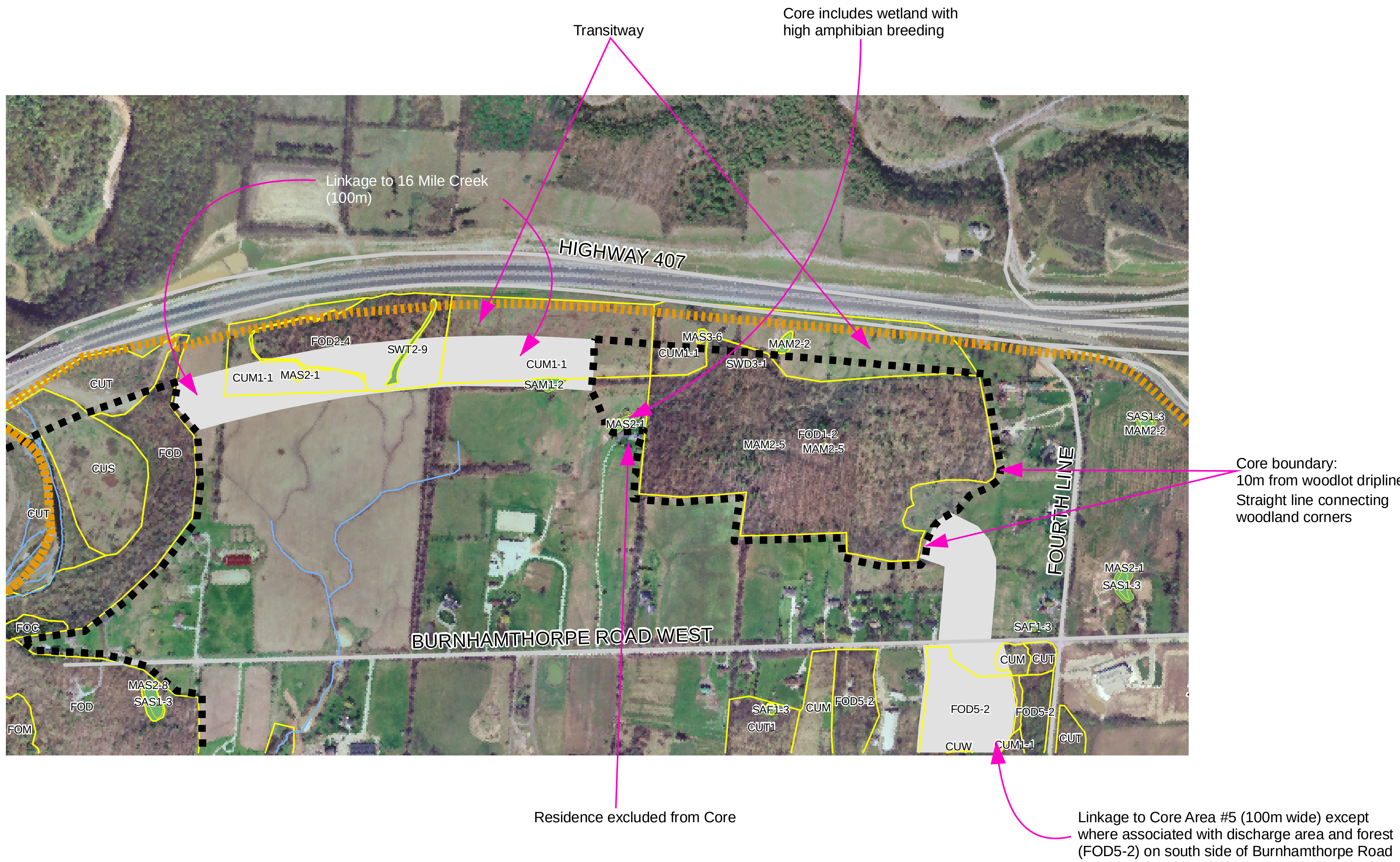
- Study Area Boundary
- Core Area 2006
- Linkage
- ELC
- Wetland
- Watercourse
- Road

Core Area #3
16 Mile Creek Valley

Scale: 1:10,000

August 2006

Figure 6.3.6



NORTH OAKVILLE CREEKS SUBWATERSHED STUDY

0 100 200 300

Meters

Legend

- Study Area Boundary
- Core Area 2006
- Linkage
- ELC
- Wetland
- Watercourse
- Road

Core Area #4
Highway 407 - East of 16 Mile Creek

Scale: 1:10,000

August 2006

Figure 6.3.7

NORTH OAKVILLE SUBWATERSHED STUDY

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N

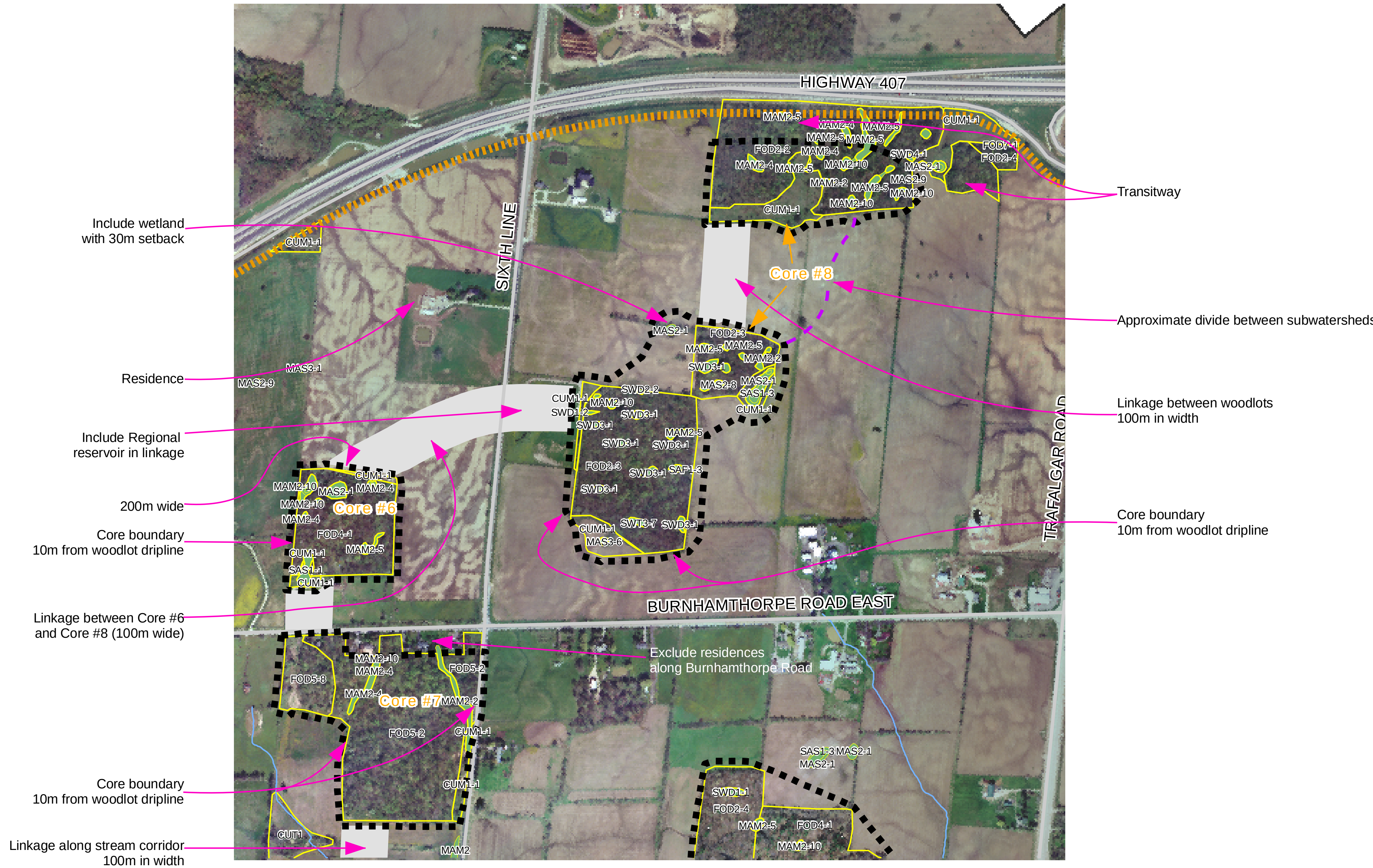
0 100
Meters

Legend
- Study Area Boundary
- Core Area 2006
- Linkage
- ELC
- Wetland
- Watercourse
- Road

Core Area #5
Neyagawa Woodlot

Scale: 1:10,000
August 2006

Figure 6.3.8



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N

0 100
Meters

Legend
- Study Area Boundary
- Core Area 2006
- Linkage
- ELC
- Wetland
- Watercourse
- Road

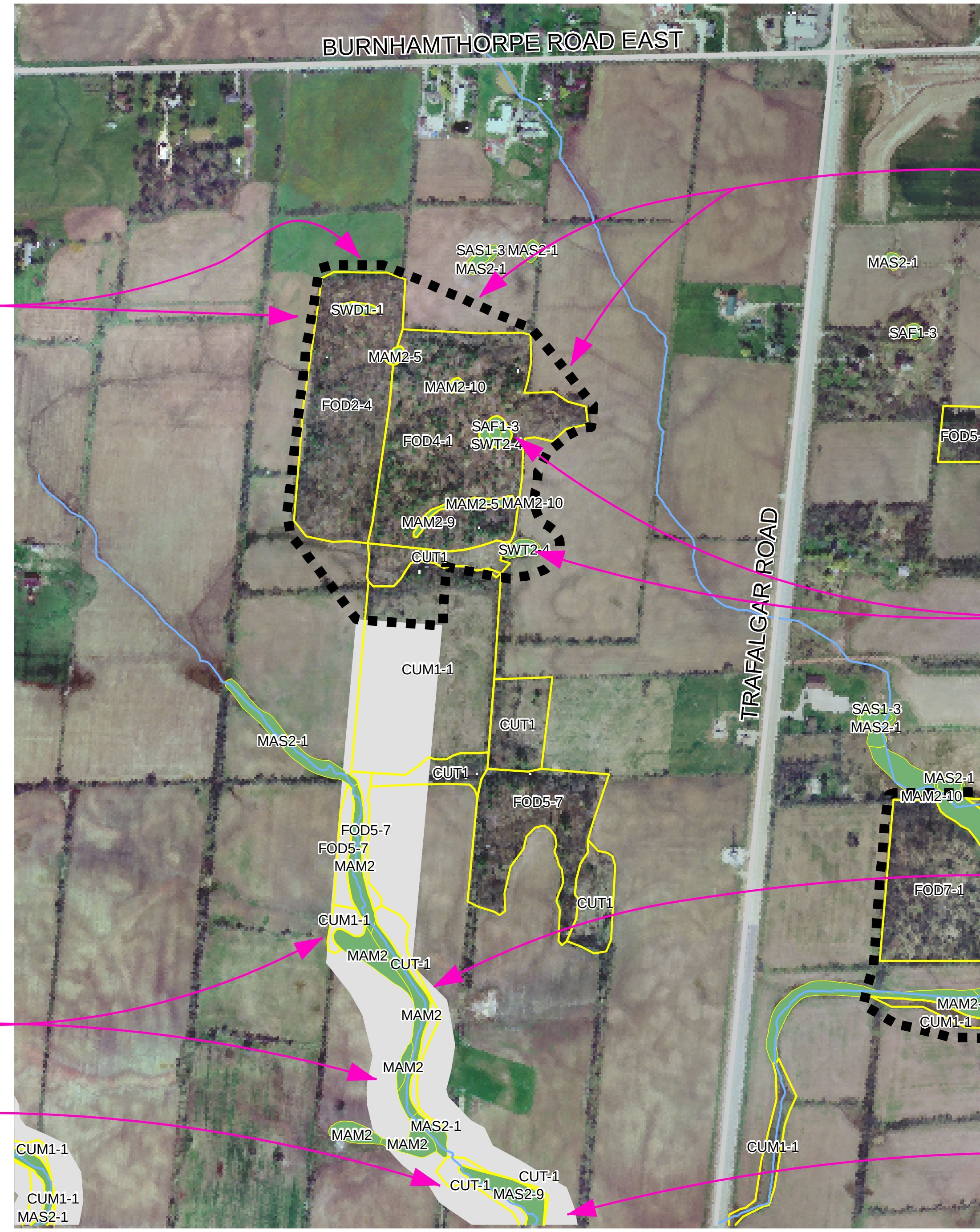
Core Area #6
NW of Burnhamthorpe and 6th Line

