West London Dyke Master Repair Plan

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Sign-off Sheet

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Introduction

The Upper Thames River Conservation Authority (UTRCA) in partnership with the City of London (City) has undertaken a Master Repair Plan (MRP). This is a strategic document to assist in the overall planning for a period of up to 20 years to address aging infrastructure, flood protection, public use, and integration of other City initiatives. The intent of the Master Repair Plan is to develop the required strategic plan to allow the UTRCA and the City to have a method for determining when a trigger point for repair and/or replacement of a portion of the dyke is required.

The Master Repair Plan is being undertaken in accordance with the Master Planning requirements of the MEA Municipal Class Environmental Assessment (October 2000, as amended in 2007 and 2011).

The MEA offers four approaches for undertaking a Master Plan and based on our review Municipal Class EA Approach #2 appears to be the most accurate. Approach #2 allows for the preparation of a Master Plan document at the conclusion of Phases 1 and 2 of the Municipal Class EA process where the level of investigation, consultation and documentation are sufficient to fulfill the requirements for Schedule B projects identified within the Master Plan. Accordingly, the final public notice for the Master Plan could become the Notice of Completion for Schedule B projects within it. Any Schedule C projects, however, would have to fulfill Phases 3 and 4 prior to filing an Environmental Study Report (ESR) for public review. The Master Plan would provide the basis for future investigations for the specific Schedule C projects identified within it. While Master Plans are not subject to requests for a Part II Order, members of the public or other stakeholders may submit a request to the Minister for a Part II Order for individual Schedule B projects identified within the Master Plan.

Overview of West London Dyke

The West London Dyke is approximately 2,300 m long and runs along the west bank of the north branch of the Thames River extending north of Oxford Street to the Forks of the Thames River and then along the north bank of the main branch to the west of the Wharncliffe Road Bridge and terminating in Cavendish Park. The West London Dyke is primarily an engineered structure which protects life and property during periods of extreme river flows. In addition to serving a critical control function, the dyke is also an integral component of the City's recreational pathway system and its location at the Forks of the Thames makes it a prominent structure in the downtown area of the City.

History of the West London Dyke

Due to the proximity of early settlements within London to the Thames River, these areas were often subjected to flood events. A catastrophic flood in July 1883 prompted the construction of a formalized dyke system. A flood event in April 1937 overtopped the dyke and resulted in five deaths, the destruction of approximately 1,100 homes and severe damage to roads and bridges. As a result of the flood, the dykes along the river were reconstructed and raised.

Flood control measures implemented subsequent to the formation of the UTRCA after the 1947 flood have resulted in the construction of several dams, flood control channels, floodwall and dyke rehabilitation.

Replacement of a 300 m section of dyke between the Queens Avenue Bridge and Rogers Avenue with a near vertical modular block wall with geogrid reinforcement was completed in 2007. This section was replaced rather than repaired after structural deficiencies were noted in 2006 during the initial stages of a concrete repair program.

Consultation

Residents within the area surrounding the West London Dyke as well as other stakeholders were provided with a Notice of Commencement, which included information on Public Information Centre 1 (PIC 1), Notice of Public Information Centre 2 (PIC 2), Notice of Public Information Centre 3 (PIC 3) and Notice of Completion through Canada Post.

Project Area Description

With regard to engineering review, costing, and trigger point determination, the Master Repair Plan considered the following segments (from upstream to downstream) which were derived based on the physical location and/or physical characteristics of the dyke:

1. Oxford North;
2. St. Patrick's (Oxford Street West – Empress Avenue);
3. Blackfriars (Empress Avenue – Cummings Avenue);
4. Natural Bank (Cummings Avenue – Leslie Street);
5. Labatt Park/Forks (Leslie Street – Dundas Street);
6. Wharncliffe (Dundas Street – Wharncliffe Road North);
7. Cavendish East; and
8. Cavendish West.

These segments however are not intended to represent exact limits for future construction projects. Future works (involving repair or replacement) may involve either work within a segment, or overlapping or portions of segments.

Project Drivers

In order to properly define the long-term planning requirements for the West London Dyke, it is critical that appropriate project drivers (potential reasons to implement or otherwise initiate work) are defined. As part of the Master Repair Plan planning process, a conceptual list of project drivers were developed based on the guiding principles for presentation to interested stakeholders and for subsequent evaluation during selection of the preferred alternative(s). The project drivers identified are as follows:

- Flood Risk Reduction
- Public Safety
- Functional Improvements
- Environmental Considerations
- Funding Opportunities
- Other (Hydrologic Considerations)

Assessment of Environment

- The following provides a general description of each component in reference to the West London Dyke Structure and surrounding area:
- Natural Environment: Element addressing the protection of the natural and physical elements of the environment (i.e., air, water, land, etc.). This includes both natural heritage and environmentally sensitive areas;
- Social/Cultural Environment: Component that addresses the potential effects on the public, including adjacent landowners (residents, businesses), community groups, social elements, historical/archaeological and heritage factors, and development objectives of the City;
- Economic: Component that addresses capital and maintenance costs, potential flood damage impacts, etc.;
- Legal: Factor that considers potential land requirements related to each proposed alternative; and

- Technical: Component that addresses the technical requirements and suitability of each alternative.

Engineering Review

As part of the technical component of the Master Repair Plan, a general engineering evaluation of the West London Dyke was undertaken. The intent of the engineering review was to establish the following:

- The current condition of the West London Dyke through a review of previous investigations and monitoring inspections;
- Information on the geotechnical characteristics of the site through literature review;
- Information related to potential legacy issues relating to environmental impacts based on past project experience and available documentation;
- Potential maintenance and constructability issues associated with the dyke;
- Requirements for approvals and permits;
- General guidelines for future work based on previous criteria established through the Phase 1 Replacement project; and
- Requirements or recommendations related to further engineering studies.

Alternative 4 has been identified as the preferred solution, with the exception of the section from Rogers Avenue to the Queens Avenue Bridge.

Review of Alternatives

The Master Plan and Class EA planning process recognizes that there are often many alternatives to address a particular issue or problem, and that these alternatives should be considered. Alternative solutions identified as part of the Master Repair Plan are listed as follows:

- **Alternative 1** – Do Nothing;
- **Alternative 2** – Replace with Similar Dyke (Existing Footprint);
- **Alternative 3** – Replace with New Dyke to 100 Year Standard + Freeboard; and
- **Alternative 4** – Replace with New Dyke to 250 Year Standard + Freeboard.

Recommended Implementation Strategy

In general, the prioritization of projects is based on a review of the project drivers. Accordingly, the determination of priority has been based on known existing information as presented in Table E.1, primarily relating to the following:

- Current condition of the dyke;
- Potential to reduce overall flood damages;
- Constructability considerations; and
- Other impacts or considerations.

Table E.1: Project Implementation Schedule

Segment	Section	Type	Preferred Alt.	Estimated Cost	Estimated EA Cost	Implementation Schedule	Priority Ranking
Oxford North	North of south limit of Oxford St. Bridge	Concrete Revetment / Vegetated Berm	Alt. 4	$3.7M / $2.6M[7]	N/A	**10 + Years**	8
St. Patrick	Oxford St. to St. Patrick St.	Concrete Revetment	Alt. 4	$2.8M	N/A	**5 to 10 Years**	4
	St. Patrick St. to Empress Ave.	Concrete Revetment	Alt. 4	$3.0M	N/A	**5 to 10 Years**	5
Blackfriars	Empress Ave. to Blackfriars St.	Concrete Revetment	Alt. 4	$3.3M / $2.2M[7]	$70-$80K	**1 to 5 Years**	2
	Blackfriars St. to Cummings Ave.	Concrete Revetment	Alt. 4	$2.2M	$70-$80K	**1 to 5 Years**	3
Natural Bank	Cummings Ave. to Leslie St.	Concrete Revetment (Naturalized Toe)	Alt. 4	$4.6M	N/A	**10 + Years**	6

Segment	Section	Type	Preferred Alt.	Estimated Cost	Estimated EA Cost	Implementation Schedule	Priority Ranking
Labatt Park/Forks	Leslie St. to Rogers Ave.	Concrete Revetment	Alt. 4	$2.6M	N/A	**1 to 5 Years**	1
	Rogers Ave. to Queens Ave. Bridge	Modular Block Wall with Geogrid	Alt. 1	$250K	N/A	**10 + Years (work completed in 2007/08)**	---
	Queens Ave. extending south to Forks	Natural Bank with Gabions	Alt. 4	$500K	N/A	**10 + Years**	9 (assumed to coincide with Wharncliffe segment work)
Wharncliffe	From Forks to Wharncliffe Rd. Bridge	Natural Bank with Gabions	Alt. 4	$4.3M / $3.3M	N/A	**10 + Years**	9
Cavendish East	Wharncliffe Rd. Bridge extending west	Concrete Revetment	Alt. 4	$2.8M	N/A	**10 + Years**	7
	From termination of concrete revetment extending west to City Works Yard	Natural Bank/Berm	Alt. 4	$2.7M	N/A	**10 + Years**	10
Cavendish West	From City Works Yard extending north, then west along adjacent property limits	Vegetated Berm	Alt. 4	$1.2M	N/A	**10 + Years**	10

Additional Studies

In addition to capital improvements and repairs, additional studies and programs have been recommended. Recommendations have been based on comments received during the consultation process, the evaluation of project drivers, input from both the UTRCA and the City, and the environmental and technical reviews completed for the West London Dyke.

1.0 INTRODUCTION

The Upper Thames River Conservation Authority (UTRCA) in partnership with the City of London (City) has undertaken a Master Repair Plan (MRP). This is a strategic document to assist in the overall planning for a period of up to 20 years. The objectives of this Master Repair Plan are as follows:

- To ensure that key problems and opportunities facing the UTRCA and the City with regard to the dyke are properly identified;
- To update the previous 2007 West London Dyke Flood Control Structure Master Plan in accordance with the Municipal Engineers Association (MEA) Municipal Class Environmental Assessment (June 2000, revised 2007 and 2011) process;
- To provide an overview of the existing condition of the dyke, level of flood protection currently provided, and present constraints (regulatory, land, transportation);
- To integrate other City initiatives pertaining to the dyke area;
- To provide general recommendations and design guidelines relating to various components of the West London Dyke and adjacent pathway system, such as wall structure, activity / use areas, natural environment, heritage features and interpretation, safety, access, etc. are properly identified; and
- The Master Repair Plan results in the implementation of the required projects on a cost effective, sustainable, and timely basis.

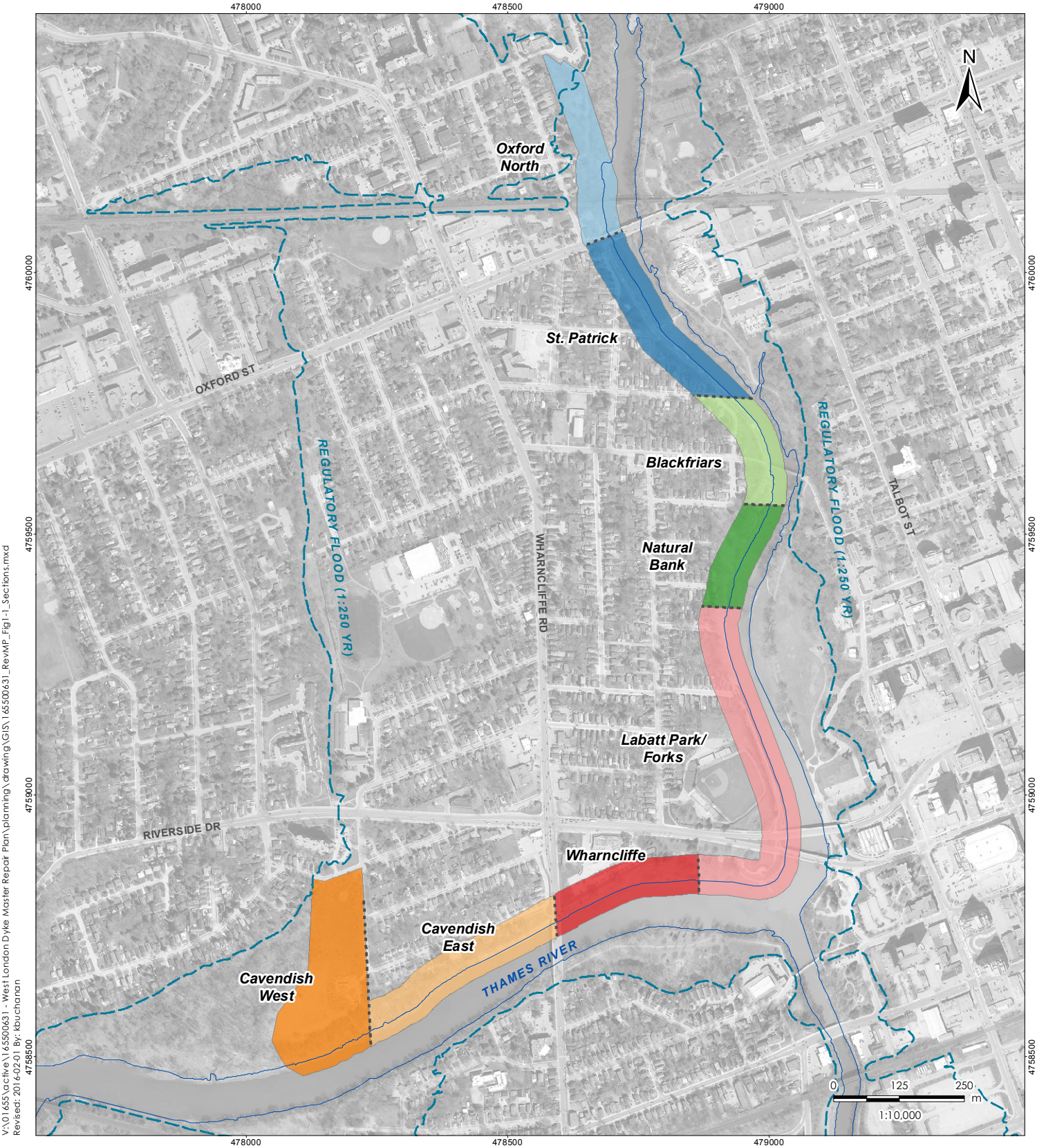
This Master Repair Plan sets out design recommendations, which will guide detailed design development for the various phases of the West London Dyke and Thames Valley Parkway upgrade and replacement. Preparation of the Master Repair Plan was undertaken after careful examination of existing conditions and findings gathered through the consultation process and review of other City initiatives.

1.1 STUDY OVERVIEW

The Master Repair Plan provides a summary of existing conditions for the West London Dyke Flood Control Structure. Figure 1.1 illustrates a general overview of the study area. Subsequent figures within the Master Repair Plan will provide further detail of the study area. The study area is defined as the geographical area that could potentially be affected by any of the alternatives presented and was determined on the basis of the expected range of effects associated with the Master Repair Plan for the existing West London Dyke. Repair and replacement needs are identified and alternatives are developed to address these needs. Key steps taken in the development of this Master Repair Plan include the following:

- On-site field visits and photo documentation to gain an in-depth appreciation of the dyke and pathway system, existing conditions, and to identify opportunities and constraints;
- Public consultation via Public Information Centres (PICs) with notification given through:
    - Mail out (Canada Post) to surrounding residents as shown in Figure 1.2, and
    - Newspaper advertisement in the London Free Press or the Londoner.
- Agency consultation;
- Aboriginal consultation;
- Technical review consisting of:
    - Planning / environmental review,
    - Hydraulic review,
    - Engineering review,
    - Costing (planning, design, implementation and maintenance), and
    - Trigger point determination.
- Preparation of preliminary design concepts for discussion purposes;
- Preparation of the draft Master Repair Plan;
- Circulation of the draft Master Repair Plan for comments; and
- Finalized Master Repair Plan document.

Through regular Project Team meetings between the City, UTRCA, and Stantec, modifications or revisions may have been made to the scope of work required as guided by the terms of reference for this project.



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February 2016
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Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Imagery and base features used under license with the City of London, © 2009-2015.

Client/Project

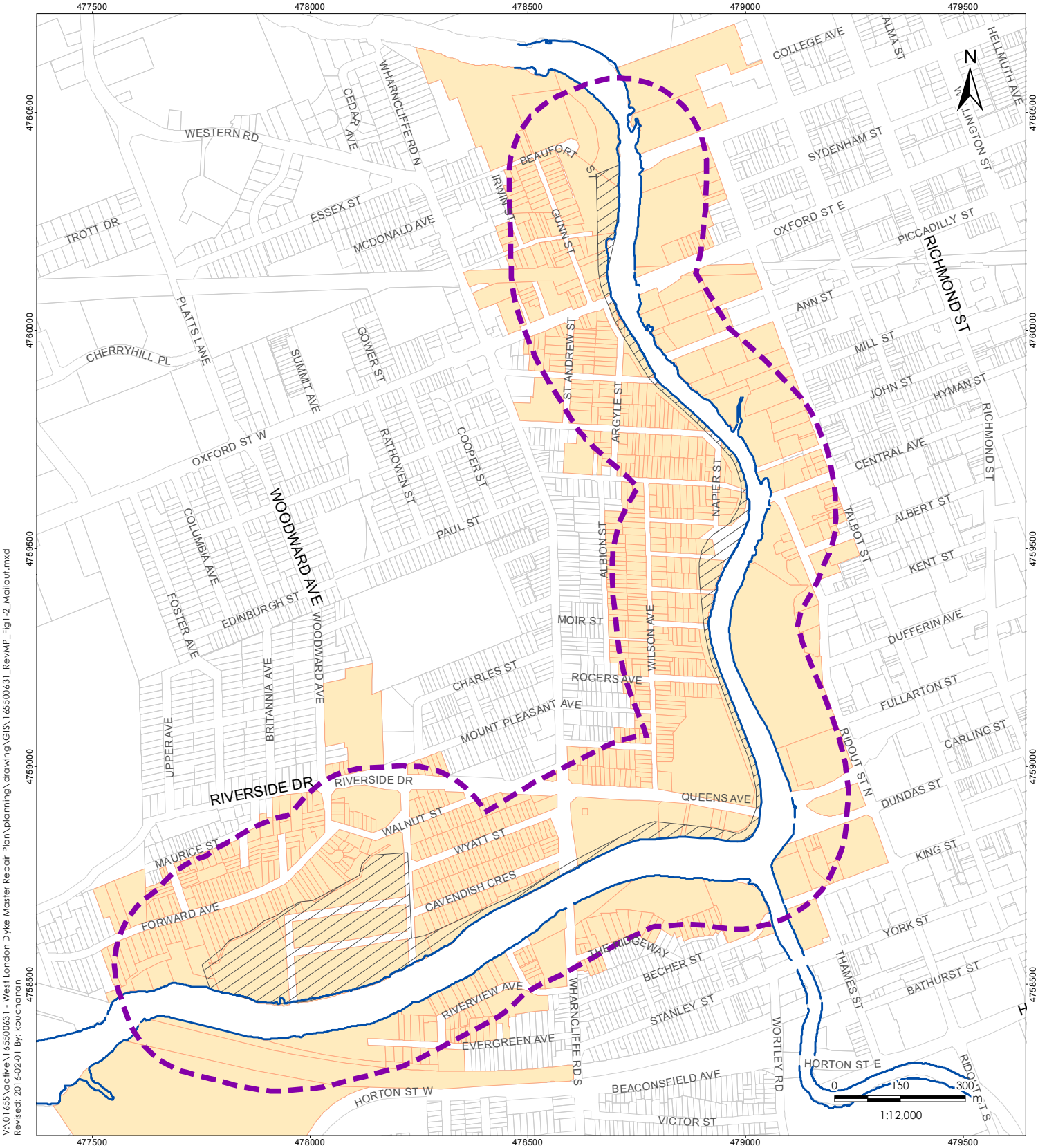
Upper Thames River Conservation Authority & City of London
West London Dyke Master Repair Plan

Figure No.

1.1

Title

Study Area



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Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
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Legend

- 200 Metre Notification Area
- Notification Parcel
- Parcel

Mail-Out Summary

Dyke Side Bank - 780 Parcels
Opposite Bank - 186 Parcels
Total - 966 Parcels

Client/Project

Upper Thames River Conservation Authority & City of London
West London Dyke Master Repair Plan

Figure No.

1.2

Title

Location of Notification Mail-Out

1.2 STUDY SCHEDULE

The Master Repair Plan was initiated in April 2010. The study was placed on hold in early 2013 pending updates to flood elevation information. Three Public Information Centres (PICs) were held throughout the duration of the study to obtain feedback and comments from the public, agencies and First Nation communities.

1.3 PROBLEM IDENTIFICATION

The UTRCA and the City of London are undertaking a Master Repair Plan covering the next 20-year period to address aging infrastructure, flood protection, public use, and integration of other City initiatives. The intent of the Master Repair Plan is to develop the required strategic plan to allow the UTRCA and the City to have a method for determining when a trigger point for repair and/or replacement of a portion of the dyke is required. Based on information known, conceptual designs will be presented; however, they will be subject to more detailed investigation prior to implementation.

1.4 INTENT OF REPORT

The intent of the Master Repair Plan is to address public, agency, and First Nation community requirements and concerns and to ensure all possible alternatives and opportunities are fairly assessed and reviewed in a public forum before being finalized and carried forward for implementation.

As shown in Figure 1.3, the objective of this report is not necessarily to detail when a specific municipal infrastructure project will be implemented but rather to review on behalf of the UTRCA and the City the following:

- Project drivers, or in other words, the reasons for the need to initiate a project (such as to enhance flood protection measures, repair or replace failing sections, integration of additional pathways, etc.); and

- Identifying the solutions that are possible and defining a preferred solution for a project.

This process is undertaken through the MEA Municipal Class Environmental Assessment (EA) process. With this information, the UTRCA and the City have the ability to identify what would constitute a "trigger point" to implement the project. A "trigger point" is reached when the need for the project (i.e., project drivers) is greater than the cost to implement it.

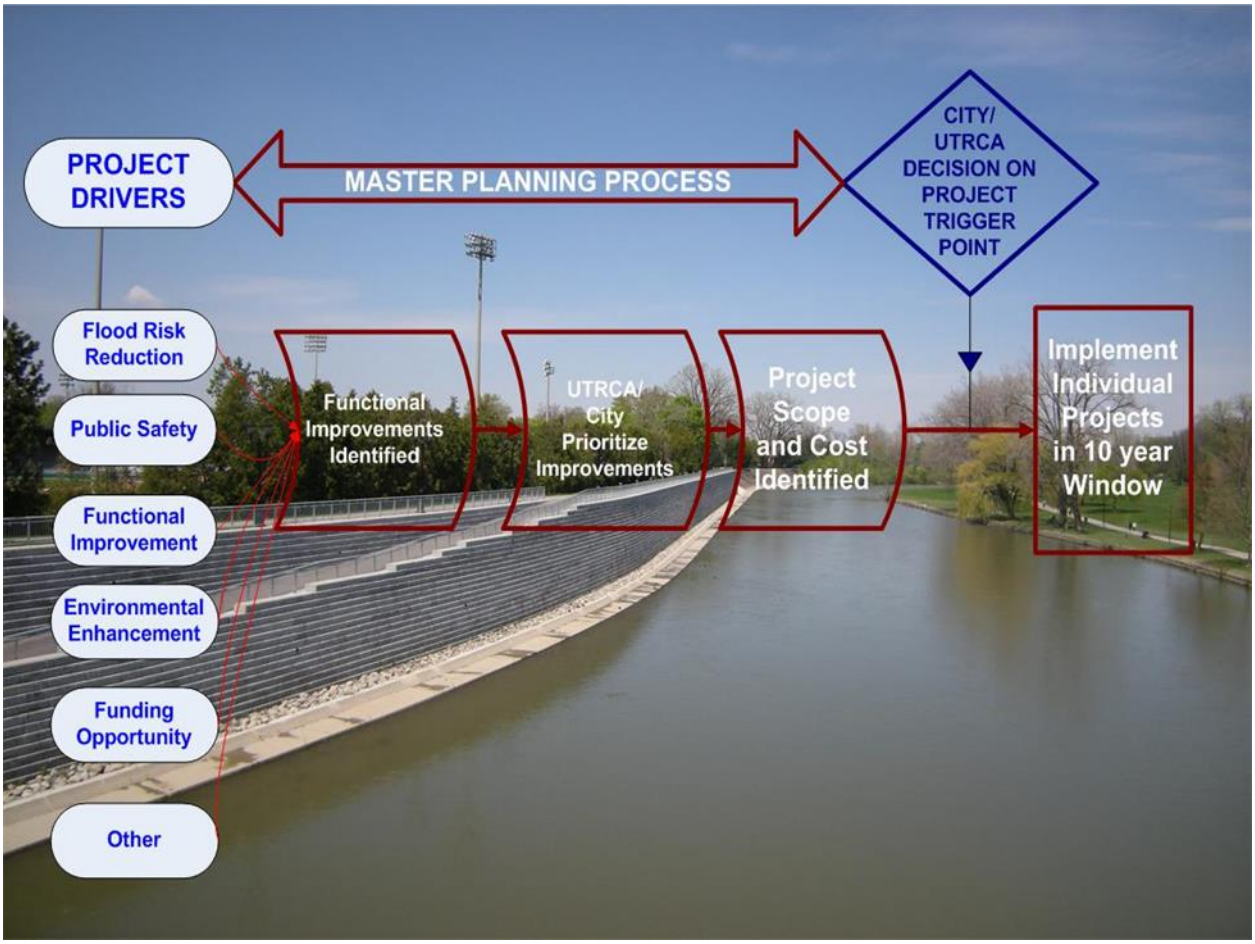


Figure 1.3: Intent of Project

1.5 BACKGOUND

The West London Dyke is approximately 2,300 m long and runs along the west bank of the north branch of the Thames River extending north of Oxford Street to the Forks of the Thames River and then along the north bank of the main branch to west of the Wharncliffe Road North Bridge and terminating in Cavendish Park. The City owns the dyke structure and undertakes minor maintenance activities. Through an agreement with the Upper Thames River Conservation Authority, the UTRCA undertakes major maintenance activities.

The West London Dyke is primarily an engineered structure, which protects life and property during periods of extreme river flows. In addition to serving a critical control function, the dyke is also an integral component of the City's recreational pathway system and its location at the Forks of the Thames makes it a prominent structure in the downtown area of the City.

Construction of the West London Dyke began in the 1880s, with extensions, reinforcements and height increases occurring at least twice by the early 1900s. Sections of the dyke were raised

after the 1937 flood and before another major flood in 1947. Select repairs to the concrete revetment component of the dyke were completed in the 1980s and consisted generally of grouting beneath revetment panels, and toe repairs and support.

Figure 1.4: Construction of the Dyke

In 2004, a 'condition assessment' of London's flood control structures identified a need for repairs to sections of the dyke, with the highest priority being in the area north of Queens Avenue. However, in 2005, while undertaking the initial stages of the concrete repair program for the West London Dyke between the Queens Avenue Bridge and Rogers Avenue, it was determined that this section needed to be replaced rather than repaired due to structural deficiencies. A preliminary design process was then undertaken to determine the type of replacement structure best suited to the technical and regulatory requirements for this section of the dyke. At that time, the dyke structure in the area of interest only protected against the 1:100 year flood event; however, preference for Special Policy Area designation required that the flood control structure protect against the 1:250 year flood event. As preliminary review indicated that the new structure was to be constructed and located within the existing footprint, the project was identified as a Schedule A (pre-approved) project. However, the City and UTRCA decided to proceed with a public information process given the high visibility of the structure, potential short term impacts to pathway use, and historical significance.

Public input was solicited at a Public Information Centre meeting held on May 25, 2006 which included an introduction to the history of the dyke and background information on how the design alternatives had been arrived at. At that meeting, a design option review, which outlined how each design alternative ranked within several categories, was also conveyed to the public. Public input from that meeting was incorporated into the final preliminary design report titled *West London Dyke Preliminary Design Report (Stantec Consulting Ltd., 2006)*. After consideration and evaluation of various alternatives, it was determined that a near-vertical, pre-cast reinforced earth system was the preferred alternative for Phase 1 of the replacement as it best met requirements relating to pathway integration, aesthetics, ability to provide required flood protection and constructability due to existing site constraints.

In addition to the functional flood protection requirements, a number of other major design considerations were addressed in the preliminary design report including the need to minimize impacts on the environment, maintain / enhance recreational use of the dyke, and consider aesthetics given the high visibility of the structure and its proximity to the downtown core. Based on these considerations, the City and UTRCA undertook a Design Charrette in order to solicit additional input from key stakeholders relating to the proposed replacement project. Results from the Design Charrette formed the basis of the *2007 West London Dyke Flood Control Structure Master Plan (Stantec Consulting Ltd., 2007)* which was intended to provide long-term design options for the Thames Valley Pathway system, and guiding principles relating to aesthetic and amenity considerations for future replacement works with emphasis on the identified 300 m section of dyke. A copy of the *2007 Master Plan* is included in Appendix 1.1 and the findings and recommendations from this process have been incorporated into this current Master Repair Plan.

Figure 1.5: Phase 1 Pre-Construction

Figure 1.6: Phase 1 Construction

Replacement of the 300 m of dyke between the Queens Avenue Bridge and Rogers Avenue with a near vertical modular block wall with geogrid reinforcement was completed in 2007 as part of the *Phase 1 West London Dyke Replacement* project. As part of this project, a transitional pathway was constructed from the top of the new dyke and terminated in order to allow for the future construction of a pedestrian pathway beneath the Queens Avenue and Dundas Street bridges.

Figure 1.7: Phase 1 Post-Construction

Since 2004, subsequent reviews of the remaining section of concrete revetment

have been undertaken in 2006, 2010, 2011, 2012, 2013, and 2014 in order to compare conditions to previous baseline findings. Results from the 2014 assessment have been referenced in this Master Repair Plan in relation to the engineering review of the original concrete structure.

In 2009, the City of London and UTRCA approved construction of the *Pathway Extension Under the Queens Avenue and Dundas Street Bridges Adjacent to the Thames River (Phase 2)* which completed the pedestrian pathway link from the termination of the Phase 1 structure to areas south of the Dundas Street Bridge. As part of this project, additional dyke replacement was completed along this segment.

Figure 1.8: Phase 2 Pathway Extension

To date, approximately $4.7M (2010 dollars) has been spent on Phase 1 and 2 dyke replacement and pathway enhancement / extension. Funding for these projects was partially procured from both the provincial and municipal governments.

Although the previous investigations revealed the need to replace the section of dyke from the Queens Avenue Bridge to Rogers Avenue, it is anticipated that over a period of years, additional sections will also need to be replaced or areas enhanced for additional flood protection or to integrate other City initiatives. Accordingly, the City and UTRCA recognized the need to prepare a comprehensive long term plan for the West London Dyke. Approval was given by the City and UTRCA for Stantec to prepare a Master Repair Plan in order to build upon the previous recommended design enhancements for the dyke and pathway system identified in the *2007 Master Plan*, with additional emphasis on the engineering and hydraulic review of the existing structure and identification of short and long term maintenance and capital projects.

1.6 HISTORIC FLOOD EVENTS

According to a review of available records, the small settlements of London West and Kensington had developed along the banks of the Thames River by the late 1800s due to reliance on the surrounding water-powered mills. Due to the proximity to the river, these communities experienced several flood events including the catastrophic July 1883 flood that killed 17 people. In response to the tragedy and recognizing the desire and need to remain close to the river,

Figure 1.9: 1937 Flood (West London Area)

construction commenced on a formalized dyke system. The worst flood ever recorded along the Thames River occurred in April of 1937, and overtopped the dyke. The flood resulted in five deaths, the destruction of approximately 1,100 homes, and severe damage to roads and bridges. Total damage was estimated at $3 million (1937 dollars). As a result of the flood, the dykes along the river were reconstructed and raised.

Figure 1.10: 1947 Flood

Figure 1.11: 1947 Flood (near Labatt Park)

Following a less severe flood in 1947, the UTRCA was formed in order to respond to citizens' concerns about flood control and undertook a program of flood control measures which up to 1990 resulted in the construction of several dams, flood control channels, floodwall, and dyke rehabilitation, including the West London Dyke and development of flood forecasting measures. Since that time, there have been additional floods in March 1977, September 1986, September 1997, July 2000, April and December of 2008; however, no breaching of the dykes have occurred.

Past flooding has generally been associated with spring snowmelt upstream of the dyke, causing high water levels and localized flooding along the banks of the Thames River and its tributaries. However, studies on the impact of climate change suggest the potential for increased flooding through all seasons with the potential for more intensified flooding in the Upper Thames River Basin with trending to more frequent and severe summer flooding (Simonovic, 2009).

Figure 1.12: 2000 Flood (Forks of the Thames)

Figure 1.13: 2008 Flood (North Branch)

Figure 1.14: 2008 Flood (Forks of the Thames)

Figure 1.15: 2008 Flood (Main Branch)

1.7 PROVINCIAL DESIGNATIONS

There are approximately 1,100 structures located behind the West London Dyke that are within the Regulatory Flood Line. The current City of London Official Plan indicates these areas as Potential Special Policy Areas, which reflects the City's application to the Province to receive a Special Policy Area (SPA) designation. If granted, this designation would allow for relaxation of flood plain policies, therefore permitting limited development and redevelopment to continue.

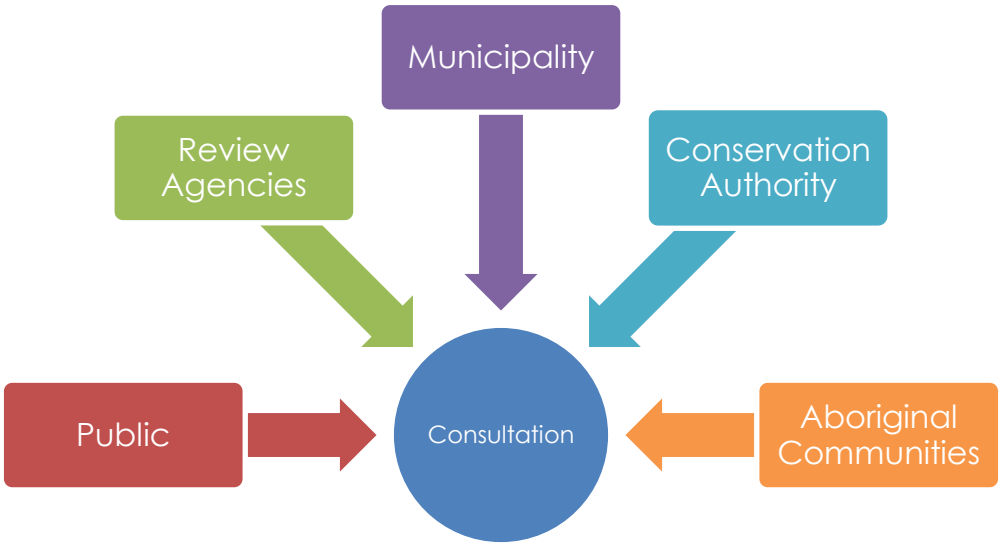
Provincial policy indicates that, in order to achieve SPA designation, the area must be protected by a dyke system with elevations set at or above the Regulatory Flood Level. However, in some instances this policy has been relaxed where it is impractical to provide this level of protection.

To date, the SPA application has not been actively pursued by the City. Further information relating to the current protection offered by the dyke system is provided in subsequent sections of this Master Repair Plan.

2.0 CONSULTATION

2.1 OVERVIEW

The consultation process is an integral component of the Municipal Class EA process. Effective communication with Aboriginal communities, agencies, stakeholders and the general public can reduce or avoid controversy that ultimately leads to project delays and general discontent of project stakeholders. This section details the consultation process followed for the Master Repair Plan.



2.2 CLASS ENVIRONMENTAL ASSESSMENT

As the West London Dyke is majority owned by the City of London, it was determined that the Ontario Environmental Assessment Act should apply. Therefore this is considered the appropriate process for this project and our work scope reflects this process. While the West London Dyke is almost entirely owned by the City, the UTRCA does own small parcels through flood plain purchases in partnership with the City and whose lands are managed by the City under agreement with UTRCA.

A Class Environmental Assessment is a planning document which sets out the process that a proponent must follow in order to meet the requirements of the Environmental Assessment Act for a class or category. Projects are divided into schedules based on the type of projects and activities. Schedules are categorized as A, A+, B, and C with reference to the magnitude of their anticipated environmental impact.

All municipalities in Ontario, including the City of London, are subject to the provisions of the Environmental Assessment Act and its requirements to prepare an Environmental Assessment for

applicable public works projects. The Ontario Municipal Engineers Association Municipal Class Environmental Assessment (October 2000, as amended in 2007 and 2011) document provides municipalities with a five-phase planning procedure approved under the Environmental Assessment Act to plan and undertake all municipal sewage, water, stormwater and transportation projects that occur frequently, are usually limited in scale and have a predictable range of environmental impacts and applicable mitigation measures.

2.2.1 Schedule A

Schedule A projects are limited in scale, have minimal adverse environmental impacts and include the majority of municipal sanitary, stormwater and water operations, and maintenance activities. These projects are pre-approved and therefore may proceed to implementation without going through the full planning process.

Schedule A projects typically include normal or emergency operation maintenance activities where the environmental effects of these activities are minimal. Examples of Schedule A projects include watermain and sewer extensions where all such facilities are located within the municipal road allowance or an existing utility corridor. As such, these projects are pre-approved and subsequently do not require any further planning and public consultation.

2.2.2 Schedule A+

Schedule A+ projects were introduced as part of the 2007 amendments to the Municipal Class EA document. This schedule was introduced to ensure that some type of public notification would occur for pre-approved projects. Although the public is to be notified, no formal public consultation process is required. The public has the right to comment to municipal staff in their area; however, considering that the projects are pre-approved there is no appeal process to the Minister of the Environment on these projects.

2.2.3 Schedule B

Schedule B projects are those which have a potential for adverse environmental impacts. A screening process must be undertaken which includes consultation with Aboriginal communities, directly affected public and relevant review agencies. Projects generally include improvements and minor expansions to existing facilities. The project process must be filed and all documentation prepared for public and agency review.

Schedule B projects require that Phase 1 and 2 of the Class EA planning process be followed and a Project File be prepared and submitted for review. If there are no outstanding concerns raised by the public, review agencies or First Nation communities then the proponent may proceed to project implementation (Phase 5). If however, the screening process raises a concern that cannot be resolved, then the Part II Order procedure (formerly referred to as a "bump-up") may be invoked. Alternatively, the proponent may voluntarily elect to complete the project as a Schedule C undertaking.

2.2.4 Schedule C

Schedule C projects have the potential for significant environmental impacts and must follow the full planning and documentation procedures specified in the Class EA document (Phase 1 to 4). An Environmental Study Report (ESR) must be prepared and filed for review by the public, review agencies and First Nation communities. If concerns are raised that cannot be resolved, then the Part II Order procedure may be invoked. Projects generally include the construction of new facilities and major expansions to existing facilities.

2.3 PLANNING PROCESS

Figure 2.1 illustrates the process followed in the planning and design of projects covered by a Municipal Class EA. The figure incorporates steps considered essential for compliance with the requirements of the Environmental Assessment Act that are summarized subsequently.

Phase 1 Identification of problem (deficiency) or opportunity;

Phase 2 Identification of alternative solutions to address the problem or opportunity. Public, review agency and First Nation community contact is mandatory during this phase and input received along with information on the existing environment is used to establish the preferred solution. It is at this point that the appropriate Schedule (B or C) is chosen for the undertaking. If Schedule B is chosen, the process and decisions are then documented in a Project File. Schedule C projects proceed through the following phases;

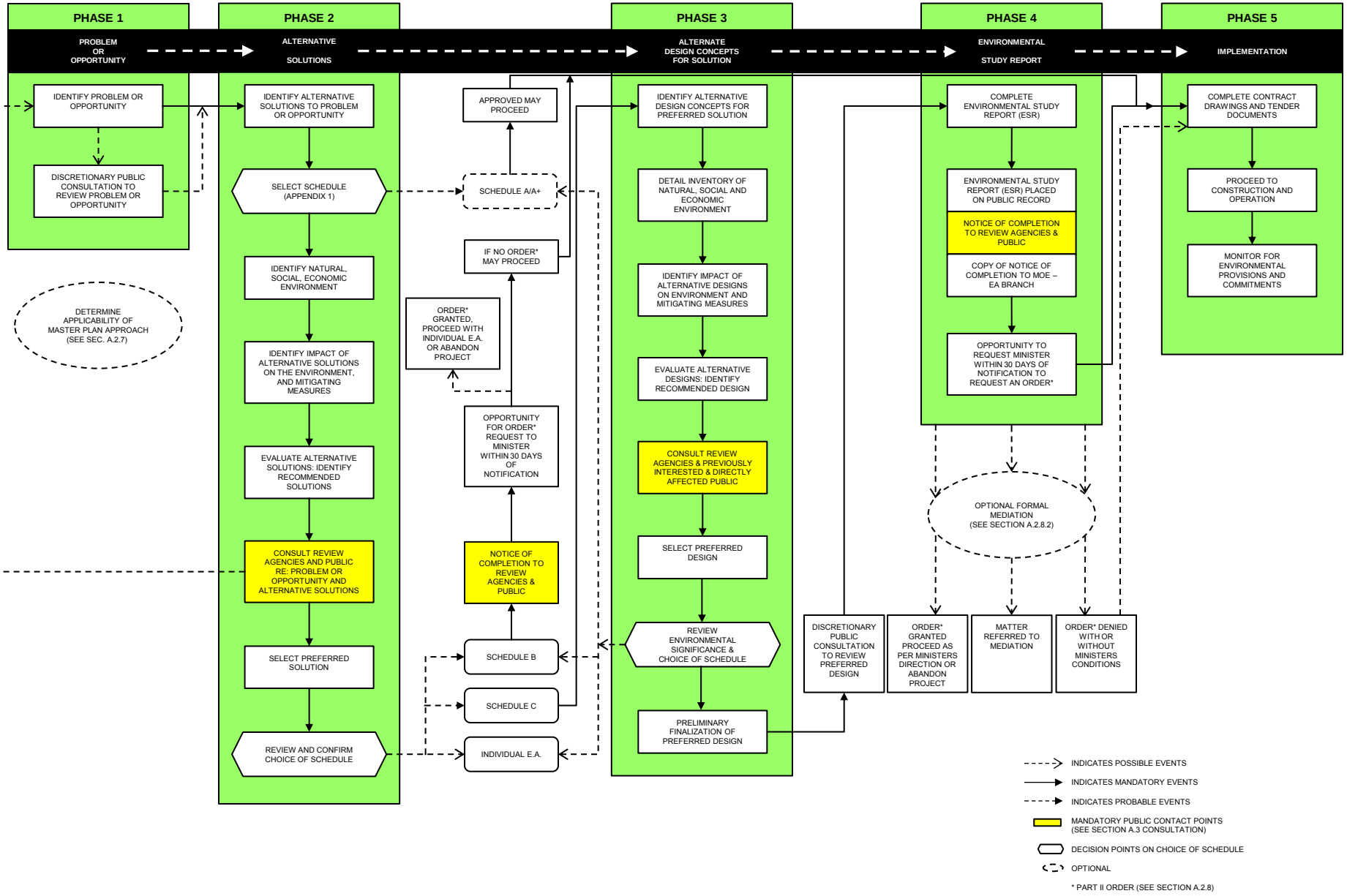
Phase 3 Examination of alternative methods of implementing the preferred solution established in Phase 2. This decision is based on the existing environment, public and review agency input, anticipated environmental effects and methods of minimizing negative effects and maximizing positive effects;

Phase 4 Preparation of an Environmental Study Report summarizing the rationale, planning, design and consultation process of the project through Phases 1-3. The ESR is then to be made available to agencies and the public for review; and

Phase 5 Completion of contract drawings and documents. Construction and operation to proceed. Construction to be monitored for adherence to environmental provisions and commitments. Monitoring during operation may be necessary if there are special conditions.

The MEA Class EA document also serves as a public statement of the decision making process followed by municipalities for the planning and implementation of necessary infrastructure.

MUNICIPAL CLASS EA PLANNING AND DESIGN PROCESS



The complexity of each project is based on the level of investigation, environmental effects, technical considerations and agency, Aboriginal communities, and public input, which may affect the selection of the project schedule. It is the responsibility of the proponent to determine and/or customize the planning process to meet the projects consultation and technical needs based on the complexity of the issues.

The Class EA process is a decision making process to promote good environmental assessment planning, with key features being:

- Early consultation;
- Consideration of a reasonable range of alternatives;
- Assessment of environmental effects;
- Systematic evaluation of alternatives; and
- Clear documentation and traceable decision making.

