UNCLASSIFIED / NON CLASSIFIÉ

REPORT

Conceptual Sediment Management Plan for the Kingston Inner Harbour

Transport Canada and Parks Canada Water Lot, Kingston, Ontario

Submitted to:

Public Services and Procurement Canada

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Distribution List

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Executive Summary

Numerous studies over the last 15 years have characterized the environmental significance of sediment contamination within the Kingston Inner Harbour (KIH), culminating in environmental risk assessments that identified unacceptable conditions in some areas of the harbour. As such, sediment management, including physical intervention in several areas of KIH, has been recommended and federal custodians have committed to risk-based management of sediment contamination in western KIH (herein referred to as the Project). The objective of the Project is to reduce the risks from sediment contamination to people and wildlife within the KIH through management of sediment quality, while also protecting sensitive species, habitats, and valued features. The Project is intended to balance the short and long-term disruptions and risks from multiple stressors and align chemical risk reductions with other values of the KIH to Indigenous Groups, stakeholders, and the public. Broadly, the Project is intended to implement targeted removals and/or isolation of contamination in a manner that will:

- Provide both localized and broad (harbour-wide) reductions of primary contaminants of concern (COCs) to reduce ecological and human health risks.
- Provide high efficiency of chemical removals per unit of effort spent, such that the positives of chemical risk reduction outweigh short-term disruptions.
- Rely on natural recovery processes in areas of the harbour that currently have risks that are negligible to low.
- Prevent or limit the degree of habitat disruption during project works, particularly for sensitive ecological components.
- Provide potential for recolonization and rehabilitation of affected areas; and where possible achieve improved conservation gains of habitat conditions.
- Provide removal and/or isolation of contaminants compatible with potential redevelopment of the shoreline conservation gains of improved habitat conditions.
- Prevent unacceptable resuspension or release of contaminants during project works, thereby mitigating impairment of water quality.

To meet these Project objectives, management units throughout KIH have been established to allow for a customized approach based on localized conditions, habitat values, and other considerations such as property ownership. The management units allow for physical intervention to be focused on areas of higher risk and accepts that low risk conditions can be managed through natural recovery or administrative controls.

In 2021, a draft conceptual Sediment Management Plan (SMP) for the KIH was issued that provided an initial analysis of the scientific issues, estimates of indicative liability costs, evaluation of alternative sediment management techniques, and a recommended approach for sediment management within the aquatic portions of the harbour. Based on the 2021 draft conceptual SMP, Indigenous Consultation and Stakeholder Engagement were undertaken to seek feedback on the risk management objectives and design considerations, including contaminant mass reduction, protection of habitats, interaction with recreational opportunities, business operations and development plans for adjacent lands, shoreline character, and offsets from infrastructure and other valued harbour components. As a result of these engagement and consultation activities, the sediment management strategy has been updated herein. Furthermore, the results from recent biological, ecological, and archaeological baseline studies for the KIH have been incorporated into this updated conceptual SMP to facilitate the evaluation of potential effects of implementing the Project.

Overall, the intent of the conceptual SMP is to advance the level of detail for the remediation planning, incorporate consideration of Indigenous groups, stakeholders, and public feedback, and support the future design and tender documents for the Project, including:

- Specification of design elements specific to each management unit, used in preliminary costing estimates and for partitioning of environmental liability among multiple water lot owners.
- Conceptual plans and indicative construction cost estimates (rough cost projections to be used for budget planning purposes) for each of the management units.

The conceptual SMP provides a summary of results from previous investigations, including identification of COCs; affected media, quantity, and quality of materials to be treated/managed; assessment of lacustrine (lake and wetland) processes including sediment stability; and initial assessment of potential environmental, biological, and social/cultural effects from the Project. It presents the recommended sediment management approach, and a discussion of how the SMP intends to avoid or minimize adverse effects from the Project to the natural and human environment (e.g., biological habitats, Species at Risk [SAR], water quality, and shoreline processes).

Project Context

Kingston Harbour is adjacent to the City of Kingston, at the eastern end of Lake Ontario. The entire Kingston Harbour is approximately 765 hectares (ha) in size and includes an Inner and Outer Harbour. The KIH is bounded by Highway 2 (LaSalle Causeway Bridge) to the south and Highway 401 to the north and includes a 5 km length of the Great Cataraqui River. The KIH is further divided into northern and southern sections by Belle Island and Cataraqui Park. The sediment management area within KIH is bounded by Highway 2 (LaSalle Causeway Bridge) to the south and Belle Island/Cataraqui Park to the north and includes an approximate 1.7 km length of the Great Cataraqui River. Jurisdiction of most of the southern section of the KIH (i.e., south of Belle Island and Cataraqui Park) is held by Transport Canada (TC). Parks Canada Agency (PCA) is the manager of harbour sediments in the portion of the KIH immediately south of Belle Park Fairways (southwest of Belle Island) and in the portion of the KIH north of Belle Island. A small percentage of the southern half of KIH is managed by other parties, including the City of Kingston and the Department of National Defense (DND).

Over the last 15 years, multiple field studies and desktop evaluations have been conducted in KIH to characterize the spatial extent and magnitude of contamination, including assessment of the risks of contaminants to humans and aquatic and semi-aquatic life. Investigations have followed the Canada-Ontario Decision-Making Framework for assessment of Great Lakes Contaminated Sediment, which uses an ecosystem approach to sediment assessment; this framework is intended to standardize the decision-making process while also being flexible enough to account for site-specific considerations. The Federal Contaminated Sites Action Plan (FCSAP) Expert Support departments (Health Canada [HC], Environment and Climate Change Canada [ECCC], Fisheries and Oceans Canada [DFO]), which provide advice regarding the technical competency of environmental investigations, have peer reviewed these studies and evaluations at milestone reporting stages.

Early Project Outcomes

The findings from the earlier risk assessment stages of the Project were characterized in a risk assessment synthesis report, which combined information from numerous complementary technical investigations. Next, a conceptual remedial options analysis (CROA) was completed in 2017, which integrated multiple scientific and logistical factors that influence the risk management decisions for KIH. The CROA represented the transition from purely technical (scientific) investigations to the risk management stage that incorporates several non-technical values and considerations. The intensity of physical intervention required to reduce environmental risk was categorized into high, moderate, and low levels. Multiple risk management strategies and technologies were identified, including both conventional intrusive options (e.g., capping, dredging) and lower intrusion options (e.g., thin-layer capping with active layers, monitored natural recovery). Consideration was given to balancing many factors, such as chemical risk reduction, feasibility, cost, habitat modification, the potential presence of cultural/archaeological resources or artifacts, and disruption to existing and future water uses including recreation. A preferred conceptual design for sediment management with a moderate level of intervention that balanced several competing risk management objectives was recommended, which was presented in the 2021 conceptual SMP.

General agreement on the recommended approach to sediment and risk management has been received from both Public Works and Procurement Canada (PSPC) and site custodian agencies (TC and PCA). However, several recommendations and concerns were identified by Indigenous groups, stakeholders, and the public, and additional site information on biology and archaeological values has recently been obtained. This updated conceptual SMP considers recommendations and concerns identified since stakeholders and Indigenous groups reviewed the 2021 draft conceptual SMP. Most of the updates to the SMP reflect refinements in the balancing of Project objectives (i.e., to reduce chemical risk by sediment removal or sequestration, while protecting shorelines and their associated sensitive biological species, their habitats, and fluvial and lacustrine processes). Further, this conceptual SMP is intended to align with Kingston's Waterfront Master Plan for shoreline development.

Path Forward

The Project is currently in the planning stage, and further opportunities for consultation and engagement remain. At this time, the Project broadly consists of the following elements:

- Installation of temporary facilities and laydown-area(s).
- Dredging of contaminated areas within KIH that have the highest concentrations of primary COCs (chromium, PAHs, PCBs), with off-site disposal of contaminated material. Since the 2021 draft conceptual SMP, the overall dredge footprint has been reduced from 15.3 ha to 12.9 ha (of the total project area of 177 ha) and replaced with monitored natural recovery or enhanced natural recovery (i.e., lower intrusion approaches) and a dredging exclusion zone along all shorelines except within Anglin Bay.
- Monitored natural recovery remains an important strategy for large volumes of sediment in the central portion of KIH. The Supplemental Sediment Sampling Program (Golder 2022) confirmed the broad patterns of sediment quality and continued to support monitored natural recovery in large portions of central KIH, while also confirming that dredging is still required in several areas of western KIH due to hotspots of high contamination that are driving unacceptable risks.

- Placement of a thin engineered cover (potentially including sand, activated carbon, and/or organic materials) in lower risk areas, where post-dredge residuals are of concern, or in areas where dredging is not feasible.
- Placement of a conventional sand cap with activated carbon within Anglin Bay.
- Nature-based shoreline rehabilitation, using principles of “green engineering” and recognition of existing habitat values, will enhance ecological habitat and prevent/reduce risk of erosion, while limiting the potential for human access to the water and addressing nearshore contamination (where applicable). This has replaced the use of shoreline hardening or revetments previously recommended to reduce human health exposures (at management units TC-RC, WM, TC-2A, TC-3A and TC-4) as discussed in the 2021 SMP.
- Buffer zones between the dredging footprint and shoreline (5 to 10 m) have been added as part of this updated SMP to preserve the integrity of shorelines, sensitive habitats, and archaeological features in some areas.
- Associated site monitoring and rehabilitation works.

Overall, the general design concept is to maintain and protect existing shoreline features, and where possible, work on improving the ecological habitat along the shorelines. Based on the conceptual SMP, a detailed design for the Project will be completed. Also, a Detailed Impact Assessment (DIA) will be completed to evaluate the potential of adverse effects on natural and cultural resources by the Project and how such effects can be mitigated or compensated for. Any predicted interactions between the Project phases (e.g., site preparation, sediment management activities, and post-construction monitoring) and their potential environmental effects will be identified and described in the DIA. Indigenous and stakeholder engagement will continue through the detailed design stage, and opportunities to provide input on more detailed project plans and effects analysis will be provided as part of the DIA process.

List of Abbreviations

Abbreviation	Definition
2LAET	Second Lowest Apparent Effect Threshold
BMP	Best Management Practices
BPA	Bisphenol A
BTEX	Benzene, toluene, ethylbenzene, and xylenes
CCIC	Conceptual Constraints and Impact Considerations
CCME	Canadian Council of Ministers of the Environment
CEC	Contaminant of emerging concern
CEPA	Canadian Environmental Protection Act
CHS	Canadian Hydrographic Services
CNWA	Canadian Navigable Waters Act
COC	Contaminant of concern
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
COSSARO	Committee on the Status of Species at Risk in Ontario
CRCA	Cataraqui Region Conservation Authority
CROA	Conceptual Remedial Options Analysis
CSO	Combined sewer overflows
DMAF	Disaster Mitigation and Adaptation Fund
DND	Department of National Defense
DFO	Fisheries and Oceans Canada
DIA	Detailed Impact Assessment
DQRA	Detailed Quantitative Risk Assessment
DOC	Dissolved organic carbon
ECCC	Environment and Climate Change Canada
EPO	Environmental Performance Objective
EMP	Environmental Management Plan
ENR	Enhanced natural recovery
ESA	Endangered Species Act
ESG	Environmental Science Group
FCSAP	Federal Contaminated Sites Action Plan
FEQG	Federal Environmental Quality Guideline
Golder	Golder Associates Limited (now WSP Canada Inc.)

Abbreviation	Definition
GOST	Guidance and Orientation for the Selection of Technologies
GPR	Ground-Penetrating Radar
HADD	Harmful alteration, disruption, or destruction
HCCL	HCCL Coastal & River Engineering
HDPE	High Density Polyethylene
IAA	Impact Assessment Act
IGLD	International Great Lakes Datum
ISQG	Interim Sediment Quality Guideline
ITRC	Interstate Technology and Regulatory Council
KIH	Kingston Inner Harbour
LAEL	Lowest Adverse Effect Level
LEL	Lowest Effect Level
LC50	Lethal concentration that causes 50% mortality to a group of test species
MBCA	Migratory Bird Convention Act
MDMER	Metal and Diamond Mining Effluent Regulation
MECP	Ontario Ministry of Environment, Conservation, and Parks
MMAH	Ontario Ministry of Municipal Affairs and Housing
MNR	Monitored Natural Recovery
MNRF	Ontario Ministry of Natural Resources and Forestry
MTCS	Ministry of Tourism, Culture and Sport
NTU	Nephelometric Turbidity Unit
OEPA	Ontario Environmental Protection Act
OMOE	Ontario Ministry of Environment (now MECP)
O.Reg.	Ontario Regulation
OWRA	Ontario Water Resources Act
PAH	Polycyclic aromatic hydrocarbon
PBDE	Polybrominated diphenyl ethers
PC-	Prefix for units owned by Parks Canada Agency
PC-N	Parks Canada North management unit
PC-OM	Parks Canada Orchard Marsh management unit
PC-W	Parks Canada West management unit
PCA	Parks Canada Agency
PCB	Polychlorinated biphenyl

Abbreviation	Definition
PEC	Probable effects concentration
PEL	Probable Effects Level
PFAS	Perfluoroalkyl and polyfluoroalkyl substances
PHC	Petroleum hydrocarbon
POD	Point of Discharge
PP-OM	Private Property Orchard Marsh management unit (ownership details of water lot to be confirmed)
PQRA	Preliminary Quantitative Risk Assessment
PPS	Provincial Policy Statement
PSPC	Public Services and Procurement Canada
PWGSC	Public Works and Government Services Canada
RMC	Residuals management cover
SAR	Species at Risk
SARA	Species at Risk Act
SARO	Species at Risk in Ontario
SAV	Submerged aquatic vegetation
SEL	Severe Effect Level
SeQG	Sediment Quality Guideline
SMP	Sediment Management Plan
S/S	Stabilization and Solidification
TBT	Tributyltin
TC	Transport Canada
TC-	Prefix for units owned by Transport Canada
TC-1	Transport Canada management unit #1
TC-2A	Transport Canada management unit #2a
TC-2B	Transport Canada management unit #2b
TC-3A	Transport Canada management unit #3a
TC-3B	Transport Canada management unit #3b
TC-4	Transport Canada management unit #4
TC-5	Transport Canada management unit #5
TC-AB	Transport Canada Anglin Bay management unit
TC-OM	Transport Canada Orchard Marsh management unit
TC-RC	Transport Canada Rowing Club management unit
TCLP	Toxicity Characteristic Leaching Procedure

Abbreviation	Definition
TSS	Total suspended solids
UNESCO	United Nations Educational, Scientific, and Cultural Organization
WM	Woolen Mill management unit
WQG	Water Quality Guideline
WSP	WSP Canada Inc.

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APPENDICES

1.0 INTRODUCTION

WSP Canada Inc. (WSP) was retained by Public Services and Procurement Canada (PSPC), on behalf of Transport Canada (TC) and Parks Canada Agency (PCA), to update the conceptual Sediment Management Plan (SMP) for the Kingston Inner Harbour (KIH) Sediment Management Project in Kingston, Ontario (the Project). The first draft of the SMP was prepared by Golder Associates Limited (Golder; amalgamated under WSP in January 2023) in August 2021.

Kingston Harbour is located at the eastern end of Lake Ontario and includes an Inner Harbour (KIH) and Outer Harbour. Sediment in KIH, which includes water lots south of Belle Island and Cataraqui Park and north of Lasalle Causeway, is known to contain contamination of historical origin. The Project has been characterized in terms of spatial extent and magnitude of sediment contamination, and the effects of those contaminants to organisms (Golder 2016, Golder 2022a, WSP 2023c). Based on the potential ecological and human health risks from sediment contamination within KIH, sediment management including physical intervention was recommended (Golder 2017a; Golder 2019). In 2021, an initial conceptual SMP (Golder 2021a) provided an analysis of the scientific issues, estimates of indicative liability costs, alternatives evaluation, and a recommended approach for sediment management within the aquatic portions of the harbour. Since then, there were several recommendations for refinement to the SMP from consultation and engagement with Indigenous groups, stakeholders and the public, and input from the site custodians; the conceptual SMP has been updated herein to incorporate these recommendations and advance the concepts presented in Golder 2021a.

2.0 PROJECT DESCRIPTION

2.1.1 Project Objective

The objective of the Project is to reduce the potential for risks from sediment contamination to people and wildlife[1] within KIH through management of sediment quality, while still protecting sensitive species, habitats, and valued features. The Project is intended to balance the short and long-term disruptions and risks from multiple stressors and align chemical risk reductions with other values of KIH to Indigenous groups, stakeholders, and the public. Broadly, the Project is intended to implement targeted removals and/or isolation of contamination in a manner that will:

- Provide both localized and broad (harbour-wide) reductions of primary contaminants of concern (COCs) to reduce ecological and human health risks.
- Provide high efficiency of chemical removals per unit of effort spent, such that the positives of chemical risk reduction outweigh short-term disruptions.
- Rely on natural recovery processes in areas of the harbour that currently have risks that are negligible to low.
- Prevent or limit the degree of habitat disruption during project works, particularly for sensitive ecological components.
- Provide potential for recolonization and rehabilitation of affected areas; and where possible achieve conservation gains of improved habitat conditions.
- Provide removal and/or isolation of contaminants compatible with potential redevelopment of the shoreline including recreational uses of the water lots.
- Prevent unacceptable resuspension or release of contaminants during project works, thereby mitigating impairment of water quality.

2.1.2 Project Location

Kingston Harbour is adjacent to the City of Kingston, at the eastern end of Lake Ontario. The entire Kingston Harbour is approximately 765 hectares (ha) in size and includes an Inner and Outer Harbour. KIH (the Site) is bounded by Highway 2 (LaSalle Causeway Bridge) to the south and Highway 401 to the north and includes a 5 km length of the Great Cataraqui River. KIH is further divided into northern and southern sections by Belle Island and Cataraqui Park. The sediment management area within KIH is bounded by Highway 2 (LaSalle Causeway Bridge) to the south and Belle Island/Cataraqui Park to the north and includes an approximate 1.7 km length of the Great Cataraqui River. The total project area including areas requiring physical intervention and monitored natural recovery [MNR] is approximately 85 ha (Figure 1).

[1] For this Project, “wildlife” includes all non-human organisms that rely on KIH aquatic habitats for all or part of their life cycle, including birds, mammals, reptiles, amphibians, fish, and benthic invertebrates. The term “semi-aquatic wildlife” refers to organisms that experience chronic exposures to sediment during some, but not all, portions of their life cycle.

2.1.3 Project Jurisdiction

Jurisdiction of most of the southern section of KIH (i.e., south of Belle Island and Cataraqui Park) (Figure 1) is held by TC. PCA is the manager of harbour sediments in the portion of KIH immediately south of Belle Park Fairways (southwest of Belle Island) and in the portion of KIH north of Belle Island. A small percentage of the southern half of KIH is managed by other parties (Figure 1), including:

- a square water lot adjacent the former Woolen Mill managed by the City of Kingston
- a triangular portion of water lot adjacent to the Orchard Street Marsh (jurisdiction for this lot is being determined)
- small areas of foreshore near the Kingston marina managed by the City of Kingston
- a Military Reserve in the southeastern corner of KIH managed by the Department of National Defense (DND)
- additional small areas of foreshore near Anglin Bay owned by DND

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- FEDERAL WATER LOT BOUNDARY
- MUNICIPALLY OWNED WATERLOT
- OWNERSHIP/JURISDICTION PENDING
- PARKS CANADA JURISDICTION

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REFERENCE(S)

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2. INSET BASE OBTAINED FROM ESRI CANADA.
3. PARKS OBTAINED FROM THE CITY OF KINGSTON
4. PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PSPC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
SPATIAL DOMAIN OF KIH STUDY AREA AND WATER LOT BOUNDARIES

CONSULTANT

YYYY-MM-DD	2023-08-15
DESIGNED	JD
PREPARED	JP
REVIEWED	JD
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
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2.1.4 Project Background

A long and complex history of industrial activity in the area surrounding Kingston Harbour resulted in contamination of the sediment that lines the harbour bed. Historical uses included a railway, shipyard, fueling areas, coal gasification, tannery, lead smelter, landfill, and other industrial operations.

Since 2010, multiple field studies and desktop evaluations have been conducted in KIH to characterize the spatial extent and magnitude of contamination, including assessment of the potential risks of contaminants to humans and wildlife (Golder 2016). Investigations have followed the Canada-Ontario Decision-Making Framework for Assessment of Great Lakes Contaminated Sediment (Ontario Ministry of Environment [OMOE] 2008), which uses an ecosystem approach to sediment assessment; this framework is intended to standardize the decision-making process while also being flexible enough to account for site-specific considerations. The Federal Contaminated Sites Action Plan (FCSAP) Expert Support departments (Health Canada, Environment and Climate Change Canada [ECCC], Fisheries and Oceans Canada [DFO]), which provide advice regarding the technical competency of environmental investigations, have peer reviewed these studies and evaluations at milestone reporting stages.

Studies have concluded that people and wildlife (e.g., fish, benthic invertebrates, mammals, birds) may experience negative health effects (risks) if exposed to contaminated sediment at the current levels of exposure (Golder 2016). Despite decades of time for natural recovery, several areas have not recovered enough to be considered safe for current uses. The primary COCs in sediment include chromium, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs); these COCs are the risk drivers for chemical management within KIH. Other metal and metalloid COCs, including arsenic, mercury, and copper are also present at levels of potential environmental concern, but are more spatially localized relative to the primary COCs mentioned above. By addressing primary COCs, the other cooccurring COCs will also be addressed adequately.

A conceptual remedial options analysis (CROA) was completed in 2017 (Golder 2017a), which integrated multiple scientific and logistical factors that could influence the risk management decisions for KIH. Management units (discussed in Section 5.1) were identified to customize candidate management options to specific portions of the water lot (Figure 2) and the overall Site-wide intensity of physical intervention was categorized into high, moderate, and low levels. Implicit in this approach was acknowledgement that a single remedial approach cannot be applied to the entirety of the Project, which requires customization to the environmental and other conditions in each management unit. Consideration was given to balancing many factors, such as chemical risk reduction, feasibility, cost, habitat modification, the potential presence of cultural/archaeological resources or artifacts, and disruption to existing and future water uses. Water lot boundaries were also used in the division of management units for larger jurisdictional areas; however, for some management units it was necessary to overlap jurisdictional boundaries in cases where similar contaminant profiles, ecological risk profiles, and/or site uses spanned jurisdictional areas. A preferred conceptual design for sediment management with a moderate level of intervention that balanced several competing risk management objectives was recommended (Golder 2017). The CROA provided a starting point for incorporating additional considerations and degree of detail, including input from stakeholders, Indigenous groups, and public engagement.

Multiple risk management strategies and technologies have been identified, including both conventional intrusive options (e.g., capping, dredging) and lower intrusion options (e.g., enhanced natural recovery [ENR] including thin-layer capping with activated carbon, MNR); these options integrated multiple scientific and logistical factors that influence the risk management decisions for KIH. The lower intrusion options are intended to provide a balance between chemical risk reduction (and associated long-term environmental liability) and the short- to medium-term consequences for ecological functions (e.g., sensitive habitats and presence of listed species).

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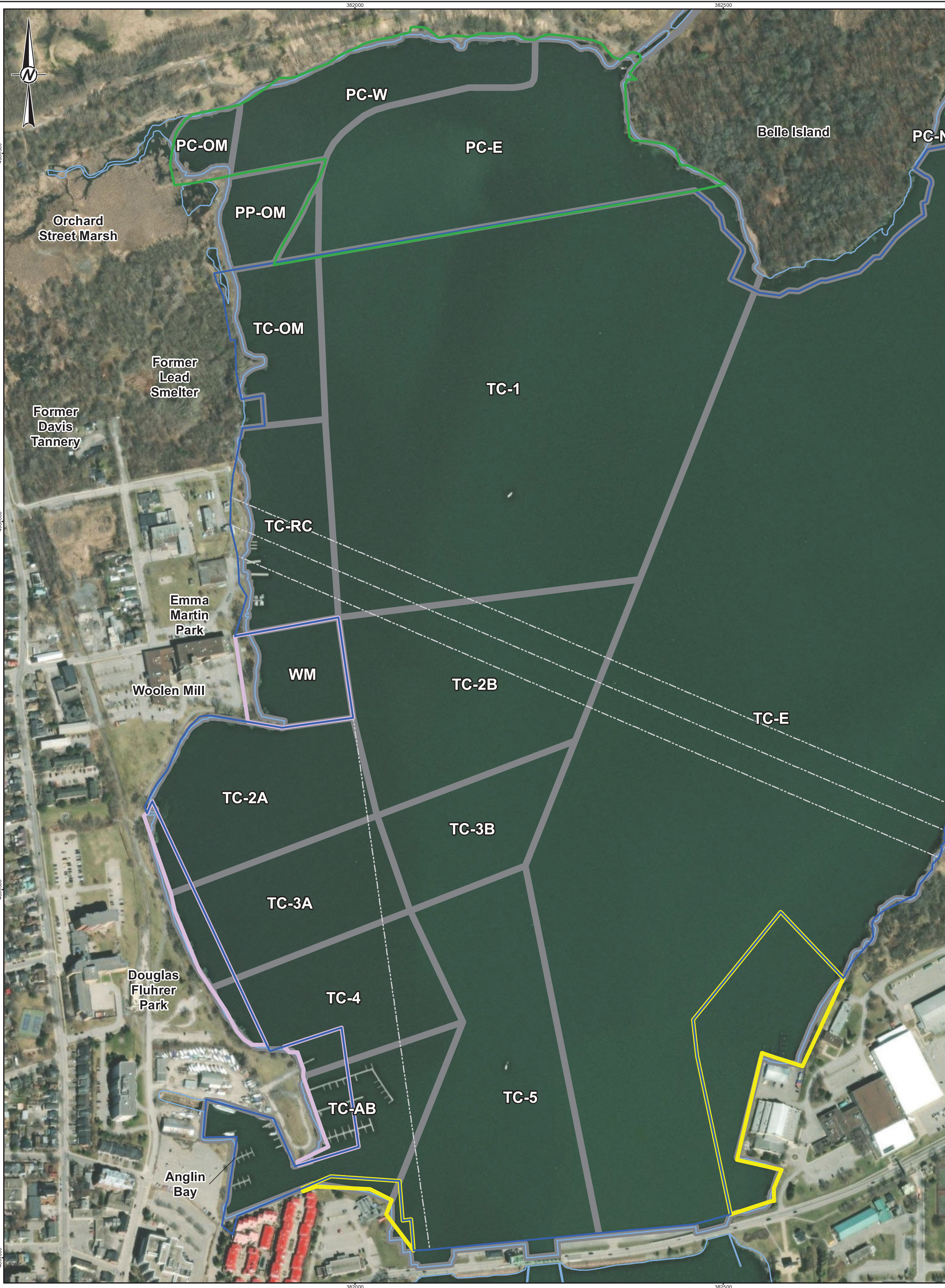

LEGEND

- MANAGEMENT UNIT
- CITY OF KINGSTON JURISDICTION
- PARKS CANADA JURISDICTION
- DEPARTMENT OF NATIONAL DEFENCE JURISDICTION
- TRANSPORT CANADA JURISDICTION
- FEDERAL WATER LOT
- WATERBODY

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1:5,000 METERS

REFERENCES
1. 1. IMAGERY COPYRIGHT © 20220711 ESRI AND ITS LICENSORS. SOURCE: MAXAR VIVID WV02. USED UNDER LICENSE, ALL RIGHTS RESERVED.
2. WATERBODY OBTAINED FROM THE CITY OF KINGSTON ONTARIO.
3. PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
STUDY AREA, MANAGEMENT UNITS AND WATERLOT BOUNDARIES

CONSULTANT

wsp

YYYY-MM-DD	2023-09-07
DESIGNED	JD
PREPARED	JP
REVIEWED	JD
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
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The conceptual remedial design report (Golder 2019) provided a summary of results to date from previous investigations including identified COCs, affected media, quantity, and quality of materials to be treated/managed, sediment stability, and the initial recommended sediment management approach. The recommended design included specification of some design elements and provided preliminary costs for sediment management.

Based on the conceptual remedial design (Golder 2019), a preliminary remedial action plan, later renamed as the conceptual SMP (Golder 2021a) was prepared to provide an analysis of the scientific issues, estimates of indicative liability costs, alternatives evaluation, and a recommended approach for sediment management within the aquatic portions of the harbour. The initial conceptual SMP included: professional judgement regarding the trade-offs among several competing considerations for sediment management; specification of design elements specific to each management unit used in preliminary costing estimates and for partitioning of environmental liability among multiple water lot jurisdictions; and conceptual plans and costing (preliminary Class C estimate, +/- 30%).

General agreement on the recommended approach to sediment and risk management was received from both PSPC and site custodian agencies (TC and PCA). Harbour-wide management has been recommended as part of this conceptual SMP, which includes work on lots managed by parties other than TC and PCA.

The initial conceptual SMP set the stage for Indigenous Consultation and Stakeholder Engagement. Between 2021 and 2023, Indigenous Consultation and Stakeholder Engagement was undertaken to seek feedback on risk management objectives and design considerations. The conceptual design considered the level of contaminant mass reduction, protection of habitats, interaction with recreational opportunities, business operations and plans for adjacent lands, shoreline character, and offsets from infrastructure and other valued harbour components. Engagement activities included a project website, virtual information sessions, formal meetings with Indigenous groups and stakeholders, public outreach events, street signage, and newspaper advertisements (WSP 2023a). As a result of the consultation and engagement activities, the sediment management strategy has been updated as presented herein. Once finalized, the SMP will provide a basis for future design and tender documents.

The updated conceptual SMP also incorporates information from several additional assessments that have been completed by WSP and SNC Lavalin to support the sediment management strategy including:

- A sediment sampling program to update and expand the current data set for Site sediment quality. This information was used to update/refine areas of contamination requiring physical intervention and assess changes in surface sediment chemistry over time to evaluate the success of natural recovery over the past decade and a half (Golder 2022a). This program was conducted both to provide a baseline for sediment quality prior to the implementation of intrusive remediation, and to provide confirmation of the rate of change (or lack thereof) in sediment quality over a decadal time scale. The latter addressed a subset of questions raised during Indigenous Consultation and Stakeholder Engagement.
- A biological and ecological inventory of the Project area (SNC Lavalin 2023a); these studies will ultimately be incorporated in the Detailed Impact Assessment (DIA) for the Project but have recently been incorporated in the SMP conceptual design where appropriate.
- An evaluation of nature-based shoreline[2] concepts (Golder 2022b); when combined with the biological and ecological inventory, the development of nature-based shoreline concepts helps to combine contaminant

[2] The terms “green engineering” or “green infrastructure” are sometimes applied in the discussion of nature-based shoreline solutions. This SMP uses the term “nature-based shorelines” to describe proposed shoreline modifications, where needed and if feasible.

controls with tools to enhance or provide conservation gains for the natural shoreline in developed areas. Consideration of these approaches incorporates feedback from Indigenous Consultation and Stakeholder Engagement, in which nature-based methods were preferred.

- Assessments on sediment quality, water quality, and lacustrine (lake or wetland) processes as it relates to potential conceptual constraints and impacts from the Project (WSP 2023b,c,d). These studies characterized the physical and chemical processes that govern the environmental fate and transport of contaminants and that influence the long-term effectiveness of physical management alternatives.
- An aquatic archaeology assessment for the Project area (WSP 2023e); this emphasized derelict vessel remains related to the centuries-old historical shipping industry and Indigenous artifacts.

2.1.4.1 Summary of Site Investigations and Assessments

Numerous environmental investigations have been undertaken in KIH over the last decade. Environmental Science Group (ESG) prepared several chapters following the Canada-Ontario Decision-Making Framework, beginning with a synthesis of historical sources, and carrying through various levels of risk assessment toward an options analysis for site management (ESG 2014). Concurrent with their efforts, additional investigations were conducted by ESG for PSPC on both the TC and PCA properties; these investigations included supplemental sediment quality assessments, data gap assessments, source evaluations, coring studies, and targeted technical research in the field of aquatic health assessment (e.g., toxicity reference value derivation, evaluation of causes of bottom fish deformities).

On behalf of TC and PCA, the following studies pertaining to KIH were completed to support the development of the Project. These studies represent a systematic application of Canada-Ontario Decision-Making Framework for Contaminated Sediments across the entire KIH, beginning with site assessment and risk assessment, and progressing through multiple steps of risk management, resulting in findings of relevance to the conceptual SMP:

- Golder Associates Ltd. (Golder). 2011a. Implementation of the Canada-Ontario Decision Making Framework for Assessment of Great Lakes Contaminated Sediment – Kingston Inner Harbour, Framework Steps 4 and 5 (Preliminary Quantitative Risk Assessment; PQRA). Prepared by Golder Associates Ltd. Project No. 10-1421-0039. PWGSC Project R.034858.001. 31 March 2011.
- Golder. 2012. Implementation of the Canada-Ontario Decision Making Framework for Assessment of Great Lakes Contaminated Sediment Kingston Inner Harbour: Framework Step 6 (Detailed Quantitative Assessment). Submitted to Public Works and Government Services Canada, on behalf of Transport Canada, Toronto, Ontario. Report Number: PWGSC Project# R.034858.001. Golder Project 10-1421- 0039. 31 March 2012.
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terms are nearly synonymous; however, nature-based shoreline rehabilitation is more comprehensive, and the term is used more commonly.

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2.1.5 Project Phases and Activities

The Project is currently in the planning stage, but will broadly consist of the following elements:

- Installation of temporary facilities and laydown-area(s).
- Dredging of contaminated areas within KIH with the highest concentrations of primary COCs (chromium, PAHs, PCBs), with off-site disposal of contaminated material. Since the 2021 draft conceptual SMP, the overall dredge footprint has been reduced from 15.3 ha to 12.9 ha and replaced with monitored natural recovery or enhanced natural recovery (i.e., lower intrusion approaches) and there will be a dredging exclusion zone along all shorelines except within Anglin Bay.
- Monitored natural recovery, although not appropriate as a blanket solution for the full study domain, remains an important strategy for large volumes of sediment in the central portion of KIH. Some of these areas are currently at low risk levels for human and ecological health, and will remain stable or further decrease slowly over future decades. The Supplemental Sediment Sampling Program (Golder 2022) confirmed the broad patterns of sediment quality and continued to support monitored natural recovery in large portions of the central KIH, while also confirming that dredging is still required in several areas of western KIH due to hotspots of high contamination that are driving unacceptable risks.
- Placement of a thin engineered cover (potentially including sand, activated carbon, and/or organic materials), in lower risk areas, where dredging residuals are of concern, or in areas where dredging is not feasible.
- Placement of a conventional sand cap with activated carbon within Anglin Bay.
- Nature-based shoreline rehabilitation to enhance ecological habitat and prevent erosion, while limiting the potential for human access to the water and addressing nearshore contamination, has been added as part of this updated SMP. This has replaced the use of shoreline hardening or revetments previously recommended to reduce human health exposures (at management units TC RC, WM, TC-2A, TC-3A and TC-4) as discussed in the 2021 SMP.
- Buffer zones between the dredging footprint and shoreline (5 to 10 m) have been added as part of this updated SMP to preserve the integrity of shorelines, sensitive habitats, and archaeological features in some areas.
- Associated site monitoring, rehabilitation works.

Figure 3 depicts the proposed layout of the sediment management plan, including areas of proposed sediment excavation (dredging) and surrounding areas of lower intervention remedial methods. Overall, the general design concept is to maintain and protect existing shore protection features, and work on improving the habitat in the foreshore (primarily between high and low water marks) and backshore (above the high-water line, acted upon only by severe storms or exceptionally high flow) areas.

The PCA Orchard Marsh (PC-OM) management unit was assigned a special category of low intervention marsh rehabilitation (as discussed in Section 11.2.1.3). The management plan for this area is likely to be shaped further through Indigenous Consultation and Stakeholder Engagement, along with input from the DIA.

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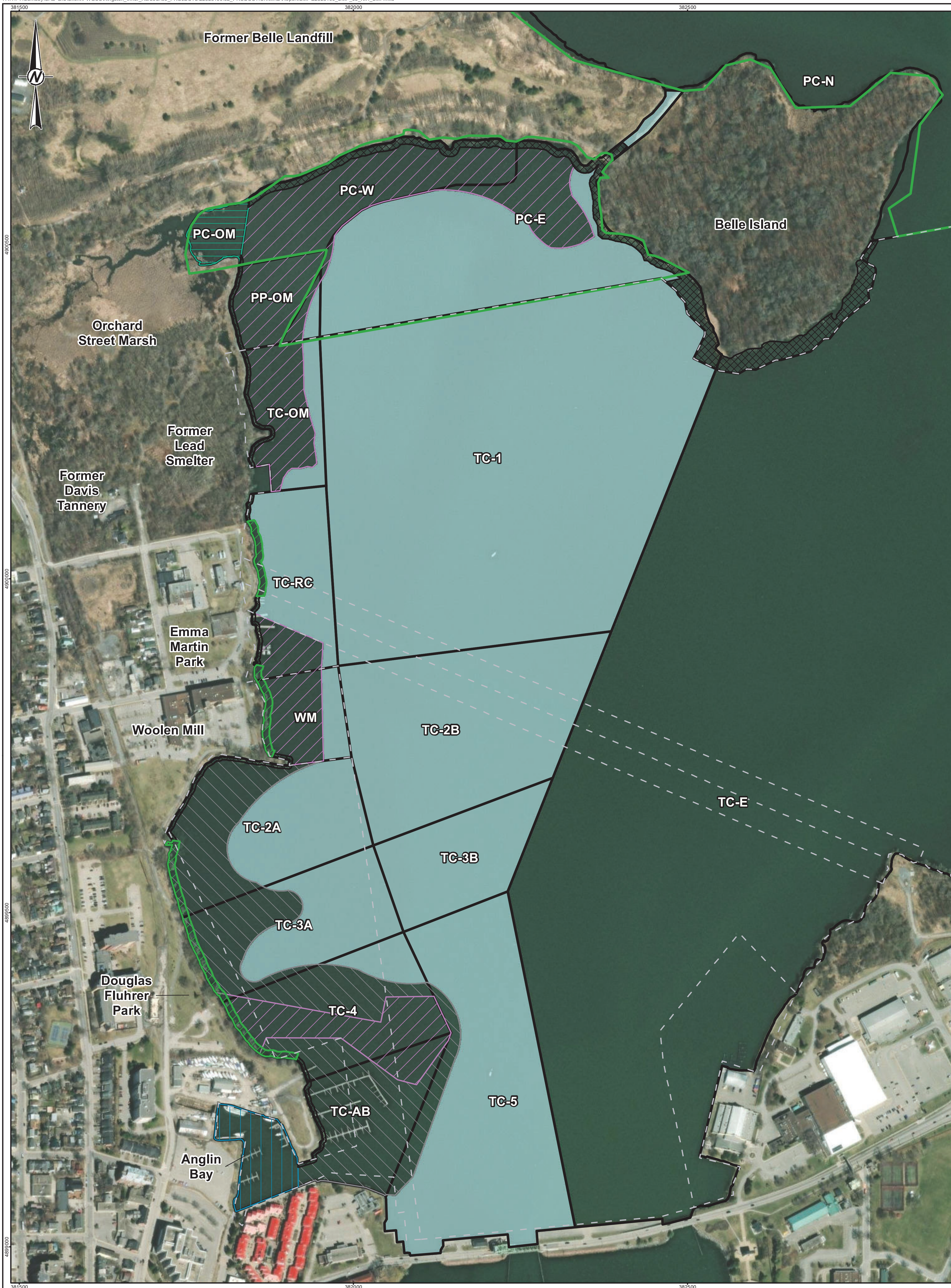

LEGEND

- FEDERAL WATER LOT BOUNDARY
- PARKS CANADA JURISDICTION
- MANAGEMENT UNIT
- DREDGING EXCLUSION ZONE
- POTENTIAL FOR NATURE-BASED SHORELINE REHABILITATION TO IMPROVE HABITAT/DREDGING EXCLUSION ZONE
- FUTURE WETLAND MANAGEMENT REQUIRING COORDINATION WITH CITY OF KINGSTON, PRIVATE LAND OWNERS AND PARKS CANADA
- DREDGE BOUNDARY WITH (1.0m) CAP WITH CARBON AMENDMENT OR REACTIVE BARIER
- DREDGE BOUNDARY WITH THIN LAYER (UP TO 0.3m) CAP/COVER
- ENHANCED NATURAL RECOVERY (THIN LAYER CAP/CARBON AMENDMENT)
- MONITORED NATURAL RECOVERY

0 110 220

1:5,500 METERS

REFERENCE(S)

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PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PSPC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
CONCEPTUAL SEDIMENT MANAGEMENT PLAN

CONSULTANT

wsp

YYYY-MM-DD	2023-02-06
DESIGNED	JD
PREPARED	JP
REVIEWED	JD
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
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The specific activities that may be associated with the major Project components are summarized in Table 1.

Table 1: Summary of Conceptual Project Phases and Activities

Project Phase	Activities
Site Preparation and Mobilization	■ Temporary access requirements (bulkhead/shoreline equipment access) ■ Temporary facilities and laydown area(s) ■ Set up sectional barges and other marine equipment ■ Installation of erosion and sediment controls ■ Site isolation (e.g., turbidity curtains, cofferdams) ■ Aquatic (fish) and semi-aquatic wildlife (e.g., reptiles, amphibians) rescue from isolated units
Sediment Management Activities	■ Dredging inside turbidity curtain—Methods may include closed clamshell environmental bucket or suction dredge with auger. Other methods may be used at discretion of Contractor due to site conditions and logistical challenges and environmental constraints ■ Storage, dewatering, treatment, and transportation of contaminated materials (includes sediment treatment facility set up) ■ Disposal of waste materials (including dredged sediments and solid non-hazardous construction waste) ■ Nature-based shoreline rehabilitation—Includes shoreline designs to preserve existing shoreline features that provide protection against shoreline erosion and provide habitat for turtle and fish species, while introducing additional features that enhance shoreline resilience and natural habitat ■ Institutional and Engineering Controls—May include fishing advisories or fencing ■ Thin-layer capping with amendments using activated carbon (i.e. ENR) ■ Conventional sand capping (1 m thick) in Anglin Bay ■ Wetland management for PC-OM—Cattail marsh areas will likely be more thoroughly assessed as separate effort due to ecological sensitivity and connection to adjacent off-Site property and shoreline development initiatives currently under consideration; remediation methods will be developed at detailed design stage and will include consideration of cattail marsh habitat in sediment trapping, low intrusion techniques specific to wetland management, and role of wildlife in sediment disturbance over time ■ Storage of equipment, temporary structures/facilities, and other ancillary project activities
Demobilization and Site Rehabilitation/Restoration	■ Removal of all environmental controls, including turbidity curtains and cofferdams ■ Tear down sectional barges and other marine equipment ■ Clean up staging and laydown areas and demobilize equipment from site
Post-construction Monitoring and Contingencies	■ Monitored natural recovery (MNR) ■ Confirmatory sampling and long-term monitoring of environmental quality and shoreline integrity ■ Adaptive measures (as required, including residuals management cover [RMC] where required)

The initial conceptual SMP has been updated herein to reflect comments received from Indigenous consultation (refer to Section 3.1.1 for further details) and recent stakeholder engagement (i.e., landowners, other government agencies, community groups) . Based on the conceptual SMP, a detailed design for the Project will be completed, as well as a DIA to examine the potential for adverse effects on natural and cultural resources by the Project and how such effects can be mitigated or compensated.

