LONDON DYKES VEGETATION MANAGEMENT PLAN
PRELIMINARY INVESTIGATION PHASE

FINAL REPORT

CITY OF LONDON

Prepared for:

Upper Thames River Conservation Authority

By:

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1 INTRODUCTION

Dougan & Associates was retained by the Upper Thames River Conservation Authority to prepare a Vegetation Management Plan for the London Dykes. The Study Area consists of the 7 major dykes within the City of London, Ontario (see Figure 1: Site Location). Terms of Reference for the present study were provided as a document accompanied by a letter dated February 17, 2005 (from Matt Wood B.E.Sc., B.Sc., Project Engineer [EIT]): London Dykes Vegetation Management Plan Terms of Reference (UTRCA 2005).

The purpose of the Vegetation Management Plan is to identify and prioritise vegetation that currently poses a threat to the structural integrity of the dykes, suggest appropriate removal & remediation methods for the hazard vegetation, and to develop a plan for the future management of vegetation along the dykes. The current report presents results based on background data collection, field surveys (conducted in May, 2005; and January, 2006) and a detailed analysis of the findings. This information was used to identify risks and opportunities with respect to existing vegetation communities, to recommend mitigation measures to further minimize risks to the structural integrity of the dykes and to identify ecological and habitat restoration opportunities within the adjacent natural context.

This report documents the results of the Preliminary Investigation Phase, the first Phase in the London Dykes Vegetation Management Plan Project. The entire scope of the project consists of the following phases:

I. Preliminary Investigation
II. City Consultation
III. Draft Design
IV. Public Consultation
V. Detailed Design
VI. Implementation

This Preliminary Investigation Report presents the baseline data and conceptual planning that will guide the subsequent stages of the project.

Key content of this report is summarized in text, tables and figures, as follows.

- Section 3.1.1 defines four risk levels based on field observations
- Table 1 presents the system used to identify and prioritize hazard tree conditions
- Table 2 summarizes dyke sub-areas by observed risk levels
- Appendix 5 presents a detailed description of Preliminary Assessment observations for each dyke
- Appendix 6 summarizes recommended actions to manage risks for each dyke
- Appendix 7 provides a Management Implementation and Design Development Flowchart, summarizing phasing and details of implementation
- Figures 02 to 11 are maps of cover conditions, property ownership, and identified risk levels for each dyke

2 DESCRIPTION OF THE ENVIRONMENT FOR THE LONDON DYKES AND ADJACENT NATURAL CONTEXT

The current assessment of the London Dykes was conducted using available background information resources, supplemented with additional data collected during field reconnaissance. Background information reviewed for the site included the following documents and databases:

- 2004 Stantec Report summarizing the structural integrity of the London Dykes
- Thames Valley Corridor Plan Phase I Terms of Reference
- Aerial photographs (where available) illustrating each dyke location, plant communities and the Thames River floodplain
- AutoCAD Base Map files showing grading contours, property lines, permanent and built structures, Thames River, Thames River Floodplain and surrounding communities

The original time frame for the study was limited and required all field work to be completed in the spring. Accordingly, a field investigation of all seven dykes was completed by Dougan & Associates on May 2 and 4th, 2005. The weather and growing conditions at the time of the survey were cold and wet; and therefore few herbaceous species had fully emerged from dormancy and woody plant material had not fully leafed out. Subsequently, a joint site visit by staff from Dougan & Associates and staff from the Upper Thames River Conservation Authority took place to all seven dykes on January 6, 2006. This site visit was a preliminary assessment of the existing vegetative conditions of each dyke by senior ecology and landscape design staff. Specific hazards were assessed in order to identify and prioritise key risk areas.

2.1 Vegetation Resources

Field work involved Dougan & Associates staff visiting each location and photographing/assessing the plant communities currently established at each site. All trees were identified, counted and measured (dbh). Diversity of woody and herbaceous plant material was itemized and general observations regarding their abundance recorded. Vegetation Communities were classified to the Community Series level according the MNR's Ecological Land Classification System (Lee et al., 1998).

2.1.1 Vascular Plant Inventory

A total of 92 vascular plant species were recorded during the survey. Of these, 39 are native with the remaining 53 species introduced resulting in only 42% of recorded species as native vegetation. Two of the native species identified are considered significant according to COSEWIC. They are:

- Butternut (*Juglans cinerea*) observed in good health at Nelson & Clarence Dyke. The Butternut was recently designated as nationally and provincially endangered (*Species At Risk Act* [Federal Legislation] and the *Endangered Species Act* [Provincial Legislation]) although it not considered a rare species in Middlesex County (Brenda Gallagher, UTRCA). All species categorized as *Endangered* are afforded habitat protection under the Provincial Policy Statement of the *Planning Act*. A special management plan will likely be required to manage the habitat for this species (see Section 5: Conclusions for further comments).

- Kentucky Coffee Tree (*Gymnocladus dioica*) specimens that were likely planted were observed at the Coves Dyke and Broughdale Dyke. The Kentucky Coffee Tree is a nationally and provincially threatened species.

A complete list of vascular plant species recorded on the survey is presented in *Appendix 1: Vascular Plant Species List*.

2.1.2 Vegetation Communities

Vegetation features were assigned following the ELC protocol (Ecological Land Classification, MNR). Vegetation communities have been designated at the ELC's "Community Series" Level, the most detailed level in the ELC that can be identified without a site visit (i.e. by aerial photo interpretation, see ELC Field Guide, 1998. pg. 18). Detailed ELC site inventories are required to advance the ELC designation to the Ecosite or Vegetation Type. A site visit and vegetation species inventory was conducted. A vascular plant list for species identified during the site visit is presented in *Appendix 1*. An Anthropogenic community type has been introduced to account for residential, commercial, industrial and public open spaces that are maintained in an ornamental setting.

The ecosystem along the Thames River and at the locations of all seven dykes has been highly disturbed by urbanization making classification and assessment technically difficult. Two general vegetation communities can be described: 1) an Anthropogenic Community comprising the actual dykes and much of the associated adjacent residential, commercial & park lands; and 2) a Floodplain Community comprising the remnant natural habitats adjacent to the Thames River. The floodplain community was classified as Fresh-Moist Lowland Deciduous Forest Ecosite (FOD7).

2.1.2.1 Description of the Anthropogenic Communities

The dykes are adjacent to urban parks and residential backyards, and are dominated by species tolerant of these habitats. A large component of planted/escaped ornamentals and invasive species were observed on all dykes. Side slopes at each dyke are steep, supporting opportunist tree species with a propensity for severe lean: many trees, specifically Manitoba maple and White willow hybrids were observed leaning and/or fallen over. In many locations concrete blocks and other construction debris, yard waste and household garbage cluttered certain areas of the individual dykes. The dyke community is a continuation of the floodplain and thus has a species composition very similar to the adjacent floodplain. However, mature Silver Maples and Sycamores are absent and Cottonwoods were less numerous on the dykes than they were in the floodplain habitat.

Tree canopy species on the dykes consisted of Manitoba Maple (*Acer negundo*), Norway Maple (*Acer platanoides*), hybrid White Willow (*Salix X rubens*), Black Walnut (*Juglans nigra*) and various ornamentals and backyard shade trees depending on the location. The subcanopy was a mixture of Buckthorn and Choke Cherry with saplings of the tree canopy species. Ground cover was similar to that of the floodplain, with more garden escapes such as periwinkle (*Vinca minor*).

2.1.2.2 Description of the Floodplain Communities

The vegetation observed in the floodplain community adjacent to each dyke along the Thames River was very similar, with some minor differences in canopy cover and species composition.

The tree canopy in the floodplain areas was generally dominated by Manitoba Maple (*Acer negundo*), Norway Maple (*Acer platanoides*), hybrid white Willow (*Salix X rubens*) and some Eastern Cottonwood (*Populus deltoides ssp. deltoides*). Less common associates included Silver Maple (*Acer saccharinum*) and Sycamore (*Platanus occidentalis*). In some locations, large diameter specimens (greater than 60cm dbh) of the latter two species were observed, usually growing in close proximity to the Thames River. The Eastern Cottonwoods observed had a broader size class range (20-100 cm+ dbh) and were

observed growing in a wider array of habitats (floodplain and on the dykes). Regeneration on the dykes and floodplain for Silver Maple, Sycamore and Cottonwood was minimal.

The understory varied from a relatively open canopy to approximately 50% cover. The most prevalent species included saplings of Manitoba Maple (*Acer negundo*), Norway Maple (*Acer platanoides*), Buckthorn (*Rhamnus cathartica*) and Choke Cherry (*Prunus virginiana ssp. virginiana*) shrubs. In some areas young Hackberry (*Celtis occidentalis*), Black Walnut (*Juglans nigra*) and White Elm (*Ulmus americana*) trees and saplings were observed.

The ground cover was heavily dominated by aggressive introduced species including Garlic Mustard (*Alliaria petiolata*), Goutweed (*Aegopodium podagraria*), and Dame's Rocket (*Hesperis matronalis*) throughout the floodplain community. At some locations large colonies of Trout Lilies (*Erythronium americanum ssp. americanum*) were observed. Soils were generally sandy and there were pools with small numbers of aquatic plant species associated with some of the floodplain areas. Skunk Cabbage (*Symplocarpus foetidus*) plants were observed in wet muddy pockets at some locations.

3 ASSESSMENT OF VEGETATION HAZARDS THREATENING DYKE INTEGRITY

The vegetative hazards that threaten the stability of the London Dykes can be attributed to two general categories. First are the direct hazards caused by the growth of tree species directly on the dyke facilities; and second, the indirect hazards caused by disturbance based impacts upon the surrounding natural heritage matrix (the riparian and floodplain communities) which contribute to the establishment and ongoing perpetuation of hazard tree conditions on the dykes.

3.1 Direct Hazard: Growth of Hazard Trees Upon Dykes

Since their construction, a variety of vegetation species and types have become established upon London's Dyke facilities. Certain specimens have developed with the potential to damage the dykes they are growing on and should be considered a "hazard tree". A "hazard tree" is a tree with structural or growth defects likely to cause failure of all or part of the tree, which in turn could damage a dyke. Some of the risks associated with the growth of hazard trees upon the dykes include:

- Fast growing shallow rooted weedy species growing on the dykes that can become top heavy and lean over, gradually heaving portions of the dyke structure.
- The effects of wind on any tree species growing on the dyke facilities will increase the heaving action described above.
- The growth and expansion of large tree trunks and roots that can separate and break hard structures such as concrete and stone facilities.
- The growth of large woody debris which can contribute to the erosive capability of high water events by focusing scour around the trunk base and donating logs to flows which could batter or block downstream flow management structures.
- The growth of certain species tend to cause dense shading of the understory, leaving the soil relatively bare and also favouring the establishment of undesirable invasive groundcovers with coarse shallow root systems, often as monocultures that leave soil susceptible to erosion.

All trees currently growing on the London Dykes **do not** represent the same level of risk to the dyke integrity. The use of the "hazard tree" concept requires an evaluation process to assess existing risk

for individual specimens. Risk should be defined by a series of management thresholds that stipulates a corresponding action.

A preliminary investigation of the risk level at each dyke was conducted on January 6th, 2006 by Dougan & Associates and UTRCA Staff to prioritise and facilitate the implementation of recommended management strategies. Table 1: Identification and Prioritization of Hazard Tree Conditions on the London Dykes outlines recommended strategies used to identify vegetative risks to dyke integrity and prioritization categories for hazard trees. The results of that investigation are presented in Table 2: Dykes Prioritized by Risk Level and Appendix 05: Preliminary Assessment Results for the Identification and Prioritization of Hazard Trees on the London Dykes, and mapped in Figures 3 through 11.