2.4 MASTER PLAN APPROACH

The Master Repair Plan is being undertaken in accordance with the Master Planning requirements of the MEA Municipal Class Environmental Assessment (October 2000, as amended in 2007 and 2011).

The MEA offers four approaches for undertaking a Master Plan and based on our review Municipal Class EA Approach #2 appears to be the most accurate. Approach #2 allows for the preparation of a Master Plan document at the conclusion of Phases 1 and 2 of the Municipal Class EA process where the level of investigation, consultation and documentation are sufficient to fulfill the requirements for Schedule B projects identified within the Master Plan. Accordingly, the final public notice for the Master Plan could become the Notice of Completion for Schedule B projects within it. Any Schedule C projects, however, would have to fulfill Phases 3 and 4 prior to filing an Environmental Study Report (ESR) for public review. The Master Plan would provide the basis for future investigations for the specific Schedule C projects identified within it. While Master Plans are not subject to requests for a Part II Order, members of the public or other stakeholders may submit a request to the Minister for a Part II Order for individual Schedule B projects identified within the Master Plan.

The intent of this report is to outline the steps that the proponent (UTRCA and City) have taken to satisfy the requirements of the Municipal Class Environmental Assessment planning and design process for Schedule B projects. The Project File should detail the following:

- Background to the project and earlier studies;

- Nature and extent of the problem or opportunity, explain the source of the concerns or issue and the need for solutions;
- Description/inventory of the environment;
- Identify solutions that are possible and define a preferred solution; and
- Identify the cost to implement the preferred solution.

The Municipal Class EA process currently allows a 10-year window for implementation following completion of the Class EA.

2.5 CHANGING PROJECT STATUS – "PART II ORDER"

Subsection 16 of the amended Environmental Assessment Act provides the Minister of the Environment or delegate an opportunity to review the status of a project. Members of the public, interest groups, review agencies and First Nation communities may submit a request to the Minister or delegate to require a proponent to comply with Part II of the Environmental Assessment Act (i.e., Individual EA) before proceeding with the proposed undertaking. The Minister or delegate determines whether the request is justified and then determines the course of the undertaking. This decision is considered final.

A request to the Minister or delegate must be in writing and must address the following issues as they relate to the identified concerns:

- Environmental impacts of the project and their significance;
- The adequacy of the planning process;
- The availability of other alternatives to the project;
- The adequacy of the public consultation program and the opportunities for public participation;
- The involvement of the person or party in the planning of the project;
- The nature of the specific concern which remains unresolved;
- Details of any discussions held between the person or party and the proponents;
- The benefits of requiring the proponent to undertake an individual EA; and
- Any other important matters considered relevant.

The person requesting the Part II Order shall forward a copy of the request to the proponent at the same time as submitting it to the Minister of the Environment or delegate.

The Minister has four options for a decision on a Part II Order (bump-up) request:

- Deny the request;
- Deny the request with conditions;
- Refer to mediation; and
- Grant the request and require the proponent to undergo an individual EA.

2.6 STAKEHOLDER CONSULTATION

The following potential stakeholders were included:

- **Public:** this includes individual members of the public including property owners who may be affected by the project, individual citizens who may have a general interest in the project, special interest groups, and community representatives.
- **Review Agencies:** this includes government agencies that represent the policy positions of their respective departments, ministries, authorities, or agencies.

The role of the members of the public with an interest in the study is to provide background information to advise the proponent of their support and concerns, and to review and provide comments and input about the study findings (as the project progresses). Members of the public with an interest in the study can ask to be placed on the mailing list to receive notification of the consultation opportunities of this project.

Residents within the area surrounding the West London Dyke as well as other stakeholders were provided with a Notice of Commencement, which included information on Public Information Centre 1 (PIC 1), Notice of Public Information Centre (PIC 2), Notice of Public Information Centre (PIC 3) and Notice of Completion through Canada Post. Advertisements were published within the London Free Press or the Londoner prior to each of the three PICs.

A list of relevant public and agency contacts were developed at the onset of the project. Throughout the process, these contacts were sent letters notifying them of the project progress. Appendix 2.1 contains the contact list. Appendix 2.2 contains public and agency comments that were received during the project as well as agency notifications. Comments received following PICs are included in a separate appendix.

Table 2.1 summarizes the agency comments received and follow up either taken or recommended by Stantec.

Table 2.1: Summary of Agency Comments

Agency	Date Received	Agency Comment and Follow Up
Union Gas	June 16, 2010	Union Gas does not foresee any conflicts (given the preliminary scope of the work).
Transport Canada	June 23, 2010	Reminder that if any elements of proposed works "cross or affect a potentially navigable waterway" then approval through Transport Canada is required.
Ministry of Natural Resources	July 5, 2010 and July 27, 2010	Requested clarification on how the Master Repair Plan relates to those in the 2007 replacement project, confirmation that works are within the existing footprint, and works will not result in an in-fill of the Thames River. Considerations should be given to impacts on wildlife resources, habitat and any at risk species. Clarification provided by Stantec, however MNR contact no longer with Ministry. Comments noted are incorporated into the Master Repair Plan.
Ministry of Tourism and Culture	July 20, 2010	If any ground disturbances are to take place outside of the existing footprint an archaeological assessment is required.
City of London Advisory Committee on the Environment	July 22, 2010	Wishes to be provided with copies of the Master Repair Plan Study to its members. July 28, 2010 copies of the PIC 1 information package were sent to the committee secretary to be forwarded to its members.
MPP – London West	August 18, 2010	Wishes to be kept informed on the development of the project.
Canadian Environmental Assessment Agency	August 24, 2010	A project description of the preferred alternative is required if the project potentially triggers CEAA.
London Hydro	September 10, 2010	Requests that Hydro's existing infrastructure remain unaffected and remain accessible and to work together to incorporate future works together.
Ministry of Aboriginal Affairs	January 18, 2011	Provided First Nations contact information for communities which may have existing or asserted rights that could be impacted by the project.
Ministry of Tourism, Culture and Sport	September 24, 2015	Screen project with MTCS Criteria for Evaluating Archaeological Potential to determine if an archaeological assessment is needed. Screen project with MTCS Criteria for Evaluating Potential for Built Heritage Resources and Cultural Heritage to determine whether EA will impact cultural heritage resources.

2.7 ABORIGINAL CONSULTATION

A list of relevant Aboriginal communities was developed at the onset of the project. Throughout the process, these communities were provided with letters notifying them of project commencement and invitation to attend PICs. The following eight communities were engaged as part of the consultation process:

- Aamjiwnaang First Nation;
- Bkejwanong Territory (Walpole Island First Nation);
- Caldwell First Nation;
- Chippewas of Kettle and Stony Point First Nation;
- Chippewas of the Thames First Nation;
- Moravian of the Thames First Nation (Delaware Nation);
- Munsee-Delaware First Nation; and
- Oneida of the Thames First Nation.

At the request of Caldwell First Nation, Stantec met with Chief Hiller on December 14, 2015 to provide an overview of the project and answer questions. At the request of Walpole Island First Nation, Stantec met with Dean Jacobs and Jared Macbeth on July 14, 2015 and again with Jared Macbeth on January 28, 2016 to provide an overview of the project and answer questions. Based on the outcome of these meetings, the following requests were made:

Caldwell First Nation requested the following:

- Remediation of disturbed areas to be completed with native wildflowers and grass mix;
- Remediation to take place immediately so as to minimize the establishment of invasive species;
- Projects should not result in harmful issues regarding health and/or detriment to the environment;
- Opportunity to provide an Aboriginal Monitor should a Stage 2 Archaeological Assessment be required for any project; and
- Be included on any future project correspondence.

Walpole Island First Nation requested the following:

- Opportunity to provide an Aboriginal Monitor should a Stage 2 Archaeological Assessment be required for any project;
- Be provided with a copy of any Archaeological Assessment reports that are completed; and
- Be included on any future project correspondence.

After review of the documentation provided, Moravian of the Thames First Nation stated that additional consultation was not required. Chippewas of Kettle and Stony Point First Nation stated that further consultation with regards to this project was not required unless project scope changes occurred which may affect or impact their Traditional Territory. Aamjiwnaang First Nation indicated that they would like to continue to receive project information. After reviewing project information and discussions via phone conversation with Chippewas of the Thames First Nation, additional consultation was not required. Munsee-Delaware First Nation and Oneida of the Thames First Nation did not provide any comment.

At the conclusion of the study, the Notice of Completion was sent to the above listed communities as outlined in the Aboriginal Consultation Log. Appendix 2.3 contains the Aboriginal Consultation Log which was completed for this project to document the consultation process with Aboriginal communities contacted as part of the Class EA process. Appendix 2.4 contains a copy of each response received.

2.8 PUBLIC INFORMATION CENTRES

Public Information Centres are a method to communicate with the general public, interested parties, review agencies and First Nation communities. For this project, three PICs were held.

2.8.1 Public Information Centre 1

PIC 1 was held Wednesday, June 16, 2010 at the Kiwanis Seniors' Community Centre in London. The purpose of the first PIC was to inform the public of the commencement of the West London Dyke Master Repair Plan and to receive any input or comments they might have. The PIC was held as a drop in session from 6:00pm to 9:00pm in order to provide direct interaction with the public and solicit comment on the initial planning for this project. Eleven poster boards were created and put on display so that members of the public would be able to review the material at their own pace. The first display board provided an introduction to the project as well as the problem opportunity statement. The second display board briefly outlined the historical significance, as well as the dyke's primary purpose of flood protection, as illustrated by photos of previous flood events. The third display board summarized past repair and rehabilitation work carried out on the dyke structure, dating back to the early 1980's and concluding with the recent Phase 1 Replacement construction. The fourth display board provided an explanation of

the Environmental Assessment process and key features. The fifth display board was a visual representation of the Master Planning process, complete with the project drivers that are to be considered. The sixth display board outlined the West London Dyke Study area which was subdivided into eight rather distinct segments (i.e., Blackfriars, Labatt Park/Forks, etc.), each to be discussed separately during the engineering review of the structure. Photo's illustrating each segment were shown to assist the public in familiarizing themselves with each area. Display boards seven through ten outlined each of the project drivers identified as follows: flood risk reduction, public safety, functional improvements, environmental enhancements, and funding opportunities. As the project was in the initial stages at the time of PIC 1, only a brief outline was provided for the drivers above. The last display board provided project contact information and detailed the next steps to be taken. Subsequent to PIC 1, the technical review phase of the Repair Plan commenced in order to provide recommendations for PIC 2.

Throughout PIC 1, a video loop was projected of the entire length of the dyke, as filmed from the pathway along the top of dyke.

Twenty-eight people were in attendance at PIC 1. Staff from the City of London, UTRCA, and Stantec were on hand to answer questions during the drop in session. In addition, comment sheets were provided to all attendees. The comment sheet posed four questions:

1. Do you live within the proposed study area?

2. Along with protection of life and property, what other features of the dyke are important to you? Accessibility, Amenity, Architecture, Heritage/History, Lighting/Security (ranked numerically).

3. What is your opinion on the works completed to date?

4. Other comments or concerns.

Eight comment sheets were returned following PIC 1. Appendix 2.5 contains a copy of the presentation handout and comment sheet given to all attendees, a copy of the attendance sheet, and copies of all comments received.

An abbreviated description of comments received is provided in Table 2.2. Refer to Appendix 2.5 for all comments collected.

Table 2.2: Summary of Public Comments (PIC 1)

Issue	Comment
Aesthetics	• Phase 1 Structure is aesthetically pleasing
Railing	• New railing along Phase 1 increases safety • Old railings easily vandalized
Pathway	• Inclusion of bike path should be in future plans • Pedestrian underpasses are outstanding • Widened pathway along Phase 1 is beneficial / Widened pathway to City Standards is not supported
Lighting	• Reduce intensity of overhead lighting, consider direction of lighting • Future lighting plans? (i.e., what is the intent for lighting)
Fountain	• Fountain is appealing / fountain is 'useless' • What are the fountain upkeep costs?
Vegetation	• What are the plans for mature trees along dyke? • Planting of native species along rivers edge • Phase 1 plantings are nice
Access	• Access to river along St. Patrick
Flood Prevention	• Importance of dyke to prevent basement/residential flooding
Other	• Removal of old material during reconstruction work? • Further construction should only proceed after entire river corridor study has been completed

Generally, work completed during the Phase 1 Replacement project was well received by the public. However, many residents had an issue with intensity and direction of lighting that should be considered during future work.

2.8.2 Public Information Centre 2

PIC 2 was held on Thursday, February 23, 2012 at the Kiwanis Seniors' Community Centre in London. The PIC was held as a drop in session from 6:00pm to 9:00pm with a presentation at 7:00pm. Fourteen people were in attendance. Following the presentation, a question period was held. In addition, comment sheets were provided to all attendees. Staff from the City, UTRCA, and Stantec were available to answer questions during the drop in session. Appendix 2.6 contains a copy of the presentation handout and comment sheet given to all attendees, a copy of the attendance sheet, and copies of all comments received.

The purpose of the second PIC was to outline the principles and project drivers established to guide future requirements relating to repairs/replacement of the West London Dyke to the public and to receive any input or comments they might have. Seventeen poster boards were created and put on display so that members of the public would be able to review the material

at their own pace. The first display board provided an introduction to the project as well as the problem opportunity statement. The second display board outlined the West London Dyke Study area which was subdivided into eight rather distinct segments (i.e., Blackfriars, Labatt Park/Forks, etc.), each to be discussed separately during the engineering review of the structure. Photo's illustrating each segment were shown to assist the public in familiarizing themselves with each area. The third display board briefly outlined the historical significance, as well as the dyke's primary purpose of flood protection, as illustrated by photos of previous flood events. The fourth display board summarized past repair and rehabilitation work carried out on the dyke structure, dating back to the early 1980's and concluding with the recent Phase 1 Replacement construction. The fifth display board was a visual representation of the Master Planning process, complete with the project drivers that are to be considered. The sixth and seventh display board provided an explanation of the Environmental Assessment process and key features. Display boards eight through ten outlined the alternatives for each section. Display boards eleven through seventeen provided typical cross sections for various areas along the dyke.

One comment sheet was returned following PIC 2. Appendix 2.6 contains a copy of the presentation handout and comment sheet given to all attendees, a copy of the attendance sheet, and copies of all comments received.

2.8.3 Public Information Centre 3

PIC 3 was held on Thursday, September 10, 2015 at the Kiwanis Seniors' Community Centre in London. The PIC was held as a drop in session from 4:30pm to 6:30pm. Sixteen people were in attendance and comment sheets were provided to all attendees. Staff from the City, UTRCA, and Stantec were available to answer questions during the drop in session. Appendix 2.7 contains a copy of the comment sheet given to all attendees, a copy of the attendance sheet, and copies of all comments received. Six comment sheets were returned following PIC 3.

An abbreviated description of comments received is provided below in Table 2.3. Refer to Appendix 2.7 for all comments collected.

Table 2.3: Summary of Public Comments (PIC 3)

Issue	Comment
Aesthetics	• Sight lines to the river should be considered.
Vegetation	• Residents concerned over the removal of mature trees and trees planted on the embankments (around 2 Carrothers Avenue and east end of Cherry Street).
Access	• Would like access to the river maintained/facilitated for fishing, walking, boating, picking up garbage, etc. (west side at St. Patrick Street). Concern was also expressed for the wildlife that currently inhabits the bank.

The third PIC was held in recognition of the change from Approach #1 to #2, potential changes to the Master Repair Plan findings, the time that had elapsed since the last public meeting, and the City and UTRCA's commitment to ensure sufficient consultation was provided in support of finalizing each identified Schedule B project through Approach #2.

2.9 NOTICES

Four notices were published throughout the planning process for the West London Dyke Master Repair Plan.

2.9.1 Notice of Commencement & PIC 1

The Notice of Commencement was published in the London Free Press in two separate issues on July 5, 2010 and July 12, 2010. As well, the Notice was displayed on the City of London website prior to the meeting. Appendix 2.8 contains of copy of the Notice of Commencement.

2.9.2 Notice of PIC 2

The Notice of PIC 2 was published in the London Free Press in two separate issues on February 11, 2012 and February 18, 2012. As well, the Notice was displayed on the City of London website prior to the meeting. Appendix 2.8 contains a copy of each date of the newspaper notice.

2.9.3 Notice of PIC 3

The Notice of PIC 3 was published in the Londoner on two separate issues on August 27, 2015 and September 3, 2015. As well, the Notice was displayed on the UTRCA's website as well as the City of London's website prior to the meeting. Appendix 2.8 contains a copy of each date of the newspaper notice.

2.9.4 Notice of Completion

The Notice of Completion was published in the Londoner on February 25, 2016 and March 3, 2016. The publishing of this Notice (February 25, 2016) signals the beginning of the 30-day review period.

3.0 GUIDING PRINCIPLES

The West London Dyke has been in place since initial development within the floodplain area first began. Its primary function has been to provide flood protection to areas located behind the dyke. Since upgrading of the dyke following the 1937 flood, it has successfully protected the area against floods approaching the 100 year flood elevation.

In order to review the issues and opportunities for the West London Dyke with regards to repairs and/or replacement over the 20-year planning period, the following principles to guide future requirements were established.

1. The primary purpose of the West London Dyke is to provide flood protection to the area and therefore any future changes or enhancements should be based on a risk management approach to determine:

    a. Level of flood protection to be provided, including freeboard,

    b. Preference for hard (passive) flood protection measures,

    c. Identification of areas where active flood protection measures are required due to existing constraints and process of identifying active areas on a periodic basis for incorporation into the overall flood management strategy,

    d. Need to introduce changing risk due to climate change.

2. Recognizing the presence of the West London Dyke as a significant feature within the core of the downtown area, identify opportunities to incorporate amenity and functional improvements (pathway, recreation, etc.) as identified in the *2007 West London Dyke Flood Control Structure Master Plan* or noted in other City initiatives into future works.

3. Preference should be for long term solutions over interim solutions.

4. Identify opportunities to incorporate environmental considerations where possible to:

    a. Minimize environmental impacts during construction,

    b. Ensure no net loss in environmental quality as much as possible,

    c. Provide for environmental gains as much as possible.

4.0 PROJECT STUDY AREA DESCRIPTION

The subject area generally reaches from the Oxford Street Railway Bridge, south along the west side of the Thames River, to Cavendish Park and is shown in Figure 4.1.

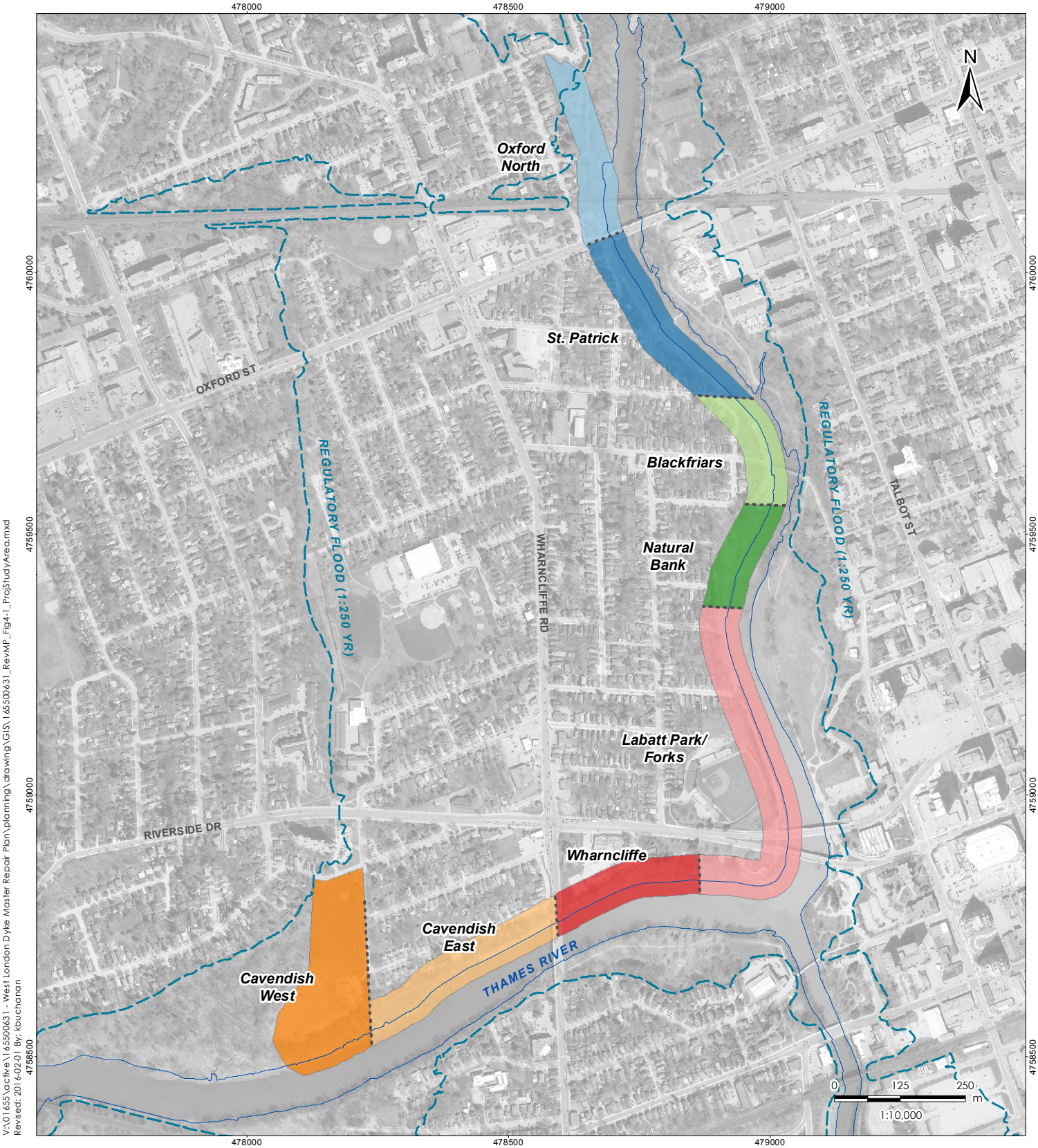
Given the length of the West London Dyke, major differences in the structure, level of flood protection provided, condition and surrounding land use, there is a need through the various components of this Master Repair Plan review to subdivide the dyke into segments. The *West London Dyke Flood Control Structure Master Plan* identified four general sections with regard to planning and environmental issues. These are (from upstream to downstream):

1. Oxford Street West to Blackfriars Bridge;
2. Blackfriars Bridge to Labatt Park;
3. Labatt Park to Wharncliffe Road North; and
4. Wharncliffe Road North to Cavendish Park.

With regard to engineering review, costing, and trigger point determination, this Master Repair Plan considers the following segments (from upstream to downstream) which were derived based on the physical location and/or physical characteristics of the dyke:

1. Oxford North;
2. St. Patrick's (Oxford Street West – Empress Avenue);
3. Blackfriars (Empress Avenue – Cummings Avenue);
4. Natural Bank (Cummings Avenue – Leslie Street);
5. Labatt Park/Forks (Leslie Street – Dundas Street);
6. Wharncliffe (Dundas Street – Wharncliffe Road North);
7. Cavendish East; and
8. Cavendish West.

These segments are shown in Figure 4.1. General descriptions of each section are provided in the following subsections.



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Revised: 2016-02-01 By: kbuchanan

February 2016
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Stantec

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Imagery and base features used under license with the City of London, © 2009-2015.

Client/Project

Upper Thames River Conservation Authority & City of London
West London Dyke Master Repair Plan

Figure No.

4.1

Title

Project Study Area

4.1 OXFORD NORTH

This area is generally bordered by Beaufort Street to the north and terminates to the south limit of the Oxford Street Bridge. The CP Railway Bridge is located within this segment. This section consists of the following:

- Densely vegetated slope with natural toe from the northern extent to approximately 30 m south of the CP Railway Bridge; and
- Concrete revetment and toe from 30 m south of the CP Railway Bridge to the south limit of the Oxford Street Bridge.

Access to the northern (vegetated) segment is provided by a partially paved pathway/lane extending from the end of Beaufort Street to Saunby Street. Overhead hydro lines are present near the end of Beaufort Street and extend across the river. Additional hydro poles and sanitary and storm manholes are located near the top of dyke at Saunby Street.

Figure 4.2: Oxford North (Facing South)

Access to the concrete revetment segment is generally provided via an existing private parking lot off Gunn Street attributed to the adjacent commercial development, or through the parcel of land occupied by the CP Railway Bridge west abutment.

Adjacent land use consists mainly of residential development transitioning to commercial development approaching Oxford Street West. Railing along the top of dyke generally coincides with the limits of the concrete revetment and consists of the original steel pipe style railing. Unpaved pathways also run along this segment.

Along this section, the majority of land is currently owned by the City; however two existing residences located north of the CP Railway Bridge extend to the river's edge and therefore intersect this segment.

At present, areas north of the CP Railway Bridge are generally not considered a portion of the West London Dyke, however adjacent lands are located within the current damage reach in the event of a flood event. Should additional freeboard be required to address enhanced flood protection requirements, extension of the dyke structure within this area may be required. Currently, this area is characterized as moderately sloped from the river's edge for a distance of approximately 40 to 60 m, then increasing in slope over a marginal distance west of the existing pathway. West of the pathway, the slope is generally flat. Drainage is towards the river.

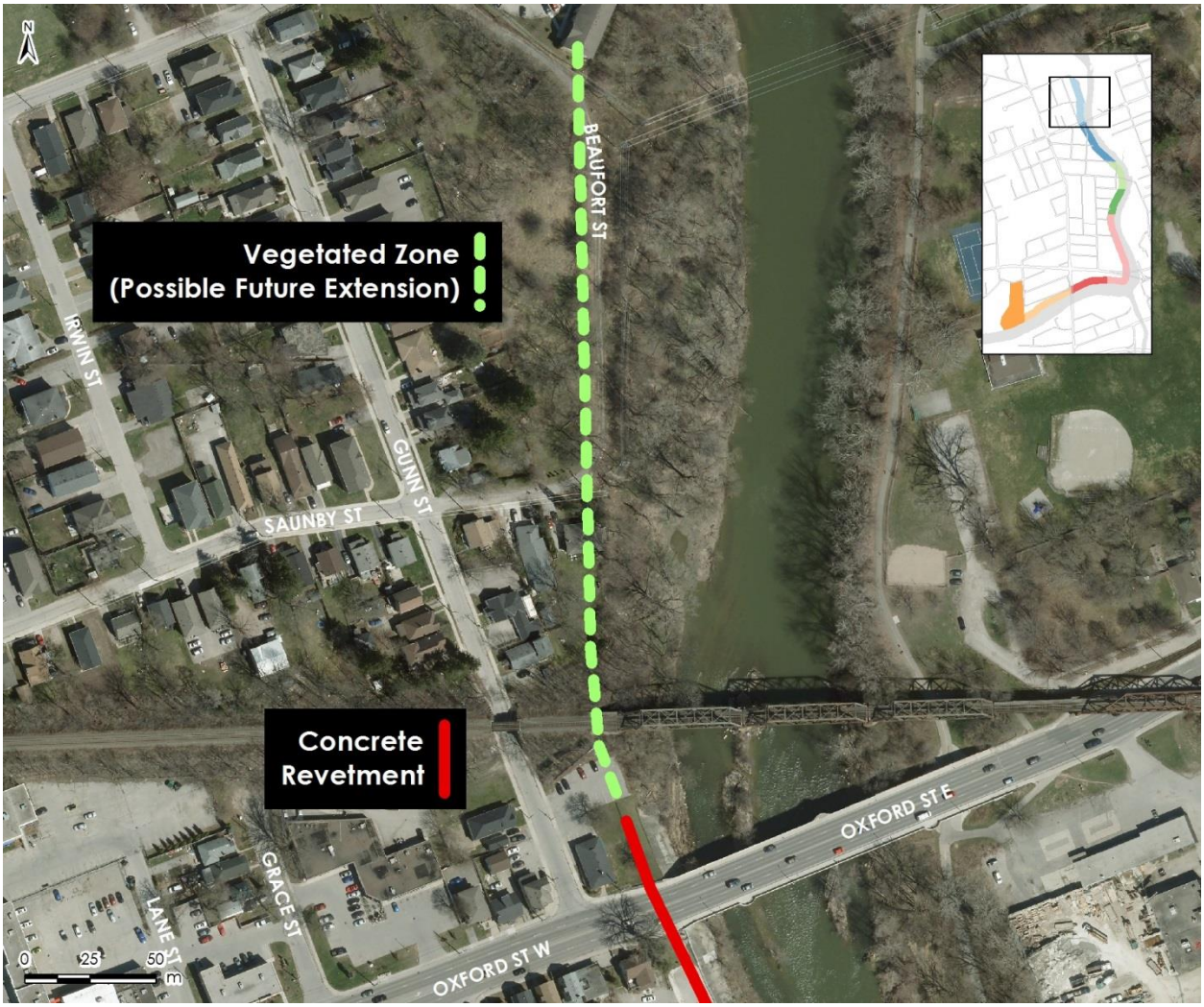


Figure 4.3: Oxford North (Aerial)

4.2 ST. PATRICK (OXFORD – EMPRESS)

Commencing from the south limit of the Oxford Street Bridge, this section consists of concrete revetment panels, supporting concrete toe, and ballast blocks and extends south approximately 500 m terminating at Empress Avenue. Noticeable vegetation is also present along the toe area for the majority of this segment.

The pathway system commences at Oxford Street West and abuts the top of the dyke along the length of this section. At Empress Avenue, an open space area is present with bench seating and connection of the pathway to the City sidewalk. The section of path along this area has quite an open character with more expansive views to both Blackfriars Street, Oxford Street West and the railway bridge, as well as to the east side of the river which is quite heavily treed. The

existing railing along this section consists of galvanized steel. Adjacent land use along this area is classified as residential with a City owned park located at the end of St. Patrick Street.

Figure 4.4: St. Patrick's (Aerial)

Figure 4.5: St. Patrick's (Facing South)

Figure 4.6: St. Patrick's (Facing South)

4.3 BLACKFRIARS (EMPRESS – CUMMINGS)

This section runs from Empress Avenue to Cummings Avenue, bordering Napier Avenue along most of its length and includes the historic Blackfriars Bridge. With the exception of the abutment structure which forms a part of the dyke, the remaining structure generally consists of concrete revetment panels on underlying soil, with toe and supporting ballast blocks. Downstream of the Blackfriars Bridge, the revetment is located within an area of accretion, resulting in only partial visibility of the concrete panels.

Figure 4.7: Blackfriars (North of Bridge, Facing South)

An open space area is present along a significant portion of the dyke, primarily north of the Blackfriars Bridge. The pathway is particularly narrow along portions of this area. Access to the pedestrian walkway on the Blackfriars Bridge off the pathway system is provided by means of a ramp on the north side of the bridge.

Figure 4.8: Blackfriars (Aerial)

4.4 NATURAL BANK (CUMMINGS – LESLIE)

The area between the Blackfriars Bridge and Leslie Street consists of concrete revetment panels that are only partly visible due to the presence of a heavily vegetated area of accretion along the base of the wall. The area behind the existing pathway and adjacent residential land use varies from marginal at approximately 7 m to 9 m between Carrothers Avenue to Leslie Street, with upwards of 20 m further north in the vicinity of Cummings Avenue adjacent to City parkland.

Figure 4.9: Natural Bank (Aerial)

Figure 4.10: Natural Bank (South of Bridge, Facing South)

Figure 4.11: Cast Iron Streetlight Base (Facing South)

Characteristics along this section of the pathway range from fairly open views that highlight Blackfriars Bridge as a focal point, to relatively narrow sections shaded by trees and shrubbery on both sides, creating a more intimate experience. A small, relatively hidden, informal access path to the river within the area of accretion is situated approximately one block south of Blackfriars Bridge. In general, this section of pathway and dyke represents a softer, more natural edge along the river due to the mix of vegetation along both the west side of the path and the base of the dyke.

The path in this section is slightly narrower than the City's standard width of 3 m, and access via stairs or ramps exist at all abutting streets. Sections of the railing along the pathway are in relatively poor condition and do not meet current standards. They are interspersed by old cast iron streetlight bases, which have an attractive design and historical pedigree, but are generally in poor condition (rusting, chipped paint, broken fronts) and tend to be used for garbage.

Figure 4.12: Natural Bank (Facing South)

A small playground is located at the bend on Cummings Avenue.

4.5 LABATT PARK / FORKS

This section extends from Leslie Street on the north branch of the Thames River to west of the confluence of the Forks terminating south of the Dundas Street Bridge.

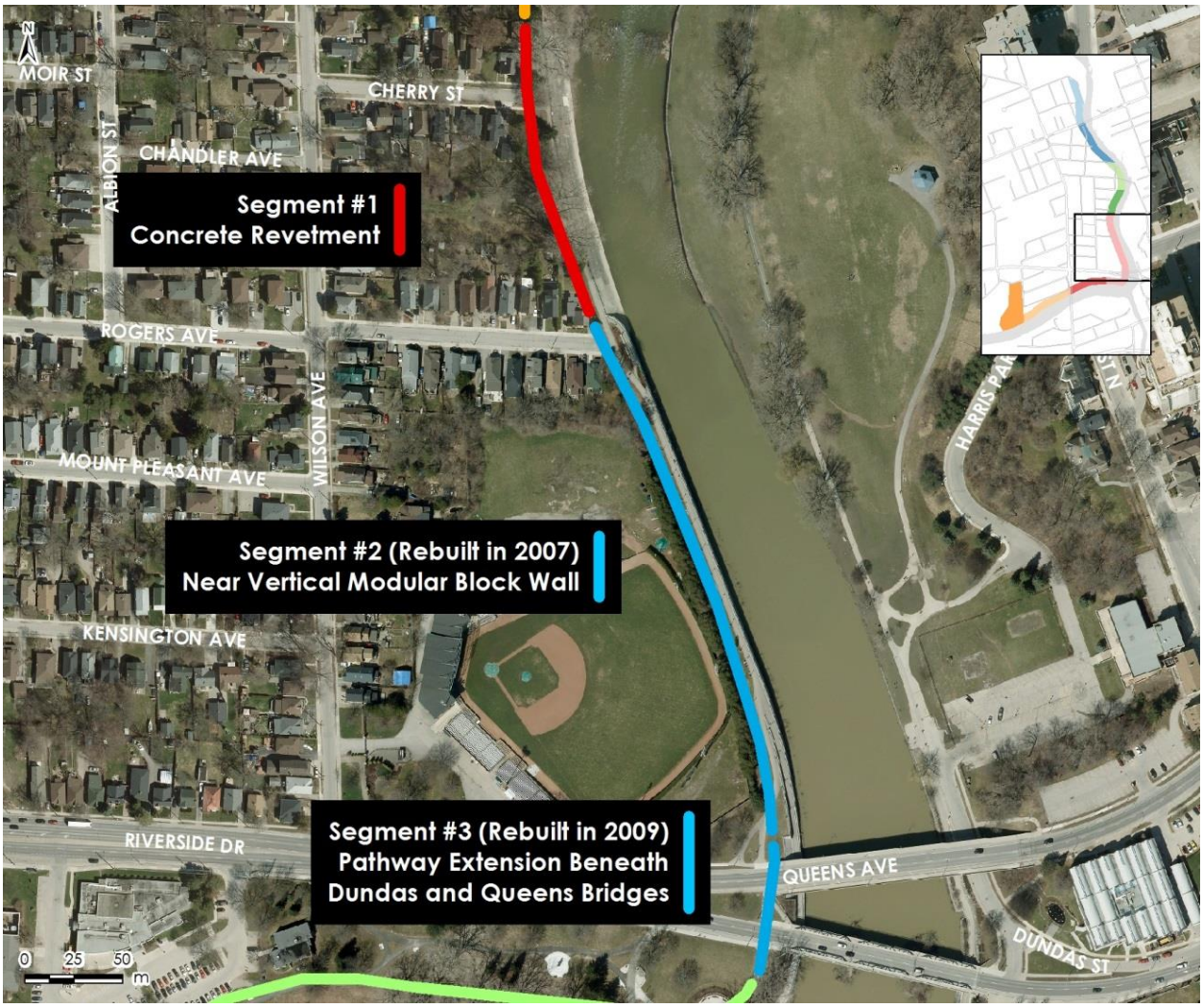


Figure 4.13: Labatt Park / Forks (Aerial)

Three distinct structures are located along this section:

- Existing concrete revetment consisting of panels, toe, and ballast block from Leslie Street to Rogers Avenue;
- Precast modular block wall with geogrid support from Rogers Avenue to the Queens Avenue Bridge; and
- Pedestrian pathway with armour stone, concrete toe and pour in place stamped panels beneath the Queens Avenue and Dundas Street Bridges.

From Leslie Street to Rogers Avenue along the north branch of the Thames River, the concrete revetment transitions from partially buried (within the downstream limits of the area of accretion) to full panel. Adjacent land use is exclusively residential and borders this segment of dyke at approximately 7 m to 12 m from top of dyke structure to property line. This section of dyke provides views into Harris Park and conversely is very visible from Harris Park, and therefore events occurring in the park tend to draw crowds of onlookers to this section of pathway. A number of mature cottonwood trees are situated along the west side of the pathway along this segment, shading both the pathway and residences. The path in this section was also observed to be slightly narrower than the City's standard width of 3 m. Railing along this section north of Rogers Avenue is similar to the Natural Bank area and consists of the original steel railing with interspersed old cast iron streetlight bases which were observed to be in poor condition.

Figure 4.14: Phase 1 Structure (Pre-Cast Modular, Facing North)

Figure 4.15: Pedestrian Pathway (Facing South)

At Rogers Avenue, the dyke structure transitions to a pre-cast modular near vertical block wall which extends to the vicinity of the Queens Avenue Bridge. A seating and lookout area is located at the transition of the newer and original dyke structure at Rogers Avenue, with ramps leading to the abutting street. Residential properties are located adjacent to the dyke along the north end, with Labatt Park abutting the dyke length to the Queens Avenue Bridge. Labatt Park is North America's oldest operating baseball park and is a historical feature located along this segment of dyke. The baseball park is obscured from the dyke and pathway system by a cedar hedge except for one small gap in the hedge.

The pathway along this section of dyke meets the City standard width of 3 m. Further south, the wall transitions into a two tiered structure providing a pathway from the top of dyke to the underside of the adjacent bridges.

Further south, the West London Dyke pathway consists of a 3 m wide asphalt path providing passage beneath the Dundas Street and Queens Avenue Bridges. This pathway consists of a modular block wall supported by the original concrete toe. South of the pathway, the dyke consists of vegetated berms with gabion baskets to termination of this section in the vicinity of the Blackburn Memorial Fountain.

4.6 WHARNCLIFFE (WHARNCLIFFE – DUNDAS)

The hard structure gives way to a natural edge between the Dundas Street and Wharncliffe Road North bridges consisting of light to dense vegetation along the dyke face complete with gabion basket toe and open park space.

Figure 4.16: Blackburn Memorial Fountain (Facing West)

Figure 4.17: Wharncliffe Berm (Near Kiwanis Seniors' Community Centre, Facing West)

The Blackburn Memorial Fountain, the fourth phase of the Forks of the Thames development, is located behind the dyke structure along this section which also borders the Kiwanis Seniors' Community Centre and parking lot area. The West London Dyke pathway is present along the entire section. An additional pathway connection to the Wharncliffe Road Bridge is present at grade, adjacent to the parking lot at the Kiwanis Seniors' Community Centre.

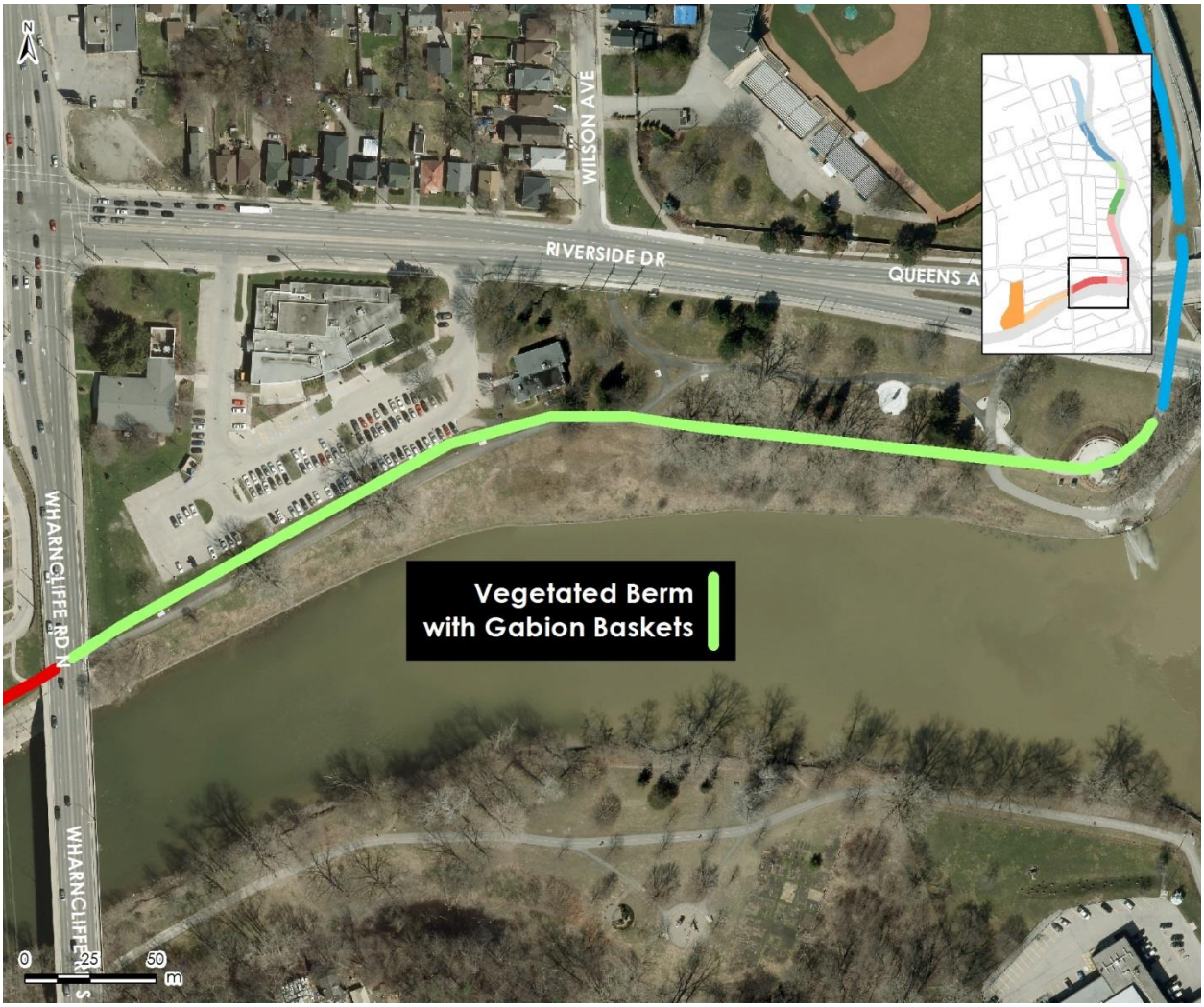


Figure 4.18: Wharncliffe (Aerial)

4.7 CAVENDISH EAST

This section extends from the east limit of the Wharncliffe Road North Bridge to the City Works yard located on Cavendish Crescent. In general, the dyke consists of concrete revetment panels with supported toe structure from the underside of the Wharncliffe Road North Bridge extending approximately 180 m west, and then becoming an earthen berm that has become overgrown with trees. A galvanized steel railing extends along the length of the concrete revetment only.