In support of the DIA process, a Conceptual Constraints and Impact Considerations (CCIC) document was completed (SNC-Lavalin 2023b) to provide preliminary high-level considerations of potential impacts from the Project based on information gathered to date. This document was assembled to provide important information for refinement of the conceptual design, and in advance of the formal comprehensive DIA deliverable. Several of these considerations were already articulated in the conceptual planning stages of the Project (Golder 2016, 2017a, 2019, 2021a), including consideration of chemical, ecological, archaeological, administrative, infrastructure-related, and other constraints to the remedial strategy. However, the CCIC document provided a more complete inventory of these factors and provides: (1) early identification of remaining information gaps; (2) specification of additional works required to address the information gaps; and (3) identification of any Project implementation constraints that are known at this time.

The Project team has recently completed biological, ecological, and archaeological baseline studies to gain a better understanding of wildlife presence and habitat use in KIH. These studies include information from several sources including stakeholder data, documents and reports relevant to the Project such as the Friends of Kingston Inner Harbour 2019 turtle tracking and nesting data (SNC Lavalin 2023a). Additional data collections are proposed and are ongoing as part of the continuing consultation and engagement process and will be considered in the DIA and the detailed remedial design documents. The baseline studies provide important updates to the historical information used during the risk assessment and CROA stages; the recent studies have been completed to facilitate evaluation of potential effects of implementing the SMP. Any predicted interactions between the Project phases (e.g., site preparation, sediment management activities, and post-construction monitoring) and their potential environmental effects will be identified and described in the DIA. Indigenous and stakeholder engagement will continue through the detailed design stage, and opportunities to provide input on more detailed project plans and effects analysis will be provided as part of the DIA process. As new information is obtained through engagement and/or additional biological, ecological, and archaeological studies it will be incorporated into the overall planning.

It is expected that the planning stage will be complete by the end of 2025 with the final detailed design. Implementation for the Project is planned to start in 2026 and is expected to take approximately 3 construction seasons to complete, with sequencing of the management units to avoid sensitive environmental windows and to allow placement of a cap/cover following the localized sediment removals. The current project schedule is included in the figure below.

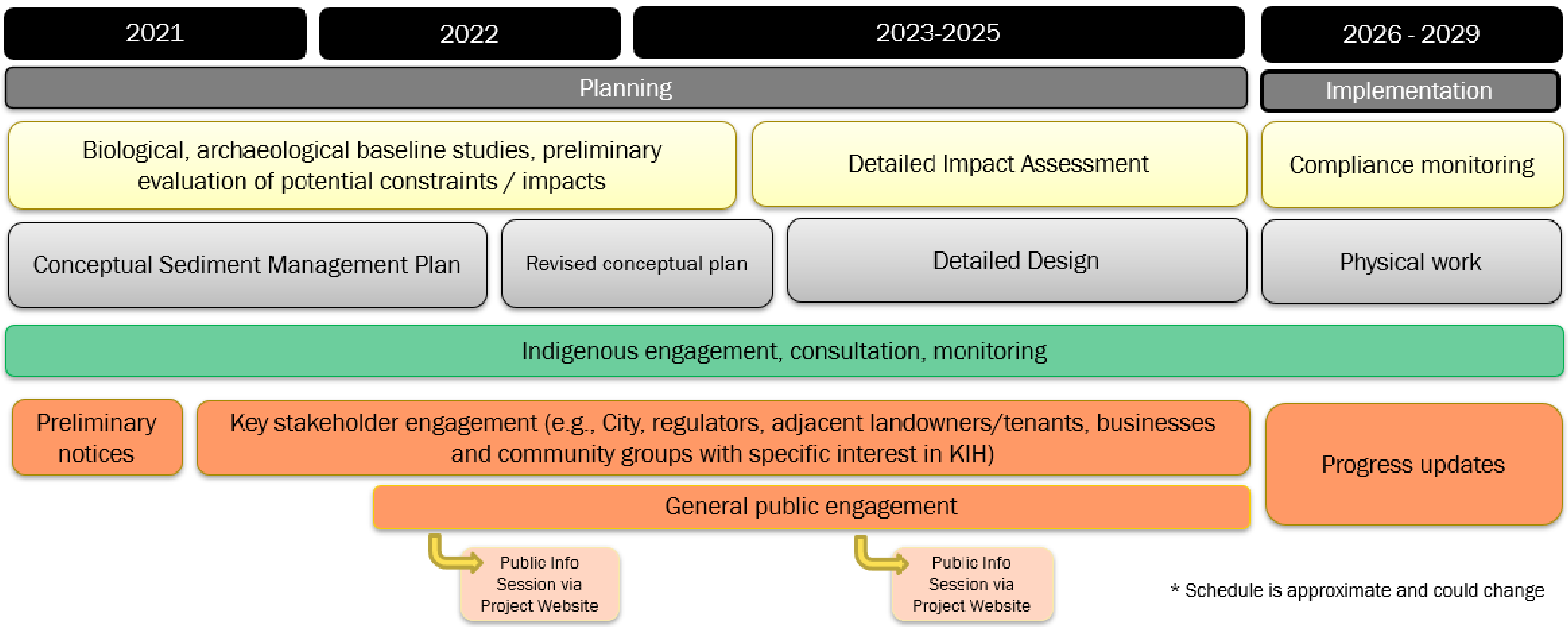

Figure 4: Project Schedule

3.0 OVERVIEW OF UPDATED CONCEPTUAL SEDIMENT MANAGEMENT PLAN

Overall, the intent of the conceptual SMP is to advance the level of detail for the remediation planning, incorporate consideration of Indigenous groups, stakeholders, and public feedback, and support the future design and tender documents for the Project, including:

- Specification of design elements specific to each management unit, used in preliminary costing estimates and for partitioning of environmental liability among multiple water lot jurisdictions.
- Conceptual plans and indicative construction cost estimates (replacing former Class C and D estimates), for each of the management units. Indicative estimates are defined as rough cost projections to be used for budget planning purposes in the concept development stage of a project.

This updated conceptual SMP incorporates the recommendations provided since Indigenous and stakeholder groups reviewed the initial conceptual SMP (Golder 2021a), as discussed in Section 3.1.1 below. Conceptually, most of the updates to the SMP reflect refinements in the balancing of Project objectives (i.e., to reduce chemical risk by sediment removal or sequestration, while protecting shorelines and their associated sensitive biological species, their habitats, and fluvial and lacustrine processes). Further, this SMP aims to align broadly with Kingston's Waterfront Master Plan (City of Kingston 2019).

The amendment to the SMP includes updates to the proposed intervention techniques across management units but does not provide detailed design features in individual management units.

3.1.1 Recommendations for Refinement of the Conceptual SMP

Several requests and recommendations for the conceptual SMP refinement were made following: consultation with Indigenous groups and engagement with stakeholders and the public; discussions with the site custodians; and collection of more recent environmental data in the last two years. The input came in several broad categories:

- Site custodian input—included planning considerations from PSPC/PCA/TC, including requests to advance the remedial design and/or refine costs.
- Indigenous groups, stakeholders, and public feedback—questions and/or concerns received to date through targeted engagement efforts.
- Input from adjacent property owners—updates to the design to accommodate upland shoreline developments or plans from third parties (such as municipal shoreline development plans).
- Technical and scientific findings—modifications to the design based on preliminary findings from the CCIC, the ongoing DIA process and sediment quality studies.

This input resulted in several important revisions to the design of the proposed remediation and the conceptual SMP document. Several key recommendations for refinements that were incorporated in the SMP included:

- **Refine areas of physical intervention based on updated contaminant concentrations.**
  - It was recommended that the areas requiring physical intervention (dredging, capping) and MNR be refined based on the most current contaminant distribution plots using the results of the 2021 sediment sampling program.
  - As discussed in Section 5.5.1, the spatial distribution and magnitude of surface sediment contamination in Fall 2021 remained broadly consistent with earlier profiling. Only minor changes to the contamination profiles were identified, including increased PAH concentrations in the southwestern corner of KIH, and confirmation that some historical PCB hotspots in the central harbour were not representative of the typical conditions in those areas.
  - Based on the above, the general areas of physical intervention were refined in some management units. For example, the dredging area was significantly reduced in TC-RC where the area is roughly one third of the original size. Minor adjustments (reduced or increased total size) to the areas of physical intervention were also made to other management units (e.g., TC-OM, PC-E, TC-4). The reduced dredging footprint reflects the refined delineation provided by the 2021 supplemental sediment quality program and the addition of shoreline buffers.
- **Refine areas of physical intervention based on Indigenous consultation and stakeholder engagement.**
  - Areas have been identified as valued habitat by Indigenous communities and stakeholder groups. Initial feedback has highlighted the importance of natural recovery of the harbour if such can be justified scientifically, and a strong preference to protect the natural shoreline features in the future project design. Potential impacts to turtles and turtle habitat have been identified as of particular concern. Based on this feedback, this conceptual SMP has been updated to incorporate nature-based shoreline rehabilitation rather than revetments (see Section 9.3 and 12.1.5), even for areas of human-modified shorelines such as those adjacent to the commercial/industrial park. In addition, placement of buffers between the shoreline and offshore dredging activities has been proposed, with lower intrusion methods adopted for these buffer areas (see Section 12.1.5.2).
- **Refine areas of shoreline modifications through coordination with City of Kingston.**
  - City of Kingston has plans to complete waterfront improvements, under the Disaster Mitigation and Adaptation Fund (DMAF), which includes plans to address waterfront stability/resiliency issues while corresponding with the Waterfront Master Plan. It was recommended that shoreline modifications in the SMP update should align with the City of Kingston in design to support DMAF goals where possible/known.
  - The City's Waterfront Master Plan was considered as part of the remedial design, including maintaining the walking paths along the shoreline and limiting alterations along the shoreline to protect natural features while providing erosion control, where possible. Any shoreline modifications proposed in the conceptual SMP are intended to align with the City's plans at this time.

- **Refine areas of physical intervention based on potential environmentally sensitive habitats or areas of archaeological significance.**
  - It was recommended that the current design be adjusted based on identified areas of archaeological significance and environmentally sensitive habitats, such as critical habitats for turtles and/or other listed species. These considerations had already been identified in the first draft of the SMP and the CROA stage, but at the time the characterization of these human and environmental values was incomplete. Additional information has recently been acquired regarding biological and ecological inventories in the vicinity of proposed work. As discussed in Section 8, an underwater archaeological impact assessment is currently being completed; preliminary adjustments have been made on this basis, and once the study is finalized, the recommended design may need to be further adjusted.
- **Stage remediation planning such that sediment management activities in wetland habitats and high-value turtle habitats are conducted outside restricted timing windows or other sensitive periods.**
  - Dredging exclusion zones along the shoreline have now been incorporated to protect critical turtle habitat (see Section 12.1.5.2) and timing windows for active works will be implemented to protect sensitive species (see Section 7.4). Construction windows for in-water work have been built into the preliminary project schedule, respecting periods of operation to avoid spring developmental periods and sensitive windows in the fall season. Although the exact dates will be subject to review and approval (e.g., as part of a Fisheries Authorization or letter of advice from the habitat section of DFO), the sequencing of work has been adapted to accommodate plausible windows for physical works.
- **Provide discussion of the relative success of natural recovery.**
  - To evaluate the effectiveness of natural recovery, changes in the last decade in terms of horizontal and vertical distribution of COCs were examined by comparing the results of the 2021 sediment sampling program surface samples against the historical data used in the quantitative risk assessments. In addition, vertical profiles assessing the burial of contaminated sediment with clean material were evaluated using additional core samples (see Section 5.5.1).
  - Overall, the results did not provide widespread evidence of significant recovery or deterioration of sediment quality over the past decade. Concentrations of inorganic and organic substances remained well above sediment quality guidelines, and at similar magnitude and spatial distribution to earlier characterizations.
  - Despite very slow recovery overall, some areas of KIH are sufficiently distant from the historical sources of contamination that the exposures are lower (i.e., above local background or reference concentrations of primary COCs in sediment, but also below concentrations resulting in potential moderate or greater contaminant risk to humans and ecological receptors). These areas, which fall into the category of low risk (but not negligible risk), are eligible for MNR.
  - MNR does not require a high rate of recovery, but rather confirmation that concentrations of COCs are stable or gradually decreasing over time (which cannot occur in KIH without intervention). Part of this long-term reduction will come from remediation of adjacent sediment units with higher baseline concentrations, as the long-term sediment quality profile will be influenced by harbour scale resuspension and sediment transport events.

- Based on the above, only minor refinements to the preliminary conceptual design were required. The central area of KIH remains recommended for MNR, and some localized reductions in the spatial extent of dredging have recently been made along the western shoreline. The broad conceptual design of physical removals in maximally contaminated areas (provided they are not biologically or archeologically sensitive), along with targeted addition of organic enhancements that will reduce the bioavailability of contaminants (i.e., ENR), remain an important component of the overall remedial strategy.

- **Provide further delineation of hotspots (if required).**
  - It was recommended that some management units may require denser sediment delineation to identify local PAH or PCB contamination (e.g., historical creosote-affected sediments in and around Anglin Bay). Recommendations for further sediment characterization are provided in Section 5.5.1.3, where it was recommended that depth profiling near Anglin Bay be completed.
  - The small areas of elevated PCB contamination in the central harbour (i.e., management units TC-1 and TC-2B) identified in historical sediment quality profiling were not confirmed in the updated sampling (Section 5.5.1). These areas had previously been identified for MNR, so the confirmation of lower PCB concentrations in the central harbour strengthens the rationale for excluding these areas from intrusive management.

- **Consider inclusion of DND Water Lots in the vicinity of Anglin Bay.**
  - The sediment quality data and risk management recommendations for the Anglin Bay water lots should be harmonized with the TC water lots in KIH.
  - WSP evaluated whether the profile of contamination in the relatively small areas of a DND water lot near Anglin Bay would have implications for cross-boundary management of sediment contamination. This review included recent environmental investigations conducted by RMC-ESG (2017a,b) and SLR (2021). The outcome of the WSP review was that the adjacent TC and DND properties shared a similar contamination profile (i.e., moderate PAHs but relatively low metals relative to other areas of KIH). No major implications for sediment management were identified on this basis, and the DND water lots could either be managed separately or combined with the TC program.

- **Include application of a residual management cover (RMC) in dredge areas.**
  - It was recommended that a RMC be applied to areas that are being dredged. The cover would provide several roles, including partial isolation and dilution of settled residuals following dredging, and provision of substrate to assist with recolonization of macrophytes, invertebrates, fish, and shellfish. For example, exposed clay following dredging would not provide a suitable habitat for macrophyte growth and the re-colonization of benthic invertebrates.
  - RMC will include approximately 15-30 cm of clean sand and organic materials combined with the possible inclusion of thin-layer activated carbon. The RMC would mix with any residual contaminants left after dredging further reducing the area wide concentrations through dilution (and bioavailability reduction where activated carbon is incorporated). A thin surficial layer cap (15-30 cm) of clean sand and organic materials with carbon amendments to enhance natural recovery has now been incorporated into the conceptual design for all dredged areas in Section 12.1.1.

- **Provide updated volume and cost estimates.**
  - WSP updated the estimated volume of contaminated sediment for disposal, and the associated remediation/risk management cost estimates based on the contaminant distributions (horizontal and vertical) obtained from the 2021 sediment sampling program. WSP completed a constructability review and updated the cost estimate based on a revised construction methodology.
- **Update disposal costs.**
  - WSP updated the sediment characterization section of the SMP to reflect the current sediment contaminant concentrations and the Toxicity Characteristic Leaching Procedure (TCLP) results. Results of the 2021 sediment sampling program indicate that leachable metals or PAHs are not likely a concern for disposal.
- **Consider nature-based approaches as an alternative to shoreline revetments, where applicable.**
  - Use of nature-based approaches as an alternative to replace riprap revetment has been considered in the revised SMP to improve KIH shorelines from a biological perspective (e.g., turtle habitat) where feasible and to reduce environmental risks. Although placement of some large granular (rock) materials may still be incorporated in the detailed design. This is intended to increase the size and roughness of the surficial material along the shoreline to improve energy dissipation and reduce the risk of erosion from wave action. The rock material would be place such would be placed within a mosaic of features that include natural elements, rather than as a widespread shoreline hardening, where applicable. Within this updated SMP, this is now referred to as nature-based shoreline rehabilitation (see Section 9.3 and 12.1.5).
- **Update description of turtle habitat.**
  - The information on turtle habitat available to date is provided in Section 7.2, including over-wintering habitat, basking-habitat, and nesting habitat. The baseline studies and information gathering process for the DIA will be a more in-depth representation of species occurrences and habitat use of the Site and once these studies are completed, the description of turtle habitat in the SMP will align with the DIA baseline information.
- **Update/replace Species at Risk screening and fish community results.**
  - The Species at Risk Screening and Fish Community Results appendix has been replaced with *Appendix D* from the Biological and Ecological Inventories in Support of the DIA for KIH report entitled Species at Risk Status, Habitat Characteristics, Preliminary Presence/Absence Determination, and Habitat Distribution and Risk (SNC Lavalin 2023a). This appendix is provided as Appendix A in this report.
- **Summarize source controls.**
  - It was recommended that the successful implementation of source control initiatives for upgradient contamination be confirmed, including groundwater, storm sewer discharges, and soil potentially subject to erosion. Information on most legacy pathways has already been covered in past memoranda (Golder 2013a, Golder 2011a, ESG 2014) prepared for PCA and TC. Therefore, an evaluation of the source control documentation emphasized ongoing pathways (Emma Martin Park treatment system, municipal discharges; see Section 5.7). Also, potential future disruptions to any source control measures from the Project were accounted for in the remedial design through dredging exclusion zones along the shorelines as discussed in Section 12.1.5.2.

- Although there are several measures that have been implemented to control on-going contamination into KIH; there are several data gaps related to the current understanding and quantification of effectiveness for the source controls, particularly related to storm sewer management (Section 5.7). Therefore, WSP has made recommendations to assess contaminant loading during dry and wet runoff events from the municipal storm system in conjunction with the baseline water quality study, which will be completed prior to in water works.

3.1.2 Document Organization

The updated conceptual SMP is organized as follows:

- **Regulatory and Permitting Requirements (Section 4.0)** – Discusses the regulatory and permitting requirements for the Project, including federal and provincial regulations.
- **Conceptual Site Model (Section 5.0)** – Provides an overview of the contamination sources, exposure pathways linking receptors to the contaminants in sediment, and the resulting human health and ecological risks. An overview of the existing contaminant conditions related to sediment and water quality is summarized, the data gaps related to the understanding of the baseline conditions is provided, along with an assessment of the causes of elevated risk related to sediment and water chemistry and the source control measures that have been implemented to minimize the continued inputs of COCs along KIH. Finally, a detailed description of the lacustrine processes and its impact on shoreline stability and resuspension/redistribution of sediment is provided.
- **Environmental Considerations (Section 6.0)** – Discusses the environmental considerations when implementing the Project so that there are not adverse effects on sediment quality, water quality, and lacustrine processes. This will depend on developing Environmental Performance Objectives (EPOs) to monitor potential environmental effects. Conceptual considerations are discussed as the Environmental Management Plan (EMP) that will be completed following the DIA will provide the framework for managing potential environmental effects.
- **Biological Considerations (Section 7.0)** – Discusses the biological considerations when implementing the Project so that any potential adverse effects on Species at Risk (SAR), vegetation, and wildlife habitat are minimized. Timing windows for Project work to avoid biological disruptions is discussed.
- **Social and Cultural Considerations (Section 8.0)** – Discusses the social and cultural considerations when implementing the Project so that any potential adverse effects on archaeological areas of significance are minimized.
- **Potential Sediment Management Techniques (Section 9.0)** – Discusses the potential sediment management techniques and technologies for the Project, including conventional approaches (e.g., dredging and capping), lower intrusive techniques (e.g., sediment amendments), and nature-based shoreline rehabilitation.
- **Sediment Management Objectives (Section 10.0)** – Provides the sediment management objectives for the Project and summarizes the level of intervention categories considered to meet these objectives. For each management unit, the overall priority for risk management based on the results of the risk assessments is summarized, along the any constraints for implementing sediment management (e.g., ecological sensitivity and shoreline structure/uses). Finally, the risk-based numerical sediment management criteria used to inform the level and spatial extent of remedial action required to meet the objectives is discussed.

- **Recommended Sediment Management Plan (Section 11.0)** – Presents the recommended sediment management plan for each management unit.
- **Design Updates (Section 12.0)** – Outlines the advances in the conceptual design and associated assumptions made since the first draft of the SMP. The design considerations to reduce risk to valued components, as suggested by the CCIC, that were incorporated into the conceptual SMP are also summarized.
- **Implementation Considerations (Section 13.0)** – Provides an overview of the schedule for implementing the Project, including anticipated project milestones and a preliminary construction schedule.
- **Project Costs (Section 14.0 and Appendix D)** – Provides indicative construction cost estimates for the implementation of the conceptual SMP.
- **Next Steps (Section15.0)** – Summarizes the path forward for project refinement, consultation and engagement with indigenous groups, stakeholders, and the public, and permitting and approvals.

4.0 REGULATORY AND PERMITTING REQUIREMENTS

The following sections discuss the regulatory and permitting requirements for the Project. Federal and provincial regulations are presented herein that may be applicable to the SMP.

The water lot is mainly under PCA and TC jurisdiction (i.e., most of the wetted area with the exception of the portions managed by the City of Kingston, DND, and a private party), and therefore provincial or municipal statues would not apply to the submerged sediments in the federally managed water lot. However, the management plan includes some shoreline areas under provincial jurisdiction, where federal, provincial, and municipal statues may apply (see Section 4.2).

4.1 Federal Jurisdiction

4.1.1 Impact Assessment Act

On 28 August 2019, the *Impact Assessment Act* (IAA) (Canada 2019) came into force. The *Impact Assessment Act* created the new Impact Assessment Agency of Canada and repeals the *Canadian Environmental Assessment Act* (Canada 2012).

The IAA sets out requirements in relation to projects on federal lands or outside Canada (Sections 81 to 91). Before acting or making a decision that would enable a project to proceed, authorities must determine whether the project is likely to cause significant adverse environmental effects. If the project is likely to cause significant adverse environmental effects, the project is not permitted to proceed unless those effects are determined by the Governor in Council to be justified in the circumstances. The *Designated Classes of Projects Order* sets out classes of the most common, routine, and straightforward projects that cause only insignificant effects or no potential for adverse environmental effects (Section 88). A project would not be exempt under the Ministerial Order if the project:

- may cause a change to a waterbody
- may cause change to a migratory bird or its nest under the *Migratory Bird Convention Act (MBCA)* (Canada 1994)
- may cause change to a wildlife species under Schedule 1 of the *Species at Risk Act (SARA)* (Canada 2002a), or its residence or critical habitat
- requires a permit or other authorization under the *Fisheries Act* (Canada 1985a), the *Canadian Navigable Waters Act (CNWA)* (Canada 1985b), or the *Canada Wildlife Act* (Canada 1985c) (e.g., Wildlife Area Regulations)
- involves the removal of or damage to any structure, site or resource that is of historical, archeological, paleontological, or architectural significance

PCA's Impact Assessment Directive (PCA 2019) outlines PCA's policy framework to ensure compliance with legal regimes for impact assessment and indicates the circumstances in which impact assessment will be undertaken, the general principles that will be respected, the processes and procedures that must be followed, and the associated responsibilities and accountabilities.

The Parks Canada Impact Assessment Guide (PCA 2020) describes the impact assessment process developed by PCA to fulfill its requirements as a federal authority under the IAA as well as its legal and mandated obligations to protect Canada's natural and cultural heritage. The purpose of this guide is to provide external proponents, stakeholders, partners, Indigenous groups, and the public with an understanding of what PCA impact assessment requirements are for project proposals within a PCA protected heritage place.

The Impact Assessment process examines how a project may have effects on:

- Natural resources – such as SAR, air, ground and surface water, sediments/soils, habitat features, as well as plants and animals found in the vicinity of a project or otherwise potentially affected by it.
- Cultural resources – including potential adverse effects on heritage value and character defining elements of known cultural resources, and risks to areas with high potential to contain cultural resources where no inventory has yet been completed.

In addition, the assessment process requires consideration of potential indirect effects of a proposed project; specifically, how the effects of a proposed project on natural resources may in turn cause:

- Adverse effects on characteristics of the environment important to key visitor experience (how the proposal is anticipated to affect activities and/or visitors' enjoyment and connection to place, in relation to defined objectives for the protected heritage place).
- Adverse effects on health and socio-economic conditions of Indigenous and non-Indigenous peoples.
- Adverse effects on Indigenous Peoples' current use of lands and resources for traditional purposes.

According to PCA's Directive, the appropriate level of impact assessment (i.e., basic or detailed) will vary according to the requirements of each project proposal and the risk and likelihood of significant adverse environmental effects associated with carrying out the project. TC and PCA determined that a DIA was appropriate for the Project given the scope of work proposed and potential Indigenous and public interest on potential impacts. TC and PCA have agreed to use PCA's DIA process in order to meet the requirements under the IAA. Individual department requirements and mandates will be included as part of the DIA.

4.1.2 Fisheries Act

The purpose of the *Fisheries Act* (Canada 1985a) is to maintain healthy, sustainable, and productive Canadian fisheries through the prevention of pollution and the protection of fish and their habitat. All projects undertaking in-water or near-water work must comply with the provisions of the *Fisheries Act*.

All projects where work is being proposed that cannot avoid impacts to fish or fish habitat require a DFO project review (DFO 2019). If it is determined through the DFO review process that the project will result in death of fish or harmful alteration, disruption, or destruction (HADD) of fish habitat, an authorization is required under the *Fisheries Act*. This includes projects that have the potential to obstruct fish passage or affect flows.

Proponents of projects requiring a *Fisheries Act* Authorization are required to also submit a Habitat Offsetting Plan, which provides details of how the death of fish and/or HADD of fish habitat will be offset; the plan also outlines associated costs and monitoring commitments. Proponents also have a duty to notify DFO of any unforeseen activities during the project that cause harm to fish or fish habitat, and outline the steps taken to address them.

The main concerns for fisheries resources and fish habitat are: 1) the dispersion of sediments and contaminants during dredging operations; 2) limitation to access to shoreline habitats within the study area during project works; 3) destruction or alteration of habitats that provide resources or refuge for fish species.

Habitat offsetting may be required for portions of the intrusive management footprint based on HADD of fish habitat under Section 36 of the *Fisheries Act*, resulting from the temporary loss and alteration of existing habitat (i.e., marsh habitats, macrophyte beds, changes to sediments) due to dredging and capping. The total loss of habitat or required compensation is currently undefined and will depend on habitat accounting calculations that will need to be completed to support future *Fisheries Act* Authorization permitting for pre and post construction conditions. Further details on the potential rehabilitation activities and mitigation measures for fish are discussed in Section 7.3.

4.1.3 Species at Risk Act

At a federal level, SAR designations for species occurring in Canada are initially determined by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). If approved by the federal Minister of the Environment, species are added to the federal List of Wildlife Species at Risk (Canada 2002a). Species that are included on Schedule 1 of the SARA as endangered or threatened are afforded protection of critical habitat on federal lands under the Act. On private or provincially managed lands, only migratory birds and aquatic species listed as endangered, threatened, or extirpated are protected under SARA, and critical habitat protection on non-federal lands is afforded only to aquatic species, unless ordered by the Governor in Council. Several federally listed species are found within the study area (Appendix A), with the SAR turtle species anticipated to be of largest concern to interest groups.

Impacted wildlife species and their habitats, including SAR, will be assessed in relation to the proposed Project as part of the DIA. If it is determined that SAR species may be impacted, a SARA Permit may be required under section 73 of the Act. SARA requires an assessment of known SAR habitat (including general and critical habitats), consideration of alternatives, development of acceptable mitigations, avoidance opportunities, and compensation when applicable. ECCC and PCA administer the Species at Risk Act and may issue a permit or SARA compliant permit depending on federal land or waters administration.

4.1.4 Migratory Birds Convention Act

The federal MBCA (Canada 1994, with updates to 2017) protects migratory birds, their eggs, and nests. It is unlawful to disturb or destroy the nest of a migratory bird protected under the MBCA, even incidentally. There are no permits available to exempt development activities. ECCC, the federal government department responsible for enforcing the Act, advises that proponents schedule activities outside of the migratory bird nesting season to avoid incidental take. Sections 5.1(1) and (2) prohibit the deposition of substance that are or can become harmful to migratory birds. Although the MBCA does not directly contain specific provisions for permits or authorizations of the deposition of such substances, mitigation measures are anticipated to protect the shoreline bird habitats and nests during construction. Best Management Practices (BMPs), including restricted timing windows, are prioritized to reduce the potential for violation of the MBCA.

4.1.5 Canadian Navigable Waters Act

The CNWA (Canada 1985b) regulates works that may result in permanent or temporary navigational interference within navigable Canadian waters. Given that the Cataraqui River is listed as a navigable waterway in the Schedule to the Act and the potential for interference with navigation by sediment management activities, an assessment and approval will be required by TC. Other requirements under the CNWA include submittal of an Application for Approval for review and approval by TC.

During construction activity, the Contractor will be required to maintain open communication lines with vessels including all construction vessels, commercial vessels, public vessels, and local harbourmaster.

4.1.6 Transportation of Dangerous Goods Act

The *Transportation of Dangerous Goods Act* (Canada 1992, updates to 2019) ensures safety of the public and environment from the transportation of dangerous goods, including hazardous wastes. The transportation of contaminated dredged materials may require an Equivalency Certificate and an Emergency Response Assistance Plan under this Act, which may further activate provincial requirements under the *Ontario Dangerous Goods Transportation Act* (Ontario 1990a).

At this time, it is unknown whether any of the contaminated sediments dredged from KIH will trigger the federal or provincial acts. However, the greatest potential for identification of dangerous goods (i.e., product, substance or organism included by its nature or by the regulations in any of the classes listed in the schedules within the acts) is expected to be for subsurface sediments within and around Anglin Bay. The latter sediments may contain layers or staining by free-product non-aqueous phase liquid originating from the historical coal gasification source. Should hazardous wastes be identified above the applicable limits for bulk sediment or leachable contamination (as determined through a toxicity characteristic leaching procedure), special requirements will apply to the transport, handling, and disposal of affected materials (e.g., safety standards, permit requirements, transport and containment requires as defined under the legislation).

4.1.7 Canadian Environmental Protection Act

The transportation of contaminated dredged material may also require a permit for “Equivalent Levels of Environmental Safety” as administered by ECCC under the *Canadian Environmental Protection Act (CEPA)* (Canada 1999), if they are categorized as “hazardous waste” and the control and movement of the materials does not comply with division 8, part 7 of CEPA.

Similar to the discussion of dangerous goods under Section 4.1.6, the designation of potentially hazardous wastes, and special requirements under that designation, will be made once material at depth has been characterized for disposal. With the possible exception of Anglin Bay and vicinity, dredged sediment is not anticipated to be identified as hazardous waste.

4.1.8 Historic Canals Regulation

According to the Historic Canals Regulations (Canada 1993), no person shall dredge, fill, or dredge and fill in a historic canal, except in accordance with a permit issued by PCA. A permit will be required for project works as KIH (Cataraqui River) forms a portion of the Rideau Canal National Historic Site of Canada and United Nations Educational, Scientific, and Cultural Organization (UNESCO) World Heritage Site.

4.1.9 Parks Canada Agency Act

The *Parks Canada Agency Act* (Canada 1998), administered by ECCC, was created to ensure that Canada's national parks, historic sites, and regulated heritage areas are protected for present and future generations. Under this act, all work completed in water within historic canals are under authority of PCA.

4.1.10 CCME Environmental Quality Guidelines

The Canadian Council of Ministers of the Environment (CCME) is a joint provincial, federal, and territorial government environmental committee that has developed and published Canadian Environmental Quality Guidelines for various environmental media and for various organic and inorganic substances. The guidelines considered to be applicable to the Site include the following:

- CCME Sediment Quality Guidelines (SeQGs) for the Protection of Aquatic Life (Fresh Water) (CCME 1999a/2003)
- CCME Water Quality Guidelines (WQGs) for the Protection of Aquatic Life (Fresh Water) (CCME 1999b/2023)

The primary SeQGs applicable to screening of sediments for identification of COCs within working harbours are the CCME Probable Effects Levels (PELs) (or their equivalent in terms of narrative protection goals) as discussed in FCSAP (2021). In absence of CCME guideline availability for a specific contaminant or group, provincial criteria, or guidelines from other jurisdictions (e.g., organotin sediment benchmarks) were considered for identification of COCs (refer to Section 4.2.4).

4.2 Provincial Jurisdiction

Generally, provincial legislation is not applicable to projects undertaken on federal land or water lots. However, consideration of and general alignment with provincial requirements should be considered for the duration of the project. Works undertaken on non-federal lands (i.e., private or municipal) would be subject to provincial legislation and may include the following:

4.2.1 Ontario Endangered Species Act

SAR designations for species in Ontario are initially determined by the Committee on the Status of Species at Risk in Ontario (COSSARO). If approved by the provincial Minister of Natural Resources, species are added to the *Endangered Species Act* (ESA) (Ontario 2007).

Subsection 9(1) of the ESA prohibits the killing, harming, or harassing of species identified as "endangered"' or "threatened" in the schedules to the Act. Subsection 10(1) (a) of the ESA states that *"No person shall damage or destroy the habitat of a species that is listed on the Species at Risk in Ontario List as an endangered or threatened species"*. As of 30 June 2008, the Species at Risk in Ontario (SARO) List is contained in Ontario Regulation (O. Reg.) 230/08.

The ESA also provides general habitat protection to all species listed as threatened or endangered under the Act. Species-specific habitat protection is only afforded to those species for which a habitat regulation has been prepared and passed into law as a regulation of the ESA. The ESA has a permitting process to allow alterations to protected species or their habitats. In addition, the ESA allows for a registration approach for projects meeting specific conditions. Several provincially listed species are found within the study area and mitigation measures applicable for their protection are provided in Appendix A.

These ESA permitting requirements would only strictly apply to the parcels under provincial jurisdiction. However, because management of the shoreline areas is complex, particularly in the southeastern portions of KIH, the habitat protection measures may need to be aligned between the provincial and federal requirements.

4.2.2 Ontario Environmental Protection Act

The Ministry of the Environment, Conservation and Parks (MECP) is responsible for oversight and implementation of Ontario's primary pollution prevention act, the *Ontario Environmental Protection Act* (OEPA) (Ontario 1990b). OEPA is aimed at preventing pollution to the natural environment that has potential to cause adverse effects. Remedial orders are applied through the OEPA, whereby any discharge or contaminant that may affect ecological or human health, or cause environmental damage, the owner must repair the damage and prevent reoccurrence. Application of the OEPA and the following *Ontario Water Resources Act* are often applied interchangeably. Again, the provincial requirements under OEPA would need to be aligned with the federal environmental requirements that apply to the majority of KIH.

4.2.3 Ontario Water Resources Act

The *Ontario Water Resources Act* (OWRA) (Ontario 1990c) regulates the quality of water (i.e., ground or surface water) and deems water to be impaired for any discharge or material that may cause injury or interfere with any living organisms that are exposed to the water, soils/sediments, and living organisms in contact with the contaminated water. The administration and enforcement of OWRA is under the jurisdiction of the MECP in Ontario.

4.2.4 MECP Environmental Quality Criteria

The MECP in Ontario are responsible for policies and guidelines for the management of the province's environmental resources and contamination regulation. The MECP has developed and published guidelines for various environmental media, including sediment, surface water and soil. Surface water and sediment guidelines have been developed for various organic and inorganic substances in freshwater settings applicable to the Project. The guidelines considered to be directly applicable to the Site include the following:

- Provincial Sediment Quality Guidelines (PSQGs) for the protection of aquatic life (freshwater)
- Provincial Water Quality Objectives (PWQO) for the protection of aquatic life and recreational uses (MOE 1994)

The application of the guidelines is described in the MECP documents, *Guidelines for the Protection and Management of Aquatic Sediment in Ontario* (MOE 1993), and *An Integrated Approach to the Evaluation and Management of Contaminated Sediments* (MOE 2008).

4.2.5 Ontario Heritage Act

The *Ontario Heritage Act* (Ontario 1990e) is concerned with heritage conservation within Ontario and serves to give municipalities and the provincial government powers to conserve Ontario's heritage. The Act has provisions for conservation of heritage at the individual property level, as a heritage district or through easements. The Act is administered by the Ministry of Tourism, Culture and Sport (MTCS). It is primarily focused on protecting heritage properties and archaeological sites. A permit issued by MTCS may be required for works within KIH areas under provincial jurisdiction.

4.2.6 Provincial Policy Statement

The Provincial Policy Statement (PPS) was issued under Section 3 of the *Planning Act* (Ontario Ministry of Municipal Affairs and Housing [MMAH] 2014) and governs development on non-federal lands within the Province that is subject to the policies of the *Planning Act*. The natural heritage policies of the PPS indicate that development and site alteration shall not be permitted in:

- Significant wetlands in Ecoregions 5E, 6E and 7E
- Significant coastal wetlands

As portions of the study area are considered provincially significant wetlands (MNRF 2023a), including areas of PC-OM and the adjacent areas of Orchard Street Marsh (Figure 3), discussions relating to works within those wetlands must occur with the responsible authority. In the case of non-federally managed parcels, the Ontario Ministry of Natural Resources and Forestry (MNRF) should be engaged to discuss intrusions into these wetlands.

4.2.7 City of Kingston

The City of Kingston has prepared an Official Plan (City of Kingston, 2019; consolidated in 2022), which is in accordance with the Provincial Policy Statement (PPS). As it relates to natural heritage features, the Official Plan identifies Provincially Significant Wetland and Riparian Corridor within the study area associated with the Cataraqui River and the shoreline (Schedule 7-A). The shoreline wetlands are identified as Environmental Protection Area, while the parks and shoreline are identified as Open Space on Schedule 3-A. The forested portion of the study area is identified as Significant Woodlands (Schedule 8-A). Together, these features form part of the City's Natural Heritage System. Development within or adjacent to the Natural Heritage System requires a municipal Environmental Impact Assessment be prepared, and that no negative impacts to the system will result from the proposed project.

The City of Kingston Official Plan also includes the "Ribbon of Life" policy that is protective of a 30 m naturalized buffer along waterfronts and includes a 30 m setback for construction activities from the highwater mark. Specific activities that are required to occur within the 30 m buffer would require an exemption permit. The official plan also sets out water quality improvement policies, dock and shoreline stabilization policies, and environmental protection areas (including rivers and riparian corridors).

4.2.8 Cataraqui Region Conservation Authority

The Cataraqui Region Conservation Authority (CRCA) is the governing body which regulates development near natural hazards, alterations to shorelines and watercourses and interference with wetlands in the Cataraqui River watershed. The CRCA maintains wetland and natural hazard (e.g., flood plain) mapping in conjunction with the City of Kingston and the Ontario MNRF. The CRCA assigns Natural Hazard related boundaries as defined under the PPS. Development within regulated areas is governed by Regulation 148/06 *Development, Interference with Wetlands and Alterations to Shorelines and Watercourses* (Ontario Legislative Assembly 2006). Regulation 148/06 was derived under the authority of O.Reg. 97/04 (Ontario Legislative Assembly 2004) and is specific to the CRCA.

Under O.Reg 97/04 a regulation may:

a) Restrict and regulate the use of water in or from rivers, streams, inland lakes, ponds, wetlands and natural or artificially constructed depressions in rivers or streams.

b) Prohibit, regulate, or require the permission of the authority to straighten, change, divert, or interfere in any way with the existing channel of a river, creek, stream, or watercourse, or change or interfere in any way with a wetland.

c) Prohibit, regulate, or require the permission of the authority for development if, in the opinion of the authority, the control of flooding, erosion, dynamic beaches, or pollution, or the conservation of land may be affected by the development.

Although development, which would include disturbance associated with the project, is not necessarily restricted within the CRCA regulated area, it designates an area which triggers the need for a permit and, in most cases, supporting studies. Based on CRCA mapping, a regulatory limit of 120 metres from Greater Cataraqui Marsh and 15 metres from the flood plain of the Cataraqui River (whichever is greater) has been applied around the majority of the harbour area.

5.0 CONCEPTUAL SITE MODEL

The following sections provide an overview of the contamination sources, exposure pathways linking receptors to the contaminants in sediment, and the resulting human health and ecological risks. An overview of the existing contaminant conditions related to sediment and water quality is summarized, along with an assessment of the causes of elevated risk related to sediment and water chemistry and the source control measures that have been implemented to minimize the continued inputs of COCs along KIH. Finally, a detailed description of the lacustrine processes and its impact on shoreline stability and resuspension/redistribution of sediment is provided.

5.1 Sediment Management Units

KIH is a large and complex area of sediment contamination, with different contamination profiles found in different portions of the harbour, and a variety of riparian and habitat conditions. Therefore, management units were developed to reflect several considerations for risk refinement and sediment management:

- Knowledge of sediment quality in KIH (based on results collected between 2008 and 2021).
- Aggregation of areas with similar contaminant profiles and/or effects (e.g., toxicity results or benthic community patterns).
- Specification of nearshore areas with increased potential for wading or other human recreational use, and for which habitat considerations play a significant role in sediment management options evaluation.
- Aggregation of areas with similar ecological and riparian features, to provide a linkage to wildlife exposures and to highlight areas with ecological sensitivity.
- Identification of zones with a spatial scale that is relevant to home ranges of wildlife that have high site fidelity, and spatial scale appropriate for preliminary sediment management options evaluation.[3]

Where possible, water lot boundaries were also used in the division of management units to reflect different jurisdictions (e.g., TC versus PCA; federal management versus City of Kingston). This provided logical divisions between larger jurisdictional areas, such as the PCA- and TC-managed portions of KIH and the City of Kingston-managed area adjacent to the Woolen Mill. However, for some management units it was necessary to overlap jurisdictional boundaries because of the considerations provided above. For example, for shoreline management units in the southern portion of KIH where the City of Kingston jurisdiction is small relative to the portion managed by TC, contaminant profiles, ecological/riparian features, and human recreational use span jurisdictional boundaries. As such, some of these management units include water lots managed by both the City of Kingston

[3] Expert Support comments emphasized the need to consider risk outcomes that are clearly linked to subunits of KIH, particularly for semi-aquatic wildlife (e.g., mammals/birds) and fish. Mobile receptors that cross management unit boundaries require a refined assessment of the home ranges and habitat preferences of these organisms. The risk refinement deliverable explicitly addressed the spatial scale of exposures and the home ranges of each receptor type (including human uses) were linked to these management units.

and TC. Sediment management in these areas will require participation from both parties. The management units, as shown in Figure 2, include:

- Parks Canada (PC) management units — West (PC-W), Orchard Street Marsh (PC-OM), and East (PC-E)
- Transport Canada (TC) management units —Orchard Street Marsh (TC-OM), Rowing Club (TC-RC), Units 1 to 5 (i.e., TC-1, TC-2A, TC-2B, TC-3A, TC-3B, TC-4 and TC-5), and Anglin Bay (TC-AB)
- Management units for other parties under municipal or undefined ownership —Woolen Mill (WM) and PP-OM

The original PC-W management unit assessed as part of the risk assessment (Golder 2016) and initial remedial assessments (Golder 2017a and Golder 2019) was subdivided for the SMP into three different sub-units: PC-W, PC-OM, and PP-OM to reflect an updated property survey and a different remedial strategy for the Orchard Street Marsh (refer to Section 11.2.1 for further discussion).