Core Area #7
SW of Burnhamthorpe and 6th Line

Core Area #8
Earth Science Woodlots

Scale: 1:10,000
August 2006

Figure 6.3.9



NORTH OAKVILLE CREEKS SUBWATERSHED STUDY

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N

0
Meters

Legend

- Study Area Boundary
- Core Area 2006
- Linkage
- ELC
- Wetland
- Watercourse
- Road

Core Area #9
Trafalgar Woodlot

Scale: 1:10,000
August 2006

Figure 6.3.10

Table 6.2.1
NORTH OAKVILLE SUBWATERSHED STUDY
Meeting the Subwatershed Goals & Objectives
Target Setting

Goals	Objectives	Associated Issues from Characterization & Analysis Management Needs	Targets
1. To minimize the threat of life and the destruction of property and natural resources from flooding, and preserve (or re-establish, where possible) natural floodplain hydrologic functions.	1.1 To ensure that runoff from developing and urbanizing areas is controlled such that it does not increase the frequency and intensity of flooding at the risk of threatening life and property.	▪ Flooding has been experienced throughout the lower subwatersheds in some areas. Flood control measures have been applied in the form of storage, diversions and channelization. ▪ Excess capacity in downstream receiving watercourses does not exist ▪ Controls must be applied to ensure that flood potential is not increased. ▪ The natural flood attenuation within the existing watercourses in the subwatersheds provides protection to downstream reaches. ▪ Some limited flood potential exists at specific locations in the watershed.	▪ Maintain existing peak discharge rates for all design events, particularly high flows. ▪ Target discharge rates required for each catchment (unit area). ▪ Stream reach floodplain storage targets to protect existing floodplain storage. ▪ Remove flood potential at identified locations within the study area. ▪ Delineate floodplains to provide development limits. ▪ Restrict development in the floodplains as per Provincial and CA policies.
	1.2 To adopt appropriate land use controls and development standards to prevent development in natural flood hazard and erosion hazard areas.	▪ Development is not to be permitted in natural floodplain areas to preserve flood storage and protect against flooding. ▪ Erosion hazard exists primarily through natural stream migration. ▪ Some valley wall hazards exist (related to erosion and valley wall stability).	▪ Delineate floodplains to provide development limits. ▪ Restrict development in the floodplains as per Provincial and CA policies. ▪ Delineate meander belt and erosion setback to be applied on all streams designated to be left as open watercourse (providing erosion protection). ▪ Apply valley wall setback standard (slope plus top of valley setback). ▪ Develop stormwater management plan to replicate flow-frequency-duration from existing conditions. ▪ Meet threshold tractive force targets. ▪ Use Distributed Runoff Control (DRC) approach
	1.3 To ensure that new development incorporates the most appropriate development form and mitigation measures necessary to optimize compatibility with natural features and their associated functions.	▪ The natural features (terrestrial and aquatic) are sensitive to both current land use (agricultural and urban), and potential urban land uses. Buffers are required to mitigate impacts. ▪ Terrestrial protection based on maintaining current species and habitat diversity. ▪ Four levels of aquatic habitats exist: - Critical - Important - Marginal - No fish habitat	▪ Aquatic protection based upon resident fish community and existing aquatic habitat conditions. • Achieve MOE 'enhanced' level of SWM protection (80% TSS Removal) for all reaches of streams supporting resident redside dace populations (14 Mile and Morrison Creeks). • For all other stream reaches, achieve 'normal' level of SWM protection (70% TSS removal) to adequately protect aquatic habitat and resident fish. Note that 'enhanced' protection of these streams will be required for reasons not directly related to aquatic habitat and resident fish. (see Section 2.2 regarding Phosphorus loadings).

Table 6.2.1
NORTH OAKVILLE SUBWATERSHED STUDY
Meeting the Subwatershed Goals & Objectives
Target Setting

Goals	Objectives	Associated Issues from Characterization & Analysis Management Needs	Targets
2. To restore, protect, and enhance water quality and associated aquatic resources and water supplies for watercourses, including their associated hydrologic and hydrogeologic functions, within the subwatershed areas.	2.1 Protect stream morphological and fluvial character; restore, where appropriate and feasible, sinuosity; maintain physical habitat attributes (e.g., pools and riffles), diversity and fluvial processes (e.g., bedload transport and energy reduction through sinuosity); and prevent increase in erosion and deposition, through maintenance of hydrological regime.	▪ Erosion varies across the subwatersheds, but is present. ▪ Erosion potential will increase with future development, unless flow regime is controlled. ▪ Geomorphic classification identified three categories of streams according to their relative sensitivity, rehabilitation potential and geomorphic form and function: 1. streams that displayed a high sensitivity to change and have a well-developed geomorphic form and function 2. streams that exhibited some sensitivity to change and geomorphic function with a moderate degree of form 3. streams that lacked geomorphic form but still performed function in the form of sediment, flow conveyance, and connectivity to other features.	▪ Streams that displayed a high sensitivity to change and have a well-developed geomorphic form and function; ▪ Streams that exhibited some sensitivity to change and geomorphic function with a moderate degree of form; and ▪ Streams that lacked a defined form but still had a geomorphic function such as sediment transport, flow conveyance, and connectivity to other features.
	2.2 To prevent the accelerated enrichment of streams and contamination of waterways from runoff containing nutrients, pathogenic organisms, organic substances, and heavy metals and toxic substances.	▪ Current water quality conditions indicate elevated: - Phosphorous - Chlorides - Nitrates - Bacteria (E.Coli) - Some Metals ▪ Potential impact concerns include increases in: - Phosphorous impacts on local streams and on the Oakville Lake Ontario shoreline - Suspended Solids - Associated urban pollutants - Chlorides from road salt - Associated urban pollutants such as metals and industrial organic chemicals	▪ Control to current nutrient levels in the streams to mitigate the potential increases in nutrients and associated impacts on algae growth; ▪ The potential increase in suspended solids and associated urban pollutants; ▪ The level of chloride and potential increase; and ▪ The need to manage stream temperature for fisheries protection.
	2.3 To maintain or restore a natural vegetative canopy along streams where required to ensure that mid-summer stream temperatures do not exceed tolerance limits of desirable aquatic organisms.	▪ Potential temperature increases have not been identified as a significant issue. ▪ Streams are all warmwater fisheries. ▪ Redside Dace in 14 Mile and Morrison ▪ To maintain or enhance the level of Biodiversity in aquatic communities ▪ 14 Mile, Morrison and Joshua's Creeks show reasonable biodiversity in the fish communities present	▪ Maintain existing riparian vegetation associated with watercourses where feasible. ▪ Active restoration of riparian zones with native plantings, in cases where watercourse modifications/alterations require permitting/authorization.
	2.4 To minimize the disturbance of the streambed and prevent streambank erosion and, where practical, to restore eroding streambanks to a natural or stable condition.	▪ Stream erosion exists at some locations to a varying degree. ▪ Protection required to ensure that erosion rates do not increase with changes in landuse.	▪ Targets as outlined in Objectives 2.1 and 2.2.
	2.5 To restore, rehabilitate, or enhance water quality and associated resources through the implementation of appropriate Best Management Practices on the land.	▪ (See 2.2)	▪ Targets for surface water as outlined in Objective 2.2. ▪ For groundwater, target of no detrimental change in existing groundwater quality.

Table 6.2.1
NORTH OAKVILLE SUBWATERSHED STUDY
Meeting the Subwatershed Goals & Objectives
Target Setting

Goals	Objectives	Associated Issues from Characterization & Analysis Management Needs	Targets
	2.6 To ensure that hydrogeologic functions are preserved and maintained and take full advantage of stream and groundwater discharge/baseflow enhancement opportunities.	▪ Current groundwater recharge rates are relatively low as a result of soil permeability conditions (low permeability) ▪ Some potential for groundwater discharge to local streams. ▪ Groundwater contribution to stream flow is primarily provided through local recharge/discharge along stream system.	▪ Maintaining groundwater supplies for existing residents while development and servicing proceed. ▪ Keeping changes in the depth to the local water table to within the seasonal fluctuations normally experienced. ▪ Maintaining the groundwater contribution to stream health (groundwater quantity and quality), where it currently exists.
	2.7 To maintain and enhance the aquatic habitat.	▪ Fisheries conditions/benthic conditions have been identified and primarily include warmwater, warmwater baitfish and degraded habitats. ▪ In degraded areas, opportunities for enhancement exist. ▪ 14 Mile and Morrison Creeks are redside dace streams and require special consideration.	▪ The targets relating to biodiversity for Fourteen Mile, Morrison, and Joshua's Creeks should be that the biodiversity of the fish community be, at a minimum, maintained at existing levels and increased if possible. ▪ Identify stream corridors for protection. ▪ Fluvial geomorphology/erosion control targets under Objective 2.1. ▪ Water quality targets under Objective 2.2. ▪ Designate reaches which support redside dace populations as "no touch" areas where stream sections cannot be relocated. ▪ Enhanced level of stormwater quality control for Fourteen Mile and Morrison Creeks. ▪ Retain wetlands associated with streams if possible and incorporate into drainage system.
	2.8 To minimize disturbance of wetlands, preserving and/or enhancing the habitat and functions they provide.	▪ Wetland characteristics have been identified through the analysis carried out. ▪ The important characteristics to be managed have been identified. ▪ Wetlands in the area consist of three general types: 1. Wetlands with no permanent inflow or outflow of water (isolated wetlands). 2. Wetlands with a direct outflow (palustrine wetlands). Associated with a watercourse or other wetland feature and may play an important hydrological role in addition to their ecological role. 3. Wetlands associated with the channels of watercourses. In some locations offline wetlands are found in close proximity to channels (in some cases direct connections are only found for short periods of time, in others show more defined outflows).	▪ Minimize the fragmentation of wetlands. ▪ Maintain the function of all wetlands associated with watercourses. ▪ Maintain the function and structure of wetlands within woodlands.
	2.9 Provide appropriate buffers to wetlands, watercourses, and valley lands to maintain or enhance their biological health and meet objectives of long-term sustainability of these features.	▪ The natural features (terrestrial and aquatic) are sensitive to both current land use (agricultural and urban), and potential urban land uses. Buffers are required to mitigate any impact. ▪ Terrestrial protection based on maintaining current species and habitat diversity. ▪ Aquatic protection based upon current fisheries. Four levels exist: Critical Important	▪ Establish appropriate feature-specific buffers for protection of natural habitats.