3.1.1 Risk Categories

Each of the seven dykes was examined for the level of direct hazards specifically affecting physical integrity. The dykes have been prioritized according to the level of risk posed and the need for intervening action to ensure the dyke's integrity. The priority levels are as follows:

1. Degraded – The physical integrity of the dyke is already compromised. Portions of the dyke have been physically damaged and are in imminent need of repair. The ability of the dyke to function properly in a flood event is in question and should be evaluated by an engineer.
2. Critical – The physical integrity of the dyke is about to be compromised. Management action to deal with hazard trees should be taken within a two year window to prevent the dyke from becoming physically degraded.
3. Threshold – Existing vegetation includes problem species and individual specimens on a trajectory toward hazardous conditions. Management action should be taken within a three to five year window to avoid the dyke reaching a critical or degraded condition.
4. No Action Required – There is no short-term threat to the integrity of the dyke. Monitoring and maintenance should be initiated to avoid the development of hazard vegetation.

Table 1: Identification and Prioritization of Hazard Tree Conditions on the London Dykes

PRIORITY CATEGORIES	HAZARD TREE RISK FACTORS				RECOMMENDED ACTION
	Species	Size & Form	Health	Location	
High Risk: Existing Hazard Tree Conditions A "hazard tree" is a tree with structural or growth defects <u>likely</u> to cause failure of all or part of the tree, which could physically damage a dyke. Dyke Risk Categories include: 1. **Degraded** – The physical integrity of the dyke is already compromised by treefall. Portions of the dyke have been damaged and are in immediate need of repair. The ability of the dyke to function properly in a flood event may be compromised and should be evaluated by an engineer. 2. **Critical** – The physical integrity of the dyke is about to be compromised due to size and/or lean of trees but no physical degradation is visible yet. Management action to deal with hazard trees should be taken within a two year window to prevent the dyke from becoming physically degraded.	Below is a list of the tree species prevalent on the London Dykes that are highly prone to structural defects, severe lean, disease, and/or damage from other environmental factors (wind throw, winter kill, ice, etc…). ▪ Crack Willow (*Salix fragilis*) ▪ Manitoba Maple (*Acer negundo*) ▪ Norway Maple (*Acer platanoides*) In the context of the current study the consideration of ecological "fit" is also a factor as certain species contribute to ancillary risk factors that present a cumulative threat to the long term physical integrity of the dyke facilities. The following species are a threat to most habitats as they tend to disperse widely (seed rain carried by birds, water or wind) and aggressively colonize newly disturbed sites. ▪ Common Buckthorn (*Rhamnus cathartica*) ▪ Crack Willow (*Salix fragilis*) ▪ Manitoba Maple (*Acer negundo*) ▪ Norway Maple (*Acer platanoides*) ▪ Tatarian Honey Suckle (*Lonicera tatarica*)	**Size**: ▪ Large diameter trees and branches are more massive and capable of inflicting greater damage due to their mass. ▪ Larger trees are generally older and have had more time to accumulate defects. ▪ Larger specimens are often regarded as an aesthetic asset by the public in spite of identified risks. Therefore, a priority should be placed on removal of identified High Risk tree species growing directly upon the dykes prior to achieving a diameter greater than 10cm; and, removal of identified Moderate Risk tree species in good form growing directly upon the dykes prior to achieving a diameter greater than 25 to 35cm. **Form**: <u>Cracks</u>: a crack is a separation of the wood; or, a split through the bark into the wood of a tree. ▪ Tree trunk has been split in two by a crack. ▪ Tree trunk has several cracks that also display evidence of decay. <u>Root Problems</u>: the tree's root system does provide a sufficient anchor for the above ground structure ▪ Roots girdling the tree's trunk. ▪ Tree is leaning with evidence of mounding or soil heaving within the root zone. ▪ Evidence of root damage, decay and/or death within >50% of the tree's dripline (USDA, 2003). <u>Weak Branch Unions</u>: present where a branch projects from the tree's trunk; or, basal unions of a multi-stemmed specimen. ▪ Epicormic Branch – a young branch that has grown to replace a lost limb; they are weaker because they are not attached all the way to the centre of the trunk. ▪ Included Bark – an area of "ingrown" bark at a branch union. Unions are strongest when formed wood to wood.	**Decay**: Decay is a condition of the wood (as opposed to the bark). Indicators of decay include missing wood, rotting wood, fungal growths, bulges and/or cavities in the trunk. <u>Cavities</u>: ▪ Decay can be difficult to determine as it often occurs inside a trunk with no exterior openings in evidence. ▪ Cavities are also significant wildlife shelters; decay should be considered severe (see below) and/or other high risk factors should be present before cavities alone place a specimen into the hazard tree category. It is recommended that any cavity tree that is otherwise healthy and in good form be left as wildlife shelter. <u>Severe Decay</u>: ▪ Indicators of decay (missing wood, rotting wood, fungal growths, bulges and/or cavities in the trunk) occur on > 40% of the trunk or major branches (USDA, 2003). ▪ Any hollow trunks with a shell thickness (remaining live wood) of < 1 inch of secure wood for each 6 inches of trunk (USDA, 2003). **Canker**: Cankers are localised areas on a tree's trunk or branches that have missing or sunken bark. Canker can be caused by disease or damage and can weaken the branch structure. ▪ Canker affects more than 40% of the tree's circumference (USDA, 2003). ▪ Canker and decay affect more than 40% of the tree's circumference (USDA, 2003). **Dead Wood**: Any dead tree or tree with > 25% dead branches is automatically a high risk. Dead trees and branches are unpredictable and could fall at any time potentially damaging dyke facilities, infrastructure such as railings or poles, other vegetation, or pedestrians.	Trees can present greater or lesser hazards depending on their location in relation to the dykes (the risk target). The proximity of a potential hazard tree and/or the position of the tree if on the dyke are all location factors that can increase the risk threshold of a potential hazard tree. **Position**: ▪ Trees larger than 10cm diameter located at the top or on the side slope of a dyke. **Proximity**: ▪ Any tree identified as a high risk species growing within 10m of a dyke with evidence of high risk defects (size, form & health).	**Removal**: High risk trees represent an immediate threat to the integrity of the London dykes and should be removed. <u>Manual Removal</u>: ▪ Cut down/top hazard trees and remove all debris from the dyke. ▪ Use qualified personnel to reduce risk of physical damage to the dykes and adjacent properties. <u>Chemical Control</u>: ▪ Applications of herbicide should be limited to the control of identified high and moderate risk species. Herbicide should only be used on the stumps or foliage of suckering and re-growing specimens after manual removal. <u>Caveat:</u> The removal of woody vegetation can present problems for dykes and embankments. The root system of woody vegetation can undermine the strength of these structures if the vegetation dies and the root system decomposes leaving behind voids. The best way to avoid this is through a preventive maintenance program; however, the problem already exists for some dykes and steps must be taken to eliminate the problem. For root systems of large trees (dbh > 30cm) removal is recommended. The excavated dyke materials should be replaced and a revegetation plan of native material (see Appendix 2) prepared to replace lost cover on earthen dykes. For other removals the site should be identified (unique site I.D. and GPS coordinate data captured in GIS recommended) and monitored for signs weakness or undermining. This can be accomplished through simple visual observation or through the use of more advanced technologies such as Ground Penetrating Radar (GPR). Undermined sites should be excavated and repaired as noted above.

Table 1: Identification and Prioritization of Hazard Tree Conditions on the London Dykes

PRIORITY CATEGORIES	HAZARD TREE RISK FACTORS				RECOMMENDED ACTION
	Species	Size & Form	Health	Location	
		Layers of bark separating the wood weaken the union. High risk factors include unions with included bark that is also cracked, or decaying (USDA, 2003). Poor Architecture: a growth pattern that displays evidence of weakness or imbalance in the trunk or major branches. ▪ Trees with excessive lean ▪ Trees with moderate lean and other structural defects such as cracks, etc. ▪ Trees with unbalanced crown form due to lean or suppression due to shading.			See Appendix 4 for detailed recommendations on the control and removal of selected high risk and exotic species.
Moderate Risk: Potential Future Hazard Tree Conditions These are trees of the identified risk factor species and/or other trees with defects that do not present an immediate threat to the integrity of the London Dykes. Moderate risk trees need to be monitored for changes in defects between inspections. An increase in the number or severity of defects will promote the specimen to the High Risk Category. Risk Categories include: 3. **Threshold** – Existing vegetation includes problem species and individual specimens on a trajectory toward becoming hazard vegetation. Management action should be taken within a three to five year window to avoid conditions reaching a critcal or degraded state. 4. **No Action Required** – There is no short-term threat to the integrity of the dyke. Monitoring and maintenance should be initiated to avoid the development of hazard vegetation.	Plants in this category can be very invasive but do not spread as widely and/or will dominate only select habitat niches. They can still be prone to structural defects but defects are either less common or severe than high risk species. ▪ Amur maple (*Acer ginnala*) ▪ Black Locust (*Robinia pseudo-acacia*) ▪ Scots Pine (*Pinus sylvestris*) ▪ Siberian elm (*Ulmus pumila*) ▪ Tree of Heaven (*Ailanthus altissima*) ▪ White Poplar (*Populus alba*)	**Form**: Cracks: ▪ Trunk with a single crack with decay. Root Problems: ▪ Evidence of root damage, decay and/or death within < 50% of the tree's dripline (USDA, 2003). Weak Branch Unions: ▪ Branch union has included bark (USDA, 2003). Poor Architecture: ▪ Large branches are twisted or have sharp bends. ▪ Large horizontal branch with vertical shoots.	**Dead Wood**: A tree with any amount of dead wood or branches should be considered a Moderate Risk. **Decay**: ▪ Moderate risk trees with cavities should be retained as wildlife shelter. ▪ Indicators of decay occur on 25% to 40% of the trunk or major branches (USDA, 2003). ▪ Shell thickness is > 1 inch and < 2 inches of secure wood for each 6 inches of trunk diameter. (USDA, 2003). **Canker**: ▪ Canker or canker plus decay affect 25% to 40% of the trunk's circumference (USDA, 2003).	**Position**: ▪ Trees under 10cm diameter on the top or side slope of a dyke that are leaning. ▪ Trees larger than 10cm diameter located at the base of a dyke. **Proximity**: ▪ Any tree identified as a medium risk species growing within 10m of a dyke with evidence of medium risk defects (size, form & health).	**Prune**: ▪ Some defects in moderate risk specimens can be corrected by pruning the defective parts. ▪ Use qualified personnel for pruning operations to reduce the risk of damaging the dyke or adjacent properties. *For a reference on proper Pruning technique see: Shigo, Alex L. 1993. A New Tree Biology: Facts, Photos, And Philosophies On Trees And Their Problems And Proper Care. Sherwin Dodge, Printers, Littleton, New Hampshire.* **Monitor**: ▪ All moderate risk specimens should be documented and monitored for evidence of further deterioration. ▪ Specimens that decline sufficiently should be reclassified into the high risk category and removed.

Table 2 is a summary of the dyke sections by level of priority, from highest to lowest.

Table 2: Dykes Prioritized By Risk Level

PRIORITY	DYKE	SECTION
Degraded – Immediate Action Recommended	Ada-Jaqueline	0+150 to 0+350
Critical – Action within 1-2 Years Recommended	Ada-Jaqueline	0+000 to 0+150
	Broughdale	0+550 to 0+675
	Byron	0+000 to 0+374
	Nelson Clarence	0+000 to 0+150
	Riverview	0+000 to 0+275
	West London	2+100 to West End
Threshold – Action within 3-5 Years Recommended	Ada-Jaqueline	0+350 to 0+525
	Broughdale	0+450 to 0+550 and 0+675 to 0+766.77
	Nelson Clarence	0+150 to 0+600
	Riverview	0+275 to 0+425
	West London	0+000 to 1+250 and 1+800 to 2+100
No Action Required – Monitor Only	Broughdale	0+000 to 0+450
	Coves	All
Other – Existing Plans for Reconstruction Address Risks	West London: Queen / Dundas / Riverside area	1+250 to 1+800

Additionally, Figure 1 shows photos of the dykes in each risk category.

Figure 1: Photographs of Identified Risk Levels for London Dykes

DEGRADED – Imminent Action Recommended

Fallen Manitoba Maples heaving section of Ada-Jaquelin Dyke east of Adelaide Street. Note physical degradation of dyke integrity. Extensive maintenance and repair required.