5.2 Upland Sources of Contamination

The shoreline and bed sediments of KIH reflect historical influence of numerous sources of contaminants, most of which have been curtailed through source control measures, as discussed in detail in Section 5.7. The main COCs that pose a risk to environmental health include:

- Inorganic metals (particularly chromium, lead, arsenic, copper, and zinc)—These contaminants are associated primarily with historical industrial activities along the western shoreline of KIH, such as the Davis Tannery, Frontenac Lead Smelter, and the Woolen Mill, although other urban sources including storm water discharges have historically contributed to contamination. Source control actions (see Section 5.7) and targeted sediment removals have occurred along the western shoreline, but legacy contamination remains in the water lot (MacLatchy 2013, pers. Comm.). Elevated concentrations of copper relative to other areas of KIH were observed in the northern portion of Anglin Bay. Copper is a common component of antifouling paints used on boat hulls. Concentrations observed may be related to the legacy of ship building and vessel maintenance activities in the area. Of the above listed metals, chromium remains the most widespread in distribution, and at the greatest level of exceedance relative to SeQGs. The remainder are more localized (e.g., arsenic is greatest near the Emma Martin Park shoreline).
- Mercury—This contaminant, which is present in organism tissues mainly in the organic form (methylmercury), is associated with discharges from industries, including historical contamination from the vicinity of the Woolen Mill (i.e., the Rowing Club). Source control actions have mitigated surface soil erosion of mercury around the Rowing Club (see Section 5.7).
- Nutrients—The entire Lower Cataraqui River, including the Upstream Reference Zone, contains elevated nutrient conditions, and therefore some sediment chemistry parameters (e.g., organic carbon, nitrogen, and phosphorus) are elevated. KIH is a eutrophic environment, and strong gradients in nutrient status do not exist due to high regional background inputs relative to local sources.
- Organotins—The spatial profiling of tributyltin (TBT) in 2010 and 2011 (Golder 2011a; 2012) indicated that exceedances of screening criteria for TBT were only observed within portions of Anglin Bay, and not in remaining areas of KIH. This is expected due to the close association of TBT contamination with the historical

usage of TBT as an antifoulant. Although TBT is now a restricted substance in antifouling paints, residual contamination of harbours can occur in areas of extensive ship moorage, particularly where scraping or blasting of ship hulls is conducted near open water.

- Polychlorinated biphenyls (PCBs)—Contamination of sediments by PCBs have been documented in the PCA water lot of KIH, associated with leachate from the former Belle Park Landfill. Golder (2011a) provides a review of pathways for this portion of the harbour, focusing on pathways to the PCA zone. Recent sediment quality assessments have documented widespread sediment PCB contamination (Golder 2012, 2014a, 2022a), and the pattern over much of KIH is consistent with landfill leachate as the primary source. Two former demolition/scrap yard properties may have also contributed to the PCBs found in KIH sediment (MacLatchy 2013, pers. Comm.). Historical poor PCB handling practices may have led to the discharge of PCBs through the storm sewer system from the Kingscourt outfall and in the vicinity of Douglas Fluhrer Park. Recent sediment quality profiling (Golder 2022a) confirms that PCB sources are linked to historical shoreline activities, and although redistribution of PCBs has occurred, the central areas of KIH contain lower bulk sediment concentrations of PCBs.
- Polycyclic aromatic hydrocarbons (PAHs)—Sediment PAH concentrations observed within KIH in the vicinity of Anglin Bay and the Douglas Fluhrer Park area are likely the result of historical contamination from a former rail yard and coal gasification plant (Golder 2013a). Although the overall contribution of PAHs from the rail yard area is unknown, the spatial extent of contamination, the PAH composition, and the type of industrial activity all suggest that rail yard activities played a significant role in contaminating the adjacent water lots of KIH. Within Anglin Bay, migration of PAHs from the large deposits of weathered coal tar historically transported via storm sewers are expected to be responsible for the PAH concentrations found in nearby sediments. These historical contributions are expected to represent the bulk of the observed PAH contamination, with ongoing sources (i.e., storm water discharges, vessel traffic, hydrocarbon spills) representing only a minor component. Recent sediment quality profiling (Golder 2022) confirms that PAH concentration patterns reflect a historical source in Anglin Bay, with surface contamination present within and near the mouth of the Bay.

5.3 Exposure Pathways

Exposure pathways for human and ecological receptors, which are routes by which receptors may be exposed to COCs in environmental media, were assessed for KIH and documented in the KIH *Risk Assessment Refinement and Synthesis Report* (Golder 2016). Only those pathways related to use of the water lot were considered. Exposure and contribution from upland, terrestrial areas were not considered because these are not part of the Site. For ecological receptors that may be exposed to both upland and riparian areas (e.g., herbivorous birds and mammals), representative species were assessed under the conservative and simplified assumption that exposures within the federal water lots (alone) reflected their overall exposure profile. A conceptual model illustrating the exposure pathways retained for the risk assessment is presented in Figure 5.

For aquatic receptors, operable exposure pathways include:

- Direct contact with COC in sediment.
- Dietary exposure to COC through bioaccumulation in food items.

For semi-aquatic mammal and bird receptors, operable exposure pathways include:

- Direct exposure to COC in sediment via incidental ingestion of sediment through foraging.
- Direct exposure to COC in surface water via drinking water.
- Dietary exposure to COC through bioaccumulation in food items.

For human health, operable exposure pathways retained for the recreational wader/swimmer/fisher receptors include:

- Incidental ingestion of COC in suspended sediment while wading.
- Dermal contact with COC in bedded sediment and surface water while wading.
- Incidental ingestion of COC in surface water and associated suspended sediment while swimming/fishing.
- Dermal contact with COC in surface water while swimming/fishing.
- Ingestion of bioaccumulative COC in recreationally caught and consumed fish (i.e., bottom and sportfish).

Receptors were only assessed in those management units where they are likely to be present based on presence of suitable habitat.

Ingestion of suspended sediment while swimming typically contributes a minor fraction of the overall exposure dose, particularly when incidental ingestion of sediment via hand to mouth contact is also considered. Exposure to COCs dissolved in surface water is also a relatively minor pathway relative to tissue and sediment-associated sources.

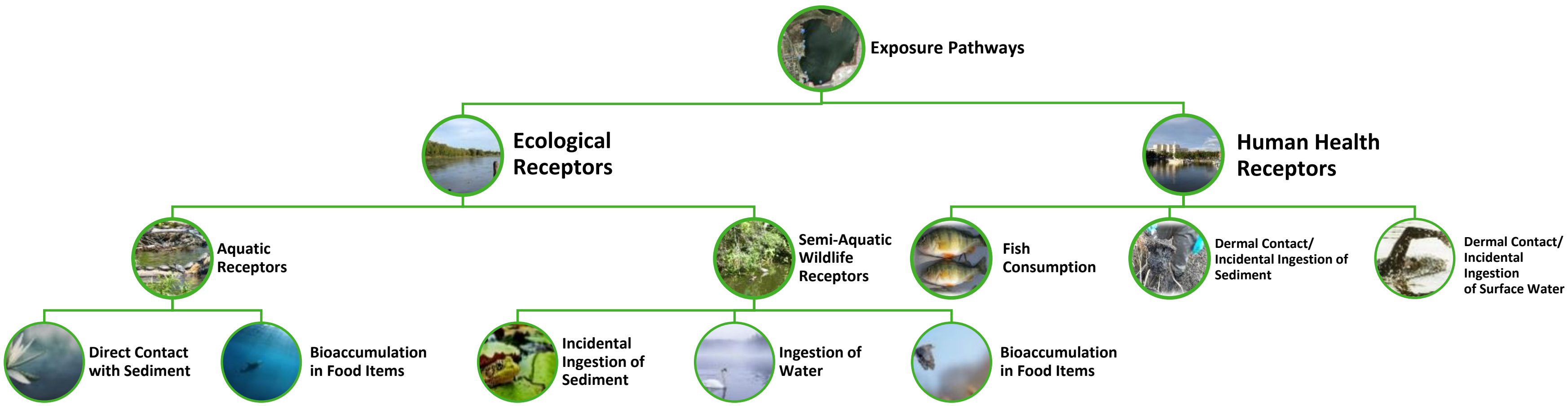

Figure 5: Exposure Pathways Retained for the KIH Project Risk Assessment

Although there is a fish consumption advisory in place for Cataraqui River (Belle Island Area) recreational fishing in KIH remains common practice. Current location- and species-specific provincial advisories are in place for Black Crappie (*Pomoxis nigromaculatus*), Brown Bullhead (*Ameiurus nebulosus*), Bluegill (*Lepomis macrochirus*), Common Carp (*Cyprinus carpio*), Largemouth Bass (*Micropterus salmoides*), Northern Pike (*Esox lucius*), Pumpkinseed (*Lepomis gibbosus*), Walleye (*Sander vitreus*), White Sucker (*Catostomus commersonii*) and Yellow Perch (*Perca flavescens*) (MECP 2019). Therefore, fish consumption was included as an operable exposure pathway in the HHRA.

5.4 Human and Ecological Risk

There are two key federal documents used to assess risks to wildlife (i.e., benthic invertebrates, fish, birds, and mammals) and human receptors from contaminated sites: the Canada-Ontario Framework (EC and OMOE 2008) and the FCSAP Aquatic Sites Guidance (Chapman 2011; FCSAP 2019).
Four key lines of evidence (i.e., sediment chemistry, toxicity to benthic invertebrates, benthic community structure, and the potential for biomagnification) are often identified and assessed to determine sediment management practices best suited to each site. Although the approaches used by the Canada-Ontario Framework and the FCSAP Aquatic Sites Guidance are similar, there are some differences in the procedural details and the use of supporting assessment tools (i.e., FCSAP Aquatic Sites Classification System; CSMWG 2009). Based on discussions with PSPC, TC, and PCA, the Canada-Ontario Framework was the primary document used to complete the risk assessment and management activities for KIH, including the problem formulation, preliminary risk assessment, detailed risk assessment, and CROA.

Results of the ecological, and human health risk assessments under the KIH *Risk Assessment Refinement and Synthesis Report* (Golder 2016) are presented in Figure 6. The results indicate several key findings of relevance to site management:

- Significant ecological risks, ranging from low to moderate in magnitude, were identified in the PCA water lot, particularly in the areas adjacent to Orchard Street Marsh and the unnamed creek that enters KIH. Although few indications of harm were documented for the benthic community, moderate risks to bottom fish (elevated risk of deformities primarily from PAH contamination, and possibly from PCBs), birds (elevated risks to omnivorous birds such as mallards and marsh wrens due to chromium contamination), and mammals (PCB risk to resident mink) were all identified for the areas close to the shoreline (i.e., management units PC-W [Parks Canada West] and TC-OM [Transport Canada Orchard Marsh]).
- Significant ecological risks, ranging from low to high in magnitude, were also identified for the southeastern portion of KIH including Anglin Bay and vicinity. However, the risk pathways were different for this area, with moderate to high risks for the benthic community and moderate risks for bottom fish identified from exposure to PAHs.
- Some areas in KIH were identified to have low overall risks relative to adjacent management units (e.g., TC-1 covers a large area of the TC water lot but yields negligible- to low-risk outcomes for all receptors). This helps to prioritize physical management on areas with multiple elevated risk levels, such that lower contamination levels can be left for monitored natural recovery (MNR). Achievement of negligible risks for all receptors, COCs, and management units was found to be impractical due to the high volume of sediments with low risk.

- Multiple drivers for elevated risks were identified, with PAHs, PCBs, and chromium driving the highest ecological risks, and PAHs, PCBs, and mercury driving the human health risks. The contaminant distributions for these COCs are often coincident (e.g., PC-W contains among the highest concentrations of these substances). However, in some portions of KIH, the concentration distributions do not align; for example, copper contamination in Anglin Bay does not correlate with chromium contamination given the distinct sources for these COCs.
- Human health risks above acceptable levels were identified for multiple contaminants, yielding moderate risk for the sediment exposure pathway (i.e., dermal contact from scenarios entailing recreation within the nearshore sediments) and low risk for the fish consumption pathway. The contaminants driving these risks are primarily carcinogenic PAHs for the sediment exposure pathway, but mercury and PCBs drive risks for the fish consumption pathway. These contaminants have different concentration distribution patterns across KIH.
- Risks to herptiles could not be quantified or categorized with the same level of confidence as other receptors, mainly due to the lack of reliable modelling approaches and toxicological data relevant to herptiles. The areas with suitable habitat for these organisms and other organisms reliant on aquatic habitats (i.e., management units PC-E, PC-W, and TC-OM) already have significant ecological risks (i.e., moderate risks) identified for other organisms. As such, risk management or sediment management to address other risk pathways will contribute to the management of risks to the herptile populations. An added consideration is that physical intervention in the wetland areas of KIH, while of benefit for reducing risks for some pathways, will have potentially significant consequence for the habitat of amphibians and reptiles.

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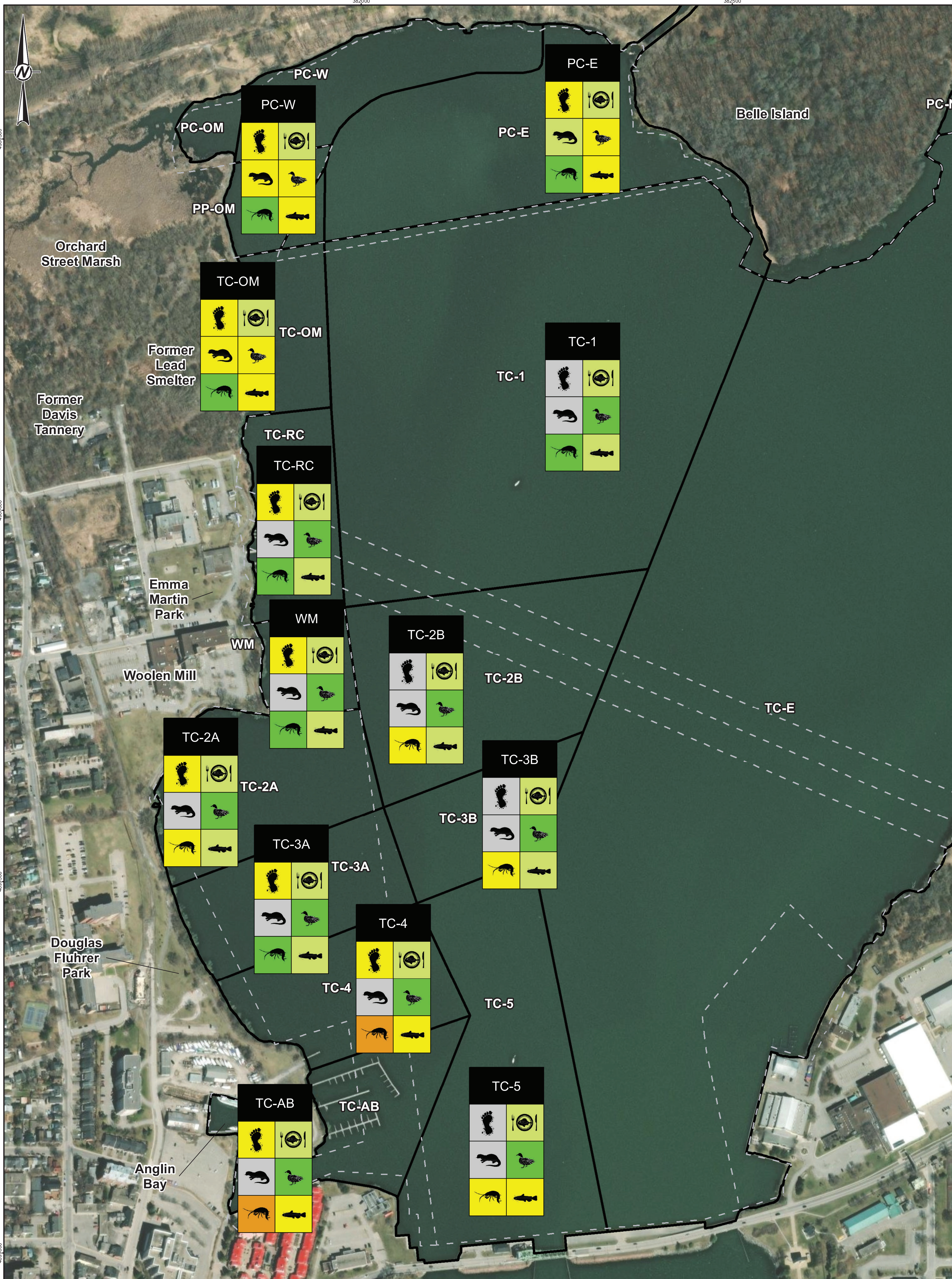

LEGEND

- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT

RISK

- NOT APPLICABLE
- NEGLIGIBLE RISK
- LOW RISK
- MODERATE RISK
- HIGH RISK

Legend

HUMANS (SEDIMENT CONTACT)	HUMANS (FISH INGESTION)
AQUATIC MAMMALS	INSECTIVOROUS BIRDS
BENTHIC INVERTEBRATES	BOTTOM FISH

0 100 200

1:5,000 METERS

NOTE(S)

1. SAMPLES COLLECTED PRIOR TO THE 2005 REMEDIAL DREDGING NEAR THE KINGSTON ROWING CLUB ARE NOT INCLUDED.
2. NA – MANAGEMENT UNIT NOT ASSESSED FOR ENDPOINT.
3. EFFECTS TO BENTHIC COMMUNITIES – NEGLIGIBLE RISK, MODERATE RISK, HIGH RISK.
4. EFFECTS TO BIRDS, MAMMALS, AND HUMAN HEALTH ENDPOINTS – NEGLIGIBLE RISK, LOW RISK, MODERATE RISK, HIGH RISK.
5. POTENTIAL RISKS TO HERPTILES WILL BE MITIGATED BASED ON THE SEDIMENT MANAGEMENT PLAN PROPOSED FOR OTHER RECEPTORS.

REFERENCE(S)

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2. INSET BASE OBTAINED FROM ESRI CANADA.
2. PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
OVERALL PRIORITY FOR RISK MANAGEMENT

CONSULTANT

wsp

YYYY-MM-DD	2023-08-15
DESIGNED	SS
PREPARED	JP
REVIEWED	
APPROVED	

PROJECT NO.	PHASE	REV.	FIGURE
22523199	3000	0	6

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25mm

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5.5 Existing Contaminant Conditions

The existing conditions related to sediment quality and water quality were assessed as part of technical memorandums completed by WSP to support the CCIC for the Project (WSP 2023b,c,d). A summary of these assessments is provided below.

5.5.1 Sediment Quality

The current conditions of sediment quality in the Project area were recently evaluated and incorporated sediment quality data collected in 2021 (Golder 2022a). The current sediment quality conditions provide a baseline against which the performance of the Project can be gauged, and also confirm that surface sediment contamination has not exhibited substantial improvement over recent decades. The exposure parameters of greatest interest include sediment concentrations of metals (particularly chromium, but also antimony, arsenic, copper, lead, mercury, silver, and zinc) and select organic contaminants (PAHs and PCBs). Other chemical contaminants (e.g., other metals, nutrients, organotins) have been screened against background and conservative SeQGs and determined not to meaningfully influence sediment quality during any stage of the Project. Similarly, the area of interest within KIH is the western half only, as the eastern half of KIH has been evaluated in detail and determined to exhibit negligible to low risk to all receptors (Golder 2016).

The characterization of current sediment conditions described below emphasizes the key chemical characteristics that drive environmental and human health risks. Additional details of the distributions of these and other parameters are provided in Golder (2016, 2022a), including depictions of conventional parameters (e.g., total organic carbon, particle size distributions). There are also several data gaps related to understanding the baseline sediment quality conditions that are discussed below.

5.5.1.1 Current Sediment Profiles

Extensive sediment quality characterization has been completed over KIH, including upstream reference areas, over multiple decades. The early conceptual planning stages of the Project (Golder 2016, 2017a, 2019, 2021a) relied mainly on sediment quality data collected between 2008 and 2012. Many of the data, including historical collections from several independent organizations, were collated by ESG (2014), and additional collections were conducted and summarized by Golder (2011a, 2012, 2013b, 2014a, 2016). All those data, following screening for relevance (e.g., removal of data for dredged sediment), were summarized in Golder (2016) as part of the synthesis of environmental quality and risk information.

To distinguish sediment quality in the upstream reference area from the contaminated portions of the Parks Canada and Transport Canada (PCA and TC) water lots south of Belle Island, sediment quality profiles and summary statistics for COCs for reference areas were determined as detailed in WSP 2023c.

The upstream sampling area was constrained to the area marked on Figure 1 as Parks Canada (Upstream Reference Zone), which has the management unit code of PC-N (Parks Canada North). The reference zone also aligns with the Cataraqui River north of management unit TC-E on Figure 2. This upstream area was identified by both ESG (2014) and Golder (2016, 2017a) as an appropriate harbour reference condition. The sediment quality in PC-N includes diffuse regional background inputs of anthropogenic substances, but is not influenced by Project-related point sources, and also has similar sediment substrate. Ecological effects in this area were negligible in magnitude based on the screening risk assessment (Golder 2016).

For all contaminants of interest, reference sediment concentrations are lower than the CCME PELs[4], including both mean and upper tail (90th percentile) estimates. These conditions, although not pristine, reflect low magnitude of urban influence and acceptable sediment quality for working harbours (FCSAP 2021). For most substances, average reference sediment quality is below the Interim Sediment Quality Guideline (ISQG), which is a highly conservative screening value for sediment quality screening.

During early consultation stages, several stakeholders raised the question of whether the contaminant distributions in KIH sediment remain stable over periods of a decade or more. To address this question, and to provide additional delineation data for advancing the conceptual design, PSPC contracted WSP (formerly Golder) to lead a supplemental sampling program in Fall 2021, emphasizing the water lot sections within and adjacent to areas proposed for active intervention. These data were combined with sediment chemistry data from within the past decade[5] to produce an updated sediment chemistry surface. Golder (2022a) describes the methods and factual results from this supplemental sampling program. Updated sediment chemistry distributions for the primary and secondary COCs are provided on Figures B-1 through B-10. These figures depict surface weighted averaged (smoothed) distributions of COCs identified in the detailed risk assessment. The updated surface sediment distributions were compared against the historical distributions (provided in Golder 2017a) to identify similarities and differences.

Some general conclusions from the updated sediment quality profiling included:

- The spatial distribution and magnitude of contamination in Fall 2021 remained broadly consistent with earlier profiling. There was no widespread evidence of significant recovery or deterioration of sediment quality over the past decade, with concentrations of inorganic and organic substances remaining well above SeQGs, and at similar magnitude and spatial distribution to earlier characterizations. This finding confirms that monitored natural attenuation is only appropriate for sediments that currently have low (i.e., acceptable) risk for all receptor groups.
- Numerous substances remain elevated relative to both upstream reference conditions and relative to the eastern half of KIH. The gradient of improving sediment quality moving from west to east was confirmed, in accordance with proximity to legacy sources along the western shoreline.
- Substantial portions of KIH, including the central areas (e.g., TC-1, TC-2B) have elevated bulk sediment concentrations relative to background and relative to conservative generic sediment quality criteria, but not at concentrations that yield unacceptable risks based on the results of quantitative risk assessment (Golder 2016). Because the remedial objective is to reduce only the substances that cause moderate or greater risks, leaving such low-level concentrations in place within the central harbour is acceptable, and the updated concentration profiles indicate that this approach remains appropriate.

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[4] Because the Site is primarily under federal jurisdiction, the screening of sediment chemistry data emphasized the CCME SeQGs for the protection of aquatic life (CCME 1999a). These guidelines were supplemented by the OMOE Provincial Sediment Quality Guidelines for the protection and management of aquatic sediment (OMOE 2008; Persaud et al. 1993). Two sets of guidelines are provided to reflect different levels of protection. The CCME ISQG and the Ontario LEL represent concentrations that can be tolerated by most sediment-dwelling organisms. The CCME PEL and Ontario SEL represent concentrations likely to affect the health of sediment-dwelling organisms. Where no screening criteria were provided by the CCME or Ontario, the Washington Department of Ecology SeQGs for freshwater were applied (Avocet 2003). Similarly, two sets of guidelines are provided - LAET and 2LAET –the 2LAET was considered applicable for chemical screening.

[5] Although data from prior to 2021 were included in the updated chemistry surfaces, most results depicted in Appendix B plots are from Fall 2021 sampling. The figures in Appendix B distinguish between the most recent results (Fall 2021 depicted as square symbols) and prior decade (2011–2020 inclusive depicted as circular symbols)

- For some contamination that was previously elevated in sub-areas of central KIH (relative to surrounding areas within the same management unit), such localized areas did not appear to be as heterogeneous in 2021 profiling relative to earlier sediment quality data summaries. In is unclear whether this increased “smoothness” of sediment quality finding relates to standardization of collection and analytical methods in recent data collections (i.e., earlier compilations reflected multiple distinct investigations with differences in collection methods and analytical techniques), or to a more homogenous field condition. Antimony, mercury, and PCBs are examples of COCs that exhibited smoother distributions in 2021 relative to the patchier profiles evident in earlier data compilations. The implications of this finding are:
  - Remediation design in most areas should continue to emphasize spatially-weighted concentrations, rather that specific geographical points. One possible exception to the above is the distribution of PAHs in the southwest corner of Anglin Bay, where potential presence of free-product staining introduces greater potential for local hotspots of contamination.
  - PCB contamination previously identified in a subset of historical central KIH samples appears not to represent the typical PCB exposure conditions in that portion of the harbour; as such the recommendation for monitored natural recovery in unit TC-1 was strengthened by the updated sediment quality profiling. This is discussed further under the bullet for “polychlorinated biphenyls” below.

The updated contamination distributions for key contaminants are provided in Appendix B and are summarized below. Comparisons to the earlier profiles summarized in Golder (2017a) are also discussed below.

Metals/Metalloids

- **Antimony** (Figure B-1)—The updated sediment quality profile indicates that antimony remains at a stable magnitude of harbour-wide contamination, with most KIH sediment falling between lower and upper SeQGs developed for freshwater sediments. Most sediment antimony concentrations in KIH fall below the second Lowest Apparent Effects Threshold (2LAET) guideline, a value calculated by Avocet (2003) using statistical analysis of co-occurring freshwater sediment chemistry and toxicological endpoint data. The main difference in the 2021 dataset is that the localized exceedances of the 2LAET guideline are now limited to the nearshore areas along the western shoreline, particularly adjacent to the WM and PC-W shorelines. Earlier characterizations indicated occasional anomalous elevated antimony concentrations in the central harbour (TC-1, TC-2B), but these hotspots have not been confirmed in recent sampling. Overall, antimony indicates similar, but smoother (i.e., fewer localized areas that deviate from the broad spatial gradient), concentration distributions in recent sampling. Furthermore, because antimony is highly coincident with other COCs, including other metals/metalloids, the remediation design for other constituents will address antimony contamination of interest.
- **Arsenic** (Figure B-2)—The updated sediment quality profile indicates that arsenic remains at a stable magnitude of harbour-wide contamination, with most KIH sediment falling between lower and upper SeQGs for freshwater sediments. Both historical and recent chemistry distributions indicate that several management units exceed the CCME PEL for freshwater sediment, although such exceedances of the PEL are small in magnitude in most locations. Exceedances of the 2LAET guideline from Avocet (2003) are restricted to two management units (WM, RC), and this spatial profile has remained generally consistent over time. The main difference in the sediment profile for arsenic is that the conditions in the northern half of the RC management unit (along the submerged utilities corridor) have improved in the last decade, and this may reflect the positive

effect of historical dredging in the affected area. Overall, distribution of arsenic at levels of concern remains localized in this one area of western shoreline sediment. The cooccurrence of these peak arsenic levels with other COCs, including other metals/metalloids, means that remediation design targeted to other contaminants will address arsenic contamination of interest.

- **Chromium** (Figure B-3)—Chromium remains the single COC with the highest overall magnitude of exceedance of generic SeQGs and background Cataraqui River sediment concentrations. Over a century of tannery activities were conducted in the Davis Tannery lands beside the Orchard Street Marsh. Although the tannery closed in the 1970s, the proximity to the marsh, which was used for discharge of industrial waste until 1974, has left a clear profile of chromium contamination in sediment. Nearly all sediment within a 500-metre radius of the brownfield (former tannery) site continues to have total chromium concentrations in sediment that exceed 500 mg/kg, a value well above the CCME PEL, the provincial Severe Effect Level (SEL), and the 2LAET. Much of the sediment contamination in the northwestern corner of KIH adjacent to the drainage from the brownfield zone exceeds 1,000 mg/kg chromium. These spatial gradients and overall magnitude of contamination remain consistent with the historical data distribution for chromium. The use of generic guidelines overstates the ecological hazard associated with chromium, as most chromium in surface KIH sediments is in the trivalent form, which is lower in toxic potency relative to the hexavalent form. Nevertheless, the chromium patterns identified in earlier delineations have been confirmed, and with no meaningful improvement in chromium concentrations over time. Chromium concentrations above 1,000 mg/kg remain common within several management units (PC-W, PP-OM PC-OM, TC-OM) in the vicinity of Orchard Marsh, providing a potential continuing long-term source to outlying portions of the harbour, and these concentrations continue to support the rationale for physical intervention in these maximally exposed areas. Successful remediation of the Site does not require removal or sequestration of all areas above 1,000 mg/kg total chromium; however, the removal of maximally contaminated sediments in the northwest corner of KIH is necessary to reduce risks to wildlife to an acceptable level, and to reduce the long-term dispersion of chromium into other portions of the harbour. Because risks are greatest for wildlife, rather than sessile invertebrates, management of chromium is best applied at the scale of individual management units, rather than localized hotspots at individual stations.
- **Copper** (Figure B-4)—Sediment copper remains a highly localized COC in KIH, with nearly the entire harbour exhibiting copper below the CCME PEL. Although the western half of KIH exhibits copper at concentrations higher than upstream reference conditions, the level of exceedance remains modest. Per FCSAP (2021) guidance for working harbours, such conditions below PEL do not, on their own, warrant remedial actions. The only area in KIH with copper contamination at levels of concern is in the head of Anglin Bay, adjacent to the shipyard operations. The innermost half of Anglin Bay contains copper at concentrations above the CCME PEL, the provincial SEL, and the Avocet (2003) apparent effect thresholds (including the 2LAET at the maximally exposed areas). These findings confirm that copper distributions have remained very stable over the past decade, and continue to identify Anglin Bay as an area of elevated metals contamination. As the entire inner portion of Anglin Bay (management unit TC-AB) has also been identified as requiring intervention based on legacy PAH contamination, the recent findings for copper do not change the sediment management plan for Anglin Bay.

- **Lead** (Figure B-5)—The distribution of lead in sediment remains fundamentally unchanged relative to the previous decade. Most of the western half of KIH exhibits lead at concentrations above the PEL, and above upstream reference concentrations, but with only localized areas exceeding the LAET from Avocet (2003). Despite these exceedances of generic guidelines and background, the detailed risk assessment indicated the risk from sedimentary lead was low, in part due to presence of local modifying factors (such as acid volatile sulphides that bind divalent metal cations). Furthermore, the few areas of maximum lead contamination are coincident with other metals and organics, such that intervention for other COCs will address any minor risk from lead.
- **Mercury** (Figure B-6)—The distribution of mercury in sediment also remains fundamentally unchanged relative to the previous decade. The only difference in the recent data collections is that the chemical distributions follow smoother gradients from the legacy shoreline source. Most of KIH, in both historical and recent sampling, remains below the CCME PEL of 0.49 mg/kg. However, contiguous areas of sediment mercury contamination above the PEL remain along the west-central shoreline in KIH, and approximately half of that contiguous area includes concentrations above the SEL of 2 mg/kg. The areas that exceed the SEL remain of interest for two reasons:
  - The areas of contiguous sediment contamination that approach, and sometimes exceed, the SEL result in average concentrations of total mercury across multiple management units that could result in bioaccumulation of mercury to levels of concern.
  - SeQGs do not explicitly incorporate biomagnification pathways, such that mercury is best assessed through monitoring of organism tissue concentrations. Observed contamination in KIH fish tissues confirms the bioavailability of sediment mercury, validates previous identification as an environmental concern, and is reflected in the development of local fish consumption advisories for the harbour. Mercury exposure levels, which have not ameliorated with time, remain a consideration in the conceptual remedial design.
- **Silver** (Figure B-7)—The updated sediment quality profile indicates that silver remains at a stable magnitude of harbour wide contamination, with most KIH sediment falling between lower and upper SeQGs developed for freshwater sediments. Both historical and recent sampling indicate a pattern of moderate silver exceedances extending from the legacy industrial activities at the Woolen Mill. Sediment concentrations in KIH are currently below the 2LAET guideline over most locations, and no link between silver concentration and adverse effects was identified in the detailed risk assessment. Overall, silver indicates similar, but smoother, concentration distributions in recent sampling. Furthermore, because silver is highly coincident with other COCs, including other metals/metalloids, the remediation design for other contaminants will address any silver contamination of interest.
- **Zinc** (Figure B-8)—The distribution of zinc in sediment remains fundamentally unchanged relative to the previous decade. Most of the western half of KIH exhibits zinc at concentrations below the PEL, and with no localized areas exceeding the LAET from Avocet (2003). The detailed risk assessment indicated the risk from sedimentary zinc was low, in part due to presence of local modifying factors (such as acid volatile sulphides that bind divalent metal cations). Furthermore, the few areas of zinc contamination above the PEL are coincident with other metals and organics; therefore, intervention for other COCs will address any minor risk from zinc.

Organics

- **Polycyclic aromatic hydrocarbons** (PAHs; Figure B-9)—Broadly, the magnitude of PAH contamination remains similar to the previous decade. Several regions of elevated PAH contamination have been identified through the western KIH; these concentrations of total PAHs provide a synthesis of the numerous individual parent PAHs and are a useful indicator of both spatial exposure gradient and temporal trend for PAH mixtures that are stable in composition. Both historical and recent sampling indicates three main regions of total PAH contamination that exceed the Probable Effect Concentration (MacDonald et al. 2000):

  - Northwestern KIH water lot adjacent to former Belle Park Landfill and Orchard Marsh
  - West central nearshore area adjacent to the Woolen Mill
  - Southern shoreline area within and adjacent to Anglin Bay

  These zones are delineated more clearly in the recent sampling relative to historical sampling and depict a clearer linkage to historical contamination sources. Sediment PAH concentrations observed within KIH in the vicinity of Anglin Bay and the Douglas Fluhrer Park area are likely the result of historical contamination from a former rail yard and coal gasification plant (Golder 2013a). Although the overall contribution of PAHs from the rail yard area is unknown, the spatial extent of contamination and, PAH composition and type of industrial activity all suggest that rail yard activities played a significant role in contaminating the adjacent water lots of KIH. Within Anglin Bay, migration of PAHs from the large deposits of weathered coal tar historically transported via storm sewers are expected to be responsible for much of the PAH contamination found in nearby sediments. These historical contributions are expected to represent the bulk of the observed PAH contamination, with ongoing sources (i.e., storm water discharges, vessel traffic, hydrocarbon spills) representing only a minor component. The legacy PAH concentrations are heterogenous in distribution at depth, with some areas exhibiting shallow PAH contamination (i.e., within upper 1 m of sediment bed) that exceeds typical surface concentrations.

  The central and eastern areas of KIH, although elevated relative to reference conditions, do not indicate PAH contamination at levels of concern for a working harbour.

- **Polychlorinated biphenyls** (PCBs; Figure B-10)—Of all COCs evaluated in KIH, the distributions of sediment PCB contamination exhibit the largest changes in distribution pattern over the last decade. The changes do not appear to indicate transport or degradation of PCBs in sediment (particularly as PCBs are highly persistent in the environment), but rather reflect a more accurate and complete characterization of PCB concentrations in surface sediment. In the recent sediment delineation, the contamination surface for total PCBs is more consistent with expected sources and gradients; the PCB contamination is focused along shoreline sediments close to the former Belle Park Landfill, and in some hot spots toward the southeastern portion of KIH. The pattern over much of KIH is consistent with landfill leachate as the primary source. Two former demolition/scrap yard properties may have also contributed to the PCBs found in the KIH sediment, although historical poor PCB handling practices may have led to the discharge of PCBs through the storm sewer system from the Kingscourt outfall and in the vicinity of Douglas Fluhrer Park (MacLatchy 2013, pers. comm.). These are the only contiguous areas in recently sampling that exceed 1 mg/kg dry weight total PCB. Remaining PCB measurements, all below 1 mg/kg total PCB, occur at concentrations higher than reference conditions, and above the PEL, throughout the entire western KIH. In historical chemistry, there was increased spatial distribution of moderate PCB concentrations in the range of 0.6 to 1.0 mg/kg dry weight total PCB, particularly in the central KIH. It is unknown whether these differences in the central harbour result from analytical variability, heterogeneity in sediments, or other cause; nevertheless, the concentrations below 1 mg/kg are unlikely to warrant intrusive management to achieve acceptable risk. Instead, emphasis on the nearshore hotspots, which overlap the contamination distributions for other primary COCs, would provide the most effective way to manage PCB exposures. PCBs cause adverse effects primarily through broad biomagnification pathways rather than localized direct effects, meaning that management should emphasize weighted average conditions in management units rather than specific locations representing small PCB mass.

5.5.1.2 Leachate Results

Leachate analytical data (TCLP) was compared to the O.Reg 347 Standards for Leachate Toxic Soils (Ontario 1990f). This waste management act provides guidelines for arsenic, barium, boron, cadmium, chromium, lead, mercury, selenium, silver, uranium, and benzo(a)pyrene. The results showed there were no exceedances of leachate criteria at any management unit for the parameters for which a criterion was available (Golder 2022a). However, sediment chemistry found at depth near Anglin Bay still requires additional characterisation (Section 5.5.1.3) and confirmation whether the sediment is considered hazardous waste, as creosote free product may be present here.

5.5.1.3 Sediment Quality Baseline

A reliable baseline for sediment quality within the Project area is required before starting any in-water works; such baseline data will maximize effectiveness of dredging and provide confidence that sediment disruption does not cause negative environmental effects (as discussed in Section 6.2). The recent sediment sampling in Fall 2021 provides solid coverage of the management units of greatest interest, and provides data collected using highly standardized field sampling and analytical methods. As such, remaining data gaps in sediment quality are limited and localized. The few remaining data gaps of greatest significance include:

- Evaluating stream sediment conditions in Orchard Street Marsh—the sediment chemistry in the unnamed channel that connects the Kingscourt Sewer to KIH has a complex pattern, due in part to the historical releases of contaminants from the tannery, but also the influence of cleaner particulate materials and water flows through the drainage channel. Depending on the remediation measures that are ultimately adopted for the land-based areas along the northern edge of the brownfield, additional horizontal and/or vertical delineation will be required in that area.
- Depth profiling near Anglin Bay—This portion of KIH has the greatest potential to uncover significant contamination at depth, due to the association of free product with historical coal tar-containing wastes. Deeper sediment samples in this area would be valuable in identifying the recommended depths of excavation prior to detailed design stage; such would assist in refining sediment volumes and development of specifications for cover depth, thickness, and composition in the vicinity of Anglin Bay.
- Sediment stratigraphy analysis for proposed dredged areas (e.g., Ground-Penetrating Radar [GPR])—GPR will refine dredge volume requirements by detailing the depths of native lacustrine clay. The maximum depth of legacy contamination could be inferred from the depth of the native lacustrine clay that underlies the depositional layers. Such layers provide a stratigraphic and physical barrier to sediment contamination at depth.

Further details on these data gaps are provided in WSP 2023c and these will be addressed prior to finalizing the detailed design.

5.5.2 Water Quality

Understanding existing water quality conditions within KIH is important for providing confidence that the Project does not result in the release of contaminants above baseline conditions. Guidance for managing federal aquatic contaminated sites in working harbours has recently been published to provide guidance to federal custodians of FCSAP sites in urban or multi-source environments (FCSAP 2021). The FCSAP *Guidance for Working Harbours* recognizes that there are ongoing diffuse inputs from anthropogenic sources into harbours. The guidance acknowledges that the comparison of contaminant concentrations to pristine natural background conditions is not appropriate for working harbour sites, and instead emphasizes comparisons to local harbour ambient background. Therefore, any changes to water quality following the implementation of the Project should be compared to baseline conditions. The most significant issue related to water quality in KIH is the potential for remobilization of particulate-bound contaminants, as opposed to dissolved phase constituents. Such resuspension can be managed during dredging and other intrusive remediation through environment protection measures focused on control of turbidity and total suspended solids. For climate change scenarios, which could entail changes to the intensity and/or frequency of major storm events, scouring of the existing sediment bed during high flow events is a potential concern, and is one of the reasons why removals of maximally exposed sediments is recommended. Our current understanding of existing water quality within KIH and at upstream reference locations is discussed below. However, there are several data gaps related to understanding the baseline water quality conditions both in the Project area and in appropriate reference areas that are also discussed below.

5.5.2.1 Current Water Quality Profiles

ESG (2014) provides a detailed review of historical surface water quality studies for areas near KIH undertaken between 1971 to 2010. Their assessment relied on surface water quality data collected from 2003 to 2010. The surface water quality data collected since 2003 reflects water quality conditions following the implementation of several source control measures to reduce contaminant inputs from the Belle Park Landfill (further discussed in Section 5.7). Based on these studies, it was concluded that the Great Cataraqui River is a eutrophic and alkaline system, with generally good water quality that, with few exceptions, met the provincial and federal water quality criteria (ESG 2014).

WSP (2023d) re-screened the data relied upon by ESG against current water quality criteria, including the Ontario PWQOs (Ontario 2016) and the CCME WQGs (1999b/2023). The updated screening indicated that chromium, copper, lead, zinc, PCBs, and several PAHs exceeded the current water quality criteria. Federal Environmental Quality Guidelines (FEQGs) have recently been established for chromium, copper, lead, and zinc that are based on recent scientific evaluations and allow for water quality parameters that influence bioavailability to be considered for the derivation of site-specific WQGs (Canada 2023). However, site-specific water quality parameters necessary to derive FEQGs, including pH, temperature, hardness, and dissolved organic carbon (DOC) were not reported by ESG (2014) and therefore the FEQGs were not further considered. The exclusion of these toxicity modifying factors means that generic (and conservative) guidelines were relied upon for screening, potentially screening through substances that would otherwise be eliminated with updated and/or site-specific guidelines; however, a baseline for toxicity modifying factors, and therefore site-specific WQGs, will be established and used to screen water quality prior to in water works (see Section 6.3.1).