Table 6.2.1
NORTH OAKVILLE SUBWATERSHED STUDY
Meeting the Subwatershed Goals & Objectives
Target Setting

Goals	Objectives	Associated Issues from Characterization & Analysis Management Needs	Targets
		Marginal No fish habitat	
3. To restore, protect, develop and enhance the Natural Heritage, historic cultural, recreational, and visual amenities of rural and urban stream corridors.	3.1 To ensure that environmental resource constraints are fully considered in establishing land use patterns in the subwatershed.	▪ Focuses on the protection of important naturally vegetated features in terms of both structure as well as function. ▪ Specific detailed discussion relative to wetlands is included under Objective 2.8 ▪ Woodlands, other vegetation communities, and wildlife are considered. ▪ Current natural features, particularly terrestrial vary in size and characteristics. ▪ As a whole, the most significant exhibit high diversity of species and habitats. ▪ Functional connectivity between a number of the features exist. ▪ There are a number of rare species of conservation concern.	▪ Minimize the fragmentation of woodlands; ▪ Maintain the function of all woodlands that are >200m in width (*i.e.,* provide potential interior conditions); ▪ Maintain the function of woodlands associated with watercourses.
	3.2 To ensure that existing wildlife linkages are preserved and that opportunities for improving these linkages are considered/implemented as part of any future development.	▪ Field analysis has identified that functional connectivity exits between some of the environmental features. ▪ General linkage types are identified as follows: 1. Wide, wooded linkages required to link stands with forest interior conditions. 2. Linkages associated with watercourse corridors in which a multiple of ecological and hydrological functions are considered. These features are likely to be narrower as they are seen to link other habitat types. ▪ Connectivity between habitat patches can occur simply as a result of proximity (without a direct physical connection)	▪ Minimize the discontinuities in linkages (especially >20 m). ▪ Linkages to be 100 m wide. ▪ Allow for linkages to habitats or other linkages located outside the study area (for example Sixteen Mile Creek valley and Bronte Creek).
	3.3 To retain, preserve or maintain Natural Heritage Features (i.e., open space and visual amenities) in urban and rural areas by establishing and maintaining greenbelts along stream corridors and adjacent natural areas and maintaining linkages between these areas.	▪ See discussions under Objectives 2.8, 3.1 and 3.2.	▪ See discussions under Objectives 2.8, 3.1 and 3.2.
	3.4 To ensure that development in the stream corridor is consistent with the historical and cultural character of the surroundings and reflects the need to protect visual amenities.	▪ Historical characteristics and visual amenities are being addressed in the Secondary Planning Process. Integration with the Subwatershed Plans is occurring.	▪ Presence of visual and historic amenities through the subwatershed and Secondary Planning Processes.
	3.5 To ensure that the recreational and fisheries potential of a steam corridor are developed to the fullest extent practicable.	▪ The fisheries assessment has considered the existing fisheries conditions and potential for enhancement. Some streams are currently degraded by past land use activities and could be enhanced by stream rehabilitation. ▪ The stream corridors and terrestrial features provide potential for recreational use with trails or parkland adjacent to the	▪ See discussion under Objectives 1.3, 2.3 and 2.7.

Table 6.2.1
NORTH OAKVILLE SUBWATERSHED STUDY
Meeting the Subwatershed Goals & Objectives
Target Setting

Goals	Objectives	Associated Issues from Characterization & Analysis Management Needs	Targets
		features.	

Table 6.3.13
NORTH OAKVILLE SUBWATERSHED STUDY
Management Elements

Goals	Objectives	Associated Issues from Characterization & Analysis Management Needs	Targets	Management Element
1. To minimize the threat of life and the destruction of property and natural resources from flooding, and preserve (or re-establish, where possible) natural floodplain hydrologic functions.	1.1 To ensure that runoff from developing and urbanizing areas is controlled such that it does not increase the frequency and intensity of flooding at the risk of threatening life and property.	▪ Flooding has been experienced throughout the lower subwatersheds in some areas. Flood control measures have been applied in the form of storage, diversions and channelization. ▪ Excess capacity in downstream receiving watercourses does not exist ▪ Controls must be applied to ensure that flood potential is not increased. ▪ The natural flood attenuation within the existing watercourses in the subwatersheds provides protection to downstream reaches. ▪ Some limited flood potential exists at specific locations in the watershed.	▪ Maintain existing peak discharge rates for all design events, particularly high flows. ▪ Target discharge rates required for each catchment (unit area). ▪ Stream reach floodplain storage targets to protect existing floodplain storage. ▪ Remove flood potential at identified locations within the study area. ▪ Delineate floodplains to provide development limits. ▪ Restrict development in the floodplains as per Provincial and CA policies.	▪ Stormwater management (quantity control) will provide storage to ensure peak flow targets are met. ▪ Can be provided by full range of SWM measures, including end-of-pipe. ▪ Flood potential will likely be eliminated through redevelopment of lands within the subwatershed. If not, flood protection can be applied where needed through berming or flood-proofing. ▪ Protection of identified floodplain storage by stream reach.
	1.2 To adopt appropriate land use controls and development standards to prevent development in natural flood hazard and erosion hazard areas.	▪ Development is not to be permitted in natural floodplain areas to preserve flood storage and protect against flooding. ▪ Erosion hazard exists primarily through natural stream migration. ▪ Some valley wall hazards exist (related to erosion and valley wall stability).	▪ Delineate floodplains to provide development limits. ▪ Restrict development in the floodplains as per Provincial and CA policies. ▪ Delineate meander belt and erosion setback to be applied on all streams designated to be left as open watercourse (providing erosion protection). ▪ Apply valley wall setback standard (slope plus top of valley setback). ▪ Develop stormwater management plan to replicate flow-frequency-duration from existing conditions. ▪ Meet threshold tractive force targets. ▪ Use Distributed Runoff Control (DRC) approach	▪ Stream corridor identification and delineation will provide for flood control and erosion control (including hazard setback).
	1.3 To ensure that new development incorporates the most appropriate development form and mitigation measures necessary to optimize compatibility with natural features and their associated functions.	▪ The natural features (terrestrial and aquatic) are sensitive to both current land use (agricultural and urban), and potential urban land uses. Buffers are required to mitigate impacts. ▪ Terrestrial protection based on maintaining current species and habitat diversity. ▪ Four levels of aquatic habitats exist: - Critical - Important - Marginal - No fish habitat	▪ Aquatic protection based upon resident fish community and existing aquatic habitat conditions. ▪ Achieve MOE 'enhanced' level of SWM protection (80% TSS Removal) for all reaches of streams supporting resident redside dace populations (14 Mile and Morrison Creeks). ▪ For all other stream reaches, achieve 'normal' level of SWM protection (70% TSS removal) to adequately protect aquatic habitat and resident fish. Note that 'enhanced' protection of these streams will be required for reasons not directly related to aquatic habitat and resident fish. (see Section 2.2 regarding Phosphorous loadings).	▪ Core area approach to provide sustainable and resilient terrestrial features (core areas). ▪ Buffers adjacent to areas reflect natural feature. ▪ Identification of non Core feature requiring consideration - hydrologic and environmental function
2. To restore, protect, and enhance water quality and associated aquatic resources and water supplies for watercourses, including their associated hydrologic and hydrogeologic functions, within the subwatershed areas.	2.1 Protect stream morphological and fluvial character; restore, where appropriate and feasible, sinuosity; maintain physical habitat attributes (e.g., pools and riffles), diversity and fluvial processes (e.g., bedload transport and energy reduction through sinuosity); and prevent increase in	▪ Erosion varies across the subwatersheds, but is present. ▪ Erosion potential will increase with future development, unless flow regime is controlled. ▪ Geomorphic classification identified three categories of streams according to	▪ Streams that displayed a high sensitivity to change and have a well-developed geomorphic form and function; ▪ Streams that exhibited some sensitivity to change and geomorphic function with a moderate degree of form; and ▪ Streams that lacked a defined form but still had a geomorphic function such as sediment transport, flow	▪ Stream corridor network to be preserved and stream density will provide for natural stream based drainage network. ▪ SWM measures will be provided to meet threshold targets.

Table 6.3.13
NORTH OAKVILLE SUBWATERSHED STUDY
Management Elements

Goals	Objectives	Associated Issues from Characterization & Analysis Management Needs	Targets	Management Element
	erosion and deposition, through maintenance of hydrological regime.	their relative sensitivity, rehabilitation potential and geomorphic form and function: 1. streams that displayed a high sensitivity to change and have a well-developed geomorphic form and function 2. streams that exhibited some sensitivity to change and geomorphic function with a moderate degree of form 3. streams that lacked geomorphic form but still performed function in the form of sediment, flow conveyance, and connectivity to other features.	conveyance, and connectivity to other features.	
	2.2 To prevent the accelerated enrichment of streams and contamination of waterways from runoff containing nutrients, pathogenic organisms, organic substances, and heavy metals and toxic substances.	▪ Current water quality conditions indicate elevated: - Phosphorous - Chlorides - Nitrates - Bacteria (E.Coli) - Some Metals ▪ Potential impact concerns include increases in: - Phosphorous impacts on local streams and on the Oakville Lake Ontario shoreline - Suspended Solids - Associated urban pollutants - Chlorides from road salt - Associated urban pollutants such as metals and industrial organic chemicals	▪ Current nutrient levels in the streams, the potential increases in nutrients and associated impacts on algae growth; ▪ The potential increase in suspended solids and associated urban pollutants; ▪ The level of chloride and potential increase; and ▪ The need to manage stream temperature for fisheries protection.	▪ SWM measures will be designed to meet targets set. A range of measures can be applied. ▪ Preservation and enhancement of natural stream corridors provide water quality improvements. ▪ Preservation and enhancement of terrestrial cores will provide water quality protection. ▪ Level 1 controls needed to meet Phosphorus target, plus additional source controls. ▪ At source controls (pollution prevention, conveyance system controls and end-of-pipe (stormwater management ponds) will be required. ▪ Road salt management (Code of Practice).
	2.3 To maintain or restore a natural vegetative canopy along streams where required to ensure that mid-summer stream temperatures do not exceed tolerance limits of desirable aquatic organisms.	▪ Potential temperature increases have not been identified as a significant issue. ▪ Streams are all warmwater fisheries. ▪ Redside Dace in 14 Mile and Morrison ▪ To maintain or enhance the level of Biodiversity in aquatic communities ▪ 14 Mile, Morrison and Joshua's Creeks show reasonable biodiversity in the fish communities present	▪ Maintain existing riparian vegetation associated with watercourses where feasible. ▪ Active restoration of riparian zones with native plantings in cases where watercourse modifications require permitting/authorization.	▪ Stream corridor protection and enhancement will protect current stream temperatures and could lead to lowering of temperatures with enhancement measures. ▪ Preservation of opportunities for groundwater discharge in areas where groundwater discharge has been observed is required. ▪ Elimination of on line ponds would improve thermal conditions. ▪ Consider subsurface infiltration of SWM facility discharge prior to outletting to stream. ▪ Reestablishment of riparian vegetation. ▪ No modification or relocation of reaches of habitats