Figure 4.19: Cavendish East (Facing West)

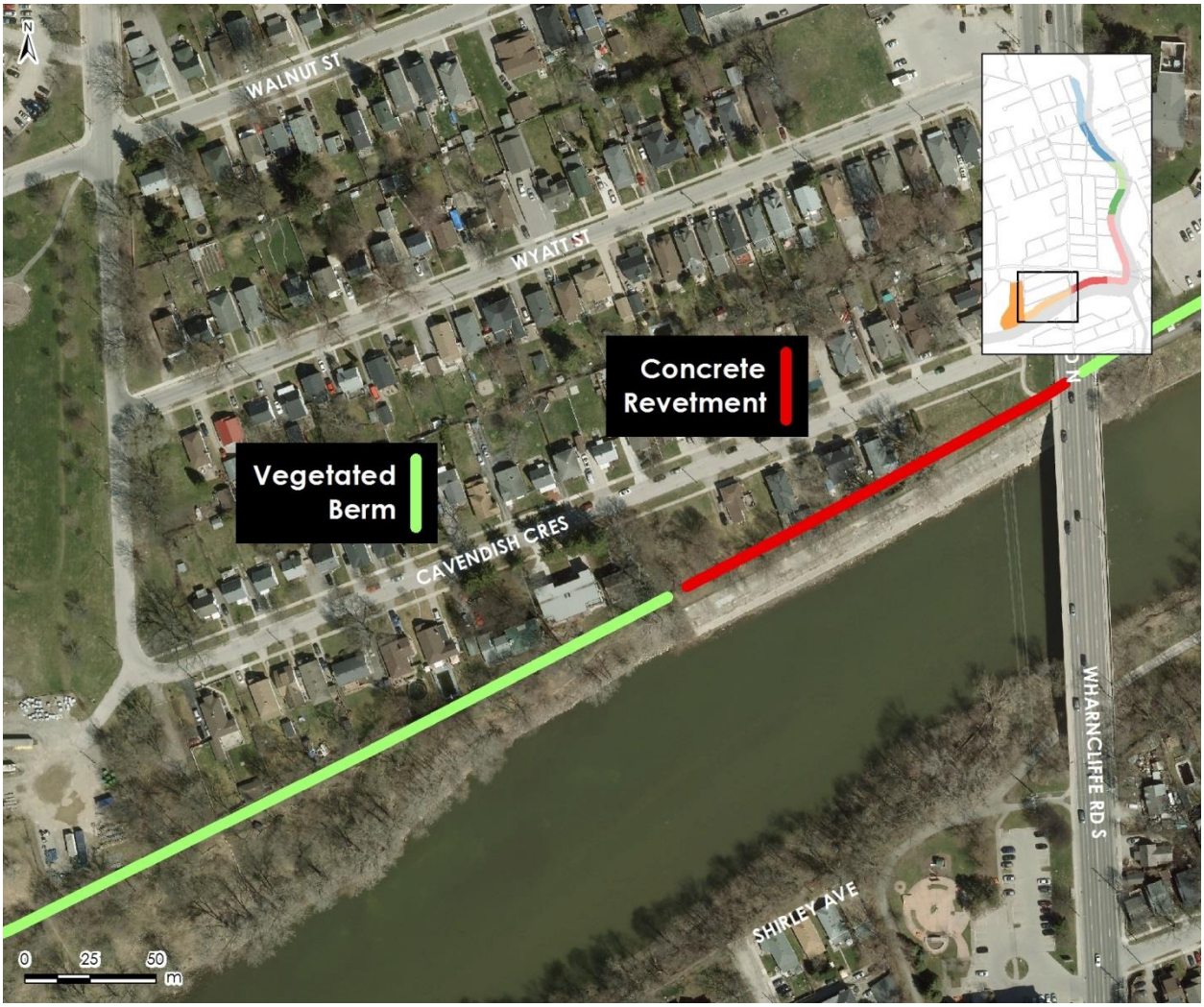


Figure 4.20: Cavendish East (Aerial)

Adjacent land use along this section of dyke is residential. The pathway along the top of dyke is currently unpaved providing a more natural character to this section of dyke. A crossing at the Wharncliffe Road North Bridge is present and is at grade with the top of dyke.

4.8 CAVENDISH WEST

The structure in this segment extends westerly for approximately 220 m along the river and consists of a heavily vegetated earthen dyke. From this point, the earthen dyke structure extends as a heavily vegetated berm continuing northeast towards Cavendish Park. The Cavendish Nature Trail is located within this segment, as is a park

Figure 4.21: Cavendish West

landscape berm, sewer cover berm, and storm sewer outlet to the Thames River. The former Douglas Avenue municipal sewage pumping station is also located in this vicinity.

The general topography of the area is south to southwest. Land adjacent to the eastern extent of the vegetated berm, including the City of London's Cavendish Works Yard and Cavendish Park, is significantly higher in elevation in comparison to lands west of the berm. Noticeable increases in elevation are also evident with the existing residential development bordering the general berm limits, including the Walnut Street apartment block to the northeast.

Figure 4.22: Walnut Street Apartments

Figure 4.23: Douglas Avenue Pumping Station

As with the Oxford North segment, should additional flood protection be required, extension of the dyke structure may be required beyond its current limit.

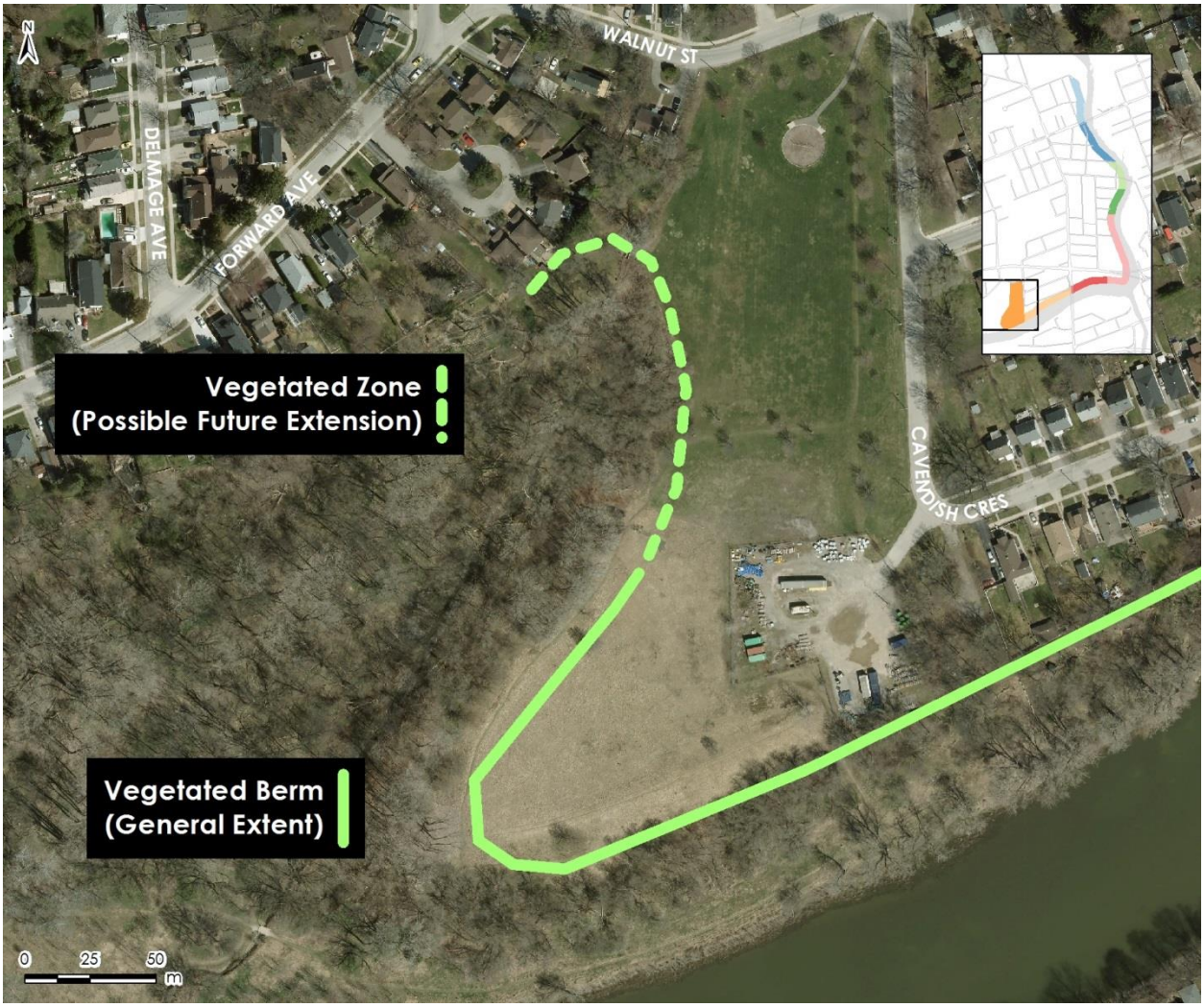


Figure 4.24: Cavendish West (Aerial)

4.9 INTERPRETATION OF SEGMENTS

The assessment of the dyke structure on a segment by segment basis, as defined by Sections 4.1 to 4.8, has been undertaken for discussion purposes only. These segments are not intended to represent exact limits for future construction projects. Future works (involving repair or replacement) may involve either work within a segment, or overlapping of portions of segments. Further information on proposed staging of work is provided in Section 9 of this report.

4.10 CURRENT FLOOD PROTECTION

Dyke elevations were determined based on integrating previous survey work completed as part of the Phase 1 and Phase 2 work in 2007 and 2009 by Stantec, with additional survey work

completed by Callon Dietz for the remaining areas. Figure 4.25 provides a general view of the updated dyke profile in comparison to the revised flood elevations provided by the UTRCA.

Refer to Appendix 4.1 for plan and profile views of the dyke which also depicts top and bottom of dyke elevations, river elevations (where available), and back of dyke elevations.

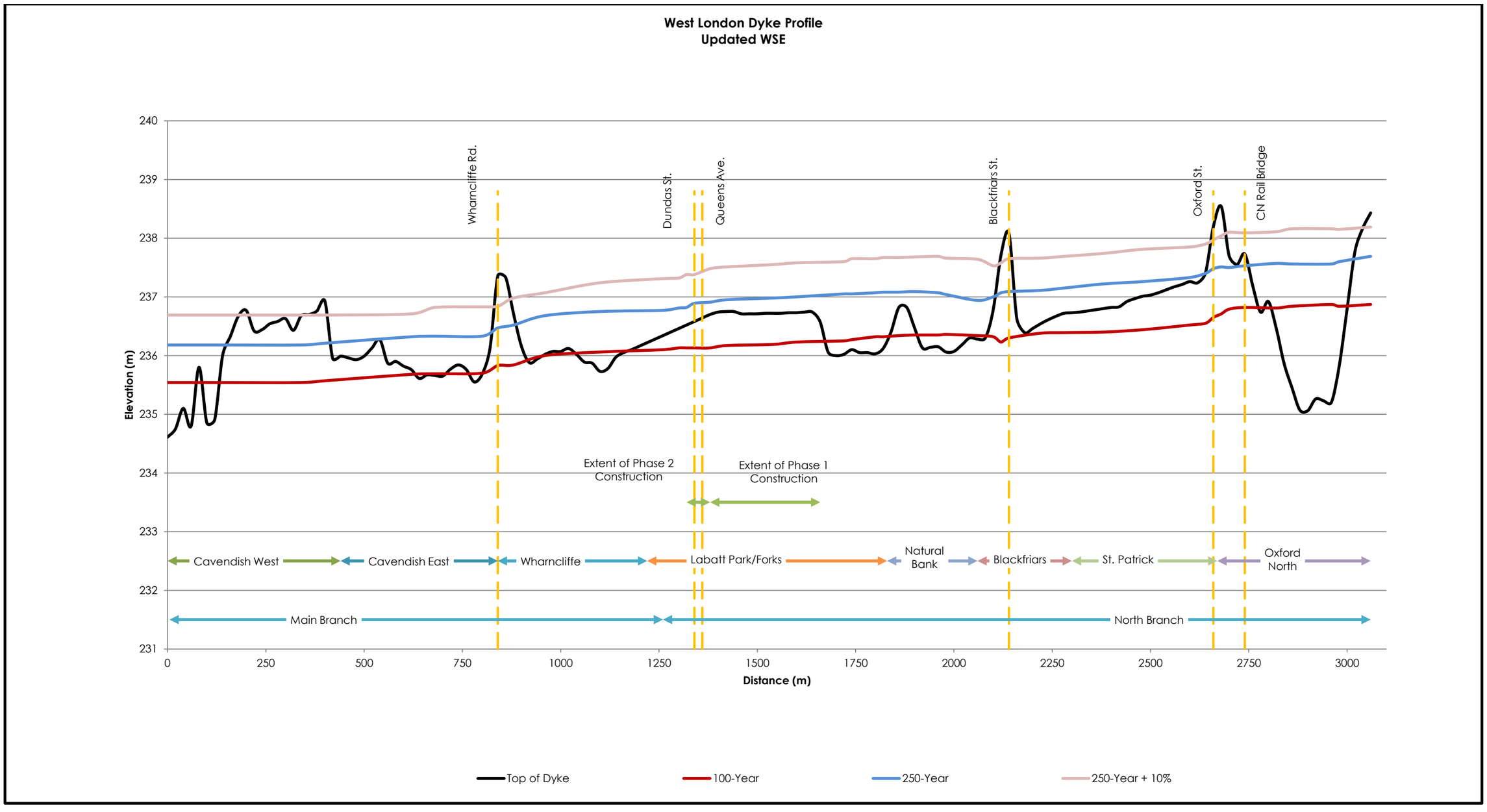


Figure 4.25: West London Dyke Profile

5.0 PROJECT DRIVERS AND RISK MANAGEMENT

5.1 PROJECT DRIVERS

Project drivers, as noted within this Master Repair Plan, are defined as potential reasons to implement or otherwise initiate work. For the West London Dyke, a project driver may result in the need for additional review, maintenance, enhancement, rehabilitation, or replacement. As noted in Section 1.4 of this report, a "trigger point" to implement a project is reached when the client considers that the need for the project (i.e., project drivers) is greater than the cost to implement it.

In order to properly define the long-term planning requirements for the West London Dyke, it is critical that appropriate project drivers are defined. As part of the Master Repair Plan planning process, the Project Team developed a conceptual list of project drivers based on the guiding principles for presentation to interested stakeholders and for subsequent evaluation during selection of the preferred alternative(s). At that time, the following project drivers were identified:

- Flood Risk Reduction;
- Public Safety;
- Functional Improvements;
- Environmental Considerations;
- Funding Opportunities; and
- Other (to be determined through the Class EA process).

The following sections provide a description of the project drivers that were carried forward for consideration within the Master Repair Plan.

5.1.1 Project Driver 1 – Flood Risk Reduction

As previously noted, the primary function of the dyke is to:

- Reduce risk of Thames River flooding to existing development, transportation routes and infrastructure, and utilities by providing separation of protected areas from the flood event;
- Support the viability and economy of the community protected by the dyke (i.e., through Special Policy Area designation, which allows for relaxation of flood plain policies and allows for limited development and redevelopment to continue);

- Address public policy and legislation (i.e., flood plain policies, emergency management, etc.); and

- Compliment watershed flood protection initiatives.

Accordingly, future projects may be initiated due to the opportunity or requirement to enhance flood protection.

Potential flood risk reduction measures may consist of the following:

- **Passive Measures** – Generally consisting of structural measures (earthen dyke or flood walls) that, by elevation, separate protected areas from the threat of flood and do not require any intervention to ensure effective flood threat reduction; and/or

- **Active Measures** – Measures that must be implemented at times of a flood threat. Examples include barriers added at low roadway crossings or bridges, pumping systems, sandbags on top of passive measures, etc.

The decision on passive versus active measures will need to be assessed by the City and UTRCA based on a review of the overall flood protection planning strategy and specific constraints along the various areas of the dyke including bridge abutments, and proximity to adjacent land uses.

5.1.2 Project Driver 2 – Public Safety

A significant portion of the existing dyke structure is over 80 years old and, is therefore susceptible to significant deterioration or damage that may result in a public safety hazard (i.e., railing failures, etc.).

Amenities such as pathway width and lighting may also impact public safety if not deemed to be appropriate. This includes both "normal" use and as part of emergency management where access to the dyke as an area of potential refuge and escape from flooding is desired. The availability of lighting and access is also important when considering worker safety from the perspective of general maintenance requirements and flood response duties.

Through the public consultation process, preference for river access was noted. While river access may enhance concerns relating to public safety and would need to be reviewed as part of the City's overall risk management strategy, access to areas of the river (i.e., key points) to permit water rescue should be considered.

As with flood protection measures, future projects may be initiated where a public safety hazard, such as localized failure, is known to exist. Should a future project be initiated, regardless of the project drivers, additional education and physical mechanisms including signage to provide warning and/or education on the safety of the dyke and proximity to the river should be considered for implementation to enhance overall public safety.

5.1.3 Project Driver 3 – Functional Improvements

In 2009, a pathway extension beneath the Queens Avenue and Dundas Street Bridges was constructed. This project consisted of additional dyke improvements; however the general purpose of the work was to implement the City Parks Department planning initiatives.

In accordance with the *Thames Valley Corridor Study*, *Bicycle Master Plan*, and previous *2007 Master Plan*, other amenity and functional improvements have been identified for areas along the dyke. These objectives may trigger future works either independently or in conjunction with other project drivers such as public safety (refer to previous subsection for additional information as it may relate to amenities) or flood protection enhancement.

5.1.4 Project Driver 4 – Environmental Considerations

A *Vegetation Management Plan* was completed by Dougan & Associates in 2006 in order to identify and prioritize vegetation that may currently pose a threat to the structural integrity of the dyke, and to provide a management plan for future maintenance of vegetation. The *2007 Master Plan* also identified potential implementation of environmental features along and within the areas surrounding the dyke, including plantings and/or grass cover to provide erosion protection.

Consideration for environmental improvements should also take into account the potential impact on existing habitat or introduction of habitat that could result in damage to the dyke structure, including potential for rodent burrowing under cover, etc.

As with amenity and functional improvements, these objectives may trigger future works either independently or in conjunction with other project drivers such as public safety or flood protection enhancement.

5.1.5 Project Driver 5 – Funding Opportunities

This project driver allows for the implementation of a project that may be required to address issues/concerns noted in Project Drivers 1 to 5 ahead of schedule due to the availability of funding. Examples include cost sharing opportunities between City departments and/or with the UTRCA (i.e., WECI), and provincial/municipal grants or programs (i.e., stimulus programs).

5.1.6 Project Driver 6 – Other

This generic project driver was identified as part of PIC 1 and was intended to allow for the identification of any additional project drivers that may be determined/established as part of the Class EA process via project team and/or stakeholder input. As part of the planning process, the following additional or "other" project driver was determined:

- Hydrologic Considerations - While connected to Project Driver 1 (Flood Risk Reduction), this project driver identifies potential hydraulic or hydrology changes that may warrant the need for future improvements.

5.2 RISK MANAGEMENT REVIEW

Several items are noted that will require further review from a risk management perspective during the preliminary and detailed design stage for future works or in relation to repairs to the current dyke structure. Many of these items were noted previously under potential project drivers. These include:

- Accessibility;
- Risk to natural environment;
- Spacing and intensity of lighting; and
- Railing.

The issue of accessibility relates to both access to the dyke and access to the river. Currently there are several areas along the dyke that rely on access by means of stairs. Beyond the general accessibility issues for some users of the dyke (cyclists, people with specific disabilities, etc.), there is also a risk of injury associated with the use of stairs, and ongoing maintenance concerns. Future design or rehabilitation should look to eliminate the use of stairs through proper walkway transitioning. Where physical room may not be available to allow for a proper transition, the use of stairs or steeper slopes should be reviewed from a risk management perspective prior to implementation.

With regards to accessibility to the river, this does not necessarily mean direct access to the river along the west and north banks, but could mean transitions in the dyke structure to areas approaching the river, in similar fashion to the recent pathway project. However, the social benefits will need to be reviewed in relation to risk management (i.e., access to areas during high water levels) and overall maintenance and operational concerns as these lower areas will be exposed to more frequent flooding.

Risk to the natural environment will need to be assessed during each phase of repair or replacement as it is possible that existing vegetation will be disturbed to permit construction. Furthermore, depending upon the area of work, in-river activities may be required and, therefore, associated risks to the natural environment including potential species at risk will need to be determined at the preliminary design stage and appropriate mitigation measures determined.

The issue of lighting was a key item noted during the public consultation process, primarily in relation to concerns regarding "light pollution". Subsequent replacement or repair phases will

need to consider the appropriate level of lighting to be provided in more detail based on an assessment of the following:

- Avoidance of "black out" areas attributed to inadequate lighting intensity and/or spacing;
- Minimizing impact to adjacent homeowners by means of utilizing directional lighting/screens, etc.;
- Current City standards with respect to the use of public spaces at dusk;
- Minimizing adverse effects to the natural environment (habitat);
- Minimizing "tunnel" effect caused by using intense lighting that may impair view of peripheral areas; and
- Appropriate lighting in the event of a flood event.

There is a combination of steel, galvanized steel and aluminum handrail along the majority of concrete revetment. Previous inspection investigations revealed that a portion of the existing railing is in poor condition and requires repair. Concern in relation to the condition of the railing was also noted during the public consultation process. In addition, with exception of the section of railing installed as part of the Phase 1 Replacement Structure project, the remaining railing does not meet current Building Code requirements. As the incline of the dyke is quite steep in many sections, the importance of a functional and protective handrail is paramount towards the safety of the public. The City and UTRCA should review the current condition of the railing and consult with their risk management policies to confirm an appropriate course of action, particularly for areas where future work is not anticipated to proceed for some time.

6.0 ASSESSMENT OF NATURAL-SOCIAL-ECONOMIC ENVIRONMENT

In order to assess the alternative solutions proposed in this Master Repair Plan, general evaluation criteria was established based on a review of the key components of "environment" as defined in Part 1 of the Environmental Assessment Act.

The following provides a general description of each component in reference to the West London Dyke structure and surrounding area:

- **Natural Environment**: Element addressing the protection of the natural and physical elements of the environment (i.e., air, water, land, etc.). This includes both natural heritage and environmentally sensitive areas.

- **Social/Cultural Environment**: Component that addresses the potential effects on the public, including adjacent landowners (residents, businesses), community groups, social elements, historical/archaeological and heritage factors, and development objectives of the City.

- **Economic**: Component that addresses capital and maintenance costs, potential flood damage impacts, etc.

- **Legal**: Factor that considers potential land requirements related to each proposed alternative.

- **Technical**: Component that addresses the technical requirements and suitability of each alternative.

General information relating to the existing environment conditions are presented in the sections that follow. An evaluation of key alternatives with respect to impact to the "environment" is provided in the summary table in Section 9.

6.1 NATURAL ENVIRONMENT

The purpose of the natural environment section is to characterize the significance and sensitivity of the natural features in the study area, identify potential impacts, and recommend appropriate measures in order to avoid or minimize potential negative impacts on the surrounding environment.

Information was collected through a review of published data as it relates to the proposed undertaking. Environmental sensitivities, additional fieldwork recommendations, and associated mitigation measures are presented to protect the identified environmental features and their functions.

6.1.1 Study Area

The study area is defined as the geographical area that could potentially be affected by any of the alternatives presented and was determined on the basis of the expected range of natural environmental effects associated with the Master Repair Plan for the existing West London Dyke.

6.1.2 Natural Environment Policy Considerations

Federal, provincial, and municipal policies provide the framework for the identification of significant natural features. These policies also provide the context in which approvals will be granted for works identified within the Master Repair Plan. Relevant policy documents are outlined below.

6.1.2.1 Provincial Policy Statement

The Provincial Policy Statement (PPS) was issued under Section 3 of the *Planning Act*, and came into effect on May 22, 1996. It was revised in 2005 and most recently in April 2014. Decisions made by Planning Authorities shall be consistent with the policy statements issued under the *Planning Act*, such as the PPS, which includes policies on development and land use patterns, resources and public health and safety. Section 2.1 of the PPS deals with Natural Heritage and requires natural heritage systems to be identified in various EcoRegions. The Project Study Area is located in EcoRegion 7E. Natural heritage policies of the PPS that are applicable to EcoRegion 7E are presented below.

According to Section 2.1.4 of the PPS, development and site alteration shall not be permitted in the following features in EcoRegion 7E:

- Significant wetlands; or,
- Significant coastal wetlands.

According to Section 2.1.5 of the PPS, development and site alteration shall not be permitted in the following features, unless it has been demonstrated that there will be no negative impacts on the natural features or their ecological functions:

- Significant woodlands;
- Significant valleylands;
- Significant wildlife habitat;
- Significant areas of natural and scientific interest; or
- Coastal wetlands that are not subject to policy 2.1.4(b).

Development and site alteration shall not be permitted in the following features, except in accordance with provincial and federal requirements:

- Significant portions of the habitat of endangered or threatened species; or
- Fish habitat.

The PPS also includes policies that highlight the importance of natural heritage systems. The diversity and connectivity of the natural features in an area should be maintained and enhanced, where possible, recognizing linkages between and among natural heritage, surface water and groundwater features.

Policy 2.2 directs planning authorities to protect, improve and restore the quality and quantity of water through a number of means, including but not limited to, the following:

- Identifying surface water and groundwater features, natural heritage features and hydrologic functions necessary for the ecological and hydrological integrity of the watershed;
- Implementing necessary restrictions on development and site alteration to protect, improve or restore sensitive water features and their hydrologic functions;
- Maintaining linkages and related functions among surface water and groundwater features, hydrologic functions and natural heritage features and functions;
- Promoting the sustainable use of water resources through conservation and sustaining water quality; and
- Ensuring stormwater management practices minimize volumes, minimize contaminant loads and maintain or increase the extent of vegetative and pervious features.

In accordance with PPS Policy 3.1, development is generally directed to areas outside of hazardous lands adjacent to rivers and streams that are impacted by flooding and erosion. No development is permitted with the regional floodway and should be adequately set back from the steep slopes to avoid potential hazards.

6.1.2.2 City of London Official Plan

The City of London OP (2006a) contains City Council's objectives and policies to guide the short-term and long-term physical development of all lands within the boundary of the municipality. The general environmental goals of the Official Plan include, but are not limited to, the following:

- Promote a healthy natural environment in the City of London;

- Maintain a healthy Natural Heritage System for the benefit of present and future generations through the implementation of an ecosystem approach to environmental planning;

- Reduce the risk to public health and safety from natural and human generated hazards, such as areas susceptible to flooding, erosion and slope instability; and

- Conserve natural resources for the benefit of present and future generations of Londoners.

The Environmental Policies (Section 15) of the Official Plan recognize lands with significant natural features and ecological functions, as well as lands that are subject to natural hazards (flooding, erosion hazards), and establishes requirements for their protection and rehabilitation. The environmental features are identified on Schedule A (Land Use) as "Open Space" and Schedule B (Natural Heritage Features).

Natural heritage features identified as Open Space areas include (a) Provincially Significant Wetlands; (b) Environmentally Significant Areas; (c) Significant River, Stream, and Ravine Corridors; (d) Life Science Areas of Natural and Scientific Interest as identified by the Province; (e) Habitat of Endangered and Threatened Species; and (f) Areas of Significant Woodlands, Significant Wildlife Habitat, Habitat of Vulnerable Species, Locally Significant Wetland and re-naturalization corridors and linkages. The intent is to protect these areas for their natural features and ecological functions and to encourage their rehabilitation where warranted (Official Plan Section 15.3).

Buffers may be required around, or adjacent to, such areas and other components of the Natural Heritage System. The location, width, composition and use of ecological buffers necessary to protect natural heritage areas from the impacts of development on adjacent lands are to be specified through an EIS (Official Plan Section 15.3.6). Other protection measures, such as site planning, establishment of parklands, and construction setbacks, may also be required to assist in minimizing the impact of development.

These environmental policies are to be addressed within an EIS, which is required where development or site alteration is proposed within or adjacent to components of the Natural Heritage System as defined in the Official Plan or Subwatershed Planning Studies. An EIS is required prior to the approval of a development plan in order to demonstrate that the proposed development will not negatively impact the natural features and ecological functions.

6.1.2.3 UTRCA Environmental Planning Policy Manual

The *Upper Thames River Conservation Authority Environmental Planning Policy Manual* (UTRCA, 2006) includes policies for the protection of natural hazards and natural heritage features within their jurisdiction (watershed), which apply to both municipal plan review and the

implementation of the UTRCA's Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation (Ontario Regulation 157/06).

UTRCA's policies are intended to protect life and property from flood and erosion, ensure a sustainable water supply, protect and enhance water quality, preserve and manage natural areas and provide outdoor recreation opportunities. The purpose of this manual is to provide policies to guide development and site alteration while protecting, preserving and enhancing the natural environment.

These policies are similar to those included in the PPS and apply to the protection and preservation of natural hazards, such as floodplains and steep or eroding slopes, and natural heritage resources, such as wetlands, woodlands, wildlife habitat, threatened and endangered species, fish habitat and adjacent land areas. The UTRCA's policies also include the protection of all wetlands from development and site alteration, but does allow for some restricted uses (i.e., municipal infrastructure, conservation uses, hazard control structures) provided they are supported by an EIS.

6.1.2.4 Endangered Species Act

The *Endangered Species Act* (ESA) protects individuals and habitat of wildlife species designated as endangered, threatened or extirpated in Ontario. Provincial species at risk are identified and designated by the Committee on the Status of Species at Risk in Ontario (COSSARO). COSSARO is a committee of wildlife experts and scientists, including those who provide Aboriginal Traditional Knowledge, that classify species according to their degree of risk based on the best available scientific information, community knowledge and aboriginal traditional knowledge.

The ESA protects species listed by COSSARO as endangered, threatened or extirpated by prohibiting anyone from killing, harming, harassing or possessing protected species, as well as prohibiting any damage or destruction to their habitat. All protected species are provided with general habitat protection under the ESA. General habitat protection extends to areas that species depend on to carry out their life processes, such as reproduction, rearing, hibernation, migration or feeding. For some species protected habit may be identified by regulation. Some species have had detailed habitat regulations passed that go beyond the general habitat protection to define specifically the extent and character of protected habitats. Regulated habitat provides a more precise definition of a species' habitat and may describe features, geographic boundaries or other unique characteristics. Once finalized, protection of regulated habitat replaces the general habitat protection for that species.

Any activity that may impact a protected species or its habitat requires the prior issuance of a Permit from the Ontario Ministry of Natural Resources and Forestry (MNRF), unless the activity or species is subject to any of the special provisions in Ontario Regulation 242/08. Permits may only be issued under certain circumstances, which are limited to activities required to protect human health and safety, activities that will assist in the protection or recovery of the species, activities

that will result in an overall benefit to the species or activities that may provide significant social or economic benefit without jeopardizing the survival or recovery of the species in Ontario.

6.1.3 Data Collection

6.1.3.1 Background Data Collection

A variety of background documents and sources of information were consulted during the preparation of this report, including the following:

- City of London Official Plan (2006) and Zoning By-Law (2013);
- Government of Canada. Species at Risk Public Registry (2012);
- Ministry of Natural Resources and Forestry (MNRF). 2012-2015. Species at Risk Ontario;
- Physiography of Southern Ontario (Chapman and Putnam, 1984);
- Aerial Photographs (City of London, 2012);
- 2007 and 2012 Upper Thames River Watershed Report Cards;
- Bank Stabilization Study - Forks of the Thames, London (Delcan, 1983);
- Bank Stabilization Study – Phase II – Forks of the Thames, London (Delcan, 1984);
- Natural Heritage Information Centre (NHIC) database. 2012 and 2015. Natural Areas and Species records search. Biodiversity explorer;
- Ministry of Natural Resources and Forestry (MNRF). Background information request submitted March 30, 2015. MNRF provided background information on natural heritage features and species at risk for the project study area in writing on April 13, 2015 [Andrea Fleischhauer, District Planner];
- Atlas of the Mammals of Ontario (Dobbyn, 1994);
- Ontario Herpetofaunal Atlas Internet Database (Oldham and Weller, 2000);
- Ontario Breeding Bird Atlas (Cadman et al., 1987-2007 in references);
- Important Bird Areas Database (Bird Studies Canada and BirdLife International, undated-added to refs);
- Ontbirds Archives (various years); and
- West London Dykes Subject Land Status Report (UTRCA, 2015).

6.1.3.2 Field Studies and Investigations

Fieldwork was not incorporated into the natural environment characterization for the Master Repair Plan. Through discussions with agency staff it was determined that the species information obtained may not be sufficiently updated at the time of project implementation. Fieldwork should be planned and completed at the preliminary design phase. Potential impacts and recommendations of appropriate mitigation measures for the selected designs are to further be identified in the Master Repair Plan.

6.1.3.3 Vegetation Surveys

Dougan & Associates prepared a Vegetation Management Plan for London Dykes in 2007. The main purpose of the plan was to identify and prioritize vegetation that may have posed a threat to the structural integrity of the dyke, however a comprehensive species list was also recorded. It is recommended that updated surveys be completed prior to undertaking future projects, and that these surveys include an assessment within the north and west extensions (Beaufort-Saunby/Cavendish West) which were not previously included.

6.1.4 Existing Natural Features and Functions

6.1.4.1 Climate

The nearest Environment Canada weather monitoring station to the West London Dyke with both temperature and measured rainfall is located in London (Climate ID 6144478). Data was collected for the years 2011 – 2015 and is summarized in Table 6.1.

Table 6.1: Climate Data (Study Area)

Climate Station ID 6144478	2011	2012	2013	2014	2015
Total Annual Precipitation (mm)	1,165	664	1,022	868	777
Daily Mean Temperature (°C)	8.5	10.0	8.0	6.6	8.1
Maximum Temperature (°C)	36.7 (July)	36.1 (July)	34.3 (September)	31.2 (June)	31.9 (September)
Minimum Temperature (°C)	-22.8 (January)	-21.4 (January)	-18.7 (February)	-27.2 (February)	-28.8 (February)
Wettest Month	September	October	October	September	June
Driest Month	July	November	March	March	March

6.1.4.2 Physiography, Geology, Soils and Topography

The West London Dyke is situated across spillways of the Thames River and two physiographic regions. A small northerly section occurs in the Stratford Till Plain with the remaining occurring across the Caradoc Sand Plains. The major physiographic unit of the study area is sand plain.

The bedrock geology consists of limestone, dolostone and shale of the Hamilton Group of Middle Devonian age (Ontario Geological Survey, 1991).

Various geotechnical investigations have been completed along the West London Dyke, including bank stabilization studies in 1983 and 1984, and a 2005 geotechnical investigation in support of the Phase 1 Replacement project. In general, boreholes advanced along the dyke indicated up to 6 m of silt, sand, and sand and gravel fill. Beneath the fill, boreholes advanced along the north branch encountered a stratum of sand, and sand and gravel, terminating in clayey silt to silty clay tills. Within the natural bank area east of the Wharncliffe Road North Bridge, sand and gravel was noted beneath the fill to termination of the borehole.

6.1.4.3 Upper Thames River Watershed

The study area is located within the Upper Thames River watershed. It is situated in a highly developed part of Southern Ontario and therefore faces ongoing pressure from urban and rural land use. The Thames River is one of the most biologically diverse rivers in Canada and is home to over 88 species of fish. The entire Thames River system is designated a Canadian Heritage River.

The study area is located within the Forks watershed, one of 28 that comprise the Upper Thames watershed, and is under the jurisdiction of the UTRCA. The Thames River continues to Chatham, into Lake St. Clair and eventually Lake Erie. It is a warmwater system characterized by low flows and high levels of turbidity and sediment deposition. The Forks watershed comprises approximately 3% of the Upper Thames River watershed.

6.1.4.4 Hydrology

The Upper Thames River watershed has a drainage area of 3,570 km^2. The watershed is drained by two main stream channels with the confluence located in downtown London, also known as the Forks of the Thames. The north Thames River drains 1,693 km^2 in the northern area of the watershed, whereas the main branch of the Thames River drains 1,374 km^2 in the southern area. Flow rates are regulated by three dams and reservoirs, Wildwood, Pittock and Fanshawe. The Wildwood Dam is located on Trout Creek, upstream of St. Mary's, on the north branch. It has a drainage area of 137 km^2 and controls approximately 8% of the north branch. Fanshawe Dam is located at the northeast limits of London and has a drainage area of 1,417 km^2 which controls roughly 84% of the north branch, and 46% of the Thames at the Forks. Pittock Dam is located on the northern edge of Woodstock and has a drainage area of 256 km^2, and controls roughly 18% of the south branch and 8% of the Thames at the Forks. Water levels along the north branch of

the Thames river are dependent on both the flow in the branch and the backwater effect caused by the combined flow at the Forks (Marshall Macklin Monaghan, 1983). Overall flow regulation controls approximately 55% of the flow at the Forks of the Thames, which has a total drainage area of 3,067 km^2.

Flooding within the City of London is predominately caused by rain on snowmelt events on a saturated watershed during the spring season. When a watershed is saturated, runoff is generally rapid with major peaks occuring within a day of extreme temperatures or heavy rainfall. To mitigate the effects of these event, the maintenance of the London dykes system is considered to be an important flood protection measure.

6.1.4.5 Flood Plain

A flood plain is generally defined as an area that is subject to natural flooding from an adjacent watercourse. Flood plain areas generally contain unconsolidated sediments.

The adjacent land areas along the West London Dyke are located within a flood plain, primarily due to sections of the dyke that are currently below the Regulatory Flood Line. Refer to Figure 6.1 which depicts the current 250 year flood hazard line.

6.1.5 Aquatic Resources

6.1.5.1 Riverine Habitat Assessment

The mean average flow of the Forks watershed is 46.1 m^3/s. The total length is 75 km. It is 76% natural, 5% channelized, and 19% buried. The flow type is 64% permanent, 31% intermittent, and 19% buried. Temperature is 55% warmwater, 2% cool/coldwater, and 44% unconfirmed. The riparian zone (30 m on either side of a watercourse) is 32% permanent vegetation. The average for the Upper Thames watershed is 34% and the ideal is 75%.

6.1.5.2 Fish Species

Based on background information provided by the UTRCA Watershed Report Cards, 59 fish species and 24 freshwater mussel species have been recorded within the Forks watershed. There are three at-risk fish and mussel species listed on the NHIC database for the study area, discussed further below.

The Bank Stabilization Study - Forks of the Thames, London (Delcan, 1983) report also noted the presence of common white sucker, rock bass, pumpkinseed, hognose sucker, carp, various small minnows, and stoneroller based on a shoreline investigation, which included the length of the current dyke.

Any project undertaken through this Master Repair Plan will require additional review of available information and may require field investigations to determine presence/absence of at-risk species.

6.1.5.3 Water Quality

The *Upper Thames 2012 Watershed Report Cards* use the provincial grading system developed for conservation authorities: *Watershed Reporting: Improving Public Access to Information, May 2003*.

Three indicators are used to assess the surface water quality for each watershed:

- Bacteria (E. coli);
- Total phosphorus; and
- Benthic invertebrates.

The UTRCA scored each of the surface water quality indicators a D, F, and D, respectively producing an overall grade of D for the Forks area. This watershed is the second most downstream section of the Upper Thames River and is heavily influenced by upstream activities. Samples were taken from the Provincial Water Quality Monitoring Network (PWQMN) station located at Byron, the watershed's downstream end. The bacteria concentration has declined since 2007 while total phosphorus has improved slightly. The benthic score has remained steady since 2001.

6.1.6 Terrestrial Resources

6.1.6.1 Vegetation Communities

The ecosystem along the Thames River has been highly disturbed by urbanization thus making vegetation community classification difficult. Two general communities were described (Dougan & Associates., 2006):

- Anthropogenic Community - This comprises the actual dyke sections and much of the adjacent residential areas; and
- Floodplain Community - This comprises the remaining natural habitat adjacent to the Thames River.

6.1.6.2 Vascular Plants Species

Vascular plant species were previously identified in the *London Dykes Vegetation Management Plan* completed for the UTRCA in 2006. A total of 28 vascular plant species were recorded along the West London Dyke. Of these, nine are native with the remaining 19 species introduced.

6.1.6.3 Species at Risk and Species of Special Concern

Based on the review of background documentation listed above, historic records of 34 Species at Risk (i.e., species listed by COSSARO as At Risk in Ontario, and afforded protection under the *Endangered Species Act, 2007*) or Species of Conservation Concern (i.e., species identified as S1-3 in Ontario, but not listed as At Risk by COSSARO) were identified in the vicinity of the project study area. These species include:

- Nine (9) plant species: American chestnut, broad beech fern, butternut, eastern green-violet, fall crabgrass, green dragon, hairy-fruited sedge, Middlesex frosted hawthorn and striped cream violet;
- One (1) insect species: Rusty-patched Bumble Bee;
- Eight (8) reptile species: Blanding's Turtle, Eastern Spiny Softshell, Northern Map Turtle, Snapping Turtle, Spotted Turtle, Eastern Milksnake, Eastern Ribbonsnake and Queensnake;
- Ten (10) bird species: Bank Swallow, Barn Swallow, Bobolink, Chimney Swift, Common Nighthawk; Eastern Meadowlark, Eastern Wood-Pewee, Henslow's Sparrow, White-eyed Vireo and Wood Thrush;
- Three (3) mammal species: Little Brown Myotis, Northern Myotis and Woodland Vole; and
- Three (3) fish and mussel species: Lake Sturgeon, Silver Shiner and Rayed Bean.

Based on preliminary ELC using air photo interpretation and imagery, potential habitat for nineteen of these species (including their Provincial/Sub-National Rank[1] and COSSARO listing) may occur in the project footprint:

- American chestnut (S2, endangered);
- Broad beech fern (S3, special concern);
- Butternut (S3?, endangered);
- Eastern green violet (S2);
- Green dragon (S2, special concern);

[1] Provincial/Subnational Status Ranking (S-Ranks) for plants and wildlife are based on the number of occurrences in Ontario, assigned by the NHIC. S-Ranks range from S1 (fewer than 5 occurrences/critically imperiled), to S5 (secure and very common). 'S?' rankings denote classifications that are deemed uncertain or unranked, based on available information. The 'B' qualifier denotes that the status ranking applies to the breeding population in the province.

- Hairy-fruited sedge (S3);
- Middlesex frosted hawthorn (S1?);
- Striped cream violet (S3, special concern);
- Eastern Spiny Softshell (S3, threatened);
- Northern Map Turtle (S3, special concern);
- Snapping Turtle (S3, special concern);
- Eastern Milksnake (S3, special concern);
- Barn Swallow (S4B, threatened);
- Common Nighthawk (S4B, special concern);
- Eastern Wood-Pewee (S4B, special concern);
- Wood Thrush (S4B, special concern);
- Little Brown Myotis (S4, endangered);
- Northern Myotis (S3?, endangered); and
- Woodland Vole (S3?, special concern).

For projects identified within the Master Repair Plan, additional field investigation may be needed in order to confirm the presence of species at risk and/or species habitat.

6.1.7 Natural Hazard Features

Natural hazards are caused by naturally occurring physical and ecological processes which continuously shape and reshape the landscape. Risks to the community develop when these processes are not fully understood or dealt with effectively in the development process. Hazard lands in the Upper Thames River watershed include the following components:

- Riverine flood hazards – flood plain;
- Riverine erosion hazards – slopes and meander belt;
- Watercourses – streams, creeks, rivers, ditches, and municipal drains; and
- Wetlands – swamps, marshes, bogs, fens, all which may contain organic soils.

The West London Dyke is within the area of the Regulated Limit as set by the UTRCA. The Regulation Limit is the maximum extent of the following areas:

- Riverine Hazard Limit;
- 15 m allowance;
- Wetland boundary; and
- Area of interference (30 m) adjacent to all wetlands.

Any development, construction, or site alteration proposed within the Regulation Limit may require prior written approval from the UTRCA.

Table 6.2: Potential Impact and Mitigation Measures

Potential Impact	Recommended Mitigation and Enhancement Measures
Aquatic Habitat, Fisheries and Water Quality	
Direct loss, alteration, or disruption of fish habitat	• Ensure sufficient fish passage is provided through all in-water works. • Restore vegetation and aquatic habitat (substrate) to pre-construction condition (or better), ensuring that any habitat features (pools, riffles, structure) are restored or enhanced. • Any Harmful Alteration, Disruption or Destruction (HADD) of fish habitat that may result from the proposed dyke improvements will require prior authorization from DFO. A compensation plan will be required for review and approval and should be discussed with UTRCA staff on behalf of DFO. • Opportunities to enhance riparian vegetation through the planting of other hanging grasses, shrubs and trees will improve stream cover, reduce temperature impacts, and provide allochthonous inputs (food source for various fish species).
Increased turbidity and siltation in downstream areas resulting in "smothered" plants and animals due to the deposition of silt and increased turbidity of surface watercourses	• Ensure enhanced erosion control measures are installed and maintained throughout all phases of construction to protect exposed surfaces, control run-off and minimize the deposition of silt or suspended sediments within downstream habitats. • Worksite isolation and dewatering plans should be prepared to identify appropriate isolation methods, siltation controls and dewatering measures to be implemented. • Any pumped water resulting from dewatering activities should be discharged to settling areas or through filter media before entering the surface water bodies.