CRITICAL – Action Within 1-2 Years Recommended

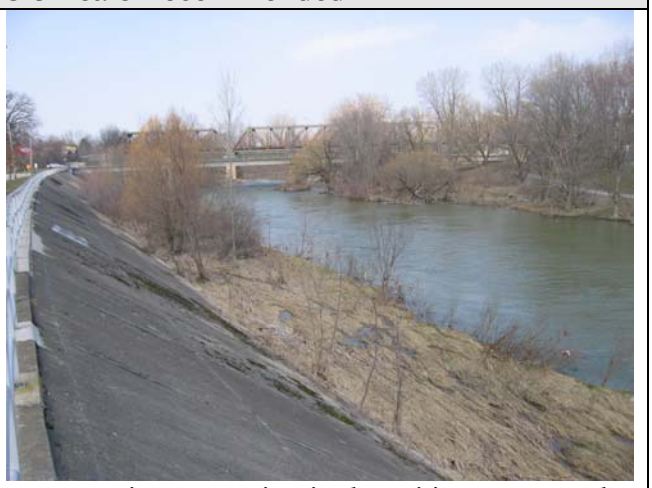
Manitoba Maple on the slopes at Riverview Dyke. Physical degradation of dyke integrity likely within 3 years. Extensive maintenance required.

Manitoba Maple growing out of the side of Byron Dyke among a ground cover of Vinca. Potential for physical degradation in near future; localized maintenance required.

Figure 1: Photographs of Identified Risk Levels for London Dykes

THRESHOLD – Action in 3-5 Years Recommended

A mixture of immature Manitoba and Norway Maples growing on the Nelson-Clarence Dyke. Selective maintenance in 3-5 years will avoid more extensive maintenance or repairs in future.



Regenerating vegetation in deposition zone south of Blackfriar Bridge. Monitoring should ensure that invasive species do not become established in gaps between concrete pads.

NO ACTION

View of Dyke at Broughdale through Park. No maintenance required.

View of the edge of Coves Dyke at crest of slope before descending to the floodplain.

3.2 Indirect Hazards: Disturbed Natural Heritage System Contributions to the Proliferation of Hazard Vegetation

The natural heritage system surrounding the London Dykes is composed of a matrix of aquatic, anthropogenic, floodplain and riparian communities that together form a complex and dynamic environment. The successful maintenance of engineered facilities (such as the dykes) in such environments requires a thorough understanding of the features and functions of floodplain ecology and how these elements affect the growth and proliferation of potential hazard vegetation that creates risks to the physical integrity of the dyke facilities.

3.2.1 Hydrology

The Thames River watershed through the City of London has become "urbanized"; i.e. runoff is collected and discharged through a series of storm sewers, catchbasins, roadways and channelized watercourses. These urban drainage systems and the general lack of natural storage opportunities results in rapid increases (and subsequent decreases) of flow in the tributaries of the Thames River during precipitation events. The flows within the Thames River through London are regulated by dams which reduce the flashy peak effects of urbanized systems; however, the regulation of the Thames has reduced the frequency and duration of inundation within the floodplain community during flood events. Plant species compositions in floodplains are typically adapted to the naturally occurring hydrological regimes: wet and occasionally inundated by flooding in the spring, with gradual drawdown and drying into the growing season. The plant species currently found in the floodplain community and the adjacent anthropogenic lands reflect the disruption of natural hydrologic conditions through a general lack of biodiversity, relatively high ratios of exotic species to native species, and the prevalence of invasive species, often in monoculture stands. These conditions contribute to the recruitment, propagation and perpetuation of undesirable hazard species on the dykes themselves.

3.2.2 Soils

The soils of the dyke facilities as well as those soils present in the adjacent environments have been impacted by compaction and fill. In a floodplain setting, soil types influence siltation and erosion dynamics which, together with hydrology, affect the resultant plant community composition. Disturbed soils favour aggressive "weedy" species that disrupt the normal succession of native species that might otherwise occur.

3.2.3 Connectivity

While remnant habitat of the original floodplain does exist, large areas of previously functional floodplain have been isolated both physically and hydrologically from the Thames River by construction of the dykes. Some of these areas are maintained as open park space and others have been developed into residential and/or commercial areas. Habitat connectivity impairments lead to other functional deficiencies in the vegetation communities including reduction in habitat size, increasing distance from other intact natural features, and reduced exposure to natural hydrologic cycles which would tend to self-manage native vegetative cover. These functional disturbances eventually lead to a shift in wildlife & vegetation composition as the communities lose the compositional and structural characteristics supporting more sensitive species.

3.2.4 Urban stress

Some residents of properties near to the London Dykes have undertaken actions that indicate that they fail to understand the sensitive nature of the habitats abutting the dykes. In many locations there was evidence that residents are routinely dumping lawn/garden waste or excess building

materials over the top edge of the dyke. In other locations, non-native and potentially invasive plant species have been planted as private landscape treatments on both sides of the dykes (residential & river). In time, many of these gardens have encroached onto the dykes and Thames River floodplain (eg. non-native vines such *Euonymus fortunei 'Coloratus'*, *Vinca minor* and *Hedera helix* climbing on mature Eastern Cottonwoods, Burr Oak etc.).

3.2.5 Invasive Species

Weedy opportunistic trees and shrubs such as Buckthorn (*Rhamnus spp.*), Honeysuckle (*Lonicera spp.*), Manitoba Maple (*Acer negundo*) and Norway Maple (*Acer platanoides*) tend to be fast growing, shallow rooted and weak limbed species that can weaken the structure and stability of the dykes, while displacing lower-growing and more conservative native species. The presence of undesirable woody species that threaten dyke stability in most cases reflects the general disturbance and impairment in the surrounding floodplain and its riparian functions. Gradually, the "seed rain" has become dominated by these few species, making them the only sources of seed available to regenerate on the dykes.

4 MANAGEMENT PLAN

Two levels of potential management strategy have been identified to address the vegetative hazards to the London Dykes; they are:

a) Management of identified direct risks (hazard tree removal), including management of vegetation cover on the dykes towards a more sustainable and less risk prone cover; and,
b) Management of the background natural heritage matrix towards a composition where problem species are greatly reduced or absent as a seed source.

The highest priority for management action is on the direct hazards. The indirect hazards consist of a set of cumulative background impacts that will perpetuate the reoccurrence of the direct hazards. Likewise, the management options for the direct risks are minimal and clear; whereas, the management options for the indirect risks are many and varied. The majority of the opportunities for ecological landscape design and habitat restoration are within the set of management options for the indirect risks.

Of note, the specimen of Butternut (*Juglans cinerea*) found during the field survey is a protected species and will require special consideration outside of the scope of the following recommendations.

4.1 Managing Direct Risks to Dyke Integrity Posed by Hazard Trees

The management of hazard trees has three main objectives: 1st, the identification and prioritization of hazard vegetation; 2nd, removal and repair strategies; and 3rd, establishment of a maintenance routine for the long term management of the dykes. These management objectives address the structural integrity risks to the dykes posed by vegetation growing directly on the facility.

4.1.1 Identification and Prioritization of Hazard Vegetation

The growth of tree species upon the London Dykes presents a set of risks that threaten the long term structural integrity of the dykes. Not all species or individual specimens present the same level of risk. Indeed, some types of vegetation, such as dense fibrously rooted shrub species, reinforce soil

stability and provide enhanced structural integrity for the dykes. The difference in characteristics between species and individual specimens necessitates the need for an assessment process to manage the risks due to the presence of hazard trees upon the London Dykes.

A preliminary assessment process has been developed and is documented in Table 1: Identification and Prioritization of Hazard Tree Conditions on the London Dykes. A field survey was conducted in January 2006 to establish a basis for management priorities. The results of the assessment are presented in Table 2: Dykes Prioritized by Risk Level and Appendix 05: Preliminary Assessment Results for the Identification and Prioritization of Hazard Trees on the London Dykes; and, mapped in Figures 3 through 11.

The assessment process identifies management thresholds corresponding to priorities for action. The primary actions identified in the following sections are removal and maintenance; thus, the purpose of the assessment is a triage aimed at classifying the dykes according to the severity of their conditions in order to ensure that management strategies are implemented most effectively. Appendix 06: Recommended Actions to Manage Risks to Dyke Integrity, stipulates the recommended management actions for each dyke according to their risk level identified through the assessment process.

4.1.2 Vegetation Removal and Dyke Repair Strategies

Removal of hazard trees is the primary management strategy to address the direct risks and avoid the potential of dyke failure for the Critical and Threshold risk categories. The removal of hazard trees in an urban and public context should be limited to cutting with some chemical control for shoots and suckers of species that have a tendency to resprout aggressively. Other techniques such as girdling and controlled burns will not be as efficient or cost effective, and may result in hazards in and of themselves. The application of a chemical control following cutting (and upon young shoots of undesirable species) is preferable to stump removal and manual pulling in order to keep soil disturbance to a minimum. Appendix 04: Exotic Species Control; provides a detailed description of the preferred removal and control strategies for the most problematic species.

For the one site in the Degraded risk category (Ada-Jaqueline from station 0+150 to 0+350), the damage potential from hazard trees has already been realised. Sections of the dyke have been lifted, opened or moved due to the upheaval of root systems from leaning and fallen trees. Hazard tree removal will necessitate the removal of exposed root systems; and, in addition to hazard tree removal, sections of the dyke must be repaired. The structural integrity of a major section of this dyke has already been compromised and its ability to function in the event of a flood should be assessed from an engineering standpoint. The identified project schedule and phasing may not be sufficient to address the risks at the Ada-Jaqueline dyke: we would recommend immediate action.

The removal of hazard trees can also be complicated by logistical issues such as access to the site, disruption of pedestrian circulation and public perceptions regarding the destruction of mature trees. Any management action should include an implementation plan detailing not only the number, sizes and species of hazard tree but also prescriptions to address any of these ancillary issues. This scope of documentation provides quantitative data that can be used to generate cost estimates necessary for planning the future project budgets. Appendix 06: Recommended Actions to Manage Risks to Dyke Integrity, provides a detailed list of priority tree removal recommendations for each dyke as well as observations on potential issues that may require attention in an implementation plan.

4.1.3 Vegetation Cover Maintenance and Management Strategies

Following removal of hazard vegetation, the dyke facilities will be susceptible to further colonization by undesirable tree species. Enhancement of the dykes to resist rapid and aggressive colonization requires focused rehabilitation of key weaknesses that favour the establishment of these undesirable plants. Strategies should focus on: a) crack management on "hard" dyke features (i.e. repair damage to concrete facilities); b) promote the diversification of species by planting native shrubs and vines to occupy available niches, and compete with undesirable species on the dykes (see Appendix 03 – Recommended Native Plants For Reintroduction Into The Landscape In The Vicinity Of The Dykes for a list of recommended native shrubs & vines); and, c) monitor dykes for re-growth of undesirable species and schedule removals of young specimens as a regular maintenance routine.

4.2 Managing Indirect Risks to Dyke Integrity Posed By the Disturbance and Impairment of the Surrounding Natural Heritage Matrix

As described in earlier sections, a decline in the natural heritage diversity and ecological functions has left the vegetation communities adjacent to the dykes in a disturbed state that favours the growth of pest species on the dykes. The management strategies in this section offer recommendations on restoring functional integrity to the natural heritage matrix surrounding the dyke facilities. Recommendations focus on improving abundance & diversity of native plant material, improving floodplain functionality and public education. The underlying principle at work within these recommendations is the holistic management of the floodplain ecosystem towards a diverse and more self sustainable ecological trajectory.

4.2.1 Improve Abundance & Diversity of Native Plant Material

4.2.1.1 Control of Exotic Species

A program to reduce the extent and spread of garlic mustard, common buckthorn, and Norway and Manitoba maples is recommended as the primary exotic species control effort. *Appendix 4 – Exotic Species Control* summarizes available methods to achieve control over these species. It will be necessary to retain the services of qualified personnel (approved contractor under supervision of an ecologist) to conduct field identification and marking, supervise removal, and proper disposal of the undesirable species. Removal of these problem species should be done in the seasons they can be readily identified, and/or prior to the release of seed.