A recent study examined the water quality in Anglin Bay located within the southern portion of KIH (ESG 2017). One surface water sample was collected at the mouth of Anglin Bay and analyzed for inorganic elements, PCBs, PAHs, petroleum hydrocarbons (PHCs), benzene, toluene, ethylbenzene, and xylenes (BTEX), TBT, and total suspended solids (TSS). PCBs, PAHs, PHCs, BTEX, and TBT were below the analytical detection limits. No inorganic parameters in these data exceeded the CCME WQGs or the PWQOs.

Semi-annual surface water sampling is undertaken in KIH as part of the Belle Landfill monitoring program (Malroz 2021). The sampling locations include a reference location upstream of the landfill and three locations within KIH. The surface water samples are analyzed for conventional water quality parameters and metals (cadmium, cobalt, copper, iron, lead, zinc). The surface water quality data from the most recent sampling program were screened against current PWQOs and CCME WQGs in WSP (2023d). Concentrations of copper and zinc exceeded the water quality criteria at the reference site and within KIH. The concentrations were higher within the surface water samples collected within KIH, but were correlated with higher TSS as a result of sediment disturbance. Nitrate and nitrite also exceeded the CCME WQGs at the reference site and within KIH; however, the concentrations were comparable to background conditions (Malroz 2021).

5.5.2.2 Water Quality Baseline

A baseline for surface water quality within the Project area is required before starting any in-water works to ensure that sediment disruption does not cause negative environmental effects during remediation and to support water quality monitoring post-remediation (as discussed in Section 6.3). There are several data gaps related to the current understanding of surface water quality within KIH that will be addressed to establish baseline conditions prior to in-water works (further details are provided in WSP 2023d), including:

- Updated water chemistry results for both the Project area and suitable reference areas for each COC group associated with sediment (total metals, PAHs, and PCBs), nutrients, and toxicity modifying factors that influence bioavailability and the development of site-specific water quality criteria (i.e., hardness, pH, DOC).
- Chromium analysis for hexavalent and trivalent forms of chromium, which WQGs are based on.
- Characterizing dissolved metal and TSS concentrations to confirm that the concentrations of metals within the water column of KIH are strongly correlated with particulates.
- Measuring dissolved oxygen levels as the re-suspension of anoxic sediments can reduce the dissolved oxygen concentration in the water column.

5.6 Causation

FCSAP Aquatic Sites Framework (FCSAP 2019) outlines that remedial planning should determine causation before taking remedial action(s) involving physical works. The causes of elevated risk related to sediment and water chemistry within KIH were assessed as part of technical memorandums completed by WSP to support the CCIC for the Project (WSP 2023c,d). A summary of these assessments is provided below.

5.6.1 Sediment Quality

The historical and recent sediment quality data presented in Section 5.5.1 indicate that concentrations of several metals/metalloids, PCBs, and PAHs have historically exceeded SeQGs. Although the specific sources of the elevated parameters are sometimes uncertain, there are known linkages of these contaminant profiles to legacy sources of soil and sediment contamination in KIH shoreline areas. Golder (2013a) summarizes the historical linkages between urban activities and the sediment contamination profiles described above.

Adverse effects have been observed, or predicted using risk-based exposure models, for the above COC groups. The presence of elevated contaminants coincident with the observation of adverse effects is necessary, but not sufficient, to provide evidence of causation. Golder (2012) summarizes evidence for causation, concluding that there is evidence that PAHs have contributed to the toxicity of sediments. A weight of evidence approach was applied to evaluate linkages among components of the Sediment Quality Triad (sediment chemistry, laboratory toxicity, and benthic invertebrate community composition), with an emphasis on identifying statistical associations between effects-based endpoints and sediment contamination. Several lines of evidence supported a linkage between sediment contamination and ecological responses, including:

- *Chironomus dilutus* toxicity endpoint—Significant negative relationships ($p < 0.05$) were identified between toxicity to a midge in a laboratory exposure and sediment contamination. Most PAHs (with the exception of 1-methylnaphthalene, acenaphthalene, anthracene, and fluorene) were observed to have a significant negative correlation with *C. dilutus* survival, including total PAHs.

- *Hyalella azteca* toxicity endpoint—Although effects on *H. azteca* survival and growth were not evident in toxicity testing (relative to the negative control performance), significant negative relationships ($p < 0.05$) were identified between the growth endpoint and several physiochemical parameters. Again, significant correlations were observed for several parameters that exceeded upper-bound SeQGs and that are not bound to acid volatile sulfide, consisting almost entirely of PAHs.

- Biological Community Responses—Significant negative correlations were identified between benthic invertebrate community metrics and physicochemical parameters in sediment for sampling stations in KIH. Significant negative correlations with benthic invertebrate metrics (richness, diversity, and dominance indicators) were observed, with most negative correlations being for PAH exposures. The above findings suggest that the associations between concentration and response that were observed in toxicity test endpoints are also translating into biological responses in the field.

- Toxicity Identification Evaluation (TIE)—A series of focused sediment experiments were conducted in response to the laboratory toxicity results mentioned above. The TIE showed that the increase in toxicity associated with UV exposure was substantial, providing a strong line of evidence that photo-activated organic toxicants (principally a subset of PAHs) were present. The ecological relevance of these contaminants is heightened in water bodies for which water depths are shallow, allowing light penetration to the sediment-water interface.

- Fish Deformities—A literature review (Golder 2014b) summarized the linkage between sediment PAH exposures and the prevalence of anomalies, including liver lesions and external deformities. The above information suggests that observed patterns in excess fish deformity rates, if not caused by viruses, may be caused by PAHs, particularly for sediment concentrations of 10 mg/kg total PAH and higher. PAHs have been identified as potential causal agents for the observed field deformities; sedimentary PAH concentrations were explored in more detail through the acquisition of additional chemistry data and correspondence to field-based evidence for tumour incidence in brown bullhead. Although definitive confirmation of causation would require histopathology, virology, and tissue and bile analysis, the review concluded that PAH contamination in sediment was a plausible explanation for observed anomalies in locally caught bullhead.

For risk predictions made for semi-aquatic wildlife (e.g., mammals, birds, reptiles) and humans, it is not possible to conduct a rigorous causation assessment with the information currently available. Such studies of causation, could include epidemiology studies, controlled laboratory bioassays (feeding studies), or detailed controlled field experiments. These types of studies suffer from high uncertainty, ethical issues, potential for destructive sampling, and technical complexity. As such, potential risk must be inferred from concentration-response information gleaned from published sources, including toxicity reference values for dose-based chemical exposure.

5.6.2 Water Quality

The water quality data presented in Section 5.5.2 indicate that concentrations of nitrate, nitrite, chromium, copper, lead, zinc, PCBs, and PAHs have historically exceeded the CCME WQGs and/or PWQOs, and that chromium, copper, lead, zinc, PCBs, and PAHs have been elevated within KIH relative to upstream reference conditions. The specific sources of the elevated parameters are often uncertain, although several of these contaminants are known to be associated with legacy sources of soil and sediment contamination in KIH:

- Lead and Zinc—Historically, there were two major smelting operations east of Orchard Street along KIH, including Frontenac Smelting Works, a lead smelter that ceased operations in 1916. These smelters used nearby railway sidings and the nearby waterfront, and discharged waste into the harbour. The signature of metals contamination remains from these sources, although it has been dispersed widely across the harbour, rather than concentrated in localized areas.
- Chromium—Over a century of tannery activities were conducted on the Davis Tannery lands beside the Orchard Street Marsh. Although the tannery closed in the 1970s, the proximity to the marsh, which was used for discharge of waste until 1974, has left a clear profile of chromium contamination in sediment.
- PCBs—Project Trackdown (Benoit et al. 2016) is an investigative environmental program aimed at tracking sources of PCB contamination in Great Lakes tributaries and has included the Cataraqui River and KIH as one of three tributaries to Lake Ontario. The program applied a multi-media weight of evidence approach for identifying sources of PCBs to the environment. In KIH, the source of PCB contamination was identified to be localized “hot spots” in inner harbour sediments, particularly along the western shoreline adjacent to commercial and historical industrial activity. Some localized remediation was undertaken in these areas, although other areas of elevated PCBs remain in western KIH. The recent sediment profiling documented in Golder (2022a) confirms that maximum PCB concentrations in sediment are associated with near shoreline areas.
- PAHs—PAHs are a ubiquitous group of substances in urban areas, but there are localized areas of elevated PAHs in portions of KIH. The areas of highest contamination tend to be in shoreline areas, adjacent to historical deposits of leachate and coal gasification byproducts:
  - North KIH—Shoreline deposits of elevated PAHs are observed adjacent to the former municipal landfill on Belle Park (Golder 2017a, 2022a). Although municipal source control actions have reduced inputs from legacy sources, the historical deposits remain in near shore sediment.
  - South KIH—Kingston’s coal gasification plant operated within the downtown area of Kingston from the mid 1800s through to the 1950s. This plant processed coal to produce coal gas, and the by-product of the coal gasification process was coal tar. Historical discharges (prior to municipal remediation of large

quantities of contaminated soil and groundwater) resulted in accumulation of concentrated coal tar deposits in and around Anglin Bay. These deposits are heterogenous, and often found at depth below the sediment-water interface but are also found in patches at the current sediment surface (Golder 2017a, 2022a). The recent sediment profiling documented in Golder (2022a) confirms that elevated PAH contamination in surface sediments remains near Anglin Bay, with possible long-term expansion of the contamination away from the mouth of Anglin Bay.

The Project plans to remediate sediment management units with the highest concentrations of COCs, including chromium, lead, zinc, PAHs, and PCBs, which are resulting in unacceptable risks to human health and the environment through sediment exposure pathways (Golder 2017a). Historical water quality assessments suggest that contamination in solid phases (sediment and suspended particulates) are more important exposure pathways to receptors than aqueous phases. In water quality monitoring, elevated concentrations of surface water quality parameters are associated with particulate rather than aqueous phases given the strong association of the COCs with TSS. ESG (2009) measured total surface water concentrations of chromium, copper, lead, and zinc within KIH above current PWQOs and CCME WQGs, but these exceedances were correlated strongly with the particulate fraction of metals; in contrast, dissolved surface water concentrations were generally below analytical detection limits. Benoit and Burniston (2010) also found elevated concentrations of COCs were correlated with TSS. Malroz (2021) concluded that metal concentrations measured within the water column of KIH were correlated with particulates resulting from sediment disturbance. The source of elevated COCs within surface water may therefore be the result of sediment resuspension, which would be heightened during high flow events (i.e., greater wave energy and shear stress during storms), and potentially exacerbated over the long-term by climate change. Natural variations in total metals concentrations are expected due to changes in natural energy levels in the water column and could also occur through human physical disturbance of the sediments during sampling under shallow water conditions (Malroz 2021). Therefore, management of TSS will be key to protecting water quality within KIH (as discussed in Section 6.3.1)

In addition to legacy sources, which have been identified to be the drivers for most contamination of KIH media in both TC and PCA water lots, there is potential for smaller loadings from ongoing land-based sources, as discussed in Section 5.7 below.

5.7 Source Controls

The FCSAP Aquatic Sites Framework (FCSAP 2019) outlines that remedial planning should determine that on-going sources of contamination are controlled before taking remedial action(s) involving physical works. Source removal or control is a pre-requisite to remediation of the aquatic environment so that the disturbance associated with remedial measures will not need to be repeated. The source control measures that have been implemented to minimize inputs of COCs along KIH were assessed as part of technical memorandums completed by WSP to support the CCIC for the Project (WSP 2023c,d). Evidence for source control as it relates to sediment contamination in KIH comes from three main types of information:

- **Historical trend evaluation**—The long-term temporal trend of contamination in harbour sediments provides a broad indication of existing source controls. If elevated concentrations of primary COCs are increasing over time, or being observed in new, previously uncontaminated locations, there is evidence that sources are not being effectively controlled. Demonstration of stable or decreasing concentrations does not provide definitive evidence for adequate source controls, as inputs could be degraded or buried over time, but trend assessment is a useful screening step. The profiles of sediment chemistry described in Section 5.5.1, particularly in relation to older historical samples, provides useful confirmation that the surface sediment contamination remains stable, without exacerbation by ongoing sources.

- **Evaluation of known legacy sources of upgradient contaminatio**n—PSPC engaged WSP to undertake reviews of several known legacy contamination sources along the Kingston waterfront to confirm that they have been controlled. These evaluations have considered demonstrated source control actions, mainly by City of Kingston, including engineering measures to control ongoing releases, fingerprinting of hydrocarbon signatures to document sources, and municipal programmes including public education to reduce contaminant inputs at the source.
- **Environmental monitoring of media potentially entering KIH** (surface water, groundwater, sewer discharges, soil, sediment)—PSPC and other federal custodians (TC and PCA) have contracted Golder to collect chemistry data along the shoreline to characterize sources and assess implications for management. In addition, the City of Kingston had used such monitoring programs to inform management of contaminant pathways to KIH and has implemented remediation programs to address identified issues.

For the most part, source control measures have been successfully implemented in KIH, such that remedial options can emphasize the legacy contamination sources (Golder 2017a). Information on ongoing source control initiative is detailed in WSP (2023d) and a summary is provided below. The potential contaminant sources for KIH are labelled on Figure 7.

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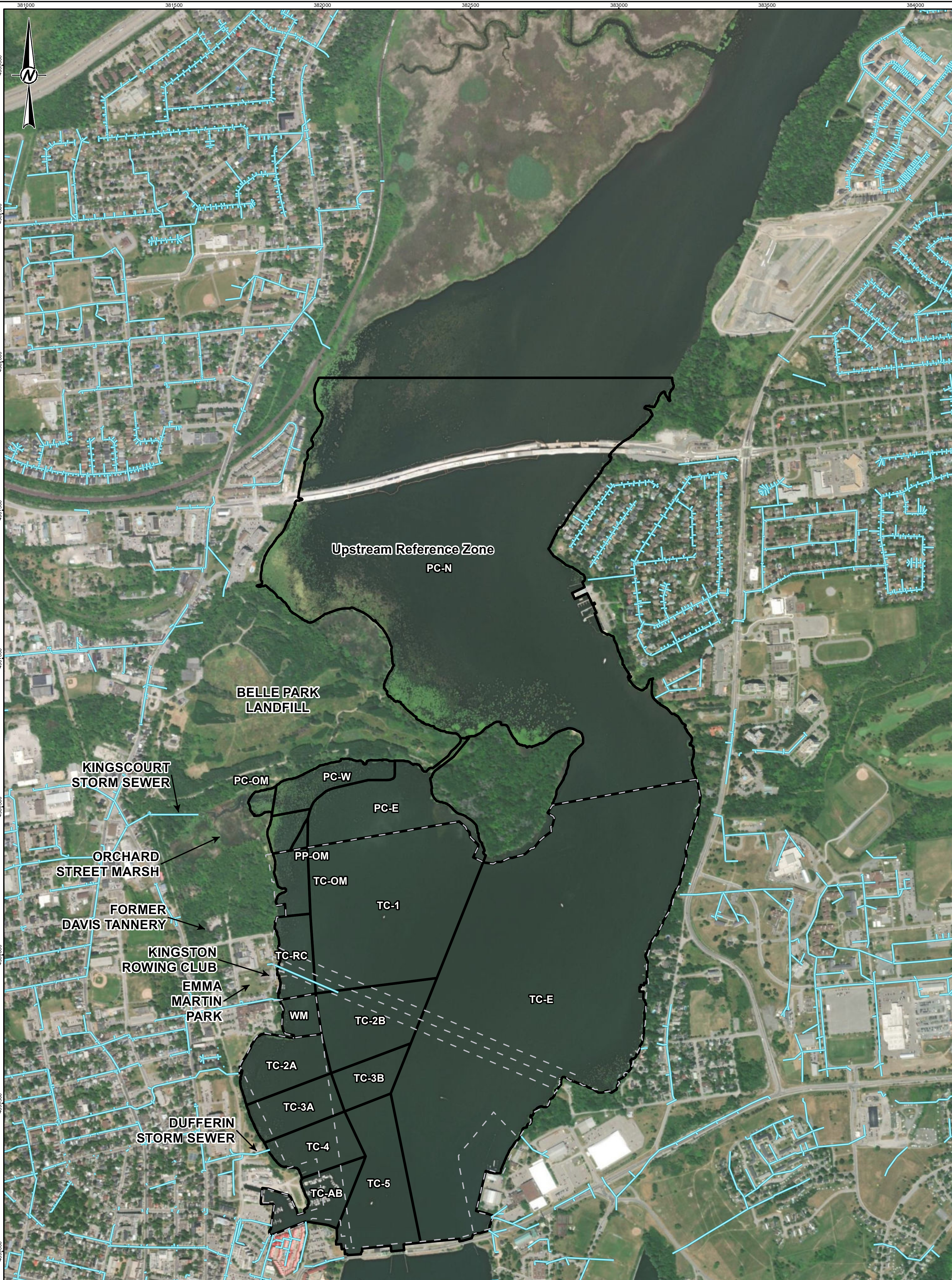

LEGEND

FEDERAL WATER LOT BOUNDARY

MANAGEMENT UNIT

STORM SEWER

0 250 500

1:12,500 METERS

REFERENCE(S)

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PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT

PSPC

PROJECT

KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE

POTENTIAL CONTAMINANT SOURCES TO KINGSTON INNER HARBOUR

CONSULTANT

YYYY-MM-DD	2023-08-15
DESIGNED	LF
PREPARED	JP
REVIEWED	
APPROVED	

PROJECT NO.	PHASE	REV.	FIGURE
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The City of Kingston has documented the following municipal controls undertaken to limit contaminant transport to KIH:

- **Belle Park Landfill leachate collection system**—Leachate control system at the closed Belle Park Landfill to prevent point source discharge of leachate-impacted shallow groundwater to KIH. These systems consist of conventional perimeter collection wells, off-site groundwater treatment, and plantings of hybrid poplar phreatophytes. The Belle Park Landfill monitoring program also includes surface water sampling at strategic locations within the Great Cataraqui River to monitor the effectiveness of the groundwater remedial measures that have been implemented. Follow-up studies between 2003 and 2011 concluded that the Belle Park Landfill was no longer a significant source of PCBs into KIH (ESG 2014). Since then, groundwater has been assessed semi-annually for site-specific indicators of landfill leachate, including ammonia (N) total, chloride, iron, pH, and TSS. The results from the most recent groundwater assessment (2019–2020) were within historically established concentration ranges; however, ammonia (N) total and iron remain above the PWQOs (Malroz 2021).

- **Emma Martin Park passive reaction barrie**r—Investment in controls to contaminated groundwater flow from Emma Martin Park to KIH. Controls consist of a funnel and gate system with a reactive wall designed to reduce dissolved arsenic loading from shallow groundwater flow; the City intends to continue to operate this system. The City of Kingston monitors groundwater discharge from this area to ensure the effective remediation of arsenic (pers. comm., Paul MacLatchy, 30 November 2022). The distribution of historically sourced arsenic in sediment along the KIH waterfront is also spatially limited relative to other metals in the harbour (Golder 2017a, 2022a).

- **Rowing Club storm water run-off upgrades**—In 2007, discharge of particulate bound mercury in surface runoff from the Rowing Club was identified as a potential source of contamination into KIH. A follow up study by the City of Kingston identified elevated mercury within the surface soil surrounding the Rowing Club. The City of Kingston subsequently implemented improvements and modifications to prevent stormwater runoff that could cause erosion of mercury contaminated soils; confirmatory monitoring during high precipitation events confirmed that unacceptable surface soil erosion was no longer occurring (ESG 2014).

- **Former Davis Tannery clay berm**—The former Davis Tannery historically discharged liquid waste containing chromium into a wetland north of the tannery (known as the Orchard Street Marsh). A clay berm was installed in the 1980s to prevent groundwater discharge of contaminants into KIH. During high precipitation events, it is possible that particulate matter with elevated COCs may be transported into KIH through surface water runoff (ESG 2014). Potential for soil erosion and slumping into the Orchard Street Marsh will continue to be evaluated in conjunction with property redevelopment proposals in the brownfield area, including landscaping controls to prevent erosion and sediment movement to KIH.

- **Storm sewers**—Storm sewers are a potential ongoing source for urban contaminants such as metals and PAHs captured from stormwater flow. The storm sewer outflows into KIH have no end of pipe controls (e.g., settling ponds), which means that particulate inputs that may be associated with contaminants are conveyed with water flows. The City of Kingston has adopted several source control measures to reduce particulate loading to storm sewers since 2005 (pers. comm., Paul MacLatchy, 6 December 2022), including street sweeping programs and catchment basin clean-up. The City of Kingston also engages in educational programs to raise awareness of the importance of reducing inputs of storm-water pollutants and reducing the dumping of waste materials into storm drains (e.g., Fish and Frogs Forever Program).

- **Combined sewer overflows (CSOs)**—CSOs consist of large pulses of nutrients and coliform bacteria associated with raw sewage that is discharged during and after heavy rainfall. The City of Kingston has completed several upgrades to control frequency and magnitude of CSO events, specifically around KIH (Utilities Kingston 2022), including Emma Martin Park CSO storage tank installation (2006) to reduce overflows from the River Street Pumping station, Harbourfront Trunk Sewer twinning (2005) and refurbishment (2008), and replacement of CSO sections with separated sanitary and storm sewers within the Kingscourt and Dufferin sewer sheds (2001–ongoing).

Federal investigations and programs have further limited sources of potential contamination:

- **Western shoreline dredging**—Project Trackdown (Benoit and Burniston 2010, Benoit et al. 2016) was established as an investigative environmental program to track sources of PCB contamination in Great Lakes tributaries. In KIH, the source of PCB contamination was identified to be localized "hot spots" in inner harbour sediments, particularly along the western shoreline adjacent to commercial and historical industrial activity. Some localized remediation was undertaken in these areas, which resulted in PCB removals, along with co-located contaminants (e.g., arsenic and mercury).
- **Organotin regulations**—The spatial profiling of TBT in 2010 and 2011 (Golder 2011a; 2012) indicated that exceedances of screening criteria for TBT were observed within portions of Anglin Bay. This is expected due to the close association of TBT contamination with the historical usage of TBT as an antifoulant, and the prevalence of ship repair and moorage within Anglin Bay (i.e., residual contamination of harbours can occur in areas of extensive ship moorage, particularly where scraping or blasting of ship hulls is conducted near open water). TBT is now a restricted substance in antifouling paints, and in June 2011 the federal government added TBTs and tetrabuytltins to Schedule 1 to *CEPA, 1999*. Although legacy sources of TBT, at moderate levels, remain in Anglin Bay, ongoing sources have been controlled through environmental regulation of sources.

Given the above source controls (municipal and federal), the fate and transport linkages of greatest relevance to remedial options analysis relate to the effect of remedial design features (whether positive or negative) on the existing situation. For example, sediment management options along the south shore of Belle Park must take into consideration how removal of sediment or alteration of shorelines may impact shallow groundwater flow (and associated leachate), while management options adjacent to the Orchard Street Marsh must consider the potential for alteration of sediment movements (e.g., bank slumping, sediment erosion control during storm events).

However, there are several data gaps related to the current understanding and quantification of effectiveness for these source controls, including:

- **Effectiveness of storm sewer management**—The storm sewer outflows into KIH have no end of pipe controls (e.g., settling ponds), such that particulate inputs may be discharged that are associated with contaminants. Recent improvements in the City of Kingston sewer system have likely decreased the potential for contamination to enter KIH via storm sewers, but this has not been formally assessed. It is recommended that storm sewers along KIH be sampled during dry outfall events to understand if they represent a major source of on-going contaminant loading. Further, the aqueous and sediment material from the storm sewer outflows during flowing conditions (i.e., wet periods) should be sampled and analyzed for COCs to establish time-weighted averages of contaminant loading.

- **Confirmation of Former Davis Tannery erosion controls**—To validate effectiveness of historical (and potential additional) contaminant transport controls near the former Davis Tannery, the storm sewer monitoring program described above should also include aqueous and suspended sediment material draining from the western shoreline into KIH during wet-weather events. No dry-weather component is needed for this pathway.
- **Contaminants of emerging concern (CECs)**—There have been several CECs identified over the past decade in urban environments that are increasingly being detected in water bodies but are not typically monitored or regulated. CECs that could be of public interest include endocrine disrupters which are known to be harmful to aquatic receptors, such as bisphenol A (BPA), perfluoroalkyl and polyfluoroalkyl substances (PFAS), and polybrominated diphenyl ethers (PBDE). None of these substances would be linked to historical sources in federal water lots, but rather would reflect municipal sources. It is recommended that samples for CEC analysis be collected from storm sewer outflows during both dry outflow and CSO events to confirm the presence of CECs.

These data gaps should be addressed prior to finalizing the detailed design.

5.8 Lacustrine Processes

Understanding sediment movement is important because many contaminants bind closely with the solids found in the sediment bed, and because lacustrine processes can influence physical properties of interest in KIH, including shoreline stability and resuspension/redistribution of sediment. KIH is a relatively wide and shallow basin feature at the mouth of the Cataraqui River, where it flows into Lake Ontario. Figure 8 shows bathymetry elevations within the Site range from approximately 75.5 m to 67.5 m (a range of 8 m). The water depths are shallow (approximately 1.5 m or less) across most of KIH except for the deeper navigational channel along the eastern and southern ends of the harbour.

The navigation channel has approximately 3 m of navigational draft depth that has been maintained by dredging in the past. The water flows are therefore deeper and faster moving on the eastern side of the harbour (Figure 9). However, much of the harbour is shallower and with low water velocities, including the western half where most legacy sediment contamination has accumulated. This results in a low-energy and primarily depositional environment, in which fine-grained surface sediments accumulate and redistribute slowly over time.

One important property of harbour sediments is that they are mobile, and they mix over time. This includes movements up and down (vertically) in the sediment bed, and sideways (laterally). These movements are governed by both physical and biological processes. The sediment bed can be described as an evolving surface of solid matter, which can be altered in the short term (large storm events), or over the longer term with the gradual movement of sediment. Biological communities can either enhance mixing (e.g., through bioturbation of surface sediments by microorganisms) or constrain mixing (e.g., presence of aquatic plants and root mats that stabilize sediments).

The broad natural processes that affect how water and sediments move within the environment are important for understanding how sediment contamination could change in response to a clean-up project. Such understanding can be linked to the remedial design to provide confidence that the Project will not result in undesirable changes to these processes.

5.8.1 Baseline Hydrodynamics

The existing hydrodynamics (physical processes) of KIH were studied in previous reports such as the Sediment Transport Study (Golder 2017b) and Sediment Stability Study (SNC-Lavalin 2020). These reports provided a basis for developing a conceptual understanding of sediment processes discussed in the conceptual SMP (Golder 2021a).

Several physical hydrodynamic processes control currents and circulation within KIH and have the potential to influence sediment and contaminant transport within KIH and the adjacent Cataraqui River. These processes are discussed in the following subsections:

- Historical dredging
- Cataraqui River hydrology
- Lake Ontario water levels including the effects of lake seiches and storm surges
- Wind generated currents
- Wind generated waves
- Submerged aquatic vegetation
- Vessel wakes
- Ice cover

5.8.1.1 KIH Bathymetry and Historical Dredging

KIH consists of a shallow U-shaped basin and is approximately 1.7 km long and 1 km wide. At the southern end of the harbour, the La Salle Causeway divides the inner harbour from the outer harbour. The outer harbour is approximately 900 m long and terminates at the mouth of the Cataraqui River, into Lake Ontario. The KIH basin shallows from its deepest point (adjacent to the La Salle Causeway) to approximately 1 m deep in areas just south of Belle Island. A very shallow marsh (depths typically < 1.5 m) extends from the south end of Belle Island (Figure 8).

According to Canadian Hydrographic Services (CHS 2007), the southern end of the harbour was dredged for navigational purposes as recently as 1965 to a depth of 5.5 m. The dredge cut runs from the mouth of Anglin Bay on the west side, to the Cataraqui River/Rideau Canal navigation channel to the east (Figure 9). The navigation channel runs approximately south to north, connecting the lock system of the Rideau Canal to Lake Ontario. A smaller channel area runs perpendicular to the navigational channel (Figure 9); this localized deepening coincides with the municipal infrastructure (utilities) corridor connecting the west and east shores of the harbour.

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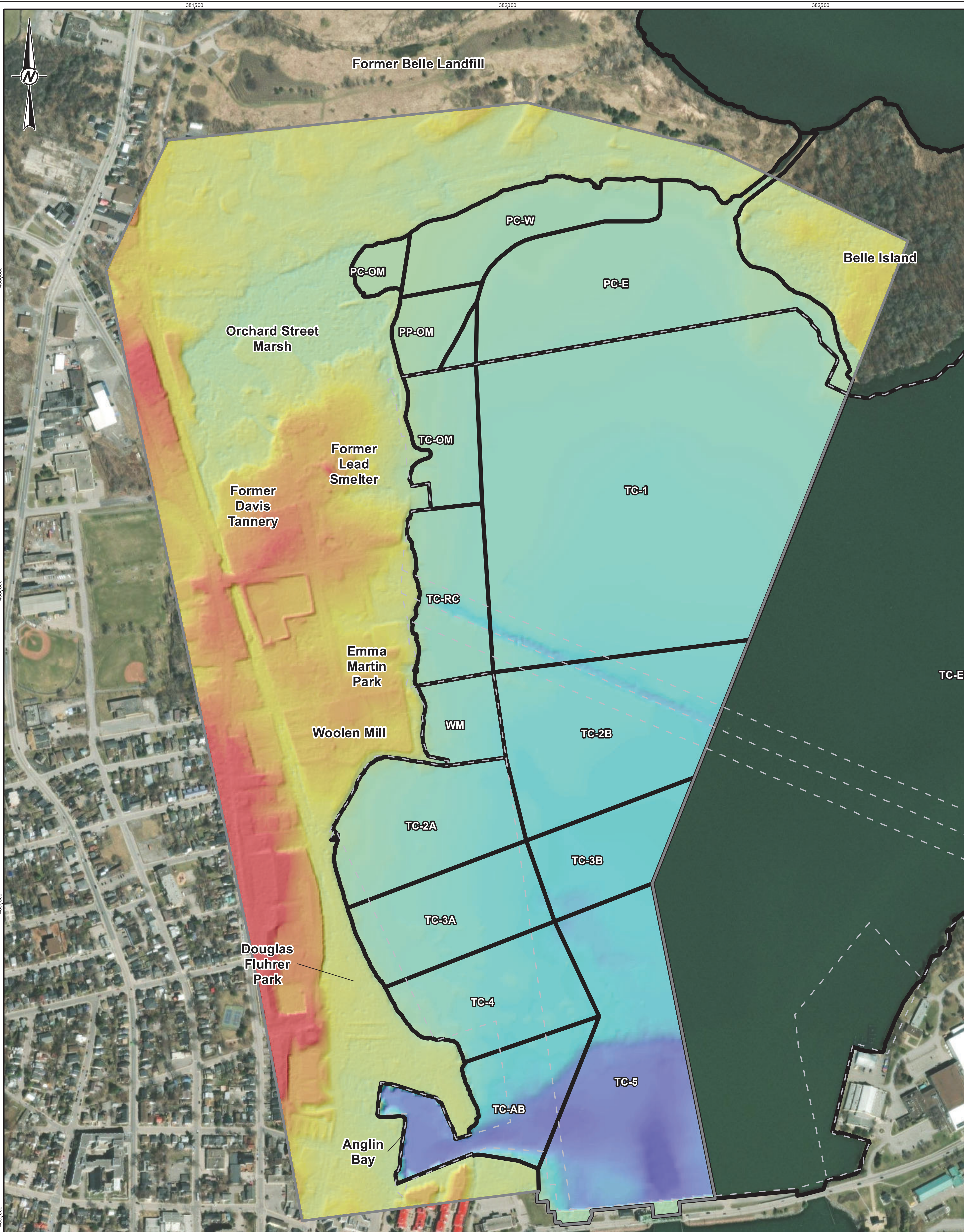

LEGEND

FEDERAL WATER LOT BOUNDARY

MANAGEMENT UNIT

ELEVATION (m, IGLD85)

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67.75

FOR DISCUSSION PURPOSES ONLY

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REFERENCES
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2. LIDAR DATA OBTAINED FROM NRCAN, ONTARION LEAP PROJECT.
PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PSPC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
LIDAR AND BATHYMETRIC ELEVATIONS (IGLD85)

CONSULTANT

wsp

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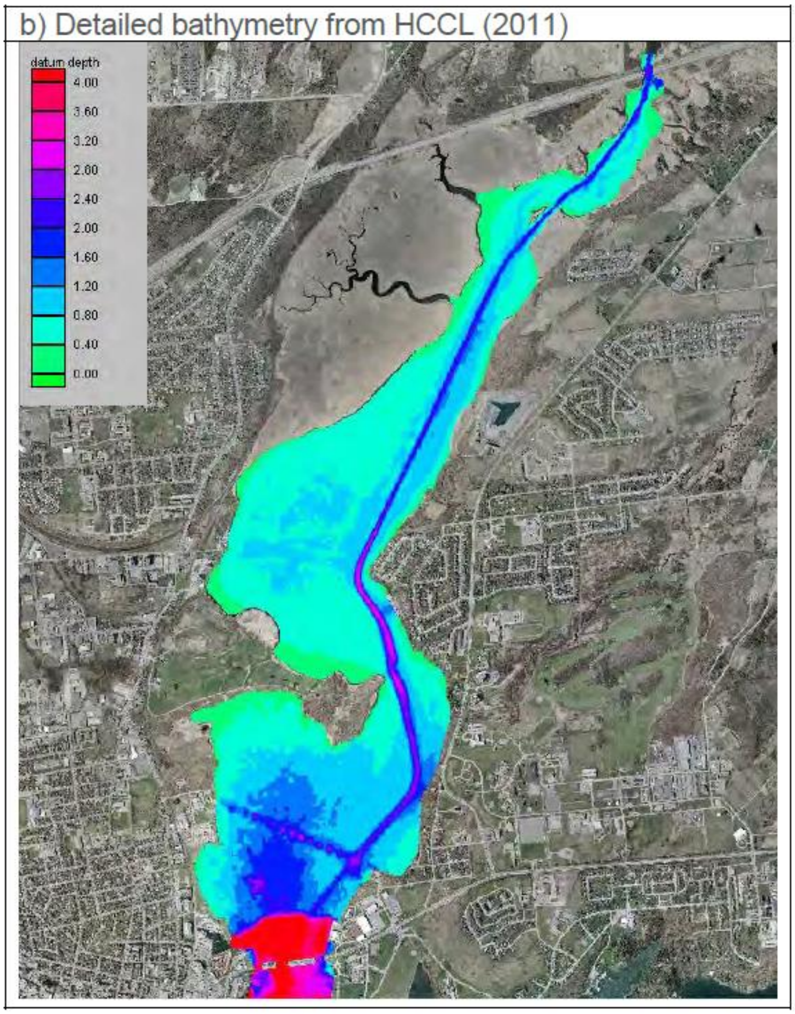


Figure 9: Bathymetry of the wider Cataraqui River from HCCL (2011). Source: SNC Lavalin (2020)

5.8.1.2 Cataraqui River Hydrology

The harbour is located at the mouth of the Cataraqui River which is part of the Rideau Canal system. The Cataraqui River watershed is within the Great Lakes Lowlands and drains an area of approximately 910 km^2 (Acres 1977). The Cataraqui River discharge regime is dominated by a spring (February-March) increase in flows due to snowmelt and modulated by periods of precipitation. Cataraqui River flows range from 4 m^3/s to 17 m^3/s up to a maximum estimated flow of 50 m^3/s recorded during an extreme storm (HCCL 2011). These flows cause KIH to flush out water volumes approximately 76 times per year (Golder 2017b).

Water levels at the mouth of the Cataraqui River are controlled primarily by the hydrologic and hydrodynamic regime of Lake Ontario (see Section 5.8.1.3). Construction of several major infrastructure projects have also significantly impacted hydrologic processes in KIH, including St. Lawrence seaway (late 1840s), Rideau Canal and lock system (1832), La Salle Causeway (1916), Lake Ontario Management Plan (1960s), and upgrades to sanitary sewer (including dredging across central KIH).

These projects have mainly resulted in a dampening of water level fluctuations and restriction of flows into and out of the harbour. This reduces the speed of currents and strength of circulation which have resulted in a reduction in sediment transport potential.

In KIH the dominant Cataraqui River currents align with the navigation channel with most of the river discharge occurring along the eastern portions of the harbour. Belle Island has a sheltering effect on the western side of the harbour and results in a slight recirculation effect (Figure 11). Minor inputs of surface water flow also occur on the western side of the harbour and have some influence on overall water movement. Smaller discharges enter the harbour through storm sewer outfalls, including at the north end of the brownfield area at the Orchard Street Marsh, which is fed by the Kingscourt storm sewer flows.

5.8.1.3 Lake Ontario Water Levels

Water levels in KIH are generally consistent with Lake Ontario levels (Dalrymple and Carey 1990). The minimum, mean and maximum historic water levels in Lake Ontario were 73.8, 74.8, and 75.7 m (International Great Lakes Datum of 1985, IGLD) (overall range 1.9 m) respectively. These calculations were based on the monthly lake wide average water levels from January 1960 through December 2016. Water supplies to Lake Ontario surpassed the historical maximum during Spring 2017 and water levels remained high throughout the summer. In 2018, peak Lake Ontario water levels decreased to approximately the 1960–2016 seasonal average but spiked again in spring 2019 (new maximum of 75.9 m) and remained high through late summer. These record setting levels were followed by recent stable water levels that have remained near historical seasonal averages from January 2021 to January 2023.

The location of KIH at the eastern end of Lake Ontario, combined with southwesterly dominant wind directions, make the Site prone to lake seiche-induced water level fluctuations and wind set-up. Lake seiches are standing waves caused when wind forcing and atmospheric pressure changes force water from one end of the water body to another resulting in set-up. When the forcing changes or reduces water level set-down occurs and oscillations occur that may persist for several hours or days.

Magnitudes of seiche at the eastern end of Lake Ontario are typically in the range of 0.25 to 0.5 m, but potentially reaching 0.7 m (HCCL 2011). Seiches can create tide-like currents (i.e., standing waves) as water is forced northward through La Salle Causeway openings. Golder (2017b) estimated that current speeds through the

Causeway of up to 0.15 m/s, associated with a 0.5 m surge draining in two hours, have the potential to re-suspend sediment in the harbour entrance area. Such conditions can transport sediments northward into KIH during the rising surge and potentially transporting fine sediment southward out of the harbour during the falling limb of the surge.

5.8.1.4 Wind Generated Currents

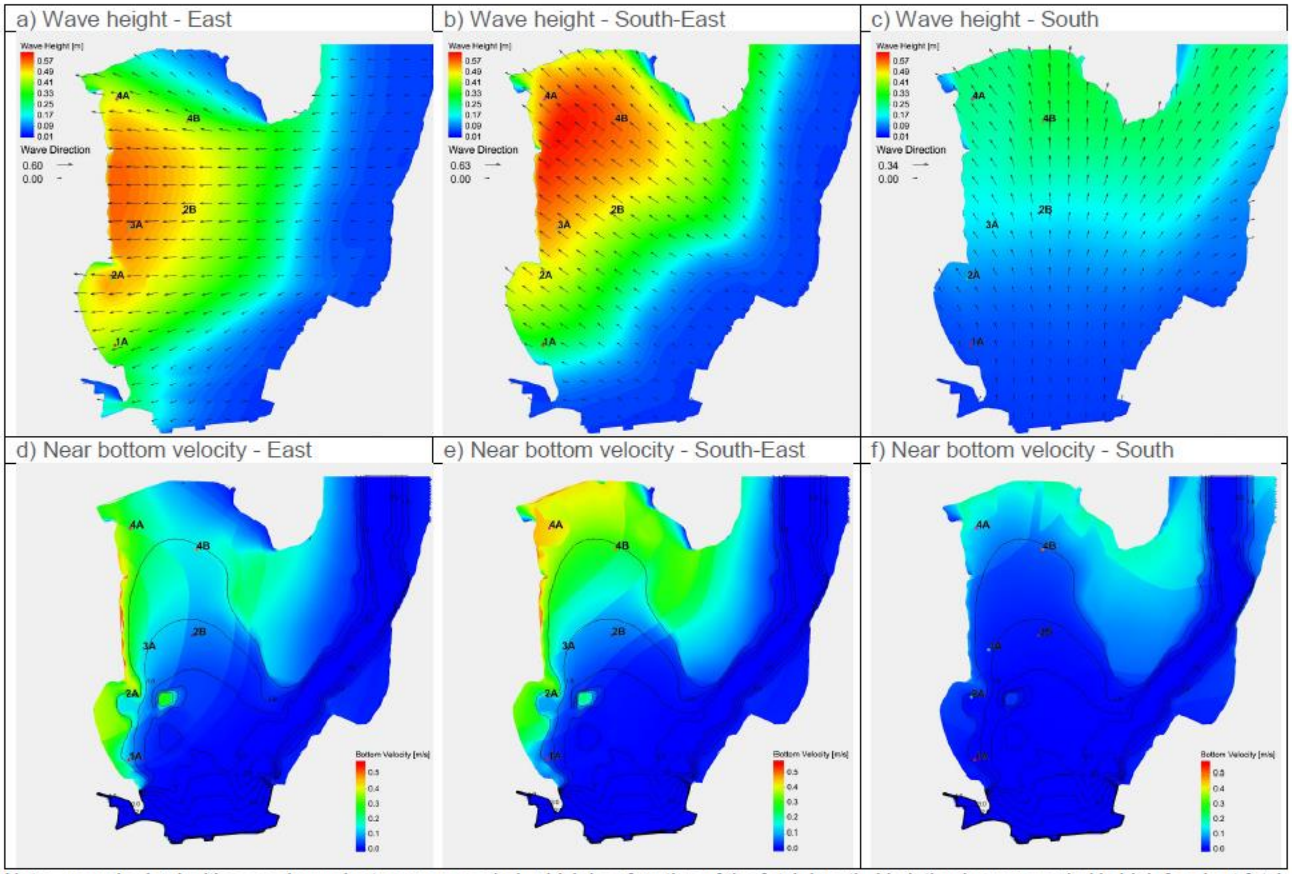
Wind patterns also influence local currents in the harbour. Dominant winter wind conditions within KIH are from the west, with less frequent winds coming from the south and the northeast. Summer wind conditions are predominantly from the south, with less frequent winds from the southwest. These winds create localized wind generated currents and small waves (Figure 10 and 11).

Winds combined with river currents generally create a clockwise circulation cell in KIH with dominant flows being southward along the eastern shore; the La Salle Causeway deflects a certain amount of flow to the west and northward along the western shore. Wind and recirculation deflect flow eastward at Belle Island (Figure 11).