Potential Impact	Recommended Mitigation and Enhancement Measures
	• Utilize suitable backfill material along banks and footings. • Stage construction activity to minimize the frequency and duration of any in-water work, as much as feasible. • Re-vegetate all disturbed areas as soon as possible following disturbance to stabilize the area and minimize erosion potential. • Effective monitoring and reporting is required.
Impacts on species at risk	• Improve water quality enhanced erosion controls. • Restore riparian vegetation cover through the planting of overhanging grasses, forbs and shrubs, to provide cover, shade and a source of food (insects). • Any work along or in the watercourse margins should be timed/scheduled to minimize impacts to fish and mussel species. A review of the particular activity may assist in negotiating the timing window.
Stress on fish communities	• Any fish that may occur within isolated work areas should be captured and released in accordance with appropriate MNR protocols.
Terrestrial Habitat and Species	
Removal or disturbance of significant trees or ground flora	• Relocate or replant any significant species in a timely manner following construction. • Minimize tree removal during construction. • Stabilize all disturbed areas upon completion of any grading works through re-vegetation of the disturbed areas utilizing native plant species (i.e., seed and mulch, compost mix, tree and shrub planting).
Stress on biological communities	• Avoid construction impacts during sensitive wildlife periods, such as breeding seasons for various bird species.
Introduction of exotic species through disturbance	• Use only native species for all re-vegetation work.
Interference with ecological corridors and linkages	• Minimize vegetation disturbance in grassland areas to ensure habitat protection.

The above-referenced mitigation measures are standard procedures used at locations where potential habitat disturbance exists. Detailed mitigation and compensation measures should be further developed as the detailed design of proposed projects are finalized in consultation with appropriate regulatory agencies.

6.2 SOCIO-ECONOMIC ENVIRONMENT

The West London Dyke is centrally located in the City. Development behind the dyke commenced prior to Annexation by the City in 1897 in response to economic activities at that time which relied on the proximity to the Thames River.

The area protected by the dyke quickly became a significant cultural base that was unique to the City. An attraction to the Thames River as a recreational resource resulted in further residential development in the area. The construction of additional corridors to connect to areas east of the river contributed to the establishment of businesses in the vicinity of these crossings to attract the increased traffic in the area.

There are currently about 1,100 structures located behind the West London Dyke that are within the Regulatory Flood Line.

6.2.1 Land Use and Zoning

The West London Dyke study area is located within land designated as Open Space Zone (OS4). The OS4 zone variation is regulated by the UTRCA pursuant to the Conservation Authorities Act and recognizes the area as hazard lands. Larger OS4 areas along the dyke include the area north of Oxford Street (Waldorf Park), south of Blackfriars Bridge (Blackfriars Park) and west of Wharncliffe Road North Bridge (Cavendish Park).

In general, land use behind the dyke structure is predominately classified as Residential R2 Zone, which provides for and regulates low density residential development including single detached dwellings, semi-detached dwellings, duplex dwellings and two unit converted dwellings.

In addition to residential use, various commercial and office establishments are located behind the dyke structure along its length. A small commercial area within the Neighbourhood Shopping Area Zone is located north of Oxford Street West to the Canadian Pacific Railway. This Zone provides for and regulates various neighbourhood scale commercial retail, service and office uses which are primarily intended for the convenience shopping and service needs of nearby residents. Along the south side of Oxford Street West immediately west of the river, a mix of Residential R3 Zone combined with Office Conversion (OC) Zone is present. Convenience Commercial Zones (CC) are located along Blackfriars Street and at the southeast corner of Wharncliffe Road North and Oxford Street West to permit convenience stores and service establishments, personal service establishments and financial institutions. Additional commercial areas near the southeast corner of Wharncliffe Road North and Riverside Drive are designated as Highway Service (HS) Commercial Zone and include a range of commercial and service uses that are intended to service the needs of the travelling public.

Land use immediately adjacent to the dyke structure north of the Queens Avenue Bridge is comprised of Labatt Park which is designated as a Regional Facility (RF). The RF Zone is intended

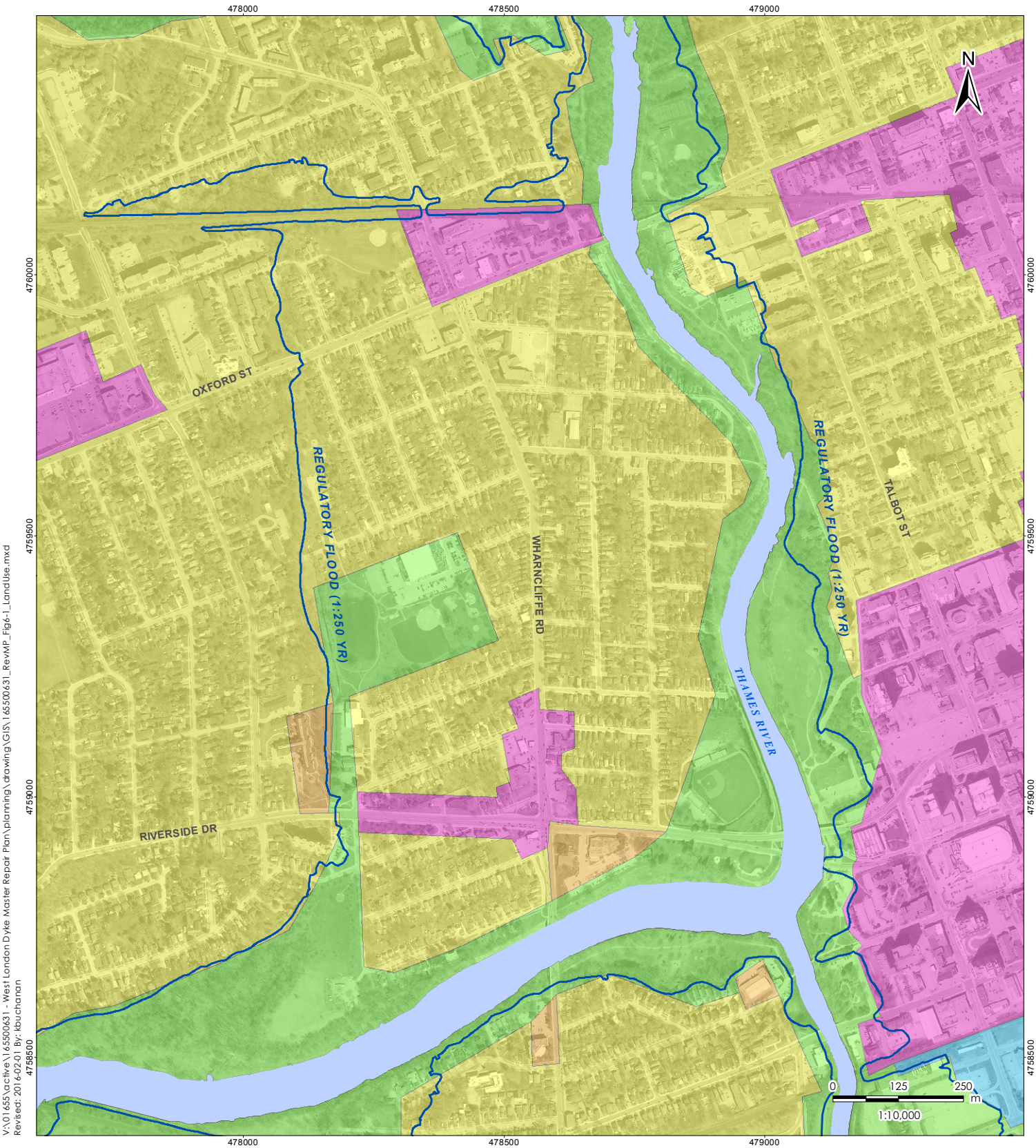
to regulate large institutional type facilities which serve a regional function, but may create impacts on adjacent land uses.

The area behind the West London Dyke south of Riverside Drive and extending to the east side of the Wharncliffe Road North Bridge is classified as a Community Facility (CF1) Zone which allows for institutional type uses that may impact adjacent land uses but are intended to provide a city-wide or community service function.

All adjacent land uses west of the study area are within the floodplain.

The Thames River borders the study area to the east and south with a mixture of Open Space (OS4) consisting of Harris Park (OS4 land), commercial, residential and institutional land beyond which forms the downtown core. Much of the dyke structure forms an important recreational corridor and park space and incorporates the Thames Valley Pathway System, providing a link to surrounding communities.

Figure 6.1 depicts the generalized Official Plan land use adjacent to the West London Dyke. Figure 6.2 depicts municipal and conservation authority lands.



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Revised: 2016-02-01 By: kbuchanan

February 2016
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Stantec

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Imagery and base features used under license with the City of London, © 2009-2015.

Legend

Generalized Land Use

- Commercial
- Industrial
- Institutional
- Open Space
- Residential

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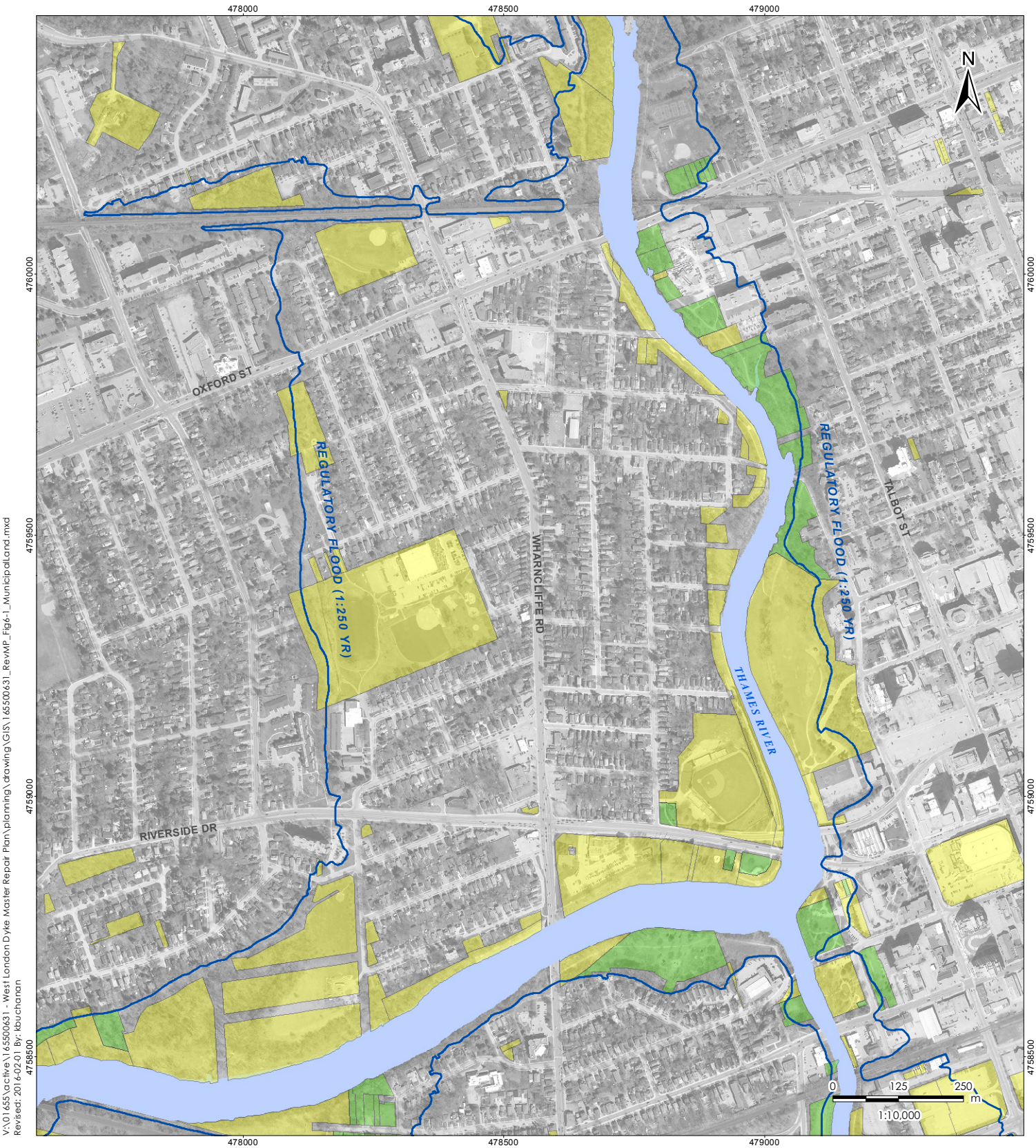
Upper Thames River Conservation Authority & City of London
West London Dyke Master Repair Plan

Figure No.

6.1

Title

Generalized Official Plan Land Use



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Revised: 2016-02-01 By: kbuchanan

February 2016
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Legend

- Owned by UTRCA
- Owned by City

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Imagery and base features used under license with the City of London, © 2009-2015.

Client/Project

Upper Thames River Conservation Authority & City of London
West London Dyke Master Repair Plan

Figure No.

6.2

Title

Municipal and Conservation Authority Lands

6.2.2 Flood Plain and Special Policy Area Designation

As noted in Section 6.1.4.5, floodplains are areas that are vulnerable to flooding, which include lands adjacent to a river, lake or other watercourse that has been or can be covered by floodwaters. Floodplain management in Ontario generally consists of three components:

- Prevention – through land use planning and regulation of development, increasing public awareness of potential risks;
- Protection – construction of protective works such as dams and dykes, purchasing of hazardous land to convert them into park lands/open spaces; and
- Emergency preparedness and response – flood preparedness plans, flood forecasting, warning and emergency action.

Within Ontario, floodplain management is generally addressed by means of three approaches or concepts:

- One-zone concept which is considered the most effective means of minimizing threats and consists of the determination of the flood hazard limits by planning authorities, and prohibition of any development or site alteration within these limits;
- Two-zone concept resulting in the identification of the floodway and flood fringe, whereby development and site alteration within the floodway would be prohibited due to the threat to public health and safety, and damage to property, and limited development within the flood fringe would be permitted due to the reduced risk within this section; and
- Special Policy Area concept to be used in exceptional situations whereby the SPA designation would be critical to the continued viability of the existing area. This concept is typically employed in areas of historical or cultural significance that were constructed prior to flood policies coming into effect and where strict adherence to provincial policies would result in significant social and economic hardships to the area.

The current City of London Official Plan identifies several potential Special Policy Areas, including the areas protected by the West London Dyke. The City of London has made an application to the Province to receive a SPA designation. If granted, this designation would allow for relaxation of flood plain policies, therefore permitting limited development and redevelopment to continue. The SPA is not intended to allow for new or intensified development and site alteration, particularly where growth opportunities exist for a community outside of the floodplain area.

Provincial policy indicates that, in order to achieve SPA designation, the area must be protected by a dyke system with elevations set at or above the Regulatory Flood Level. However, in some instances this policy has been relaxed where it is impractical to provide this level of protection.

Further information relating to the current protection offered by the dyke system is provided in subsequent sections of this Master Repair Plan.

To date, the SPA application has not been actively pursued by the City.

On a cultural level, a previous report "Petersville Neighbourhood Project" (LACAC, 1994) identified the barrier attributed to floodplain regulations and SPA restrictions. However, the report noted that these same restrictions have likely contributed significantly to the protection of the character and uniqueness of the area

In addition to Official Plan flood plain policies, all flood plain lands are subject to the construction regulations administered by the appropriate Conservation Authority pursuant to the Conservation Authorities Act. Under these regulations, construction is prohibited unless prior written consent has been received from the Authority.

6.2.3 Heritage Features

The area in and around the West London Dyke consists of several significant historical structures and spaces. Originally populated due to the presence of flat low lying plain and access to the river, the area also contained the earliest road connecting the former London West area to the City of London via the Blackfriars Bridge which resulted in additional development.

Figure 6.3: Blackfriars Bridge

Constructed in 1875, the Blackfriars Bridge represents the earliest link to the remainder of the City and is a historical landmark that has survived two major floods. The structure remains a physical, historical and metaphorical link between the West London SPA and the central core area and is cherished by the area residents.

Labatt Park (formerly Tecumseh Park), located along the West London Dyke north of the Queens Avenue Bridge is reputed to be the oldest continually used baseball park in North America, dating back to 1877. The park has been designated as a historic site in accordance with Part IV of the Ontario Heritage Act.

A Cultural Heritage Evaluation Report was completed for the North Branch of the Thames River (Queens Avenue to the CPR rail line just north of Oxford Street) and can be found in Appendix 6.1. The purpose of the Cultural Heritage Evaluation Report is to identify heritage resources,

including built heritage and cultural heritage landscapes, which are present within the study area. Potential heritage resources were identified through consultation and a pedestrian survey, inventoried and evaluated according to O. Reg. 9/06, the criteria for determining cultural heritage value or interest (CHVI). A land use history was completed to provide a cultural context for the study area and to provide a background upon which to base evaluation. The objectives of this report are summarized below:

- Prepare a land use history of the area for use in the identification and evaluation of heritage resources;
- Identify potential heritage resources within the area through a preliminary property inspection from accessible roadways;
- Evaluate the CHVI of the potential heritage resources to determine the number of heritage resources present; and
- Prepare recommendations for future work where heritage resources were identified.

Where potential negative impacts to heritage attributes are identified, strategies should be prepared to mitigate the impacts on heritage resources.

6.2.4 Archaeological Assessment

A Stage 1 archaeological assessment was completed for the North Branch of the Thames River (Queens Avenue to the CPR rail line just north of Oxford Street) and can be found in Appendix 6.2.

For the purposes of the Stage 1 archaeological assessment, the Ministry of Tourism, Culture and Sport's (MTCS) *2011 Standards and Guidelines for Consultant Archaeologists* were followed. The objectives of the Stage 1 assessment were to compile available information about the known and potential archaeological heritage resources within the study area and to provide specific direction for the protection, management and/or recovery of these resources. The objectives of the Stage 1 archaeological assessment are as follows:

- To provide information about the study area's geography, history, previous archaeological fieldwork and current land conditions;
- To evaluate in detail the study area's archaeological potential which will support recommendations for a Stage 2 survey for all or parts of the property; and
- To recommend appropriate strategies for a Stage 2 survey.

To meet these objectives, the following research strategies were employed:

- A review of relevant archaeological, historic, and environmental literature pertaining to the study area;
- A review of the land use history, including pertinent historic maps;
- An examination of the City of London's Archaeological Master Plan;
- An examination of the Ontario Archaeological Sites Database to determine the presence of known archaeological sites in and around the project area; and
- A property inspection of the study area.

The Stage 1 archaeological assessment determined that there are small pockets in the study area that have archaeological potential. The remainder of the study area has no archaeological potential due to steep slope, low and wet conditions, and modern disturbances. Therefore, portions of the study area retain archaeological potential and any area of archaeological potential that will be subject to construction disturbance will be subject to a Stage 2 archaeological assessment prior to construction. It has also been determined that portions of the study area do not retain archaeological potential and no further archaeological assessment is recommended for those areas.

The objective of the Stage 2 archaeological assessment will be to document archaeological resources within the study area and to determine whether these archaeological resources require further assessment. It will consist of a test pit survey. If the archaeological field team judges any lands to be low and wet, steeply sloped, or disturbed during the course of the Stage 2 field work, those areas will not require assessment, but will be photographically documented instead. In addition, due to the potential for deeply buried archaeological resources in the area of the former Samuel Peter's distillery, the Stage 2 assessment of that portion of the study area will include mechanical excavation to identify subsurface cultural features.

6.3 ECONOMIC ENVIRONMENT

A review of the economic environment within the area protected by the West London Dyke must consider the following components:

- Capital costs associated with future replacements or rehabilitations due to either planned or emergency events;
- Maintenance costs associated with the ongoing operation of the dyke; and
- Potential flood damages that could occur if the West London Dyke was breached during a flood event.

The following subsections provide additional information with respect to each item.

6.3.1 Capital Costs

The cost and complexity of the West London Dyke Phase 1 Replacement Project (in excess of $3.5 million 2008 Canadian dollars construction costs only) which was completed in 2007/2008 for a 300 m segment demonstrated what the impact could be on capital budgets if a repair/replacement strategy is not in place if and when other segments of the dyke fail to meet minimum performance requirements.

In addition to protecting the properties adjacent to it, the West London Dyke is considered a significant piece of infrastructure within the City. It is estimated that the cost to replace the existing structure is in the order of approximately $32 million (-10% to +40%) in 2016 Canadian dollars assuming full replacement at one time and based on the existing flood protection level (100 year), present amenities, projection of costs associated with the 2007 Phase 1 Replacement project assuming a Construction Price Index average rate of 2.7%, and other costing tools. The -10% to +40% is considered a standard preliminary cost range and reflects the variation in replacement options, phasing of work, potential market variations, site conditions, and unknown subsurface impacts.

As part of the Master Repair Plan, a cost estimation model was developed to determine order of magnitude cost estimates based on potential staging of construction, level of flood protection desired, and additional freeboard variations. Refer to Section 9 for additional information relating to costs associated with future replacement options.

6.3.2 Maintenance Costs

As with any significant infrastructure, ongoing maintenance is required in order to extend the useful life of the structure and minimize the potential for significant capital cost replacements. The existing West London Dyke is approximately 2,300 m long and consists of approximately 1,500 m of original concrete revetment which is about 85 years old. Typically, concrete structures are designed for 75 years; however, the actual useful life may extend either significantly longer or shorter depending upon the quality of the original construction and subsequent maintenance.

Additional attributes along the dyke, including railing, lighting, pathways, seating, vegetation, and utilities (water, storm, sanitary, hydro, etc.) also require periodic maintenance and these costs should be assessed for the purpose of establishing future maintenance recommendations and costing.

Estimated costs associated with maintenance of the existing dyke structure are provided in Section 10 of this report.

6.3.3 Flood Damage Estimate

River flooding is considered to be the most significant hazard to life and property within the Special Policy Area protected by the West London Dyke. In terms of cost, the West London SPA represents a significant flood damage centre within the Upper Thames River watershed. The West London Dyke runs adjacent to the confluence of the Thames River. Flows along the Thames River are attenuated by three major flood control structures: Wildwood Reservoir; Fanshawe Dam and Reservoir; and Pittock Reservoir in Woodstock as well as a series of dykes in London.

The West London Dyke area has experienced severe flooding on several occasions. In 1883, flooding along the Thames River resulted in 17 deaths and extensive property damage, resulting in the construction of dykes along the river. However, breaching of the dyke walls occurred following the worst flood event on record in April 1937, resulting in 5 deaths, the destruction of 1,100 homes, and severe damage to roads and bridges. Total damage was estimated at $3 million (1937 Canadian Dollars). As a result of the flood, the dykes along the river were reconstructed. Following another less severe flood in 1947, the current dam structures were constructed to control flooding in the urbanized area, and further raising of sections of the West London Dyke was completed. Since that time, there have been significant floods in March 1977, September 1986, September 1997, July 2000, March 2008 and December 2008; however, no breaching of the dykes occurred.

As part of a feasibility study in the 1970's and 1980's for the proposed Glengowan Reservoir, an extensive inventory of all structures in the floodplain downstream of the proposed location for the structure was completed. Results from the survey were incorporated into the Flood Damage Study in the Upper Thames River watershed (UTRCA, 2005), which provided flood depth-damage tables for various damage reaches along the Upper Thames Basin, including the West London Dyke area (consisting of reaches 8, 9, 11, 12, 13, and 14). Damage reaches were developed throughout the developed portion of the floodplain, each based on the assumption that a single water surface elevation applies to all points within the reach defined. Results from this investigation indicated that the area of the north branch of the Thames River just upstream of the Forks is comprised of the most densely populated portion of the watershed and therefore the estimated annual damage within these zones were more significant compared to other sections within the study area.

The Glengowan Reservoir was ultimately deemed to be unfeasible, but provided the basis for other more cost effective improvements to minimize flood damage within the existing urbanized area. Within the City, this included extension of the Broughdale Dyke to the Regulatory Flood Level. No additional recommendations related to West London Dyke were provided as modeling completed at that time indicated that topping of the dyke would only occur, barring failure, at flows approaching the 500 year event based on optimized regulation of flood flows.

A review of flood damage potential estimates was undertaken by the UTRCA in 1995 for the Thames River in London. Previous damage estimates and defined damage reaches from the Glengowan study and subsequent information on the dyke were used as part of the

reassessment. At that time, total damages above the Regulatory Flood condition were estimated at $19,000,000 (1995 Canadian Dollars) without the dyke in place or approximately $238,000 expressed in terms of Average Annual Damages (AAD). With the dyke system, the AAD was reduced to $50,000 (UTRCA, 1997).

In 1997, the UTRCA prepared the report "Flood Plain Technical Background Report: West London Special Policy Area" in order to assist the City with the technical implementation of flood plain planning policies for the West London Dyke area. This report also included a review of the benefits of increasing the dyke height to comply with the Regulatory Flood Standard. Based on the anticipated cost to increase the dyke height (onto existing dyke excluding potential land costs), and relatively small decrease in the AAD (by only $6,000), the benefit to cost ratio was less than 0.1.

In 2005, the UTRCA undertook an updated flood damage estimation to examine potential increases in occurrences of flooding through different climatic change scenarios. The updated assessment utilized the series of depth-damage tables developed through the Glengowan Reservoir study as well as the 1989 MNR document "Flood Damage Estimation Guide". A review of flood damage curves for each damage reach along the West London Dyke indicated the potential for approximately $23,000,000 (2005 Canadian Dollars) based on the 100 year flood and $42,000,000 (2005 Canadian Dollars) based on the 250 year Regulatory Flood Level. These costs consist of the total direct damages from residential, commercial, industrial, and public lands plus "other" damages (i.e., possessions, etc.) as per MNR recommendations, but include lands across the river included within the damage reach. However, a review of the lands within each damage reach suggests that the majority of the damage costs would be attributed to areas behind the West London Dyke.

As part of the Master Repair Plan, previous flood damage reports were reviewed in order to provide an updated estimate of the potential flood damage costs (2016 Canadian Dollars) for the West London Dyke area. In general, the review consisted of updating of the 2005 costs (which were revised in 2015 by UTRCA) to 2016 Canadian dollars based on a Consumer Price Index of 2.7 % for Damage Reach Zones 8, 9, 11, 12, 13, and 14 which represents the extent of the West London Dyke.

Table 6.3 provides an estimate of the flood damage update based on the available information. Previously, the damage reaches developed as part of the Glengowan study contained lands across the river and therefore damage estimates may have contained additional costs beyond damages attributed to areas behind the West London Dyke. As part of the update undertaken in 2015 by UTRCA, analysis of damages only considered structures that were behind the West London Dyke (i.e., structures on the right bank when facing downstream).

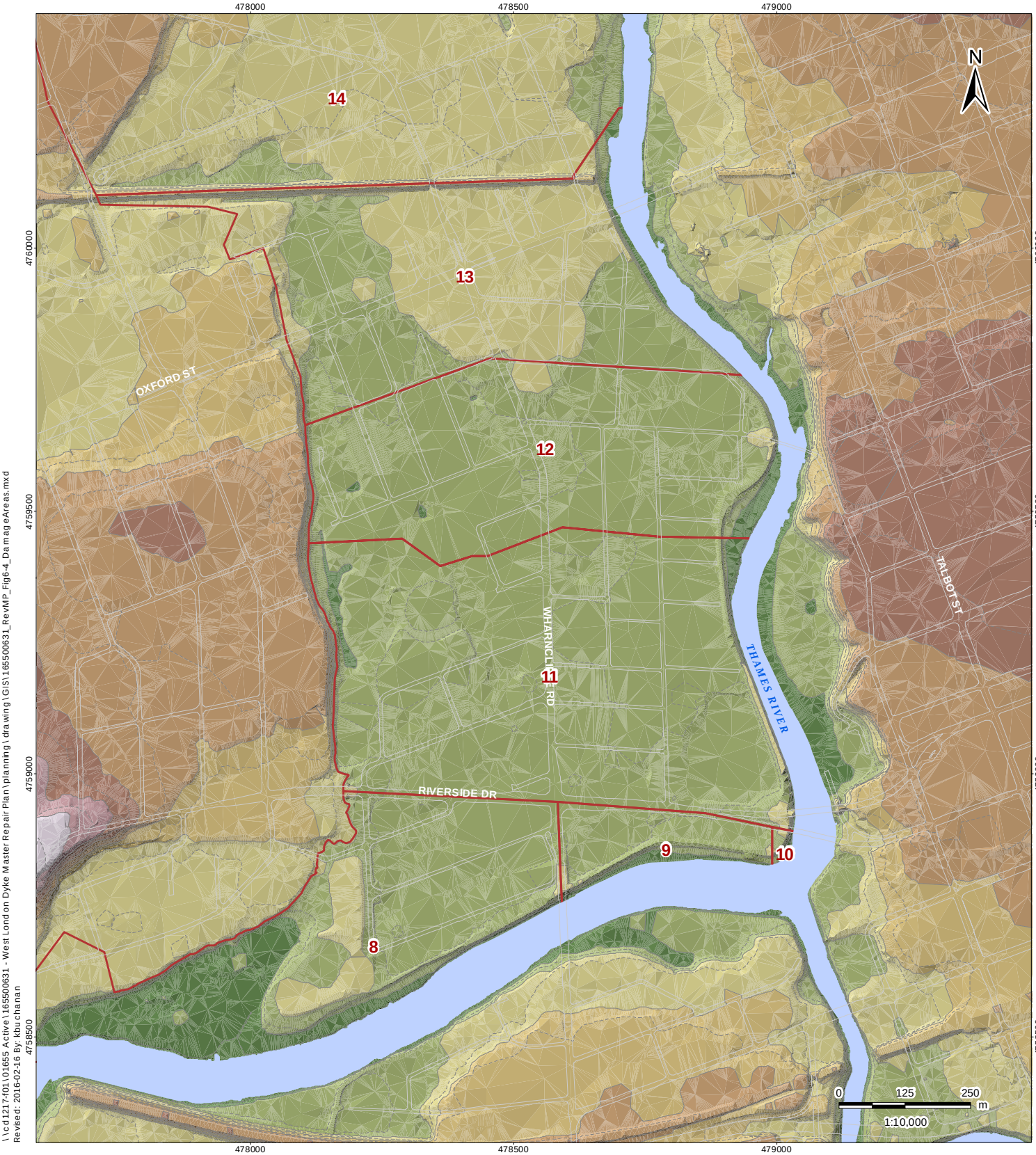
Table 6.3: Updated Flood Damage Estimate (2016 CDN Dollars)

Location	Damage Reach	Return Period	Approximate Elevation (m)	Max Elevation (m)	Lowest Dyke Elevation (m)	Approximate Damage Cost (2016 CDN)[1,2]
North of CP Rail Bridge to Oxford Street	14	1:100	236.87	237.03	235.06	$382,000
		1:250	237.57	237.69	235.06	$1,558,000
Oxford Street to Empress Ave.	13	1:100	236.64	236.79	236.74	$3,627,000
		1:250	237.34	237.48	236.74	$9,799,000
Empress Ave. to South of Blackfriars Bridge	12	1:100	236.35	236.44	236.28	$14,931,000
		1:250	237.06	237.15	236.28	$16,654,000
South of Blackfriars Bridge to Queens Ave.	11	1:100	236.23	236.35	236.00	$25,067,000
		1:250	236.95	237.08	236.00	$26,842,000
Queens Ave. to Wharncliffe Bridge	9	1:100	235.93	236.06	235.73	$1,233,000
		1:250	236.61	236.75	235.73	$1,236,000
Wharncliffe Bridge to Cavendish	8	1:100	235.61	235.70	234.61	$4,862,000
		1:250	236.25	236.33	234.61	$5,496,000
Total Estimated Flood Damages		1:100				**$50,102,000**
		1:250				**$61,585,000**

1. Updated cost based on 2005 flood damage estimates adjusted by Consumer Price Index of 2.7% (averaged from 2005 to 2016).
2. Damage estimate based on boundaries noted in damage reaches.

As noted in Table 6.3, damage reach areas #8, 9, 11, 12, 13 and 14 all contributed to the total flood damage estimate for the West London Dyke. Damage Reach #10, while located at the Fork of the Thames, had no influence on the damage estimate as it contained no significant infrastructure that would suffer damage during a flood event. The majority of damage appears to occur along Damage Reach #11 and #12 where the majority of residential homes are located within the West London area. Figure 6.4 shows the respective flood damage reaches.

Although the Phase 1 Replacement (which is included in Damage Reach #11) was raised to the previous 250 year flood level (with additional 0.3 m freeboard), areas to the north within the same reach are at a lower elevation which results in overtopping of the dyke in the reach.



\\cd1217-f01\01655 Active\165500631 - West London Dyke Master Repair Plan\planning\drawing\GIS\165500631_RevMP_Fig6-4_DamageAreas.mxd
Revised: 2016-02-16 By: kbuchanan

February 2016
165630035

Stantec

Notes
1. Coordinate System: NAD 1983 UTM Zone 17N
2. Imagery and base features used under license with the City of London, © 2009-2015.

Legend

Damage Area

Elevation (m)

- 256 - 260
- 252 - 256
- 248 - 252
- 244 - 248
- 240 - 244
- 236 - 240
- 232 - 236
- 228 - 232

Client/Project

Upper Thames River Conservation Authority & City of London
West London Dyke Master Repair Plan

Figure No.

6.4

Title

Flood Damage Reaches

7.0 UPDATE OF 2007 AMENITY MASTER PLAN

7.1 DESIGN IDEAS

The following design guidelines, vision and general recommendations related to general planning initiatives and amenity upgrades are taken directly from the *West London Dyke Flood Control Structure Master Plan* (Stantec, 2007) with minor updates to make comments current. This document should be directly referenced for details related to the process undertaken to generate the resultant information. Specific reference to processes undertaken as part of the Phase 1 Replacement project, such as the design charette, have been omitted from this chapter.

7.2 DESIGN GUIDELINES

The design guidelines have been prepared to provide guidance for detailed design of the West London Dyke and Thames Valley Parkway redevelopment, extending from Oxford Street West to Cavendish Park. Examples and illustrations are provided to help give direction, but are not intended to presuppose specific design solutions, materials or products that are to be determined during the detailed design stages. The Master Plan Concept is provided as Figure 7.1.

This section discusses the following subjects:

- Vision;
- Areas of use;
- Wall structure;
- Natural environment;
- Heritage;
- Safety;
- Access to the river; and
- Gateways.

7.3 VISION

The following vision statement was prepared after examination of existing site conditions and the results of the consultation process. The vision will be achieved through implementation of the design guidelines.

LEGEND

- CIRCULATION NODE
- LAND MARK
- CITY OWNED LAND
- DYKE STRUCTURE
- LOOKOUT
- VIEW
- DESTINATION/ATTRACTION
- POINT OF INTEREST
- TRAIL CONNECTION
- POINT OF TRANSITION
- PEDESTRIAN CIRCULATION
- UNPAVED PEDESTRIAN CIRCULATION

RAILWAY TRACKS
PICCADILLY ST
ANN ST
MILL ST
OXFORD ST
GATEWAY FOR TRAIL / HIGHLIGHT CONNECTION
ST. PATRICK ST
ST ANDREW ST
EMPRESS AVE
ARGYLE ST
BUTTERFLY AND BIRD WATCHING GARDEN
TALBOT ST
JOHN ST
BARTON ST
LOOK OUT / HISTORICAL INTERPRETIVE SIGNAGE / ACCESS TO RIVER
BLACKFRIARS ST
HISTORICAL INTERPRETIVE SIGNAGE
GATEWAY FOR TRAIL / HIGHLIGHT CONNECTION
BLACK FRIARS BRIDGE
ENHANCED PLAYGROUND / SPLASH PAD AND SEATING
CUMMINGS AVE
VIEW TO BLACK FRIARS BRIDGE
ALBERT ST
CARROTHERS AVE
ACCESS TO RIVER
RIDOUT ST
WHARNCLIFFE RD
LESLIE ST
WILSON AVE
KENT ST
CHERRY ST
CHANDLER AVE
HARRIS PARK
LOOK OUT / VIEW OF HARRIS PARK
EXISTING TRAIL
TRANSITION
ROGERS AVE
MOUNT PLEASANT AVE
KENSINGTON AVE
INTEREST AT TOP OF WALL / SEATING / HIGHLIGHT
LABATT PARK
LABATT PARK
GARDEN
RIVERSIDE DR
QUEENS AVE
GATEWAY FOR TRAIL SYSTEM
RIDOUT ST
GATEWAY FOR TRAIL SYSTEM
WALL STREET
CAVENDISH PARK
CAVENDISH CRES
CAVENDISH CRES
THAMES RIVER
WALTER BLACKBURN MEMORIAL FOUNTAIN
BOARDWALK / SEATING / INTERPRETIVE SIGNAGE
INTERPRETIVE SIGNAGE
ACCESS TO RIVER
INTERPRETIVE SIGNAGE

0 20 40 60 80 100
METERS

Figure 7.1 Master Plan Concept

The West London Dyke is directly connected with both the culture and environment of the Forks of the Thames area in London. The natural processes of the river have been intertwined with culture throughout the City's history and they continue to play a part in everyday lives. In addition to the obvious need for improved flood control, the vision for the West London Dyke is to preserve the natural environment, historic character and cultural connections to the river, while creating a usable, attractive and distinct place within the City.

7.4 AREAS OF USE

The dyke and the land surrounding it has many uses for people, which include biking, running, walking, fishing, sitting, bird watching, playing, commuting and dog walking. Improvements for these uses and expanding the range of uses are important and necessary, but certain sections are better suited for particular activities. Four distinct areas along the West London Dyke have been identified as having different uses and are listed below:

1. Oxford Street West to Blackfriars Bridge
2. Blackfriars Bridge to Labatt Park
3. Labatt Park to Wharncliffe Road North
4. Wharncliffe Road North to Cavendish Park

7.4.1 Oxford Street West to Blackfriars Bridge

The top of the dyke between Oxford Street West and Blackfriars Bridge abuts a mixture of residential and park space. The dyke extends slightly to the north of the Oxford Street West Bridge as well. The areas adjacent to open space have been identified as having potential as gathering spaces. Access to the river and variations in the wall structure are desirable. Areas, which are in close proximity to houses, should be sensitive to such uses and minimize the potential for activities that would generate excessive noise or impact resident privacy.

7.4.2 Blackfriars Bridge to Labatt Park

The section between Blackfriars Bridge and Labatt Park abuts only residential land use. Because of the limited space and close proximity to houses this section should keep much of its existing character. The following points describe the items that can help achieve this.

- Maximize the landscape buffer to residences;

Figure 7.2: Playground at Cummings Avenue

- Minimize the number of gathering spaces and locate gathering spaces away from residential buildings / in higher visibility areas;
- Use of natural looking materials is preferred where it is practical and feasible;
- Implement informal native planting; and
- Preserve existing trees.

The only existing gathering space is a small playground located at the bend in Cummings Avenue (Figure 7.2). Serving an expanded use for play would make better use of this space.

7.4.3 Labatt Park to Wharncliffe Road North

The portion of the dyke and pathway system between Labatt Park and Wharncliffe Road North has been identified as a section that suits higher use because it runs next to Labatt Park and the open space around the Kiwanis Seniors' Community Centre. As mentioned previously, the pathway passes through Phase 4 of the Forks of the Thames project. As the Forks of the Thames will have a very different character and appearance from the dyke, the West London Dyke and Thames Valley Parkway redevelopment can be an extension of what will be high volume usage and should cater to people with a variety of interests. Look outs, gardens, and seating areas should be incorporated. Where the hard structure gives way to a natural edge, access to the river is desirable, but the existing edge condition should be preserved (Figure 7.3).

7.4.4 Wharncliffe Road North to Cavendish Park

The area between Wharncliffe Road North and Cavendish Park is the only portion with an unpaved pathway. This section abuts a residential area and the pathway leads into Cavendish Park and the Cavendish Nature Trail. The paved pathway should blend into the open space system making the required community linkages and support the recommendations of the recreational routes of the City of London Bicycle Master Plan. Unpaved side trails will be maintained in this area to preserve the character of the natural space.

7.5 WALL STRUCTURE

The West London Dyke structure is primarily an engineered structure to protect life and property during periods of extreme river flows. As such there are many technical considerations, which determine its functional design. Therefore, the design concept presented in this section is intended to complement the overall design and not to take precedence over functional considerations. The wall structure will have the most visual impact upon the area because of its sheer vertical size. Creating an aesthetically pleasing and interesting view from the east side of the river has been identified as a major consideration, as well as creating continuity throughout the structure and creating interest from across the river.

7.5.1 Wall Material

The wall material used in both Phase 1 and Phase 2 of the West London Dyke replacement was selected based on an extensive list of criteria. The pre-cast product gives the greatest chance for long-term availability to ensure continuity throughout the phases of the structure replacement process. A more natural look was created by selecting a large, gray style of block that resembles natural stone. The use of large wall blocks/modules rather than small helps to reduce the perceived scale of the wall. Because the dyke will be replaced in phases there is a possibility that the same wall material will not be available at such time that the next section is ready for construction. Accordingly, it is strongly suggested that sections are replaced in sequence to give the appearance of a seamlessly constructed structure or else replaced in sections allowing for logical termination points (i.e. bridges, natural edge areas, etc.).

7.5.2 Creating Interest

Creating an interesting, aesthetically pleasing and culturally significant structure is key to achieving the vision for the dyke. The wall should be visually varied, horizontally and vertically. Horizontal and/or vertical banding, possibly to indicate significant flood levels, could be considered. Planting at the toe of the slope would shorten the wall visually and give some softness to the hard structural components (Figure 7.4). The use of lighting on the wall face would give interest at night, but lighting should not shine directly on water, so it does not adversely affect wildlife. The application of shape and form to create interest should be strongly considered in the context of technical requirements of the wall construction. A smooth, natural curve to the wall (Figure 7.3) creating platforms at the top of wall or closer in elevation to the water would accomplish this. Large shade trees, plantings, railings and lighting will give interest and texture to the top of the wall and offset its overall dominance.

Figure 7.3: Natural Curve Observed in Existing Structure

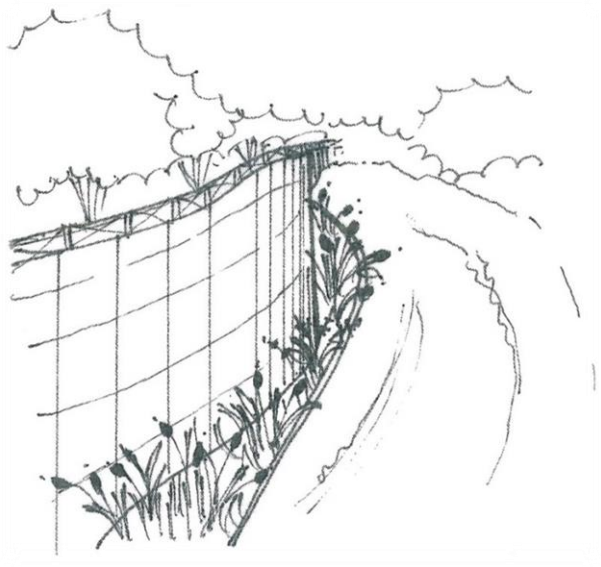


Figure 7.4: Curved Wall Gives Varying Amounts of Space Between Wall and Toe Structure

7.6 NATURAL ENVIRONMENT

The naturally vegetated areas along the water's edge and the native trees existing at the top of the wall are significant to the character of the dyke. The trees give shelter from the wind, shade from the sun, homes for wildlife, and provide a colourful and varied backdrop through the four seasons. Existing significant vegetation must be preserved and protected. Where appropriate the shape of the wall and/or pathway alignment should be altered to save trees of significance.

7.6.1 Environmental Enhancement

An attempt should be made to plant native aquatic material at the toe of the dyke structure that will soften hard surfaces and stabilize soils. Vegetation will introduce itself by means of erosion and deposition, so establishing desirable, non-invasive native species is valuable. An effort should be made to create habitat for aquatic and terrestrial life along the edge of the river where conditions allow for self-sustaining habitat. It is important to preserve and enhance all existing natural edges for this reason (Figure 7.5). If these remaining natural edges become unstable, bioengineering should be considered as a method of stabilization. Management of vegetation to remove invasive species will go a long way to reestablishing native plant diversity.

Figure 7.5: Natural Edge Condition between Dundas Street and Wharncliffe Road North

7.6.2 Urban Tree Management

Refer to the Dougan & Associates report for information related to the recommended urban tree management program for the West London Dyke. This report includes not only documentation of trees of significance, but also identification of areas in need of maintenance, plantings and/or removals.

7.6.3 Plant Design

Informal, natural plantings are suited for areas of lower use, particularly where the site borders on residential land use. Areas identified as gathering spaces should make use of more formal plantings to create emphasis. Native plant material should be used throughout to create continuity and protect the natural environment, but varying layouts can identify the intended use. Year round form and colour should be taken into consideration at the planting design stage. Planting should also be used to emphasize significant views. The creation of these views is discussed further in Section 7.6.5.