It is recommended that manual removal methods be used as the primary practice, accompanied with herbicide treatments, as described in *Appendix 4*, limited to larger stumps to prevent re-sprouting. Given the ubiquitous nature of these species in urban environments, and experience elsewhere in the control of these species, it is anticipated that regular removal efforts will have to persist for several years to maintain control. Development of an exotic species monitoring program is key to scoping maintenance to required levels as removal efforts achieve manageable levels of control over these problem species, as well as reducing public concern over the removal of large trees.

4.2.1.2 Planting Appropriately Selected Native Plant Species

Based on the inventory and assessment studies it is evident that the natural heritage matrix surrounding the dykes is in a state of transformation by exotic species. As control efforts re-expose niches for plant regrowth, it will be essential to reintroduce more diverse native trees and shrubs into the landscape in the vicinity of the dykes to restore and conserve the remnant natural plant populations. Reintroductions should gradually reduce the long-term maintenance requirements (i.e.

exotic species control) by occupying (and thereby reducing) disturbed lands that provide opportunity for the spread of problematic exotic species.

Species selections should be made based not only on historical plant communities but also on an understanding of the underlying functional characteristics currently driving the community trajectory. Consideration should also be given to the selection of species that complements other management strategies to maximise the benefits of the overall management plan. *Appendix 3 - Recommended Native Plants for Reintroduction into the Landscape In The Vicinity Of the Dykes* provides recommendations for native species to include in a planting program.

4.2.2 Improve Floodplain Functionality

4.2.2.1 Soil

The focus of efforts to improve soil conditions in the floodplain should be on the limitation of further disturbance (i.e. soil exposure due to digging, waste/compost dumping or fill activities) that would reintroduce seedbanks of undesirable exotics; and, the management of fluvial soil transport (i.e. erosion and sedimentation). Reducing soil disturbance can be accomplished largely through the implementation of the management recommendations in other sections of this report; such as: manual removal of exotic species, introducing and maintaining a formalized trail system, and public education regarding dumping and the relationship of backyard plantings to the adjoining open space areas. Should any infrastructure works take place in the floodplain that expose soils, these should include a requirement to re-plant native vegetation cover and ensure its establishment.

Management of fluvial soil transport is dependant on the fluvial geomorphic characteristics of the Thames River. In general, a well established community of deep fibrously rooted native trees and shrubs will provide adequate protection from erosion. However, in problem systems vegetation alone is inadequate to address long term erosion and sedimentation problems. Erosion and sedimentation has not been specifically included in this study and a fluvial geomorphic assessment and management strategy is beyond the scope of the current report. Nonetheless, such an assessment on sites with particular erosion or sediment issues would complement the management strategies recommended in this report that address indirect risks to dyke integrity posed by the disturbance and impairment of the surrounding natural heritage matrix.

4.2.2.2 Hydrology

Historically, the City of London was vulnerable to spring flooding as a result of spring freshet runoff from upstream agricultural areas. The construction of the dams and dykes was completed to protect properties from these flooding hazards. The result is a river disconnected from its floodplain and a change in the hydrology of the floodplain community. The frequency and duration of inundation in the remaining floodplain has been generally reduced. The plant populations are responding to the hydrologic changes with a shift in species composition that more effectively tolerates the new moist to mesic range. Management strategies should address the functional relationship between the river and floodplain and focus on efforts to reconnect these two elements.

The management strategies include a) the gradual adjustment of existing cover towards a more diverse native species community to restore native 'seed rain' (*see section 4.3.1.2 and Appendix 3*), and b) restoration of a more typical hydroperiod in the floodplain where opportunities exist. The second option involves the physical alteration of the local topography to facilitate inundation and flood storage within the floodplain in appropriate seasons. Techniques include:

a) the creation of on-line backwater channels (swales or culverts connecting the river to floodplain pools);
b) the creation of new depressions in the floodplain to serve as wetlands and vernal pools; and,
c) the removal or relocation of dyke facilities to expand and reconnect available floodplain habitat opportunities.

4.2.2.3 Connectivity

Issues of connectivity are closely related to previous recommendations for hydrology and plant reintroductions; many of the recommended management strategies to improve habitat connectivity are already mentioned in these sections. These include:

a) reintroduction of native plant species to fill in gaps between existing vegetation communities;
b) reintroduction of native plant species to expand existing habitat;
c) reintroduction of native plant species to buffer existing and restored habitats from surrounding land uses and urban disturbances; and,
d) the removal or relocation of dykes.

4.2.3 Public Education

4.2.3.1 Garbage & Dumping

The dumping of garbage, fill, compost and garden waste on both sides of the dykes (residential & river) is a contributing factor to the spread of problem species affecting the physical integrity of dykes. Preventing these actions will greatly improve the success of the overall vegetation management objectives. Unfortunately there is no easy way to guarantee a cessation of these activities through education alone. Recommendations to control litter and dumping should be two-fold; first, to enact a by-law prohibiting these activities that is enforceable through fines to prevent dumping on the public lands; and second, to provide adjacent residents and pedestrians with educational material that explains the ecological sensitivity of the dykes and associated natural heritage framework, discourages dumping and littering, and seeks their cooperation as stewards. Recommended educational materials include signage for pedestrians and the production and distribution of a community environmental handbook. These items are further described in the following sections.

4.2.3.2 Signage & Formalized Trail System

Pedestrians should be allowed access to the dykes and river side environments but uncontrolled access creates risks of environmental disturbance such as soil compaction, litter, spread of exotic plant seed and damage to sensitive vegetation resources. Concentrating pedestrian access to controlled trail networks limits the distribution of impacts, allows more focused management, and creates opportunities for education through strategic combinations of routing, viewsheds and signage.

The message content for educational signage should focus on:

a) User information to explain location, routes and features or hazards
b) Trail use regulations including policies on access (pedestrian, bicycle, etc.), pets, litter, staying on designated trails, by-laws in effect etc.
c) Selected interpretive signage at strategic locations to educate users on features encountered on the route. Of specific interest within the context of this study would be content on the

purpose of dykes, management and rehabilitation projects, and environmental features and/or issues such as wetlands and/or invasive species.

4.2.3.3 Community Handbook

Several municipalities in southern Ontario have developed resources for residents that explain environmental goals and policies. These "environmental handbooks" become valuable educational tools which can be distributed in targeted neighbourhoods as part of awareness campaigns as well as to new home buyers and trail users. In the present situation the recommendation is that such a handbook for London residents would contain a section on the dykes and the associated natural heritage framework outlining values and sensitivities and providing direction for those seeking additional information and resources. Examples of existing community handbooks can be found online at:

- Guelph:
  - http://guelph.ca/living.cfm?itemid=65169&smocID=1946&searchwords=environmental,handbook
- Mississauga:
  - http://www.mississauga.ca/portal/residents/naturalgreenspaces?paf_gear_id=9700018&itemId=8700012&returnUrl=%2Fportal%2Fresidents%2Fnaturalgreenspaces
  - http://www.mississauga.ca/portal/residents/naturalgreenspaces?paf_gear_id=9700018&itemId=5900086&returnUrl=%2Fportal%2Fresidents%2Fnaturalgreenspaces
  - http://www.mississauga.ca/portal/residents/naturalgreenspaces?paf_gear_id=9700018&itemId=5900080&returnUrl=%2Fportal%2Fresidents%2Fnaturalgreenspaces
- Toronto:
  - http://www.toronto.ca/wes/techservices/envir_directories/index.htm

4.3 Management Implementation and Design Development

The identified management strategies provide a conceptual framework of options to be developed in future phases of the London Dykes Vegetation Management Project. This Preliminary Assessment has also provided recommendations on priority actions to preserve dyke integrity. However, several steps remain before the UTRCA can implement the recommended management strategies. Appendix 7: Management Implementation and Design Development Flowchart; provides a vision for the implementation of the recommended management strategies. The chart identifies the tasks, priorities & perceived data gaps associated with future phases of the project.

5 CONCLUSIONS

This report has documented the existing vegetation resources (ELC Community Series and vascular plant species) of the London Dykes identified during a spring field survey. Based on this survey as well as available background documentation we have been able to characterize the habitats present, their health and diversity, and the associated risks posed to the integrity of the dyke facilities.

Based on our assessment, the dykes have undergone colonization by aggressive invasive exotic species within a disturbed natural heritage context. The growth of undesirable woody species poses direct risks to physical integrity of some dykes due to hazard tree conditions. Additionally, a series of functional impairments in the hydrology, soils, habitat connectivity, and native plant diversity in the surrounding natural heritage matrix indirectly threaten the long term physical integrity of the dykes.

The recommended management strategies identify two levels of potential intervention; addressing the direct tree hazards, and a range of options that address the broader ecological framework of the dyke environs. Such progressive measures look at the contributing factors in the local ecosystems that eventually lead to hazards. Strategies include diversification plantings, an aggressive exotic species control program, education and management of pedestrians and adjacent residents, localized adjustments to site hydrology, and consideration of buffers and linkages.

A preliminary assessment ranking for the identification and actions on hazard tree conditions are summarized in Table 1. The broader management strategies will need further site specific analysis and detailed design for application to site specific areas. Tools have been provided in the appendices to assist with this process; however, the UTRCA will need to identify which strategies will best fit within the fiscal and management objectives of the Authority and its partners.

Although not covered by the scope of this study it is likely a special management strategy will need to be developed because of the discovery of a *Juglans cinerea* (Butternut) specimen. Butternut is classified as an Endangered Species according to both the *Species at Risk Act* (Federal) & the *Endangered Species Act* (Provincial). Endangered Species in Ontario are afforded habitat protection under the Provincial Policy Statements of the *Planning Act* (Provincial). The Provincial Policy Statements stipulate:

> The protection of threatened and endangered species requires that significant portions of their habitat be protected. As the habitat requirements of individual threatened or endangered species are extremely varied, the assessment of what constitutes the significant portions of the habitat must be made on a species-by-species and case-by-case basis.

In Ontario the Ministry of Natural Resources (OMNR) is responsible for the identification, evaluation and listing of provincially endangered and threatened species. The UTRCA may want to consult with the OMNR to determine whether or not the discovery of this specimen requires special action.

The implementation of the broader ecological management strategies will benefit from additional studies to fill in current data gaps. Recommended studies include:

- Seasonal field work, especially a summer-fall vegetation survey to supplement the spring survey. This would round out the vascular plant list by identifying species that are only evident during the shoulder seasons.
- A detailed plant community characterization. This would involve bringing the ELC classification to the ecosite or vegetation type level. The detailed vegetation community data would assist in the identification of intact natural habitat remnants for the purposes of planning the conservation and restoration of the broader natural heritage system.
- A hydrological and fluvial geomorphology assessment to characterise the flooding dynamics in the available floodplain to assist in predicting a habitat trajectory and appropriate species compositions for restoration plantings. This would also determine the best strategies and locations for implementing site specific river bank and floodplain augmentations to successfully mimic natural flooding regimes.
- Refinement AND Implementation of the Preliminary Assessment Methodology for the Identification and Prioritization of Hazard Trees on the London Dykes. Details would include data gathering for attributes such as quantities, species, sizes and location as well as data on the site itself to determine access, public use and other potential interim measures.
- Detailed survey data for the dykes including topographical contours and an inventory of site features such as trails, recreation equipment, utilities, etc. This data will be required for restoration design and planning purposes.
- Identify a set of goals, objectives and targets for the programming of the restoration design. The programme should be a set of instructions from UTRCA to the Consultant on UTRCA's restoration priorities. Alternatively the programme can be developed in a consultative process between the agency and consultant. Specific options to consider may include: the management of the natural heritage matrix to reduce recruitment of problem species affecting dyke integrity; restoration of historic plant communities to the Thames River floodplain; recovery of ecological functionality within the natural heritage matrix; targeted habitat restoration as part of a species recovery plan; improvement of the aesthetics of the Thames River Trail System; etc.

The findings and strategies outlined in this report should provide the necessary tools to begin the management of prioritized direct tree hazards on the London dykes and offer a palette of options for decision makers to plan the future phases of natural heritage system management along the Thames corridor in the vicinity of the dykes.