Table 6.3.13
NORTH OAKVILLE SUBWATERSHED STUDY
Management Elements

Goals	Objectives	Associated Issues from Characterization & Analysis Management Needs	Targets	Management Element
				deemed as critical or important in subwatershed categorization . ▪ Preservation or improvement of water quality in all watercourses. ▪ Inclusion of watercourses in protected stream corridors.
	2.4 To minimize the disturbance of the streambed and prevent streambank erosion and, where practical, to restore eroding streambanks to a natural or stable condition.	▪ Stream erosion exists at some locations to a varying degree. ▪ Protection required to ensure that erosion rates do not increase with changes in landuse.	▪ Targets as outlined in Objectives 2.1 and 2.2.	▪ SWM and stream corridor management plan will provide erosion provision. ▪ Stream corridor enhancement is proposed to mitigate current erosion problems and enhance geomorphologic processes.
	2.5 To restore, rehabilitate, or enhance water quality and associated resources through the implementation of appropriate Best Management Practices on the land.	▪ (See 2.2)	▪ Targets for surface water as outlined in Objective 2.2. ▪ For groundwater, target of no detrimental change in existing groundwater quality.	▪ (See 2.2)
	2.6 To ensure that hydrogeologic functions are preserved and maintained and take full advantage of stream and groundwater discharge/baseflow enhancement opportunities.	▪ Current groundwater recharge rates are relatively low as a result of soil permeability conditions (low permeability) ▪ Some potential for groundwater discharge to local streams. ▪ Groundwater contribution to stream flow is primarily provided through local recharge/discharge along stream system.	▪ Maintaining groundwater supplies for existing residents while development and servicing proceed. ▪ Keeping changes in the depth to the local water table to within the seasonal fluctuations normally experienced. ▪ Maintaining the groundwater contribution to stream health (groundwater quantity and quality), where it currently exists.	▪ Stream corridors identified for protection in areas of potential discharge. ▪ Infiltration will be required to meet targets set. Provide through at source and conveyance measures. ▪ Recharge and/or discharge function remains the same as current in protected and core areas.
	2.7 To maintain and enhance the aquatic habitat.	▪ Fisheries conditions/benthic conditions have been identified and primarily include warmwater, warmwater baitfish and degraded habitats. ▪ In degraded areas, opportunities for enhancement exist. ▪ 14 Mile and Morrison Creeks are redside dace streams and require special consideration.	▪ The targets relating to biodiversity for Fourteen Mile, Morrison, and Joshua's Creeks should be that the biodiversity of the fish community be, at a minimum, maintained at existing levels and increased if possible. ▪ Identify stream corridors for protection. ▪ Fluvial geomorphology/erosion control targets under Objective 2.1. ▪ Water quality targets under Objective 2.2. ▪ Designate reaches which support redside dace populations as "no touch" areas where stream sections cannot be relocated. ▪ Enhanced level of stormwater quality control for Fourteen Mile and Morrison Creeks. ▪ Retain wetlands associated with streams if possible and incorporate into drainage system.	▪ Stream corridor protection. ▪ Enhancement plan. ▪ Water Quality Control and Erosion Control provided through SWM measures. ▪ Aquatic protection based upon resident fish community and existing aquatic habitat conditions. Achieve MOE 'enhanced' level of SWM protection (80% TSS Removal) for all reaches of streams supporting resident redside dace populations (14 Mile and Morrison Creeks). For all other stream reaches, achieve 'normal' level of SWM protection (70% TSS removal) to adequately protect aquatic habitat and resident fish. Note that 'enhanced' protection of these streams will be required for reasons not directly related to aquatic habitat and resident fish (see Section 2.2 re. phosphorus loadings). ▪ Buffers of redside dace habitat will be developed as part of an overall management philosophy for streams where form and function must be retained. These streams will be protected by default either through core area strategies or meander belt width or floodplain provisions.

Table 6.3.13
NORTH OAKVILLE SUBWATERSHED STUDY
Management Elements

Goals	Objectives	Associated Issues from Characterization & Analysis Management Needs	Targets	Management Element
	2.8 To minimize disturbance of wetlands, preserving and/or enhancing the habitat and functions they provide.	▪ Wetland characteristics have been identified through the analysis carried out. ▪ The important characteristics to be managed have been identified. ▪ Wetlands in the area consist of three general types: 1. Wetlands with no permanent inflow or outflow of water (isolated wetlands). 2. Wetlands with a direct outflow (palustrine wetlands). Associated with a watercourse or other wetland feature and may play an important hydrological role in addition to their ecological role. 3. Wetlands associated with the channels of watercourses. In some locations offline wetlands are found in close proximity to channels (in some cases direct connections are only found for short periods of time, in others show more defined outflows).	▪ Minimize the fragmentation of wetlands. ▪ Maintain the function of all wetlands associated with watercourses. ▪ Maintain the function and structure of wetlands within woodlands.	▪ Natural Heritage System approach provides for protection of wetlands <u>and</u> supporting adjacent area. ▪ Linkages to wetland for hydrologic functions <u>and</u> wildlife provided.
	2.9 Provide appropriate buffers to wetlands, watercourses, and valley lands to maintain or enhance their biological health and meet objectives of long-term sustainability of these features.	▪ The natural features (terrestrial and aquatic) are sensitive to both current land use (agricultural and urban), and potential urban land uses. Buffers are required to mitigate any impact. ▪ Terrestrial protection based on maintaining current species and habitat diversity. ▪ Aquatic protection based upon current fisheries. Four levels exist: Critical Important Marginal No fish habitat	▪ Establish appropriate feature-specific buffers for protection of natural habitats.	▪ Core Area approach to provide sustainable and resilient terrestrial features. ▪ Buffers adjacent to areas reflect natural feature and are included in the Core. ▪ Buffers for important and critical aquatic habitats will be developed as part of an overall management philosophy for red streams (i.e. streams where form and function must be retained). These streams will be protected by default either through core area strategies or meander belt width provisions.
3. To restore, protect, develop and enhance the Natural Heritage, historic cultural, recreational, and visual amenities of rural and urban stream corridors.	3.1 To ensure that environmental resource constraints are fully considered in establishing land use patterns in the subwatershed.	▪ Focuses on the protection of important naturally vegetated features in terms of both structure as well as function. ▪ Specific detailed discussion relative to wetlands is included under Objective 2.8 ▪ Woodlands, other vegetation communities, and wildlife are considered. ▪ Current natural features, particularly terrestrial vary in size and	▪ Minimize the fragmentation of woodlands; ▪ Maintain the function of all woodlands that are >200m in width (*i.e.,* provide potential interior conditions); ▪ Maintain the function of woodlands associated with watercourses.	▪ Core areas and stream corridor identified for protection based upon providing a sustainable Natural Heritage System. ▪ Linkages to provide for flora and fauna functions ▪ Hydrologic networks will protect water based function ▪ Buffers provided within Cores.

Table 6.3.13
NORTH OAKVILLE SUBWATERSHED STUDY
Management Elements

Goals	Objectives	Associated Issues from Characterization & Analysis Management Needs	Targets	Management Element
		characteristics. ▪ As a whole, the most significant exhibit high diversity of species and habitats. ▪ Functional connectivity between a number of the features exist. ▪ There are a number of rare species of conservation concern.		
	3.2 To ensure that existing wildlife linkages are preserved and that opportunities for improving these linkages are considered/implemented as part of any future development.	▪ Field analysis has identified that functional connectivity exits between some of the environmental features. ▪ General linkage types are identified as follows: 1. Wide, wooded linkages required to link stands with forest interior conditions. 2. Linkages associated with watercourse corridors in which a multiple of ecological and hydrological functions are considered. These features are likely to be narrower as they are seen to link other habitat types. ▪ Connectivity between habitat patches can occur simply as a result of proximity (without a direct physical connection)	▪ Minimize the discontinuities in linkages (especially >20 m). ▪ Linkages to be 100 m wide. ▪ Allow for linkages to habitats or other linkages located outside the study area (for example Sixteen Mile Creek valley and Bronte Creek).	▪ Corridors will be identified in the land use planning. ▪ Stream corridors provided as part of linkage network.
	3.3 To retain, preserve or maintain Natural Heritage Features (i.e., open space and visual amenities) in urban and rural areas by establishing and maintaining greenbelts along stream corridors and adjacent natural areas and maintaining linkages between these areas.	▪ See discussions under Objectives 2.8, 3.1 and 3.2.	▪ See discussions under Objectives 2.8, 3.1 and 3.2.	▪ Corridors will be provided for within the land use planning. ▪ Stream corridors provided as part of linkage network.
	3.4 To ensure that development in the stream corridor is consistent with the historical and cultural character of the surroundings and reflects the need to protect visual amenities.	▪ Historical characteristics and visual amenities are being addressed in the Secondary Planning Process. Integration with the Subwatershed Plans is occurring.	▪ Presence of visual and historic amenities through the subwatershed and Secondary Planning Processes.	▪ Visual amenities associated with the Natural Heritage System are being preserved through the protection of core areas. ▪ Historic amenities and other visual considerations are being dealt with in the overall land use plans.
	3.5 To ensure that the recreational and fisheries potential of a steam corridor are developed to the fullest extent practicable.	▪ The fisheries assessment has considered the existing fisheries conditions and potential for enhancement. Some streams are currently degraded by past land use activities and could be enhanced by stream rehabilitation. ▪ The stream corridors and terrestrial features provide potential for recreational use with trails or parkland adjacent to the features.	▪ See discussion under Objectives 1.3, 2.3 and 2.7.	▪ The areas to be preserved (terrestrial and streams) provide for recreational opportunities. This is being integrated into the Secondary Planning Process. ▪ Site specific management recommendations to be made, by reach where rehabilitation has the potential to improve core areas and/or enhance linkage components of the stream corridor.

Table 6.3.13
NORTH OAKVILLE SUBWATERSHED STUDY
Management Elements

Goals	Objectives	Associated Issues from Characterization & Analysis Management Needs	Targets	Management Element

Table 6.3.2
Summary of Core Area Themes and Management

Name:	Location	Themes	Management
Core #1: 14 Mile Creek (Main)	Associated with the main branch of 14 Mile Creek between Tremaine Rd. and Bronte Rd. (Regional Rd. 25)	**Forest Interior**: associated with woodland in northern portion of core **Linkage**: habitats provide a potential linkage to lands north of Highway 407 and south of Dundas St **Open Country**: open country habitats are found along the northern and eastern edges of this area **Redside Dace**: population of known redside dace in lower portions of creek in this area	• The existing woodlands and wetlands are recommended for retention. • Linkages between the forested component of the Core and lands to the south, east and north should be connected. Significant gaps in these connections will be created by major roadways and highways in the area. • The connections should be wooded. • Balance is required between management of the open and wooded habitats. The configuration of the Core would allow for a block of open country habitat in the north of approximately 5.2 ha and a block approximately 8.8 ha in area in the southeastern portion of the Core. The rest of the Core should be wooded.
Core #2: ORC (14 Mile Creek East)	Associated with a side tributary of 14 Mile Creek east of Bronte Rd. (Regional Rd. 25) on the ORC lands	**Forest Interior**: associated with wooded portion of the area	• The existing woodlands and wetlands are recommended for retention. • Focus of long term management of this Core is to allow the majority of it to reforest to maximize the extent of forest habitat.
Core #3: 16 Mile Creek	Associated with main valley of 16 Mile Creek **Not studied in detail as part of this study.	**Forest Interior**: associated with woodlands throughout the valley **Linkage**: valleylands provide a linkage to lands north of Highway 407 and south of Dundas St.	• The existing woodlands and wetlands are recommended for retention. • Forested linkages to Core #4 and #5 are recommended.
Core #4: Hwy 407 East of 16 Mile Creek	Associated with habitats east of 16 Mile Creek, south of Hwy 407.	**Forest Interior**: associated with wooded portion of the area **Linkage**: the western end of this core provides a potential link to the 16 Mile	• The existing woodlands and wetlands are recommended for retention. • Forested linkages to Core #3 and #5 are recommended.