7.6.4 Signage

There is an opportunity to expand the existing interpretive signage program to incorporate information on natural systems and natural heritage in the area. Refer to Section 7.8 where the interpretive signage program is discussed further. Trail information signage should also be incorporated throughout the trail system. Suitable locations for signage are identified on the Master Plan Concept.

7.6.5 Views

Several significant views were identified as having connections with the river and natural heritage. These views should be preserved and enhanced. They have been identified in Section 7.8.1 along with suggestions for preservation and enhancement.

7.6.6 Bird and Butterfly Garden

The opportunity for users to participate in passive recreation activities was established as an important attribute of the trail system. Activities such as sitting, reading, people watching, bird and butterfly watching and walking are all considered types of passive recreation. A portion of the small open space at the end of St. Patrick Street is currently used as a community garden. It seems natural that this area be expanded to incorporate a seating area and a garden that attracts birds and butterflies. This would serve as a destination along the pathway.

7.7 HERITAGE

The West London Dyke and the surrounding area have a strong historic character. The most significant features to recognize are the existing Dyke itself, the Thames River, Labatt Park and Blackfriars Bridge. In addition, Eldon House and the Old Courthouse are important heritage buildings in the area. The dyke replacement is an opportunity to create a place, which provides information on the area's rich history while meeting the current needs of users.

7.7.1 Lighting and Site Furnishings

Through the consultation process it was determined that site lighting and furnishings should be consistent with the dyke's strong links to cultural heritage. The historic style of post and fixture (Figure 7.7) and existing light post base (Figure 7.8) were used as inspiration for the new light posts implemented in Phase 1 of the West London Dyke Replacement (Figure 7.6). The new light posts should be considered for future phasing implementation to create continuity along the dyke.

Figure 7.7: Historic Light Post

Figure 7.6: Phase 1 Light Post

Figure 7.8: Historic Light Base

All furnishings should be durable, vandal resistant and cohesive with the area's cultural heritage. The existing railing was also recognized as significant to the identity of the dyke (Figure 7.9). The master plan process indicated that the existing railing should be used as inspiration for the new railing design that will meet safety codes. Due to budget restrictions, project timeline and safety requirements, the railing implemented in Phase 1 and Phase 2 of the West London Dyke replacement was of a generic variety (Figure 7.10), but was designed to allow for custom design panels to be installed at a later date. The new railing design should be considered for future phasing implementation to create continuity along the dyke.

Figure 7.9: Existing Dyke Railing

Figure 7.10: New Dyke Railing, Complete with Inserts

In addition, the historic style bench (Figure 7.11) and trash receptacle (Figure 7.12) used in Phase 1 of the West London Dyke replacement should be used consistently in future phases to create continuity. Any other furnishings such as bollards that are implemented in future phases should be consistent with the historic style. The use of public art within destination areas or incorporating art within site furnishing design should also be considered.

Figure 7.11: Bench (Phase 1)

Figure 7.12: Phase 1 Trash Receptacle

7.8 SIGNAGE

An interpretive signage program for the dyke and pathway system exists and it is seen to be an inherent element to incorporate into and expand on in such a culturally rich area. The content of the existing interpretive signage program should be carried through, but it is suggested that a new format and unique appearance be implemented throughout the dyke and pathway system. This altered signage program should be in keeping with site lighting and furnishings, be durable, unique in appearance and vandal resistant. Consideration should be given to incorporating signage into the design of site elements (i.e., railings and pavement). Unique signage will assist in establishing the distinct character of the dyke. Suitable locations for interpretive signage are identified on the Master Plan Concept. Trail information signage is valuable and should be incorporated throughout the pathway system as well.

7.8.1 Views

It was determined that views of significance along the dyke and pathway system have direct links with cultural and natural heritage in the area. Significant views are identified below, along with suggested approaches to preserve/enhance these views.

- View of the Wharncliffe Road North Bridge, Thames River and the Fork of the Thames from Kiwanis – marked by lookout, seating area and interpretive signage (Figure 7.5);
- View of Dyke structure and Thames River from the Queens Avenue Bridge – implement attractive wall structure and a discrete, aesthetically pleasing transition (Figure 7.13);
- View of the Queens Avenue Bridge and the Fork of the Thames from outside of Labatt Park – look out and interpretive signage to remark on significant features (Figure 7.14);
- View into Labatt Park – mark with interpretive signage and seating area (Figure 7.15);
- View of Harris Park – look out and interpretive signage to allow users to stop along pathway (Figure 7.16, Figure 7.17);
- View of Blackfriars Bridge from the South – should not be obscured (Figure 7.18); and
- View of Blackfriars Bridge from the North – look out and interpretive signage to mark point of significance (Figure 7.19).

Figure 7.13: Phase 1 (from Queens Avenue Bridge)

Figure 7.14: View of Queens Avenue Bridge

Figure 7.15: View into Labatt Park

Figure 7.16: View of Thames River and Harris Park

Figure 7.17: View into Harris Park

Figure 7.18: View of Blackfriars Bridge (from South)

Figure 7.19: View of Blackfriars Bridge (from North)

7.9 SAFETY

Improved site features and pathway system improvements will increase the number of users. With this increase, improved safety becomes a very necessary consideration. Circulation, visibility, lighting and vandalism are among those items that must be addressed.

7.9.1 Circulation

The existing pathway system crosses five major streets, without any form of traffic control to give users the right-of-way. Not only is this dangerous, but it is inconvenient for pathway users. As identified in the City of London Bicycle Master Plan, access under road bridges would increase safety for pedestrians and cyclists and improve circulation for those who choose to use the pathway functionally as a green method of transportation. A continuous path encourages users, especially cyclists, to make use of a pathway system because of its convenience. For the reasons noted above, implementing pathways under each bridge should be given serious

consideration. The existing pathway also varies in width and material. As the pathway is redeveloped, its design should be consistent with City of London Standard Multi-Use Pathway to improve circulation, safety, and create continuity.

Figure 7.20: View West to the Wharncliffe Road North Crossing

7.9.2 Lighting

As noted earlier, lighting can aid in creating continuity and cultural connections with the dyke system in the daylight. In the evening hours lighting will not only create continuity, but will have a direct impact on the safety of the dyke pathway system. Pathway lighting is required along segments of the dyke because the overall park/pathway design and surrounding land uses have been developed to accommodate and encourage evening use by the public. This is a very different situation than other parks and pathway systems throughout the City.

The existing lighting system is not consistent and leaves dark patches due to the presence of overgrown vegetation or a lack of light posts and fixtures. The dyke system requires consistent lighting throughout. The use of full cut-off optics will help decrease light pollution to adjacent areas. Light post placement and the use of housing shields should be given careful consideration when adjacent to residential areas. It is important to note that pathway lighting does differ from the type, intensity, and spacing of lighting required for City roadways and does not necessarily need to be lit to the same standard.

7.9.3 Vegetation

Vegetation can play a role in how safe a pathway system is and how safe users perceive it to be. Existing vegetation and proposed planting should adhere to CPTED (Crime Prevention Through Environmental Design) principles.

7.9.4 Flood Response

Although not originally noted in the previous *West London Dyke Flood Control Structure Master Plan* (Stantec, 2007), access to the dyke as an area of potential refuge and escape from flooding should be considered in the design of any rehabilitated or replaced segments, as these relate to other previously noted items such as pathway design and lighting. Furthermore, access to the river via the dyke at key locations may require further consideration from a public safety perspective as a means to permit water rescue.

7.9.5 Vandalism

The existing dyke and pathway system has been subject to numerous acts of vandalism over the years (Figure 7.21). A reduction in vandalism can be achieved through appropriate lighting and site design. CPTED principles should be considered during design development in order to reduce occurrences of vandalism. Vandal-resistant site furnishings are available and should be used wherever possible.

Figure 7.21: Existing Sign Damaged by Vandals

7.10 ACCESS TO THE RIVER

It was identified that access to the river is very important to users, whether it is just to be near the edge to look into the water or to fish, feed the geese or canoe. Although the river can be more readily accessed from the east side of the river there are still several existing access points. Access is provided at Cummings Avenue (Figure 7.2) the Kiwanis Seniors' Community Centre and at Cavendish (Figure 7.23) and should be preserved/enhanced as described below. It becomes challenging to provide access where the wall structure exists.

7.10.1 Cummings Avenue

Access to the water is currently available, but not encouraged at Cummings Avenue. As noted previously, the natural vegetation in this area should be preserved and maintained. A wood chip path or gravel path should be provided to encourage users to stay on the path, and to reduce soil compaction and damage to plant material. Steps should be taken during design development to ensure that the water's edge is protected from pedestrian traffic. Access to cyclists should be restricted to protect the natural area from damage. Providing seating at the water's edge would allow for sitting, reading and fishing and should be incorporated.

7.10.2 Blackfriars Bridge

The area north of the bridge has been suggested as a possible location for access to the river by alterations to the design of the wall structure. This area has more room to work with than many other locations along the dyke. Figure 7.22 illustrates this concept.

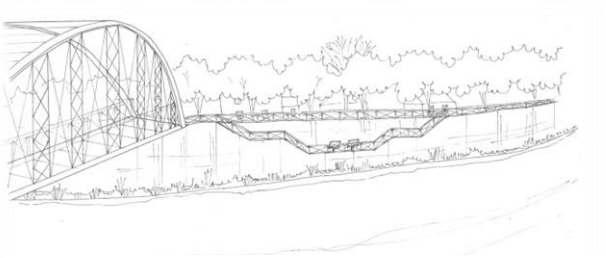


Figure 7.22: Sketch Illustrating Possible Outlook at Blackfriars Bridge

7.10.3 Kiwanis Seniors' Community Centre

The stretch between the Queens Avenue Bridge and the Wharncliffe Road North Bridge currently gives access to the river and has a natural edge condition. This natural edge should be maintained but this section has been identified as a place that would suit higher usage. There is potential for a discreet and unobtrusive boardwalk and lookout with seating and interpretive signage. Implementing a dock into the lookout for canoes and kayaks would expand the number of recreational activities in the area. Seating would allow for reading, people-watching and observing wildlife.

7.10.4 Cavendish Park

There is currently access to the river between Cavendish Park and east to where the hard structure of the dyke begins (Figure 7.23). This natural edge condition should remain in its present state or be enhanced. The existing edge gives an opportunity for fishing.

Figure 7.23: Pathway Looking West Towards Cavendish Park

7.11 GATEWAYS

Gateways have been identified on the concept plan at various locations where the pathway system intersects major roadways. These specific nodes have the opportunity to identify where the pathway system connects with major streets, while being aesthetically pleasing. The gateways should be in keeping with the aesthetic of the pathway system and dyke redevelopment initiatives. As these connections are where many pedestrians and cyclists enter the pathway, these are ideal locations for trail information signage.

7.12 GENERAL DESIGN RECOMMENDATIONS

The general recommendations found below detail how to specifically implement design recommendations, which apply to all phases of development. All recommendations, which apply, should be addressed during each phase of development.

- Options for creating a functional and interesting dyke layout and structure should be investigated during each phase of the redevelopment and accordingly be detailed in each set of tender documents;

- Confirm the suitability of naturalization plantings at the toe of the dyke for potential environmental enhancement throughout all phases of development;

- Investigate opportunities for naturalization planting areas for environmental enhancement during design development;
- Investigate opportunities for terrestrial and aquatic habitat creation during design development;
- Seating should be incorporated into the pathway system at regular intervals throughout all phases of redevelopment;
- Lighting and furnishing design, including signage, should consider design guidelines and be determined through design development;
- Significant views / lookout locations should be identified and confirmed at the site design scale, during design development for each phase of redevelopment;
- Investigate opportunities to implement pedestrian underpasses under all bridges within the study area where appropriate;
- Lighting design for all phases of the redevelopment should have consistent lighting types and levels to increase safety and should be adjusted to suit adjacent land uses;
- Consider Crime Prevention Through Environmental Design principles when preparing planting plans for all phases of redevelopment;
- CPTED principles should be considered for all phases of redevelopment to reduce the occurrences of vandalism and increase safety for its users;
- Investigate all opportunities during each phase of the redevelopment to provide access to the river for a broad range of activities;
- Functionality and aesthetics should be key design considerations for any transitions in all phases of development;
- The buffer between residences and the pathway system should be maximized during all phases of design development;
- The wall layout determined through the design development stage should consider both technical requirements and the recommendations given in the design guidelines regarding shape and composition. Where possible it should be varied to create interest and give adequate room at the top of wall for things such as lookouts, buffers and gathering spaces; and
- Public input should be solicited for each phase of the dyke replacement.

7.13 FUTURE PHASING IMPLEMENTATION

The design guidelines and recommendations in the following documents should be considered / incorporated during future phasing implementation:

- "The City of London Bicycle Master Plan: Planning and Design Guidelines", (MMM Group, Stantec Consulting Ltd., August 2007);
- "The City of London Parks and Recreation Strategic Master Plan", (Monteith Brown Planning Consultants, Tucker-Reid & Associates, The JF Group, November 23, 2009); and
- "Thames Valley Corridor Plan" (Dillon Consulting, DR Poulton and Associates Inc., 2011).

7.13.1 Bicycle Master Plan

The City of London Bicycle Master Plan identifies Riverside Drive (turns into Dundas Street and Queens Avenue going east) as a primary bicycle commuter route which cross the West London Dyke pathway system. Cyclist access to the pathway system should be encouraged from Riverside Drive.

The Master Plan also identifies the West London Dyke pathway system as a Secondary Recreation Route. It is essential that cyclists and pedestrians have access to the pathway system from all community access points. The West London Dyke pathway system is an important route that in the future will connect communities along the west side of the Thames River, west to Cavendish Park and north to the University of Western Ontario.

8.0 ENGINEERING REVIEW

8.1 GENERAL

As part of the technical component of the Master Repair Plan study, a general engineering evaluation of the West London Dyke was undertaken. The intent of the engineering review was to establish the following:

- The current condition of the West London Dyke through a review of previous investigations and monitoring inspections;
- Information on the geotechnical characteristics of the site through literature review;
- Information related to potential legacy issues relating to environmental impacts based on past project experience and available documentation;
- Potential maintenance and constructability issues associated with the dyke;
- Requirements for approvals and permits;
- General guidelines for future works based on previous criteria established through the Phase 1 Replacement project; and
- Requirements or recommendations related to future engineering studies.

Additional information related to each of the above noted items is provided in the following sections.

8.2 PAST INVESTIGATIONS AND INSPECTIONS

A review of past documentation was undertaken in order to provide general characteristics related to the West London Dyke. The information provided herein may not represent current conditions and should not be interpreted as a definitive assessment of existing conditions, as these may vary over time and may also vary between test locations, where testing has been carried out. The intent is to provide an understanding of the surface and subsurface conditions along the project area and how these conditions may impact upon the current state of the existing dyke and requirements for future work.

General information on these previous studies is provided in chronological order in the following subsections based on information provided.

8.2.1 Geotechnical Work Undertaken in the 1980's

Prior to work undertaken as part of the Phase 1 Replacement Structure in 2007, the only record of any major rehabilitation work to the concrete revetment involved a multi-year program from 1983 to 1986 undertaken by Delcan Corporation and Golder Associates. The following documentation relating to this work was reviewed:

- Golder Associates Report to Delcan Geotechnical Investigation Bank Stabilization Study, Forks of the Thames, London, Ontario, October 1982 (report #821-3056);
- Delcan Report Bank Stabilization Study, Forks of the Thames, London, Ontario, February 1983 (report #07-1386);
- Delcan Report Bank Stabilization Study, Forks of the Thames, London, Ontario – Phase II, March 1984 (report #07-1418);
- Golder Associates Report to Delcan Geotechnical Investigation Proposed Repairs to Concrete Revetment and Erosion Control Work - 1986 Forks of the Thames, London, Ontario, March 1986 (report #851-3282); and
- Golder Associates Report to Delcan Repairs to Concrete Revetment, Forks of the Thames Phase III, London, Ontario, November 1986 (report #851-3282-1).

The Bank Stabilization Study involved the evaluation of bank stabilization over approximately 4.5 km of river banks extending on both sides of the Thames River. The Golder Associates' reports relate to the initial geotechnical investigation and subsequent monitoring during the repair work. In general, work pertinent to the west river bank was divided into two sections, concrete lined and un-lined.

Based on the results of the investigations, the following items were noted relevant to the West London Dyke:

- Boreholes advanced along select areas of the dyke revealed up to 6 m of fill overlying sand or sand and gravel. Along the revetment areas, the boreholes encountered clayey silt to silty clay tills to termination;
- Revetment panels with substantial movement producing a broken back slope were observed at the north end at Rogers Avenue during the 1982 investigation. Documentation provided in preparation of the report also suggested voids of up to 1 m in depth behind revetment panels in the vicinity of the Queens Avenue Bridge;
- Vegetated slopes along the unlined segment of dyke (between the Dundas Street and Wharncliffe Road North Bridges) appeared to be stable and showed no signs of instability. No additional geotechnical investigation was completed along this area;

- The concrete revetment was generally found to be in fair to poor condition. In general, revetment in fair condition was categorized for very minor shifting of panels which caused some localized cracking, wider than normal joint separation and minor changes in slope inclination. The toe wall was noted as being intact and relatively stable. Concrete revetment in poor condition was noted for shifting and tilting of concrete panels and major abrupt changes in overall slope inclination with associated cracking and panel distortion. The toe wall was also considered to be ineffective in supporting the panels;

- No sufficient deterioration of the concrete revetment was noted during the 1982 visual assessment of the dyke structure;

- Six concrete cores were recovered during the 1982 investigation from two separate locations along the revetment. Compressive strength testing of the cores revealed strengths ranging from 16.8 MPa to 59.9 MPa. Additional testing conducted on the core samples indicated little to no air entrainment at either location;

- The initial geotechnical investigation report (October 1982) recommended that fair condition panels undergo rehabilitation by providing additional support beneath the slab and to the toe, sealing of all cracks and joints, and provision of positive drainage for the subgrade through the revetment slab. Panels considered to be in poor condition were recommended for replacement; and

- Revetment panels reviewed during the March 1986 report were evaluated by means of a drilling and probing program. Penetration depth of the probe within areas along the west bank of the north branch varied from 30 to 790 mm. Recommendations for revetment repairs generally consisted of grout injection with the placement of precast concrete blocks along the toe wall as a means for providing toe protection.

The Golder Associates report dated November 1986 summarized the geotechnical testing and inspection performed during the 1986 repair program. This repair program generally consisted of toe rehabilitation and support from Queens Avenue Bridge extending approximately 165 m upstream and grouting of voids behind the concrete revetment panels to provide support. The intent of the grouting program was to extend the lifespan of the panels for approximately 30 years.

No panel replacement was completed at that time, despite recommendations for replacement for areas where known voids exceeded 15 cm (0.15 m) in depth.

8.2.2 2004 Inspection of Flood Control Structures

In 2004, the UTRCA identified seven dyke structures, including the West London Dyke, as requiring periodic inspections in an attempt to determine the general condition and to identify future maintenance requirements. The need for a condition assessment recognized the potential

susceptibility of these structures to deterioration over time due to environmental conditions. Stantec was ultimately retained to undertake the study and provided the UTRCA with the following:

- Preparation of an inspection protocol with the development of an inspection sheet based upon non-intrusive visual observation;
- Assessment of the current condition of each structure to allow the UTRCA to undertake periodic inspections in the future or to respond to incidents with baseline data on the 2004 condition of the structures;
- Cost estimates for repair and/or maintenance to each dyke structure and the recommended timing for this work; and
- Recommendations relating to the frequency for subsequent periodic inspections for each structure.

Based on the 2004 review which consisted of a non-intrusive investigation of the entire length of the dyke, several sections of concrete revetment were observed to be in poor condition and a recommendation was made to conduct additional intrusive investigations and determine an appropriate repair strategy. Additional deficiencies relating to the pathway, railing, and gabion baskets within the vegetated portion of the dyke were also observed.

8.2.3 Geotechnical Work Undertaken as Part of the Phase 1 Replacement Project

In 2005 a geotechnical investigation was completed by Trow Associates Inc. (West London Dyke Concrete Assessment, dated May 2005, report #LNGE00007940A) along select areas of the concrete revetment between the Queens Avenue Bridge and Rogers Avenue. The intent of the investigation was to confirm the condition of existing concrete panels in order to establish a repair program as recommended by a 2004 visual inspection of the area.

The work plan consisted of the following:

- Examination of the study area including delaminated areas of the concrete revetment through visual observation, hammer tap (surface sounding) and chain drag;
- Recovery of eight core samples at select areas based upon the findings from the 2004 inspection and subsequent site review; and
- Recovery of subgrade material at the location of cores for additional review.

In summary, the Trow investigation reported:

- Results from the surface sounding program indicated areas of surface delamination, surface misalignment, surface deterioration, sunken zones, bulging zones, and prominent cracks and holes;
- All core samples recovered were noted to contain a shattered zone varying in depth;
- Of the eight cores advanced, three could not be penetrated to full depth due to the weak condition of the concrete below 100 mm;
- The remaining cores penetrated the soil fill, which appeared to consist of loose, brown, cohesive silty sand;
- The fill beneath four of the cores was easily probed to a depth of 1.4 m;
- Compressive tests performed on the only two cores where the required minimum solid section was recovered revealed compressive strengths of 15.4 MPa and 6.7 MPa respectively;
- Only two of the eight cores revealed grout at the bottom of the core; and
- Large voids and porous concrete was noted in the majority of the cores recovered.

Additional comments noted in the Trow memorandum titled *Supplementary Comments Riverside Drive Dyke* indicated that the results from the compressive strength tests were less than the typical concrete strength for this class of concrete (20 MPa). Based on a materials testing standpoint, the memorandum stated that the concrete likely had reached the end of its life cycle.

8.2.4 2005/2006 Inspection of Erosion Control Structures in the City of London

A review of existing erosion control structures was undertaken by Stantec between 2005 and 2006 at the request of the UTRCA. The intent of the investigation was to develop a similar inspection protocol for erosion control works within the City of London as had been developed for the dyke structures through the 2004 review. As part of this investigation, the north bank of the main branch of the Thames River, west of the forks and located between Dundas Street and Wharncliffe Road was identified as requiring review.

This section of erosion control had also been reviewed during the 2004 inspection, and therefore findings from the updated review were compared to the previous baseline results.

In general, findings revealed the area to be in fair to good condition with only localized damage observed to gabion baskets along the river. Recommendations were also provided

with respect to the need to install a protective barrier along the pathway in the vicinity of the Wharncliffe Road Bridge due to the steep slopes noted immediately adjacent.

8.2.5 2005 Geotechnical Investigation – Phase 1 Replacement Structure

A geotechnical investigation was completed as part of the preliminary design for the Phase 1 Replacement project in order to characterize the subgrade soils and groundwater conditions within the study area and to determine the slope stability of the existing dyke structure. The result of the work is presented in the Trow Associates Inc. report Geotechnical Assessment *West London Dyke, London, Ontario* dated April 19, 2006 (report #LNGE00007940A).

The investigation revealed the following:

- Boreholes advanced along the top of dyke encountered approximately 6 m of loose to very loose silty sand fill with trace gravel overlying compact to dense sand and gravel. Beneath the sand and gravel, the boreholes generally encountered dense to very dense silt till;

- Short term groundwater level observations indicated groundwater to be generally within the sand and gravel layer at a depth of approximately 6 m (Elevations 229 to 230 m). Fluctuations in groundwater level were expected to vary with changes in river water levels and periods of wet weather;

- No significant stability concern was anticipated for the toe in the near to medium term, however ongoing maintenance and observation was recommended to ensure the integrity of the structure;

- Based upon the results of the slope stability analysis, the worst case event occurred with a 100-year flood followed by rapid draw down of the river level. This resulted in a factor of safety below 1;

- For moderate annual flood events, factors of safety were above 1, but below the recommended 1.4 as per UTRCA standards and the Ministry of Natural Resources report "Geotechnical Principles for Stable Slopes". Factors of safety for small localized failures of the face were below 1 and appeared to correlate to general bulging noted along the lower panel above the toe apron;

- The friction angle of the silty sand fill is 29 degrees, which is less than the existing slope inclination; and

- To increase the slope stability of the dyke, the filled zone must be strengthened or replaced with approved granular backfill. Some form of toe protection should also be implemented to key into the competent native till.

8.2.6 2006 Inspection of Concrete Revetment Structure

In 2006, the UTRCA retained Stantec to conduct an updated assessment of the concrete revetment component of the West London Dyke. This updated inspection included the area of dyke between Oxford Street West to Rogers Avenue, and a small segment of revetment west of the Wharncliffe Road North Bridge. The review excluded the previously identified segment of dyke between the Queens Avenue Bridge and Rogers Avenue which was identified for replacement. The intent of the investigation was to update the results from the baseline investigation from 2004 utilizing the same inspection protocol developed as part of the previous study.

Based on the results of the investigation, several new deficiencies to the concrete structure were observed compared to the 2004 findings and recommendations related to appropriate corrective actions and additional review were provided to the UTRCA.

8.2.7 2010 – 2014 Inspection of Concrete Revetment Structure

Visual assessments of the concrete revetment components of the West London Dyke were undertaken annually between 2010 and 2014 utilizing the inspection protocol. The purpose of these reviews was to confirm any further changes in the condition of the concrete revetment in comparison to previous reviews. Results of these investigations were provided in annual reports and excluded the modular block wall constructed as part of the Phase 1 West London Dyke Replacement Project.

Based on the results of these investigations, significant additional deficiencies were noted in both delamination/deterioration and bulging/cracking of the concrete panels and toe over the previous investigations. Recommendations relating to each deficiency were generally divided into the following three main categories:

- **Monitor**: Item requires regular monitoring. Visual monitoring utilizing the inspection protocol (non-intrusive) was recommended annually or until subsequent results indicate the need for additional review (i.e., hammer tap), intrusive testing (i.e., coring), or repairs.

- **Additional Investigation and Repair**: Item required more detailed monitoring in addition to the visual assessment due to the current condition and the potential for further damage. Intent of additional investigation was to determine extent and type of repair required. Additional investigation may consist of chain drag and/or concrete coring. Information may be used to establish a common repair methodology for similar deficiencies which can be utilized for future areas requiring repair. Note: In general, deficiencies noted during the review that required additional investigation and repair were located either along the concrete toe structure or underneath the bridges. These areas exhibited evidence of change in comparison to previous inspections; however, no signs of soil loss were observed. Given that the damage is located along areas that, if left unattended, could result in substantial damage or failure, it was recommended that

the additional investigation be performed as early as possible to assess whether further repairs should be undertaken.

- **Repair**: Item required repair. This work was generally well defined and, as such, did not require further investigative work. Examples include rail and post repair, and concrete repairs. As a minimum, damaged rails and posts should be repaired immediately to prevent failure and possibility of a public safety hazard. Note: Concrete deficiencies that required repair were generally located along the concrete toe structure with select areas observed underneath the bridges. These areas exhibited damage extending to the full depth of the concrete, resulting in soil exposure or resulted in the exposure of wire mesh and rebar. Given that the damage is located along areas that, if left unattended, could result in substantial damage or failure, it was recommended that the repairs be performed as early as possible.

8.2.8 Phase 1 Bolt Monitoring Program

Following the completion of the Phase 1 structure extending from the Queens Avenue Bridge north to Rogers Avenue, Stantec and Golder Associates Ltd. established a monitoring program which consisted of the following:

- Initial Set Up & Baseline Monitoring
    - Placement of two bolts within the face of the retaining wall structure one below the cap stone and the other above the base. The location of the bolts represented the most likely zone for movement of the structure due to toe shifting or geogrid failure,
    - Each set of bolts was installed at approximately 15 m intervals along the retaining wall structure to provide adequate coverage,
    - Establishment of a site benchmark for ongoing monitoring,
    - Completion of a survey of the bolts to establish their baseline horizontal and vertical position,
    - Preparation of the bolt position survey in AutoCAD and in a spreadsheet detailing the horizontal and vertical position of each bolt,
    - Preparation of an initial report detailing set up, defining thresholds for bolt movement, outlining the periodic monitoring program and preparing a template for future reporting; and
- Follow Up Monitoring
    - An updated survey of the bolts to establish their horizontal and vertical position,

- Preparation of the bolt position survey in AutoCAD and in a spreadsheet detailing the horizontal and vertical position of each bolt,

- Preparation of a monitoring report detailing any changes between the updated survey results and baseline data and recommendations for the frequency of additional review.

The initial set up and baseline data was obtained in November 2009. Follow up monitoring was carried out in June 2010, June 2013 and May 2015. A comparison between the May 2015 survey results and baseline measurements from November 2009 indicated minor differences in horizontal and vertical readings beyond the accuracy range of the survey equipment. Additional comparisons to previous follow up survey results from 2010 and 2013 were also undertaken.

Based on the results, the following comments and recommendations were provided:

- A significant length of the Phase 1 structure, within Sections 9 to 21, appeared to indicate movement of the wall towards the east (towards the river). There was no distinct correlation to construction activity that could explain these readings. Further follow up review was suggested and subsequent bolt monitoring was recommended;

- In general, the majority of variations from baseline results occurred in easting readings with little to no noticeable variations beyond equipment tolerance and estimated human error observed with the northing and vertical measurements;

- Tolerance of +/- 2 mm is in respect to equipment accuracy but may not reflect potential additional error attributed to reference markings on survey bolts nor movement with the bolt itself. Note that each survey bolt consisted of approximate 1 mm wide markings used as the reference point. It is estimated that additional +/- 2 mm error should be allowed for to reflect potential referencing (human) errors;

- Additional monitoring on a semi-annual to annual basis should be undertaken to confirm whether any further variations are observed, primarily if differences are noted beyond the +/- 4 mm tolerance (equipment plus bolt accuracy errors) from baseline data. In the event that subsequent monitoring should indicate little to no movement, the frequency of the survey review can be reassessed;

- Additional errors attributed to the horizontal and vertical control monuments should be considered when reviewing results. In addition, it is possible that, over time, the monuments may become damaged or may vary from previous readings. It should be noted that the vertical and horizontal monuments were last updated in May 2013, but that neither coordinate varied from the previous inspection by the City; and

- If larger variations are observed, survey bolts should be reviewed to confirm whether any potential movement has occurred (i.e., loose bolts, movement due to freeze/thaw

action, etc.). At that time, a visual investigation should also be completed to determine any potential indicators of movement including possible cracking of the modular blocks, seepage through the joints, settlement of the walkway, differential movement along the railing, settlement of areas behind the dyke, and/or signs of soil loss.

8.2.9 London Earth Dykes Stability Review

The *London Earth Dykes Stability Review (AECOM, LVM)* was completed in 2013. The purpose of the study was to conduct a technical assessment of the existing geotechnical stability of the dykes and to provide recommendations for the long-term planning and maintenance of the London earth dykes. The technical assessment included the following components:

- Field inspection and condition assessment of the dykes, including observations of erosion, excessive or hazard vegetation, visible infrastructure, encroachments, and other identifiable features;
- Research into standards and guidelines employed for the management of dykes in other jurisdictions and preliminary recommendations for dyke standards to be applied for the management of the London Dykes;
- Development of engineering base plans and profiles to characterize dyke geometry and provide a basis for future design efforts;
- Development of a generic Operations, Maintenance, and Surveillance (OMS) manual for the ongoing management of the dykes;
- Geotechnical boreholes and soil testing to characterize the structural properties of the dyke fill;
- Environmental testing of selected soil samples to characterize potential contamination issues to be considered during dyke improvement works; and
- Dyke stability analysis based on the technical data collected to determine the stability safety factors at representative locations along the dykes. The stability analysis considered four different loading conditions at each of the representative locations.

The study identified that the West London Dyke (Station 0+525 to 0+980 and Station 1+825 to 1+985) did not meet the recommended factors of safety for the outside/riverside slope under dry conditions. Six sections of the West London Dyke were also prioritized for implementation of stability improvements. In addition, a visual condition assessment was undertaken which identified several areas with a condition score of 2 (out of 5) indicating issues related with erosion, excessive vegetation, slope failure and condition issues. These condition ratings were similar to those observed during previous annual inspections of the West London Dyke.

Findings from the *London Earth Dykes Stability Review* pertinent to the West London Dyke are presented in Table 8.1 below. Corresponding segments as defined in the Master Repair Plan are provided in bold. Further evaluation and explanation of these findings can be found in the *London Earth Dykes Stability Review* report (AECOM, LVM, 2013).

Table 8.1: London Dyke Rating Analyses

Dyke Section	Overall Condition Rating	Dyke Stability Analysis Results	Comments and Recommendations
Sta. 0+000 to Sta. 0+525 (Oxford Street to Blackfriars Bridge) **St. Patrick's / Blackfriars**	2 to 3	Dyke Outside Dry, FS = 1.1 Dyke Inside Dry, FS = 2.9 Dyke Outside, Rapid Drawdown, FS = 0.4 Dyke Inside with Seepage, FS = 1.2 (Analyses at Borehole WL18)	Condition rating reflects deterioration and movement of concrete panels, and loose fill. Recommend monitoring and repair of deficiencies with eventual full replacement of concrete dyke facing or reconstruction of dyke with geogrid reinforced precast concrete block wall.
Sta. 0+525 to Sta. 0+980 (Blackfriars Bridge to Rogers Avenue) **Blackfriars / Natural Bank / Labatt Park**	2 to 3	Dyke Outside Dry, FS = 1.0 Dyke Inside Dry, FS = 2.9 Dyke Outside, Rapid Drawdown, FS = 0.5 Dyke Inside with Seepage, FS = 1.8 (Analyses at Borehole WL15)	Condition rating reflects deterioration and movement of concrete panels, tree growth at joints, and loose fill. Recommend monitoring and repair of deficiencies with eventual full replacement of concrete dyke facing or reconstruction of dyke with geogrid reinforced precast concrete block wall.
Sta. 1+350 to Sta. 1+805 (Riverside Drive to Wharncliffe Road) **Wharncliffe**	3	Dyke Outside Dry, FS = 1.4 Dyke Inside Dry, FS = 2.7 Dyke Outside, Rapid Drawdown, FS = 0.5 Dyke Inside with Seepage, FS = 1.6 (Analyses at Borehole WL8)	Condition rating reflects presence of loose fill, relatively steep banks, fallen trees and hazard trees.

Dyke Section	Overall Condition Rating	Dyke Stability Analysis Results	Comments and Recommendations
			Recommend removal of hazard trees, flattening of slopes on outside and toe erosion protection at riverbank.
Sta. 1+825 to Sta. 1+985 (Concrete panel section west of Wharncliffe Road) **Cavendish East**	2 to 3	Dyke Outside Dry, FS = 1.0 Dyke Inside Dry, FS = N/A Dyke Outside, Rapid Drawdown, FS = 0.4 Dyke Inside with Seepage, FS = N/A (Analyses at Borehole WL6)	Condition rating reflects cracking, spalling and bulging of concrete panels with vegetation growth at joints, and loose fill. Recommend monitoring and repair of concrete panels as required. Toe scour should be checked. Eventual replacement of concrete panels or construction of a geogrid reinforced precast concrete block wall.
Sta. 1+985 to Sta. 2+035 (Section with rip rap facing) **Cavendish East**	3	Dyke Outside Dry, FS = 1.3 Dyke Inside Dry, FS => 3.0 Dyke Outside, Rapid Drawdown, FS = 0.5 Dyke Inside with Seepage, FS = 1.6 (Analyses at Borehole WL4)	Condition rating reflects presence of steep bank, older unmaintained rip rap, vegetation growth, loose fill and toe erosion. Recommend removal of trees from rip rap and placement of additional rip rap to fill voids as required.
Sta. 2+035 to Sta. 2+275 (West end) **Cavendish East**	3	Dyke Outside Dry, FS = 1.4 Dyke Inside Dry, FS = 2.4 Dyke Outside, Rapid Drawdown, FS = 0.8 Dyke Inside with Seepage, FS = 1.0 (Analyses at Borehole WL1)	Condition rating reflects presence of overgrown vegetation, hazard trees, impaired access, encroaching buildings, loose fill, erosion at riverbank and

Dyke Section	Overall Condition Rating	Dyke Stability Analysis Results	Comments and Recommendations
			unmaintained storm outfalls. Recommend placing toe erosion protection along riverbank west of Sta. 2+175, replacement of existing storm sewer outlets, and removal of trees and overgrown vegetation.

8.3 LEGACY ISSUES/CONCERNS

Construction of portions of the West London Dyke commenced in the late 1800's to early 1900's. Historical records reviewed as part of the Phase 1 Replacement Structure project indicated that portions of the earth berms were constructed by means of fill placement of unknown quality. Additional review of available mapping and aerial photography dating to 1922 also indicated former roadways along what is now the top of dyke structure and the potential for contamination beneath roadways of that era was particularly high due to the common practice of dispensing waste oil as a dust suppressant. Accordingly, the risk of environmental impact of the subsoil is considered moderate to high along areas of the dyke.

During excavation relating to the Phase 1 Replacement structure, impacted soil was discovered. The impacted soil was attributed to suspect fill used to construct the original dyke structure in the early 1900's and generally consisted of cinder material, stained soil, shingles, bricks, glass, and miscellaneous garbage. In order to determine the appropriate disposal requirements for this material, composite samples were recovered for laboratory analysis. In total, four distinct impacted areas were visually observed during excavation and were individually sampled and analyzed for indicator parameters consistent with the visual characterization of the material recovered and site history. The results of each analysis were compared to applicable MOECC standards in accordance with the Environmental Protection Act to assess whether contamination was present. Based on the results, significant impact attributed to metals and petroleum hydrocarbon contamination was determined to be present, requiring that the soil be removed and disposed of at a landfill at waste material.

A review of existing documentation on the West London Dyke also revealed potential impact in an area extending south from Charles Street to Cavendish Crescent, which includes parts of West Lions Park and Cavendish Park. Information suggests that the natural watercourse from West Lions Park extending to the river was enclosed with a storm sewer pipe and backfilled with

unknown fill material. In addition, the area south of Walnut Street and west of Cavendish Crescent was filled with garbage in 1946 in order to widen and strengthen the breakwater for flood control purposes. Accordingly, this area is regularly tested for methane as part of the City's ongoing methane monitoring program.

As previously discussed, there exists the possibility that future works may encounter impacted soils due to the historic land use in the area. As a result increasingly stringent regulations relating to the disposal of such soils, the cost for remediation may significantly alter the construction cost estimate and should therefore be considered during the preliminary design phase for any portions of the dyke. Since the implementation of these more stringent guidelines, the City of London has revised their tender documents to include costing for the excavation and disposal of impacted materials. In addition, initial geotechnical investigations which have typically been completed as a precursor to the detailed design phase now includes requirements for environmental screening and testing in order to qualify the nature of the subsoil. While this approach will not eliminate the risk that unexpected contaminated soil may be encountered, it does provide a general indicator of potential environmental impacts and a means to address these additional costs, which can be significant.

Conceptual cost estimates related to future works are included in the overall cost projections provided in Section 9.

8.4 EXISTING MUNICIPAL INFRASTRUCTURE

Various types of municipal infrastructure are present either within or in a close vicinity to the West London Dyke. If this infrastructure was compromised due to flooding or overtopping of the dyke, or through localized failure or damage during construction, repair costs could be significant.

Given the presence of infrastructure along the dyke, it is critical that appropriate planning of future repairs/replacement to the dyke or repairs/replacement to the infrastructure be carried out in consideration for one another. For example, the decision to construct future replacement structures utilizing geogrid reinforcement (as with the Phase 1 Replacement Structure) may impact placement of utilities or maintenance of utilities if not properly planned as geogrids cannot be cut without compromising the structural integrity of the dyke/wall.

If future replacement of the dyke occurs, consideration for oversizing of the infrastructure may be necessary on a case by case basis and this should be coordinated during the preliminary design phase with the utility provider.

Known infrastructure located either through or along the West London Dyke is listed in Table 8.2. This information has been assembled from available data and, as such, may not be representative of complete conditions. It is recommended that utility locates be conducted early in the preliminary design phase in order to confirm the presence of infrastructure within the area under review.

Table 8.2: List of Key Infrastructure

Utility/Service	Size	General Location
Storm Sewers *(Including various seepage drains located along the dyke face)*	450 mm diameter	Near St. Patrick Street
	300 mm diameter	Near Rogers Street
	600 mm diameter	
	1050 mm diameter	West of Wharncliffe Road North Bridge
	450 mm diameter	West of Wharncliffe near Cavendish Crescent
	1200 mm diameter	West of Cavendish Crescent and City yard
Sanitary Sewers *(Including various sanitary manholes and appurtenances in the vicinity of the dyke)*	900 mm diameter *(crossing Thames River)*	Near St. Patrick Street
	300 mm diameter *(crossing Thames River)*	South of Dundas Street Bridge
	900 mm diameter *(crossing Thames River)*	
	1050 mm diameter *(along north bank of Thames River)*	West of Wharncliffe Road North Bridge
	300 mm diameter *(crossing Thames River)*	Near Cavendish Park
Watermains *(Including all appurtenances)*	300 mm diameter	Along Oxford Street West Bridge
	300 mm diameter	Along Queens Avenue Bridge
	300 mm diameter	Along Wharncliffe Road North Bridge
Bridges	4 Lane	Oxford Street West Bridge
	Single Rail	CP Rail Bridge
	2 Lane	Blackfriars Bridge (historical landmark)
	2 Lane	Queens Avenue Bridge
	2 Lane	Dundas Street Bridge
	4 Lane	Wharncliffe Road North Bridge
Hydro	Pole Line Circuit	Crossing Thames River from St. James Street to Beaufort Street and running South along

Utility/Service	Size	General Location
		the west side of the river
	Pole Line Circuit	Crossing Thames River from Ann Street to St. Patrick Street (plans for future additional circuit crossing at this location, and to run north along the west bank)
	Pole Line Circuit	Crossing Thames River parallel to Wharncliffe Road North Bridge (on west side)
	Underground Duct Structure & Cables	Along north side of Thames River east of Wharncliffe Road North
Gas	Gas main present immediately upstream of Blackfriars near Empress Avenue	Additional gas services may be present, to be confirmed during preliminary design phase
Bell	Not known at this time	To be confirmed during preliminary design phase, not anticipated to impact review of options as Bell service can be relocated if necessary
Flood Structures	2.3 km	West London Dyke

Note:

1. Table 8.2 should not be interpreted as an exact representation of all features and utilities that may be present along the West London Dyke or immediate vicinity. The data provided is for information purposes only and should not be used for detailed design. Location and extent of services must be confirmed through utility locates.

In addition to the utilities/services noted above, the following additional infrastructure is present along the West London Dyke area:

- Walter J. Blackburn Memorial Fountain; and
- Municipal parks (including playground equipment, benches, buildings).

8.5 CONSTRUCTABILITY

There are generally three main issues with respect to constructability:

- Access for construction vehicles to and from the "site" (i.e., for hauling of materials);

- Adequate room to allow the Contractor to stage the project (i.e., adequate room for stockpiled material excavated, delivered material, trailer, etc.); and

- Adequate room to physically construct or place the structure.

Site access and construction staging, whether it is for repair or for replacement, has the potential to be problematic along the West London Dyke due to the proximity of residential properties. During the Phase 1 Replacement project, the Contractor was able to access and make use of Labatt Park for staging activities. For future work, in particular areas to the north of Rogers Avenue, access to the site would generally be limited to the residential streets that run perpendicular to the dyke. The impact of these temporary haul routes would need to be considered during each phase of work and properly planned to minimize damage to the roadways and disruption to the public. Depending on the exact location of repair or replacement, municipal park land may be required for temporary construction staging and therefore these impacts would also need to be addressed in terms of short term disruption to public use and potential additional costs for repair to these areas following construction. Working easements may also be necessary, and would require coordination and approval from impacted landowners.

In terms of constructability and based on a review of existing survey and legal information, there is presently as little as 5 m between existing property lines and the top of the dyke structure. While the distance between the top of dyke and existing property lines is not provided for each segment, the distance from toe to property line is listed in Table 8.5. Depending on the type of structure chosen, the top of dyke distance may vary whereas the distance from toe should not. Although it is difficult to predict the exact distance required for construction or repair at this time (as the exact methodology for repair or replacement is a detailed design issue), it is anticipated that significant space will be required to allow for the following:

- Maintenance of safe slopes from the property line to the working area (based on information to be provided through geotechnical review);

- Potential for wider pathways to meet current City standards;

- To raise the dyke structure to the Regulatory Flood Level, which may require additional room for grading behind the structure to property line and/or space to accommodate structural elements (i.e., Phase 1 Replacement Structure required approximately 6 m of geogrid from the face of the modular block extending behind the structure);

- To implement any other initiatives as may be established through the preliminary and detailed design phase; and

- To avoid or otherwise protect existing vegetation along the dyke, including mature vegetation present along the natural bank, adjacent to Cavendish Park, within the area of accretion, and large willow trees north of Rogers Avenue.