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APPENDIX 1 - VASCULAR PLANT SPECIES LIST

Coves		Byron		Riverview		Nelson & Clarence		Ada		Broughdale		Concrete Dyke		Scientific Name	Common Name	cc	cw	COSEWIC (Nov. 2004)	MNR Species at risk (April 2004)	srank	Family	Native Status
Dyke	FP	Dyke	FP	Dyke	FP	Dyke	FP	Dyke	FP	Dyke	FP	Dyke	FP									
x	x	x	x	x		x	x	x	x	x	x	x	x	*Acer negundo*	Manitoba Maple		-2			S5	ACERACEAE	N
	x	x	x	x		x		x	x	x	x	x	x	*Acer platanoides*	Norway Maple		5			SE5	ACERACEAE	I
			x		x		x							*Acer saccharinum*	Silver Maple	5	-3			S5	ACERACEAE	N
x	x	x	x	x	x			x	x				x	*Aegopodium podagraria*	Goutweed		0			SE5	APIACEAE	I
									x					*Aesculus hippocastanum*	Horse Chestnut		5			SE2	HIPPOCASTANACEAE	I
							x							*Aesculus X carnea*	Red Horsechestnut						HIPPOCASTANACEAE	I
x	x	x	x	x		x		x	x	x	x	x	x	*Alliaria petiolata*	Garlic Mustard		0			SE5	BRASSICACEAE	I
	x													*Angelica atropurpurea*	Great Angelica	6	-5			S5	APIACEAE	N
					x			x	x	x				*Arctium lappa*	Greater Burdock		0			SE5	ASTERACEAE	I
						x							x	*Arctium minus ssp minus*	Lesser Burdock		5			SE5	ASTERACEAE	I
			x				x		x					*Aster puniceus var puniceus*	Purple-stemmed Aster	6	-5			S5	ASTERACEAE	N
						x					x			*Aster sp*	Aster Species		0				ASTERACEAE	
		x												*Berberis vulgaris*	European Barberry		3			SE5	BERBERIDACEAE	I
								x						*Betula papyrifera*	Paper Birch	2	2			S5	BETULACEAE	N
									x					*Carex sp*	Sedge Species		0				CYPERACEAE	
x	x	x	x	x			x		x	x	x			*Celtis occidentalis*	Common Hackberry	8	1			S4	ULMACEAE	N
		x		x		x								*Chelidonium majus*	Greater Celandine		5			SE5	PAPAVERACEAE	I
					x									*Cirsium arvense*	Creeping Thistle		3			SE5	ASTERACEAE	I
			x											*Claytonia virginica*	Narrow-leaved Spring Beauty	5	3			S5	PORTULACACEAE	N
	x												x	*Cornus stolonifera*	Red-osier dogwood	2	-3			S5		N
					x	x							x	*Dactylis glomerata*	Orchard Grass		3			SE5	POACEAE	I
								x						*Dipsacus fullonum ssp sylvestris*	Common Teasel		5			SE5	DIPSACACEAE	I
x	x	x	x								x			*Erythronium americanum ssp americanum*	Yellow Trout-lily	5	5			S5	LILIACEAE	N
											x			*Euonymus fortunei*	Winter-creeper		5			SE1	CELASTRACEAE	I
			x											*Euonymus obovata*	Running Strawberry-bush	6	5			S5	CELASTRACEAE	N
											x		x	*Fraxinus pennsylvanica*	Green Ash	3	-3			S5	OLEACEAE	N
	x								x		x			*Geum sp*	Avens Species		0				ROSACEAE	
x	x	x	x					x					x	*Glechoma hederacea*	Ground Ivy		3			SE5	LAMIACEAE	I
x										x				*Gymnocladus dioicus*	Kentucky Coffee-tree	6	5	THR	THR	S2	FABACEAE	N
x										x				*Hedera helix*	English Ivy						ARALIACEAE	I
			x								x			*Hemerocallis fulva*	Orange Daylily		5			SE5	LILIACEAE	I
											x		x	*Heracleum sp.*								
x	x	x		x	x	x	x	x			x		x	*Hesperis matronalis*	Dame's Rocket		5			SE5	BRASSICACEAE	I
	x										x			*Iris sp*	Iris Species		0				IRIDACEAE	
							x							*Juglans cinerea*	Butternut	6	2	END	END	S4	JUGLANDACEAE	N
x	x	x		x	x	x			x		x			*Juglans nigra*	Black Walnut	5	3			S4	JUGLANDACEAE	N
				x		x					x			*Leonurus cardiaca ssp cardiaca*	Common Motherwort		5			SE5	LAMIACEAE	I
x		x		x					x		x			*Lonicera tatarica*	Tartarian Honeysuckle		3			SE5	CAPRIFOLIACEAE	I
	x										x			*Lysimachia nummularia*	Moneywort		-4			SE5	PRIMULACEAE	I
										x				*Malus baccata*	Siberian Crabapple					SE1	ROSACEAE	
		x												*Osmunda cinnamomea*	Cinnamon Fern	7	-3			S5	OSMUNDACEAE	N
x		x	x											*Parthenocissus inserta*	Thicket Creeper	3	3			S5	VITACEAE	N
	x				x				x					*Phalaris arundinacea*	Reed Canary Grass	0	-4			S5	POACEAE	N
										x			x	*Picea abies*	Norway Spruce		5			SE3	PINACEAE	I
														Picea glauca	White Spruce	6	3			S5	PINACEAE	N
												x		*Pinus nigra*	Black Pine		-5			SE2	PINACEAE	
			x											*Pinus strobus*	Eastern White Pine	4	3			S5	PINACEAE	N
			x							x				*Pinus sylvestris*	Scotch Pine		5			SE5	PINACEAE	I
													x	*Plantago lanceolata*	English Plantain		0			SE5	PLANTAGINACEAE	I
											x			*Plantago major*	Nipple-seed Plantain		-1			SE5	PLANTAGINACEAE	I
			x								x		x	*Platanus occidentalis*	Sycamore	8	-3			S4	PLATANACEAE	N
	x								x		x			*Polygonatum pubescens*	Downy Solomon's Seal	5	5			S5	LILIACEAE	N
	x													*Polygonum cuspidatum*	Japanese Knotweed		3			SE4	POLYGONACEAE	I
x		x	x	x							x	x	x	*Populus deltoides ssp monilifera*	Eastern Cottonwood	4	-1			S5	SALICACEAE	N
x		x	x			x	x		x	x				*Prunus avium*	Sweet Cherry		5			SE4	ROSACEAE	I
x		x		x	x	x		x		x	x		x	*Prunus virginiana ssp. virginiana*	Choke Cherry	2	1			S5	ROSACEAE	N

Coves		Byron		Riverview		Nelson & Clarence		Ada		Broughdale		Concrete Dyke		Scientific Name	Common Name	cc	cw	COSEWIC (Nov. 2004)	MNR Species at risk (April 2004)	srank	Family	Native Status
Dyke	FP	Dyke	FP	Dyke	FP	Dyke	FP	Dyke	FP	Dyke	FP	Dyke	FP									
x														*Quercus macrocarpa*	Bur Oak	5	1			S5	FAGACEAE	N
										x				*Quercus robur*	English Oak					SE1	FAGACEAE	
x	x	x	x		x	x	x		x	x	x		x	*Rhamnus cathartica*	Buckthorn		3			SE5	RHAMNACEAE	I
x	x													*Rhamnus frangula*	Glossy Buckthorn		-1			SE5	RHAMNACEAE	I
		x	x			x	x				x			*Ribes sp*	Currant Species		0				GROSSULARIACEAE	
		x				x						x	x	*Robinia pseudo-acacia*	Black Locust		0			SE5	FABACEAE	I
		x				x		x						*Rosa multiflora*	Rambler Rose		3			SE4	ROSACEAE	I
		x												*Rubus occidentalis*	Black Raspberry	2	5			S5	ROSACEAE	N
			x						x		x			*Rumex occidentalis*	Western Dock					S5	POLYGONACEAE	
	x												x	*Salix petiolaris*	Meadow Willow	3	-4			S5	SALICACEAE	N
														Salix purpurea	Basket Willow		-3			SE4	SALICACEAE	I
													x	*Salix sp*	Willow Species		0				SALICACEAE	
	x	x		x		x	x		x		x		x	*Salix x rubens*	Reddish Willow		-4			SE4	SALICACEAE	I
													x	*Saponaria officinalis*	Bouncing-bet		3			SE5	CARYOPHYLLACEAE	I
		x				x		x						*Solidago canadensis*	Canada Goldenrod	1	3			S5	ASTERACEAE	N
							x							*Solidago flexicaulis*	Broad-leaved Goldenrod	6	3			S5	ASTERACEAE	N
						x								*Spiraea sp*	Meadow-sweet Species		0				ROSACEAE	
	x		x											*Symplocarpus foetidus*	Skunk Cabbage	7	-5			S5	ARACEAE	N
										x				*Syringa vulgaris*	Common Lilac		5			SE5	OLEACEAE	I
				x		x		x			x		x	*Taraxacum officinale*	Common Dandelion		3			SE5	ASTERACEAE	I
								x	x			x		*Thuja occidentalis*	Northern White Cedar	4	-3			S5	CUPRESSACEAE	N
				x										*Tilia americana*	American Basswood	4	3			S5	TILIACEAE	N
x								x	x	x				*Tilia cordata*	Small leaf Linden					SE1	TILIACEAE	
													x	*Trifolium pratense*	Red Clover		2			SE5	FABACEAE	I
											x			*Tulipa sp.*								
						x								*Tussilago farfara*	Colt's Foot		3			SE5	ASTERACEAE	I
x		x	x			x		x	x		x		x	*Ulmus americana*	American Elm	3	-2			S5	ULMACEAE	N
			x					x	x				x	*Ulmus pumila*	Siberian Elm		5			SE3	ULMACEAE	I
	x		x					x	x					*Urtica dioica ssp dioica*	Stinging Nettle		-1			SE2	URTICACEAE	I
						x								*Verbascum thapsus*	Common Mullein		5			SE5	SCROPHULARIACEAE	I
									x					*Viburnum opulus*	Guelder-rose Viburnum		0			SE4	CAPRIFOLIACEAE	I
		x												*Vinca minor*	Periwinkle		5			SE5	APOCYNACEAE	I
	x	x		x										*Viola odorata*	English Violet		5			SE2	VIOLACEAE	I
x	x	x		x										*Viola sororia*	Woolly Blue Violet	4	1			S5	VIOLACEAE	N
										x	x			*Viola sp*	Violet Species		0				VIOLACEAE	
x								x						*Vitis riparia*	Riverbank Grape	0	-2			S5	VITACEAE	

APPENDIX 2 - RECOMMENDED NATIVE SHRUBS FOR DYKE REHABILITATION

Native Plants For London Dykes				
Scientific Name	Common Name	Light		
		S	P	F
Shrubs				
Celastrus scandens	Bittersweet		x	x
Cornus alternifolia	Alternate leaved Dogwood	x	x	
Cornus racemosa	Grey Dogwood			x
Physocarpus opulifolius	Ninebark		x	x
Prunus pensylvanica	Pin Cherry			x
Prunus virginiana	Choke Cherry	x	x	x
Ptelea trifoliata	Hop Tree		x	x
Rhus aromatica	Fragrant Sumac		x	x
Rhus typhina	Staghorn Sumac		x	x
Rosa carolina	Pasture Roase			x
Rubus idaeus	Wild Red Raspberry			x
Rubus odoratus	Purple-flowering Raspberry		x	
Sambucus canadensis	Common Elderberry		x	x
Sambucus racemosa	Red-berried Elderberry			
Vines				
Clematis virginiana	Virgin's bower		x	x
Menispermum canadense	Canada Moonseed		x	x
Parthenocissus inserta	Thicket Creeper			