Table 6.3.2
Summary of Core Area Themes and Management

Name:	Location	Themes	Management
		Creek valley	
Core #5: Neyagawa	Associated with the east-west array of forest and wetlands east of Neyagawa. Located near potential groundwater discharge area (west of Neyagawa, north of the closed landfill). Although linked to the main 16 Mile Creek valley, for the purposes of this analysis considered a separate Core.	**Forest Interior**: associated with wooded portion of the area **Linkage**: the western end of this core provides a potential link to the 16 Mile Creek valley **Open Country**: inclusion of the landfill area within the core	• The existing woodlands and wetlands are recommended for retention. • The north and south linkages associated with West Morrison Creek are 100 m wide. • Management of the landfill portion of the Core is recommended to be a balance of created forested connection in the south margin and continued open country habitat.
Core #6: Woodlot NW of Burnhamthorpe/ 6th Line Core #7: Woodlot SW of Burnhamthorpe/ 6th Line	A woodlot located northwest of the intersection of Burnhamthorpe Rd. and 6th Line A woodlot located southwest of the intersection of Burnhamthorpe Rd. and 6th Line	**Forest Interior**: core is entirely wooded **Linkage**: woodlot provides part of potential linkage between other woodlands in this area (due to proximity and through direct connections)	• The existing woodlands and wetlands are recommended for retention. • These two Cores are proposed to be linked to each other over a fairly short span (approx. 100m), although this includes residences and a major roadway. • Connection of the southern Core to West Morrison Creek and to Core #5. • The northern Core is proposed to be linked to Core #8 to the north, again across a major roadway. • The connectivity of these two Cores is likely more a function of proximity. This may help to explain the presence of some forest interior bird species in the smaller northern Core, despite it being only 200 m x 200 m large.
Core #8: Earth Science Woodlots	Associated with the two woodlots east of 6th Line (north of Burnhamthorpe Rd.) and with the candidate Trafalgar Moraine earth science ANSI. The two forested	**Forest Interior**: associated with wooded portion of the area Pits and hummocks have created small seasonal and event level water pondings, some of which are significant vegetation	• The existing woodlands and wetlands are recommended for retention. • Although potential linkages are shown to the north across Highway 407, this highway will

Table 6.3.2
Summary of Core Area Themes and Management

Name:	Location	Themes	Management
	areas composing the Core are connected via a 200 m long linkage.	communities **Linkage**: woodlot provides part of potential linkage between other woodlands in this area (due to proximity and through direct connections)	create a substantial barrier to many species. • As noted under Core #6, the linkage from this Core to the south will also be affected by major roads and considerable distances. The proximity of the Cores #6 and 7 is seen as a potential connectivity opportunity for some species in these Cores. Direct forested linkages beyond the Core itself are fairly limited.
Core #9: Trafalgar Woodlot	Associated with the woodlot between 6th Line and Trafalgar Rd. (south of Burnhamthorpe Rd.)	**Forest Interior**: associated with wooded portion of the area **Buttonbush Swamp**: associated with the small pockets of swamp within the Core	• The existing woodland and wetlands are recommended for retention. • Linkage to the south associated with the creek provides possible connectivity to habitats south of Dundas Street. Linkage is to remain open country habitat based on redside dace.
Core #10: Buttonbush	Associated with the large buttonbush swamp and neighbouring habitats, east of Trafalgar Rd.	**Forest Interior**: associated with wooded portions of the area **Open Country**: open country habitats are found associated with the southern portion of this Core **Linkage**: associated with connections between the three wooded 'nodes' within the Core, as well as a linkage to Core #11 to the east **Buttonbush Swamp**: associated with large swamp within the Core	• The existing woodlands and wetlands are recommended for retention. • Within the Core, connectivity between the forested blocks of a minimum 200 m width.
Core #11: Joshua Creek	Associated with the main valley of Joshua's Creek (south of Burnhamthorpe Rd., west of 9th Line)	**Forest Interior**: associated with wooded portions of the area **Linkage**: associated with linkage to lands south of Dundas St	• The existing woodlands and wetlands are recommended for retention. • A key linkage for this Core is a potential forested connection west to Core #10. The proposed location follows a tributary and

Table 6.3.2
Summary of Core Area Themes and Management

Name:	Location	Themes	Management
			incorporates a portion of the large floodplain west of the Core. • A second linkage along the main creek to the south of Dundas Street is also proposed. The natural habitats to the south of Dundas are quite wide (approx. 150 m), but the 30 to 40 m gap created by Dundas Street is noted. • Reforestation of open portions of this Core is recommended and will substantially increase the amount of forest interior.

TABLE 6.3.4: Aquatic and Riparian Habitat Management by Reach	
STREAM REACH	**Recommended Habitat Management**
JOSHUA'S CREEK	
JC-1	Plant woody riparian vegetation to supplement existing herbaceous vegetation. Maintain a 100 m wide wooded corridor to provide linkage to habitats south of Dundas Street.
JC-2	Allow vegetative succession of woody vegetation to continue undisturbed. Match 100 m wide corridor recommended for JC-1. Northern portion is within Core 11. Monitor for invasive plant species.
JC-3	Allow succession of woody vegetation to continue undisturbed. Within wooded portion of Core #11, monitor invasive plant species.
JC-4	Allow succession of woody vegetation to continue undisturbed. Within wooded portion of Core #11, monitor invasive plant species.
JC-5	Plant woody riparian vegetation to supplement existing herbaceous vegetation. Within wooded portion of Core #11, monitor invasive plant species. Maintain separation of groundwater discharge area from adjacent areas by establishing dense vegetative buffer.
JC-6	Recommended as part of linkage between Core #10 and #11, retain existing woody vegetation along watercourse where possible, re-vegetate corridor.
JC-7	Re-vegetate corridor, especially un-vegetated northern portion.
JC-8	Recommended as part of linkage between Core #10 and #11, retain existing woody vegetation along watercourse where possible, re-vegetate corridor.
JC-9	Re-vegetate un-vegetated corridor.
JC-10	No management required from an aquatic and riparian habitat perspective.
JC-10A	Re-vegetate un-vegetated corridor.
JC-11	No management required from an aquatic and riparian habitat perspective.
JC-12	Within wooded portion of Core #11. Allow vegetative succession of woody vegetation to continue undisturbed and monitor invasive plant species.
JC-13	Retain existing wetland and upland vegetation, allow for naturalization with native woody species.
JC-14	Retain existing wetland vegetation, re-vegetate corridor.
JC-15	No management required from an aquatic and riparian habitat perspective.
JC-19	Retain existing upland vegetation, allow for naturalization with native woody species.
JC-20	Retain existing lowland woodland, allow vegetative succession of woody vegetation to continue undisturbed downstream of Burnamthorpe Rd.
JC-20A	Upstream of Burnhamthorpe Rd. plant woody riparian vegetation to supplement existing herbaceous vegetation.
JC-22	Bank revetment is required to stabilize eroding banks, followed by planting woody riparian vegetation.
JC-27	No management required from an aquatic and riparian habitat perspective.
JC-27A	No management required as this is a road ditch and woody vegetation would impact on sight lines for traffic.
JC-28	No management required from an aquatic and riparian habitat perspective.
JC-29	No management required from an aquatic and riparian habitat perspective.
JC-30	No management required from an aquatic and riparian habitat perspective.
JC-31	Re-vegetate corridor.
JC-31A	No management required from an aquatic and riparian habitat perspective.
JC-32	No management required from an aquatic and riparian habitat perspective.
JC-36	Fully wooded. Leave undisturbed and plant outside of dripline with native trees to achieve minmum corridor width.
EAST MORRISON	
MOC-2	South end of reach may be realigned to accommodate gas station expansion. If so, opportunity to naturalize bank and remove gabion treatments should be realized. Plant woody riparian vegetation to supplement existing herbaceous vegetation and combine with east edge of woodlot (north end of reach).
MOC-4	Use planting of native species to achieve fluvial cooridor width. This will allow for 30 m buffer on either side as per protection of redside dace survival habitat. Within this reach, maintain 2 to 3 m wide swath of herbaceous vegetation on either side of creek to provide maximum habitat benefit for redside dace.
MOC-5	No management required from an aquatic and riparian habitat perspective.
MOC-5A	Allow succession of woody vegetation to continue undisturbed within corridor.

TABLE 6.3.4: Aquatic and Riparian Habitat Management by Reach	
STREAM REACH	**Recommended Habitat Management**
WEST MORRISON	
MOC-W1	Plant woody riparian vegetation to supplement existing herbaceous vegetation within corridor.
MOC-W2	Re-vegetate to width of corridor.
MOC-W3	Move channel to the west, away from Sixth Line, to separate it from road ditch. Corridor is recommended to be incorproated into wooded 100 m linkage.
MOC-W5	Re-vegetate to width of corridor.
MUNN'S CREEK	
MUN-1	No management required from an aquatic and riparian habitat perspective.
MUN-2	Allow succession of woody vegetation to continue undisturbed within corridor.
MUN-3	Allow succession of woody vegetation to continue undisturbed within corridor.
SHANNON'S CREEK	
SHC-1	Allow succession of woody vegetation to continue undisturbed within corridor.
SHC-2	Allow succession of woody vegetation to continue undisturbed within corridor.
SHC-3	No management required from an aquatic and riparian habitat perspective.
16 MILE CREEK	
SMA-1	Leave heavily wooded ravine undisturbed and allow vegetative successsion within corridor.
SMA-2	Retain existing woody vegetation along watercourse. Where possible, re-vegetate corridor to width of corridor.
SMA-3	Retain existing woody vegetation along watercourse. Where possible, re-vegetate corridor to width of corridor. Recommended to be part of wooded linkage.
SMA-4	Retain existing woody vegetation along watercourse. Where possible, re-vegetate corridor to width of corridor. Recommended to be part of wooded linkage.
SMA-5	Within Core # 5. Leave undisturbed.
SMA-6	Within Core # 5. Leave undisturbed.
SMA-7	Leave undisturbed and allow vegetation to succeed naturally within the corridor.
SMA-8	Leave undisturbed and allow vegetation to succeed naturally within the corridor.
SMA-9	Leave undisturbed and allow vegetation to succeed naturally within the corridor.
SMB -1	No management required from an aquatic and riparian habitat perspective.
SMB-2	No management required from an aquatic and riparian habitat perspective.
SMB-3	No management required from an aquatic and riparian habitat perspective.
SMB-4	No management required from an aquatic and riparian habitat perspective.
SMC-1	Leave wooded ravine undisturbed and allow vegetative successsion within corridor.
SMC-2	Remove online pond and replace with swale matched to existing land elevation and tied into invert of culvert on Burnamthrope Rd.
SMC-3	Remove online pond, reestablish channel and replant with woody riparian vegetations.
SMC-4	No management required from an aquatic and riparian habitat perspective.
SMC-5	No management required from an aquatic and riparian habitat perspective.
16W-1	No management required from an aquatic and riparian habitat perspective.
16W-2	No management required from an aquatic and riparian habitat perspective.
16W-3	No management required from an aquatic and riparian habitat perspective.
16W-4	No management required from an aquatic and riparian habitat perspective.
16WA-1	leave undisturbed.
16WA-1A	leave undisturbed.
16WA-2	No management required from an aquatic and riparian habitat perspective.
16WA-3	No management required from an aquatic and riparian habitat perspective.
16WA-4	No management required from an aquatic and riparian habitat perspective.