5.8.1.5 Wind Generated Waves

Although the dominant wave direction in Lake Ontario is from the southwest, the effect of these waves is reduced by the La Salle Causeway across the mouth of the harbour (Figure 11). Water and sediment movement are influenced more by local conditions inside the harbour, and the modest dimensions of the harbour limit the strength of wave action inside the harbour. For example, the limited fetch (distance of open water over which the wind can blow) limits the size of wind generated waves in KIH.

Wind waves on the west side of KIH have been estimated to range from 0.2 to 0.5 m for annual storms to extreme winter storms respectively with wave periods ranging from 1.6 to 2.3 seconds (Golder 2017b). SNC Lavalin (2020) applied a two-dimensional wave growth and transformation model to predict wind waves within KIH for three directions (East, South-East and South) for 1, 10, and 50-year return periods. An example of significant wave height and associated near bottom wave orbital velocities is shown in Figure 10. The results indicated the waves may reach 0.5 m or higher on the western and northwest shoreline during east and south-east winds with 50-year return periods with corresponding bottom velocities of 0.2 to 0.5 m/s. However, the model did not include the attenuation effect of submerged aquatic vegetation on wave growth and transformation in KIH; as such the actual wave heights and bottom velocities are likely to be smaller than predicted by the model.



Note: near-bed velocities are dependent on wave period, which is a function of the fetch length. Variation in wave period is high for short fetch length. The abrupt changes in near-bed velocities apparent on figures d, e and f are a result of this and show the limitations of numerical modelling for short fetch areas.

Figure 10: Significant wave height for winds with 50-year return period for the (a) East; (b) South-East; (c) South directions and the associated near bottom water velocities for (d) East I South-East (f) South directions. Source: SNC Lavalin 2020

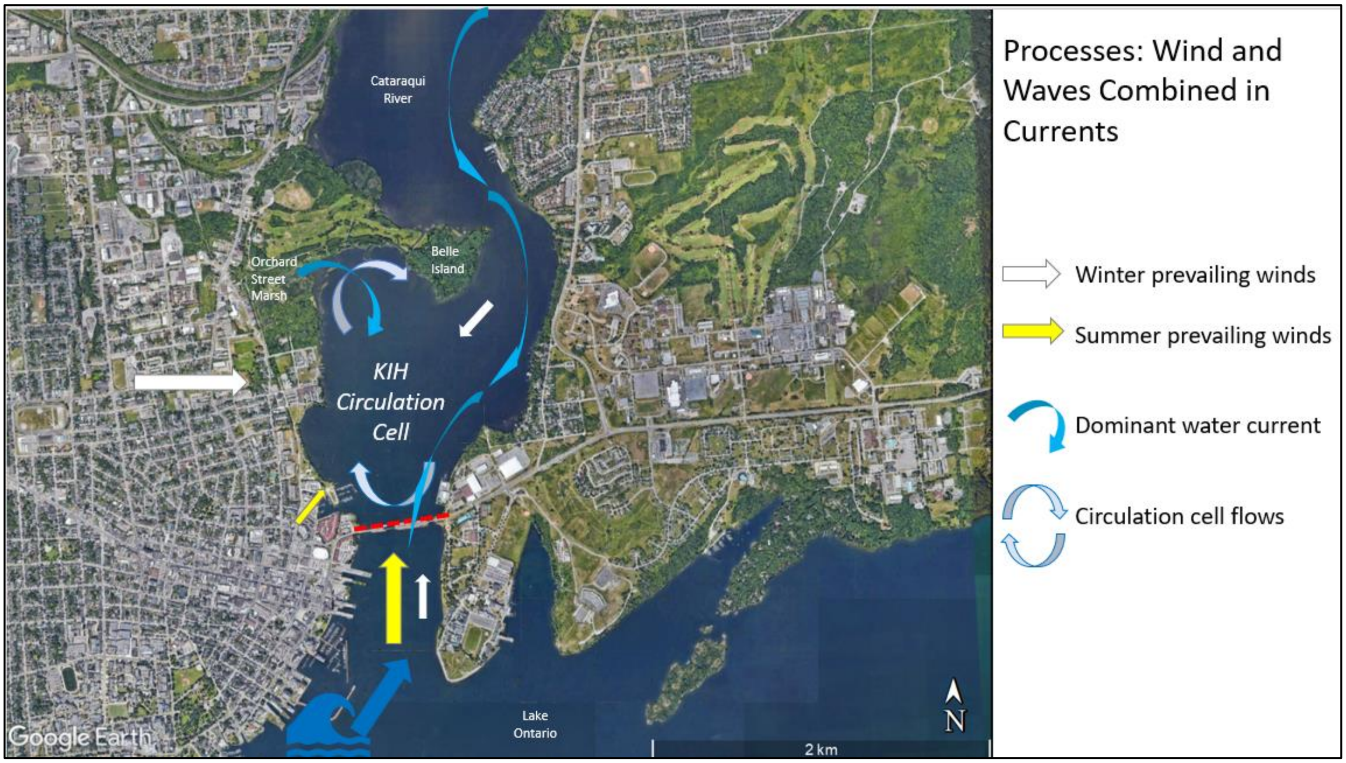


Figure 11: Conceptual overview of wind and wave processes in Kingston Inner Harbour

5.8.1.6 Submerged Aquatic Vegetation

The impact of submerged aquatic vegetation (SAV) and broader aquatic vegetation on reducing current speeds and wave energy has been well documented and can significantly increase sediment deposition and bed stability due to increased friction and root binding. Golder (2011a) reported the presence of the following primary SAV types in KIH: Eurasian watermilfoil, coontail, pondweeds, and eelgrass. The increased presence of cattails and Eurasian watermilfoil are associated with the accumulation of sediments related to human-induced hydrological changes. Dalrymple and Carey (1990) indicate that portions of KIH deeper than 1.7 m water depth are typically devoid of vegetation. Based on the bathymetry shown in Figures 8 and 9, and observations from historical air photos, the northern two thirds of the harbour (north of the harbour limits), and east of the navigation channel are well covered with aquatic vegetation and not significantly affected by physical disturbance through vessel activity (Golder 2017b).

SNC Lavalin (2020) report observations of SAV during the open water season in 2018 and reported significant difficulties in navigating the study area west of the navigational channel, with repetitive clogging and fouling of the propeller by SAV. SNC (2020) further classified a September 2015 aerial image for floating, submerged, and mixed (floating and submerged) vegetation types (Figure 12).

Based on SNC Lavalin (2020) analysis of satellite images, the northern two-thirds of KIH and the area west of the navigation channel were well covered with aquatic vegetation. The water lots in KIH requiring sediment management cover a total surface area of 85 ha. Of this, 81 % (69 ha) is covered by extensive macrophyte beds (floating: 14 ha, submerged: 9 ha; mixed: 46 ha). The water lot management units with limited presence of vegetation are located in the deeper reaches at the south end of KIH (TC-5, TC-AB, and part of TC-4).

The role of SAV for erosion protection and habitat for fish and other aquatic life requires that recovery of the SAV community be planned for and confirmed through monitoring. Much of the recolonization will occur naturally through propagule drift from upstream habitats, combined with proper design of shoreline habitat features. Where recovery is delayed, adjustments are possible through planting of macrophytes and/or removal of invasive species.

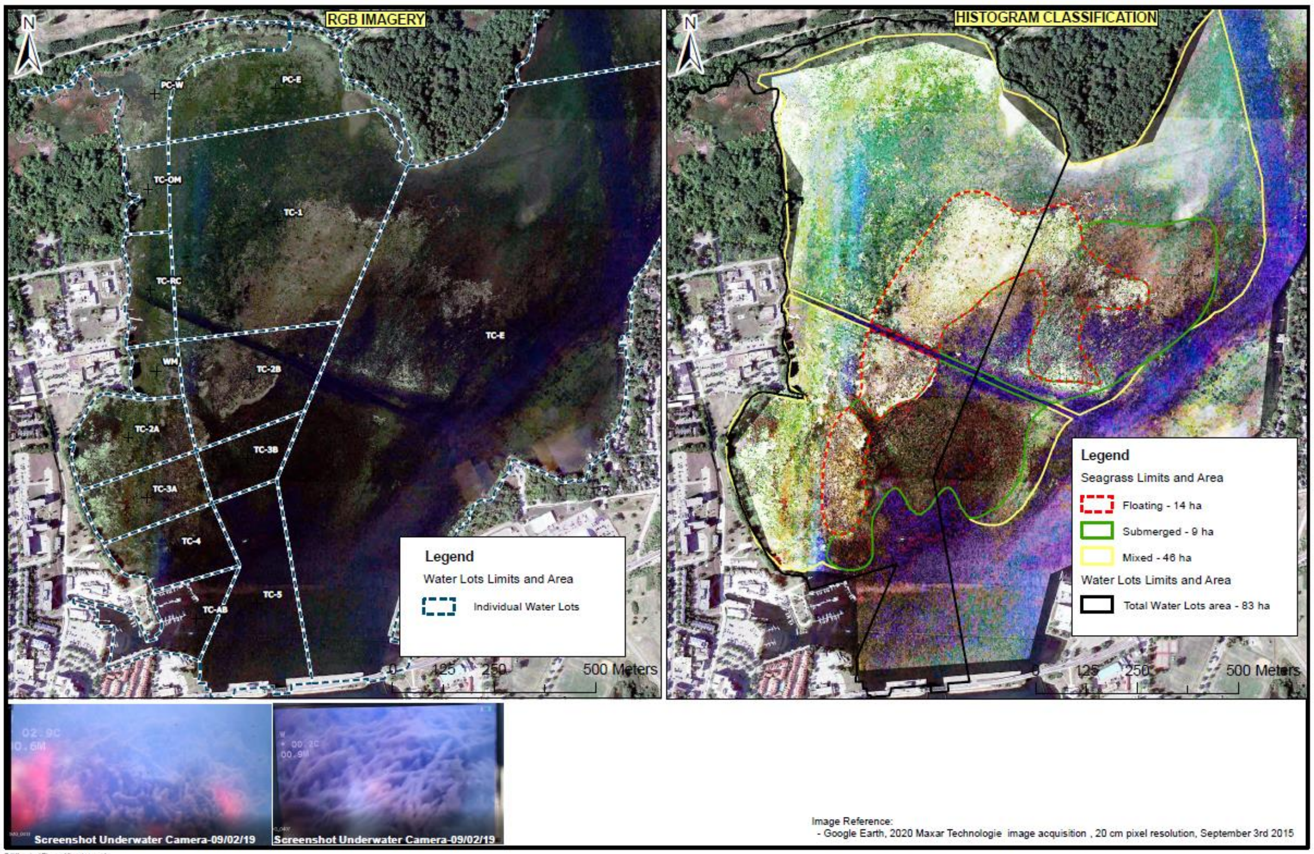


Figure 12: Macrophyte beds in the KIH basin using delimitation from satellite imagery (September 2015) and underwater camera imagery (February 2019) Source: SNC Lavalin 2020

5.8.1.7 Vessel Wakes and Propeller Wash

Propeller scour from vessel movements within the water lot may resuspend and transport materials within the harbour, although dense vessel traffic is limited to the vicinity of La Salle Causeway and Anglin Bay. In these areas sediments are primarily silts (fine-grained) and the water depth is shallow (i.e., <1.5 m). Vessel speeds and wakes are restricted for the remainder of the water lot, where boating consists mainly of rowing and kayaking; sediment resuspension from propeller action and vessel traffic is not expected to contribute to resuspension in areas outside of the navigation routes (Golder 2017b). There was limited vessel activity identified north of the harbour limit and west of the navigation channel in the available historical imagery. It is unlikely that either wakes or propeller action contribute significantly to resuspension in the study area due to speed restrictions imposed by navigation requirements; the presence of SAV further limits the influence of vessel wake and propeller wash.

5.8.1.8 Seasonal Ice Cover

Seasonal ice cover occurs typically from mid to late December until mid to late April depending on severity of winter conditions. Ice cover reduces the effects of wind on currents and circulation and reduces the effects of wave action. Ice formation occurs most often along the shoreline and may freeze from the surface to the sediment bed in shallow water. The latter process may result in ice-related transport of sediments from shallow water areas. Ice thickness and movement may be a key design consideration for shallow water capping and shore protection design.

The DIA for Kingston Third Crossing concluded that the potential for ice jam flooding during either the temporary works or post-construction (bridge in place) was extremely low. This was related to the low velocities within the Project area and lack of supply ice due to Kingston Mills upstream (Hatch 2019).

Ice processes are expected to have a small to negligible effect on sedimentary processes in KIH and similarly, the implementation of the SMP is unlikely to result in significant changes to the ice cover and ice dynamics in the Project area. However, there is a lack of quantitative ice thickness and ice movement data for KIH. Quantitative data could be obtained from modelling, or with field observations.

5.8.1.9 Summary of Currents and Circulation

Currents and circulation within KIH are most strongly influenced by Cataraqui River hydrology as well as Lake Ontario water levels including the effects of lake seiches and storm surges, wind generated currents, wind generated waves, vessel wakes, and seasonal ice cover (Figure 14).

The dominant factors that cause movement of sediment, and water that may contain suspended sediment in KIH, include:

- Cataraqui River flows, which are strongest on the eastern side of the harbour and drives a clockwise circulation of water and sediment in the inner harbour between the La Salle Causeway and Belle Island.
- Surface water runoff from land to the KIH basin.
- Wind-generated waves and vessel-generated wake effects which have potential to disturb and mix sediments in the shallow areas along the western shoreline.
- Changes in regional water levels in Lake Ontario, which can periodically result in a reversal in flow, or backwater effect through the LaSalle Causeway into KIH.

Factors that inhibit or reduce the movement of sediment and water in KIH include:

- Dense SAV that occurs over large parts of the western half of the harbour and particularly the northern embayment to the south of Belle Island in water depths less than approximately 1.7 m. SAV reduces currents, traps sediments, and increases local deposition of sediment on the harbour bed.
- Lack of mechanical disturbance due to the type and degree of vessel activity in KIH.

The La Salle Causeway structure restricts the flow of water and sediment from the harbour into Lake Ontario. The river flows through three 40-meter gaps in the Causeway representing 30% of the cross-sectional area of the original opening with as much as 70% blocked by the Causeway.

A modelling-based assessment of the relative influence of environmental factors on water velocities and levels for the Kingston Third Crossing project north of Belle Island revealed that wind is the primary driver of water movement in the study area, with lake surge having a significant but secondary influence (Hatch 2019). Wind from the south was the main environmental factor adopted for analysis of average water movement conditions.

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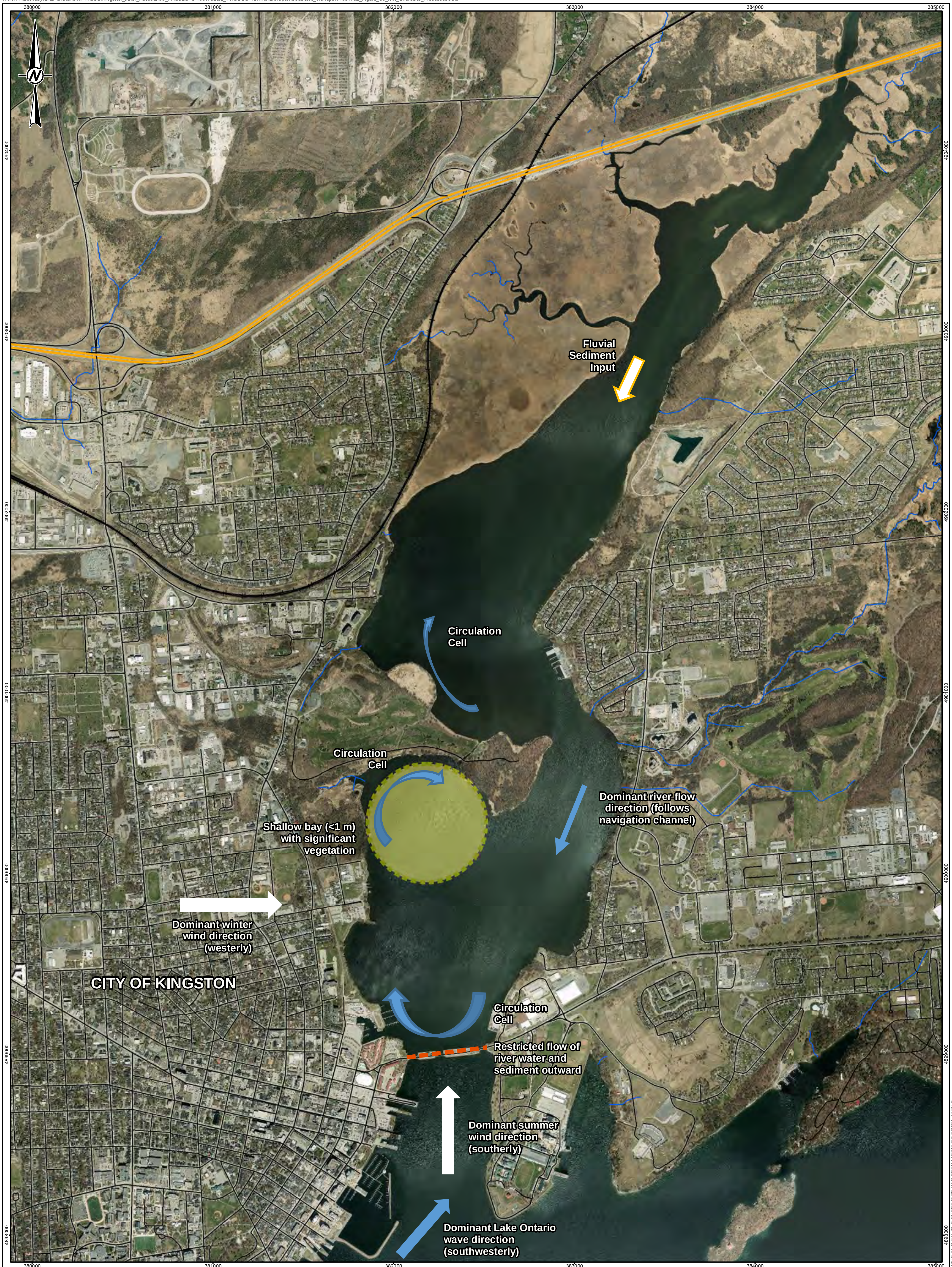

LEGEND

- SHALLOW AREA
- FLUVIAL SEDIMENT INPUT
- WATER FLOW/WAVE DIRECTION
- CIRCULATION CELL
- DOMINANT WIND DIRECTION
- BARRIER
- HIGHWAY
- ROAD
- RAILWAY
- WATERCOURSE

0 400 800

1:20,000 METERS

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3. PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
SHORELINE PROCESSES

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-01-03
DESIGNED	SS
PREPARED	JP
REVIEWED	JD
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
1661792		0	13

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25mm

5.8.2 Baseline Sediment Processes

The geology in KIH consists of surficial deposits of quaternary and Holocene sediments overlying limestone bedrock (Gull River formation) (Golder 2009). Depth to bedrock ranges from 3 m on the western side of the harbour to 22 m on the eastern side (Golder 2009, 2017b).

Older sediments overlying bedrock are interpreted as being glaciolacustrine clays deposited in glacial Lake Iroquois (Dalrymple and Carey 1990). Alternating layers of peat and gyttja overlying the clay suggest cyclical variations in water levels of Lake Ontario over time where peat is formed in shallower waters, and gyttja accumulates in deeper waters. Most KIH sediment profiles contain a layer of loosely consolidated material, composed of sand, silt and organics, which exists at the surface of sites up to depths of 5 to 20 cm, with material becoming more consolidated silt and/or clay with increasing depth. Peat and gyttja accumulation are indicative of a low energy, sediment sink environment. The gyttjas are soft, water rich (generally well above 80%), with fine particle sizes (muds) and with a wide range of organic contents (20–70%). Gyttjas with high organic content contain abundant root material and commonly have a mottled appearance due to bioturbation. The inorganic content of the peat is silt and clay with mean grain sizes of 0.0155 mm to 0.0055 mm. These fine soft sediments occur over most of KIH with the mostly organic peats mainly in the shallow areas along the west shoreline (Dalrymple and Carey 1990; Golder 2017b, SNC Lavalin 2020).

The process of bioturbation (mechanical disturbance of sedimentary deposits by living organisms) can contribute to the resuspension and/or redistribution of previously buried contaminated sediments (Golder 2017b). Although a detailed analysis of species-specific bioturbation was outside the scope of Golder (2017b), reference values of 0.13 m (5 inches) and 0.15 m (6 inches) of bioturbation depth (below the sediment bed) was considered appropriate for KIH based on studies of fine-grained sediments in the Great Lakes region (Avista Utilities 2015) and maximum depths observed in highly depositional environments (White and Miller 2008).

A relatively recent distribution of fine-grained surface sediments occurs across KIH (Golder 2014a), which shows a fining of material from the western side of KIH to the east (Figure 14). An area of silty sand is present offshore of Douglas Fluhrer Park north towards the rowing club. Sandy silt occupies the area east of the silty sand followed by the dominant surface sediment deposit of silty clay as well as a smaller area southeast of Belle Island covering part of the navigation channel. Silty clay surface sediment covers approximately 60% of the bed within KIH. Fine grained material is indicative of low-energy areas of deposition and coarser materials are indicative of higher-energy conditions. The slightly sandier sediment on the west side of the harbour reflects influence of higher wave energy in the shallow water.

A sediment plume from the Cataraqui River visible from the air photo imagery (Golder 2017b) suggests that the river sediments delivered to KIH are primarily deposited within the harbour while a smaller fraction are flushed out into Lake Ontario where they likely settle offshore. The lack of observable dynamic sedimentary features (e.g., flow-induced bedforms) in KIH and in the vicinity of the mouth of Cataraqui River, supports the hypothesis that this is a low energy environment from a sediment transport perspective. It is likely that the local sediment regime within KIH is dominated by a combination of fine-grained sediments delivered via the Cataraqui River, resuspension of local bed sediments by local wind waves and contributions from local storm water outfalls.

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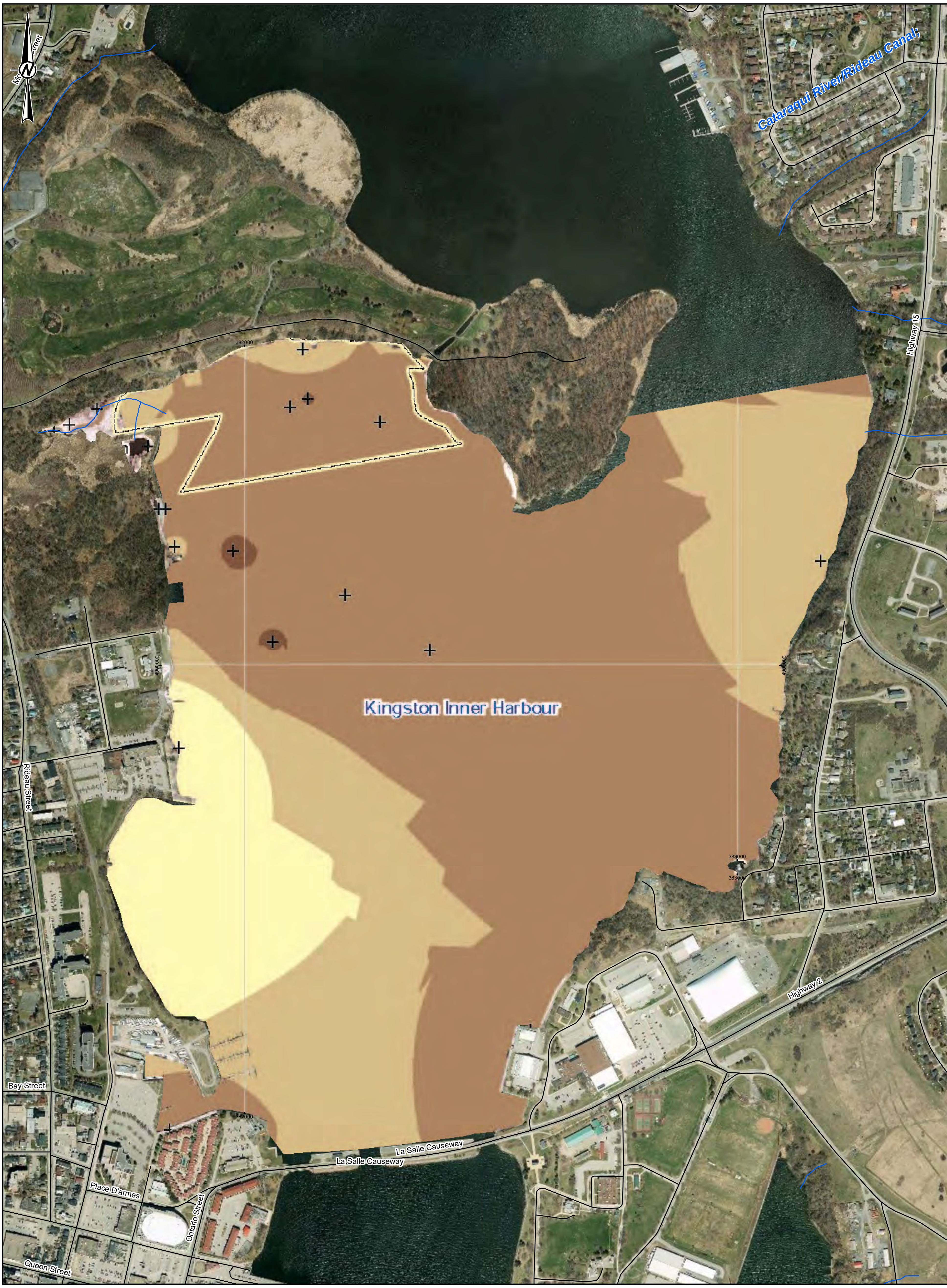

LEGEND

HIGHWAY
ROAD
RAILWAY
WATERCOURSE
PARKS CANADA BOUNDARY

GRAIN SIZE

< 63 SILTY SAND
63-81 SANDY SILT
81-96 CLAYEY SILT
>97 SILTY CLAY
KINGSTON INNER HARBOUR GRAIN SIZE SAMPLE

0 150 300

1:7,500 METERS

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3. FINE-GRAINED SEDIMENT DATA OBTAINED FROM THE ROYAL MILITARY COLLEGE OF CANADA. RMC-ESG. 2014. APPLICATION OF THE CANADA-ONTARIO DECISION-MAKING FRAMEWORK FOR CONTAMINATED SEDIMENTS IN THE KINGSTON INNER HARBOUR. PREPARED BY ENVIRONMENTAL SCIENCES GROUP, ROYAL MILITARY COLLEGE, KINGSTON, ONTARIO. FEBRUARY 2014.
4. PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
DISTRIBUTION OF FINE-GRAINED SEDIMENTS IN KINGSTON INNER HARBOUR

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-01-11
DESIGNED	SS
PREPARED	JP
REVIEWED	JD
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
1661792		0	14

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25mm

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A sediment transport study was undertaken by Golder (2017b) that examined hydrology, bathymetry, topography, geology, wind and wave action, vessel-related sediment disturbance, presence of aquatic vegetation, and potential for bioturbation. These processes were examined in relation to the distribution of contaminants within the sediments to conceptually model the physical processes governing transport and fate. It was determined that a complex sediment transport regime exists within KIH. Distributions of contaminated sediments within the harbour were influenced by a clockwise gyre in the north and east portion of KIH. The trajectory of the suspended sediments carried by the Cataraqui River is influenced by the La Salle Causeway, with some discharges to Lake Ontario and the remaining sediment redirected toward Anglin Bay (Golder 2017b; Figure 13). The low degree of flushing of sediments through the La Salle Causeway is confirmed by the continued presence of high concentrations of contaminants from historical sources at or near the surface of sediments. The study concluded that the La Salle Causeway is acting as a partial sediment trap during sediment transport events. The dominant source of sediments to KIH is a combination of fine-grained sediments delivered via the Cataraqui River flows and resuspension of localized bed sediments through wave/winds, currents, and contributions from local stormwater flows (Golder 2017b). SNC Lavalin (2020) completed a KIH sediment stability study in 2019 to gain a better understanding of the hydraulic circulation dynamics in KIH. Water velocities within the KIH basin were assessed as low in magnitude, with no strong circulation pattern. Suspended sediment loads and turbidity were also assessed as low in magnitude, and peak turbidity was observed during wind-induced wave action originating from southeasterly winds. Water levels within the KIH basin were shown to align with fluctuations in water level within Lake Ontario (SNC Lavalin 2020).

As observed in previous studies, very low sedimentation rates were confirmed, with the northern portion of the water lot (PC-W and TC-1) having slightly higher rates (SNC Lavalin 2020). Erodibility experiments showed low, near bottom water velocities, reaching critical water velocity for resuspension under easterly or southeasterly wind conditions. The generally low rates of accumulation, low magnitudes of resuspension, and physical mixing from bioturbation, combine to result in slow changes to surface sediment quality over time.

SNC Lavalin (2020) summarizes the wind wave directions and return period at which sediment may be potentially resuspended for selected locations in KIH as follows:

- In water lot PC-W, resuspension of bottom sediment is expected from easterly and south westerly winds with a 1-year return period and from southerly winds with a 10-year return period.
- In water lot TC-2A, resuspension is more likely to occur from easterly winds with a 1-year return period, less often from south easterly winds with a 10-year return period and rarely from southerly winds with a 50-year return period.
- In water lots TC-4 and TC-RC, resuspension events from wave activity are unlikely as such events require winds with a return period of 50 years or more.

SNC Lavalin (2020) did not include the attenuation effect of SAV on either waves or bottom orbital velocity in KIH, therefore the recurrence of resuspension for the existing condition is likely to be significantly over-estimated by this method. The recurrence used for the baseline assessment is likely more representative of the post-remediation condition until vegetation is recolonizing/re-growing.

The hydraulic influence on water velocities and subsequent sediment resuspension from the Cataraqui River is limited. Overall, KIH is classified as a quiescent environment that promotes sediment settling; the presence of aquatic plants has a stabilizing effect on the fine organic sediments. Risks associated with large sediment resuspension events were determined to be unlikely in the current state due to the low mean water velocities and extensive macrophyte bed coverage. The process of bioturbation may contribute to the resuspension and/or redistribution of previously buried contaminated sediments. Bioturbation may rework sediment to depths up to 0.15 m below the sediment bed level in KIH.

Processes affecting how sediments interact with both shorelines and the different habitat types found in the harbour may be summarized as follows:

- Coarse sediments enter the harbour from the Cataraqui River, mainly during peak flows associated with storm surges.
- Additional fine-grained sediments enter the harbour from the Cataraqui River. Because particles are smaller in size, they can be transported during both low and high flows.
- Sediment may be resuspended through forces of wind-generated waves, boat wake, propeller wash, and currents as well as bioturbation.
- Sediment movement, either towards or away from the shoreline is affected by wind, waves, and boat wake. Eroded sediment may be redistributed by currents generally moving into deeper water on the east side of the harbor or into the marshes south of Belle Island.
- The extensive presence of aquatic vegetation throughout KIH significantly reduces the sediment transport potential (sediment mobility) in most areas of the KIH study area.
- Additional inputs of coarse and fine sediments come from upland sources such as eroded soils; they are flushed in the harbour by small creeks and storm water systems.
- Fine-grained sediments are transported from the river to the marshes during storms and floods.
- Coarser sediments are trapped by vegetation and accumulate in the outer marshes.
- Fine-grained sediment, including silts and muds, are trapped and accumulate within the inner marshes.

5.8.3 Lacustrine Baseline

There is a good baseline understanding of the existing lacustrine processes within the Project area. However, there are some information gaps that should be addressed prior to beginning in water works:

- Analysis of spatial and temporal sediment transport dynamics for KIH based on the proposed combined configuration of remedial activities for each Management Unit. If required, the latter should include 2D modelling of the potential effects of the proposed remedial activities (dredging, cap thickness, changes in depth and SAV) on currents, waves, and sediment transport potential.
- Development of dredge prism configurations (limits for level of increase or decrease in water depth, slopes between adjacent management units) to maintain existing lacustrine processes within acceptable limits based on potential changes in sediment transport identified by the recommended modelling as described above.

- Measurement and analysis (e.g., modelling) of water level fluctuations in KIH at various timescales (e.g., monthly, annually) and effects on local currents and sediment transport potential in KIH.
- Analysis of extreme weather events and their affect on the riverbed within the Project area. This would include the intensity and frequency of storm surges and hazard wave effects in KIH, as well as potential climate impacts during all Project phases. This analysis should include measurement and modelling as described above.
- Ice thickness and movement may be the key design consideration for shallow water capping and shore protection design; site specific ice thickness and mobility data are not available at this time.

6.0 ENVIRONMENTAL CONSIDERATIONS

The following sections discuss the environmental considerations of greatest relevance to Project implementation; an understanding of these constraints is needed to avoid unintended consequences to sediment quality, water quality, and lacustrine processes. This will depend on developing Environmental Performance Objectives (EPOs) to monitor potential environmental effects in relation to baseline conditions. Only conceptual considerations are discussed here; the Environmental Management Plan (EMP) that will be completed following the DIA will provide the operational framework for managing potential environmental effects.

6.1 Environmental Management Plan

During intrusive physical work (e.g., dredging, capping, or construction), an EMP will be required to provide a framework for the management of potential environmental effects during the Project through the implementation of protection measures. The EMP is meant to provide site-specific details on how the mitigation measures identified in the DIA, the environmental specifications in the design tender package, and associated permit conditions will be met once a contractor is retained. These specifications cannot yet be developed as they require input from the detailed design stage.

Specifically, the EMP will identify:

- Regulatory and permitting requirements, such as those outlined in Section 4.0, that apply during the implementation of the sediment management activities.
- Roles and responsibilities of the project team (e.g., PSPC, environmental and construction monitors, the prime contractors, and their subcontractors).
- Best Management Practices (BMPs) and other established protocols that will be implemented during various phases of sediment management.
- Measurable environmental protection requirements, including environmental mitigation measures and monitoring that are to be undertaken during the Project.
- Environmental incident reporting protocols to apply if an environmental incident occurs during implementation of the Project.
- Appropriate response procedures if environmental emergencies (e.g., severe storms) occur.

The EMP will address how Project effects and mitigation measures identified in the DIA (as required by the *Impact Assessment Act;* discussed in Section 4.1.1) will be met in the implementation of the Project, along with issues identified through subsequent Indigenous Consultation and Stakeholder Engagement, engineering design, and permit conditions. The EMP will allow for a process of continuous improvement through adaptive management if additional effects are identified as intrusive works progress.

In the event of a discrepancy between the EMP and the provisions of any legislation, regulations, or municipal bylaws, the more stringent provisions resulting in the lower discharge of contaminants, and the higher degree of environmental protection and safety will prevail.

The potential environmental effects related to sediment quality, water quality, and lacustrine processes from the Project were evaluated as part of technical memorandums completed by WSP to support the CCIC for the Project (WSP 2023b,c,d). The following sections provide an overview of the potential environmental effects that may result if not appropriately managed during the Project. Data gaps related to the current understanding of surface sediment and water quality within KIH are also identified. Finally, a brief overview of the approach used to establish EPOs to monitor potential environmental effects is also provided.

6.2 Sediment Quality Management

As described in Section 2.1.1, the broad purpose of the Project is to address unacceptable levels of contaminants in KIH, requiring physical intervention to achieve this goal. Provided that the remediation program is conducted responsibly, with consideration given to managing short-term habitat disturbances to the sediment substrate, the long-term condition of sediment quality (including status of benthic community, and provision of food and habitat for other trophic levels) will be improved. The potential environmental effects discussed in this section relate to unintended consequences of the proposed interventions, which would either hinder the effectiveness of the Project, or exacerbate the short-term disruptions. The nature of these potential unintended consequences varies depending on the project stage considered within the remediation program.

- **Baseline (existing) condition**—Unintended consequences for baseline conditions could include lack of accuracy or precision around the current spatial extent of contamination, including both horizontal and vertical dimensions. The underlying risk of this scenario is that, should the baseline conditions not be characterized adequately, the effectiveness of the remediation could be compromised, either by missing important areas of contamination or by assigning undue priority to respective parcels of sediment.

- **Conditions during active works**—Unintended consequences during active works consist primarily of uncontrolled sediment disturbances, resulting in undesirable sediment resuspension and/or bank erosion. Such sediment disturbances, if not effectively controlled, could have direct short-term adverse effects to aquatic life, or could result in redistribution of contaminated sediments into adjacent areas of the water lot. The effects of excessive suspended particulate matter have been well documented and include habitat disturbances, physical smothering, reduced photosynthesis, gill abrasion, and decreased ability to capture food or avoid predation (CCME 2002).

- **Conditions immediately following completion of active works**—Unintended consequences following competition of the initial remediation phase consist of unacceptable levels of dredge residuals or leaving a new surface sediment profile that is prone to slumping, scour, or bed instability.

- **Long-term stabilized conditions**—Unintended consequences for long-term conditions relate to failure to meet the long-term management goals articulated in Section 2.1.1. Such could occur through incomplete or ineffective sediment removals, or through inability of the new sediment surface to effectively recolonize following remedial works.

The above unintended consequences could occur if the EMP does not provide appropriate mitigations and contingencies. To identify the potential for unintended consequences, the following are required:

- An understanding of the existing sediment quality to establish baseline conditions against which any changes caused by the Project can be compared (as discussed in Section 5.5.1.3).
- Defining EPOs for sediment quality indicators that can be implemented during and after remediation to prevent potential environmental effects (discussed below).

This will allow appropriate measures to be adopted to reduce or eliminate potential environmental effects if EPOs are not initially met.

6.2.1 Sediment EPOs

Sediment contaminant mapping, as described in Section 5.5.1.1, identified distributions of organic contaminants (total PAH, total PCBs) and metals/metalloids (antimony, arsenic, chromium, copper, lead, mercury, silver, and zinc). Without mitigation and/or specific Project design considerations, in-water works such as staging, dredging, and capping may adversely impact quality of adjacent (i.e., unimpacted or low-contaminated) KIH sediments. Design elements and appropriate environmental controls for limiting the mobility of resuspended contaminated sediments must be considered (i.e., turbidity and suspended solids management). Containment of suspended solids during dredging is the most important risk factor for construction and remediation stages, and turbidity controls are commonly included in EMPs for dredging projects, including use of physical controls (e.g., turbidity curtains), shoreline filter materials, and application of TSS and/or turbidity objectives to prevent unacceptable redistribution of sediments and reduce the effect of dredge residuals. Construction staging and planning should include the deployment of mitigations to prevent the introduction of new contaminants to KIH sediments, such as spill containment areas, designated spill kit locations, and a filter bag for dredging waters.

To prevent the potential for adverse effects from sediment resuspension during in-water works, implementation of EPOs based on TSS and/or turbidity are recommended, which will align with the EPOs for the protection of water quality as discussed in Section 6.3. In this manner, both water quality and sediment quality EPOs for assessing conditions during active works will be maintained simultaneously.

The Project is expected to significantly improve sediment quality conditions in KIH overall, but there is the potential for negative impacts to localized areas where: (1) dredge residuals could mix with adjacent low contamination areas outside the excavation area; or (2) sediments at depth are mobilized and allowed to mix with the post-remediation surface sediment layer. To ensure the successful remediation of contaminated sediment the following conditions will have to be assessed:

- **Baseline (existing) condition**—This includes adequate delineation of present-day contamination profiles and confirming appropriate source controls of contaminants from upland/off-shore areas prior to implementation of remedial works.
- **Conditions during active works**—This includes managing changes in sediment quality due to mechanical sediment disturbance, and through appropriate spill controls during works.
- **Conditions immediately following completion of works**—This includes confirmation of dredging effectiveness and associated contingency measures to manage dredge residuals (e.g., application of a residual cover as discussed in 12.1.1).
- **Long-term stabilized conditions**—This includes rehabilitation and recolonization of disturbed areas and monitoring of strongly bioaccumulative substances for long-term reductions in tissue concentrations.

Site-specific (or management unit-specific) numerical EPOs have not yet been developed for individual contaminants. However, such numerical thresholds, which are sometimes called site-specific target levels or site-specific performance objectives, will need to be developed as part of detailed design. Some principles that will apply to the development of these numerical EPOs are:

- Numerical EPOs will reflect site-specific and risk-based values. The generic sediment quality criteria, including CCME PEL, are not appropriate for making remedial decisions or specifying performance objectives.
- Numerical EPOs will reflect the transition from low to moderate risk magnitude and emphasize area-averaged conditions rather than point measurements, to remain consistent with the conceptual framework for sediment management in KIH.
- In all cases, numerical EPOs for individual substances will be maintained at concentrations (in dry weight sediment units) equal to or greater than the reference sediment quality. Reduction of COC concentrations to below local background would be neither practical nor effective, as long-term sediment movements from resuspension and deposition of sediments from adjacent management units will gradually blend surface sediment quality, such that long-term sediment quality in remediated areas will resemble the reference and low-risk conditions left outside the dredging footprint.
- The scale at which numerical EPOs apply may vary depending on the type of contaminant and the pathway driving risk for that contaminant. For example, PCBs should be managed on a broader spatial scale than PAHs, because the former exert their effects primarily through biomagnification pathways rather than direct toxicity.
- The selection of receptor and endpoint used to develop numerical EPOs may be informed by consultation and engagement with Indigenous groups, stakeholders, and the public. For example, the sediment PAH exposure concentration causing minor adverse effects to fish (e.g., increased incidence of liver and/or external lesions) is lower than the concentration expected to cause significant toxicity and/or community impairment to freshwater invertebrates.
- Numerical EPOs may vary among management units. Because sediment contamination will be managed as a complex mixture, it is sometimes necessary to adapt the threshold for an individual substance to provide protection against mixture effects from multiple substances. Furthermore, some substances have toxicity modified by sediment properties such as organic carbon or particle size, which are not consistent across the entire KIH.
- Numerical EPOs will be developed for total concentrations of PAHs and PCBs, but not for individual congeners or compounds within these groups.

6.3 Water Quality Management

The Project will involve in-water works, such as dredging and capping material placement, that will temporarily result in the re-suspension of particulate-bound contaminants into the water column. The water quality changes may cause the following environmental effects:

- The suspension of sediments into the water column (assessed as TSS) can have physical effects on fish and other organisms and cause behavioural changes. The effects of excessive suspended particulate matter have been well documented and include habitat disturbances, physical smothering, reduced photosynthesis, gill abrasion, and decreased ability to capture food or avoid predation (CCME 2002).
- The suspension of contaminated sediments into the water column can cause direct toxicity to aquatic organisms.
- The re-suspension of sediments that may be in an anoxic state can also reduce the dissolved oxygen concentration in the water column to potentially harmful levels.
- Contaminants released from fuel and hydraulic spills associated with dredging equipment can be toxic to aquatic life (e.g., BTEX and phthalates). These risks will be mitigated through a response plan to be formalized in the Environmental Management Plan for the remediation stage of the Project.

These risks can be effectively mitigated using environmental controls, such as turbidity curtains and environmental monitoring of water quality. As such, water quality management is needed during in-water works to (1) reduce potential impacts to the environment from sediment disruption, and (2) provide confidence that sediment resuspension does not deteriorate surface water quality in comparison to existing (or baseline) conditions present within KIH prior to remediation. To meet these objectives, the following are required:

- An understanding of the existing surface water quality to establish baseline conditions against which any changes caused by the Project can be compared (as discussed in Section 5.5.2.2).
- Defining EPOs for water quality indicators that can be implemented during and after remediation to prevent potential environmental effects (discussed below).