LIGHT:
S = Shade
P = Part Shade
F = Full Sun

APPENDIX 3 - RECOMMENDED NATIVE PLANTS FOR REINTRODUCTION INTO THE LANDSCAPE IN THE VICINITY OF THE DYKES

Native Riparian Plants								
Scientific Name	Common Name	Light			Zone			
		S	P	F	Emergent	Riverside Thicket	Saturated Thicket	Well-drained Forest
Herbaceous Plants								
Acorus americanus (A. calamus)	sweet flag		x	x	x			
Arisaema triphyllum	Jack-in-the-pulpit	x					x	x
Asarum canadense	wild ginger	x						x
Asclepias incarnata	swamp milkweed		x	x	x	x		
Aster novae-angliae	New England aster		x	x			x	
Aster umbellatus	flat-top white aster		x	x			x	
Bidens cernua	nodding beggar-ticks		x	x	x	x		
Caltha palustris	marsh marigold		x	x			x	
Chelone glabra	white turtlehead	x	x			x	x	
Coreopsis tripteris	tall coreopsis		x	x		x	x	x
Dicentra cucullaria	Dutchman's breeches	x						x
Equisetum hyemale	horsetail, scouring rush	x	x	x		x	x	x
Eupatorium maculatum	Joe Pye Weed		x	x		x	x	
Eupatorium perfoliatum	common boneset		x	x	x	x	x	
Helenium autumnale	sneezeweed		x	x	x	x	x	
Helianthus decapetalus	ten-petaled sunflower		x	x			x	x
Heliopsis helianthoides	oxeye sunflower		x	x			x	x
Hibiscus moscheutos	Eastern rosemallow			x	x	x		
Iris virginica	Virginia blue flag		x	x	x	x		
Lilium superbum	Turk's cap lily		x	x			x	x
Lobelia cardinalis	cardinal flower		x	x	x	x	x	
Lobelia siphilitica	great blue lobelia	x	x				x	x
Maianthemum racemosa	false Solomon's seal	x	x				x	x
Mertensia virginica	Virginia bluebells	x	x				x	x
Mimulus ringens	monkeyflower			x	x	x	x	
Monarda didyma	bee balm	x	x				x	x
Nymphaea odorata	American water lily			x	x			
Oenothera fruticosa	sundrops			x	x	x	x	x
Peltandra virginica	arrow arum		x	x	x	x		
Phlox divaricata	woodland phlox		x				x	x
Phlox paniculata	summer phlox		x	x			x	x
Podophyllum peltatum	mayapple		x	x				x
Pontederia cordata	pickerel weed			x	x			
Rudbeckia laciniata	cut-leaved coneflower		x	x		x	x	x
Sagittaria latifolia	broadleaf arrowhead			x	x	x		

Native Riparian Plants								
Scientific Name	Common Name	Light			Zone			
		S	P	F	Emergent	Riverside Thicket	Saturated Thicket	Well-drained Forest
Saururus cernuus	lizard's tail		x	x	x	x		
Senecio aureus	golden ragwort	x	x			x	x	x
Solidago rugosa	rough-stemmed goldenrod		x	x		x	x	x
Verbena hastata	blue vervain		x	x		x	x	
Vernonia noveboracensis	New York ironweed		x	x		x	x	x
Viola pubescens	yellow violet	x	x					x
Ferns And Fern Allies								
Athyrium asplenioides	Southern ladyfern	x					x	x
Botrychium virginianum	Rattlesnake fern	x	x					
Matteucia stuthiopteris	Fiddlehead Fern							
Onoclea sensibilis	sensitive fern		x	x			x	x
Osmunda cinnamomea	cinnamon fern	x	x			x	x	
Osmunda regalis	royal fern		x				x	
Polystichium acrostichoides	Christmas fern	x						x
Thelypteris palustris	marsh fern		x	x	x	x	x	
Woodwardia virginica	Virginia chain fern	x	x	x	x	x		
Grasses, Sedges, Reeds								
Agrostis perennans	autumn bentgrass	x	x	x	x	x	x	x
Andropogon gerardii	big bluestem		x	x		x	x	
Carex crinita var. crinita	long hair sedge		x	x	x	x	x	
Carex lurida	sallow sedge		x	x	x	x	x	
Carex stricta	tussock sedge		x	x	x	x	x	
Elymus hystrix (Hystrix patula)	bottlebrush grass	x	x	x				x
Elymus virginicus	Virginia wild rye	x	x			x	x	x
Juncus canadensis	Canada rush		x	x	x	x	x	
Juncus effusus	soft rush		x	x	x	x	x	
Leersia oryzoides	rice cutgrass		x	x	x	x	x	
Panicum virgatum	switch grass		x	x	x	x	x	
Scirpus cyperinus	woolgrass bulrush		x	x	x	x	x	
Sparganium americanum	American bur-reed		x	x	x			
Typha latifolia	broad-leaved cattail			x	x			
Vines								
Celastrus scandens	climbing bittersweet	x	x	x				x
Clematis virginiana	virgin's bower		x	x	x	x	x	x
Parthenocissus quinquefolia	Virginia creeper		x	x		x	x	x
Shrubs								
Aronia melanocarpa	black chokeberry		x	x		x	x	x
Cephalanthus occidentalis	buttonbush		x	x	x	x		

Native Riparian Plants								
Scientific Name	Common Name	Light			Zone			
		S	P	F	Emergent	Riverside Thicket	Saturated Thicket	Well-drained Forest
Cornus amomum	silky dogwood	x	x			x	x	
Ilex verticillata	winterberry		x	x		x	x	x
Lindera benzoin	spicebush	x					x	x
Rubus allegheniensis	alleghany blackberry			x		x	x	x
Sambucus canadensis	common elderberry			x		x	x	x
Spiraea alba	narrow-lvd. meadowsweet			x		x	x	
Spiraea latifolia	broad-lvd. meadowsweet			x		x	x	x
Vaccinium corymbosum	highbush blueberry	x	x	x		x	x	x
Viburnum dentatum	arrow wood		x	x				
Small Trees								
Amelanchier arborea	downy serviceberry		x	x				x
Amelanchier canadensis	Canada serviceberry			x		x	x	x
Amelanchier laevis	smooth serviceberry		x	x				x
Asimina triloba	paw paw	x	x				x	x
Cornus alternifolia	alternate-leaf dogwood	x	x					x
Ostrya virginiana	Eastern hop-hornbeam	x	x					x
Persea borbonia	redbay, sweet bay	x	x				x	
Rhus glabra	smooth sumac			x			x	x
Salix nigra	black willow		x	x	x	x	x	
Medium to Large Trees								
Acer nigrum	black maple							
Acer rubrum	red maple			x	x	x	x	x
Betula lenta	sweet birch, black birch		x	x			x	x
Betula nigra	river birch			x		x	x	
Celtis occidentalis	hackberry							
Fraxinus americana	white ash		x	x		x	x	x
Fraxinus pensylvanica	green ash		x	x		x	x	
Juglans nigra	black walnut		x	x		x	x	x
Liriodendron tulipifera	tulip-tree, tulip poplar			x			x	x
Nyssa sylvatica	black gum		x	x		x	x	x
Platanus occidentalis	sycamore		x	x		x	x	x
Quercus bicolor	swamp white oak	x	x			x	x	
Quercus palustris	pin oak	x	x			x	x	
Ulmus rubra	red elm							

LIGHT:
S = Shade
P = Part Shade
F = Full Sun

APPENDIX 4 - EXOTIC SPECIES CONTROL

Control of Garlic Mustard

Garlic mustard (*Alliaria petiolata*) is a cool season monocarpic biennial that has invaded woodlands and natural areas throughout Canada. The plant has a three-year lifespan with all plants producing flowers and fruit in their second year and then dying (Cavers et al. 1979, Byers and Quinn 1988, Bloom et al. 1990).

To effectively control this invasive alien, seed production must be prevented until the seed bank is exhausted. This entails removing the species on an annual basis, usually in late June prior to seed ripening, until the plant is absent from the site for a minimum of three years. (Nuzzo 1991). Numerous studies have taken place to examine the best method of control (Paddock 1992). In fire intolerant systems, cutting of mature flowering plants in early summer resulted in a 98% reduction in seed production (Nuzzo, 1991).

A combination of cutting of mature plants and removing first year plants is recommended to accelerate the removal of this non-native species. Roots should be pulled as completely as possible; any intact root crown will produce new shoots. Cutting and pulling of plants should be done at the same time so that the year one plants are recognizable. This procedure must be repeated until the seed bank is exhausted which could take up to five years. (Nuzzo 1991).

Cavers, P.B., M.I. Heagy and R.F. Kokron. 1979. The biology of Canadian weeds. 35. Alliaria petiolata(M. Bieb.) Cavara and Grande. Canadian Journal of Plant Science 59: 217-229.

Byers, D.L. and J.A. Quinn. 1988. Plant size as a factor in determining flowering time and reproductive output in Alliaria petiolata(abs.). American Journal of Botany 75:71.

Bloom, C.T., C.C. Baskin and J.M. Baskin. 1990. Germination ecology of the facultative biennial Arabis laevigata variety laevigata. American Midland Naturalist 124:214-230.

Nuzza, V.A. 1991. Experimental Control of Garlic Mustard (Alliaria petiolata (Bieb.) Cavara & Grande) in Northern Illinois Using Fire, Herbicide and Cutting. Natural Areas Journal 1991. 11:158-167.

Paddock, D.N. 1992. Natural Areas Association. Compendium on Exotic Species. Articles 1-43, October 1992.

Control of Norway Maple

Norway Maple (*Acer platanoides*) is a persistent non-native tree that was introduced from Europe. It dominates the canopy and subcanopy in ravines and natural areas, especially those close to urban areas. This species has been extensively planted as a street tree and it commonly escapes into natural areas via seed. Norway maples are known for their dense shade, which in a forest community reduces the native groundcover, understorey shrub and canopy tree species diversity. Removal of seedlings and saplings based on recognition in woodlands is easiest in mid to late fall once native maples have lost their leaves. The Norway maples hold their leaves for a month or more longer than native maples.

Control of this species can be difficult and expensive depending on the severity and age of the infestation. Treatment of this species is similar to the Buckthorns and other non-native woody plants. Fall cutting of trees and an immediate chemical application of Glyphosate or preferably Garlon 4 (at 25% to 30%) to the cut surface and the 6 to 8 inches of remaining stump works effectively. Care must be taken when applying the chemical, so that no herbaceous vegetation is coated with this chemical. Glyphosate is a non-specific herbicide that kills all photosynthetically active vegetation, while Garlon is a translocated herbicide. For saplings up to 50 mm in diameter, a 'Weed Wrench' (a manually operated mechanical device which grasps and lifts saplings on a lever principle) can be used, being careful not to excessively disturb the seed bank or provide habitat for more non native species.

Sauer, L.G., and Andropogon Associates. 1998. The Once and Future Forest. Island Press. 381 pp.

Control of Manitoba Maple (and Crack Willow, *Salix fragilis*)

Manitoba Maple (*Acer negundo*), also called Boxelder, is a native deciduous small to large tree with an irregular form. Manitoba Maple has a fast growth rate and a short life span. At maturity growth slows and brittle trunks and limbs shatter; old trunks frequently put out clusters of sprouts. Manitoba Maple generally grows on moist sites along lakes and streams, on floodplains, and in low-lying wet places where its shallow root system can find abundant moisture. Hardy to extremes of climate, Manitoba Maple is drought tolerant once well established and can also withstand short periods of flooding. Manitoba Maple is aggressively opportunistic and tends to shade out smaller, herbaceous flora in wetlands and other areas.

Manitoba Maple establishes by seed under a wide range of conditions: immediately after disturbance on moist disturbed soil, along riverbanks, and in areas with heavy cover and medium to heavy competition. Manitoba Maple reproduces both sexually and asexually. Large seed crops are produced each year. Manitoba Maple bloom between March and May, depending on region. The flowers produce samaras during summer and fall, and the seeds persist through the winter; they are dispersed by wind or by birds and squirrels. Reproduction can also take place vegetatively through suckers, sprouts, and root shoots. New shoots will appear on exposed or injured roots.

As with the Norway Maple controlling Manitoba Maple can be difficult to control. Large-diameter trees can be removed with a chainsaw and seedlings can be hand pulled. Because new shoots sprout from severed trunks, cut stems and stumps must be treated with an herbicide, such as Glyphosate or preferably Garlon 4 (at 25% to 30%) to the cut surface and the 6 to 8 inches of remaining stump. Cut trees will re-sprout without painting. For this reason girdling should not be considered as a control option for Manitoba Maple as it will send up multiple shoots below the point where its bark

is removed. For shrubs up to 50 mm in diameter, a 'Weed Wrench' (a manually operated mechanical device which grasps and lifts the shrub on a lever principle) can be used, being careful not to excessively disturb the seed bank or provide habitat for more non native species.