The issue of vegetation maintenance and protection and its impact on nearby habitat was a predominant item of concern for nearby residents during the public consultation process. With regards to vegetation, the impact by future construction or repairs may not be eliminated completely, but through proper planning and design can be minimized. Although all attempts should be made to maintain significant vegetation along the dyke, it will be necessary to ensure that such vegetation does not have a negative impact on the structural integrity of the dyke (i.e., damage due to toppling of trees, intrusive roots into joints or geogrid supports, etc.). During the Phase 1 Replacement project in 2007, design of the replacement structure considered the protection of the existing large cedars adjacent to the outfield of Labatt Park with the protection of the structure itself by locating the structural zone of the wall system (including geogrids) beyond the zone of impact from the existing root system. Attempts to make provision for the same should be made for other areas of the dyke, if this is reasonable.

With exception to challenges relating to traffic maintenance, there are generally less constructability issues associated with the non-structural or vegetated segments of the dyke including areas north of Oxford Street West, between the Dundas Street and Wharncliffe Road North Bridges, and within or adjacent to Cavendish Park west of Wharncliffe Road North. These areas typically offer larger staging opportunities and are not immediately adjacent to residential properties.

Depending upon the area along the dyke, it is possible that future maintenance or replacement activities, depending on the scale and extent of the project, may require that the Contractor work within the river although all attempts through design should try to eliminate this need. If deemed to be necessary, appropriate regulatory processes and approvals must be followed, and are outlined in this report.

Additional information related to constructability on a section by section basis is provided in Table 9.1.

8.6 DEVELOPMENT OF FUNCTIONAL, OPERATIONAL, AND SAFETY ISSUES

During the preliminary design phase for the Phase 1 Replacement Structure, a workshop was held between the City, UTRCA, and Stantec to discuss the major functional, operational, and safety issues that would need to be addressed as part of the detailed design for the replacement structure. As a part of the Master Repair Plan process, these previous issues were reviewed and updated along with additional items discussed during the consultation process in order to act as general design principles from an engineering perspective for future projects (vegetated or structural, repair or replacement).

The following subsections note the key issues for consideration:

8.6.1 Issue 1 – Slope Stability

Previous slope stability analysis along localized areas of the concrete revetment component of the dyke revealed the potential for slope failure due to the presence of the fill material. In accordance with the Ministry of Natural Resources document "Geotechnical Principles for Stable Slopes", a minimum factor of safety of 1.4 is recommended. This factor of safety is the ratio of the strength of the soil to resist shearing stresses to the shear stress imposed on the soil along the surface (Coduto, 1999). A factor of safety value of 1 indicates imminent slope failure. Shear stress imposed on a slope can be from the weight of the slope itself, ground or elevated flood water within the soil matrix or "live loads" such as those imposed by snow, structures, vehicles, etc.

Additional investigations in support of preliminary and detailed design for future phases should include an updated slope stability analysis for the proposed works based on the expected soils conditions. The analysis should consist, at minimum, of the following:

- Accurate characterization of soil conditions including groundwater conditions;
- Potential modes of failure, at either soil interfaces or attributed to proposed structural characteristics; and
- Drain or undrained conditions at various water levels (up to Regulatory Flood Level) including assessment of sudden drawdown.

8.6.2 Issue 2 – Physical Constraints

Future repairs and replacements will need to consider physical constraints and critical sections along and behind the West London Dyke as a result of proximity to adjacent private and public lands and river, or potential existing conditions along the dyke that may prohibit work (i.e., proximity to impacted soil areas, former landfill areas, etc.). Depending on the extent of any impacted soils, removal of impacted soils would likely be preferred (as noted in the cost estimates). These space constraints may impact the following:

- Accessibility for maintenance, construction vehicles, construction staging areas, etc.;
- Selection and configuration of the replacement dyke structure, including overall footprint pending further review and assessment of extent of impact;
- Corresponding hydraulic impacts or constraints due to space limitations (i.e., either reduced elevation or otherwise encroachment closer to river that may reduce available storage);
- Opportunity to provide additional or enhanced amenities (i.e., lookout areas, wider pathways, seating, etc.); and

- Opportunity to construct the replacement structure/segment within the existing footprint, specifically in areas where raising of the dyke may be required.

Additional information related to the available spacing relative to the toe of the dyke is provided in Table 8.5.

8.6.3 Issue 3 – Life Expectancy

Major structural components of the dyke such as the revetment facing and restraints (if applicable) should be designed for a life expectancy of 75 years. Sub-drain systems, where present or required, should be over designed to allow for reduced capacity that is expected to occur over time.

For vegetated portions of the dykes, the life expectancy is not easily determined as the requirement for replacement/restoration will be dependent on several factors including frequency of maintenance, slopes, presence of hazard trees/vegetation, and impacts of river hydraulics.

8.6.4 Issue 4 – Special Policy Area and Flood Protection

As noted in Section 1.8, an application was made to the Province in order to designate the area as a Special Policy Area. This would permit the relaxation of provincial policy regarding development. Although policy usually requires that the SPA be protected by a dyke at or above the Regulatory Flood Line (1:250 year), this policy has been relaxed at other locations where it was found to be impractical. During the preliminary design of the Phase 1 Replacement Structure, the UTRCA indicated that the SPA application should not be affected by the final height chosen for the revetment.

A critical component to the replacement of any existing segment of dyke will be the decision on the height for the new structure/segment. For the purpose of this Master Repair Plan review, it is assumed that any replacement segments will be raised to the Regulatory Flood Line. However, an overall assessment of the City and UTRCA's flood management plan should be undertaken to identify the cost-benefit in whole and on a segmented basis should specific limitations on a segment exist (thereby requiring active flood protection measures). However, it should be noted that the overall flood protection benefit would diminish should a segment approach be undertaken.

For areas where raising of the dyke to the Regulatory Flood Level (or above) is not technically, environmentally, or socially/economically feasible, alternative measures may be considered including emergency flood control barriers (active measures).

8.6.5 Issue 5 – Environmental Considerations

Future works will require additional assessment for environmental impacts based on the proposed work scope as part of subsequent approvals or permitting requirements. Additional information on potential permits and approvals related to future works is provided in Section 8.8.

In addition to assessing impacts, planning for future improvements/replacements should consider, where appropriate, opportunities for environmental enhancements along the dyke area. These enhancements may include plantings of native vegetation along the toe area or other such works to encourage and support the native species in the area.

8.6.6 Issue 6 - Walkway

Future replacement phases should incorporate walkway widths and grading in accordance with current City standards. The design of the walkway should also consider loadings due to service and emergency vehicles. Placement of bollards at the transition of walkways to adjacent roads may be required to prevent unauthorized entry.

Wherever walkways are constructed beneath existing bridges in order to provide passageway, the design of the walkways should consider potential impacts to river hydraulics. In addition, the walkway should be designed to withstand the potential effects of erosion and submergence.

8.6.7 Issue 7 - Aesthetics

Given the high visibility of the structure, its proximity to the downtown core, and the City's recent revitalization projects in the general vicinity, aesthetics would have to be considered in the selection of the preferred structure.

8.6.8 Issue 8 - Vandalism

There is noticeable graffiti along the concrete revetment components of the dyke. If left unattended, graffiti has a serious cumulative effect and often gives the appearance of areas of neglect. An effective means of addressing graffiti is to ensure timely removal following the initial appearance in order to discourage future markings. However, the cost for labour and materials to address graffiti abatement can be high.

As part of the Phase 1 Replacement project, an anti-graffiti coating was applied following construction of the surface of the wall structure and seating area. While this coating does not remove the threat of graffiti, it allows for easy and quick removal of the graffiti with minimal equipment (spray bottle and container of water). The anti-graffiti system also considers the proximity to the Thames River and therefore limitations on alternative removal methods such as pressure washing, sand blasting, or painting.

Future replacement projects incorporating hard surfaces for either dyke facing, seating areas, etc. should consider potential impacts of graffiti and incorporate measures to address these potential issues and minimize the potential longer term maintenance requirements.

8.7 OPPORTUNITIES FOR GREEN DESIGN

Through the planning review and the public consultation process, Stantec has defined possible opportunities that may exist for green design. These include:

- As part of the functional design of the pathway;
- On the top of the dyke;
- Maintaining existing vegetated areas of the dyke;
- Plantings along the toe of the dyke; and
- Consideration for vegetated dyke in place of concrete or similar structure.

With regards to the options for vegetated dyke surfaces, several options for replacement of the revetment structure were considered as part of the preliminary design for the Phase 1 Replacement Structure. These included green options such as reinforced slope systems, gabion basket/gabion mat, and composite structures (i.e., concrete base with vegetated upper level). Based on the selection process at that time, none of the proposed vegetated structures were shortlisted due to concerns with performance under flood events, extensive maintenance requirements, and potential for soil loss. A part of this decision was also attributed to the steeper slopes required within the area of the Phase 1 structure and, therefore, each future segment should be reviewed independently to confirm whether green options for the facing is appropriate. Along the existing naturalized segments of the dyke (i.e., Natural Bank, Cavendish Park, and area of accretion), an attempt should be made to maintain the existing vegetated cover if both flood protection/hydraulics and engineering allows for it.

Besides the facing, the planning objectives noted the opportunity to integrate green design along the dyke, both along the toe, path, and behind the dyke. These items should be considered as part of future replacement or enhancement strategies.

In addition to the interpretation of green design as the preservation or installation of plantings, vegetated cover, etc., it may also be representative of sustainable design. Examples of sustainable design elements for the West London Dyke include:

- Selection of low impact materials (i.e., recycled materials or materials that can be recycled, materials requiring reduced transport requirements, production practices that minimize adverse environmental impacts);
- Selection of lighter coloured material to minimize potential for heat absorption;

- Selection of long-lasting materials to minimize future maintenance and requirements for future removals/landfilling;
- Energy efficiency (i.e., selection and spacing of lighting);
- Green asphalt surfaces (utilizing recycled material with cold-mix laying processes); and
- Optimization of existing on-site material (i.e., fill material that can be reused in non-structural zones, etc.).

These sustainable options should be considered in further detail during preliminary and detailed design of any future works.

8.8 PERMITS AND APPROVALS

Potential future works identified within this Master Repair Plan may require various permits and approvals from local, provincial and federal agencies. Verification as to the required permits and approvals would be subject to the completion of detailed design for each project.

There are many factors that may impact requirements for approvals. Construction schedules may pose restrictions regarding the timeline for work allowed within the vicinity of the Thames River. Staging for construction may require the temporary use of adjacent lands (i.e., issuance of temporary easements, etc.). Verification of land ownership through completion of a legal survey has been completed and this information will help to determine the boundary between municipal and private property for assessment of future works.

Floodplains, unstable slopes and erosion are examples of naturally occurring hazardous processes. Natural hazard planning involves planning for risks associated with these processes such as loss of life, property damage, social disruption and environmental impacts. Since there is always a risk associated with natural hazard processes, the Province sets the minimum standards for acceptable levels of risk. Recognizing that the dyke is within the Riverine Flood Hazard or floodplain regulation limit (Figure 4.1), an Upper Thames River Conservation Authority permit through Section 28 of the *Conservation Authorities Act* will be required for all work in the floodplain.

Additionally, a permit to take water will be required if deep excavation or dewatering (i.e., below the water table) is needed for dyke repair, rehabilitation, or replacement. Water takings in Ontario are governed by the *Ontario Water Resources Act* and the *Water Taking and Transfer Regulation*. Section 34 of the Act requires anyone taking more than a total of 50,000 litres in a day, with some exceptions, to obtain a Permit To Take Water from the Ministry of the Environment.

There are no requirements related to Certificates of Approval (C of A) for the West London Dyke, however various infrastructure adjacent or intersecting the dyke (i.e., storm, water, sanitary, etc.) may require separate approval for future work.

Table 8.3 provides a general list of permits and approvals that may be required for future work in relation to the West London Dyke. Estimated costs related to procurement of permits are provided in Table 8.5 of this report.

Table 8.3: General List of Permits and Approvals

Agency	Permit or Approval
Upper Thames River Conservation Authority	Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Permit
	Federal Fisheries Act Letter of Advice through UTRCA-DFO Level 2 Fish Habitat Agreement
Department of Fisheries and Oceans	Authorization for the Harmful Alteration, Disruption and Destruction of Fish Habitat (HADD) Species at Risk Act (aquatic species)
	Species at Risk Act (2002)
Ministry of Natural Resources	Endangered Species Act (2007)
	Public Land Act
	Lakes and River Improvement Act (LRIA)
Transport Canada	Navigable Waters Protection Act
Canadian Environmental Assessment Agency	Canadian Environmental Assessment Act (CEAA)
Ministry of Environment	Certificate of Approval (C of A)
	Permit-To-Take-Water (PTTW)

Section 2.2 of the Master Repair Plan details the Environmental Assessment Process. In accordance with this process, the City of London and UTRCA may be required to undertake further EA work depending on the magnitude of the anticipated environmental impact. As previously noted, this Master Planning process has been initiated with the intention of completion as a Schedule B project. This approach provides a broad level of assessment or mechanism to implement further projects. Although the proposed works may be implemented as separate projects, the Master Plan approach recognizes the larger management system.

At the implementation stage, the proponent will need to address each project on a case by case basis to confirm any additional requirements to satisfy the Environmental Assessment Act beyond this Master Repair Plan process. Table 8.4 provides a general outline of potential EA

requirements that may be applicable to the West London Dyke. Reference should be made to the EAA and MEA for complete information when planning for future projects.

Table 8.4: Potential Requirements for Additional Class EA Approvals

Schedule	Description
Schedule A (Pre-Approved)	On-going maintenance activities.
	Maintenance and/or minor improvements to grounds and structures.
	Replace traditional materials in an existing watercourse or in slope stability works with material of equal or better properties, at substantially the same location and for the same purpose.
Schedule A+ (Pre-Approved)	No relevant references to the West London Dyke.
Schedule B	Construct berms along a watercourse for purposes of flood control in areas subject to damage by flooding.
	Modify existing water crossings for the purposes of flood control.
	Works undertaken in a watercourse for the purposes of flood control or erosion control, which may include: • Bank or slope regrading. • Deepening the watercourse. • Relocation, realignment or channelization of watercourse. • Revetment including soil bio-engineering techniques. • Reconstruction of a weir or dam.
	Enclose a watercourse in a storm sewer.
Schedule C	Construct a new dam or weir within a watercourse.
	*Note: It is anticipated that a Schedule C would be required for work involving the Blackfriars Bridge given the heritage classification of the structure and the public interest.

For projects that are identified as requiring a Schedule C Class EA, the proponent would be required to complete Phase 3 and Phase 4 of the Planning Process. The preparation of an Environmental Study Report (ESR) would need to be completed. Depending on the sensitivity of the project, in terms of both the social and environmental impacts, an additional PIC should be undertaken.

Table 8.5: Permit and Approval Estimated Costs

Permit of Approval	Task	Estimated Cost
PTTW	Application	$4,000
	Hydrogeological Review	$9,000
	Total	**$13,000**
UTRCA	Application (Consent)	**$1,000**
C of A		Subject to municipal infrastructure
Approvals	Temporary Easements	Unknown
Class EA	Schedule A	**$10,000 - $20,000**
	Schedule B	**$45,000 - $50,000**
	Schedule C	**$70,000 - $80,000**
	Environmental (Site Assessment)	**$12,500**

8.9 CLIMATE CHANGE

The previous study "Floods: Mapping Vulnerability in the Upper Thames Watershed under a Changing Climate, (CFCAS, August 2007) completed by a research team from the University of Western Ontario (UWO) with collaboration from the University of Waterloo, Environment Canada, and the UTRCA concluded that climate change was expected to increase the area exposed to flooding under higher return period floods including the 1 in 50 year flood.

Following this initial study, the City of London retained UWO researchers to review existing Intensity-Duration-Frequency (IDF) curves in order to assess potential changes to address climate change impacts. Results from the analysis indicated that rainfall intensity within the Thames River watershed had increased and was likely to continue to increase. The report recommended the potential increase in sizing for storm water management facilities and revision to flood lines within the watershed which would result in changes to the City's Official Plan and other related policies.

Based on the report recommendations, the City proceeded with the development of a comprehensive climate change adaptation strategy for London. This strategy consisted of two phases:

- Phase 1 – Climate Change Adaptation Transition Strategy; and
- Phase 2 – Climate Change Adaptation Long Term Strategy.

The City has completed Phase 1 of its strategy, with recommendations approved by Council in July 2011. Key items from Phase 1 of the strategy included direction to the Planning, Environmental and Engineering Services departments of the City of London to proceed with increasing the City's existing Intensity Duration Frequency (IDF) Curves by 21%, and that this change is incorporated in a phased approach commencing with the update of several subwatershed studies. Approval to proceed with Phase 2 of the strategy was also granted.

In addition to the City's investigation, the UTRCA continues to review the impacts of climate change first addressed in the 2007 study.

It is noted that results from these additional studies, potential City of London Official Plan modifications, and policy revisions by both the City and UTRCA may impact recommendations related to future infrastructure improvements noted herein. At that time, the City of London in collaboration with the UTRCA should review the benefits of raising the dyke further with other socio-economic and physical characteristics and impacts to the area to determine the following:

- Need to address the impacts of flood protection from climate change at the area of concern (i.e., raising of the dyke); or
- Potential opportunities to control or minimize climate change impacts along the West London Dyke by means of upstream mitigation measures.

8.10 FREEBOARD

Freeboard is defined as the height above the predetermined high water mark (or Regulatory Flood Level) of a structure such as a dam or dyke. This height acts as a buffer area between the 250 year flood elevation and the actual top of dyke. When work on the Master Repair Plan first commenced, specific information relating to the proposed elevation of any new dyke structure and associated freeboard could not be defined until such a time as updated hydraulic and hydrologic model results were available. Updated flood elevations were obtained in 2015 based upon work completed by UTRCA in conjunction with the City and the desired freeboard could now be evaluated in terms of both risk and social, natural and economic factors.

The document "*United States Department of Agriculture, Natural Resource Conservation Service, National Handbook of Conservation Practices, November 2002*" provides guidelines on the construction of Class 1 dykes. A Class 1 dyke is defined as a dyke that, if it should fail, could result in loss of life or serious damage to infrastructure including homes, businesses, bridges, etc. By definition, the West London Dyke is defined as a Class 1 dyke. For Class 1 dykes, the handbook recommends a minimum freeboard based on the difference between the normal ground elevation at the dyke centerline (at approximately Labatt Park) and the design high water level. A review of the available topographic information for the dyke indicates an estimated normal ground elevation of approximately 233.0 m at the approximate centerline location, with a corresponding 250 year flood elevation of 236.9 m, for a difference in elevation

of 3.9 m or 12.8 ft. In accordance with the guideline, the minimum freeboard is 0.6 m (2 ft). Accordingly, it is recommended that a minimum freeboard of 0.6 m be provided based on the height of the structure. This is an increase over the freeboard provided for the Phase 1 Replacement Structure (0.3 m). If this is in addition to the adjustment to suit the Regulatory Flood Level, the potential increase over the existing top of dyke may be as high as 2 m which is considered significant.

Potential impacts as a result of climate change also affect the decision on the level of freeboard to be provided. Additional freeboard may provide a buffer to protect areas against potential additional or intensified flood events as are anticipated through the ongoing climate change studies.

Regulated 100 year and 250 year flood profiles were provided by the UTRCA in 2015 which replaced the flood level profiles previously used for the design of Phases 1 and 2. The profiles represent regulated flows for the Thames River watershed through the City of London. The change in profiles was the result of updating of watershed flood flows and the development of a new hydraulic model for the Thames River in London. A regulated 250 year + 10% flood profile was also provided by the UTRCA to evaluate freeboard flood flow capacity which considered preliminary increases in flood flows for the north and main branches of the Thames River at the West London Dyke. It was determined through consultation with the City and UTRCA that the regulated 250 year + 10% flood profile represents the necessary freeboard for any future dyke repairs and reconstruction and accounts for impacts due to climate change. The proposed freeboard was approximately 0.6 m based on this flood profile.

Currently, there are five municipally owned bridges and one railroad bridge that spans the Thames River within the West London Dyke footprint. Regardless of the freeboard to be provided, these significant pieces of infrastructure may limit the passive flood protection capabilities of the dyke, unless raising of the structures is to occur. Table 8.6 provides a general assessment of the potential freeboard present between the existing bridges and 250 year flood elevation.

Table 8.6: Review of Existing Freeboard at Bridges

Crossing	Low Chord Elevations [1] (m)	250 Year Flood Elevation [2] (m)	Available Freeboard (m)
CP Rail	240.12	237.53	2.59
Oxford Bridge	238.02 (238.6)	237.48	0.54
Blackfriars Bridge	237.99 (238.2)	237.09	0.90
Queens Bridge	235.31 (236.7)	236.91	-1.6
Dundas Bridge	235.85 (236.6)	236.82	-0.97
Wharncliffe Bridge	235.90 (237.3)	236.47	-0.57

Note:

1. Bridge low chord elevations (low chord selected to reflect effects on bridge during flood events). Approximate bridge abutment elevations shown in brackets.
2. Calculated water surface elevations from UTRCA HEC-RAS model at upstream bridge face.

As previously noted, there may be a requirement to implement active flood protection measures where it is not considered feasible or cost effective to raise the structure to the Regulatory Flood Level without significant impact. Although potential damages associated with toppling of the dyke are considered significant, the costs associated with raising existing bridges are also substantial and are anticipated to exceed the cost of the dyke improvement itself. Accordingly, these areas may be best addressed by means of active measures such as sand bags, stop logs, etc. and integrated into the overall flood management strategy. With regards to the Oxford Street Bridge which underwent substantial rehabilitation work in 2009, it is anticipated that the end of its useful life has been extended well beyond the current 20 year planning period.

It is noted that there is available freeboard from Blackfriars Bridge, north to the CP Rail crossing. However, Queens, Dundas and the Wharncliffe Road North bridge low chord elevations are less than the 250 year flood elevation and therefore have no available freeboard.

The impact of additional freeboard will also require further review within areas both north and west of the current dyke limits. North of the upstream limit of the dyke, the current regulatory flood limit encroaches near the intersection of Gunn Street and Saunby Street, northwest of the CP rail crossing. Along the downstream end of the dyke, a segment of Walnut Street north of the West Lions Park and west of Cavendish Crescent provides protection to areas along the west. Localized improvements or otherwise extension of the dyke may be required to protect these areas should additional freeboard be required.

8.11 AMENITY/FUNCTIONAL DESIGN IMPROVEMENTS

The Thames River is viewed as a natural amenity by many. Originally, the Thames River provided transportation for settlers and trade, power and irrigation for the local trades. As the surrounding area became settled, the river also became a cultural and recreational amenity. It is now also considered to be a historical amenity and was named as one of Canada's Heritage Rivers. Structural alteration to the west side of the riverbank with the construction of the West London Dyke has taken away some of the 'natural' commodity of the area. However, the dyke offers citizens a viewing area with a walkway that encourages people to enjoy the river. The river also allows for recreational activities such as boating and fishing. The river flats south of the Blackfriars Bridge provide some service access to the water's edge.

Section 7.0 of this Master Repair Plan provided general guidelines and principles relating to amenity and functional improvements along the West London Dyke. These included:

- Signage (interpretive signage and signage indicating natural heritage and natural systems);
- Maintaining views of the river;
- Opportunities for users to participate in passive recreation activities (sitting, reading, walking, etc.) through pathway improvements, provision of additional seating, lookouts, etc.; and
- Accessibility to the river.

The principle role of the dyke as an amenity however, is its role as a walkway. As an area frequented by many pedestrians, cyclists, etc. pathway lighting has been installed in some areas and the pathway widened to safely and comfortably accommodate its users. Park benches and garbage receptacles are also spaced intermittently along the pathway. Future work along the dyke should incorporate all these aspects, and respectfully consider both the needs of the community with those of nearby residents (i.e., consider potential for increase in noise levels, additional traffic, etc.).

During the public consultation process, concerns in relation to lighting spacing and intensity were raised. Comments from adjacent residents suggest "light pollution" as a key issue with respect to lighting design for future projects. The issue of adequate lighting for future projects will need to be assessed further during the preliminary and detailed design stage.

8.12 SUMMARY OF EXISTING DYKE CHARACTERISTICS

Table 8.7 provides a general summary of the existing conditions, characteristics, and issues/items associated with the dyke. This information has been summarized based on a review of the results of previous investigations, and assessment of proposed future requirements.

The condition rating score for each dyke section is based on the rating system utilized during condition assessments of the dykes. The rating system is as follows:

1 – Unsafe Condition (Structure or element in very poor or unsafe condition which poses an immediate public safety hazard);

2 – Poor Condition (Structure or element in poor condition with significant deterioration noted. Deteriorations noted may impact on integrity and may require significant capital cost to bring to fair to poor condition rating. No safety hazard noted);

3 – Fair/Poor Condition (Structure or element condition varies from fair to poor with some signs of significant deterioration in localized areas. Able to perform function but at reduced capacity);

4 – Fair Condition (Structure or element in fair condition with no visible signs of significant deterioration. Able to perform intended function with no apparent hindrance); and

5 – Good Condition (Structure or element in good condition with minor deterioration. Able to perform intended function with no apparent hindrance).

Table 8.7: Summary of Existing Dyke Characteristics

Section	Location (Extent)	Damage Reach	Top of Dyke Elevation (m)	Approximate Distance from Dyke Toe to Property Line (m)	TYPE OF DYKE STRUCTURE				TYPE OF PATH WAY		Existing Infrastructure	EXISTING DEFICIENCIES								Condition/Comments
					Natural Bank	Concrete Revetment	Gabion Basket	Modular Block (Geogrid)	Asphalt	Vegetated (Trail)		Concrete Distress	Settlement	Bulging	Exposure (Loss of Granular)	Hand Rail	General Damage (Gabion Baskets Torn, etc.)	Other (Erosion, Vegetation Loss)	Condition Rating (Previous inspections)	
Area North of Dyke (North Branch)	Earthen Berm (Natural) with Vegetation extending north of concrete revetment	#14	235.06 to 238.43	15-25	✓				✓	✓	• Hydro pole line circuit crossing (overhead). • Saunby Street and Beaufort Street adjacent to dyke in this area.								N/A	• Currently no lighting along the trail. • North of revetment, dyke is moderately to heavily vegetated. • No defined pathway in vegetated area with exception of small access road linking Saunby Street to Beaufort Street. • No handrail north of concrete revetment.
Oxford North	Concrete Dyke	#14	237.55 to 238.54	15-25		✓				✓	• Oxford Street Bridge along south limit. • CP Rail Bridge (single rail). • 300mm ø watermain supported on bridge.					✓			2	• Currently no lighting along the trail. • Pathway generally vegetated along revetment. • Vegetation present in joints between concrete panels. • Handrail (along concrete revetment) is in poor condition.
St. Patrick's	Oxford Street Bridge to Empress Avenue	#13	236.74 to 238.20	15-20		✓			✓		• Oxford Street Bridge along north limit. • 450mm ø storm outlet. • 900mm ø sanitary crossing (St. Annes). • Hydro pole line circuit crossing. • Argyle Street borders back of dyke for approximately 75 m. • Argyle Street, St. Patrick Street and Empress Avenue adjacent to dyke in this area.	✓	✓	✓	✓	✓			2	• Many of the deficiencies are localized just south of the Oxford Street Bridge, spalling, bulging, cracked and separated panels are all present. • Broken and damaged concrete with exposed wire mesh. • Algae is present along the dyke face (also noted in 2004 and 2006 reviews near vicinity of sanitary sewer). • Sinkhole developing along pathway, majority of pathway however is in good condition. • Hydro poles present near top of dyke, would have to be relocated if dyke required replacement. • Aluminum handrail present along this segment observed to be in poor condition at select locations. • Pathway does not meet City standards (< 3m). • Mature vegetation (trees and shrubs) present at toe of dyke, height of vegetation equal to or greater than height of dyke (provides natural buffer between river and residential properties) • North end of Argyle Street, Empress Avenue/Napier Street may allow access to top of dyke for repair. • Potential staging area at end of St. Patrick St., but limited. • Pathway lighting located on hydro poles. • No hazard trees noted in this area but maintenance required to prevent intrusive species.

Section	Location (Extent)	Damage Reach	Top of Dyke Elevation (m)	Approximate Distance from Dyke Toe to Property Line (m)	TYPE OF DYKE STRUCTURE				TYPE OF PATH WAY		Existing Infrastructure	EXISTING DEFICIENCIES								Condition/Comments
					Natural Bank	Concrete Revetment	Gabion Basket	Modular Block (Geogrid)	Asphalt	Vegetated (Trail)		Concrete Distress	Settlement	Bulging	Exposure (Loss of Granular)	Hand Rail	General Damage (Gabion Baskets Torn, etc.)	Other (Erosion, Vegetation Loss)	Condition Rating (Previous inspections)	
Blackfriars	Empress Avenue to Cummings Avenue	#12	236.28 to 238.08	15-20		✓			✓		• Blackfriars Bridge (historical landmark). • Empress Avenue, Blackfriars Street, and Cummings Avenue adjacent to dyke in this area.	✓	✓	✓	✓	✓			2	• Access via Blackfriars Bridge not considered an option due to historical significance and anticipated load restrictions. • In the event that any work should be required on the bridge to accommodate dyke improvements, approvals would likely be significant due to historical landmark classification. • Spalling, bulging, cracked and deteriorated concrete panels are present throughout this section. • Exposed wire mesh and rebar, concrete in poor condition in some areas. • Original steel handrail generally present along this segment. Steel handrail observed to be damaged at various areas. • Mature vegetation present along toe of dyke south of Blackfriars Bridge as well as top of dyke. • Potential staging areas present north (off Empress Avenue) and south (off Cummings Avenue) of Blackfriars Bridge. • Any replacement work may require vegetation removal in area of accretion due to work and staging area requirements. • Little to no lighting fixtures along this segment of dyke. • Pathway does not meet City standards (< 3m). • No hazard trees noted in this area but maintenance required to prevent intrusive species.
Natural Bank	Cummings Avenue to Leslie Street	#11,12	236.25 to 236.10	11-15* *not including accretion area	✓	✓			✓		• Cummings Avenue, Carrothers Avenue, and Leslie Street adjacent to dyke in this area.	✓	✓	✓		✓			4	• Concrete revetment present along the Natural Bank section, however extent of concrete revetment (depth) is unknown due to area of accretion at toe of structure. It is anticipated that a toe structure may not be present in this area based on a review of aerial photography. Only 1 to 2 m of concrete exposed at top of dyke. • Spalling, bulging, and cracked panels present along this section. • Pathway lighting is present. • Pathway does not meet City standards (< 3m), however it is in generally good condition. • Mature vegetation and trees present along revetment. • Residential properties in close proximity to top of dyke/pathway, construction staging for repair/replacement could be an issue. • Cedar hedge (planted by homeowner) very close to pathway. • Potential staging area within area of accretion, however this would require removal of vegetation in this area. • No hazard trees noted in this area but maintenance required to prevent intrusive species.

Section	Location (Extent)	Damage Reach	Top of Dyke Elevation (m)	Approximate Distance from Dyke Toe to Property Line (m)	TYPE OF DYKE STRUCTURE				TYPE OF PATH WAY		Existing Infrastructure	EXISTING DEFICIENCIES								Condition/Comments
					Natural Bank	Concrete Revetment	Gabion Basket	Modular Block (Geogrid)	Asphalt	Vegetated (Trail)		Concrete Distress	Settlement	Bulging	Exposure (Loss of Granular)	Hand Rail	General Damage (Gabion Baskets Torn, etc.)	Other (Erosion, Vegetation Loss)	Condition Rating (Previous inspections)	
Labatt Park / Forks **Deficiencies do not pertain to Phase I Replacement*	Leslie Street to Dundas Street	#11	236.00 to 236.75	20-26		✓		✓	✓		• 900mm ø storm outlet. • 300mm ø storm outlet. • 300mm ø sanitary crossing. • 900mm ø sanitary crossing. • Dundas Street Bridge. • Queens Avenue Bridge. • 300mm ø watermain supported on bridge. • Hydro underground duct structure and cables. • Walter J. Blackburn Memorial Fountain. • Riverside Drive and Wharncliffe Road North adjacent to dyke in this area.	✓	✓	✓	✓				3	• Original concrete revetment with a transition to the modular block structure (Phase 1) at Rogers Avenue to the Queens Avenue Bridge. • Spalling, bulging and cracked panels present north of Phase 1 with vegetation growing between panel joints (original concrete revetment only). • Dyke is fully visible from Harris Park and downtown bridges. • Residential properties in close proximity to top of dyke/pathway. • Pathway along Phase I meets City of London standards. • Pathway lighting is present. • No deficiencies noted along Phase I structure. • Walter J. Blackburn Memorial Fountain present at Forks.
Wharncliffe	Dundas Street to Wharncliffe Bridge	#9	235.73 to 237.36	>15			✓		✓		• Wharncliffe Road North Bridge. • 300mm ø watermain supported on bridge. • Wharncliffe Road North and Cavendish Crescent adjacent to dyke in this area.						✓		4	• Concrete revetment transitions to gabion basket south of Dundas Street Bridge to the Wharncliffe Road Bridge. • Natural bank, grasses and trees present along this section. • Adequate area for construction staging. • Pathway lighting is present. • Pathway runs along top of berm, land slopes down towards Riverside Drive. • No hazard trees noted in this area but maintenance required to prevent intrusive species.
Cavendish East	Wharncliffe Road North Bridge to Cavendish Crescent	#8	235.55 to 236.27	12-20	✓	✓				✓	• 1050 mm ø storm outlet and spillway. • 1050 mm ø sanitary along north bank. • 300 mm ø sanitary crossing. • Cavendish Crescent adjacent to dyke in this area.							✓	3	• Concrete revetment present along this section. Revetment steep in this area. • Cracked and deteriorated concrete panels present. • Handrail repaired prior to 2010 inspection. • No dedicated lighting present. Some lighting present on adjacent bridge. • No defined pathway present, however, an earthen walking trail was observed. • Steep slope from property line to rivers edge • Repair or replacement work may be difficult due to lack of staging area, unless access is through Cavendish West area. • Manitoba Maple infestation noted (refer to Dougan & Associates report). Potential for heaving damage.

Section	Location (Extent)	Damage Reach	Top of Dyke Elevation (m)	Approximate Distance from Dyke Toe to Property Line (m)	TYPE OF DYKE STRUCTURE				TYPE OF PATH WAY		Existing Infrastructure	EXISTING DEFICIENCIES								Condition/Comments
					Natural Bank	Concrete Revetment	Gabion Basket	Modular Block (Geogrid)	Asphalt	Vegetated (Trail)		Concrete Distress	Settlement	Bulging	Exposure (Loss of Granular)	Hand Rail	General Damage (Gabion Baskets Torn, etc.)	Other (Erosion, Vegetation Loss)	Condition Rating (Previous inspections)	
Cavendish West	Cavendish Crescent to Cavendish Park	#8	234.61 to 236.93	>15	✓					✓	• Cavendish Park. • City of London Works Yard. • 1200 mm ø storm outlet. • Cavendish Crescent and Forward Avenue adjacent to dyke in this area.								4	• City trail system present. • Moderate to dense vegetation in the area. • City of London Works Yard present. • Flood protection provided by berm that extends from rivers edge north, then transitions west near adjacent residential property lines. • Active methane monitoring site. • Suspect fill in area attributed to site filling (berm construction) and backfilling of storm sewer. • Increasing vegetation near edge of water. Relatively steep edge to river with combination of vegetation and rip rap in area. • No staging issues anticipated. • Manitoba Maple infestation noted (refer to Dougan & Associates report). Potential for heaving damage.

9.0 REVIEW OF ALTERNATIVES AND IMPLEMENTATION SCHEDULE – TRIGGERS

As part of the Class EA planning process reasonable and feasible alternative solutions to the Phase 1 problem statement are to be identified and described in Phase 2. The magnitude of the net positive and negative effects of each alternative solution, as well as mitigating measures, are to be identified and evaluated. Based on this evaluation a preliminary preferred alternative is selected and confirmed based on public, agency, and stakeholder consultation.

9.1 REVIEW OF BACKGROUND INFORMATION

In order to develop alternative solutions for the West London Dyke the following inputs were utilized:

- Review of the guiding principles related to the dyke;
- Review of the environmental components as defined under the Environmental Assessment Act including:
    - Natural Environment – component having regard for the protection of the natural and physical elements of the environment including natural heritage,
    - Social/Cultural Environment – component evaluating the potential effects to residents, businesses, neighbourhoods, community character, social impacts, historical and archaeological issues, and municipal development objectives,
    - Legal/Jurisdictional – consideration for potential land requirements for each alternative,
    - Economic/Financial – consideration for potential capital and maintenance costs,
    - Technical – consideration of the technical suitability of the alternative, including integration with existing infrastructure;
- Review of existing dyke profiles and potential flood line elevations based on HEC-RAS modeling results;
- Review of existing dyke structure and condition;
- Review of existing site constraints;
- Review of existing infrastructure in the area;
- Review of planning initiatives and other City documents and policies; and

- Review, if any, of previous Class EA planning solutions that could be revisited.

Given the length and varying characteristics of the West London Dyke, both the alternatives and the preferred solution for a specific segment of the dyke may not be the same everywhere along the dyke. In general, recommendations were provided for each of the eight segments reviewed; however, a few of these segments required further breakdown to address specific needs.

9.2 QUALITATIVE EVALUATION

In order to maintain consistency with other City of London Master Plan and Class Environmental Assessment projects, the subjective evaluation of each alternative was completed and ranked in accordance with the following standard system:

The decision to incorporate a qualitative evaluation system recognizes the difficulty with determining statistically relevant and accurate numerical systems in evaluating alternatives. Rather, each individual consideration is assessed separately and the preferred solution determined by means of balancing all issues.

The Master Plan and Class EA planning process recognizes that there are often many alternatives to address a particular issue or problem, and that these alternatives should be considered. Alternative solutions identified as part of the Master Repair Plan are listed as follows:

- **Alternative 1** – Do Nothing;
- **Alternative 2** – Replace with Similar Dyke (Existing Footprint);
- **Alternative 3** – Replace with New Dyke to 100 Year Standard + Freeboard; and
- **Alternative 4** – Replace with New Dyke to 250 Year Standard + Freeboard.

The following sections provide further information on each alternative.

9.3 ALTERNATIVE 1 – DO NOTHING

As with all Class EAs, alternative solutions to the project must be reviewed against the "Do Nothing" alternative. The "Do Nothing" alternative would have direct negative consequences if it was selected as the proposed alternative. As a "Do Nothing" option, the UTRCA and City of London would continue to undertake minor maintenance activities only on the existing dyke.

With regards to the concrete revetment component of the dyke, this is not considered a viable alternative as past inspections and testing have identified key problems with the integrity of the structure. In addition, the age of the structure would suggest that it has or is approaching the end of its useful life and will therefore require replacement or substantial rehabilitation within the timeline of this Master Repair Plan.

Impacts of this option to the 20-year horizon are minimal for the natural, cultural and socio-economic environments, with exception of the flood protection component. However, this is not necessarily representative as a significant portion of the dyke would eventually require repair/replacement and, therefore, the impacts to the environment would be similar to Alternatives 2, 3, and 4.

Accordingly, the "Do Nothing" alternative does not address the needs defined in the problem statement and therefore will not be carried forward for further review in this Class EA process with respect to the existing concrete segments. With regards to the existing earth berm segments and for segments located both upstream and downstream of the current dyke limits, the "Do Nothing" option will be carried forward for consideration; however, noting that potential stability issues may exist and may warrant remedial or replacement measures. Stability issues, whether or not they exist, can only be determined pending further detailed investigation.

Table 9.1 summarizes the impacts to the environment and qualitatively evaluates the alternatives.

9.4 ALTERNATIVE 2 – REPLACE WITH SIMILAR DYKE (EXISTING FOOTPRINT)

This option assumes replacement of the dyke to existing conditions and within the existing footprint, with minor flood enhancements where allowed. Essentially, this option is intended to maintain the existing dyke appearance.

With exception of the "Do Nothing" option, this option is anticipated to result in the least impact to the natural environment as it is intended to remain within the existing footprint. From a socio-economic standpoint, this alternative provides a "status quo" option which is expected to appeal to a minority of adjacent residents, based on comments received during the public consultation process. However, this option does not address the potential need for enhanced flood protection beyond the 100 year level and associated socio-economic impacts related to the increased potential for flood damage. In addition, this option may not allow for amenity

improvements such as pathway widening to areas behind the dyke due to current constraints identified. This option would also not meet the SPA policy requirements.

Impacts to the natural environment may be marginally less than Alternatives 3 and 4; however, that will be subject to the area in question and extent of subsurface work required. It is possible that work in the river may still be required along segments of the dyke due to the lack of proper staging areas to accommodate mobilization and material stockpiling, etc.

Table 9.1 summarizes the impacts to the environment and qualitatively evaluates the alternatives.

9.5 ALTERNATIVE 3 – REPLACE WITH NEW DYKE TO 100 YEAR STANDARD + FREEBOARD

This option assumes replacement of the existing dyke with a new dyke to meet the 100 year flood elevation with additional freeboard. For the purpose of conceptual planning, a freeboard of 2 feet (0.6 m) was assumed. Unlike Alternative 2, this option may result in the construction of the new dyke outside of the existing footprint to permit additional amenity and functional improvements.

However, this option does not address the potential need for enhanced flood protection beyond the 100 year level and associated socio-economic impacts related to the increased potential for flood damage. This option would also not meet the SPA policy requirements. From an economic perspective, this option is also considered the highest cost relative to flood protection provided, although the total capital cost is less than Alternative 4.

From an environmental perspective, this option is anticipated to have similar impact as Alternative 4. It is possible that work in the river is required in some areas due to the lack of proper staging areas. Land acquisition is not anticipated, but would need to be assessed in greater detail during preliminary design and based on further assessment of staging areas.

Table 9.1 summarizes the impacts to the environment and qualitatively evaluates the alternatives.

9.6 ALTERNATIVE 4 – REPLACE WITH NEW DYKE TO 250 YEAR STANDARD + FREEBOARD

This option assumes the replacement of the existing dyke structure with a new dyke structure to accommodate the flood protection and amenity improvements, with additional freeboard. As with Alternative 3, for the purpose of conceptual planning a freeboard of 2 feet (0.6 m) was assumed as per the discussion in Section 8.10 of this report. In some areas, it is anticipated a higher dyke may require a steeper slope and potential placement closer to the river to accommodate the change in grade and area behind the dyke to incorporate amenity improvements.

The largest negative impact on this option is the economic impact (highest capital cost); however, this option would better address the existing economic impacts related to flood damage. This option is also considered to provide the least impact on the social/cultural environment as it could look to implement amenity and functional improvements with flood protection, unlike Alternatives 1, and 2, and to a lesser extent Alternative 3 which may still provide amenity improvements but at reduced flood protection. Impacts to the natural environment may be marginally greater than Alternative 2; however, that will be subject to the area in question and extent of subsurface work required. It is possible that work in the river is required in some areas due to the lack of proper staging areas. Land acquisition is not anticipated, but would need to be assessed in greater detail during preliminary design and based on further assessment of staging areas.

Although this option has the highest initial (capital) cost, it is predicted to have the lowest long-term cost. The existing dyke structure is reaching the end of its useful life and will require either extensive repair or replacement. Alternatives 2 and 3 provide newer dykes, but at lower elevations which may be toppled more regularly in the future based on preliminary findings from current climate change studies unless active flood protection measures are implemented.

Table 9.1 summarizes the impacts to the environment and qualitatively evaluates the alternatives.