Mitigation measures for the Project if water quality EPOs are not initially met will be established as part of the DIA and design process.

6.3.1 Water Quality EPOs

Water quality in and adjacent to KIH may be temporarily impacted by sediment management activities. The primary effects expected from intrusive management efforts (e.g., dredging, dewatering of dredged material, in-water transport of dredged material and debris, placement of substrate in-fill, placement of engineered cap) is the potential increase in TSS and subsequent release of contaminants from re-suspension of contaminated sediments.

To ensure water quality is not deterred from the Project the following conditions will have to be assessed:

- **Baseline (existing) condition**—This includes adequate understanding of the existing water quality within KIH and reference areas (see Section 5.5.2.2) and confirming appropriate source controls of contaminants from upland/off-shore areas prior to implementation of remedial works (see Section 5.7).
- **Conditions during active works**—This includes managing changes in water quality due to mechanical sediment disturbance, and through appropriate spill controls during works.
- **Conditions immediately following completion of works**—This includes contingency measures to manage dredge residuals (e.g. application of a residual management cover as discussed in Section 12.1.1.
- **Long-term stabilized conditions**—This includes monitoring to ensure water quality has returned to reference conditions.

The release of contaminants from suspended particulates into the aqueous phase is unlikely to be a driver for environmental effects, as the historical water quality assessments completed within KIH have shown that the COCs have a strong association with TSS (Section 5.5.2.1). Given the strong association of contaminants with sediments and the diffuse inputs of contaminants from urban and agricultural activities in the surrounding area, it is expected that TSS management with respect to changes above baseline (or existing) conditions can form the basis of the EPOs to be implemented during remediation.

There are presently no specific regulations pertaining to discharge from dredging projects, nor are there provincial discharge standards applicable to the point of discharge (POD) from a dredging project. The specific parameters and points of compliance are generally agreed upon at the Project level through the process of environmental review and consultation with the responsible regulatory agencies such to meet the general provisions of the environmental statutes[6]. Regulatory compliance is typically evaluated at the point at which an operator no longer exercises control over a discharge, often called the “end of pipe”[7]. In a dredging operation, there is no pipe terminus and control ends at the point at which turbidity is no longer managed. Accordingly, the functional equivalent to end of pipe is the edge of the turbidity curtain for the dredging and at the POD[8] for the dewatering barge and the treatment system, if applicable.

[6] In low-contamination environments, PCA, DFO, and MECP typically apply the CCME guidelines for total particulate matter of 25 mg/L (8 Nephelometric Turbidity Unit; NTU) above background for short term exposures, and 5 mg/L (2 NTU) above background for long term exposures (CCME 1999b/2023). However, a maximum TSS concentration of 75 mg/L (as an absolute concentration rather than as induced above background) would be expected for discharges from a construction site during wet weather to protect fish from the physical effects of suspended particles (DFO 1992). Where contamination is higher, this default requires evaluation for protectiveness of the environment and human health.

[7] This reasonable operational concept is adapted from the *Metal and Diamond Mining Effluent Regulation* (MDMER) (Canada 2002b), a regulation made pursuant to the *Fisheries Act*. Although the dredging project is obviously not a metal mine and the regulations do therefore not apply, the definition of a discharge point contained in the MDMER is a contemporary workable definition for the present purpose and one intended to have conformity with the parent legislation, the *Fisheries Act*.

[8] The MDMER defines a discharge point as being the point at which the operator ceases to have control over the effluent. This definition provides a workable parallel to prevailing environmental statutes and enables an assessment of ecological risks within the context of federal and provincial regulatory requirements. PCA has commonly interpreted the discharge point to equate to within 5 m of a turbidity curtain for environmental dredging applications. The same would be applied for barge water drainage into the dredging area.

The objectives of the development and application of the water quality EPOs are two-fold:

- Lethal conditions (to fish) do not exist at the POD or the immediately surrounding work zone. This is often operationally defined by ECCC as 96 h LC50 ≥100% for rainbow trout and sometimes 48 h LC50 ≥100% for *Daphnia magna*. The potential for acute lethality may also be evaluated against the proposed benchmarks.
- Chronic sub-lethal conditions (to fish) do not exist outside the work zone, most commonly defined as 100 m away from the POD (also called the assessment point). The assessment point represents the end of the initial dilution zone. Ambient WQGs (protective against chronic toxicity) or the proposed site-specific benchmark divided by 10, depending on how the benchmark is derived, would be used to screen water quality data from the edge of the work zone.

WSP (2023d) provides a detailed discussion of how EPOs may be established at compliance points (including the POD and the receiving environment outside the work area), and how EPOs can be linked to TSS levels that can be monitored in-situ using turbidity levels[9]. Briefly, a step-wise approach is recommended for calculating and establishing EPOs, including application of mass-balance models to estimate contaminant concentrations in water associated with varying TSS levels, comparisons to environmental quality guidelines, and application to "real-time" water quality management using site-specific TSS:turbidity relationships. Using this approach, the need for additional mitigation measures during in-water works can be informed rapidly before potential environmental effects occur. Such mitigation measures may include a turbidity curtain during dredging, positioning of equipment to avoid propeller wash, placement of barge spuds to avoid sediment disturbance, and additional filtration during dewatering.

Following the remedial program, long-term monitoring of COCs will also be required to confirm that remediation activities have not negatively impacted water quality at the Site. The results of this monitoring should be compared against chronic benchmarks protective of aquatic life, pre-remediation baseline concentrations, and upstream reference concentrations to assess the success of the Project. If it is determined that the elevated COCs in water are the result of the Project and not other sources, additional remedial measures may be considered (e.g., capping within sediment management units that have elevated COCs).

6.4 Lacustrine Processes

Lacustrine processes within KIH may be affected by Project activities due to modifications of the sediment surface, either in terms of bathymetry or particle sizes of the new materials. Effects of most activities are expected to be minor in terms of degree of influence on long-term or broad scale hydrological and limnological processes. Most disruptions will be short term, associated with construction activities, and will be managed with controls. Minor to moderate longer-term changes in hydrodynamic and sediment processes may occur from Project activities that directly modify the harbour bathymetry and substrate type, such as dredging and capping. The thickness of dredging in most areas will be confined to approximately 1.0 m below current grade, and even in these areas various options for backfilling with an environmental substrate are being considered.

[9] TSS is a gravimetric measurement (mass per volume) whereas turbidity is an optical measurement which can be influenced by particle size, shape, color, and reflectivity. As a result, two materials occurring at the same TSS concentration in a waterbody may result in different turbidity values. A site-specific TSS:turbidity relationship should therefore be established prior to any in-water works. The TSS:turbidity relationship would have to be specific to the type of sediment being disturbed; therefore, the different sediment types (i.e., particle sizes) throughout the sediment management area should be confirmed to determine if different TSS:turbidity relationships are required for different areas. Additional bench-scale testing of clean remedial management cover to be placed within the remediation area is also recommended to confirm whether the TSS:turbidity relationship developed for dredging needs to be revised for placement of clean material.

Overall, the implementation of the broad design in the conceptual SMP will result in an increase in water depths (net lowering of sediment bed elevation) over portions of the western KIH. For example, dredging to a net depth of 0.5 metres below existing bed level will result in a small but potentially measurable reduction in near-bed wave orbital velocities with a commensurate reduction in local sediment transport potential. Such changes would potentially be offset by an increase in wave energy elsewhere or by an increase in sediment transport potential due to reduction in submerged aquatic vegetation. The use of dredging combined with selective capping means that minor changes in water and sediment transport dynamics will occur. However, their influence is not expected to be sufficient to cause major changes to the baseline condition described in Section 5.8.3; rather the influences would be localized depending on the configuration of the final dredging prisms, design of slopes between adjacent areas, and geotechnical properties of the post-remediation sediment substrate. The net effect of the lacustrine processes, including in terms of resuspension potential, shoreline erosion, and flood control could be evaluated by a model comparison of existing conditions compared with the dredged and capped condition (see Section 5.8.3). The purpose of this section is to identify, at a preliminary level, the potential for unintended consequences, such that appropriate measures can be adopted to reduce or eliminate potential for their occurrence.

6.4.1 Lacustrine EPOs

Without mitigation and/or specific Project design considerations, in-water works such as staging, dredging, and capping could adversely impact some lacustrine processes at the local scale. However, the design of the overall remediation plan will limit these alterations, and the remaining changes will be both minor in magnitude and addressed through design of shoreline elements and other techniques. Lacustrine processes generally do not have quantified criteria similar to EPOs; rather the detailed design will consider the potential for undesirable or desirable changes to the baseline condition. In general, minimizing or selectively limiting changes (e.g., maintaining bathymetry and shoreline geometry where appropriate) and implementing appropriate mitigation (e.g., designing slopes, depths, and geotechnical features to maintain desired properties of sediment resuspension, erosion potential, and habitat value) helps meet Sediment Quality and Water Quality EPOs.

The key indicators related to lacustrine processes identified for each stage of the Project are listed below:

- **Baseline (existing) condition**—This includes establishing adequate baseline conditions prior to in-water works that any changes from the Project can be compared to (see Section 5.8.3).
- **Conditions during active works**—Relate primarily to managing changes in lacustrine processes due to mechanical sediment disturbance, and through appropriate controls on the release or generation of suspended sediments during works.
- **Conditions following completion of works**—Relate to management of parameters that affect lacustrine processes such as restoring depth parameters, slopes, and substrate type to agreed upon limits and the rehabilitation of submerged aquatic vegetation.
- **Long-term stabilized conditions**—Relates to functional engineered solutions that meet shore protection requirements and habitat enhancement expectations.

7.0 BIOLOGICAL CONSIDERATIONS

The following sections discuss the biological considerations of greatest relevance during Project implementation; the planning goal is that the potential for long-term adverse effects on SAR, vegetation, and wildlife habitat is limited and/or negligible. Physical interventions have the potential to result in a significant short-term alteration of biological resources, although post remediation alterations with the proper application of rehabilitation design are anticipated to be similar or better in terms of condition, diversity, richness, and productivity. Disruptions due to physical works may be managed through the appropriate application of mitigation measures and BMPs, or avoided through the application of construction activity timing windows.

The conceptual SMP reflects biological considerations based on the information available to date, as well as high level constraints identified in the CCIC related to valuable biological components (SNC Lavalin 2023b). However, baseline studies and information gathering process for the DIA will be a more in-depth representation of species occurrences and habitat use of the Site, and will outline procedures to ensure that sensitive ecological features are not harmed as part of sediment management work. As such, the high level constraints identified herein may be refined in the DIA.

7.1 Species at Risk

Based on the desktop records review and SAR screening for KIH conducted for the development of the initial conceptual SMP (Golder 2021a) and subsequent reviews completed by SNC Lavalin as part of the CCIC for the Project (SNC Lavalin 2023b), suitable habitat was identified for [redacted] SAR species within and adjacent to KIH (the study area). These SAR, identified as having moderate or high potential to be present in the study area, include species listed federally (under SARA) and/or provincially (under the ESA) as endangered, threatened, or special concern, and are listed below:

- Herpetofauna—Turtles: Blanding's turtle (*Emydoidea blandingii*), Northern map turtle (*Graptemys geographica*), Snapping turtle (*Chelydra serpentina*), Eastern musk turtle (*Sternotherus odoratus*), Midland painted turtle (*Chrysemys picta*); Snakes—Eastern ribbonsnake (*Thamnophis sauritus sauritus*), Milksnake (*Lampropeltis triangulum*); Amphibians: Western Chorus Frog Great Lakes/St. Lawrence – Canadian Shield) (*Pseudacris triseriata*)
- Birds—Bald eagle (*Haliaeetus leucocephalus*), Barn Swallow (*Hirundo rustica),* Black Tern *(Chlidonias niger),* Common Nighthawk *(Chordeiles minor)*, Eastern Whip-poor-will (*Antrostomus vociferus*), Eastern wood-pewee (*Contopus virens*), Evening Grosbeak (*Coccothraustes vespertinus*), King Rail (*Rallus elegans*), Least Bittern (*Ixobrychus exilis*), Red-headed woodpecker (*Melanerpes erythrocephalus*), Wood Thrush (*Hylocichla mustelina*)
- Bats—Little brown myotis (*Myotis lucifugus*), Tri-colored bat (*Perimyotis subflavus*), Northern myotis (*Myotis septentrionalis*), Eastern Small-footed Myotis (*Myotis leibii*)
- Arthropods—Monarch (*Danaus plexippus*), Nine-spotted Lady Beetle (*Coccinella novemnotata*), Transverse Lady Beetle (*Coccinella transversoguttata*)
- Vascular Plants- Butternut (*Juglans cinerea*), White Wood Aster (*Eurybia divaricate*)

No federally listed fish SAR are known to be located within the study area (DFO 2023a). Bowfin (2011) indicated the potential for some aquatic SAR to occur as transients within [redacted] is provincially ranked as Endangered and as critically imperiled (S1/S2 [NHIC 2022, NatureServe 2022]) and is afforded general habitat protection under the ESA (Ontario 2007), whereas the species has no designation under SARA and COSEWIC ranks it as Threatened (Appendix A). This species' historical range includes all freshwater connected to the Atlantic Ocean, including within Canada (COSEWIC 2012). American eel historically occurred in the Ottawa and St. Lawrence rivers and Lake Ontario and its tributaries. They then migrate thousands of kilometres from freshwater rivers and streams to the ocean to spawn, based on current understanding, in the Sargasso Sea in the Atlantic Ocean (COSEWIC 2012). [redacted] were considered to be migratory and identified as unlikely to use the Site habitats extensively, particularly as more suitable habitats exist both upstream and downstream of the study area. Therefore, American eel was ranked as having low potential to be present in the study area.

Lake sturgeon - Great Lakes Upper St Lawrence populations are provincially ranked as Endangered with general habitat protections protection under the ESA (Ontario 2007), whereas the species has no designation under SARA and COSEWIC ranks it as Threatened (Appendix A). Lake sturgeon are migratory species that travel between several habitats to fulfill seasonal and life history stage requirements (Golder 2011b). Habitat selection generally favours high quality shoal areas of large lakes and rivers at depths of 5 m to 10 m or more. Lake sturgeon spawn in early May to late June in relatively shallow, fast flowing water (usually below waterfalls, rapids, or dams) with gravel and boulders at the bottom, or on shoals in large rivers with strong currents and at depths of 0.6 m to 4.5 m (Scott and Crossman 1973). Individuals generally begin migration from lakes not long after the ice melt, sometimes beginning their travel upriver under the ice, and continuing up to 400 km to reach spawning habitat (Scott and Crossman 1973). Smaller movements occur seasonally, where Lake sturgeon move from warm, shallow waters to cooler, deeper waters in summer, returning to the shoal areas in the fall, and back to deeper waters for winter (Scott and Crossman 1998). Overwintering begins in early fall, where adults retreat to downstream portions of rivers or return to offshore habitats in lakes with moderate depths and soft substrates (i.e., mud or sand), remaining relatively immobile over the winter (Golder 2011b; Rusak and Mosindy 1997). Based on known habitat requirements (Scott and Crossman 1998; Golder 2011b) and geographic distributions, Lake sturgeon have a reasonable potential to occur as migratory transient species through the study area, but no spawning/rearing/overwintering habitats have been identified. Therefore, Lake sturgeon was ranked as having low potential to be present in the study area. Nevertheless, consideration for the timing of their migration was incorporated into the recommended Project timing windows and site-specific mitigations, such that isolation measures may need to be in place prior to June of any given year. In addition, fish will be rescued and relocated outside of any isolation areas prior to construction.

In addition to the species identified above, other endangered and threatened species and species of concern listed either provincially or federally have been identified in the region but have a lower potential to be present in the study area. These include numerous additional birds (e.g., King rail [Endangered], Loggerhead shrike [Endangered], Henslow's sparrow [Endangered], Least bittern [Threatened], Black tern [Special Concern], Common nighthawk [Threatened], Chimney swift [Threatened], Short-eared owl [Special Concern]). No threatened or endangered mammals other than bats have been identified in the vicinity of the Site.

In addition to endangered and threatened species and species of special concern, there may also be species of high cultural value within the study area. For example, American eel and Lake sturgeon have been identified near [redacted], and these species have importance for First Nations uses. These species will be considered in the DIA for the Project.

Appendix A provides an updated SAR screening based on baseline biological and ecological inventories completed at the Site (SNC Lavalin 2023a). The DIA will identify sensitive habitats and ecological functions, and the SAR species will be re-evaluated and updated as part of the DIA.

Potential SAR are not expected to be impacted by the management activities on-site, with the exception of the listed turtles. Restricted activity periods for any sensitive species with moderate potential to be present on-site will be established along with other mitigation measures as planning progresses.

The biological considerations related to vegetation, wildlife habitat, and timing windows for the Project is discussed below. However, this is based on information available to date, as well as high level constraints identified in the CCIC related to valuable biological components (SNC Lavalin 2023b). The DIA will provide a more in-depth representation of species occurrences and habitat use of the Site, and will outline the final mitigations to ensure that sensitive ecological features are not harmed as part of sediment management work.

7.2 Terrestrial Vegetation and Habitats

Much of the terrestrial lands adjacent to the study area is dominated by anthropogenic disturbances and uses, including buildings, streets and parking, and manicured areas. The terrestrial and wetland natural areas within the study area are concentrated in the northern portion of KIH, particularly adjacent to the Orchard Marsh brownfield area, and consist of:

- Graminoid Meadow (MEGM3-4)
- Dry-Fresh Deciduous Forest (FODM2-4)
- Fresh-Moist Lowland Deciduous Forest (FODM7-3/7)
- Fresh-Moist Deciduous Forest (FODM 8/9)
- Deciduous Plantation (FODM12)
- Deciduous Swamp (SWDM3-4)
- Cattail Organic Shallow Marsh (MAS3-1)
- Pondweed Submerged Shallow Aquatic (SAS1-1)
- Cultural Meadow (CUM), Cultural Woodland (CUW), Cultural Thicket (CUT)

Terrestrial and wetland vegetation within the study area will be impacted by the proposed works in the short-term; however, the proposed post-remediation rehabilitation aims to maintain, improve, or re-establish the ecological community classification of each disturbed area. A vegetation barrier along TC-RC, WM, TC-2A, TC-3A, and TC-4 will also act as a deterrent for wading along the shoreline by humans to reduce sediment exposure. Disturbance to natural vegetation will be limited to the extent feasible while also satisfying the contaminant risk reduction goals. Follow-up seasonal vegetation monitoring (spring, summer, fall) including Ecological Land Classification (Lee et al., 1998) for 5 years following remediation is also recommended to evaluate the re-establishment of vegetation in replanted areas, with recommendations for contingency actions should recolonization not meet project objectives. In addition, a pre-construction survey following the methods for “monitoring impacts on native vegetation” as specified in the Guide to Monitoring Exotic and Invasive Plants (Environment Canada 1997) is recommended to assess invasive species within the remediation areas. Follow-up seasonal vegetation monitoring (spring, summer, fall) is recommended for 3 years, with annual recommendations should control of invasive species be required, the monitoring methods for “Monitoring impacts on native vegetation” in the Guide to Monitoring Exotic and Invasive Plants (Environment Canada 1997) using the same monitoring quadrats established during the pre-construction survey.

Both the anthropogenic and natural areas of the study area provide habitat for a range of native wildlife and plant species, including both aquatic and terrestrial species. Based on previous work, terrestrial wildlife SAR known to occur within the study area include turtles, birds, bats, and snakes. No terrestrial plant SAR species are known to occur. In addition, the study area provides a variety of nesting habitats for migratory birds. Certain portions of the study area have been identified as providing particularly important or sensitive habitat, each of which is discussed further below.

7.2.1 Turtle Over-Wintering Habitat

Turtle over-wintering habitat was identified throughout the in-water portion of the study area. Species with preference for sand substrates and species with preference for muck substrates have been confirmed to over-winter in the study area. Avoidance of in-water works during the turtle over-wintering period (1 October to 1 April) will reduce the potential for mortality, accidental capture, or disturbance of over-wintering turtles. Additional mitigations, including isolating the work area prior to the over-wintering period and performing a rescue of turtles (organism salvage) within the work area, will reduce this risk further. The proposed 15 m temporary dredging area within the northern units required for construction access will result in a small, temporary reduction in the amount of available turtle over-wintering habitat. The amount of habitat that will be temporarily disturbed will be quantified at the DIA stage. Alternative over-wintering habitat is abundant in the study area, and no mitigations for this temporary loss are recommended at this time. In post-remediation, the study will be designed to function as over-wintering habitat for the various turtle species known to use the study are for this purpose, and on-going monitoring will be conducted to verify it is functioning as such (per MNRF 2015 methodologies).

7.2.2 Turtle Basking Habitat

Turtle basking habitat, consisting of structures at and above the water surface as well as exposed shorelines, was identified along [redacted] Avoidance of disturbance to these areas and all associated basking structures will reduce impacts to individuals, particularly impacts to follicular development in females during the most sensitive periods (1 April – mid-June and again from late-July to 1 October). In addition, a 10-metre dredging exclusion zone [redacted] been recommended to protect these features (and to simultaneously protect against disruption of leachate controls for the former municipal landfill). Turbidity curtains should be designed with large, round floats covered in High Density Polyethylene (HDPE) to exclude turtles from in-water work areas by preventing them from crossing over top. Minimum height is recommended to be 60 cm above water level (MNRF 2016). HDPE cover also prevents wildlife such as muskrats from chewing and burrowing into floats. In areas where basking structures are disturbed, the structures should be salvaged and replaced after remediation wherever feasible, and additional basking structures could be placed outside the work area during in-water works to provide suitable basking habitat, prioritizing areas near nesting habitat. Monitoring should be implemented after rehabilitation to confirm turtles are using the re-established and any new basking structures (per MNRF 2015 methodologies).

7.2.3 Turtle Nesting Habitat

Detailed surveys of turtle nesting activity in the study area have been completed and have identified nesting areas along [redacted], excluding areas of tree cover and dense vegetation. To minimize risk to nests, nesting activity, and terrestrial movement of hatchlings, the terrestrial mobilization, stockpile, and laydown areas associated with the Project have been proposed for placement away from known nesting areas. Exclusion fencing to keep turtles from nesting in work areas, including shoreline work areas, must be installed prior to 1 May of each year, but must allow for migration of females and hatchlings between the river and nesting areas (i.e., allowing for movement of turtles between isolated work areas through inclusion of open corridors). At this time, impacts to nesting areas, if any, are not known. If impacts are identified, alternative nesting mounds can be placed in areas where no work will be completed, or where work has already been completed. Any nests identified in or near the work areas should be protected and monitoring until hatching or until 1 July the following year, whichever is sooner. Terrestrial work areas are to be rehabilitated to original condition or enhanced for turtle nesting.

General improvements to turtle habitat within the study area proposed as part of the remediation works include:

- Softening the existing bank slopes in select areas to make it easier for turtles to travel between water and land (e.g., mitigating hazards such as boulder shorelines where hatchlings may become trapped in crevices).
- Adding nodes and line segments of boulders, logs, and root wads within 5 m of the shoreline in selected areas to increase cover and basking opportunities for turtles.
- Improving shoreline vegetation in selected areas to provide cover in heavily disturbed or otherwise human-influenced areas.

7.2.4 Nesting Habitat for Migratory Birds (including waterfowl) and SAR Birds

Although suitable habitat for migratory birds exists throughout the study area, including on anthropogenic structures, natural habitats for nesting are primarily concentrated in the [redacted] Vegetation clearing should not take place within the breeding bird nesting season (1 April – 31 August), unless preceded by a nesting survey completed by a qualified biologist. Construction should abide by municipal noise bylaws to avoid disturbing sensitive nesting periods. Nesting surveys should be repeated if vegetation in the area surveyed is not cleared within 24 hours of the survey being completed. If an active nest of a migratory bird is located, it must be buffered until such time as it is no longer active. Any work within 50 m of a nest should be kept at or below 50 decibels. It is recommended that additional surveys be completed on [redacted] to identify if any nesting habitat for SAR birds is present within 50 m of the work area. A 5 m dredging exclusion zone around the barn swallow nesting kiosk [redacted] should be established if this species is utilizing the structure. Monitoring to confirm presence / absence of least bittern within 500 m of the work area should be conducted and, if confirmed present, a 500 m dredging exclusion zone for vegetation removal during the breeding season (1 April – 31 August) would apply for suitable habitat around the nest. Terrestrial and wetland habitats should be rehabilitated post-remediation with the aim of returning the areas to pre-disturbance conditions or better.

7.2.5 Bat Maternity Roost Habitat

Suitable bat maternity roost habitat, for SAR and non-SAR bats, was identified [redacted], although no such roosts were confirmed as part of targeted studies. To reduce the risk to disturbing or destroying any such habitat, removal of mature trees should be limited to the extent feasible, and where necessary, be conducted outside the active period for bats in Ontario (1 April – 30 September). If mature trees suitable for maternity roosting must be removed, exit surveys paired with acoustic monitoring should take place at [redacted]o determine presence/no detection for SAR bats. If presence is confirmed within a disturbance area, the associated habitat must be mapped including a roost tree inventory to assist with required permit applications and determination of appropriate compensation.

7.2.6 Snake Hibernacula

A snake hibernaculum was confirmed within the study area near [redacted] (rocks/rubble, gaps in the earth, and low herbaceous vegetation), and a possible second hibernaculum was identified at [redacted]. To mitigate for disturbance to these features, exclusion fencing around the feature that does not impede movement of snakes should be installed (recommended 5 m dredging exclusion zone) for the duration of local work. Ground disturbance in the vicinity should be limited to the extent feasible from 1 October – 1 March.

7.2.7 Amphibian Breeding Habitat

Studies have confirmed amphibian breeding within [redacted] and breeding of bullfrogs along [redacted] for Western chorus frog habitats. If work is proposed in these habitats during the active season for amphibians (1 April – 31 October) amphibian rescues are to be performed in isolated work areas within 48 hours of the proposed work being initiated. Suitable breeding habitats are to be rehabilitated post-remediation to pre-disturbance conditions.

7.3 Aquatic Vegetation and Habitats

Most of the aquatic portion of the study area is dominated by anthropogenic disturbances and uses, including historical contamination, water outfalls, navigational routes, and harbour use. The aquatic natural areas within the study area include KIH and associated riparian areas.

The impact of aquatic vegetation on reducing current speeds and wave energy has been well documented and can significantly increase sediment deposition and bed stability due to increased friction and root binding. Golder (2011a) reported presence of the following primary aquatic vegetation types in KIH: Eurasian watermilfoil, coontail, pondweeds, and eelgrass. The increased presence of cattails and Eurasian watermilfoil are associated with the accumulation of sediments related to human-induced hydrological changes. Dalrymple and Carey (1990) indicate that portions of KIH deeper than 1.7 m water depth are typically devoid of vegetation. The northern two thirds of the harbour (north of the harbour limits), and east of the navigation channel are well covered with aquatic vegetation and not significantly affected by physical disturbance through vessel activity (Golder 2017b). Additional aquatic vegetation surveys and collection of samples is scheduled for late summer/fall 2023.

SNC Lavalin (2020) showed observations of aquatic vegetation during the open water season in 2018 and reported significant difficulties in navigating the study area west of the navigational channel, with repetitive clogging and fouling of the propeller by aquatic vegetation. SNC Lavalin (2020) further classified a September 2015 aerial image for floating, submerged, and mixed (floating and submerged) aquatic vegetation types (Figure 12 and 12.1.5).

Based on SNC Lavalin (2020) analysis of satellite images, the northern two-thirds of KIH and the area west of the navigation channel were well covered with aquatic vegetation. The water lots in KIH requiring sediment management cover a total surface area of 85 ha. Of this, 81 % (69 ha) is covered by extensive macrophyte beds (floating: 14 ha, submerged: 9 ha; mixed: 46 ha). The water lot management units with limited presence of vegetation are in the deeper reaches at the south end of KIH (TC-5, TC-AB, and part of TC-4).

Based on community consultation, where practicable, the shoreline should be maintained as natural aquatic habitat suitable for turtles and with native aquatic and riparian vegetation to maintain ecological status and the aesthetics of the shoreline. This consideration must be balanced with the requirements for contaminant exposures (i.e., removals, isolation, and/or bioavailability reduction).

The conceptual design for nature-based shoreline rehabilitation currently includes three vegetation zones integrated with the beach berm from backshore to offshore as follows:

- Riparian zone – this includes above ground plant structures in the backshore region of the rehabilitation area. It is intended that a single row of native species be planted along the existing pathway to deter human access. Existing vegetation will be kept intact to minimize disturbance to existing turtle hatching habitat. Riparian vegetation including larger trees and shrubs are intended to serve the following functions:
  - Discourage direct access to the beach and foreshore; it is expected to include native trees, shrubs, grasses including species such as native roses (e.g., *Rosa acicularis*; *R. blanda*), prickly ash (*Zanthoxylum americanum*), blackberry (*Rubus allegheniensis*) and black raspberry (*Rubus occidentalis*) to further deter human access.
  - Stabilize the land surface and reduce potential for soil erosion during precipitation events.
  - Provide topographic wind blocking to reduce wind energy.
  - Provide overhead cover and shading for fish and fish habitat (e.g., trees, shrubs, long grasses, woody debris along the shoreline).
- Cobble beach, or boulders and large woody debris (LWD) vegetation zone – this includes above-ground plant structures that includes, beach grasses and large woody debris such as logs and rootwads that serve the following functions:
  - Maintain, and where possible enhance, turtle habitat.
  - Adapt to changing water levels and periodic inundation and drying.
  - Provide additional beach stabilization and wave attenuation function.
- Aquatic vegetation zone – this includes aquatic vegetation plant structures that includes, emergent, submerged, and floating plants such as water lily (*Nymphea odorata*), pondweeds (*Potamogeton* spp.), coontail
(*Ceratophyllum demersum*), marsh grasses (e.g., *Calamagrostis canadensis; Leersia oryzoides*), sedges

(e.g., *Carex lacustris;* C*. aquatilis; Scirpus cyperinus*) and cattails (*Typha latifolia*; *T. angustifolia*) that serve the following functions:

- Enhance turtle and fish habitat.
- Reduce nearshore wave heights and nearshore current.
- Stabilize the lakebed to reduce sediment mobility and transport.
- Provide resilience to changing water levels.
- Provide cover, refugia, and spawning surfaces for fish.

The Nature Based Shoreline Concepts Memo provides additional information regarding plant selection criteria for restoring backshore to offshore vegetation zones (Golder 2022b). The species and concepts described above are examples rather than prescriptive decisions and can be customized to specific shoreline areas during detailed design.

The aquatic vegetation within the study area will be impacted by the proposed works in the short-term; however, the proposed post-remediation rehabilitation aims to maintain, improve, or re-establish the ecological community classification of each disturbed area. Disturbance to natural vegetation will be limited to the extent feasible while also satisfying the contaminant risk reduction goals. Follow-up seasonal vegetation monitoring (spring, summer, fall) is recommended for 3 to 5 years, with control of invasive species, if required.

No fish, mussel or aquatic vegetation SAR have been previously documented within the study area, although targeted mussel surveys have not been completed due to the presence of contaminated sediments. To fill this data gap, and determine presence / absence of SAR mussel species, targeted mussel surveys may be undertaken prior to rehabilitation. No areas projected for rehabilitation activities are considered sensitive SAR habitats and are amenable to rehabilitation.

Fish habitat within many of the water lots is considered to contain a number of habitat features, as it supports numerous species with specific habitat preferences and requirements, and life cycle functions. However, the historical contamination of the sediments degrades the potential quality in some locations of the harbour. Targeted removal of contaminated sediments remains a key element of the overall Site rehabilitation and can be conducted in a manner focussed on long-term net benefit. Fish habitat features designed as part of rehabilitation should focus on rehabilitating habitats for use by target species, for a variety of life functions to similar or improved conditions. This includes a variety of substrate types to support substratum spawners including coarser materials (i.e., boulders/cobbles) as well as a combination of sand and fines for nesting species such as bass. A mixture of primarily fine substrates will closely match the existing substrate conditions; such will support the return to normal ecological functions such as the recolonization of benthic aquatic organisms and provide a suitable growth medium for aquatic vegetation. In-water cover features should include a mix of woody debris to provide refugia to small-bodied fish and juvenile life stages and undercut/overhanging banks.

Avoidance of in-water works during the fish and fish habitat restricted activity timing window will reduce the potential for mortality, accidental capture, or disturbance of fish during sensitive life history events (i.e., spawning, migrations, egg/larval development periods). Further mitigation measures, including isolating the work area prior to the restricted activity timing window and performing a fish rescue within the work area and relocation to outside the work area, will reduce this risk further. Application of standards and codes of practices developed by DFO for routine works should be applied to the Project mitigations, where possible (DFO 2022a ,2022b).

Fish habitat will need to be quantified and qualified to determine the potential of the Project to result in HADD of fish habitat and/or death of fish under the *Fisheries Act* (Canada 1985a). Habitat accounting calculations (including aquatic vegetation components) will need to be completed to support future *Fisheries Act* Authorization permitting for pre and post construction conditions. The rehabilitation activities should consider incorporating the applicable objectives of the Indigenous communities through consultation and engagement, DFO and Indigenous Women of Canada Framework to Identify Fish Habitat Rehabilitation Priorities (DFO, no date), DFO Draft Policy for Applying Measures to Offset Harmful Impacts to Fish and Fish Habitats (DFO 2023b), and MNRF Fish Management Zone Objectives (MNRF 2023b). To compensate for the potential temporary loss of fish habitat, all habitats should be rehabilitated to the former condition or better (DFO 2023b). Fish will have access to alternative habitats and aquatic vegetation upstream and downstream of the work area during this time. In post-remediation, the study area will be designed to function as spawning, rearing/feeding, migratory, refugia and over-wintering habitat for the various fish species known to use the study area for this purpose. Landscape designs for reseeding (where feasible) and natural recovery of the vegetation communities will be developed and on-going monitoring for three to five years post-construction will be conducted to verify it is functioning as such.

7.4 Timing Windows

Physical interventions have the potential to result in a significant short-term alteration of biological resources; it is important to identify sensitive habitats and ecological functions for which habitat disruption may be discouraged altogether or avoided through the application of timing windows (i.e., restricted activity periods; Table 2). It is proposed that the Project be constrained by a timing window of 1 June to 30 September based on protecting fish spawning and on turtle overwintering. However, this is subject to regulatory approval, review of the DIA, detailed design factors etc.

Table 2: Restricted Activity Periods and Recommended Mitigation Measures for Species at Risk and Fish Communities within the KIH Study Area

Major Taxa	Location of Suitable Habitat in the Study Area	Recommended Restricted Activity Period[a]	Recommended Mitigation Measures
Fish Community	Warmwater fish community exists within the water lot. No federally listed fish SAR were found with records in the Study Area. Provincially listed fish SAR may [redacted], although habitat suitability was ranked as low.	DFO (2013) recommends a default restricted activity period of 15 March – 15 July for exclusion of in-water works (i.e., in water work may occur between 16 July to 14 March). However, a timing window exemption will be sought from the MNRF and DFO to begin works as early as 1 June. This will be protective of spring-spawning species with the exception of some later spring/early summer spawning species such as bass.	Isolate the work area and complete a fish rescue prior to work being undertaken. Conduct turbidity monitoring throughout construction. Apply erosion and sediment control, spill management, and working in-water BMPs. Install isolation measures prior to June of each year. Complete a fish rescue and relocation prior to construction. Additional mitigation measures would be required for work outside recommended periods.

Major Taxa	Location of Suitable Habitat in the Study Area	Recommended Restricted Activity Period[(a)]	Recommended Mitigation Measures
SAR Turtles—Blanding's turtle, northern map turtle, snapping turtle, eastern musk turtle, midland painted turtle	These species are known to be present [redacted]. Map turtles are known to concentrate in the s[redacted] where abundant basking structures are present. Snapping turtles are also known to nest on shore at this location.	1 October – 31 March (Over-wintering) 1 April – 30 September (Active Period) Late May through early July (Nesting)	Avoid in-water work during the over-wintering period when turtles are less mobile. Avoid disturbance to basking structures during the key periods for basking / follicular development (April to mid-June and late-July to October). Install exclusion fencing around terrestrial work areas prior to 1 April to stop turtles from nesting in those areas and maintain until end of July. Additional mitigation measures would be required for work outside recommended periods.
SAR Snakes—Eastern ribbonsnake, milksnake	Suitable habitat for Eastern ribbonsnake is present in the study area i[redacted]. Suitable habitat for milksnake is present [redacted] in the study area.	October through March (Hibernating) April through September (Active)	Conduct searches for wildlife prior to any removal of terrestrial vegetation. If soil disturbance is required during the hibernation period, a Wildlife Encounter Protocol should be developed to identify appropriate actions in case hibernating snakes are uncovered.
SAR birds — Bald eagle, Eastern wood-pewee, Red-headed woodpecker, Least bittern	Suitable nesting habitat includes wooded areas and wetlands. Bald eagle prefers to nest in super-canopy trees, whereas red-headed woodpecker prefers forest edges or scattered trees in parkland. Eastern wood-pewee may nest in a variety of wooded habitats. Least bittern nests in [redacted]	1 April – 31 August (Nesting)	Avoid removal of terrestrial vegetation or disturbance to marshes during the nesting period. If removal of vegetation is necessary during the nesting period, a qualified biologist must conduct a search for active nests within 24 hours of the proposed clearing activity. If an active nest is located, it must be buffered, and the area left uncleared until the nest is no longer active.
SAR bats — Little brown myotis, Tri-colored bat, Northern myotis	Roosting habitat may occur in [redacted] within the study area. No hibernation habitat has been identified in the study area.	1 April – 30 September (Roosting)	Only for non-federal lands (not applicable to federal water lots) Avoid clearing trees during the roosting period. If tree clearing is required during the roosting period, each tree must be assessed by a qualified biologist for potential to support bat roosting. If potential roosting habitat is identified, the trees must be assessed through targeted surveys to determine presence/absence of SAR bats. If presence is found, additional mitigations and permitting may be required.
Monarch butterfly	Adults of this species may be found wherever flowering plants are present and may roost in forested habitats. Eggs and larvae are found on milkweed plants (*Asclepias* spp.) which are most often found in open or semi-open habitats.	May through October (Active) May through September (Eggs / Larvae Development)	Avoid clearing areas containing milkweed plants during May and September, if possible.

(1) Restricted Activity Period: Period of time where it is recommended that work be avoided to protect sensitive species life history events (i.e., reproductive periods, hatching, over wintering) or sensitive life stages (i.e., larval, egg, juvenile development).

8.0 SOCIAL AND CULTURAL CONSIDERATIONS

This section discusses the social and cultural considerations that apply to Project implementation, with the goal to prevent adverse effects on archaeological areas of significance. It is expected that the Project will provide opportunities for enhancement of other cultural values, including recreational and aesthetic values, in conjunction with the broader shoreline development as part of the City Master Plan. For example, use of nature-based solutions for shorelines will maintain shoreline characteristics that are highly valued by Indigenous groups, stakeholders, and the public, including those that access shoreline paths (e.g., walking, cycling) or that enjoy the natural character of shorelines when rowing or paddling.

There are two specific constraints to the urban planning aspects of the proposed design:

- The implementation of nature-based designs, including required offsets and exclusion zones, will provide limitations to human access to the water lot. It is intended that most shoreline areas (with the exception of designated recreational areas such as the Kingston Rowing Club) be configured to avoid human trampling, wading, or beach-like usage. This serves two purposes, including protection of ecological habitat values, and limitation of dermal contact with residual contamination that is not physically removed.
- The shorelines of the brownfield zones adjacent to Orchard Street Marsh cannot be prescribed at this time, given the private ownership of these areas and the uncertain status of property redevelopment plans. For the time-being, the remediation plan assumes that habitat offsetting measures will be maintained (e.g., restrictions on physical dredging) but has not assumed engineering for areas that are not owned by municipal or federal government entities.

The remainder of this section discusses the protection of archaeological values, focussing on culturally significant shipwrecks and historical artifacts.

A total of [redacted] shipwrecks have been identified in KIH prior to 2021, with [redacted] (Tocher Heyblom Design Inc. 2014), that may be considered part of Kingston's cultural heritage resources and may be protected under the Ontario Heritage Act (Moore 1995). Additional archaeological features have been documented within KIH during the ongoing underwater archaeological assessment and artifacts may also be present in the harbour, either from its use by the French in 1675 to 1758 during their occupation of Fort Frontenac, or from Indigenous traditional uses. To this end, ESG (2014) documents that at least [redacted] archaeologically sensitive areas along the [redacted] have been identified (Archaeological Services Inc. 2008), including two pre-contact Indigenous sites. Two historical Euro-Canadian areas have also been identified on the [redacted], including an archaeologically sensitive area along the [redacted] (ESG 2014). The fourth archaeologically sensitive area is on [redacted] and therefore will not be influenced by sediment management activities. The City of Kingston Archaeological Master Plan (Archaeological Services Inc. 2008) identifies the entire shoreline on both sides of the river as having potential for pre-contact archaeological significance. The underwater archaeological impact assessment currently being completed will confirm archaeological sensitive areas, which will be incorporated into the DIA. As such, adjustments may be made prior to the detailed design stage to avoid adverse effects on archeological areas of significance based on these results.

9.0 POTENTIAL SEDIMENT MANAGEMENT TECHNIQUES

The following sections discuss the potential sediment management techniques for the Project, including conventional approaches, lower intrusion techniques, and nature-based shoreline rehabilitation. The techniques described in this section include multiple approaches that, once combined, are intended to provide an appropriate balance between chemical risk reduction and protection or enhancement of the environmental considerations (Section 6.0), biological considerations (Section 7.0), and sociocultural considerations (Section 8.0).

In 2019, Golder conducted a review of candidate sediment management technologies applicable to sediment contamination that would meet the sediment management objectives for the Site and address known Site constraints identified at that time (Golder 2019). Initial assessments included identification of available technologies, and the potential applicability of these technologies to the Site, using the federal Guidance and Orientation for the Selection of Technologies (GOST) tool. The GOST analysis provided preliminary indications of applicable sediment management technologies, assuming conditions of no time constraints, preference for in situ treatment, and no preference between control or reduction treatment.

Due to the broad extent of low-level contamination at the Site and physical and practical constraints, the intrusive management options considered for the Site (summarized in Section 9.1) will be used in conjunction with passive options including risk management in place (summarized in Section 9.2). The management options therefore addressed the water lot areas with the highest priorities for active intervention based on risk to aquatic life, semi-aquatic wildlife, or human health risks, rather than meeting conservative numerical standards across the Site. This decision was made based on the impracticality of remediating all contamination above regional reference levels, combined with constraints identified in the previous report sections. Early consultation and engagement with Indigenous groups, stakeholders, and the public also confirmed that MNR was preferred for the central areas of the harbour where contamination is not severe.