Havinga, Donna and Invasive Plants Working Group. 2000. Sustaining Biodiversity; A Strategic Plan for Managing Invasive Plants in Southern Ontario. Toronto: City of Toronto Urban Forestry Services.

Natural Areas Association. 1992. Compendium on Exotic Species; Articles 1 - 43. Natural Areas Association, 108 Fox Street, Mukwanago, WI 53149.

White D.J., E. Haber and C. Keddy. 1993. Invasive Plants Of Natural Habitats In Canada: An Integrated Review Of Wetland And Upland Species And Legislation Governing Their Control. Canadian Wildlife Service, Ottawa, Canada. 121 p.

Control of Common and Glossy Buckthorn

Common Buckthorn (*Rhamnus carthartica*) and Glossy Buckthorn (*R. frangula*) are serious invaders of natural environments. These shrubs can grow to a height of 5 m and shade out native shrubs and herbs. Seed distribution is by birds, and regeneration from stumps may occur (Heidorn, R 1991). Fire is the most effective control of Rhamnus species. In non-fire tolerant wetlands, restoration of the water levels will often kill Glossy Buckthorn. In other natural systems, a cutting and chemical treatment program is an effective technique. Common buckthorn is easily spotted in mid to late autumn as it retains green leaves long after native species have dropped their leaves. Stems should be cut in autumn, with a chemical application of Glyphosate or preferably Garlon 4 (at 25% to 30%) to the cut surface and the 6 to 8 inches of remaining stump applied immediately to the cut surface. Care must be taken when applying the chemical, so that no herbaceous vegetation is coated with this chemical. Glyphosate is a non-specific herbicide that kills all photosynthetically active vegetation, while Garlon is a translocated herbicide. Management over successive seasons should focus on cutting and treating the re-sprouts. This multi year approach will reduce and remove the seed source from the natural area. For shrubs up to 50 mm in diameter, a 'Weed Wrench' (a manually operated mechanical device which grasps and lifts the shrub on a lever principle) can be used, being careful not to excessively disturb the seed bank or provide habitat for more non native species.

Heidorn, Randy. 1991. Vegetation Management Guideline: Exotic Buckthorns Common Buckthorn (Rhamnus carthartica L.), Glossy Buckthorn (Rhamnus frangula L.) and Dahurian Buckthorn (R. davurica Pall.). Natural Areas Journal. 1999. 11:216-217.

Packard, S. and C. Mutel. 1997. The Tallgrass Restoration Handbook. Washington. Island Press.

Control of Tatarian Honeysuckle

Tatarian Honeysuckle (*Lonicera tatarica*) is native to Eurasia and has been introduced to North America as an ornamental which has escaped into the wild. It is a large shrub and can form dense stands or shrub masses. In North America, Tatarian Honeysuckle can be found growing in open woods, ravines, and woodland edges. It is one of the first plants to leaf out in the spring and has berries that persist through the winter. Its primary impact upon natural areas includes the displacement of native understory species and ground flora, the alteration of vegetation structure, and impeding the regeneration of tree seedlings. Tatarian Honeysuckle flowers white to pink blossoms in May and produces fruit by July or August. The berries are consumed and spread primarily by birds.

To control Tatarian Honeysuckle it is best to remove the plants in the spring or summer before fruiting otherwise the seeds will be spread by birds that eat the persistent berries. Tatarian Honeysuckle will sprout back vigorously if the stems are cut off, so the stumps must either be pulled or treated with herbicide, such as Glyphosate or preferably Garlon 4 (at 25% to 30%) applied to the cut surface and to the 6 to 8 inches of remaining stump immediately after cutting. For shrubs up to 50 mm in diameter, a 'Weed Wrench' (a manually operated mechanical device which grasps and lifts the shrub on a lever principle) can be used, being careful not to excessively disturb the seed bank or provide habitat for more non native species.

Havinga, Donna and Invasive Plants Working Group. 2000. Sustaining Biodiversity; A Strategic Plan for Managing Invasive Plants in Southern Ontario. Toronto: City of Toronto Urban Forestry Services.

Natural Areas Association. 1992. Compendium on Exotic Species; Articles 1 - 43. Natural Areas Association, 108 Fox Street, Mukwanago, WI 53149.

White D.J., E. Haber and C. Keddy. 1993. Invasive Plants Of Natural Habitats In Canada: An Integrated Review Of Wetland And Upland Species And Legislation Governing Their Control. Canadian Wildlife Service, Ottawa, Canada. 121 p.

APPENDIX 5 - PRELIMINARY ASSESSMENT RESULTS FOR THE IDENTIFICATION AND PRIORITIZATION OF HAZARD TREES ON THE LONDON DYKES

DYKE	SITE CHARACTERIZATION	VEGETATION CHARACTERIZATION	PRIORITY RANKING
Ada-Jaqueline *(Figure 10)*	• Dyke is earth construction. West of Adelaide the dyke runs through maintained parkland. East of Adelaide the dyke is set back from the Thames allowing some hydrological interaction in the remnant floodplain before turning south at approximately 0+150. From this point to the start of the dyke at 0+000 the dyke has been rebuilt with rip rap which slopes directly into the Thames. • Station 0+000 to 0+150 at the east end of Ada Street was rebuilt approx. 20 years ago. • Pedestrian access throughout. An asphalt trail runs along the river on the west side of Adelaide Street and an informal foot path traverses the top of the earthen dyke east of Adelaide. • Steep drop along trail to the floodplain. Approx 1-2 meters west of Adelaide and 2-5 meters east of Adelaide. • Poor hydrological connection to floodplain west of Adelaide. The dyke east of Adelaide is further back from the river and a poor quality floodplain has developed. • Proximity to residents is close east of Adelaide. Access is tight. Should identify pertinent by-laws & regulations regarding zoning & land use to scope out requirements for dyke repairs. • Storm drain with flap gate west of Adelaide street bridge may eventually be destabilized due to Manitoba Maple. • Geotechnical data would assist design stage. • Rail line defines the west end of site.	• Buckthorn, Garlic Mustard & Manitoba Maple in the natural areas. • West end of dyke is mowed lawn; no other vegetation. • Tree species observed west of Adelaide represent a future hazard on remainder of dyke. • Park portion has specimen plantings of Red Oak and Green Ash. • Station 0+000 to 0+150 (rebuilt approx. 20 years ago) includes Manitoba Maple, Choke Cherry, Eastern White Cedar and plantings of Red Oak and Paper Birch. • Relatively low-quality floodplain cover. • Floodplain West of Adelaide is mostly recreational: i.e. mowed lawn & sports field; not much habitat. • There has been some recent tree coppicing adjacent to the Adelaide Bridge.	• 0+000 to 0+150: **CRITICAL** o Extreme east end is rip-rapped and the tree covered here should be managed in the next two years to avoid structural damage from hazard trees. • 0+150 to 0+350: **DEGRADED** o East end of the dyke is in advanced stage of physical degradation. Hazard trees have fallen and heaved relatively large areas of earth from the dyke. A major flood may result in a breach.. • 0+350 to 0+525: **THRESHOLD** o The species present in the remnant floodplain west of Adelaide Street are high risk species that will eventually develop into hazard trees. The dyke is away from the floodplain but the slope adjacent to the paved path and recreation areas are targets for hazard tree damage. Tree covere should be managed in the next three to five years to avoid future structural damage.
Broughdale *(Figure 08)*	• North End (0+00 to 0+425) consists of an earthen dyke within a context of open manicured lawn, planted trees, paved pathway. Open space apparently not used for active recreation. • South end (0+425 to 0+766.77) is an intact floodplain on river side of dyke; dyke is filled on landward side and residential development is directly adjacent. • South end is starting to exhibit risk indicators and hazard trees on dyke. • Extreme south end has back channel flow in floodplain. Gabion replacement in embankment protects residents (approx 0+675). • Good hydrological connection to remnant flood plain in south section. • High quality floodplain condition on east side of the Thames opposite the dyke. • The dyke is very close to residences in the south end. • Dumping is evident within the residential areas. • South end of dyke has hydro poles installed directly into the dyke.	• No trees on dyke in the northern section. • Garlic Mustard present. • River's edge includes Black Walnut, Norway Maple, Manitoba Maple, Red Maple, Sycamore and Eastern Cottonwood. • No trees on dyke in the northern manicured section. • Garlic Mustard prevalent on the dyke. Soil disturbance from the dyke construction appears to have triggered establishment of many invasive species.	• 0+000 to 0+450: **NO ACTION REQUIRED** o The dyke is within the manicured park and no trees are growing upon the structure. • 0+450 to 0+550 & 0+675 to 0+766.77: **THRESHOLD** o Problem species are in an early stage of development. Hazard trees will form as specimens age. Management action should be taken within three to five years. • 0+550 to 0+675: **CRITICAL** o Hazard trees have developed and present a risk not only to the dyke but to the hydro utility poles which have been installed here. Management action should be taken within two years to avoid structural.
Byron *(Figure 07)*	• Byron is an earthen dyke construction set back from the river allowing some hydrological interaction within the remnant floodplain. • Only a few properties are being protected by this dyke. Adjacent properties are residential • Hydrology is sustaining species diversity within the floodplain. • The dyke itself covered in invasive species and has developed hazard trees along its entire length. • Infrequently used by public as there are no trails.	• Dyke is threatened by hazard trees, including Manitoba Maple (dominant), Eastern Cottonwood, Norway Maple and Black Locust. • The dominant ground cover on the dyke is Garlic Mustard. • Adjacent high quality floodplain consists of Silver Maple, Sugar Maple, Basswood, Sycamore and Red Maple. Norway Maple has begun to colonise the floodplain and will become a problem for the dyke in the future if the infestation is not managed. • High quality floodplain exists adjacent to the Thames	• 0+000 to 0+374: **CRITICAL** o The dyke is infested with hazard trees. The floodplain is still fairly intact but Norway Maple infestation has begun which will diminish the floodplain quality and eventually colonise the dyke. Management action should be taken within two years to avoid damage to the dyke as the hazard trees begin to fall and heave portions of the dyke.
Coves *(Figure 06)*	• Coves is a backfilled earthen dyke with a flap gate built into the dyke as part of a storm water management release structure. A backwater channel between the gate and the Thames has developed within the floodplain.	• Short dyke section consisting of Willow, American Elm and Manitoba Maple.	• 0+000 to 0+190: **NO ACTION REQUIRED** o The dyke here forms more of the valley slope leading down to the floodplain as the dyke is backfilled. Few hazard trees have developed.