Figure 9.1: Qualitative Evaluation of Alternatives

Segment	Approximate Length (m)	Condition Rating	Type	Flood Elevation			Lowest Elevation (mASL)	Approx. # of Properties within Hazard Area	Est. Current Flood Damage 100 yr / 250 yr	Alternatives	Compliance with Guiding Principles		Natural Environment	Social / Cultural	Economic/Financial		Future Class EA Requirements	Technical Issues / Requirements	Preferred Alternative
				100 yr (mASL)	250 yr (mASL)	250 yr + 10% (mASL)					Flood Protection	Amenity/Functional Improvements			Estimated Capital Costs[2]	Estimated Maintenance Costs			
													-Potential impacts to the natural environment due to siting requirements	-Short-term construction related impacts including traffic, noise, access -Potential siting or routing issues, including impacts to cultural or heritage (archaeological), impacts to recreational use	-Initial cost to undertake the alternative	-Estimated maintenance and/or operational requirements	-Anticipated Class EA requirements to implement project	-Ability to implement alternative -Consideration for constructability of proposed solution, timing, potential for disruptions - Ability of the solution to suit potential regulatory requirements	Least Preferred ○ ◔ ◑ ◕ ● Most Preferred
Oxford North	300	2	Concrete Revetment with Toe (includes 250 m vegetated area to north)	236.81 to 237.03	237.50 to 237.69	238.09 to 238.26	235.06	20	$382,000 / $1,558,000	**Alternative 1**: Do Nothing	Does not provide protection to Regulatory Flood Level.	Does not provide for amenity / functional improvement opportunities including potential future pathway extension.	None identified as no work is proposed.	None identified as no work is proposed.	None identified.	Highest maintenance costs over the planning period due to concrete distress.	Not applicable.	Existing dyke may require replacement within 20 year period due to condition.	○ Not preferred as it does not meet the guiding principles for the dyke. Also, it is anticipated that structure may need replacement within 20 year horizon.
										Alternative 2: Replace w Similar Dyke (existing footprint)	Does not provide protection to Regulatory Flood Level.	Does not provide for amenity / functional improvement opportunities including potential future pathway extension.	Least impact compared to Alternatives 3 and 4.	Least impact compared to Alternatives 3 and 4 relating to construction activities.	$2,333,000 (excludes pathway)	No significant maintenance costs anticipated.	Covered by Master Repair Plan	Work within vicinity of Oxford Street Bridge. No anticipated issues noted.	◔ This option not preferred as the cost/benefit is anticipated to be significantly less than Alternative 4.
										Alternative 3: Replace w 100 yr + Freeboard	Does not provide protection to Regulatory Flood Level.	Allows opportunities for improvements including pathway upgrades (per 2007 Master Plan Concept).	Potential requirement to conduct work in river due to existing constraints and potential need to construct future pathway beneath Oxford St. Bridge, however impacts can be mitigated through best management practices.	Moderate increased impact compared to Alternative 2, but can be mitigated using best management practices.	$3,449,000 (includes pathway)	No significant maintenance costs anticipated.	Covered by Master Repair Plan	Work within vicinity of Oxford Street Bridge. In order to accommodate amenity/functional improvements, slope of dyke may be increased. In addition, extension of the dyke to the north may be required to address the enhanced flood protection.	◑ Viable solution, however it does not provide protection to Regulatory Level. Opportunity to incorporate active flood protection measures due to proximity to nearby road for access.
										Alternative 4: Replace with 250 yr + Freeboard	Provides protection to Regulatory Flood Level with ~ 0.6 m freeboard.	Allows opportunities for improvements including pathway upgrades (per 2007 Master Plan Concept).	Potential requirement to conduct work in river due to existing constraints and potential need to construct future pathway beneath Oxford St. Bridge, however impacts can be mitigated through best management practices.	Moderate increased impact compared to Alternative 2, but can be mitigated using best management practices.	$3,687,000 (includes pathway)	No significant maintenance costs anticipated.	Covered by Master Repair Plan	Due to limited footprint, slope of dyke would need to increase to accommodate height increase. Would need to consider impact on flood storage due to reduction in cross section area. In addition, extension of the dyke to the north may be required to address the enhanced flood protection.	● Preferred solution as it best meets the guiding principles. Impacts through construction can be mitigated through best management practices. Costs for enhancement are comparable to 100 year structure.
St. Patrick	350	2	Concrete Revetment with Toe	236.52 to 236.79	237.22 to 237.48	237.81 to 238.04	236.74	200	$3,627,000 / $9,799,000	**Alternative 1**: Do Nothing	Currently provides up to 100 year flood protection with minimal freeboard. Does not meet Regulatory Flood Level requirements.	Does not provide for amenity / functional improvement opportunities.	None identified as no work is proposed.	None identified as no work is proposed.	None identified.	Highest maintenance costs over the planning period	Not applicable	Existing dyke likely to require replacement within 20 year period due to current condition.	○ Not preferred as it does not meet the guiding principles for the dyke. Existing condition of dyke would indicate that replacement versus repair is likely required within the 20 year planning period.
										Alternative 2: Replace w Similar Dyke (existing footprint)	Provides up to 100 year flood protection. Does not meet Regulatory Flood Level requirements.	Current pathway does not meet City standards. Presence of City owned land would permit potential Butterfly/Bird Watching garden.	Potential requirement to conduct work in river due to existing constraints (proximity to adjacent landowners).	Minimal impact based on construction activities, but can be mitigated using best management practices. May require work in river.	$5,403,000	No significant maintenance costs anticipated.	Covered by Master Repair Plan	Construction/staging constraints.	○ This option not preferred as the cost/benefit is anticipated to be significantly less than Alternative 4.
										Alternative 3: Replace w 100 yr + Freeboard	Does not provide protection to Regulatory Flood Level.	Allows opportunities for improvements including potential Butterfly/Bird Watching garden near existing park (per 2007 Master Plan Concept).	Potential requirement to conduct work in river due to existing constraints (proximity to adjacent landowners).	Moderate impact based on construction activities, but can be mitigated using best management practices. May require work in river.	$5,567,000	No significant maintenance costs anticipated.	Covered by Master Repair Plan	In order to accommodate amenity/functional improvements, slope of dyke may be increased. Construction staging and access may be difficult.	◑ Viable solution, however it does not provide protection to Regulatory Level. Opportunity exists to incorporate active flood protection measures due to proximity to nearby roads for access. However, significant measures would be necessary to accommodate length of entire section.
										Alternative 4: Replace with 250 yr + Freeboard	Provides protection to Regulatory Flood Level with ~ 0.6 m freeboard.	Allows opportunities for improvements including potential Butterfly/Bird Watching garden near existing park (per 2007 Master Plan Concept).	Potential requirement to conduct work in river due to existing constraints (proximity to adjacent landowners). Increase in elevation may require placement of structure closer to toe.	Moderate impact based on construction activities, but can be mitigated using best management practices. May require work in river.	$5,788,000	No significant maintenance costs anticipated.	Covered by Master Repair Plan	In order to accommodate increased height to 250 year level (+ freeboard), and amenity/functional improvements, increase dyke slope may be required. Would need to consider impact on flood storage due to reduction in cross section area.	● Preferred solution as it best meets the guiding principles. Significant number of properties protected by dyke in this area, therefore passive protection to 250 year level (+ freeboard) is preferable. Cost/benefit advantage over Alternative 3 is significant.
Blackfriars	260	2	Concrete Revetment with Toe	236.23 to 236.44	236.94 to 237.15	237.53 to 237.74	236.28	210	$8,959,000 / $9,993,000	**Alternative 1**: Do Nothing	Does not provide 100 year flood protection or meets Regulatory Flood Level requirements.	Does not provide for amenity / functional improvement opportunities. Deficiencies along pathway noted that would require action.	None identified as no work is proposed.	None identified as no work is proposed.	None identified.	Highest maintenance costs over the planning period.	Not applicable.	Existing dyke likely to require replacement within 20 year period due to current condition.	○ Not preferred as it does not meet the guiding principles for the dyke.
										Alternative 2: Replace w Similar Dyke (existing footprint)	Does not provide 100 year flood protection or meets Regulatory Flood Level requirements.	Current pathway does not meet City standards. This option would not allow additional amenity/functional improvements including lookout area and pathway beneath bridge due to proximity to adjacent lands.	Potential requirement to conduct work in river due to existing constraints (proximity to adjacent landowners).	Moderate impact based on construction activities, but can be mitigated using best management practices. No impact to Blackfriars Bridge anticipated.	$4,057,000 (excludes pathway)	No significant maintenance costs anticipated.	Covered by Master Repair Plan	Construction/staging constraints.	○ This option is not preferred as the cost/benefit is anticipated to be significantly less than Alternative 4. Not preferred as structure would not meet 100 year flood protection or meet Regulatory Flood Levels.
										Alternative 3: Replace w 100 yr + Freeboard	Does not provide protection to Regulatory Flood Level.	Allows opportunities for improvements including pathway beneath Blackfriars Bridge and Lookout Area (per 2007 Master Plan Concept).	Potential requirement to conduct work in river due to existing constraints (proximity to adjacent landowners). Staging requirements may call for removal of vegetation along south boundary.	Moderate impact based on construction activities, but can be mitigated using best management practices. No impact to Blackfriars Bridge anticipated.	$5,367,000 (includes pathway)	No significant maintenance costs anticipated. Maintenance costs associated with pathway may be higher (impact of high water level).	Potential for Schedule C EA requirement due to presence of Blackfriars Bridge and potential transportation impacts.	In order to accommodate amenity/functional improvements, slope of dyke may be increased.	◑ Viable solution, however it does not provide protection to Regulatory Level. Opportunity to incorporate active flood protection measures due to proximity to nearby roads for access.
										Alternative 4: Replace with 250 yr + Freeboard	Provides protection to Regulatory Flood Level with ~ 0.6 m freeboard.	Allows opportunities for improvements including pathway beneath Blackfriars Bridge and Lookout Area (per 2007 Master Plan Concept).	Potential requirement to conduct work in river due to existing constraints (proximity to adjacent landowners). Staging requirements may call for removal of vegetation along south boundary.	Moderate impact based on construction activities, but can be mitigated using best management practices. No impact to Blackfriars Bridge anticipated, but likely subject to final dyke elevation.	$5,546,000 (includes pathway)	No significant maintenance costs anticipated. Maintenance costs associated with pathway may be higher (impact of high water level).	Potential for Schedule C EA requirement due to presence of Blackfriars Bridge and potential transportation impacts.	In order to accommodate amenity/functional improvements and increase in dyke height, slope of dyke may be increased.	● Preferred solution as it best meets the guiding principles. It is anticipated that additional increase in height of ~1.5m would be sufficient to provide 250 yr + protection. Significant number of properties protected by dyke in this area, therefore passive protection to 250 year level (+ freeboard) is preferable. Cost/benefit advantage over Alternative 3 is significant.
Natural Bank	230	4	Concrete Revetment with Naturalized Toe	236.32 to 236.36	237.04 to 237.09	237.64 to 237.69	236.06	180	$8,480,000 / $9,347,000	**Alternative 1**: Do Nothing	Does not provide 100 year flood protection or meets Regulatory Flood Level requirements.	Does not provide for amenity / functional improvement opportunities.	None identified as no work is proposed.	None identified as no work is proposed.	None Identified	Highest maintenance costs over the planning period.	Not applicable	None identified.	◔ Not preferred as it does not meet the guiding principles for the dyke. Invasive species in area could result in further damage to the dyke. Not preferred as it does not meet 100 year flood protection or the Regulatory Flood Level.
										Alternative 2: Replace w Similar Dyke (existing footprint)	Does not provide 100 year flood protection or meets Regulatory Flood Level requirements.	Current pathway does not meet City standards. This option could still allow additional amenity/functional improvements including enhanced playground area as per 2007 Master Plan Concept behind dyke.	Potential significant impact to existing vegetated area. Could require substantial clearing and grubbing, however mostly invasive species noted. Marginal impact to river. Work in river not anticipated.	Moderate impact based on construction activities, but can be mitigated using best management practices. Work in river not anticipated.	$3,271,000	No significant maintenance costs anticipated, however, if segment is to remain vegetated, minor vegetation control costs should be budgeted.	Covered by Master Repair Plan	Need to determine extent of dyke (as it is partially buried by deposition), could require significant earthworks.	◑ This option is not preferred as the cost/benefit is anticipated to be significantly less than Alternative 3 or 4.
										Alternative 3: Replace w 100 yr + Freeboard	Does not provide protection to Regulatory Flood Level.	Allows opportunities for improvements including enhanced playground area and river access (per 2007 Master Plan Concept).	Potential significant impact to existing vegetated area. Could require substantial clearing and grubbing, however mostly invasive species noted. Marginal impact to river. Work in river not anticipated.	Moderate impact based on construction activities, but can be mitigated using best management practices. Work in river not anticipated.	$3,487,000	No significant maintenance costs anticipated, however, if segment is to remain vegetated, minor vegetation control costs should be budgeted.	Covered by Master Repair Plan	Need to determine extent of dyke (as it is partially buried by deposition), could require significant earthworks.	◕ Viable solution, however it does not provide protection to Regulatory Level. Would negatively impact mature vegetation along the dyke face, but could be mitigated using proper planning and best management practices.
										Alternative 4: Replace with 250 yr + Freeboard	Provides protection to Regulatory Flood Level with ~ 0.6 m freeboard.	Allows opportunities for improvements including enhanced playground area and river access (per 2007 Master Plan Concept).	Potential significant impact to existing vegetated area. Could require substantial clearing and grubbing, however mostly invasive species noted. Marginal impact to river. Work in river not anticipated.	Moderate impact based on construction activities, but can be mitigated using best management practices. Work in river not anticipated.	$3,646,000	No significant maintenance costs anticipated, however, if segment is to remain vegetated, minor vegetation control costs should be budgeted.	Covered by Master Repair Plan	Need to determine extent of dyke (as it is partially buried by deposition), could require significant earthworks.	● Preferred solution as it best meets the guiding principles. Significant number of properties protected by dyke in this area, therefore passive protection to 250 year level (+ freeboard) is preferable. Cost/benefit advantage over Alternative 3 is significant.

Segment	Approximate Length (m)	Condition Rating	Type	Flood Elevation			Lowest Elevation (mASL)	Approx. # of Properties within Hazard Area	Est. Current Flood Damage 100 yr / 250 yr	Alternatives	Compliance with Guiding Principles		Natural Environment	Social / Cultural	Economic/Financial		Future Class EA Requirements	Technical Issues / Requirements	Preferred Alternative	
				100 yr (mASL)	250 yr (mASL)	250 yr + 10% (mASL)					Flood Protection	Amenity/Functional Improvements	-Potential impacts to the natural environment due to siting requirements	-Short-term construction related impacts including traffic, noise, access -Potential siting or routing issues, including impacts to cultural or heritage (archaeological), impacts to recreational use	Estimated Capital Costs[2] -Initial cost to undertake the alternative	Estimated Maintenance Costs -Estimated maintenance and/or operational requirements	-Anticipated Class EA requirements to implement project	-Ability to implement alternative -Consideration for constructability of proposed solution, timing, potential for disruptions - Ability of the solution to suit potential regulatory requirements	Least Preferred ○ ◔ ◑ ◕ ● Most Preferred	
Labatt Park/Forks	135	3	Concrete Revetment with Toe	236.32 to 236.35	237.05 to 237.08	237.65 to 237.67	236.00	340	$22,560,000 / $24,158,000	**Alternative 1**: Do Nothing	Does not provide 100 year flood protection or meets Regulatory Flood Level requirements.	Does not provide for amenity / functional improvement opportunities.	None identified as no work is proposed.	None identified as no work is proposed.	None identified	Highest Maintenance Costs over the planning period	Not applicable	Existing dyke likely to require replacement within 20 year period due to current condition.	○	Not preferred as it does not meet the guiding principles for the dyke
										Alternative 2: Replace w Similar Dyke (existing footprint)	Does not provide 100 year flood protection or meets Regulatory Flood Level requirements.	Current pathway does not meet City standards. This option could not allow additional amenity/functional improvements including look out area to Harris Park as per 2007 Master Plan Concept behind dyke.	Potential requirement to conduct work in river due to existing constraints (proximity to adjacent landowners). Large trees located near property line likely impacted based on existing footprint.	Moderate impact based on construction activities, but can be mitigated using best management practices. May require work in river.	$2,347,000	No significant maintenance costs anticipated.	Covered by Master Repair Plan	Construction/staging constraints.	◔	This option is not preferred as the cost/benefit is anticipated to be significantly less than Alternative 4. Not preferred as structure would not meet 100 year flood protection or meet Regulatory Flood Levels.
										Alternative 3: Replace w 100 yr + Freeboard	Does not provide protection to Regulatory Flood Level.	Allows opportunities for improvements including pathway widening and ability to incorporate look out area depending on alignment of wall.	Potential requirement to conduct work in river due to existing constraints (proximity to adjacent landowners). Impact to large trees located near property line may be minimized depending on placement of wall.	Moderate impact based on construction activities, but can be mitigated using best management practices. May require work in river.	$2,476,000	No significant maintenance costs anticipated.	Covered by Master Repair Plan	In order to accommodate amenity/functional improvements, slope of dyke may be increased.	◑	Viable solution, however it does not provide protection to Regulatory Level. Opportunity to incorporate active flood protection measures due to proximity to nearby roads for access.
										Alternative 4: Replace with 250 yr + Freeboard	Provides protection to Regulatory Flood Level with ~ 0.6 m freeboard.	Allows opportunities for improvements including pathway widening and ability to incorporate look out area depending on alignment of wall.	Potential requirement to conduct work in river due to existing constraints (proximity to adjacent landowners). Impact to large trees located near property line may be minimized depending on placement of wall.	Moderate impact based on construction activities, but can be mitigated using best management practices. May require work in river.	$2,578,000	No significant maintenance costs anticipated.	Covered by Master Repair Plan	Consider same type of dyke structure as Phase 1 for continuity/ connection at Rogers Ave.	●	Preferred solution as it best meets the guiding principles. It is anticipated that additional increase in height of ~1.5m would be sufficient to provide 250 yr + protection. Cost/benefit advantage over Alternative 3 is significant.
	300	4	Concrete Modular Block Wall with Geogrid (2007 - 2009 Replacement Projects)	236.23 to 236.27	236.95 to 237.00	237.55 to 237.60	236.71	-		**Alternative 1**: Do Nothing	Current structure provides up 100 year flood protection.	Amenity/functional improvements identified in 2007 construction	None identified as no work is proposed.	None identified as no work is proposed.	Not applicable	Minor maintenance required, primarily along lower pathway.	Not applicable	Not applicable	◕	Viable alternative.
										Alternative 2: Replace w Similar Dyke (existing footprint)	Does not meet revised Regulatory Flood Level.	Generally not applicable due to current condition of the dyke (not anticipated to need replacement within the 20 year study period). Amenities were incorporated as part of replacement phase.	Limited impact anticipated due to availability of lands for staging, etc. and setback of river to property line.	Moderate impact based on construction activities, but can be mitigated using best management practices.	$4,560,000	No significant maintenance costs anticipated.	Covered by Master Repair Plan	Construction/staging constraints.	X	Not applicable. Structure constructed in 2007 and not anticipated to require replacement within 20 year planning period.
										Alternative 3: Replace w 100 yr + Freeboard	Not applicable as current modular wall provides above 100 year limit. This option would not meet Regulatory Flood Level.	Generally not applicable due to current condition of the dyke (not anticipated to need replacement within the 20 year study period). Amenities were incorporated as part of replacement phase.	Limited impact anticipated due to availability of lands for staging, etc. and setback of river to property line.	Moderate impact based on construction activities, but can be mitigated using best management practices.	$4,786,000	No significant maintenance costs anticipated.	Covered by Master Repair Plan	Construction/staging constraints.	X	Not applicable. Structure constructed in 2007 and not anticipated to require replacement within 20 year planning period.
										Alternative 4: Replace with 250 yr + Freeboard	Current structure provides up to Regulatory Flood Level but does not provide up to the revised Regulatory Flood Level plus freeboard.	Generally not applicable due to current condition of the dyke (not anticipated to need replacement within the 20 year study period). Amenities were incorporated as part of replacement phase.	Limited impact anticipated due to availability of lands for staging, etc. and setback of river to property line.	Moderate impact based on construction activities, but can be mitigated using best management practices.	$5,177,000 (includes entire wall reconstruction. Cost estimate of $250,000 for raising of the existing wall)	No significant maintenance costs anticipated.	Covered by Master Repair Plan	Construction/staging constraints.	●	Replacement not viable. Consideration given to raising of the dyke is the preferred solution.
	175	4	Natural Bank with Gabion Toe	236.10 to 236.19	236.77 to 236.91	237.32 to 237.51	236.22	--		**Alternative 1**: Do Nothing	Does not provide 100 year flood protection or meets Regulatory Flood Level requirements.	Does not provide for amenity / functional improvement opportunities.	None identified as no work is proposed.	None identified.	Not applicable.	Maintenance costs associated with vegetation control.	Covered by Master Repair Plan	Not applicable.	○	Viable alternative as amenity improvements can be integrated without dyke upgrades. Does not meet the Regulatory Flood Level, however less impacted properties in area, therefore cost benefit of raising the structure is less.
										Alternative 2: Replace w Similar Dyke (existing footprint)									X	This option not applicable to earth dyke segments as it is generally no different than the "Do Nothing" option or Alternative 3.
										Alternative 3: Replace w 100 yr + Freeboard	Does not provide protection to Regulatory Flood Level.	Forks of the Thames Phase 4 completed. Not known whether additional amenity/functional improvements are required.	No significant impact anticipated due to working area present. Return to prior natural/vegetated conditions.	None identified.	$452,000	Depends on type of dyke selected and amenity requirements. Not anticipated to be significantly higher costs than existing dyke maintenance.	Covered by Master Repair Plan	None identified.	◕	Viable solution, however it does not provide protection to the Regulatory Flood Limit. Adequate land behind dyke would make Alternative 4 more preferable.
										Alternative 4: Replace with 250 yr + Freeboard	Provides protection to Regulatory Flood Level with ~0.5 m freeboard.	Forks of the Thames Phase 4 completed. Not known whether additional amenity/functional improvements are required.	No significant impact anticipated due to working area present. Return to prior natural/vegetated conditions.	None identified.	$514,000	Depends on type of dyke selected and amenity requirements. Not anticipated to be significantly higher costs than existing dyke maintenance.	Covered by Master Repair Plan	None identified.	●	Preferred solution as it best meets the guiding principles and assuming additional flood protection accomplished by means of berm enhancements. It is anticipated that additional increase in height of ~1m would be sufficient to provide 250 yr + protection. Cost/benefit advantage is marginal, however, due to smaller impacted area.
Wharncliffe	380	4	Natural Bank with Gabion Toe	235.83 to 236.06	236.47 to 236.75	236.98 to 237.31	235.73	1	$1,233,000 / $1,236,000	**Alternative 1**: Do Nothing	Currently provides up to 100 year flood protection with little to no freeboard. Does not meet Regulatory Flood Level requirements.	Capable of implementing amenity or functional improvements separately within the area due to its size.	None identified as no work is proposed.	None identified as no work is proposed.	Not applicable	Maintenance costs associated with vegetation control.	Not applicable.	Not applicable.	○	Not preferred as it does not meet the guiding principles for the dyke
										Alternative 2: Replace w Similar Dyke (existing footprint)									X	This option not applicable to earth dyke segments as it is generally no different than the "Do Nothing" option or Alternative 3.
										Alternative 3: Replace w 100 yr + Freeboard	Does not provide protection to Regulatory Flood Level.	Capable of implementing amenity or functional improvements separately within the area due to its size.	No significant impacts expected as construction could proceed out of river. Minor repairs to existing gabions may be required at rivers edge.	None identified.	$4,242,000 (includes pathway)	Maintenance costs associated with vegetation control.	Covered by Master Repair Plan	May need to relocate pathway.	◕	Viable solution, however it does not provide protection to the Regulatory Limit. Adequate land behind dyke would make Alternative 4 more preferable without a significant increase in cost.
										Alternative 4: Replace with 250 yr + Freeboard	Provides protection to Regulatory Flood Level with ~0.5 m freeboard.	Capable of implementing amenity or functional improvements separately within the area due to its size.	No significant impacts expected as construction could proceed out of river. Minor repairs to existing gabions may be required at rivers edge.	None identified.	$4,376,000 (includes pathway)	Maintenance costs associated with vegetation control.	Covered by Master Repair Plan	May need to relocate pathway.	●	Preferred solution as it best meets the guiding principles and assuming additional flood protection accomplished by means of berm enhancements. It is anticipated that additional increase in height of ~1.5m would be sufficient to provide 250 yr + protection. Cost/benefit advantage is marginal, however, due to smaller impacted area.

WEST LONDON DYKE MASTER REPAIR PLAN

Segment	Approximate Length (m)	Condition Rating	Type	Flood Elevation			Lowest Elevation (mASL)	Approx. # of Properties within Hazard Area	Est. Current Flood Damage 100 yr / 250 yr	Alternatives	Compliance with Guiding Principles		Natural Environment	Social / Cultural	Economic/Financial		Future Class EA Requirements	Technical Issues / Requirements	Preferred Alternative	
				100 yr (mASL)	250 yr (mASL)	250 yr + 10% (mASL)					Flood Protection	Amenity/Functional Improvements			Estimated Capital Costs[2]	Estimated Maintenance Costs				
													-Potential impacts to the natural environment due to siting requirements	-Short-term construction related impacts including traffic, noise, access -Potential silting or routing issues, including impacts to cultural or heritage (archaeological), impacts to recreational use	-Initial cost to undertake the alternative	-Estimated maintenance and/or operational requirements	-Anticipated Class EA requirements to implement project	-Ability to implement alternative -Consideration for constructability of proposed solution, timing, potential for disruptions - Ability of the solution to suit potential regulatory requirements	Least Preferred ○ ◔ ◑ ◕ ● Most Preferred	
Cavendish East	160	3	Concrete Revetment with Toe	235.69 to 235.70	236.33 to 236.33	236.83 to 236.84	235.55	70	$4,376,000 / $4,947,000	**Alternative 1**: Do Nothing	Does not provide protection to Regulatory Flood Level.	Does not provide for amenity / functional improvement opportunities including potential future pathway extension.	None identified as no work is proposed.	None identified as no work is proposed.	Not applicable	Highest maintenance costs compared to other alternatives over the planning period.	Not applicable	Existing dyke likely to require replacement within 20 year period due to current condition.	○	Not preferred as it does not meet the guiding principles for the dyke.
										Alternative 2: Replace w Similar Dyke (existing footprint)	Does not provide protection to Regulatory Flood Level.	Does not provide for amenity / functional improvement opportunities including potential future pathway extension or construction of pathway at top of dyke.	Potential requirement to conduct work in river due to existing constraints (proximity to adjacent landowners).	Moderate impact based on construction activities, but can be mitigated using best management practices. May require work in river.	$2,280,000	No significant maintenance costs anticipated.	Covered by Master Repair Plan	Construction/staging constraints.	○	This option is not preferred as the cost/benefit is anticipated to be significantly less than Alternative 3 or 4.
										Alternative 3: Replace w 100 yr + Freeboard	Does not provide protection to Regulatory Flood Level.	Allows opportunities for improvements including pathway construction depending on alignment of wall.	Potential requirement to conduct work in river due to existing constraints (proximity to adjacent landowners).	Moderate impact based on construction activities, but can be mitigated using best management practices. May require work in river.	$2,758,000	No significant maintenance costs anticipated. Maintenance costs associated with pathway may be higher (impact of high water level).	Covered by Master Repair Plan	In order to accommodate amenity/functional improvements, slope of dyke may be increased.	◑	Viable solution, however it does not provide protection to the Regulatory Limit. Could potentially implement active flood control measures.
										Alternative 4: Replace with 250 yr + Freeboard	Provides protection to Regulatory Flood Level with ~0.5 m freeboard.	Allows opportunities for improvements including pathway construction depending on alignment of wall.	Potential requirement to conduct work in river due to existing constraints (proximity to adjacent landowners).	Moderate impact based on construction activities, but can be mitigated using best management practices. May require work in river.	$2,820,000	No significant maintenance costs anticipated. Maintenance costs associated with pathway may be higher (impact of high water level).	Covered by Master Repair Plan	In order to replace dyke to 250 yr, area available for construction may result in increased slope of dyke, similar to Phase I structure (also to minimize height).	●	Preferred solution as it best meets the guiding principles for the dyke.
	240	4	Natural Bank	235.68 to 235.68	236.32 to 236.22	236.82 to 236.82	235.61	60	$487,000 / $550,000	**Alternative 1**: Do Nothing	Currently provides protection up to the 100 year flood level. Does not provide protection to Regulatory Flood Level.	Does not provide for amenity / functional improvement opportunities.	None identified as no work is proposed.	None identified as no work is proposed.	Not applicable	Maintenance costs associated with vegetation control.	Not applicable	Not applicable	◔	Not preferred as it does not meet the guiding principles for the dyke.
										Alternative 2: Replace w Similar Dyke (existing footprint)									X	This option not applicable to earth dyke segments as it is generally no different than the "Do Nothing" option or Alternative 3.
										Alternative 3: Replace w 100 yr + Freeboard	Does not provide protection to Regulatory Flood Level.	Capable of implementing amenity or functional improvements (signage) within the area due to its size.	Mature trees along this section, could impose constraints on construction.	None identified.	$2,486,000	Maintenance costs associated with vegetation control.	Covered by Master Repair Plan	Significant mature vegetation to address during construction.	◕	Viable solution, however it does not provide protection to the Regulatory Limit.
										Alternative 4: Replace with 250 yr + Freeboard	Provides protection to Regulatory Flood Level with ~0.5 m freeboard.	Capable of implementing amenity or functional improvements (signage) within the area due to its size.	Mature trees along this section, could impose constraints on construction.	None identified.	$2,707,000	Maintenance costs associated with vegetation control.	Covered by Master Repair Plan	Significant mature vegetation to address during construction.	●	Preferred solution as it meets the guiding principles. Would negatively impact mature vegetation along the dyke face, but could be mitigated using proper planning and best management practices.
Cavendish West	220	4	Natural Bank with Berms	235.54 to 235.70	236.18 to 236.33	236.69 to 236.84	234.61	--	--	**Alternative 1**: Do Nothing	Does not provide protection to Regulatory Flood Level.	Capable of implementing amenity or functional improvements separately within the area due to its size.	None identified as no work is proposed.	None identified as no work is proposed.	Not applicable	Maintenance costs associated with vegetation control.	Not applicable,	Not applicable,	◔	Not preferred as it does not meet the guiding principles for the dyke.
										Alternative 2: Replace w Similar Dyke (existing footprint)									X	This option not applicable to earth dyke segments as it is generally no different than the "Do Nothing" option or Alternative 3.
										Alternative 3: Replace w 100 yr + Freeboard	Does not provide protection to Regulatory Flood Level.	Capable of implementing amenity or functional improvements separately within the area due to its size.	No significant impact anticipated due to working area present. Return to prior natural/vegetated conditions. Implement best management practices.	None identified.	$1,079,000	Maintenance costs associated with vegetation control.	Covered by Master Repair Plan	None identified, however extension of the dyke may be required to address the enhanced flood protection requirements.	◕	Viable solution, however it does not provide protection to the Regulatory Level.
										Alternative 4: Replace with 250 yr + Freeboard	Provides protection to Regulatory Flood Level with ~0.5 m freeboard.	Capable of implementing amenity or functional improvements separately within the area due to its size.	No significant impact anticipated due to working area present. Return to prior natural/vegetated conditions. Implement best management practices.	None identified.	$1,182,000	Maintenance costs associated with vegetation control.	Covered by Master Repair Plan	None identified, however extension of the dyke may be required to address the enhanced flood protection requirements.	●	Preferred solution as only moderate increase in the dyke height is required in order to achieve Regulatory Flood Level. Sufficient space available to integrate height increase.

Notes:
1) Estimated capital cost includes construction cost, engineering costs at 12.5%, architectural costs at 2% and geotechnical/environmental costs at 1.5%.
2) Denotes total estimated costs in 2015 dollars. Refer to Table 9.2 for potential costs associated with segmenting of work.
3) X - denotes non-applicable action.

9.7 SELECTION OF THE PREFERRED ALTERNATIVE

Refer to Table 9.1 which provides a list of the preferred alternatives for each study segment. With the exception of the section from Rogers Avenue to the Queens Avenue Bridge, Alternative 4 has been identified as the preferred solution.

9.8 ANTICIPATED CAPITAL COSTS

Refer to Table 9.1 which provides the anticipated capital costs associated with the preferred alternative for each dyke segment. All capital costs are reported in 2016 Canadian dollars. Use where applicable has been made of the costs associated with the 2007 Phase 1 Replacement Structure project and the 2009 Phase 2 project. These previous costs have been adjusted to 2016 costs using the average Canadian Non-Residential Building Construction Price Index and include the following:

- Investigation costs (geotechnical and environmental);
- Construction costs;
- Architectural design costs; and
- Engineering costs, including design, tender, construction administration and post-construction services.

Table 9.1 details the construction and non-construction costs. Approval costs, including costs associated for land acquisition, if required, are not included at this time subject to further detailed review. In addition, the cost estimates provided do not include HST or other value added taxes as may be applicable over time. With regards to costs associated with potential additional Class EA commitments (finalization of Schedule C in conjunction with component of Phase 1 and 2 completed as part of this Master Plan), the following high level cost estimate should be considered in addition to the Table 9.1 costs:

- Schedule C: estimated $70,000 to $80,000.

Actual Class EA costs will also be dependent of the segment of dyke structure to be considered, as it may influence additional study/field work requirements to be completed as part of the Class EA. Estimated costs should be determined during the preliminary stage.

As noted in Section 4.10 of this report, the assessment of the dyke structure on a segment by segment basis is not intended to represent exact limits for future construction projects. Future works (involving repair or replacement) may involve either work within a segment, or overlapping of portions of segments.

9.9 RECOMMENDED IMPLEMENTATION STRATEGY

In Section 5.0, five primary drivers were described. These drivers were defined as potential reasons to implement or otherwise initiate work. The process of undertaking a specific capital upgrade project begins when a "trigger point" requiring action by the City and UTRCA has been reached. A "trigger point" is defined as when a set of circumstances occur that warrant the commencement of a capital upgrade project.

With exception of potential future pathway extensions beneath the remaining bridges which may trigger future work on its own (similar to the Phase 2 project undertaken in 2009), amenity improvements will likely not initiate significant dyke replacement or restoration projects. Conversely, public safety can, on its own, trigger the commencement of a future project if a segment of the existing dyke was to fail or be at risk of failure. With regards to flood protection enhancement, it is anticipated that future works may be subject to additional planning, securing of funds, and consensus by the City and UTRCA on the appropriate level of flood protection as part of the overall flood management strategy for the area.

Table 9.2 provides an overview of the recommended project implementation schedule for each area, and estimated cost in 2016 Canadian dollars. For the purpose of assessing costs on a comparative time basis, each cost is assumed to occur at the same time (i.e., 2016). Reference should be made to the Cost Estimation Model for variations in cost on a per segment basis subject to the proposed date of implementation. In general, the prioritization of projects is based on a review of the project drivers, noting however that several of these drivers are currently not defined but will require further coordination between the City of London and UTRCA (i.e., with respect to flood risk reduction, and funding opportunities), or internally between various City departments (coordination with functional improvement projects, transportation work, cost sharing, etc.). Accordingly, the determination of priority has been based on known existing information as presented in Table 9.1, primarily relating to the following:

- Current condition of the dyke;
- Potential to reduce overall flood damages (i.e., opportunity to reduce the number of landowners impacted by flooding, based on current flood damage reach data);
- Constructability considerations; and
- Other impacts or considerations, including coordination with other City initiatives/projects.

The actual implementation schedule may vary depending upon several items including the availability of funds, decision from the City and UTRCA on the appropriate flood protection to be provided, condition of the segment, and/or coordination with other projects or initiatives within the area, including:

- Coordination with the Blackfriars Bridge Environmental Study Report. For preliminary planning purposes, it is assumed that work along the dyke structure will be kept separate from the bridge (no impact to use or appearance);
- Coordination with future WADE projects within the area;
- Coordination with ongoing CSO program work, including but not limited to:
    - Potential future CSO facility within Cavendish area; and
    - Potential future North Thames Low Level Trunk.

Table 9.2: Recommended Project Implementation Schedule

Segment	Section	Type	Preferred Alt.	Estimated Cost[1]	Estimated EA Cost[2]	Implementation Schedule	Priority Ranking[3]
Oxford North	North of south limit of Oxford St. Bridge	Concrete Revetment / Vegetated Berm	Alt. 4	$3.7M / $2.6M[7]	N/A	10 + Years[4]	8
St. Patrick[5]	Oxford St. to St. Patrick St.	Concrete Revetment	Alt. 4	$2.8M	N/A	5 to 10 Years	4
	St. Patrick St. to Empress Ave.	Concrete Revetment	Alt. 4	$3.0M	N/A	5 to 10 Years	5
Blackfriars[6]	Empress Ave. to Blackfriars St.	Concrete Revetment	Alt. 4	$3.3M / $2.2M[7]	$70-$80K	1 to 5 Years	2
	Blackfriars St. to Cummings Ave.	Concrete Revetment	Alt. 4	$2.2M	$70-$80K	1 to 5 Years	3
Natural Bank	Cummings Ave. to Leslie St.	Concrete Revetment (Naturalized Toe)	Alt. 4	$4.6M	N/A	10 + Years	6
Labatt Park/Forks	Leslie St. to Rogers Ave.	Concrete Revetment	Alt. 4	$2.6M	N/A	1 to 5 Years	1
	Rogers Ave. to Queens Ave. Bridge	Modular Block Wall with Geogrid	Alt. 1	$250K	N/A	10 + Years (work completed in 2007/08)	---
	Queens Ave. extending south to Forks	Natural Bank with Gabions	Alt. 4	$500K	N/A	10 + Years	9 (assumed to coincide with Wharncliffe segment work)
Wharncliffe	From Forks to Wharncliffe Rd. Bridge	Natural Bank with Gabions	Alt. 4	$4.3M / $3.3M[7]	N/A	10 + Years	9
Cavendish East	Wharncliffe Rd. Bridge extending west	Concrete Revetment	Alt. 4	$2.8M	N/A	10 + Years	7
	From termination of	Natural	Alt. 4	$2.7M	N/A	10 + Years	10

Segment	Section	Type	Preferred Alt.	Estimated Cost[1]	Estimated EA Cost[2]	Implementation Schedule	Priority Ranking[3]
	concrete revetment extending west to City Works Yard	Bank/Berm					
Cavendish West	From City Works Yard extending north, then west along adjacent property limits	Vegetated Berm	Alt. 4	$1.2M	N/A	10 + Years	10

Note:

1. Order of magnitude cost estimate (-10% to +40%). Estimate includes engineering costs and costs for geotechnical/environmental investigations, but excludes Value Added Taxes. Costs for approvals are not included.
2. Estimated cost for the completion of either a Schedule A, B or C Class EA, as outlined in Table 9.1.
3. Priority ranking generally based on the current condition of dyke structure based on past reviews, with consideration for damage reach within the area protected by that segment of dyke. In some cases, potential damage reach reduction favoured implementation prior to condition rating (i.e., for segment of dyke between Leslie Street and Rogers Avenue).
4. Denotes recommendation based on current structural condition only and does not include potential for pathway construction which could alter timing for work (cost sharing with other projects/initiatives). This timeline also assumes separate construction from St. Patrick's area, although savings could be provided should portions of work be combined.
5. Segmenting of St. Patrick's area based on ensuring staging/access requirements. Could allow for potential phasing of work, should this be required due to budget constraints.
6. Denotes recommendation based on current structural condition only and does not include potential coordination of work with any Blackfriars Bridge initiatives. Assumes completely isolated work from bridge rehabilitation.
7. Initial cost includes a provision for a pedestrian underpass while the second cost excludes a provision for a pedestrian underpass.

The proposed implementation schedule reflects the general timing for the improvement to be constructed. As with any complex infrastructure project, scheduling must also allow for the completion of the following tasks:

- Additional Class EA requirements related to the individual project;
- Obtaining appropriate approvals (MNR, DFO, UTRCA, etc.);
- Undertaking geotechnical/environmental investigation;

- Preliminary Design (Engineering);
- Detailed Design (Engineering);
- Architectural Design; and
- Tendering and Contract Award.

Table 9.3 provides a general assessment of timelines associated with each of the above noted tasks.

Table 9.3: Estimated Timelines for Planning, Design and Approvals

Task	Estimated Timeline for Completion	Additional Comments
Class EA Obligations	6 to 8 months	To be identified.
Approvals	6 months	Estimated, based on anticipated levels of approvals required. Should work within river be required, additional time for obtaining approvals may be necessary.
Geotechnical/Environmental Investigation	2 months	To be undertaken following completion of Class EA obligations (or immediately should project be identified as pre-approved).
Preliminary Design	4 months	Can proceed as part of the Class EA obligations.
Detailed Design	3 months	Following completion of any Class EA obligations.
Architectural Design	3 months	To coincide with preliminary and detailed design phase.
Tendering	2 months	Based on 3 week tender close, and estimated timeline for approval by City and UTRCA (including council and board approval).
Total Estimated Timeline	15 to 17 months	Considers overlapping of certain tasks as noted.

Sketches of preliminary cross sections have been provided in Figure 9.3 to Figure 9.11. These sketches include the illustration of features such as edge of river, existing bank/revetment and existing pathway, as well as property boundaries. The 100-year, 250-year and 250-year + 10% flood elevations are superimposed on each figure, along with the preferred alternative relevant to each section (i.e., pre-cast block wall). Figure 9.1 and Figure 9.2 are provided as key maps for the cross sections outlined below.

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WEST LONDON DYKE
MASTER REPAIR PLAN

Figure No.
1.1

Title
NORTH BRANCH
KEY PLAN

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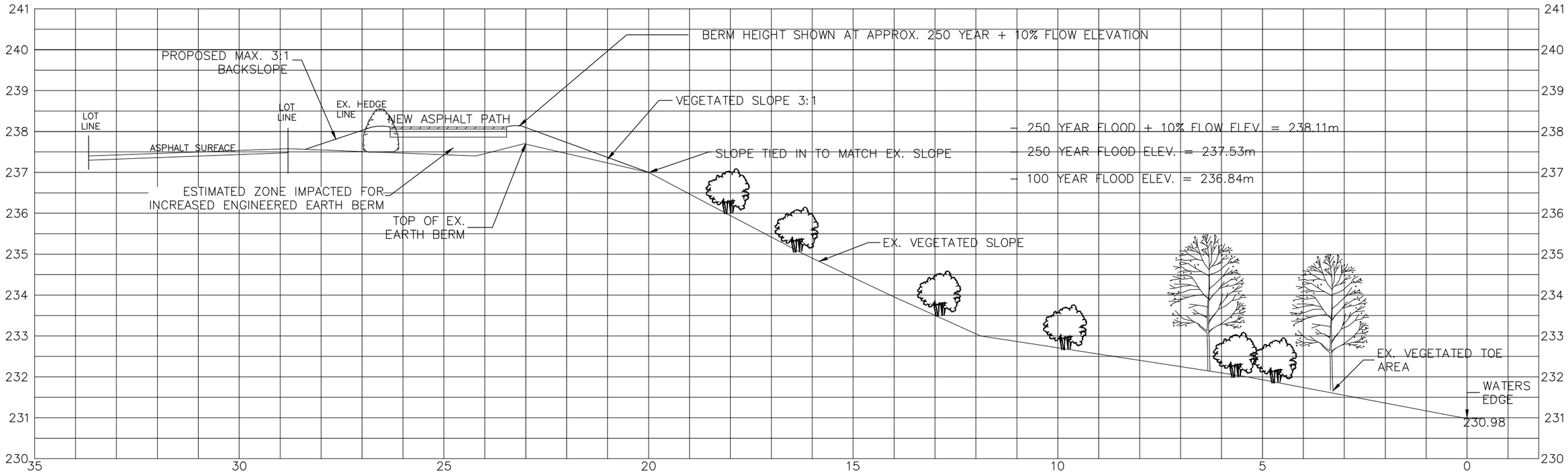
MASTER REPAIR PLAN

Figure No.
1.2

Title
MAIN BRANCH
KEY PLAN

Dyke Cross Section
Section 1 - Oxford North

APPROXIMATE STATION -0+015



NOTE:
ARCHITECTURAL CONCEPT ONLY. FINAL CONFIGURATION TO BE DETERMINED DURING DETAILED DESIGN

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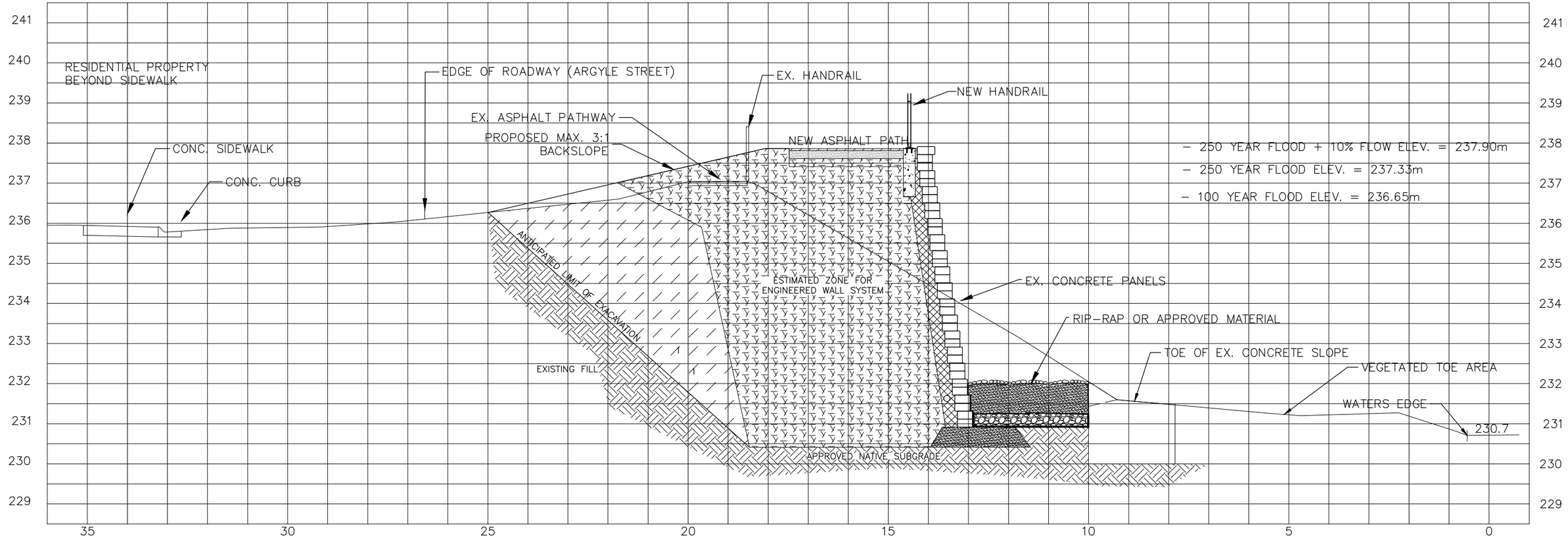
Figure No.
1.3

Title
SECTION 1 - OXFORD NORTH

Dyke Cross Section
Section 2 - St. Patrick

APPROXIMATE STATION 0+130

CONCEPTUAL WALL PLACED IN APPROX. CENTER OF EXISTING STRUCTURE. LOCATION SUBJECT TO CHANGE.