TABLE 6.3.4: Aquatic and Riparian Habitat Management by Reach	
STREAM REACH	**Recommended Habitat Management**
16WA-5	No management required from an aquatic and riparian habitat perspective.
16WA-6	No management required from an aquatic and riparian habitat perspective.
16WA-7	No management required from an aquatic and riparian habitat perspective.
16WA-8	No management required from an aquatic and riparian habitat perspective.
16WA-8A	No management required from an aquatic and riparian habitat perspective.
GLEN OAKS CREEK	
GO-1	No management required from an aquatic and riparian habitat perspective.
TAPLOW CREEK	
TC-1	No management required from an aquatic and riparian habitat perspective.
TC-2	No management required from an aquatic and riparian habitat perspective.
TC-2A	No management required from an aquatic and riparian habitat perspective.
McCRANEY CREEK	
MC-1	Plant woody and herbaceous vegetation.
MC-2	No management required from an aquatic and riparian habitat perspective.
MC-4A	No management required from an aquatic and riparian habitat perspective.
MC-4	No management required from an aquatic and riparian habitat perspective.
14 MILE CREEK	
14E-1	Maintain pond but plant riparian zone with woody vegetation and nursery stock native trees to establish canopy for temperature moderation through shading within Core #2.
14E-2	Plant woody riparian vegetation to supplement existing herbaceous vegetation within corridor (Core #2).
14E-2A	Plant woody riparian vegetation to supplement existing herbaceous vegetation within corridor (Core #2).
14E-3	Plant woody riparian vegetation to supplement existing herbaceous vegetation within corridor (Core #2).
14E-4	No management required from an aquatic and riparian habitat perspective.
14E-6	Plant woody and herbaceous material in corridor.
14E-7	Leave heavily wooded corridor intact and undisturbed and supplement with plantings in corridor.
14E-8	Plant woody and herbaceous vegetation where presently plowed through as fish found in this degraded reach.
14E-9	No management required from an aquatic and riparian habitat perspective.
14E-10	No management required from an aquatic and riparian habitat perspective.
14W-1	Within Core #1. Use planting of native species to achieve corridor width. This will allow for 30 m buffer on either side as per protection of redside dace survival habitat. Within this reach, maintain 2 to 3 m wide swath of herbaceous vegetation on either side of creek to provide maximum habitat benefit for redside dace.
14W-1A	Within Core #1. Allow vegetative succession of woody vegetation to continue undisturbed within corridor.
14W-2	Within Core #1. Allow vegetative succession of woody vegetation to continue undisturbed within corridor.
14W-3	Within Core #1, manage as per Core management recommendations.
14W-4	Within Core #1, manage as per Core management recommendations.
14W-9	Within Core #1, manage as per Core management recommendations.
14W-9A	Within Core #1, manage as per Core management recommendations.
14W-10	Within Core #1, manage as per Core management recommendations.
14W-11	Allow succession of woody vegetation to continue undisturbed within corridor.
14W-11A	Allow succession of woody vegetation and mature trees to continue undisturbed within corridor.

TABLE 6.3.4: Aquatic and Riparian Habitat Management by Reach	
STREAM REACH	**Recommended Habitat Management**
14W-12	Use planting of native species to achieve fluvial corridor width. Allow for an additional 10 m of vegeated buffer on either side to achieve a total of 30 m on each side as per protection of redside dace survival habitat. Within this reach, maintain 2 to 3 m wide swath of herbaceous vegetation on either side of creek to provide maximum habitat benefit for redside dace.
14W-13	No management required from an aquatic and riparian habitat perspective.
14W-14	Allow succession of woody vegetation and mature trees to continue undisturbed within corridor.
14W-14A	Leave pond undisturbed and consider supplementing riparian zone with woody vegetation.
14W-16	Allow succession of woody vegetation and mature trees to continue undisturbed within corridor.
14W-17	Allow succession of woody vegetation and mature trees to continue undisturbed within corridor.
14W-18	No management required from an aquatic and riparian habitat perspective.
14W-20	No management required from an aquatic and riparian habitat perspective.

TABLE 6.3.5 OVERALL RIPARIAN CORRIDOR CLASSIFICATION

SUB-CATCHMENT AREA	STREAM REACH/ HABITAT UNIT (HU)	AQUATIC HABITAT CATEGORIZATION	OVERALL GEOMORPHOLOGY CLASSIFICATION	RELATIVE HYDROLOGIC FUNCTION	HYDROGEOLOGIC CONTRIBUTION TO STREAM HEALTH (FISHERIES, WETLANDS, ETC.)	TERRESTRIAL/WETLAND HABITAT	OVERALL CLASSIFICATION	Potential for Rehabilitation
JOSHUA'S CREEK	JOSHUA'S CREEK							
JC15	JC-1	Important Habitat	HIGH	HIGH	LOW	manicured golf course	LEVEL 1	N/A
JC10/ JC15	JC-2	Important Habitat	HIGH	HIGH	LOW	manicured golf course and lowland deciduous woodland; northern portion falls within Core #11	LEVEL 1	N/A
JC10	JC-3	Important Habitat	HIGH	HIGH	LOW	within Core #11, vegetation consists of lowland deciduous woods	LEVEL 1	N/A
JC10/ JC9	JC-4	Important Habitat	HIGH	HIGH	MEDIUM	within Core #11, vegetation consists of mixed woods, especially along slopes	LEVEL 1	N/A
JC9	JC-5	Critical Habitat	MEDIUM	HIGH	MEDIUM	within Core #11, vegetation consists of mixed woods, especially along slopes	LEVEL 1	N/A
JC9	JC-6	Important Habitat	MEDIUM	HIGH	LOW	partly outside Core #11, vegetation includes mixture of open savannah and thicket vegetation, with some mixed forest in extreme southern section	LEVEL 1A	HIGH
JC9	JC-7	Marginal Habitat	MEDIUM	HIGH	LOW	outside Core #11, thicket vegetation, with agricultural dominated lands further upstream	LEVEL 2	MEDIUM
JC9	JC-8	Marginal Habitat	LOW	HIGH	LOW	narrow band of marsh vegetation, agricultural dominated lands	LEVEL 2	LOW
JC7/ JC9	JC-9	Marginal Habitat	LOW	HIGH	LOW	narrow band of marsh vegetation, agricultural dominated lands	LEVEL 2	LOW
JC7	JC-10	No Direct Habitat	LOW	MEDIUM	LOW	agricultural lands, no natural vegetation	LEVEL 3	LOW
JC7	JC-10A	Marginal Habitat	LOW	MEDIUM	LOW	agricultural lands, no natural vegetation	LEVEL 2	LOW
JC8/ JC9	JC-11	No Direct Habitat	LOW	LOW	LOW	narrow band of marsh vegetation, agricultural dominated lands	LEVEL 3	MEDIUM
JC6/ JC9	JC-12	Important Habitat	MEDIUM	HIGH	LOW	within Core #11, vegetation consists of lowland deciduous woods	LEVEL 1	N/A
JC6	JC-13	Important Habitat	MEDIUM	HIGH	LOW	predominantly outside Core #11, vegetation includes mixture of open savannah, thicket, and cultural meadow, with some marsh along channel	LEVEL 1	N/A
JC5/ JC6	JC-14	Marginal Habitat	LOW	HIGH	LOW	predoinantly unvegetated agricultural lands, scattered pockets of marsh along northern section of reach	LEVEL2	LOW
JC1/ JC2/ JC3/ JC5	JC-15	No Direct Habitat	LOW	MEDIUM	LOW	narrow band of marsh along channel	LEVEL 3	LOW
JC10/ JC8B/ JC9	JC-19	Important Habitat	MEDIUM	MEDIUM	MEDIUM	lowland decidous woodland, within Core #11	LEVEL 1	N/A
JC7B/ JC8B	JC-20	Marginal Habitat	MEDIUM	MEDIUM	LOW	lowland deciduous woodland, predominantly outside Core #11	LEVEL 1	N/A
	JC-20A	Marginal Habitat	LOW	MEDIUM	LOW	dominated by agricultural fields, some meadow	LEVEL 2	MEDIUM
JC15	JC-22	Marginal Habitat	MEDIUM	HIGH	LOW	thicket vegetation on adjacent slopes	LEVEL 1A	MEDIUM
JC17	JC-27	No Direct Habitat	LOW	LOW	LOW	un-vegetated, agricultural dominated lands	LEVEL 3	LOW
	JC-27A	Marginal Habitat	MEDIUM	LOW	LOW	road side ditch	LEVEL 2	MEDIUM
JC17	JC-28	No Direct Habitat	LOW	MEDIUM	LOW	un-vegetated, agricultural dominated lands	LEVEL 3	LOW
JC17	JC-29	No Direct Habitat	LOW	LOW	LOW	un-vegetated, agricultural dominated lands, some meadow	LEVEL 3	LOW
JC15/ JC16	JC-30	No Direct Habitat	MEDIUM	LOW	LOW	un-vegetated, agricultural dominated lands	LEVEL 3	LOW
JC16/ JC17	JC-31	Marginal Habitat	LOW	MEDIUM	LOW	shallow water marsh and agricultural fields	LEVEL 2	LOW
JC16/ JC17	JC-31A	No Direct Habitat	LOW	MEDIUM	LOW	un-vegetated, agricultural dominated lands	LEVEL 3	LOW
JC16/ JC10	JC-32	No Direct Habitat	LOW	MEDIUM	LOW	un-vegetated, agricultural dominated lands	LEVEL 3	LOW
JC17	JC-36	Critical Habitat	MEDIUM	MEDIUM	HIGH	deciduous woodland, thicket, shallow water marsh	LEVEL 1	N/A