Early design concepts included consideration of a physical layer (including large-diameter materials such as armored stone) along some shoreline areas, intended to provide isolation of human contact from contaminated sediments while also providing shoreline protection benefits. However, based on initial feedback regarding the proposed shore protection options for management units TC-RC, WM, TC-2A, TC-3A and TC-4, nature-based approaches for shoreline rehabilitation are now being emphasized in preference to shoreline hardening (summarized in Section 9.3).

9.1 Conventional Approaches

Conventional strategies and technologies considered as candidates to meet the sediment management objectives included:

- **Dredging**—Removes contaminated sediment to reduce risks to human health and the environment. Removal is particularly effective for source control (mass removal of hot spots) but potentially less effective for overall risk reduction because of resuspension and residual contamination (Interstate Technology and Regulatory Council [ITRC] 2014). This strategy is favourable for portions of KIH due to the low gradient shoreline in most areas (except for areas with supporting sheet pile or stone retaining walls), relatively uniform grain size, and absence of obstacles such as permanent piers. Dredging is not suitable for all areas, however, due to geotechnical or engineering constraints (e.g., dredging may undermine the geotechnical stability of retaining walls, or endanger infrastructure) and/or conflict with habitat protection constraints.

- **Conventional Capping**—This strategy is useful for stabilizing sediment to prevent resuspension, diluting exposures, and isolating contaminated sediments from receptors. The thickness and composition of the cap can vary depending on the contaminants ability to migrate through sediment due to the upwelling of groundwater, the stability of the underlying sediment to support the cap and prevent consolidation, and the depth of which sediment is mixed either naturally (i.e., through wave action or by benthic invertebrates [bioturbation]) or through physical disturbances (i.e., boat wakes or propeller wash) (Palermo 1998; ITRC 2014). However, conventional capping has several significant constraints, particularly for the shallow water depths over much of KIH where the conventional thicknesses of engineered covers are impractical. Furthermore, conventional capping is disruptive to shoreline areas where ecological (habitat) values are limiting factors for highly engineered options.
- **Dredging and Capping**—A combination of the above two strategies is a potential management strategy for areas where dredging or capping alone is not possible. Capping becomes a feasible option when used in combination with selective dredging, particularly for areas for which contamination at depth is a concern. There are some localized areas in KIH, specifically near Anglin Bay, where conditions of bathymetry and urbanized shorelines make this option feasible.
- **Monitored Natural Recovery (MNR**)—MNR is a sediment management strategy that relies on natural processes to contain, remove, or reduce the bioavailability of contaminants and protects the environment and receptors from unacceptable exposures (NRC 1997). This management approach depends on natural processes to decrease chemical contaminants in sediment to acceptable levels within a reasonable time frame and can only be possible once source control of the contaminant has been achieved (ESTCP 2009). Given the persistence of metals, PAHs, and PCBs in KIH, as confirmed in Golder (2022a), MNR is not a viable option for all areas of KIH. However, it may be appropriate for some areas that are sufficiently distant from the historical sources of contamination that the exposures are lower, which results in low risks to human and ecological health, and for which gradual burial of contaminated sediments is ongoing. The efficacy of the MNR approach is evaluated through long-term monitoring to ensure concentrations are gradually decreasing over time or have at least stabilized. Part of this long-term reduction will come from remediation of adjacent sediment units with higher baseline concentrations.
- **Institutional Controls**—Risks to human health may be mitigated through institutional controls (i.e., limiting fish consumption through fishing advisories) or through engineering controls (i.e., fencing or boardwalks that reduce the potential for sediment exposure). Although these controls may mitigate against the contaminants ability to affect people, they do not reduce the concentrations of contaminants, and do not reduce ecological risks to wildlife. Institutional controls that place constraints on access or aesthetics of the harbour may also have negative consequences for some social and cultural values, including recreation and/or aesthetics.
- **No Action**—For areas where contaminant concentrations are low and with negligible risks to human health or the environment, no intrusive actions or follow up monitoring are required. The entire eastern half of KIH has been identified to be appropriate for this category.

9.2 Lower Intrusion Techniques

Higher costs (financial and short-term environmental) are often associated with the isolation or removal of contaminated sediment, as well as uncertainty regarding the implementation success (e.g., imperfect delineation, dredge residuals). Recent advances in design and implementation are available for less intrusive methods for sediment management. With advantages in terms of habitat conservation, economic costs, carbon balance, and environmental management of dredge spoils and residuals, these techniques achieve a lower degree of contaminant removal or sequestration relative to conventional dredging and capping options. These methods were considered in conjunction with conventional dredging and capping options to provide a customized design suited to the features of each management unit.

These innovative sediment management techniques include several variants:

- Thin-layer capping—selective placement of clean cover materials not requiring permanent profile stability.
- Sediment amendments—application of substances, either natural or prepared, to sequester contaminants and reduce bioavailability.
- Managed wetlands—specialized techniques designed to preserve hydric soil structure and the presence of sensitive ecological receptors; methods are diverse but include staged remediation with surgical remediation and natural recovery, and application of engineered sequestration agents.

These approaches can also be combined, using a concept called enhanced natural recovery (ENR)—ENR is a form of MNR in which materials or amendments are added to augment and accelerate the natural recovery processes (e.g., addition of a thin-layer cap or a carbon amendment). Adequate control of sources of contamination is also essential to ensure the effectiveness of recovery processes (PSPC 2017). It is expected that carbon amendments added to the areas using natural recovery will help to reduce the bioavailability, and therefore toxicity, of the COCs (see Section 12.1.4 for further details). The areas with ENR proposed would include a thin layer (no more than ~0.3 m of material), with a preference for natural organic matter containing materials, and/or inclusion of active carbon amendments.

Further detail on the implementation of lower intrusion techniques in the recommended sediment management plan is provided in Section 11.0.

9.3 Nature-Based Shoreline Rehabilitation

Sustainable and resilient coastal rehabilitation and protection infrastructure provides an opportunity to use processes and functions found in natural systems (e.g., nature-based solutions) to strengthen the overall performance and expand the coastal infrastructure value (Bridges et al. 2021). Nature-based shoreline techniques can be used as an alternative to, or a complement to, the engineering methods summarized in Sections 9.1 and 9.2.

Nature-based shore protection features can include several components of plant systems such as uplands, wetlands, and submerged aquatic vegetation. These plant systems are an important component of the harbour, providing benefits to improve shoreline resilience and stability, and may be used to reduce wave and current action to protect the riverbed and the shorelines from erosion, where applicable. For example, upland plants reduce wind energy, stabilize land surfaces, and provide habitat for many species and adapt to changing water levels. Submerged aquatic vegetation provides direct attenuation of waves and currents reducing the potential for riverbed erosion and sediment transport. A nature-based approach may be suited for KIH given the sheltered nature of the harbour, as the lower wave action limits shoreline stress, making it easier for shoreline plants to establish. Some of the opportunities within a nature-based approach for KIH include:

- Providing habitat improvement for already impacted or hardened shorelines, especially the enhancement of turtle habitat and the establishment of aquatic coastal and riparian vegetation.
- Maintaining shoreline aesthetics while limiting the potential for human access to the water to reduce human exposure to COCs and to reduce trampling hazard in sensitive habitats.
- Replacement of invasive species with native species.

The existing western shoreline of KIH includes habitat features that are potential constraints to physical remediation (e.g., sensitive habitats for turtles and other animals that require protection against unacceptable disruptions), but provide potential opportunities for habitat conservation gains (e.g., naturalization of shorelines, contouring of slopes for animal migration to riparian areas, native plantings to support desired ecological and hydrological properties). Specifically, the TC-RC management unit near Emma Martin Park, the WM management unit in front of the Woolen Mill, and TC-3A and TC-4 management units along Douglas Fluhrer Park appear to offer the greatest potential for habitat improvements and shoreline rehabilitation after nearshore contamination (Figure 3). Although pockets of quasi-natural habitat existing in these areas, including emergent aquatic vegetation and basking logs for reptiles, some of the shoreline areas have large diameter rocks and retaining structures that are less suited to the local ecology. Several shoreline areas in the harbour, such as the [redacted] and shoreline vegetation in the vicinity of [redacted], remain important habitat for turtles and other wildlife, and will require special care and delicate remediation methods. Based on the identification of critical/important sensitive habitats from the DIA, some of these areas may require incorporation of natural recovery approaches.

Based on early feedback from consultation and engagement with Indigenous groups, stakeholders, and the public, four guiding principles were proposed in designing nature-based shorelines that were applied in this SMP, where applicable, and these should be applied into the detailed design phases. These principles include:

1) Develop turtle-friendly habitat to support their shoreline uses; this may include shoreline planting, use of natural shoreline stabilization like large woody debris, and intermittent but selective use of large rock.
2) Balance human and recreational values with ecosystem, habitat, and aesthetic values. Examples include re-naturalized shorelines, hidden erosion protection, and increasing shoreline planting. Human access to water may need to be limited in some areas to protect against trampling of habitat and to prevent dermal contact with contaminated sediments.
3) Where possible, use the natural shoreline features of KIH including small size materials or rocks, aquatic plants, and contouring of shoreline to increase project benefits.
4) Design objectives also include separation of sensitive aquatic habitat features from human recreational access to prevent disturbance of natural habitat features, while still allowing paths for humans and mitigate contact with contaminated sediments, and achieving compatibility with the Waterfront Master Plan.

In selected areas of KIH where the implementation of nature-based shorelines is appropriate, these principles will help to preserve or rehabilitate physical processes, maintain or enhance the habitat and function of the shoreline, prevent or reduce contamination, and protect the shorelines from erosion. Where localized interventions are required to access highly contaminated sediments, activities will be timed, sequenced, and managed to limit habitat disruptions.

The basis of design for shoreline protection is detailed in Appendix C and summarized throughout the remaining sections.

10.0 SEDIMENT MANAGEMENT OBJECTIVES

The following sections discuss the sediment management objectives for the Project and summarize the levels of intervention categories considered to meet these objectives (Section 10.1). For each management unit, the overall priority for risk management (based on the results of the risk assessment) is provided, along with constraints for implementing sediment management (e.g., ecological sensitivity and shoreline structure/uses) (Section 10.2). Finally, the risk-based numerical sediment management criteria used to inform the level and spatial extent of remedial action required to meet the objectives is discussed (Section 10.3).

The sediment management objectives were developed based on our understanding of the Project goals as articulated by the site custodians and PSPC, and by applying the FCSAP decision-making process for Risk Management.[10] The primary sediment management objective is to balance passive and intrusive management techniques to be protective of human health and the environment; this will be achieved through a combination of:

- Removal or reduction of contamination
- Preservation of sensitive habitats, particularly where contamination risks are marginal
- Shoreline protection and improvement/rehabilitation
- Modifying or limiting site use by human receptors
- Interception or removal of the exposure pathways

The interactions among these five factors are impacted by the effectiveness and implications of selected methods for adjacent management units. Multiple constraints (ecological, economic, socio-political, logistical) exist for each of the methods; these influence the ease of application and preference for each method. Differences in existing land use, development plans, riparian habitat conditions, infrastructure, and other Indigenous and stakeholder preferences must be taken into consideration along with contaminant risk reduction.

10.1 Level of Intervention Categories

The sediment management objectives were evaluated broadly (i.e., site wide, at a conceptual level) to categorize the management units based on the level of intervention required. The categories ranged from high intervention (e.g., dredging of contaminated sediments, physical barriers), where substantial intrusive management is required, to low intervention (e.g., management in place, small and focussed sediment removals, nature-based shoreline rehabilitation), where judicious intervention is preferred (Table 3). The 2021 conceptual SMP presented potential sediment management options for each management unit based on a high, medium, and low level of intervention (Golder 2021a); and the selected level of intervention is summarized in Section 11.2 – Table 6.

[10] http://www.federalcontaminatedsites.gc.ca/default.asp?lang=En&n=B4AC7C22-1&offset=3&toc=show#X-2012091011445732

Table 3: Summary of Sediment Management Intervention Categories

Intervention Level	Approach	Additional Considerations
High Intervention	▪ Sediment management options emphasize contaminant-based risk pathways ▪ Focused on the removal of contaminants contributing to moderate and high risks ▪ Approaches assume that the benefits of contaminant removal or isolation (i.e., chemical risk reduction) offset the disruption to existing natural resources and infrastructure	Emphasis on long term reduction of liability associated with contamination.
Moderate Intervention	▪ Sediment management options seek to find an intermediate approach that will minimize disruption to significant "social and ecological areas" [11] ▪ Addresses the most heavily contaminated areas to reduce human and ecological risks associated with contaminant exposure. ▪ Additional consideration given to the impacts of the rehabilitation activities of the adjacent land use and ecological features	Further consideration is given to the weight of the impacts associated with the sediment management options (i.e., increased potential for environmental harm) versus risk of not implementing the sediment management options (i.e., leave contaminants in place).[a, b]
Low Intervention	▪ Adopts a cautious approach to physical intervention, adopting intrusive measures only where the chemical risk reduction is great, and with high weighting assigned to social, economic, and environmental attributes. ▪ Solutions often emphasize either risk management (i.e., MNR, ENR, or institutional controls) or localized (targeted) removals of sediments focussing on areas of greatest concern. ▪ Solutions also consider nature-based shoreline rehabilitation, which will stabilize the shoreline (reducing the potential for riverbed erosion and transport) and limit potential human access, while protecting or enhancing turtle habitat and native riparian vegetation.	Greater emphasis is placed on short-term conditions, seeking not to disturb conditions that would require an extended recovery period to reach a desirable state.
No Intervention	▪ Reliance on maintenance of existing habitat features without disruption. This approach is required where critical habitat requirements negate the feasibility of removing contaminant mass, or where the net benefits of contaminant removals or containment are outweighed by environmental costs.	Areas of "no action" have been identified at a broad scale (e.g., eastern KIH management units PC-N and TC-E) based on negligible priority designations (Section 10.2), but localized areas within the remaining units may be assigned a "no action" designation at detailed design stage following input from ongoing detailed impact assessment.

(a) US EPA 1998

(b) Chapman 2008

[11] Social and ecological areas include: areas of ecologically significant habitat to be designated for protection; areas with geotechnical issues (sheet pile walls, etc.); high uses areas; and, areas with potential for future shoreline redevelopment (brownfields, etc.).

10.2 Priority Rankings for Risk Management

Determination of overall priority for risk management of a management unit considered:

- Degree of overlap of risk determinations for separate pathways, particularly for those indicative of moderate to high risk based on the findings presented in the Risk Refinement and Synthesis (Golder 2016)
- Degree of overlap of multiple stressors, both within and among exposure pathways
- Non-quantifiable risk pathways
- Cost-efficiency and mass removal
- Level of uncertainty
- Professional judgement

The overall priority for risk management was based on the following rankings:

- **Negligible**—These areas have conclusively been demonstrated, following the Canada-Ontario Decision-Making Framework, to be acceptable without need for physical management or requirement for additional studies or monitoring.
- **Low**—These areas have some indications of risk, but not to a degree warranting physical management. Such areas are strong candidates for MNR, or at most, spot management.
- **Moderate**—These areas have multiple indications of risk, including at least one receptor group at "moderate" magnitude or greater. However, risk estimates have higher uncertainty, lower magnitude of contamination, and/or reduced evidence of harm relative to "High" category. Some areas with moderate priority could be refined or partitioned into smaller parcels.
- **High**—These areas have multiple indications of risk, including at least one receptor group at "moderate" magnitude or greater. In addition, these areas have greater average exposure conditions (and calculated hazards/risks relative to low or moderate classifications) and are adjacent to source areas of contamination, yielding greater benefit from remediation relative to costs as compared to the "Moderate" category.
- **Very High**—These areas have multiple indications of risks of at least "moderate" magnitude or greater. Such areas contain the highest concentrations of COC (often co-located). These areas are the top priority for physical management.

The overall priority ranking for risk management selected for each of the management units is provided in Table 4, along with any site constraints that should be considered when selecting the appropriate risk management approach (i.e., biological sensitivities, structural/shoreline/water lot uses, identified archeological resources). The selected sediment management approach for each management unit is discussed in Section 11.0, which considered the priority ranking for risk management and any site constraints discussed in Table 4.

Table 4: Priority Ranking and Site Constraints for Risk Management

Unit	Overall Priority for Risk Management[1]	Contaminants Driving Significant Ecological Risk	Other COC Elevated in Management Unit	Site Constraints Overview				
				Ecological Sensitivity Rating		Structural/ Shoreline / Water Lot Uses	Identified Archaeological Resources	Additional Considerations
PC-W (incl. PC-OM and PP-OM) [2]	Very High	PAHs, PCBs, chromium	antimony, lead, zinc	Very High	Orchard Street Marsh wetland, shallow water, macrophyte beds; presence of multiple listed species of concern. Presence of herptiles adjacent to marsh, plus bird species suited to this habitat. High quality habitats for vegetation associated fish species. Variety of sediment sizes and vegetation present to support numerous fish species.	The wetland area has no defined shoreline (cattail marsh). Surrounding shoreline is loose rocks with soil and some vegetation.	None.	The sediment management strategy will need to strike a compromise between chemical risk and habitat alteration. The southern shoreline of Belle Park Landfill is more amenable to intrusive management relative to Orchard Street Marsh. Dredging south of the golf course could open preferential pathways for landfill seeps. Storm sewer flows could remobilize contaminants associated with soils in Orchard Street Marsh.

Unit	Overall Priority for Risk Management[1]	Contaminants Driving Significant Ecological Risk	Other COC Elevated in Management Unit	Site Constraints Overview				
				Ecological Sensitivity Rating		Structural/ Shoreline / Water Lot Uses	Identified Archaeological Resources	Additional Considerations
TC-RC	High	PAHs	antimony, arsenic, lead, mercury, silver, PCB	Moderate-High	Shallow water, emergent and submerged macrophyte beds. Multiple herpetofauna species observed and turtle nests. Variety of sediment sizes and vegetation present to support numerous fish species.	Sheet pile wall around Emma Martin Park boat launch. Public boat launch currently too shallow for use. Kingston Rowing Club docks and water access.	One submerged feature, which retains cultural heritage value.	Existing structures provide obstacles for access to sediments. Engineered shoreline provides options for creative solutions to isolate sediments and modify shoreline. City of Kingston endorsed dredging to increase water depth and reduce macrophytes, provided shoreline appears natural (MacLatchy 2013, pers. comm.). Presence of water/sewage force mains here—will need to confirm the depth of utilities with plans.
TC-AB	High	PAHs, PCBs, Cu	antimony	**Low**	Marina and industrial embayment; highly engineered shoreline. No turtle observations (2021). Lacking in aquatic vegetation, substrate variety and habitat features to support higher quality fish habitats.	Structural sheet pile retaining wall around north side of bay. Kingston Marina docks and boat launch.	Two submerged features, both of which retain cultural heritage value	Geotechnical considerations for access to nearshore sediments. Marina structures provide barriers to sediment access. Logistical issues working in and around industrial embayment.

Unit	Overall Priority for Risk Management[1]	Contaminants Driving Significant Ecological Risk	Other COC Elevated in Management Unit	Site Constraints Overview				
				Ecological Sensitivity Rating		Structural/ Shoreline / Water Lot Uses	Identified Archaeological Resources	Additional Considerations
WM	**Moderate—High**	PAHs	arsenic, chromium, lead, mercury, silver, zinc, PCB	**Low-Moderate**	Riparian zone is artificial relative to adjacent shoreline. Multiple herpetofauna species observed. Lack of access to turtle nesting sites. Variety of sediment sizes and vegetation present to support numerous fish species.	Woolen Mill—City Managed Water Lot. Wooden boardwalk, rock wall noted on southern edge of WM shoreline.	One submerged feature that retains cultural heritage value.	Potential for vessel hulls (Moore 1995). Engineered shoreline provides options for creative solutions to isolate sediments and modify shoreline.
PC-E	**Moderate**	PAHs, PCBs, chromium	antimony	**High**	Shallow water, macrophyte beds. Naturalized habitats, suitable of supporting a variety of herpetofauna species.	Water lot (on eastern end) includes portion of "Ecological Protection Area" adjacent to Belle Island.	None.	First Nations conservation/ management agreement for Belle Island.
TC-OM	**Moderate**	Chromium	—	**High**	Shallow water, emergent macrophyte beds. Multiple turtle species observed and nests. Amphibian breeding habitat. Variety of sediment sizes and vegetation present to support numerous fish species.	Upland area designated as parkland.	None.	Appear to have lower COC concentrations. Sensitive shoreline areas may need to be maintained for habitat value.

Unit	Overall Priority for Risk Management[1]	Contaminants Driving Significant Ecological Risk	Other COC Elevated in Management Unit	Site Constraints Overview				
				Ecological Sensitivity Rating		Structural/ Shoreline / Water Lot Uses	Identified Archaeological Resources	Additional Considerations
TC-4	**Moderate**	PAHs, PCBs	mercury (shoreline), lead, silver	**High**	Shallow water, macrophyte beds, upland turtle nesting sites Snake habitats present. Variety of sediment sizes and vegetation present to support numerous fish species.	Shoreline trail area.	14 submerged features, of which 13 retain cultural heritage value	The ribs of two hulls can be seen above the water surface. Hulls may be protected under the Ontario Heritage Act (Moore 1995).
TC-2A	**Moderate**	PAHs	arsenic, mercury, silver	**High**	Shallow water, macrophyte beds, shoreline turtle nesting sites on logs. Snake habitats present. Variety of sediment sizes and vegetation present to support numerous fish species.	Stone landscaped retaining wall along waterfront at Molly Brant Point. Culvert also present.	Five submerged features, of which four retain cultural heritage value.	The ribs of two hulls can be seen above the water surface. Hulls may be protected under the Ontario Heritage Act (Moore 1995). Evidence of herptile use (turtles).
TC-5	**Low—Moderate**	PAHs, PCBs	antimony	**Low**	Open-water area; high vessel traffic. Lacking in aquatic vegetation, substrate variety and habitat features to support higher quality fish and turtle habitats.	Provides access to/from Kingston Marina and navigation channel.	Three submerged features, all of which retain cultural heritage value	Potential for vessel hulls

Unit	Overall Priority for Risk Management[1]	Contaminants Driving Significant Ecological Risk	Other COC Elevated in Management Unit	Site Constraints Overview				
				Ecological Sensitivity Rating		Structural/ Shoreline / Water Lot Uses	Identified Archaeological Resources	Additional Considerations
TC-1	**Low**	None	PCB, chromium, antimony, lead, mercury, silver	**Moderate**	Shallow water, submerged macrophyte beds. Lacking in substrate complexity and habitat features to support higher quality fish habitats.	Central harbour portion; therefore, no significant obstacles to physical management.	Four submerged features, with two retaining cultural heritage value.	Due to the shallow water depth in this area, dredging may be required to allow barge access to shoreline areas through this unit.
TC-2B	**Low**	Metals (lead, silver)	PCB, antimony	**Moderate**	Shallow water, submerged macrophyte beds. Lacking in substrate complexity and habitat features to support higher quality fish habitats.	Open water area.	One submerged feature. Feature does not retain cultural heritage value.	Potential for vessel hulls (archaeology value).
TC-3A	**Low**	PCBs, PAHs	mercury (shoreline)	**High**	Shallow water, macrophyte beds, upland turtle nesting sites. Snake habitats present. Variety of sediment sizes and vegetation present to support numerous fish species.	Shoreline trail area.	Three submerged features, all of which retain cultural heritage value.	Potential for vessel hulls.
TC-3B	**Low**	PCBs	PAH	**Low-Moderate**	Open-water area, submerged macrophyte beds. Lacking in substrate complexity and habitat features to support higher quality fish habitats.	Open water area.	None	Potential for vessel hulls

Unit	Overall Priority for Risk Management[1]	Contaminants Driving Significant Ecological Risk	Other COC Elevated in Management Unit	Site Constraints Overview				
				Ecological Sensitivity Rating		Structural/ Shoreline / Water Lot Uses	Identified Archaeological Resources	Additional Considerations
PC-N	**Negligible**	None	—	**N/A**	Varied—this is the upstream reference area north of Belle Island	Varied—ecologically sensitive area on north side of Belle Park; mostly residential on east and west banks of Cataraqui River.	None (Area not assessed for archaeological resources).	There are a few localized areas (individual stations) that exhibit elevated chemistry, but these are either anomalies or insufficient to influence KIH management.
TC-E	**Negligible**	None	—	**N/A**	Varied—this is the eastern half of KIH, where risks are negligible to low	Varied—riparian corridor along most of eastern shoreline.	None (Area not assessed for archaeological resources).	Weight of evidence is that the entire eastern half of Lower KIH can be excluded from physical intervention.

Notes:
1. Refer to Section 5.4 for a summary of human health and ecological risks.
2. PC-W management unit described here includes three subunits: (a) PC-W sub-unit—open water property managed by PCA (a subset of the water lot previously defined as PC-W); (b) PC-OM sub-unit—Orchard Street March area managed by PCA; (c) PP-OM sub-unit—open water area, jurisdiction pending confirmation (PP-OM). The original PC-W management unit assessed as part of the risk assessment (Golder 2016) and initial remedial assessments (Golder 2017a and Golder 2019) was subdivided for the SMP into three different sub-units: PC-W, PC-OM, and PP-OM to reflect an updated property survey and a different remedial strategy for the Orchard Street Marsh (refer to Section 11.2.1 for further discussion).

10.3 Numerical Sediment Management Criteria

Risk-based numerical sediment management criteria were developed to inform the management decisions, including the level and spatial extent of remedial action requited to meet the remedial objectives.

The proposed numerical sediment management criteria were derived to achieve the following set of protection goals: no unacceptable risks to humans (i.e., hazard quotients less than 0.2 for non-carcinogenic substances and incremental lifetime cancer risks less than 0.00001 for carcinogenic substances); an overall level of risk not greater than “low” for mammals, birds, amphibians, and fish; and an overall level of risk not greater than “moderate” for benthic invertebrates.

Based on the methods and results of the Risk Assessment Refinement and Synthesis (Golder 2016), numerical sediment management criteria were derived for those combinations of substances, receptor groups, and management units with risk levels that exceeded the stated protection goals. These include:

- total PAHs in TC-4 and TC-AB for the benthic invertebrate community
- total PAHs in all management units (excluding PC-N and TC-E) for fish populations
- total PCBs in TC4, TC3A and PC-W for fish populations
- total PCBs and chromium in PC-W, PC-E, and/or TC-OM for semi-aquatic wildlife (includes birds, mammals, and herptiles)

For the remaining combinations of substances, receptor groups, and management units, risk levels under existing conditions (i.e., before implementation of the SMP) are acceptable based on the stated protection goals and results of the Risk Assessment Refinement and Synthesis. As a result, it was not considered necessary to derive numerical sediment management criteria for those substances, receptor groups, and management unit combinations.

Although potentially unacceptable risks were identified in the Risk Refinement and Synthesis for human receptors from dermal contact with PAHs in sediment, nature-based shoreline rehabilitation will be implemented as part of the SMP; this approach is expected to reduce exposure by deterring human access to water. Inherent in this approach is an assumption that other shoreline areas of KIH provide better locations for human access (e.g., beach-like areas for wading, swimming, or other activities). Potentially unacceptable risks were also identified for human receptors from dietary exposure to PCBs and mercury from the ingestion of fish caught in KIH, using tissue consumption estimates similar to those outlined in the 2017–2018 Guide to Eating Ontario Fish. However, potential risks were categorized as “low” and implementation of the SMP throughout KIH is expected to reduce the weighted average concentrations of these substances by focussing on remediation of localized areas of elevated sediment contamination (i.e., hot spots). In addition, maintenance of fish consumption advisories specific to these substances (i.e., largemouth bass, northern pike and walleye for mercury, and black crappie, bluegill sunfish, brown bullhead, common carp, largemouth bass, northern pike, walleye, and white sucker for PCBs), will limit exposure through dietary uptake. As a result of the planned reductions in exposure, and because the fish consumption advisory will remain in place due to the Site being a working harbour, it was not considered necessary to derive numerical sediment management criteria for the protection of human health.

The numerical sediment management criteria derived for each management unit (or group of management units depending on the receptor), and the type of exposure concentration used to meet the criteria are provided in Table 5. Rationale for the selection of sediment management criteria is provided in the following section for each receptor type.

Table 5: Numerical Sediment Management Criteria and Type of Exposure Concentration to Meet Criteria

Management Unit	Total PAHs mg/kg	Total PCBs mg/kg	Chromium mg/kg	Type of Exposure Concentration to Meet Criteria
Benthic Invertebrates				
Each management unit subject to physical intervention (PC-E, PC-W [including subunit PP-OM][1], TC-OM, TC-RC, WM, TC-2A, TC-3A, TC-4, TC-AB).	22.8	—	—	Average concentration in each management unit
Fish Health				
North	8	1.0	—	75th percentile concentration across large contiguous areas of water lot that have foraging habitat for bottom fish.
PC-W (including subunit PP-OM)[1]				
PC-E				
TC-OM				
North Central	8	1.0	—	
TC-1				
TC-RC				
South Central	8	1.0	—	
WM				
TC-2B				
TC-2A				
TC-3A				
TC-3B				
South	8	1.0	—	
TC-4				
TC-5				
TC-AB				
Semi-Aquatic Wildlife				
PC-E	—	—	Marsh Wren: 250	90th percentile concentration across management units that provide suitable foraging habitat for receptor.
PC-W (including subunit PP-OM)[1]	—	Mink: 0.92	Mallard: 2500	
TC-OM			Marsh Wren: 250	

Notes:

— = not calculated because acceptable risk level under existing conditions (see Risk Refinement and Synthesis)

Concentrations presented in mg/kg dry weight

1 The remedial strategy for the PC-OM management unit (originally part of PC-W in Golder 2016; Golder 2017a; and Golder 2019) will be addressed separately, likely through a hybrid of MNR and/or ENR (e.g., thin layer capping) and wetland remediation as discussed in Section 11.2.1.3.

10.3.1 Benthic Invertebrates

The numerical sediment management criterion derived for the protection of the benthic community (i.e., 22.8 mg/kg) is protective against risks exceeding moderate magnitude for this receptor group. The management actions for the protection of benthic invertebrates are focused on total PAHs. The criterion was set equal to the upper range of the probable effects concentration (PEC; MacDonald et al. 2000), which was categorized as having the potential for moderate risk to benthic invertebrates in the Risk Refinement and Synthesis. The PEC and the results form the ecological risk assessment support the use of this value for management of sediment areas; localized sediment toxicity to benthic invertebrates was generally observed in sediments with PAH concentrations above 22.8 mg/kg, and toxicity identification evaluations conducted in the detailed quantitative risk assessment (DQRA; Golder 2012) confirmed PAHs as a plausible causal agent at these concentrations. Given the observed heterogeneous distribution of PAHs within management units and prevalence of benthic invertebrate communities throughout KIH, it is recommended that the numerical sediment management criteria for benthic invertebrates be applied to all management units in KIH that are subject to physical intervention in the conceptual SMP, and not just those previously identified as having greater than moderate risks.

As benthic invertebrates require protection at the community level, the average PAH concentration is considered an appropriate measure of exposure. Localized areas of sediment contamination may exceed 22.8 mg/kg total PAH provided that the average concentrations within each management unit do not exceed this value.

10.3.2 Fish

The numerical sediment management criteria derived for the protection of fish health (i.e., 8 mg/kg for total PAHs and 1.0 mg/kg for total PCBs) are protective against risks exceeding low magnitude. The numerical sediment management criteria were set equal to benchmarks derived in the Risk Refinement and Synthesis to be protective against increases in deformity rates in bottom-dwelling fish. These include the 8 mg/kg total PAH concentration benchmark categorized as having moderate risk of increased deformity incidence and the 1.0 mg/kg total PCB concentration benchmark categorized as having high risk of increased deformity incidence. These benchmarks meet the overall protection goal of a level of risk not greater than “low” for fish health; more conservative estimates of thresholds for adverse effects were not required because the incidence of external deformities and/or liver lesions is a less ecologically meaningful endpoint relative to biological endpoints that are commonly used to evaluate ecological health (i.e., survival, growth, reproduction, and development). Furthermore, the PCB benchmarks developed in the fish deformity evaluation are highly conservative, as they were developed based on empirical associations between sediment PCB concentrations and deformity incidence. The strength of evidence was much stronger for PAHs as a causative agent, based on a known mechanism of action and the conclusions of several independent researchers cited in the literature review. As such, the PCB criterion in Table 5 was based on high magnitude responses, recognizing that PCBs likely contributed negligible to low response to the deformity profile compiled from the literature.

As fish require protection at the population level, the 75th percentile is considered an appropriate measure of exposure. This accounts for the possibility that some fish within each area may preferentially use habitats that have higher than average sediment concentrations. Localized areas of sediment contamination may exceed the sediment criteria (i.e., 8 mg/kg for total PAHs and 1.0 mg/kg for total PCBs) provided that the 75th percentile concentrations do not exceed the criteria across large contiguous areas of water lot, corresponding with foraging habitat for bottom fish.

10.3.3 Semi-Aquatic Wildlife

The numerical sediment management criteria derived for the protection of semi-aquatic wildlife are protective against risks exceeding low magnitude. The numerical sediment management criteria were back-calculated using the food chain model (and associated input parameters) used in the Risk Refinement and Synthesis to derive sediment concentrations that result in low risk (i.e., hazard quotients below 1.0 using the lower-bound toxicity reference values derived by Golder [2012] for chromium and total PCBs). In the Risk Refinement and Synthesis, risks to wildlife receptors were negligible or low for all receptors except for exposures of:

- mink to total PCBs in PC-W and TC-OM
- mallards to chromium in PC-W and TC-OM
- marsh wrens to chromium in PC-E, PC-W, and TC-OM

Semi-aquatic wildlife receptors such as mammals and birds require protection at the population level at minimum and require protection at the individual level for listed species (if present). As such, the 90th percentile is considered an appropriate measure of exposure for semi-aquatic wildlife to avoid potential underestimation of exposure, such as would occur if receptors forage over more contaminated portions of the exposure unit.

- **Total PCBs (mink)**: The criterion derived for the protection of mink (0.92 mg/kg) is protective of sensitive piscivorous mammals. This criterion should only be applied within management units or groups of management units that provide suitable habitat for piscivorous mammals (i.e., within PC-E and within PC-W and TC-OM). Localized areas of sediment contamination may exceed 0.92 mg/kg total PCBs provided that the 90th percentile concentrations do not exceed the sediment management criterion protective of sensitive piscivorous mammals.
- **Chromium (marsh wren)**: The criterion derived for the protection of marsh wren (250 mg/kg) is protective of sensitive herbivorous birds that inhabit marsh areas. This criterion should only be applied within management units that provide suitable habitat for these receptors (i.e., within PC-E, PC-W, and TC-OM). Localized areas of sediment contamination may exceed 250 mg/kg chromium provided that the 90th percentile concentrations do not exceed the sediment management criterion protective of sensitive herbivorous birds that inhabit marsh areas.
- **Chromium (mallard)**: The criterion derived for the protection of mallard (2,500 mg/kg) is protective of avian receptors both inside and outside marsh areas within KIH. This criterion should be applied across the large contiguous areas that provide suitable habitat for these receptors, where current sediment chromium concentrations exceed acceptable risk thresholds (i.e., within PC-W and TC-OM). Localized areas of sediment contamination may exceed 2,500 mg/kg chromium provided that the 90th percentile concentrations do not exceed the benchmark for protection of avian receptors.

11.0 RECOMMENDED SEDIMENT MANAGEMENT PLAN

This section presents the recommended sediment management plan for each management unit.

The 2021 draft conceptual SMP presented potential sediment management options for each management unit based on a high, medium, and low level of intervention (Golder 2021a). Based on feedback on the 2021 conceptual SMP, a high intervention scenario is not applied to any of the management units. This plan provides an intermediate approach (blending low- to moderate-intervention) that lessens the disruption to significant “social and ecological areas”, with emphasis on reducing the highest chemical risks.

The recommended sediment management plan is based on integration of the scientific findings, a preliminary assessment of constraints (summarized in Table 4 above), and Indigenous and stakeholder concerns. The selected remedial approach for each management unit considered the following:

- **Lacustrine Considerations**—Minimizing or selectively limiting changes to bathymetry, shoreline geometry, and submerged aquatic vegetation to maintain desired properties of sediment resuspension, erosion potential, and habitat value (see Section 6.4 for details).
- **Biological Considerations**—Limiting the alteration of biological resources from physical interventions such as dredging (see Section 7.0 for details).
- **Nature-Based Shoreline Rehabilitation**—Incorporating nature-based shoreline protection features where possible to stabilize the shoreline (reducing the potential for riverbed erosion and transport) and limit potential human access, while enhancing turtle and other wildlife habitat and native riparian vegetation (see Section 9.3 for details).
- **Archaeological Considerations**—Avoiding, through buffers or other controls, the disturbance of archeological sensitive areas; details of these locations are currently being confirmed with an underwater archaeological impact assessment (see Section 8.0).
- **Lot Management**—Lot ownership and management within KIH is complex and the jurisdiction of each management unit was taken into consideration. The majority of the KIH study area falls under the management and jurisdiction of the federal government. There are, however, some parcels of water and sediment that fall under separate jurisdiction (both private and municipal), requiring liaison among affected parties to achieve a mutually satisfactory sediment management design.
- **Urban Development Planning**—The City of Kingston development plan for the North King’s Town district has direct relevance to the sediment management planning for KIH, particularly as the City of Kingston Official Plan (2019 [consolidated in 2022]; under which the North King’s Town Secondary Plan is being prepared) contains information relevant to the development or alteration of waterfront lands. Section 2.8.3 of the draft Official Plan deals with the protection of waterfront areas and references a goal of protecting a 30-metre “Ribbon of Life” zone along waterfronts where practical.

Additional considerations included:

- Candidate techniques available for sediment management (Section 9.0).
- Contiguous areas of contamination that may influence the practicality and economies of scale for a dredging program.
- Sediment management options that eliminate or reduce contaminant-based hazards (particularly where multiple risk pathways or contaminants can be reduced simultaneously) but also those that align well with urban redevelopment, biological, recreation, and aesthetic values.
- Upland fate/transport linkages to which upgradient sources of contamination have been controlled.
- An evaluation of costs and benefits of candidate management alternatives.

The proposed remedial design includes a combination of dredging, conventional capping, ENR (such as thin-layer activated carbon capping), nature-based shoreline rehabilitation, and MNR. In all cases, the final design will depend on the outcomes of the DIA to ensure that SAR, cultural and archeological considerations, and sensitive ecological features are not harmed as part of sediment management work, as well as to ensure that permit requirements are met.

Figure 3 depicts the draft layout of the sediment management plan, including areas of proposed sediment excavation (dredging) and surrounding areas of lower intervention remedial methods.

11.1 Harbour-Wide Summary

The following bullets summarize key elements of the recommended sediment management plan:

- **Primary Sediment Management Strategy**—The management method with the greatest area and volume of sediments in KIH is monitored natural recovery, due to the large areas of sediment in the central and eastern portions of KIH that do not require physical intervention. The primary intrusive sediment management strategy for KIH will be dredging, with off-site disposal of contaminated material. There are some areas for which a thin-layer (up to 0.3 m) cover with activated carbon (referred to herein as a thin-layer cap) is more appropriate, such as portions of management units TC-AB, TC-2A, TC-3A, TC-4, and PC-W. Within Anglin Bay, a thicker (0.7 m) sand cap, followed by a thin-layer cap (0.3 m) with activated carbon is recommended.
- **Level of Intervention**—Relative to the draft conceptual remedial options and based on the refinements to incorporate nature-based shoreline rehabilitation and shoreline exclusion zones for dredging to protect sensitive biological, archeological, and lacustrine features, the dredge footprint has been reduced for multiple management units. Management in place (MNR or ENR) will be a significant component of the recommended sediment management strategy, considering the magnitude of risk and the preferences of stakeholders and Indigenous communities. This considers the cost and high short-term environmental disturbance associated with a large dredging program. Focused physical management will be in areas with lower degree of environmental disturbance but a high degree of contaminant removal, particularly where multiple contaminants and/or receptors can receive reduced contaminant-related risk where dredging is performed.

- **Nature-Based Shoreline Rehabilitation**—This is a new design concept incorporated into the revised conceptual SMP to address Indigenous groups and stakeholder's recommendations for shoreline enhancements that will improve ecological habitat, improve shoreline stability, reduce erosion, and deter human uses. Other benefits of the nature-based approach for KIH include maintenance or enhancement of shoreline fish and turtle habitat, establishment of aquatic coastal and riparian vegetation, beautifying the shorelines, limiting the potential for human access to the water, and replacement of invasive species with native species. Nature-based shoreline rehabilitation is proposed for management units TC-RC, WM, TC-2A, TC-3A and TC-4.

- **Dredging Exclusion Zones**—A buffer between shorelines and dredging areas has been added to protect lacustrine processes (Section 6.4), sensitive species and habitats (Section 7.0), and in-land source control measures for legacy contaminants from any potential adverse effects. This includes a setback of 10 m from the north of PC-E and PC-W, and a setback of 5-10 m across all other shorelines (except for within Anglin Bay).

- **Management Unit Priorities**—Management units categorized with a minimum rating of moderate priority for risk management were the emphasis of physical intervention (Golder 2016). The risks in PC-N and TC-E were demonstrated to be negligible and it was recommended by Golder (2017a) that management units TC-1, TC-2B, TC-3A, TC-3B, and TC-5 be excluded from active management (dredging or ENR) and instead considered for MNR, given that the estimated degree of contaminant reduction per unit area is low relative to other management units. As a result, some risk tolerance for sensitive ecological endpoints (e.g., fish deformities and modest benthic invertebrate community alterations) would be required for these management units. Dredging of sediments in these management units would be expensive to implement, has low environment benefit per unit cost relative to other areas, and would yield significant short-term environmental alteration, including disruption of dense macrophyte beds used by fish. The residual risks associated with some of the contaminated sediment being left in place is discussed in Section 11.3.

11.2 Customization to Management Units

Recommended sediment management actions for each management unit are summarized in Table 6. Cost estimates for the conceptual SMP are presented in Appendix D for each management unit. The following subsections provide a narrative for each management unit, including key assumptions that guided the sediment management action for each unit.