- 250 YEAR FLOOD + 10% FLOW ELEV. = 237.90m
- 250 YEAR FLOOD ELEV. = 237.33m
- 100 YEAR FLOOD ELEV. = 236.65m

NOTE:
ARCHITECTURAL CONCEPT ONLY. FINAL CONFIGURATION TO BE DETERMINED DURING DETAILED DESIGN

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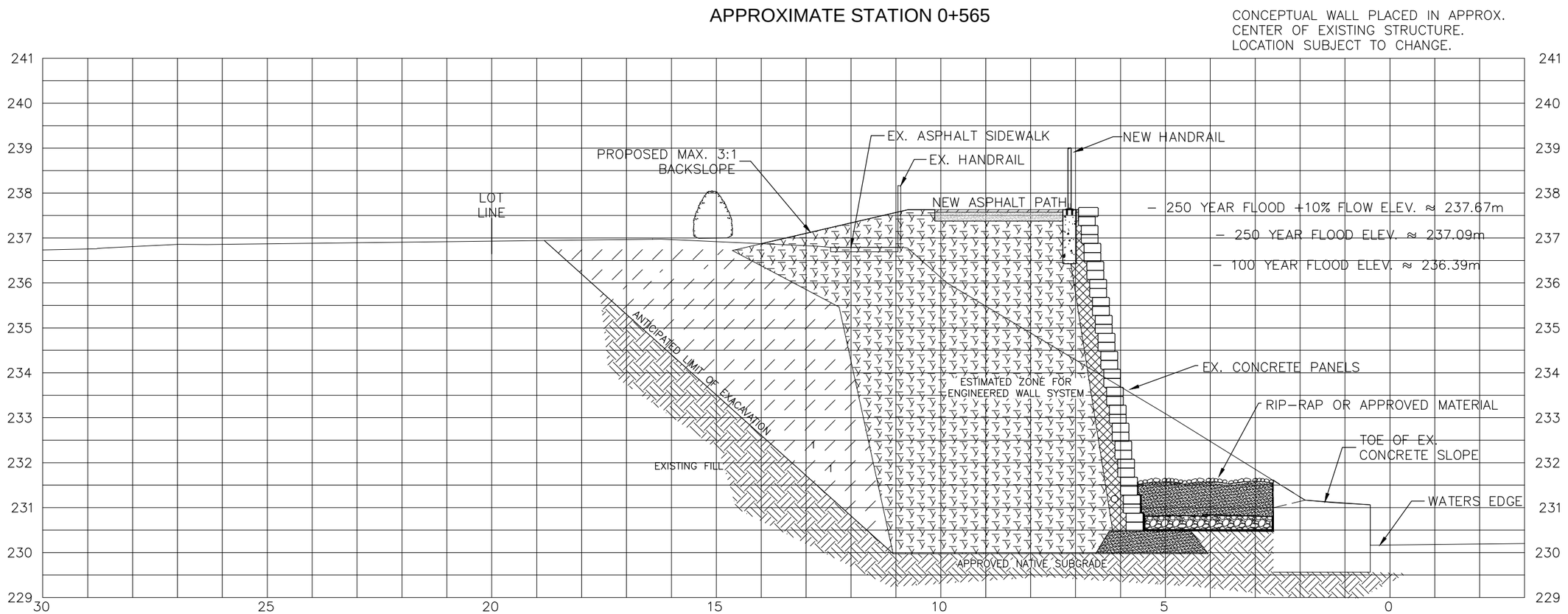
Figure No.
1.4

Title
SECTION 2 - ST. PATRICK

Dyke Cross Section
Section 3 - Blackfriars



NOTE:
ARCHITECTURAL CONCEPT ONLY. FINAL CONFIGURATION TO BE DETERMINED DURING DETAILED DESIGN

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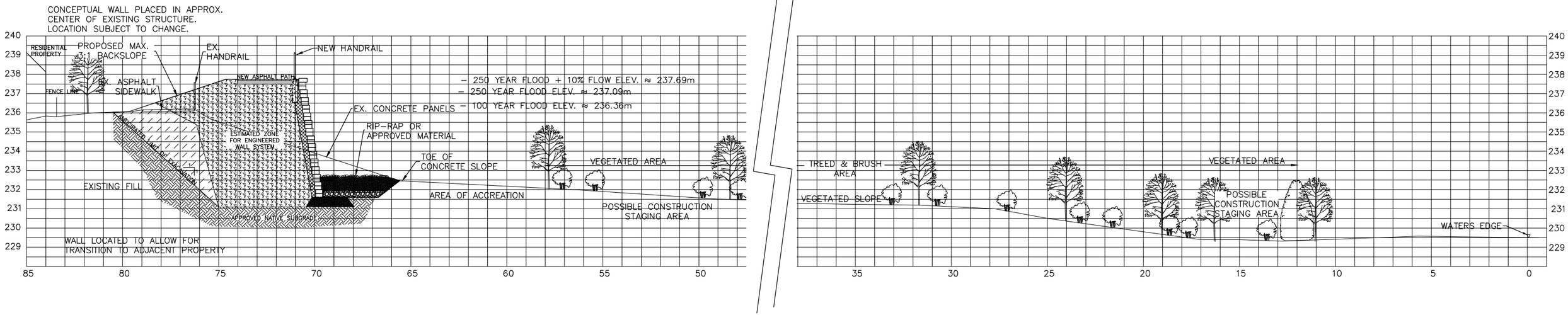
Figure No.
1.5

Title
SECTION 3 - BLACKFRIARS

Dyke Cross Section
Section 4 - Natural Bank

APPROXIMATE STATION 0+810



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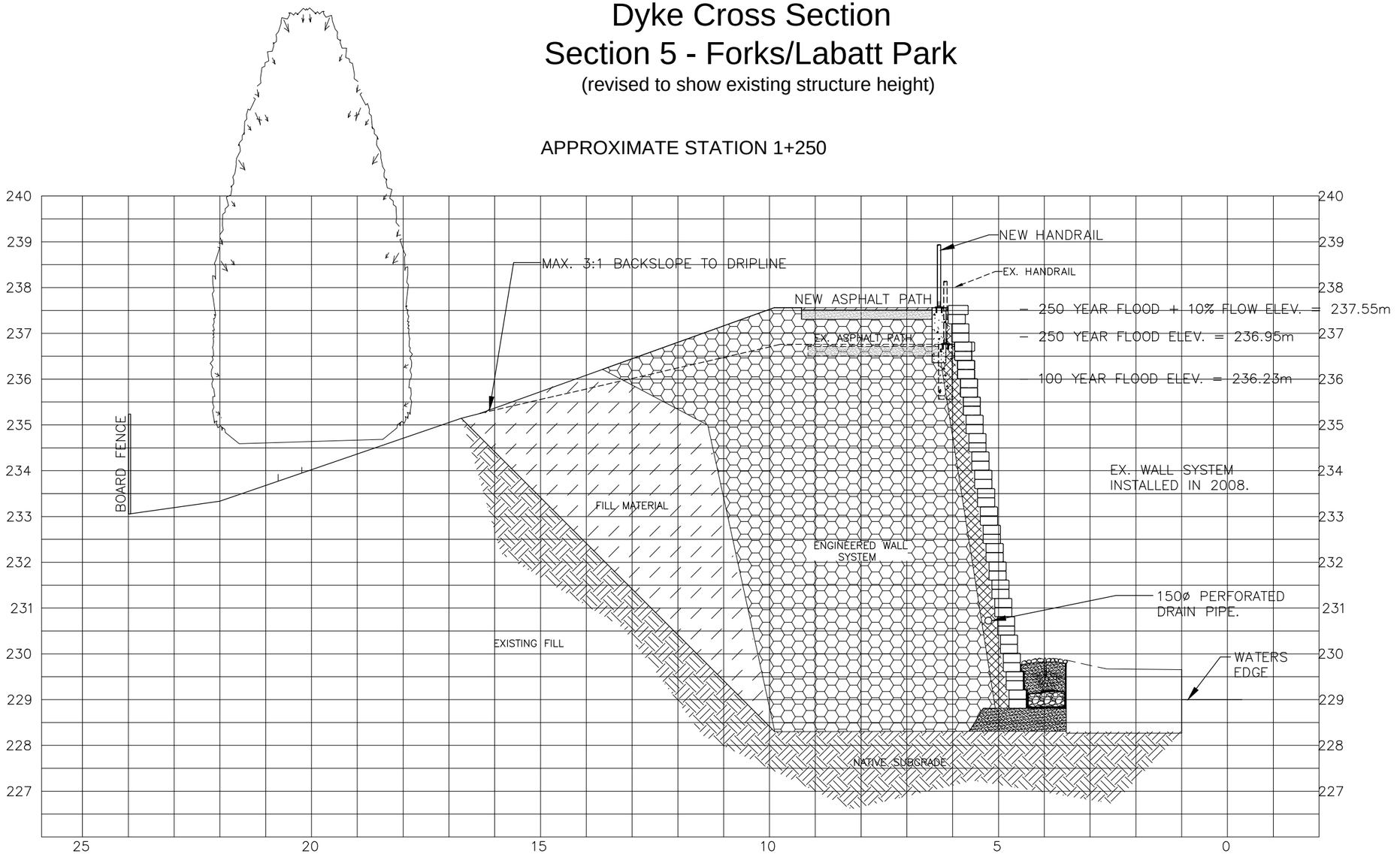
MASTER REPAIR PLAN

Figure No.
1.6

Title
SECTION 4 - NATURAL BANK

Dyke Cross Section
Section 5 - Forks/Labatt Park
(revised to show existing structure height)

APPROXIMATE STATION 1+250



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1.7

Title
SECTION 5 - FORKS/LABATT PARK

Dyke Cross Section
Section 6 - Wharncliffe

APPROXIMATE STATION 1+750

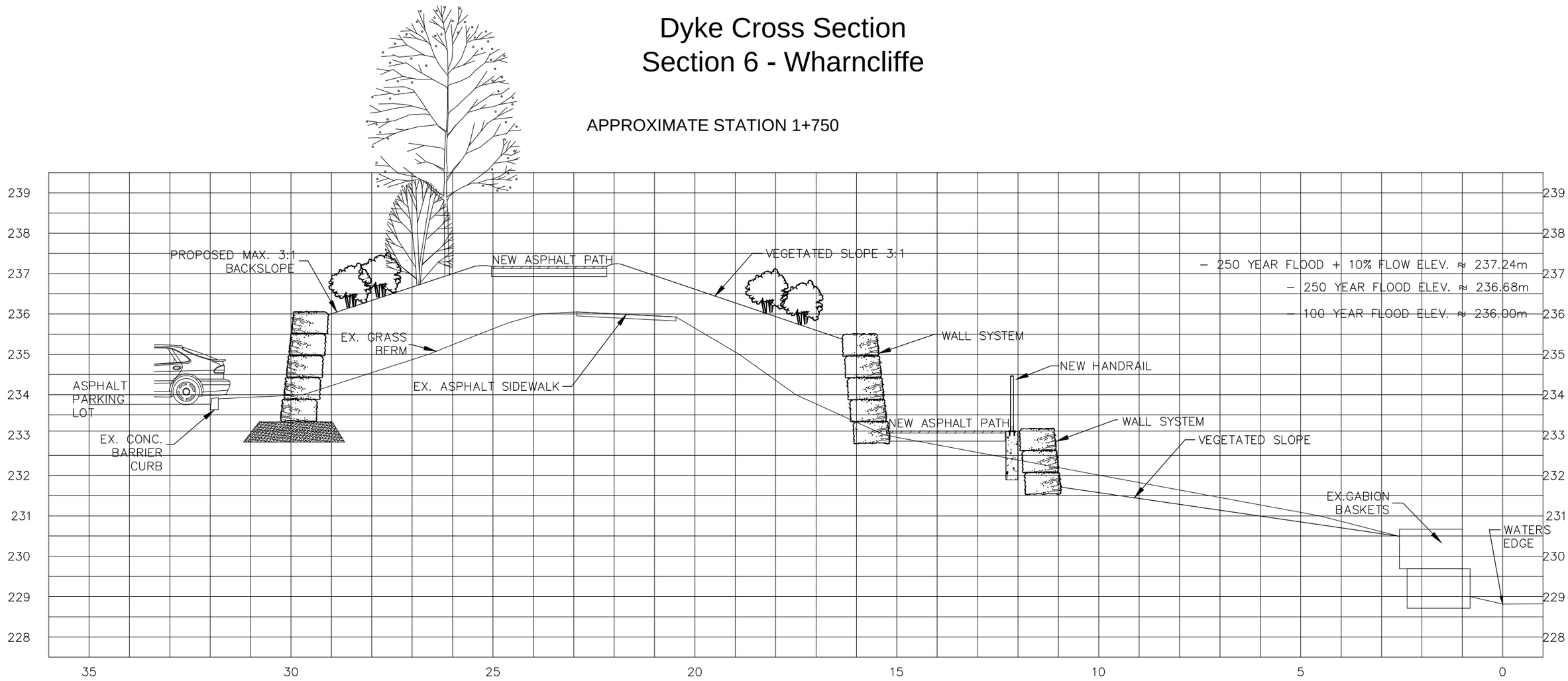

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Figure No.
1.8

Title
SECTION 6 - WHARNCLIFFE

Dyke Cross Section
Section 7 - Cavendish East

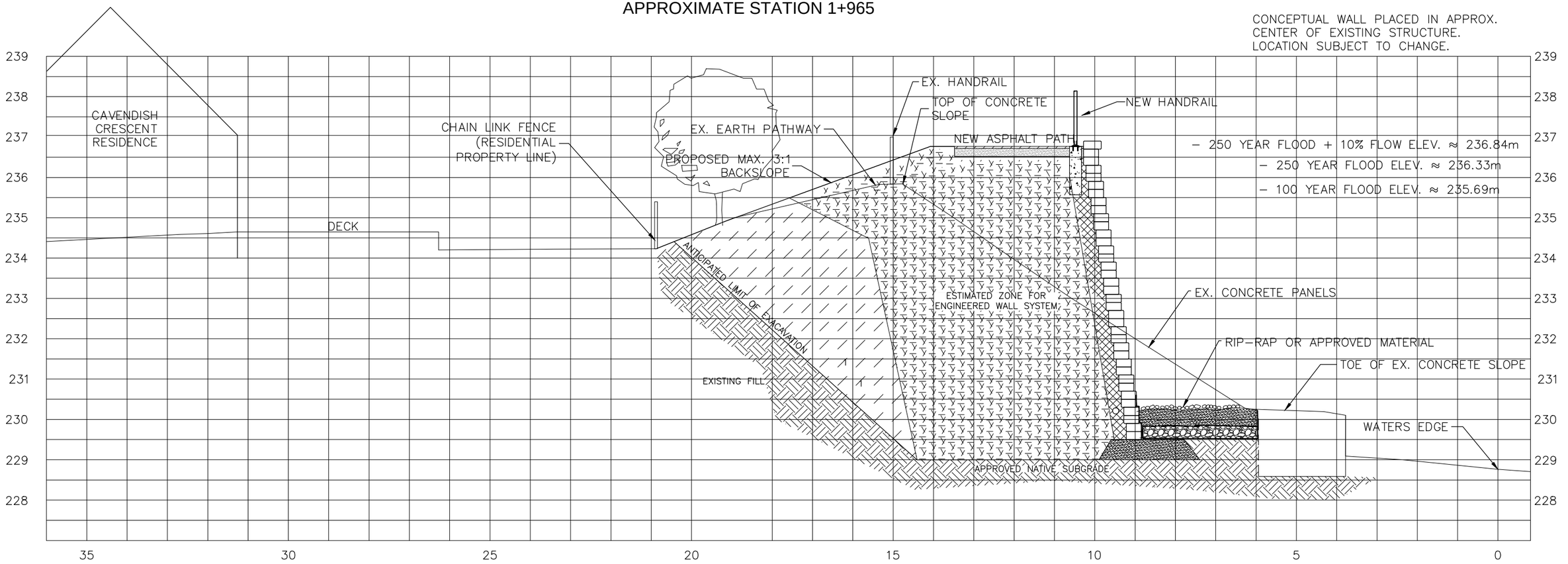

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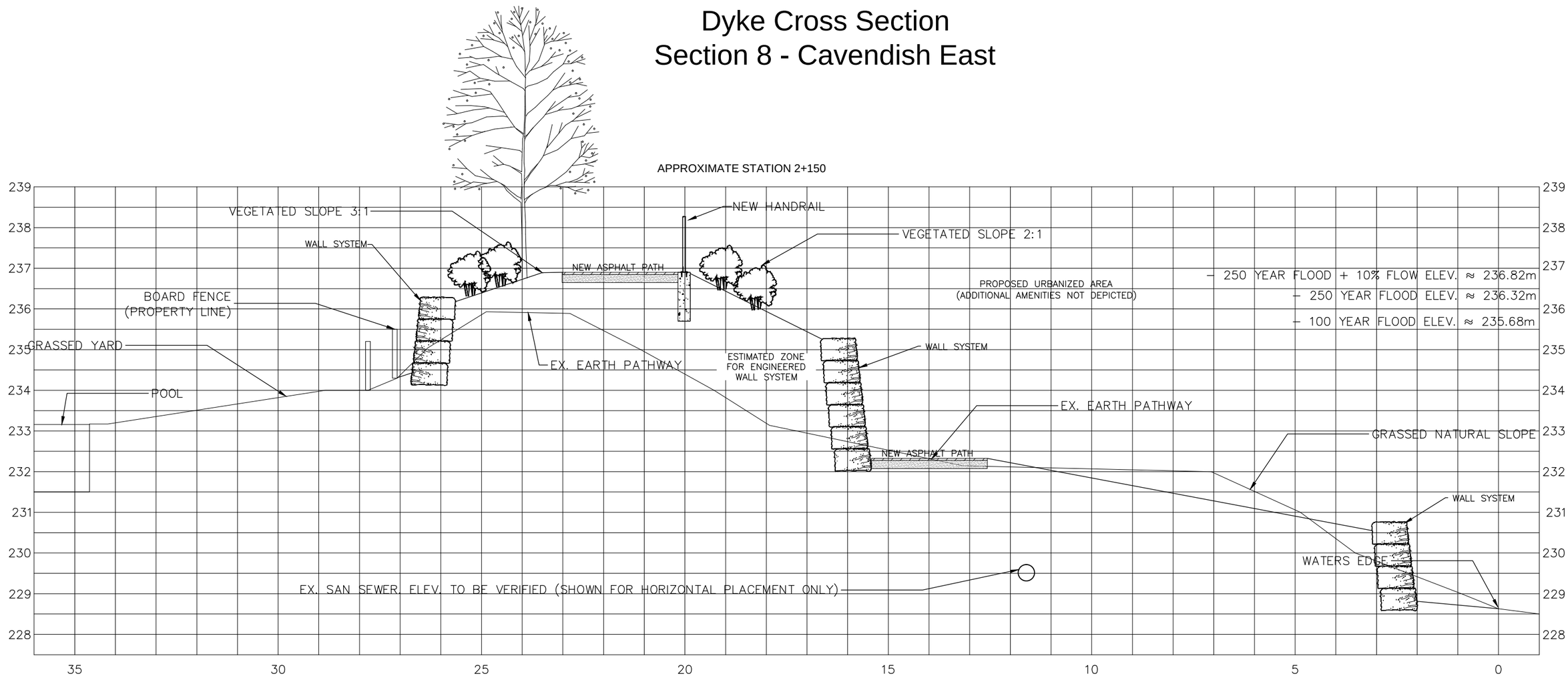
Figure No.
1.9

Title
SECTION 7 - CAVENDISH EAST

Dyke Cross Section
Section 8 - Cavendish East



NOTE:
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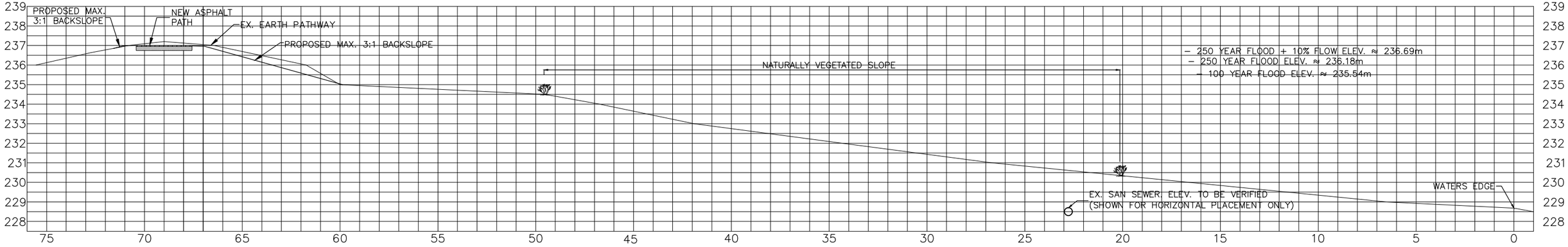
Figure No.
1.10

Title
SECTION 8 - CAVENDISH EAST

Dyke Cross Section
Section 9 - Cavendish West

APPROXIMATE STATION 2+385



NOTE:
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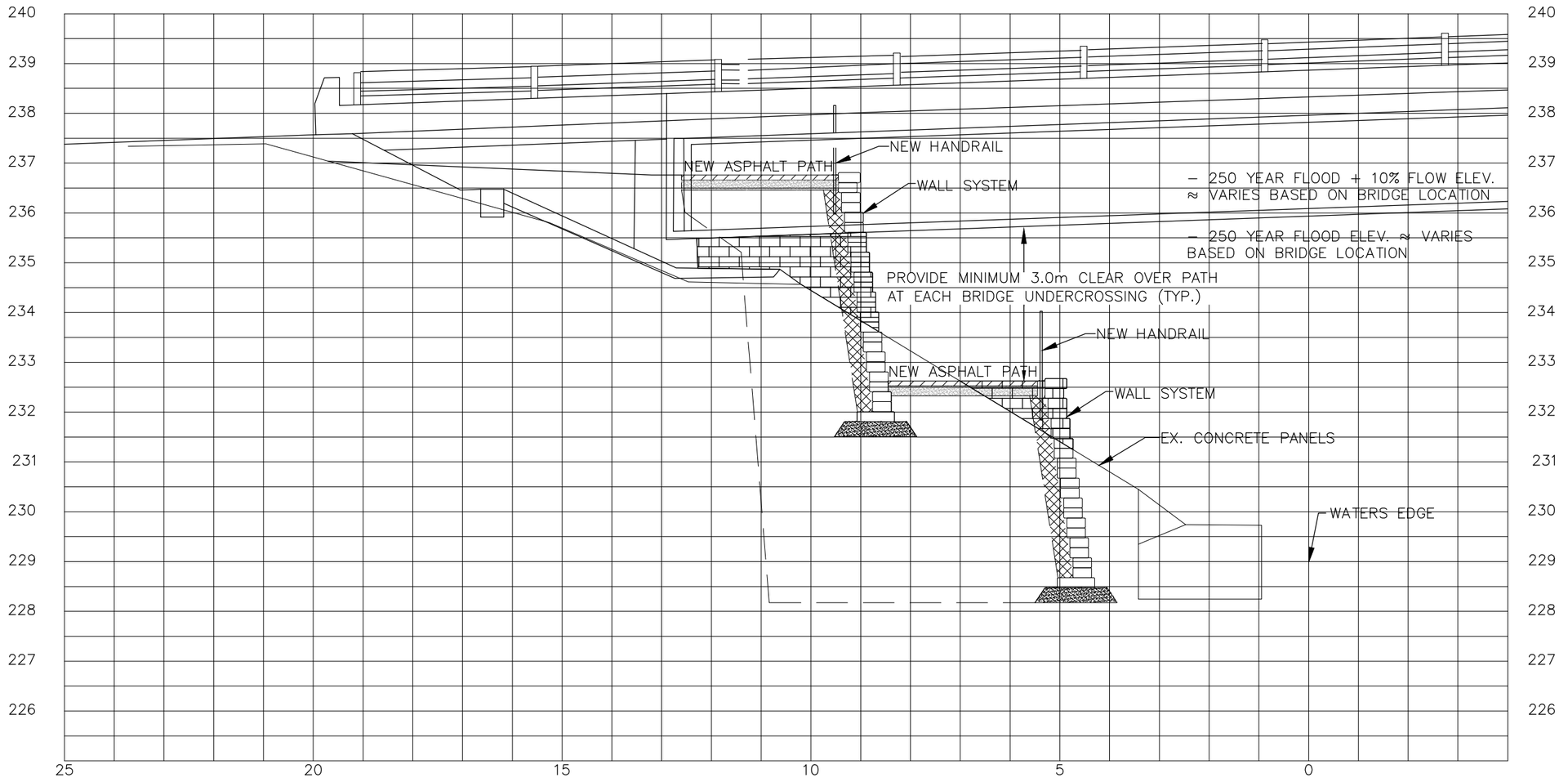
Figure No.
1.11

Title
SECTION 9 - CAVENDISH WEST

Dyke Cross Section
Section 10 - Typical Bridge

TYPICAL SECTION FOR BRIDGE UNDERCROSSING



NOTES:
1. ILLUSTRATES TYPICAL APPROACH TO BRIDGES
2. ARCHITECTURAL CONCEPT ONLY. FINAL CONFIGURATION TO BE DETERMINED DURING DETAILED DESIGN

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Figure No.
1.12

Title
SECTION 10 - TYPICAL BRIDGE UNDERCROSSING

Dyke Cross Section
Section 11 - Blackfriars Bridge

SECTION FOR BLACKFRIARS BRIDGE UNDERCROSSING

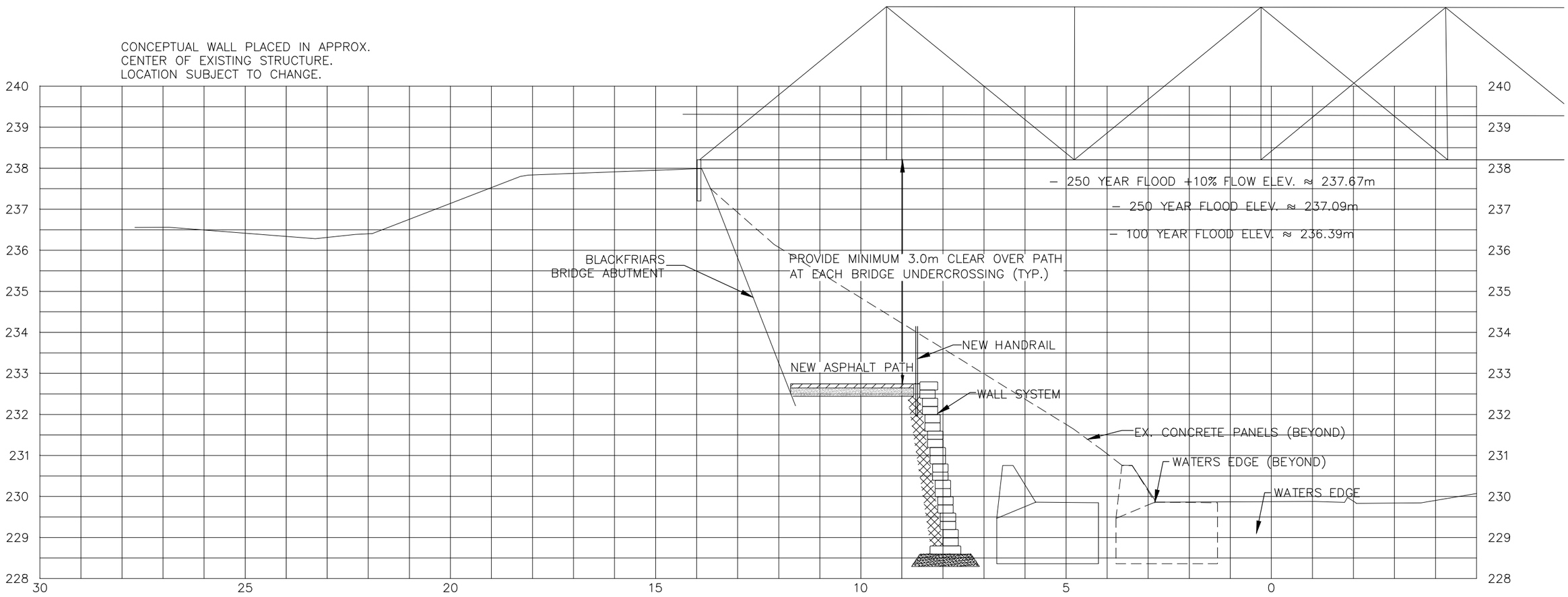

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Figure No.
1.13

Title
SECTION 11 - BLACKFRIARS BRIDGE UNDERCROSSING

10.0 OTHER STUDIES AND MAINTENANCE REQUIREMENTS

10.1 OTHER IDENTIFIED STUDIES AND NEEDS

In addition to the capital improvements identified in this study associated with the preferred alternatives, the following additional studies and programs are recommended:

- Update and calibration of the HEC-RAS model (updated in 2015);
- Update to flood damage reach study (updated in 2015);
- Handrail repair and replacement program;
- Annual monitoring program; and
- Annual maintenance program.

The following subsections provide additional information on each recommended task.

10.2 UPDATE AND CALIBRATION OF THE HEC-RAS MODEL (UPDATED IN 2015)

The existing HEC-RAS model is a critical tool to assist the UTRCA, as the Regulatory Agency, assess appropriate design flows throughout the Thames River watershed, including flows and water levels along the West London Dyke. UTRCA completed an update of the hydraulic model for the Thames River in the City of London through the GIS based HECGeoRAS model in 2015 following review of the existing HEC-RAS model by Stantec in 2010. As with any model, its accuracy is based on the information used to develop the model and the level of calibration performed. Based on a review of the previous hydraulic model, the following recommendations were provided by Stantec in 2010:

- The Thames River design discharges should be recalculated using all available relevant data;
- Obtain surveyed channel cross sections from the downstream limit of the West London Dyke to the Byron Bridge;
- Adjust the downstream model boundary to coincide with the Byron stream gauge and use the gauge rating curve to estimate the boundary water surface elevations for each corresponding design flow. This way, the boundary condition is based on measured data, rather than calculated values with associated error that could be propagated upstream;

- The initial channel roughness prior to model calibration should be calculated using the available stream gauge rating curve data;

- Undertake model calibration. The model should be calibrated using at least two design events, both a bankfull event and a large flood event. The bankfull event should be used to verify the hydraulic roughness of the channel cross sections. The large flood event should be used to calibrate the overbank roughness values; and

- The HEC-RAS cross sections should be represented looking downstream, rather than upstream. While this does not affect the calculation results if it is performed consistently in the model, the HEC-RAS geometry editor shows the cross sections backwards when they are entered in the upstream orientation. Furthermore, the downstream cross section orientation is standard industry practice.

In updating to the HECGeoRAS model in 2015, UTRCA considered the recommendations made by Stantec.

10.3 UPDATE TO FLOOD DAMAGE REACH STUDY (UPDATED IN 2015)

As previously noted, the flood damage cost estimates provided in this Master Repair Plan was generally based on the original Flood Damage Study undertaken as part of the Glengowan Reservoir work in the 1970's and 1980's, with updates as noted by the UTRCA in 2005 to reflect different climate change scenarios. The Flood Damage Reach Study was further updated in 2015 by UTRCA.

The costs associated with potential damages attributed to breaching of the dyke is a key factor in accessing the cost-benefit of undertaking any future upgrade/replacement work. Accordingly, the City and UTRCA may want to consider an updated flood damage reach study. This study should incorporate updated information on the adjacent topography of lands protected by the dyke, along with an updated inventory on structure type. Assessment of potential sewers should also be considered. The exact methodology (i.e., standards, software, etc.) to develop flood damages could be determined subject to additional discussion between the City and UTRCA.

Previously, the damage reaches developed as part of the Glengowan study contained lands across the river and therefore damage estimates may have contained additional costs beyond damages attributed to areas behind the West London Dyke. As part of the update undertaken in 2015 by UTRCA, analysis of damages only considered structures that were behind the West London Dyke (i.e., structures on the right bank when facing downstream).

An estimated cost associated with undertaking an updated Flood Damage Study is included in Table 10.1.

10.4 HANDRAIL REPLACEMENT PROGRAM

As previously noted, a combination of steel, galvanized steel and aluminum handrail runs along the length of the West London Dyke. Based on past visual inspections, a portion of the railing is in poor condition and, with exception of the railing installed as part of the Phase 1 Replacement Structure project, the remaining railing does not meet current Ontario Building Code requirements.

Figure 10.1: Handrail Deficiency

Given the current condition of the handrail, it is recommended that the City and UTRCA consider a yearly replacement program. This program could be funded through an ongoing maintenance budget for the dyke structure, similar to the current road rehabilitation programs within the City. For continuity, the same style railing design could be implemented as was used in the 2007 Phase 1 and 2009 Pathway construction. Installation of the railing would be via a bolt-on design in order to allow for ease of removal and reinstallation as part of any subsequent repair or replacement work for the dyke. By implementing a yearly replacement program, the replacement cost would be spread over a longer period of time, reducing the initial capital cost of replacing the entire length of rail at once.

The cost of the replacement project is included in Table 10.1 and is based on replacement of existing railing on a priority basis.

10.5 ANNUAL MONITORING PROGRAM

The initial visual assessment in 2004 provided general information on the baseline condition of the dyke at that time. Subsequent studies conducted in 2005, 2006, 2010, 2011, 2012, 2013 and 2014 have provided an update on the change in condition along select sections in relation to previous reviews.

Figure 10.2: Panel Deficiency Noted During Inspection

Given the age of the West London Dyke, particularly in relation to the concrete revetment and associated infrastructure, there is a need to

undertake periodic review to confirm any changes in condition and potential impact on the future works/implementation schedule for repairs/replacement. Based on the findings from previous inspections which indicated an increase in deficiencies from past reviews, it is recommended that future inspections be carried out on an annual basis.

The estimated cost for annual inspection of the West London Dyke is provided in Table 10.1.

10.6 ANNUAL REPAIR PROGRAM

Based on the results from the annual monitoring program, areas identified for immediate repair or additional monitoring and repair should be addressed in order to extend the useful life of the dyke until full replacement can be completed. Accordingly, these repairs should be budgeted for in order to ensure that they are completed in a timely manner prior to the development of larger scale issues. It should be noted that these repairs generally reflect issues with either the dyke or pathway, but exclude replacement of the railing which would be addressed under the separate railing replacement program previously proposed.

Figure 10.3: Panel Deficiency Repair

Replacement, rather than repair of the dyke, would occur once it becomes apparent that further repair is either ineffective or cost prohibitive, or where a trigger point is reached.

Refer to Figure 10.4 which provides an illustration of dyke deficiencies based on past reviews. Table 10.1 provides an estimated annual budget to undertake repairs. It should be noted that the annual budget should be reviewed periodically to ensure that adequate budgeting is available based on the findings of future monitoring programs. Over time, it is expected that costs for the annual repair program will decrease as areas are replaced.

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Revised: 2016-02-01 By: kbuchanan

February 2016
165630035

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- Repair Location

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Imagery and base features used under license with the City of London, © 2009-2015.

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Upper Thames River Conservation Authority & City of London
West London Dyke Master Repair Plan

Figure No.

10.4

Title

Deficiencies Repaired 2012-2014

10.7 SUMMARY OF STUDY/MAINTENANCE COSTS

Table 10.1 provides an overall summary of the recommended additional studies and maintenance programs for the West London Dyke.

Table 10.1: Additional Study and Program Costs

Item	Task	Estimated Cost
Updated Flood Damage Reach Study	Field verification of land uses, area survey, and flood damage modeling.	**$180,000**
Handrail Replacement Program	Replacement of Damaged Rail with New Railing.	**$55,000**
Annual Monitoring Program	Non-Intrusive Visual Assessment Based on Inspection Protocol.	**$12,500**
Annual Repair Program	Repair of Dyke (concrete, gabions, handrail repair, etc.) excluding handrail replacement.	**$165,000**

11.0 RECOMMENDATIONS

The recommendations presented below in Table 11.1 have been summarized to provide a complete and concise list to be reviewed prior to the initiation of any subsequent preliminary and detailed design phases. In addition to capital improvements and repairs, additional studies and programs have been recommended and summarized below. Recommendations have been based on comments received during the consultation process, the evaluation of project drivers, input from both the UTRCA and the City, and the environmental and technical reviews completed for the West London Dyke.

Table 11.1: Recommendations

No.	Recommendation	Category	Section[1]
Flood Risk and Public Safety			
1	The decision on passive versus active measures will need to be assessed by the City and UTRCA based on a review of the overall flood protection planning strategy and specific constraints along the various areas of the dyke including bridge abutments and proximity to adjacent land uses.	Flood Risk Reduction	5.1.1
2	The City and the UTRCA should continue to collaborate on Climate Change initiatives in regard to the potential impacts on land use planning, land management, and flood control system adaptation in the City, specifically as it relates to the West London Dyke.	Climate Change	8.9
3	The City and the UTRCA should continue to evaluate the desired freeboard elevation in terms of both risk and social, natural and economic factors prior to preliminary and detailed design of each section.	Freeboard	8.10
4	Access to the river at key points must be reviewed as part of the City's overall risk management strategy. Social benefits will need to be reviewed in relation to risk management and overall maintenance and operational concerns as these lower areas will be exposed to more frequent flooding.	Public Safety	5.1.2 / 5.2
5	Consideration should be given to the availability of lighting as well as access when considering worker safety from the perspective of general maintenance requirements and flood response duties.	Public Safety	5.1.2
6	The City and UTRCA should review the current condition of the railing and consult with their risk management policies to confirm as appropriate course of action, particularly for areas where future work is not anticipated to proceed for some time.	Public Safety	5.2

No.	Recommendation	Category	Section[1]
Amenity Improvements			
7	Implementation of functional improvements should also consider recommendations from the Thames Valley Corridor Study, Bicycle Master Plan, 2007 Amenity Master Plan for areas along the dyke.	Functional Improvements	5.1.3
8	Additional or enhanced amenities should be considered in future designs (i.e., lookout areas, wider pathways, seating, etc.).	Amenities	8.6.2 / 8.11
9	Future replacement phases should incorporate walkway widths and grading in accordance with current City standards.	Amenities	8.6.6
10	Aesthetics must be considered in the selection of the preferred structure due to the high visibility, proximity to the downtown core, and recent City revitalization projects.	Aesthetics	8.6.7
11	Future design or rehabilitation work should eliminate the use of stairs through proper walkway transitioning.	Accessibility	5.2
12	Consideration should be given to the appropriate level of lighting to be provided based on the six factors presented within this document.	Lighting	5.2
13	Future replacement projects incorporating hard surfaces for either dyke facing, seating areas, etc., should consider potential impacts of graffiti and incorporate measures to address these (i.e., anti-graffiti coatings).	Vandalism	8.6.8
14	Consideration should be given to the potential for pedestrian underpasses under all bridges, where feasible.	Design Considerations	7.12
15	The buffer between residences and the pathway system should be maximized during all phases of design development.	Design Considerations	7.12
16	During design when possible, consideration should be given for adequate room at the top of the wall for features such as lookouts, buffers and gathering spaces.	Design Considerations	7.12
Environmental Considerations			
17	Consideration should be given for environmental improvements and should take into account the potential impact on existing habitat or introduction of habitat that could result in damage to the dyke structure, including potential for rodent burrowing under cover, etc.	Environmental Considerations	5.1.4
18	Environmental field studies and investigations should be planned and completed at the preliminary design phase of a project.	Natural Environment	6.1.3.2

No.	Recommendation	Category	Section[1]
19	Updated vegetation surveys should be completed prior to undertaking future projects (should include an assessment within the north and west extensions which were not previously included in the Dougan and Associates Vegetation Management Plan).	Natural Environment	6.1.3.3
20	Any project undertaken through this Master Repair Plan will require additional review of available information and may require field investigations to determine presence/absence of at risk species.	Natural Environment	6.1.6.3
21	Detailed natural environment mitigation and compensation measures should be further developed as the detailed design of proposed projects are finalized in consultation with appropriate regulatory agencies.	Natural Environment	6.2.7
22	Sustainable options (green design principles) should be further considered during detailed design.	Green Design	8.7
23	Opportunities for naturalization planting areas and terrestrial and aquatic habitat creation should be considered during the design phase.	Design Considerations	7.11
24	Undertake a Stage 1 and Stage 2 (if required) Archaeological Assessment prior to construction.	Social/Cultural Environment	6.2.4
25	Undertake a Heritage Impact Assessment (if required) to mitigate negative impacts on heritage resources prior to construction.	Social/Cultural Environment	6.2.3
Planning, Construction & Miscellaneous Considerations			
26	The City should consider the potential for cost sharing opportunities between City departments and/or with the UTRCA (i.e., WECI) and provincial/municipal grants or programs (i.e., stimulus programs).	Funding Opportunities / Municipal Infrastructure	5.1.5 / 8.4
27	Hydrologic or hydraulic considerations associated with the Thames River may warrant the need for future improvements.	Other Project Drivers	5.1.6
28	Consideration during design should be given to potential constructability issues such as access for construction vehicles, available staging area, and adequate room to physically construct the structure.	Constructability	8.5
29	Future phases should involve additional investigations to determine the extent of potential contaminated soils and allowances required for removals during subsequent work.	Legacy Issues	8.3

No.	Recommendation	Category	Section[1]
30	The City and UTRCA should undertake a continuous review of functional, operational, and safety issues related to future detailed designs, such as slope stability, physical constraints, etc.	Functional, Operational and Safety Issues	8.6
31	Initiation of future individual projects should involve a review of Class EA and legislation requirements.	Permits and Approvals	8.8
32	Future work should be in coordination with other projects or initiatives within the area including the Blackfriars Bridge Class EA, WADE projects, and CSO program work.	Project Triggers	9.9
Studies			
33	The UTRCA HEC-RAS model should be updated and calibrated as new information becomes available (updated in 2015).	Other Studies	10.2
34	Continue to update the Flood Damage Reach Study as new information becomes available, including updated inventory on structure type as well as assessment of potential sewers (updated in 2015).	Other Studies	10.3
35	The City and UTRCA should implement a handrail repair and replacement program.	Other Studies	10.4
36	The City and UTRCA should continue to undertake an annual dyke monitoring program.	Other Studies	10.5
37	The City and UTRCA should continue to undertake an annual dyke maintenance program.	Other Studies	10.6

Notes:

1. *Reference to applicable section within the Master Repair Plan document.*

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