TABLE 6.3.5 OVERALL RIPARIAN CORRIDOR CLASSIFICATION

SUB-CATCHMENT AREA	STREAM REACH/ HABITAT UNIT (HU)	AQUATIC HABITAT CATEGORIZATION	OVERALL GEOMORPHOLOGY CLASSIFICATION	RELATIVE HYDROLOGIC FUNCTION	HYDROGEOLOGIC CONTRIBUTION TO STREAM HEALTH (FISHERIES, WETLANDS, ETC.)	TERRESTRIAL/WETLAND HABITAT	OVERALL CLASSIFICATION	Potential for Rehabilitation
EAST MORRISON	EAST MORRISON							
EM1/ EM4	MOC-2	Marginal Habitat	MEDIUM	MEDIUM	LOW	dominated by meadow with some deciudous woodland, north portion in Core #10 and surrounded by woodlands	LEVEL 2	MEDIUM
EM1	MOC-4	Important Habitat	MEDIUM	HIGH	LOW	dominated by meadow , marsh of variable width	LEVEL 1	N/A
EM1	MOC-5	No Direct Habitat	LOW	MEDIUM	LOW	north portion is un-vegetated, south portion consists of narrow marsh	LEVEL 3	LOW
EM1	MOC-5A	Marginal Habitat	LOW	MEDIUM	LOW	through agricultural field, cultural meadow, and deciduous forest	LEVEL 2	LOW
EM2/ EM3/ EM4	MOC-6	Marginal Habitat	No Information	MEDIUM	LOW	adjacent to deciduous forest	LEVEL 1	LOW
WEST MORRISON	WEST MORRISON							
WM1/ WM2	MOC-W1	Marginal Habitat	MEDIUM	MEDIUM	LOW	domninated by meadow	LEVEL 2	N/A
WM1	MOC-W2	Marginal Habitat	No Information	MEDIUM	LOW	partly vegetated, partly marsh and swamp in Core #5	LEVEL 2	N/A
WM1	MOC-W3	Important Habitat	MEDIUM	MEDIUM	LOW	un-vegetated along roadside with some marsh and neighbouring agricultural lands	LEVEL 2	N/A
WM1	MOC-W5	Marginal Habitat	No Information	MEDIUM	LOW	mostly un-vegetated, some thicket	LEVEL 2	HIGH
FOURTEEN MILE CREEK	FOURTEEN MILE CREEK							
FM1109	14W-1	Critical Habitat	HIGH	HIGH	LOW	meadow with scattered pockets of trees and shrubs, woodland along neighbouring slopes, inside Core #1	LEVEL 1	N/A
FM1107/ FM1109	14W-1A	Critical Habitat	HIGH	HIGH	LOW	meadow with scattered pockets of trees and shrubs, woodland along neighbouring slopes, inside Core #1	LEVEL 1	N/A
FM1107/ FM1108	14W-2	Important Habitat	HIGH	MEDIUM	LOW	meadow with thicket and scattered trees, inside Core #1	LEVEL 1	N/A
FM1108	14W-3	Important Habitat	HIGH	MEDIUM	LOW	deciduous woodland dominated, inside Core #1	LEVEL 1	N/A
FM1108	14W-4	Important Habitat	MEDIUM	MEDIUM	LOW	dominated by meadow, inside Core #1	LEVEL1	N/A
FM1108	14W-9	Important Habitat	MEDIUM	MEDIUM	LOW	dominated by deciduous woodland, inside Core #1	LEVEL 1A	HIGH
FM1108	14W-9A	Important Habitat	MEDIUM	MEDIUM	LOW	dominated by deciduous woodland, inside Core #1	LEVEL 1	N/A
FM1006/ FM1108	14W-10	Marginal Habitat	MEDIUM	MEDIUM	LOW	dominated by meadow with marsh in places, forms boundary of Core #1	LEVEL 2	MEDIUM
FM1107	14W-11	Important Habitat	MEDIUM	MEDIUM	LOW	deciduous woodland and meadow, only downstream end is in Core #1	LEVEL 1A	LOW
FM1107	14W-11A	Important Habitat	LOW	MEDIUM	LOW	meadow dominated, outside Core #1	LEVEL 2	LOW
FM1104/ FM1105	14W-12	Critical Habitat	MEDIUM	HIGH	LOW	narrow band of meadow, with lowland deciduous woodland at Dundas	LEVEL 1	N/A
FM1105	14W-13	No Direct Habitat	LOW	LOW	LOW	narrow band of meadow	LEVEL 3	LOW
FM1105	14W-14	Marginal Habitat	LOW	MEDIUM	LOW	meadow dominated by marsh in northern portion of reach	LEVEL 2	MEDIUM
FM1105	14W-14A	Important Habitat	LOW	MEDIUM	LOW	meadow dominated by marsh in northern portion of reach	LEVEL 2	MEDIUM
FM1104	14W-16	Important Habitat	LOW	MEDIUM	LOW	dominated by meadow and agricultural fields	LEVEL 2	LOW
FM1104	14W-17	Marginal Habitat	LOW	LOW	LOW	dominated by meadow	LEVEL 2	LOW
FM1108	14W-18	No Direct Habitat	LOW	LOW	LOW	dominated by meadow	LEVEL 3	LOW
FM1109	14W-20	No Direct Habitat	MEDIUM	HIGH	LOW	inside Core #1, the southern portion dominated by meadow, with northern portions un-vegetated	LEVEL 3	LOW
FM1111	14E-1	Important Habitat		MEDIUM	LOW	associated with wetland/pond at Dundas	LEVEL 1A	HIGH
FM1111	14E-2	Important Habitat		MEDIUM	LOW	dominated by meadow and thicket vegetation	LEVEL 2	HIGH
FM1111	14E-2A	Important Habitat		MEDIUM	LOW	dominated by meadow and thicket vegetation	LEVEL 2	MEDIUM

TABLE 6.3.5 OVERALL RIPARIAN CORRIDOR CLASSIFICATION								
SUB-CATCHMENT AREA	STREAM REACH/ HABITAT UNIT (HU)	AQUATIC HABITAT CATEGORIZATION	OVERALL GEOMORPHOLOGY CLASSIFICATION	RELATIVE HYDROLOGIC FUNCTION	HYDROGEOLOGIC CONTRIBUTION TO STREAM HEALTH (FISHERIES, WETLANDS, ETC.)	TERRESTRIAL/WETLAND HABITAT	OVERALL CLASSIFICATION	Potential for Rehabilitation
FM1111	14E-3	Important Habitat		MEDIUM	LOW	dominated by meadow and marsh vegetation	LEVEL 2	HIGH
FM1111	14E-3A	Important Habitat		LOW	LOW	un-vegetated, agricultural dominated	LEVEL 2	LOW
FM1111/ MC1012	14E-4	No Direct Habitat	LOW	LOW	LOW	un-vegetated except for extreme southern portion that is dominated by meadow	LEVEL 3	LOW
FM1111	14E-6	Important Habitat	LOW	MEDIUM	LOW	dominated by thicket and meadow vegetation	LEVEL 1	N/A
FM1111	14E-7	Important Habitat	MEDIUM	MEDIUM	LOW	dominated by lowland deciduous woodland	LEVEL 1	N/A
FM1111	14E-8	Marginal Habitat	LOW	LOW	LOW	road side ditch	LEVEL 2	LOW
FM1110.1	14E-9	No Direct Habitat	LOW	MEDIUM	LOW	manicured lawns (private properties)	LEVEL 3	LOW
FM1110/ FM1110.1	14E-10	No Direct Habitat	LOW	LOW	LOW	un-vegetated, agricultural lands	LEVEL 3	LOW
McCRANEY CREEK	McCRANEY CREEK							
MC1114	MC-1	Marginal Habitat	LOW	MEDIUM	LOW	un-vegetated, agricultural lands	LEVEL 2	LOW
MC1114	MC-2	No Direct Habitat	LOW	LOW	LOW	un-vegetated, agricultural lands	LEVEL 3	LOW
MC1114	MC-4	No Direct Habitat	LOW	LOW	LOW	un-vegetated, agricultural lands	LEVEL 3	LOW
MC1114	MC-4A	Marginal Habitat	MEDIUM	LOW	LOW	un-vegetated, agricultural lands	LEVEL 2	LOW
TAPLOW CREEK	TAPLOW CREEK							
TC1115	TC-1	No Direct Habitat	LOW	LOW	LOW	un-vegetated, agricultural lands	LEVEL 3	LOW
TC1115	TC-2	No Direct Habitat	LOW	LOW	LOW	un-vegetated, agricultural lands	LEVEL 3	LOW
SM1117/ TC1115	TC-2A	No Direct Habitat	LOW	LOW	LOW	un-vegetated, agricultural lands, downstream end flows through small deciduous woodland	LEVEL 3	LOW
GLEN OAK CREEK	GLEN OAK CREEK							
GO1116	GO-1	No Direct Habitat	LOW	MEDIUM	LOW	un-vegetated, agricultural lands	LEVEL 3	LOW
SHANNON'S CREEK	SHANNON'S CREEK							
SC1	SHC-1	Marginal Habitat	LOW	MEDIUM	LOW	narrow band of meadow	LEVEL 2	MEDIUM
SC1	SHC-2	Marginal Habitat	MEDIUM	MEDIUM	LOW	narrow band of meadow and marsh	LEVEL 2	MEDIUM
SC1	SHC-3	No Direct Habitat	LOW	LOW	LOW	downstream portion dominted by meadow but periodically plowed, northern portion un-vegetated	LEVEL 3	LOW
SIXTEEN MILE CREEK	SIXTEEN MILE CREEK							
ES5/ ES9	SMA-1	Important Habitat	HIGH	HIGH	LOW	dominated by deciduous woodland	LEVEL 1	N/A
ES5/ ES8	SMA-2	Marginal Habitat	HIGH	MEDIUM	LOW	dominated by deciduous woodland	LEVEL 1A	HIGH
ES8	SMA-3	Marginal Habitat	MEDIUM	MEDIUM	LOW	dominated by meadow adajcent to landfill	LEVEL 2	MEDIUM
ES7/ ES8	SMA-4	Important Habitat	MEDIUM	MEDIUM	LOW	dominated by thicket and deciduous woodland	LEVEL 1	HIGH
ES7	SMA-5	Important Habitat	MEDIUM	MEDIUM	LOW	dominated by decidous woodland and swamp	LEVEL 1	N/A
ES6/ ES7	SMA-6	Important Habitat	MEDIUM	MEDIUM	LOW	dominated by deciduous woodland and thicket in upstream portion	LEVEL 1	N/A
ES5	SMA-7	Marginal Habitat	HIGH	MEDIUM	LOW	dominated by deciduous woodland	LEVEL 1A	HIGH
ES5	SMA-8	Marginal Habitat	MEDIUM	MEDIUM	Medium	dominated by meadow adajcent to landfill	LEVEL 2	MEDIUM
ES5	SMA-9	No Direct Habitat	MEDIUM	MEDIUM	LOW	un-vegetated, agricultural lands	LEVEL 2	MEDIUM
ES4	SMB-1	Important Habitat	HIGH	MEDIUM	LOW	dominated by deciduous woodland	LEVEL 1A	HIGH
ES4	SMB-2	Important Habitat	HIGH	MEDIUM	LOW	dominated by deciduous woodland	LEVEL 1A	HIGH
ES4	SMB-3	Important Habitat	MEDIUM	MEDIUM	LOW	dominated by deciduous woodland	LEVEL 1A	HIGH
ES4	SMB-4	Important Habitat	HIGH	MEDIUM	LOW	dominated by deciduous woodland	LEVEL 1A	HIGH
ES3	SMC-1	Important Habitat	HIGH	MEDIUM	LOW	dominated by deciduous woodland	LEVEL 1A	HIGH
ES2/ ES3	SMC-2	Marginal Habitat	HIGH	MEDIUM	LOW	un-vegetated, agricultural lands	LEVEL 1A	HIGH
ES2	SMC-3	Important Habitat	Pond	LOW	LOW	un-vegetated, agricultural lands	LEVEL 2	HIGH
ES2	SMC-4	No Direct Habitat	LOW	LOW	LOW	un-vegetated, agricultural lands	LEVEL 3	LOW
ES2	SMC-5	No Direct Habitat	MEDIUM	LOW	LOW	un-vegetated, agricultural lands	LEVEL 3	LOW
SM1020	16W-1	Important Habitat	NO INFORMATION	HIGH	LOW	deciduous and mixed woodland	LEVEL 1	N/A
SM1020	16W-2	Important Habitat	NO INFORMATION	HIGH	LOW	deciduous and mixed woodland	LEVEL 1	N/A
SM1020	16W-3	Important Habitat	NO INFORMATION	MEDIUM	LOW	deciduous and mixed woodland	LEVEL 1	N/A
SM1020	16W-4	No Direct Habitat	NO INFORMATION	LOW	LOW	agricultural lands with narrow meadow strip	LEVEL 3	N/A
SM1117	16WA-1	Important Habitat	MEDIUM	MEDIUM	LOW	dominated by lowland deciduous woodland	LEVEL 1	N/A