DYKE	SITE CHARACTERIZATION	VEGETATION CHARACTERIZATION	PRIORITY RANKING
	• A large section of floodplain separates the dyke from the Thames in this location. • A wide road traverses the top of the backfilled dyke providing access to the Sewage Plant. Roadside is manicured turf and planted caliper trees.		Little risk of a breach in the dyke due to vegetation.
Nelson Clarence *(Figure 09)*	• Nelson Clarence is an earthen dyke construction with vegetation growing directly on the facility. • There has been some recent reworking of sewers within the site and through the dyke. • UTRCA staff indicated that this dyke may be decommissioned as most flood prone properties have been purchased. • The dyke is located directly adjacent to the Thames; the remnant natural floodplain community is separated from the river hydrology. • Most of the remnant natural floodplain community is in recreational use; i.e. lawn, play structures, paved trails.	• Manitoba Maple and White Willow are growing in abundance directly upon the dyke. Many qualify as hazard trees. • Norway Maple has begun to colonise the dyke. • Some native canopy in floodplain behind dyke, including Black Walnut, American Elm, Hackberry and Red Maple. • Butternut, and Endangered species, was documented here. • Good opportunity for restoration of floodplain forest cover and hydrology (assuming dyke is decommissioned).	• 0+000 to 0+150: **CRITICAL** o Hazard tree development is at its worst in this portion of the dyke. o Residential homes and paved pedestrian pathways are directly adjacent to the dyke in this location and present a damageable target. • 0+150 to 0+600: **THRESHOLD** o Hazard trees have developed along the dyke here but have not yet begun to lean or heave the soil. o The land behind the dyke is largely open space and is not as risk prone as in other situations.
Riverview *(Figure 05)*	• The dyke is an earthen construction at the top of the existing bank down to the Thames. Dyke is an enhancement to the riparian slope. • The dyke is built at the rear of residential lots on the landward side. Access to site is constrained as the dyke is between the river and the residential lots. • River is undercutting the vegetated slope of the dyke in some areas, threatening structural stability.	• Manitoba Maple and Willow are growing in abundance directly upon the dyke. Many qualify as hazard trees. • Hackberry is regenerating to the north on private lots. • Floodplain restoration opportunity west of dyke.	• 0+000 to 0+275: **CRITICAL** o Hazard trees in advanced state of lean are present. The entire slope along this section is threatened by hazard trees and bank undercutting. o Management action should be taken within the next two years to avoid the potential of bank failure and property loss. • 0+275 to 0+425: **THRESHOLD** o The dyke angles southward and perpendicular to the Thames at this point which lessens the risk of failure due the lack of the undercut bank and the presence of floodplain to the west.
West London *(Figures 02, 03 & 04)*	• This is the largest of London's dykes. The majority of the northern section is a slope of reinforced concrete panels with a paved trail system and rail at the top overlooking the Thames. The remainder of the dyke, from approx station 1+350 (the Queen – Dundas / Riverside intersection) is earthen construction except for a short continuation of concrete between 1+825 and 1+975. • Engineering priorities overshadow ecological issues at the Queen/ Dundas/ Riverside/ stadium areas as the concrete is failing. • Park is to be constructed south of Queens-Dundas/Riverside in conjunction with the dyke reconstruction. • Conditions south of Wharncliff Bridge include: informal trails, dumping from adjacent residences, presence of a Works Yard backfilled dyke at south end. • Deposition is allowing floodplain vegetation to regenerate at the base of the concrete slope near Oxford bridge, and downstream of Blackfriar bridge.	• Deposition is allowing floodplain vegetation to regenerate at the base of the concrete slope near Oxford bridge, and downstream of Blackfriar bridge; including: Black Locust fringe above floodline, and then Manitoba Maple at the base of the revetment. , Willow and Sycamore on floodplain shelf. • Vegetation in the concrete cracks is not apparent, possibly due to City spraying or due to winter kill (surveyed in January). • Manitoba Maple infestation south of Wharncliff Bridge around Works Yard causing critical risk in dyke structure; also more vegetation in cracks of dyke.	• 0+000 to 1+250: **THRESHOLD** o No hazard trees have developed directly on the dyke but continued maintenance is required to prevent specimens from establishing. • 1+250 to 1+800: **OTHER** o The dyke at the Queen/ Dundas/ Riverside/ stadium area is planned for reconstruction due to concrete failure and park development planning. • 1+800 to 2+100: **THRESHOLD** o No hazard trees have developed directly on the dyke but continued maintenance is required to prevent specimens from establishing. • 2+100 to 2+374: **CRITICAL** o A Manitoba Maple infestation has colonised the dyke and many hazard trees have established. Management action should take place within the next two years to avoid heaving damage to the dyke as specimens begin to lean and heave the dyke.

APPENDIX 6 - RECOMMENDED ACTIONS TO MANAGE RISKS TO DYKE INTEGRITY

DYKES		DIRECT IMPACT RISKS TO DYKE INTEGRITY	INDIRECT IMPACT RISKS TO DYKE INTEGRITY
Ada-Jaqueline *(Figure 11)*	*Possible Goals & Objectives*	• The structural integrity should reviewed by an engineer. • Removal of existing hazard trees and repair of damage to the dyke should be priority. • Management of immature problem species in Critical condition areas should be undertaken to avoid future damage potential.	• Improve biodiversity in remnant floodplain. • Monitor and manage invasive and exotic species problem to reduce recruitment of hazard species upon the dyke. • Buffer urban influence: remove informal trails through critical areas; erect fences & buffer plantings; educate residents to reduce dumping and property encroachment. • Stakeholder consultation required.
	Opportunities & Constraints	• Access to the degraded areas of the Dyke east of Adelaide is constrained. Residential lots and floodplain bound the dyke through this section. The most likely route would be a temporary access route cleared through the floodplain.	• Opportunity to expand existing natural area; especially in the land to the west of Adelaide where manicured park land is prevalent. • Opportunity to rehabilitate degraded site; especially the remnant floodplain east of Adelaide Street. • Access to the critical areas of the dyke east of Adelaide is constrained.
	Design Considerations	• Following management of direct risks the repaired sections should be revegetated with species recommended in Appendix 02 to delay recruitment of problem species. • Access to the dyke by pedestrians and adjacent residents should be minimised. Consider the use of fencing and buffer plantings. • Consider grading within any disturbed floodplain to improve hydrological conditions (e.g. seasonal pools).	• Locate buffer plantings to reduce urban influences. • Recommended target communities for restoration and enhancement include riparian and swamp systems. • Grading and hydrology of the local floodplain should be assessed in greater detail to assist plans for swamp restoration. • Interpretive opportunity in areas frequented by pedestrians through the park in the west sections of the site. • Stakeholder consultation required.
Broughdale *(Figure 09)*	*Possible Goals & Objectives*	• Management of hazard trees in Critical condition areas is a priority.	• Maintain and restore floodplain habitats. • Manage dumping. • Control invasive species. • Stakeholder consultation required.
	Opportunities & Constraints	• Hydro utility installed in dyke. The utility may be approached as a partner in the management of hazard trees in this area.	• Opportunity to rehabilitate degraded site. • Opportunity to expand existing natural area. • Flood frequency data is available.
	Design Considerations	• May want to consider design options that limit access to the natural floodplain to deter access and dumping by pedestrians and residents. Options include fencing and plantings or a combination. • Revegetate managed areas to avoid recruitment of problem species. See Appendix 02 & 03.	• Target community for restoration and enhancement is floodplain forest. • Grading and hydrology of the floodplain should be documented in greater detail to assist plans for habitat restoration and enhancement. • Interpretive opportunity in areas frequented by pedestrians through the park in the north sections of the site. • Stakeholder consultation required.
Byron *(Figure 08)*	*Possible Goals & Objectives*	• Management of hazard trees in Critical condition areas is a priority. • The dyke is partially composed of concrete and construction waste) and has been altered by residents (i.e. stairs, informal paths). The dyke should be amended with better quality soil..	• Invasive species management is a long term priority at this site; especially Vinca and garlic mustard in the understory and Norway & Manitoba Maple in the overstory. • Stakeholder consultation required.
	Opportunities & Constraints	• The floodplain between the dyke and the Thames is still relatively intact. Any management or dyke repairs should attempt to minimise impacts to this habitat.	• Opportunity to rehabilitate degraded site. • Opportunity for buffers or edge management.
	Design Considerations	• Prevent access to the dyke by adjacent residents: fencing, buffer plantings, education.	• Target community for restoration and enhancement is floodplain forest. • Develop a residential education package to dissuade use of invasive exotics as ornamentals and eliminate dumping.
Coves *(Figure 07)*	*Possible Goals & Objectives*	• This is a low priority for management. The priority here should be regular monitoring.	• Control of invasive species and improvement of biodiversity. • Stakeholder consultation required.
	Opportunities & Constraints	• No immediate opportunities and constraints present.	• Opportunity to rehabilitate floodplain forest by improving diversity through native plantings. • Opportunity to expand existing natural cover. • Opportunity for buffers or edge management along manicured park.
	Design Considerations	• No special short term design considerations.	• Efforts are perhaps best spent on edge management and biodiversity enhancement. • Stakeholder consultation required.
Nelson Clarence *(Figure 10)*	*Possible Goals & Objectives*	• Management of Critical condition areas is priority to avoid potential damage to the dyke and adjacent area.	• Reconnect remnant floodplain forest to a functional hydrological regime. • Maintain and improve species diversity; expand floodplain forest cover. • Outer face of dyke (riparian zone) requires vegetation management: replacing existing trees with

DYKES		DIRECT IMPACT RISKS TO DYKE INTEGRITY	INDIRECT IMPACT RISKS TO DYKE INTEGRITY
			shrubs. • Stakeholder consultation required.
	Opportunities & Constraints	• Remnant floodplain community behind dyke is an opportunity for restoration. Short term strategies should keep long term strategies in mind to avoid implementing any plantings that may be removed or damaged in an attempt to restore a functional hydrology to the remnant community. • Access and removal operations should avoid damage to high quality specimen trees.	• Opportunity to rehabilitate degraded floodplain forest. • Opportunity to re-establish a functional hydrology to the remnant floodplain behind the dyke. • Some plantings have already been installed. • Opportunity for interpretive signage due to pedestrian use. • Private property ownership constrains the options for restoration of a functional hydrology due to flood control requirements.
	Design Considerations	• Tree protection fencing should be used during removal of hazard trees to avoid damage to desirable floodplain forest species. • Existing Butternut (an Endangered species) should be considered in future management	• Critical to determine whether or not it is possible to decommission the dyke to facilitate the hydrological design scenarios to rehabilitate the remnant floodplain. • If dyke must remain, consider moving sections of the dyke back from the Thames to reduce steep slopes in the riparian zone. • If dyke must remain, consider a hydrological design that analyses the storage capacity and grading requirements within the floodplain behind the dyke and adapt dyke to allow overflow under certain storm events (i.e. a hydrological connection to meet vegetation response targets).
Riverview *(Figure 06)*	*Possible Goals & Objectives*	• Slope stability and undercutting are a priority that may require the regrading of the slope and dyke. • Remove hazard trees.	• Invasive species management on riparian slope and dyke. • Limit access to dyke and slope from adjacent residents. • Educate adjacent residents to eliminate dumping, yard extensions and construction upon the dyke and riparian slope. • Stakeholder consultation required.
	Opportunities & Constraints	• Limited access is a constraint.	• Opportunity to create new riparian habitat after regarding entire slope.
	Design Considerations	• Use soil bioengineering techniques to revegetate regraded slope to establish native shrub cover and provide slope stability function (note: ecological consultant should inspect willow cuttings to ensure species are native shrub willow rather than tree willows that will merely perpetuate hazard problems.). • Consider buffer plantings, property demarcation bollards and/or fencing to deter landowner incursions.	• Consider property acquisition for long term management as the Thames is exerting erosive forces on the riparian slopes in this location and access will continue to be a problem as long as residents own adjacent property. • In the event property acquisition is not feasible consider acquiring an easement along the dyke to facilitate access and maintenance. • Designs should incorporate property demarcation such as plantings and bollards and/or fencing (living fences).
West London *(Figures 03, 04 & 05)*	*Possible Goals & Objectives*	• Management of hazard trees in critical areas is a priority. • Revegetation should respect long term goals and objectives; i.e. avoid extensive replanting in areas scheduled for reconstruction or where restoration is planned.	• Invasive species management, including White Mulberry, Manitoba Maple and Japanese Knot Weed. • Engineering priorities vs. priorities should be determined to scope the extent of native planting opportunities. • A strategy for crack management; i.e. eliminate all plant species or encourage desirable natives? • Educate adjacent residents to discourage dumping; especially in south end. • Stakeholder consultation required.
	Opportunities & Constraints	• Many opportunities for restoration exist if coupled with existing reconstruction and park development plans.	• Opportunity for Green Ash to regenerate south of Queens/Dundas. • Restoration opportunities are limited by the engineering priorities so long as dykes are constructed with hardened materials.
	Design Considerations	• Initial plantings should be a dense native cover crop to discourage recruitment of problem species until the long term restoration plans have been developed.	• As sections of the concrete dyke age consider replacing with softer materials such as vegetated armour stone terraces or the like. • Where possible consider regrading earthen portions of the dyke to increase available floodplain and re-establish a functional hydrology. • Plant community targets could include floodplain forest, swamp and marsh. • Public access to the dyke is extensive. There are interpretive opportunities along the trail system to educate users on the engineering and ecology of the dykes and river system. • Stakeholder consultation required.

APPENDIX 7 - MANAGEMENT IMPLEMENTATION AND DESIGN DEVELOPMENT FLOWCHART