TABLE 6.3.5 OVERALL RIPARIAN CORRIDOR CLASSIFICATION								
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SM1117	16WA-1A	Important Habitat	MEDIUM	LOW	LOW	meadow and marsh associated with channel	LEVEL 1	MEDIUM
SM1117	16WA-2	No Direct Habitat	LOW	LOW	LOW	un-vegetated, agricultural lands	LEVEL 3	LOW
SM1117	16WA-3	No Direct Habitat	LOW	LOW	LOW	un-vegetated, agricultural lands	LEVEL 3	LOW
SM1117	16WA-4	No Direct Habitat	LOW	MEDIUM	LOW	un-vegetated, extreme northern portion in Core #3	LEVEL 3	LOW
SM1117	16WA-5	No Direct Habitat	MEDIUM	LOW	LOW	un-vegetated, agricultural lands	LEVEL 3	LOW
SM1117	16WA-6	No Direct Habitat	LOW	LOW	LOW	un-vegetated, agricultural lands	LEVEL 3	LOW
SM1117	16WA-7	No Direct Habitat	LOW	LOW	LOW	un-vegetated, agricultural lands	LEVEL 3	LOW
SM1117	16WA-8	No Direct Habitat	LOW	MEDIUM	LOW	dominated by deciduous woodland, associated wetlands	LEVEL 1	LOW
SM1117	16WA-8A	No Direct Habitat	LOW	LOW	LOW	agricultural lands with narrow meadow strip	LEVEL 3	
MUNN'S CREEK	MUNN'S CREEK							
MC2	MUN-1	No Direct Habitat	LOW	MEDIUM	LOW	un-vegetated, agricultural lands	LEVEL 3	LOW
MC1	MUN-2	Marginal Habitat	LOW	MEDIUM	LOW	marsh and meadow	LEVEL 2	LOW
MC1	MUN-3	Marginal Habitat	LOW	MEDIUM	LOW	un-vegetated, agricultural lands	LEVEL 2	LOW

TABLE 6.3.6 TARGET UNIT AREA PEAK FLOW RATES
EXISTING LAND USE

Location	Culvert No.	Drainage Area (ha.)	Regional Storm	100 year storm	50 year storm	25 year storm	10 year storm	5 year storm	2 year storm
				m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s
14 Mile Creek									
Dundas St. W.	FM-D2	46.56	2.07	0.73	0.64	0.55	0.41	0.33	0.18
	Flow rate / Area (m^3/s/ha)		0.044	0.016	0.014	0.012	0.009	0.007	0.004
	FM-D3	11.71	0.53	0.19	0.17	0.15	0.11	0.09	0.05
	Flow rate / Area (m^3/s/ha)		0.045	0.016	0.015	0.013	0.010	0.008	0.005
	FM-D4	423.70	18.85	6.68	5.85	5.04	3.83	3.05	1.70
	Flow rate / Area (m^3/s/ha)		0.044	0.016	0.014	0.012	0.009	0.007	0.004
	FM-D5	339.99	14.39	4.93	4.27	3.64	2.71	2.10	1.05
	Flow rate / Area (m^3/s/ha)		0.042	0.014	0.013	0.011	0.008	0.006	0.003
	FM-D6	16.91	0.77	0.28	0.24	0.21	0.16	0.13	0.08
	Flow rate / Area (m^3/s/ha)		0.045	0.016	0.014	0.013	0.010	0.008	0.005
	FM-D6a	26.23	1.14	0.41	0.36	0.31	0.23	0.19	0.10
	Flow rate / Area (m^3/s/ha)		0.044	0.016	0.014	0.012	0.009	0.007	0.004
	FM-D7	247.92	10.77	3.77	3.29	2.82	2.13	1.68	0.90
	Flow rate / Area (m^3/s/ha)		0.043	0.015	0.013	0.011	0.009	0.007	0.004
	FM-D8	8.45	0.37	0.14	0.12	0.10	0.08	0.07	0.04
	Flow rate / Area (m^3/s/ha)		0.044	0.016	0.014	0.012	0.009	0.008	0.005
	FM-D9	18.58	0.85	0.31	0.27	0.23	0.18	0.15	0.08
	Flow rate / Area (m^3/s/ha)		0.046	0.017	0.015	0.013	0.010	0.008	0.005
McCraney Creek									
Dundas St. W.	MC-D1	126.46	5.64	2.02	1.77	1.53	1.17	0.93	0.53
	Flow rate / Area (m^3/s/ha)		0.045	0.016	0.014	0.012	0.009	0.007	0.004
Taplow Creek									
Dundas St. W.	TC-D1	33.61	1.50	0.53	0.47	0.41	0.31	0.25	0.14
	Flow rate / Area (m^3/s/ha)		0.045	0.016	0.014	0.012	0.009	0.007	0.004
Glen Oak Creek									
Dundas St. W.	GO-D1	47.16	2.14	0.77	0.68	0.59	0.45	0.36	0.21
	Flow rate / Area (m^3/s/ha)		0.045	0.016	0.014	0.012	0.010	0.008	0.004
West 16 Mile Creek Tribs.									
Dundas St. W.	SM-D1	83.84	3.57	1.25	1.09	0.94	0.71	0.56	0.30
	Flow rate / Area (m^3/s/ha)		0.043	0.015	0.013	0.011	0.008	0.007	0.004
	SM-D1a	12.53	0.57	0.21	0.18	0.16	0.12	0.10	0.06
	Flow rate / Area (m^3/s/ha)		0.046	0.016	0.014	0.013	0.010	0.008	0.005
	SM-D2	8.01	0.37	0.13	0.12	0.10	0.08	0.06	0.04
	Flow rate / Area (m^3/s/ha)		0.046	0.016	0.014	0.012	0.010	0.008	0.004
East 16 Mile Creek Tribs.									
Sixteen Mile Creek	----	383.1	16.24	5.55	4.80	4.08	3.02	2.32	1.14
	Flow rate / Area (m^3/s/ha)		0.042	0.014	0.013	0.011	0.008	0.006	0.003
Osenego Creek									
Dundas St. W.	OC-D1	43.93	2.01	0.73	0.64	0.56	0.43	0.35	0.20
	Flow rate / Area (m^3/s/ha)		0.046	0.017	0.015	0.013	0.010	0.008	0.005
Shannon's Creek									
Dundas St. W.	SC-D1	84.37	3.61	1.26	1.09	0.94	0.71	0.55	0.29
	Flow rate / Area (m^3/s/ha)		0.043	0.015	0.013	0.011	0.008	0.007	0.003

TABLE 6.3.6 TARGET UNIT AREA PEAK FLOW RATES EXISTING LAND USE									
Location	Culvert No.	Drainage Area (ha.)	Regional Storm	100 year storm	50 year storm	25 year storm	10 year storm	5 year storm	2 year storm
				m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s
Munn's Creek									
Dundas St. W.	MC-D1	29.99	1.35	0.49	0.43	0.37	0.29	0.23	0.14
	Flow rate / Area (m^3/s/ha)		0.045	0.016	0.014	0.012	0.010	0.008	0.005
	MC-D4	59.61	2.66	0.95	0.84	0.72	0.55	0.45	0.26
	Flow rate / Area (m^3/s/ha)		0.045	0.016	0.014	0.012	0.009	0.007	0.004
West Morrison Creek									
Dundas St. E.	MW-D3	200.06	8.71	3.11	2.72	2.35	1.79	1.43	0.80
	Flow rate / Area (m^3/s/ha)		0.044	0.016	0.014	0.012	0.009	0.007	0.004
East Morrison Creek									
Dundas St. E.	ME-D2	356.80	15.43	5.42	4.71	4.06	3.02	2.39	1.32
	Flow rate / Area (m^3/s/ha)		0.043	0.015	0.013	0.011	0.008	0.007	0.004
Joshua's Creek									
Dundas St. E.	JC-D1	978.37	42.63	15.13	13.24	11.41	8.68	6.92	3.86
	Flow rate / Area (m^3/s/ha)		0.044	0.015	0.014	0.012	0.009	0.007	0.004
	JC-D2	134.48	5.82	2.05	1.79	1.54	1.17	0.93	0.51
	Flow rate / Area (m^3/s/ha)		0.043	0.015	0.013	0.011	0.009	0.007	0.004

TABLE 6.3.7
TOPOGRAPHY OF DEPRESSIONS

ID	DRAINAGE AREA	TYPE	DEP NUM	DEPRESSION SIZE (ha)
15	JC7a-	depression	50	0.0073
17	EM2	depression	51	0.1510
30	WM1	depression	52b	0.0212
32	WM1	depression	106	0.0217
33	EM3	depression	52	0.0280
34	EM1	depression	52	0.0424
35	EM1	depression	102b	0.0440
36	EM1	depression	103	0.2004
37	EM1	depression	29	0.1134
38	EM1	depression	31	0.2102
39	EM1	depression	30	0.0171
40	EM1	depression	32	0.0537
41	EM1	depression	28	0.2708
42	EM4	depression	33	0.0837
43	EM4	depression	34	0.2002
45	ES2	both	116b	0.0267
47	ES4	both	107	0.0832
48	ES5	depression	109	0.0362
49	ES5	depression	55	0.0019
50	ES5	depression	20	0.0174
66	ES6	depression	53	0.1410
67	ES6	depression	64	0.0794
68	ES6	both	65	0.0474
71	ES6	depression	68	0.0974
73	ES6	both	54	0.0372
74	ES8	depression	19b	0.1570
80	FM1103	depression	1	0.0923
81	FM1105	depression	101	0.0944
82	FM1105	depression	2	0.0727
83	FM1107	depression	3	0.0394
86	FM1109	depression	4	0.1610
87	FM1110	depression	4	0.1061
88	FM111	depression	8	0.2229
90	FM111	depression	7	0.0343
91	FM1110	depression	5	0.0636
92	FM1110	depression	6	0.0546
93	GO1116	depression	15	0.1007
94	GO1116	depression	14	0.2987
95	GO1116	depression	13	0.0506
96	TC1115	depression	12	0.0185
97	GO1116	depression	12	0.0750
99	JC11	depression	115	0.0194
100	JC12	both	43	0.0980
101	JC13	depression	48b	0.0991
102	JC16	depression	35	0.5246
103	JC3	both	49	0.1079

TABLE 6.3.7
TOPOGRAPHY OF DEPRESSIONS

ID	DRAINAGE AREA	TYPE	DEP NUM	DEPRESSION SIZE (ha)
110	JC6	depression	59	0.0796
111	JC6	depression	60	0.0537
112	JC6	depression	105	0.0543
116	JC7b	both	44	0.0906
120	JC7b	depression	48	0.1901
123	JC7b	depression	46	0.0913
124	JC7b	depression	45	0.0601
125	JC7b	both	47	0.0651
126	JC10	depression	58	0.0611
127	JC8b	depression	58	0.1100
128	JC9	depression	61	0.1711
129	JC9	depression	104	0.1850
130	JC9	depression	62	0.1901
131	MC1	depression	24	0.0372
132	MC1	depression	25	0.2226
133	MC2	depression	25	0.0699
134	MC1	depression	22	0.1144
135	MC1	depression	23	0.0457
136	MC2	depression	26	0.1321
141	MC1114	both	9	0.2826
142	MC1114	depression	10	0.0617
143	MC1114	depression	11	0.1432
144	OC1	depression	21	0.0873
145	SC1	depression	67	0.0472
146	SC1	depression	66	0.0781
147	SC1	depression	69	0.0377
156	SM1117	depression	17	0.1132
157	SM1117	depression	16	0.0545
158		both	108	0.0220
159	SM1117	both	108	0.0389
161	SM1117	depression	18	0.5974
162	SM1117	depression	18	0.5549
163	TC1115	depression	102	0.3253

Table 6.3.8 Assessment of Management Measures Addressing Targets for Different Objectives					
Objective	Infiltration	Baseflow	Flood Protection	Erosion Control	Water Quality
Target Measure	Maintain pre development level				TP – no increase over predevelopment TSS – 80% or 70% control
Infiltration trench/basin	H	H	M	M	H
Source quantity controls	L	L	M	M	M
Source pollution prevention					H
Natural surface drainage	L	L	L	L	M
Wet pond					H
Extended detention		H	H	H	M