Table 6: Recommended Sediment Management Actions for Each Management Unit

Unit	Jurisdiction(s) within Management Unit	Overall Priority for Risk Management	Contaminant(s) Targeted for Intervention [2]	Other COCs Elevated in Management Unit [3]	Primary Management Options [1]					Summary of Sediment Management Actions
					Dredging	Monitored Natural Recovery	Nature-based shoreline rehabilitation	Conventional Capping	Enhanced Natural Recovery (thin-layer cap/ amendments)	
PC-W	PCA Potentially Private or Municipal Party	**Very High**	PAHs, PCBs, Cr	Sb, Pb, Hg, Ag, Zn	☑	☑		—	☑	Includes sediment removal through dredging in the open water portion of the PC-W management unit and the PP-OM subunit [4]. Following dredging a mixed thin layer cap with carbon amendments is recommended. In the western portion (PC-OM subunit), a variety of alternatives will be considered to carefully balance among contaminant risk removal, maintenance of sensitive habitat features, and alignment with recreational uses of KIH. These will be completed in future design stages; refer to Section 11.2.1.3 for further details. A dredging buffer zone from the shoreline (10 m) is included along the north shore of PC-W, specific to protecting turtle-basking habitat and other wildlife. A dredging buffer zone is also included along the PP-OM shoreline (5 m) to protect wildlife and shoreline integrity. **(moderate intervention)**
TC-RC	TC	**High**	PAHs	Sb, As, Cr, Pb, Hg, Ag, Zn, PCBs	☑	☑	☑	—	☑	Includes sediment removal through dredging followed by the placement of a thin layer cap in the southwest portion of the management unit. This provides the best opportunity for chemical risk reduction by focussed dredging in the most contaminated area. Nature-based shoreline rehabilitation also proposed and will focus on nature-based rehabilitation to preserve sensitive ecological habitats and deter human access to the water. A dredging buffer zone from the shoreline (5 – 10 m) is included along the western shoreline to protect wildlife and shoreline integrity. **(low-moderate intervention)**
TC-AB	TC City of Kingston DND	**High**	PAHs	Sb, Cr, Cu, Pb, Ag, Zn, PCBs	☑	☑	—	☑	☑	The use of dredging and various cap types in TC-AB is focussed primarily on reducing the level of PAH exposure associated with historical sources. There is a high probability that significant PAH mass removal could be achieved within the interior portion of TC-AB (Anglin Bay). A conventional cap with carbon amendments will also be applied in Anglin Bay following dredging to further reduce any residual risk. A small area (0.4 ha) that borders TC-4 also includes dredging to remove the higher levels of contamination. A thin-layer cap is recommended to enhance the recovery across the management unit (except in Anglin Bay where a conventional cap is placed) **(low-moderate intervention)**
WM	City of Kingston	**Moderate—High**	PAHs	Sb, As, Cr, Pb, Hg, Ag, Zn, PCBs	☑	minor	☑	—	☑	Includes the use of dredging followed by the placement of a thin layer cap in the western and central portion of the management unit. Nature-based shoreline rehabilitation is also proposed and will focus on preserving sensitive ecological habitats and deter human access to the water. A dredging buffer zone from the shoreline (5 – 10 m) is included along the western shoreline to protect wildlife and shoreline integrity. **(moderate intervention)**
PC-E	PCA	**Moderate**	PAHs, Cr	Sb, Pb, Ag, PCBs	☑	☑	—	—	☑	Includes the use of dredging followed by the placement of a thin layer cap in the northeast portion of the management unit, which provides the best opportunity for chemical risk reduction. A dredging exclusion zone from the shoreline (10 m) is included specific to protecting turtle basking habitat, archaeological features, and other sensitive wildlife. **(low-moderate intervention)**

Unit	Jurisdiction(s) within Management Unit	Overall Priority for Risk Management	Contaminant(s) Targeted for Intervention [2]	Other COCs Elevated in Management Unit [3]	Primary Management Options [1]					Summary of Sediment Management Actions
					Dredging	Monitored Natural Recovery	Nature-based shoreline rehabilitation	Conventional Capping	Enhanced Natural Recovery (thin-layer cap/ amendments)	
TC-OM	TC	**Moderate**	PAHs, PCBs, Cr	Sb, Pb	☑	minor	—	—	☑	Includes the use of dredging followed by the placement of a thin layer cap across most of the management unit. A dredging buffer zone from the shoreline (5 m) is included along the western shoreline to protect wildlife and shoreline integrity. **(moderate intervention)**
TC-2A	TC City of Kingston	**Moderate**	PAHs	Sb, As, Cu, Cr, Pb, Hg, Ag, Zn, PCBs	—	☑	☑	—	☑	Although there are moderate elevations of COCs, the spatial extent is constrained by habitat and other water lot characteristics (e.g., cultural features), requiring caution in the level and intensity of intrusive works. Rather than apply intrusive methods such as dredging, less intrusive measures including thin-layer capping and nature-based shoreline rehabilitation are planned. The shoreline rehabilitation will preserve sensitive ecological habitats and deter human access to the water. A dredging buffer zone from the shoreline (5 – 10 m) is included along the western shoreline to protect wildlife and shoreline integrity. **(low intervention)**
TC-4	TC City of Kingston	**Moderate**	PAHs, PCBs	Sb, As, Cr, Hg, Pb, Ag, Zn	☑	minor	☑	—	☑	A hybrid of actions including focussed dredging, partial placement of thin-layer caps, and shoreline rehabilitation and/or enhancement is planned. The ultimate configuration of these techniques will require customization following detailed design with consideration of the archaeological features in the area. The footprint for intrusive management is more likely to decrease than to expand. Nature-based shoreline rehabilitation will preserve sensitive ecological habitats and deter human access to the water. A dredging buffer zone from the shoreline (5 – 10 m) is included along the western shoreline to protect wildlife and shoreline integrity. **(low-moderate intervention)**
TC-5	TC DND	**Low—Moderate**	PAHs	Sb, Cr, Pb, Ag, PCBs	—	☑	—	—	minor	Sediment management would be limited to the placement of a thin layer cap along the border of TC-AB and TC-4, and MNR across most of this management unit. Although there are additional areas of elevated PAH contamination, they are difficult and expensive to delineate, and physical intrusion in this zone would confer low net benefit relative to areas closer to shore. **(low intervention)**
TC-1	TC	**Low**	PAHs	Cr, Pb, Hg, Ag, Zn, PCBs	—	☑	—	—	—	Sediment management would be limited to MNR for this management unit. Although there are some moderate elevations of PCBs and a hotspot of elevated chromium concentrations, the contaminant distribution is variable and would not likely yield a high mass removal per unit of dredging effort. **(low intervention)**
TC-2B	TC City of Kingston	**Low**	PAHs	Cr, Pb, Hg, Ag, PCBs	—	☑	—	—	—	Sediment management would be limited to MNR for this management unit. Although there are some moderate elevations of PCBs, the distribution is variable and would not likely yield a high mass removal per unit of dredging effort. **(low intervention)**
TC-3A	TC City of Kingston	**Low**	PCBs, PAHs	Sb, Cr, Pb, Ag, Hg, Zn	—	☑	☑	—	☑	Although there are moderate elevations of COCs the spatial extent is constrained by habitat and other water lot characteristics (e.g., cultural features), requiring caution in the level and intensity of intrusive works. Rather than apply intrusive methods such as dredging, less intrusive measures including thin-layer capping and nature-based shoreline rehabilitation are planned. Shoreline rehabilitation will preserve sensitive ecological habitats and deter human access to the water. A dredging buffer zone from the shoreline (5 – 10 m) is included along the western shoreline to protect wildlife and shoreline integrity. **(low intervention)**

Unit	Jurisdiction(s) within Management Unit	Overall Priority for Risk Management	Contaminant(s) Targeted for Intervention [2]	Other COCs Elevated in Management Unit [3]	Primary Management Options [1]					Summary of Sediment Management Actions
					Dredging	Monitored Natural Recovery	Nature-based shoreline rehabilitation	Conventional Capping	Enhanced Natural Recovery (thin-layer cap/ amendments)	
TC-3B	TC	**Low**	PAHs	Cr, Pb, Ag, PCBs	—	☑	—	—	—	Sediment management would be limited to MNR for this management unit. Although there are some moderate elevations of PCBs, the distribution is variable and would not likely yield a high mass removal per unit of dredging effort. **(low intervention)**
PC-N	PCA	**Negligible**	None	—	—	—	—	—	—	No action required—sediments are considering local reference conditions **(no intervention)**
TC-E	TC DND	**Negligible**	None	—	—	—	—	—	—	No action required—sediments were evaluated in screening level risk assessment stage and determined to be suitable for in place management **(no intervention)**

Notes:

1. Other options such as institutional controls (e.g., fish consumption or fencing) may be implemented to further reduce risks in selected areas.
2. Contaminants target for intervention include those where potential risks exceed the stated protection goals (as discussed in Section 10.3):

total PAHs in TC-4 and TC-AB for benthic invertebrate communities exceeding moderate- risk thresholds;

total PAHs in all management units (excluding PC-N and TC-E) for fish populations exceeding low-risk thresholds;

total PCBs in TC-4, TC-3A, and PC-W for fish populations exceeding low-risk thresholds; and

total PCBs and chromium in PC-W, PC-E, and/or TC-OM for semi-aquatic wildlife (includes birds, mammals, and by extension, herptiles) exceeding low-risk thresholds.

3. Other COCs in management unit include those that exceed the applicable risk-based screening criteria (e.g., PELs, or 2LAET guideline from Avocet (2003) in absence of PELs)
4. The original PC-W management unit assessed as part of the risk assessment (Golder 2016) and initial remedial assessments (Golder 2017a and Golder 2019) was subdivided for the SMP into three different sub-units: PC-W, PC-OM, and PP-OM to reflect an updated property survey and a different remedial strategy for PC-OM (refer to Section 11.2.1 for further discussion).

11.2.1 PC-W

Because the Parks Canada West (PC-W) management unit includes both federal and non-federal management areas, the sharing of costs and liability, as negotiated amongst the property managers, would benefit and facilitate the sediment management in this area. The management unit has unacceptable risk levels to fish from PAHs and PCBs, and to semi-aquatic wildlife from PCBs and chromium.

The original PC-W management unit presented in Golder (2019) is now subdivided into three management sub-units to reflect an updated property survey where a large portion of the interior wetland habitats along the western edge of the PC-W water lot, previously identified as being managed by PCA, has been clarified to be owned by the City of Kingston (i.e., outside of the formal Project boundary). The sub-units within the Project domain (shown on Figure 2) include:

- PC-W sub-unit—open water property managed by PCA (a subset of the water lot previously defined as PC-W)
- PC-OM sub-unit—Orchard Street March area managed by PCA
- PP-OM sub-unit—open water area, jurisdiction pending confirmation (PP-OM)

The same management strategy is recommended for PC-W and PP-OM, but there is additional complexity involved with management of PC-OM owning to its higher value habitats such as the presence of SAR, potential additional offsetting requirements, and Indigenous and stakeholder concerns. An initial management strategy was included in the cost estimates for PC-OM, but it has been assigned to a special category of low intervention marsh rehabilitation (i.e., not broad scale dredging or capping options). Further planning is needed to address the habitat complexity and sensitivity in this area prior to detailed design.

Due to the complexity in management of wetland habitats, it is recommended that the City of Kingston address sediment management in the interior portion of the wetland as a separate project. Although a unified and collaborative sediment management plan for all three sub-units is preferred, the legal and regulatory requirements for the non-federal portions would differ from the areas managed by PCA. Within the constraints of the federal project, the most important consideration is that shoreline development and/or risk management by other parties in properties adjacent to PC-OM should not exacerbate the current conditions of wetland sediment stability and contaminant flux. For example, erosion protection measures would need to be confirmed for proposed alterations to the brownfield and/or municipal portions of the adjacent wetland. Provided that hydrology, sedimentation, and erosional features are maintained within the cattail marsh, there is flexibility in the implementation schedule for PC-OM, including possible partnerships and exploration of specialized wetland remediation techniques.

The conceptual SMP for each sub-unit within PC-W is discussed below.

11.2.1.1 Main PC-W Sub-Unit

The PC-W management sub-unit requires dredging to address several risk pathways and includes the highest concentrations of several contaminants of interest as well as those that drive the highest environmental risks (i.e., PAHs, PCBs, and chromium). Furthermore, the current distribution of environmental risks across the PC-W unit introduces potential for PC-W sediments to be a source for sediment contamination in other areas as surface sediments are remobilized and transported over time (Golder 2017b). Much of the sediment contamination in KIH, particularly the portion derived from the former tannery development, has been transported through PC-W, gradually spreading into the outlying areas of the harbour over several decades.

As such, the following sediment management actions have been identified for PC-W:

- Dredging 3.4 ha of surface sediment, emphasizing hotspots of chromium and/or organic contamination.
- Placement of 3.4 ha of a thin-layer cap with activated carbon across PC-W. Thin-layer caps would be placed judiciously in near-shore areas to limit the degree of habitat disruption.

Key assumptions and constraints for the proposed sediment management design in PC-W included:

- A dredging exclusion zone from the shoreline of 10 m has been assigned to protect ecological habitat (i.e., turtle basking habitat), lacustrine processes, and the leachate management system for the former Belle Park Landfill.
- Confirmation that upland soil contamination has been appropriately managed through erosion protection measures. This activity would be required only if the sediment management plan was coordinated with an upland brownfield development, to ensure that upland activities (considered as an off-site environmental protection measure, and not included in the cost estimates for sediment management) do not create a pathway for migration of contaminants to the water lot.

Final sediment management details should acknowledge that people may practice recreational sports such as kayaking, canoeing, and paddling, and that these activities may result in direct sediment contact. In these shallow areas, detailed design will consider the slopes and sediment substrate that are appropriate to maintain recreational use, protect against slumping and erosion, and reduce exposure from direct contact.

11.2.1.2 PP-OM Sub-Unit

The PP-OM management unit requires dredging to address several risk pathways and includes the highest concentrations of several contaminants of interest as well as those that drive the highest environmental risks (i.e., PAHs and chromium). Furthermore, the current distribution of environmental risks across the PP-OM unit introduces potential for PP-OM sediments to be a source for sediment contamination in other areas as surface sediments are remobilized and transported over time (Golder 2017b). In this respect, PP-OM is similar to PC-W, with both management units historically serving as conduits to the outlying areas of the harbour.

A significant portion of PP-OM has been identified as recommended for intrusive management. Accordingly, the sediment management actions planned for PP-OM include the following combination of approaches:

- Dredging 1.3 ha of contaminated sediments.
- Placement of a thin-layer cap over 1.3 ha with activated carbon. Thin-layer caps would be placed judiciously in near-shore areas to limit the degree of habitat disruption.

- MNR for the sediments at the eastern margin of the water lot, where concentrations are lower than in nearshore areas.
- A dredging exclusion zone from the shoreline of 5 m to protect ecological habitat and lacustrine processes along the shoreline.

There is some uncertainty with respect to the ownership and environmental liability for this parcel. Federal custodians have not yet confirmed whether the water lot is under their property ownership, but the contamination has moved across multiple water lots in this area. There is ongoing discussion about whether this area will be considered for property redevelopment and the type of plans for shoreline development (e.g., engineered design for viewscapes, recreational use, habitat protection). Any shoreline modifications that physically isolate sediments would confer chemical risk reductions, even if they are not strictly necessary for sediment risk management.

11.2.1.3 PC-OM Sub-Unit

The Parks Canada Orchard Marsh (PC-OM) management unit was assigned a special category of low intervention marsh rehabilitation which may include a hybrid of MNR and/or ENR (e.g., thin layer capping) and wetland remediation. The wetland management component is likely to be shaped further through Indigenous Consultation and Stakeholder Engagement, along with input from the DIA. The methods proposed for wetland management include recognition of sensitive habitats, special techniques for cattail marsh zones, and intrusive methods that are surgical in nature rather than broadly applied.

The specific areas recommended for each method will depend on the habitat values assigned to different portions of the PC-OM management sub-unit (e.g., presence of rare or endangered species, maintenance of habitat for recolonization of disturbed areas, alignment with other shoreline design features), and other factors. Depending on access and the contractor's selected methodology, a thin-layer cap and/or carbon amendment may be placed via hydraulically pumping out of a barge placed at the edge of nearby PC-W or land-based containment box and spreading with a discharge end configured to reduce velocity. Following cap placement, vegetation could be planted using a suitable mix of native plant species.

If any physical intrusive remediation is required to remove hot spots, it would need to be fine-scale and use specialized equipment to minimize disruption. In addition, two special considerations for PC-OM relate to the presence of wetland wildlife species:

- Avian Species at Risk—At indicated in Table 8, the presence of SAR birds [redacted] will influence the final remediation design, both in terms of methods and timing of disturbances. Special consideration will be afforded to [redacted] which is in this management subunit due to the presence of tall marsh vegetation.
- Beaver presence—This is not a SAR, but theses mammals require consideration for the long-term stability and character of the cattail marsh habitat. Beavers can accelerate changes to the hydrological and bioturbation processes in surface sediments relative to other sediment disturbances, partly due to aggressive digging in some areas, and changes to flow regime from construction of canals and dams. The SMP has deferred development of detailed remediation methods linked to beaver activity pending the results of the DIA The latter will identify both sensitive ecological features and species that can

modify the flow and sediment transport regime (including "ecosystem engineers" like beavers). Some of the beaver activities may challenge the implementation of soil and sediment erosion protection measures, whereas other impacts of beavers may be favorable (sediment traps reducing flow velocity, increased structural heterogeneity of the environment).

The management of the wetland areas must be undertaken with great care to provide confidence that the habitat alterations and/or modification to flow regime do not result in undesired and unintended consequences. For this reason, it is unlikely that remediation of PC-OM will be undertaken concurrently with open-water sediment parcels. Careful review of low-intervention methods for the wetland area (including incorporation of new information on sensitive habitats and species at risk) is warranted.

11.2.2 PC-E

The Parks Canada East (PC-E) management unit contains moderate levels of chemical contamination for several COCs (PAHs, Cr). The concentrations of PAHs have resulted in unacceptable risk to fish, and the concentrations of chromium have resulted in unacceptable risks to semi-aquatic wildlife. However, much of the management unit contains sediments within acceptable ecological and human health risk levels.

The sediment management plan for PC-E includes the following combination of approaches:

- Dredging 1.5 ha of contaminated sediments. This includes the portion of the management unit that is adjacent to the eastern lobe of PC-W, and with similar sediment contamination profile, plus a small portion of the southeastern edge that is closest to PP-OM and TC-OM.
- Placement of 1.5 ha of a thin-layer cap with activated carbon across dredged areas. Thin-layer caps would be placed judiciously in near-shore areas to limit the degree of habitat disruption.
- MNR for the sediments in the remaining areas of the water lot, where concentrations are expected to be lower than in nearshore areas.
- A dredging exclusion zone of 10 m from the shoreline adjacent to Belle Park, intended to protect ecological habitat (i.e., turtle basking habitat), lacustrine processes, and the leachate management system for the former Belle Park Landfill.

11.2.3 TC-OM

Elevated PAHs to the south, chromium to the north, and widespread PCBs are the main driver for sediment management within the Transport Canada Orchard Marsh (TC-OM) management unit. The concentrations of PAHs have resulted in unacceptable risk to fish, and the concentrations of PCBs and chromium have resulted in unacceptable risks to semi-aquatic wildlife.

A significant portion of TC-OM has been recommended for intrusive management. Part of this recommendation comes from the identification of shared concentrations of elevated chromium near the northwestern shoreline. Accordingly, the sediment management actions planned for TC-OM include the following combination of approaches:

- Dredging 1.6 ha of contaminated sediments.
- Placement of a thin-layer cap over 1.6 ha with activated carbon. Thin-layer caps would be placed judiciously in near-shore areas to limit the degree of habitat disruption.
- MNR for the sediments at the eastern margin of the water lot, where concentrations are lower than in nearshore areas.
- A dredging exclusion zone from the shoreline of 5 m to protect ecological habitat and lacustrine processes along the shoreline.

The small square unit of private water lot along the southern end of TC-OM will not be physically managed, due to the complexity of ownership and the slightly lower chemical concentrations in this area. Leaving this area of water lot non-remediated would not significantly impact the overall remediation effectiveness for the Transport Canada water lot (e.g., unit TC-OM). However, if the upland soil brownfield redevelopment proceeds, the proponent would need to delineate and address any contamination associated with sediment disturbance in that area, and confirm lack of enhanced erosion potential to KIH. Those management decisions need not be tied directly to the federal sediment management program. In contrast to the privately owned square unit, the northern and central portions of TC-OM are currently shown as being under TC jurisdiction right up to and including the riparian area. It was assumed that the shoreline would be maintained in a quasi-natural state.

11.2.4 TC-RC

Higher concentrations of PAHs were observed within the southern portion of the Transport Canada Rowing Club (TC-RC) management unit, especially along the shoreline. TC-RC exhibits hot spots for several other COCs indicative of historical industrial sources. The concentrations of PAHs have resulted in unacceptable risk to fish.

The sediment management actions planned for TC-RC include the following combination of approaches:

- Dredging 0.64 ha of contaminated sediments in the southernmost portion of TC-RC.
- Placement of 0.64 ha of a thin-layer cap with activated carbon where dredging occurs. Thin-layer caps would be placed judiciously in near-shore areas to limit the degree of habitat disruption.
- MNR for the TC water lots associated with the utilities corridor across KIH and the northern portion of TC-RC. Both the bathymetric profiles and sediment quality data confirm that the historical removals of sediments along this corridor have reduced risks to acceptable levels.
- A dredging exclusion zone from the toe of the existing rock protection on the shoreline of 5 – 10 m to protect ecological habitat and lacustrine processes along the shoreline, as well as to accommodate the nature-based shoreline rehabilitation design for conservation, erosion protection and chemical risk mitigation where practical (See Section 12.1.5).

- Existing rock armouring is present intermittently along the shoreline, and opportunities for conservation gains or habitat improvement are potentially possible at select locations without compromising shoreline stability.
- Planting of a single row of native species along the existing pathway to deter human access to the water. Existing vegetation will be kept intact to minimize disturbance to existing turtle hatching habitat.
- Placing large woody debris to be stabilized using boulders in the buffer zone between the shoreline toe and dredged area. The proposed approach is expected to enhance aquatic habitat and reduce wave impact on existing shoreline.

Key assumptions and constraints for the proposed management in TC-RC included:

- The central area of the utilities corridor will remain undisturbed. Recent delineation sampling along the margins of the utilities corridor confirms that sediment chemistry remains less contaminated relative to other parts of TC-RC, and the bathymetry in that corridor is already deeper than proposed dredged areas. We do not recommend additional excavations in this area due to potential for infrastructure damage.
- Disruptions in shoreline uses, including existing boat docks, will be accommodated within the construction designs, or even enhanced long-term through engineering.

11.2.5 TC-AB

PAH contamination was observed to variable degrees within the Transport Canada Anglin Bay (TC-AB) management unit, resulting in moderate to high environmental risk determinations for benthic invertebrates, fish, and humans.

The sediment management actions planned for TC-AB include the following combination of approaches:

- Dredging 1.6 ha of contaminated sediments over most of the interior portion of the management unit (i.e., enclosed portion of Anglin Bay) and some outer portions.
- Replacement of the sediment in Anglin Bay with a multi-layer engineered cap consisting of a moderate thickness (0.7 m) sand layer overlain by a thinner activated carbon cap layer (0.3 m).
- Placement of 3.1 ha of a thin-layer cap and activated carbon over the rest of the management unit. Thin-layer caps would be placed judiciously in near-shore areas to limit the degree of habitat disruption.
- MNR for some sediments underneath marina structures that cannot be accessed without significant disruption.

Key assumptions and constraints for the proposed management activities in TC-AB included:

- Ship mooring infrastructure and geotechnical constraints were determined to be the primary constraints to the dredging activities, and would limit the proximity of dredging to the margins of the management unit and/or necessitate slopes to dredge cuts that reduce the volumes of sediment that can be safely excavated.

- Existing bathymetry within the enclosed portion of Anglin Bay would be satisfactory for long-term operation of the bay as both a recreational and industrial port.
- Removal of the uppermost one metre of contaminated sediment was determined sufficient for costing purposes. Gross contamination (i.e., free product concentrations of non-aqueous phase liquid) would not be prevalent at the new sediment surface prior to cap placement. Given the heterogeneity of the PAH contamination, additional volumes of removal may be necessary and/or consideration of additional cap design elements to limit upward migration of PAH contamination.

11.2.6 WM

The Woolen Mill (WM) management unit is currently wholly managed by the City of Kingston and exhibits locally high elevated concentrations of PAHs and PCBs and concentrations of several other COCs (e.g., mercury, and arsenic). The concentrations of PAHs have resulted in unacceptable risk levels to fish. These COCs are indicative of historical industrial sources, especially along the shoreline. Multiple contaminants are co-occurring, yielding high efficiency (benefit per unit of effort) mass reduction in these areas that would also reduce harbour-wide average exposure for multiple contaminants. Accordingly, the sediment management actions planned for WM include the following combination of approaches:

- Dredging 1.1 ha of contaminated sediments.
- Placement of a thin-layer cap over 1.1 ha with activated carbon. Thin-layer caps would be placed judiciously in near-shore areas to limit the degree of habitat disruption.
- MNR for the sediments at the eastern margin of the water lot, where concentrations are lower than in nearshore areas.
- A dredging exclusion zone from the toe of the existing rock protection on the shoreline of 5 to 10 m to protect ecological habitat and lacustrine processes along the shoreline, as well as to accommodate the nature-based shoreline rehabilitation design for conservation, erosion protection, and chemical risk mitigation where practical (See Section 12.1.5).
- Existing rock armouring is present intermittently along the shoreline, and opportunities for conservation gains or habitat improvement are potentially possible at select locations without compromising shoreline stability.
- Planting of a single row of native species along the existing pathway to deter human access to the water. Existing vegetation will be kept intact to minimize disturbance to existing turtle hatching habitat.
- Placement of large woody debris to be stabilized using boulders in the buffer zone between the shoreline toe and dredged area. The proposed approach is expected to enhance aquatic habitat and reduce wave impact on the existing shoreline.

Key assumptions and constraints for the proposed sediment management plan in WM included:

- WM will be remediated (including dredging and thin layer capping) in a manner compatible with adjacent sediment units, and that the remedial methods will align with adjacent remediation at TC-2A to the south and TC-RC to the north.

- Cost estimates were calculated without consideration of long-term liability, and without any requirement for cost-sharing among multiple responsible parties. Costs could be reduced though efficiencies that may occur from conducting works in this area concurrently with management activities in neighbouring units.

11.2.7 TC-4

PCB contamination within the Transport Canada Unit 4 (TC-4) management unit is heterogeneous but contributes to harbour-wide bioaccumulation in fish. PAH contamination in TC-4 also appears more widespread and higher in magnitude than in TC-2A or TC-3A, and contributes to unacceptable risk levels for benthic invertebrates and fish.

The recommended sediment management approach for TC-4 is to apply the following combination of approaches:

- Dredging 1.8 ha of TC-4 sediment to address areas of maximum PCB and PAH contamination.
- To limit the areal extent of dredging, application of 3.7 ha of thin-layer cap with activated carbon (both on the dredge cut zone and the non-dredged areas), where water depth will accommodate. Thin-layer caps would be placed judiciously in near-shore areas to limit the degree of habitat disruption.
- A dredging exclusion zone from the toe of the existing rock protection on the shoreline of 5 to 10 m to protect ecological habitat and lacustrine processes along the shoreline, as well as to accommodate the nature-based shoreline rehabilitation design for conservation, erosion protection and chemical risk mitigation where practical (See Section 12.1.5).
- Existing rock armouring is present intermittently along the shoreline, and opportunities for conservation gains or habitat improvement are potentially possible at select locations without compromising shoreline stability.
- Planting of a single row of native species along the existing pathway to deter human access to the water. Existing vegetation will be kept intact to minimize disturbance to existing turtle hatching habitat.
- Placement of large woody debris to be stabilized using boulders in the buffer zone between the shoreline toe and dredged area. The proposed approach is expected to enhance aquatic habitat and reduce wave impact on existing shoreline.

Key assumptions and constraints for the proposed sediment management plan in TC-4 include:

- Due to the presence of shipwreck hulls, the ultimate configuration of intrusive remediation (e.g., dredging) will require customization following detailed design with consideration of the archaeological features in the area. Shoreline designs in this area may need to consider additional ways to deter human access to manage shoreline contaminants through physical isolation or administrative controls.

11.2.8 TC-2A

The Transport Canada Unit 2A (TC-2A) management unit has environmental risks driven primarily by PAHs, with localized elevation of other COCs such as PCBs and mercury. The concentration of PAHs has resulted in unacceptable risk levels to fish. Due to the habitat values of the area, including the presence of turtle nesting sites, and shipwreck hulls, intrusive dredging for this management unit was not recommended. Maintenance of the dense macrophyte community is an example of an ecological feature in the nearshore areas that may be valued by Indigenous communities and other stakeholders.

Accordingly, the management activities planned for TC-2A include the following combination of approaches:

- Thin-layer capping of contaminated sediments, incorporating an activated carbon amendment to reduce exposure in 2.4 ha. Thin-layer caps would be placed judiciously in near-shore areas to limit the degree of habitat disruption.
- A dredging exclusion zone from the toe of the existing rock protection on the shoreline of 5 to 10 m to protect ecological habitat and lacustrine processes along the shoreline, as well as to accommodate the nature-based shoreline rehabilitation design for conservation, erosion protection and chemical risk mitigation where practical (See Section 12.1.5).
- Existing rock armouring is present intermittently along the shoreline, and opportunities for conservation gains or habitat improvement are potentially possible at select locations without compromising shoreline stability.
- Planting of a single row of native species along the existing pathway to deter human access to the water. Existing vegetation will be kept intact to minimize disturbance to existing turtle hatching habitat.
- Placing large woody debris to be stabilized using boulders at the edge of the shoreline toe. The proposed approach is expected to enhance aquatic habitat and reduce wave impact on existing shoreline.

11.2.9 TC-3A

The Transport Canada Unit 3A (TC-3A) management unit has environmental risks driven primarily by PAHs, with localized elevation of other COCs such as mercury and PCBs. The concentration of PAHs and PCBs is contributing to unacceptable risks to fish. A similar approach to TC-2A (Section 11.2.8) is recommended for TC-3A. Accordingly, the management activities planned for TC-3A include the following combination of approaches:

- Thin-layer capping of contaminated sediments, incorporating an activated carbon amendment to reduce exposure in 1.6 ha; thin-layer caps would be placed judiciously in near-shore areas to limit the degree of habitat disruption.
- A dredging exclusion zone from the toe of the existing rock protection on the shoreline of 5 to 10 m to protect ecological habitat and lacustrine processes along the shoreline, as well as to accommodate the nature-based shoreline rehabilitation design for conservation, erosion protection and chemical risk mitigation where practical (See Section 12.1.5).
- Existing rock armouring is present intermittently along the shoreline, and opportunities for conservation gains or habitat improvement are potentially possible at select locations without compromising shoreline stability.
- Planting of a single row of native species along the existing pathway to deter human access to the water. Existing vegetation will be kept intact to minimize disturbance to existing turtle hatching habitat.
- Placing large woody debris to be stabilized using boulders at the edge of the shoreline toe. The proposed approach is expected to enhance aquatic habitat and reduce wave impact on the existing shoreline.

11.2.10 Remaining Management Units

MNR is the primary management method proposed for the remaining management units listed in Table 6 and depicted in Figure 3. For these areas, physical intrusion would reduce chemical exposures to several ecological receptors, including mobile receptors such as sportfish that integrate their exposure over wide areas. However, the magnitude of risk reduction, relative to the costs of management measures and other constraints (short term habitat destruction, navigational depth, etc.) result in a much lower priority for active management:

- **Transport Canada Units 1 and 2B**—Some moderate magnitude elevations of PCB and chromium concentrations in sediment were observed but the distribution was heterogeneous and unlikely to provide high mass removal per unit of dredging effort.
- **Transport Canada Unit 3B**—Although there are some moderate magnitude elevations of PCB concentrations in sediment, the distribution is uncertain and would not likely yield a high mass removal per unit of dredging effort. No intrusive management actions are planed for this unit.
- **Transport Canada Unit 5**—The limited areas of elevated PAH contamination would be difficult and expensive to delineate, and management of this management unit would confer low net benefit relative to areas closer to shore. Intrusive management activities planned for this management unit includes the placement of 0.7 ha of thin layer capping at the edge of TC-4 and TC-AB.

In addition to the above management units, the Transport Canada East (TC-E; eastern portions of KIH) sediments, and the entirety of Parks Canada North (PC-N; upstream reference) had previously been excluded from any consideration of intrusive management (Golder 2012, 2016, 2017a). The sediment management plan for these areas remains a "no action" recommendation based on the negligible risks identified for those areas.

11.3 Residual Risks

As described above, not all contaminated sediments that exceed the "negligible" risk category in the Risk Refinement and Synthesis (Golder 2016) are planned for removal in the conceptual SMP and MNR/ENR will be a significant component of the sediment management plan. Therefore, a degree of residual risk is assumed in the successful completion of the Project to the specifications shown in Figure 3.

To evaluate the predicted overall reductions in risk associated with implementation of the conceptual SMP, post-implementation sediment concentrations were calculated for each management unit (or group of management units depending on the receptor being assessed) and used to evaluate residual risks based on the numerical sediment management criteria presented in Section 10.3. The details on this evaluation are presented in Appendix E.

A summary of the results of the assessment of residual risks to ecological receptors is presented in Table 7. As shown in the table, it is predicted that the protection goals listed in Section 10.3 will be met with full implementation of the SMP (i.e., an overall level of risk not greater than "moderate" will be achieved for benthic invertebrates and an overall level of risk not greater than "low" will be achieved for fish health, birds, and mammals). This is a conservative (i.e., cautious) evaluation as the calculations for residual risk only considered the potential for reduced concentrations from the proposed dredging, whereas a much larger footprint will also include ENR (i.e., thin layer capping with carbon amendments) that will also reduce concentrations across several management units.

Table 7: Summary of Residual Risks to Ecological Receptors from Sediment in KIH

<table>
<tr><th rowspan="2">Management Unit</th><th colspan="4">Ecological Receptors</th></tr>
<tr><th>Effects to Benthic Community</th><th>Effects to Fish Health</th><th>Effects to Birds</th><th>Effects to Mammals</th></tr>
<tr><td>PC-N*</td><td>Negligible</td><td>Negligible</td><td>Negligible</td><td>Negligible</td></tr>
<tr><td>TC-E*</td><td>Negligible</td><td>Negligible</td><td>Negligible</td><td>Negligible</td></tr>
<tr><td>PC-E</td><td>Low</td><td rowspan="3">Low</td><td>Low</td><td>Low</td></tr>
<tr><td>PC-W (including PP-OM sub-unit) [1]</td><td>Low</td><td>Low</td><td>Negligible</td></tr>
<tr><td>TC-OM</td><td>Negligible</td><td>Low</td><td>Low</td></tr>
<tr><td>TC-1*</td><td>Negligible</td><td rowspan="2">Low</td><td rowspan="2">Negligible</td><td rowspan="10">Negligible</td></tr>
<tr><td>TC-RC</td><td>Negligible</td></tr>
<tr><td>WM</td><td>Low</td><td rowspan="5">Low</td><td rowspan="3">Negligible</td></tr>
<tr><td>TC-2B*</td><td>Moderate (localized)</td></tr>
<tr><td>TC-2A</td><td>Negligible</td></tr>
<tr><td>TC-3A</td><td>Low</td><td rowspan="3">Negligible</td></tr>
<tr><td>TC-3B*</td><td>Moderate (localized)</td></tr>
<tr><td>TC-4</td><td>Negligible</td><td rowspan="3">Low</td></tr>
<tr><td>TC-AB</td><td>Low</td><td rowspan="2">Negligible</td></tr>
<tr><td>TC-5*</td><td>Moderate (localized)</td></tr>
</table>

Notes:

N/A = not applicable; management unit not assessed for endpoint

* Monitored natural recovery is the primary management method proposed for these management units

Negligible Risk

Low Risk

Moderate

1 The original PC-W management unit assessed as part of the risk assessment (Golder 2016) and initial remedial assessments (Golder 2017a and Golder 2019) was subdivided for the SMP into three different sub-units: PC-W, PC-OM, and PP-OM to reflect an updated property survey and a different remedial strategy for the Orchard Street Marsh (refer to Section 11.2.1 for further discussion). As such, PC-OM is not included in the residual risk analysis.

The implementation of the SMP will result in a long-term steady improvement of conditions throughout the entire western half of KIH for all above receptor groups. Some long-term improvements in exposure reductions will also be observed in areas that are not directly physically managed. Recirculation of sediments via resuspension and settling will occur, although the rate of lateral sediment mixing will be restricted due to the overall low energy environment and sediment transport dynamics of KIH. The removal of the most heavily contaminated sediments is anticipated to result in positive effects to adjacent sediments flagged for MNR areas over subsequent decades.

12.0 DESIGN UPDATES

The following sections outline the advances in conceptual design and associated assumptions made since the first draft of the SMP. Design drawings are provided in Appendix F. The design considerations to reduce risk to valued components are summarized at the end of this section based on the suggestions provided in the CCIC (SNC Lavalin 2023b).

12.1 Engineering Design

12.1.1 Mechanical Dredging

It has been assumed for preliminary design and costing that mechanical dredging would be performed using a closed clamshell environmental bucket inside of a turbidity control curtain. However, dredging methods may be adjusted to address site conditions and logistical challenges. It is assumed that the Contractor will determine the appropriate dredging method based upon past experience, available equipment, site limitations, and BMPs. For costing and equipment access purposes, a dredge depth of 1 m has been assumed.

During dredging, the following environmental controls should be implemented to reduce the potential for the mobilization and transport of dredged sediments:

- The dredge will control the penetration depth of the bucket to:
  - minimize the total number of passes needed to dredge the required sediment volume
  - minimize the loss of sediment due to extrusion through bucket vents openings or hinge area
- The dredge will control the rate of descent of the bucket to maximize the vertical cut of the clamshell bucket while not penetrating the sediment beyond the vertical dimension of the open bucket (i.e., overfilling the bucket).
- The closed clamshell environmental bucket will be lifted slowly through the water to reduce induced turbidity.
- The dredged material will be deliberately placed into a barge to prevent spillage of material overboard.
- The discharge (i.e., overflow) of untreated water from the barge into which dredged material is placed will be prohibited. Water should be physically treated (i.e., by filtration or settlement) to remove suspended solids prior to release into the harbour following dewatering of dredged sediment.

The dredged sediment will be transported on the barge to a dewatering location (either a temporary dock barge or anchored within the turbidity curtain at an approved place) where free water would drain from the dredgeate and be physically treated prior to discharge to the receiving environment once water quality is acceptable (refer to Section 6.3.1 for further discussion on the development of water quality EPOs).

The dredged area within Anglin Bay will be replaced with a conventional cap (see Section 12.1.3), whereas all other dredged areas will be covered with a thin surficial layer cap (15−30 cm). In all cases, sand mixed with organic materials and carbon amendments will be used for the thin layer capping material to promote macrophyte growth, the re-colonization of benthic invertebrates and to reduce the bioavailability of any dredged residuals (see Section 12.1.4).

12.1.2 Stabilization and Solidification

Following dewatering, the dredgeate will be treated ex situ using a stabilization and solidification process. Stabilization and solidification (S/S) are a soil remediation process by which contaminants are rendered immobile through reactions with additives or processes, such as mixing with cement powder. During this process, also called immobilization, fixation, or encapsulation, contaminants may be chemically bound or encapsulated into a matrix. Solidification does not remove nor degrade contaminants but prevents their transport by eliminating or significantly hindering their mobility. Stabilization and solidification as a process accomplishes one or more of the following:

- Improves physical characteristics of sediment (i.e., by decreasing the water content and slump) to facilitate handling, trucking, and offsite disposal.
- Limits solubility of hazardous contaminants in the waste.

12.1.3 Conventional Capping

A conventional cap entails covering contaminated sediment, which remains in place, with clean material that may or may not include geotextiles, liners, and other permeable or impermeable materials in multiple layers. Conventional capping is only proposed in Anglin Bay (TC-AB). The conventional cap will consist of roughly 70 cm of sand overlain by 15-30 cm thin layer cap of sand and organic material combined with a carbon amendment .

Method for placement will be determined by the Contractor but will likely involve placement of the cap using a clamshell bucket to remove the sand from a material barge and lowering it to the bottom, or by hydraulically pumping the sand out of a barge or land-based containment box and spreading it with a discharge end configured to reduce velocity. The spreading could be performed through use of baffle plates, upturned ends, and/or wider end sections. Alternatively, the sand may be pumped into a floating box with a grated bottom or through a grate to allow sand to “rain down” to the bottom.

12.1.4 Enhanced Natural Recovery

A thin layer cap (~15−30 cm) including sand and organic material combined with a carbon amendment offers some potential for assisting the natural recovery. Particularly, for some areas for which there are low-to-moderate risks following dredging, and in areas where it would be extremely difficult to reliably delineate hotspots for dredging. Furthermore, the potential spatial extent of these marginally contaminated areas is large for substances such as PAHs and PCBs, rendering a dredging-based solution costly and with high short-term impact to the ecological communities.

Activated carbon materials (and other carbonaceous amendments such as coal and coke breeze) have been used in pilot- and full-scale applications for in situ sediment remediation and are attractive amendments because of their strong sorbent properties (i.e., often 10 to 100 times greater than absorption to organic carbon alone) (US EPA 2013). This amendment has been demonstrated to be effective in sorbing PAHs, PCBs, and dioxins/furans, making them less bioavailable (Ghosh et al. 2011; Patmont et al. 2015). The resulting adsorption is strong enough to lower the pollutant’s bioavailability and mobility significantly, limiting its release from sediment into the water and uptake into organisms (Abel and Akkanen 2018). Bench scale testing with field-collected sediments will be completed prior to the remedial program to test the effectiveness of the sediment amendments. In addition to activated carbon, organoclays may also be tested to evaluate its effectiveness in reducing the bioavailability of metal contaminants.

Options for the placement of the thin-layer cap would be similar to the placement methodology options for the conventional cap: placement using a clamshell bucket or by hydraulically pumping. Placement of the activated carbon amendment can be accomplished using several different methods. It can be spread out over the bottom as a thin layer, spread out and then “tilled” into the bottom to mix with the existing sediment, or mixed with the sand cap. Equipment such as clamshell buckets, submerged diffusers, energy dissipaters, submerged discharge points, and tremies (specialized underwater pipes, typically used for pouring concrete) can be used to apply amendments evenly to a required thickness.

The material quantity necessary for activated carbon varies by delivery method. Bulk placement typically is incorporated at a rate of 5 to 10 percent activated carbon dry weight to the top 10 cm of sediment which is approximately 5 kg/m^2 (1 lb/ft^2). Laboratory studies indicate that a one-centimeter thickness of activated carbon or other carbon material beneath a sand cap can effectively mitigate contaminant flux of PCBs from sediment (US EPA 2013). Other forms of activated carbon are also commercially available, including concentrated pellet forms that can be placed directly as a thin layer on the existing sediment bed, rather than mixed with sandy materials. The choice of preferred method of product and delivery method will be location-specific.

12.1.5 Nature-Based Shoreline Rehabilitation

Based on initial Indigenous groups and stakeholder feedback, nature-based design approaches will be considered as an alternative for shoreline protection and improvements along management units TC-RC, WM, TC-2A, TC-3A, and TC4, where feasible. An analysis of the potential nature-based shoreline rehabilitation principles and concepts that may be appropriate for application in these management units was presented in the Nature Based Shoreline Concepts memo (Golder, 2022b). A Basis of Design for Shoreline Protection is presented in Appendix C. There is no shoreline protection work currently planned for the northern management units PC-E, PC-W, PC-OM, PP-OM, TC-OM, or the northern portion of TC-2A with existing rock wall. Using rock material to protect the shoreline may be considered in the next stage of the design for TC-AB and small sections of TC-RC that contain existing boat docks.

For management units TC-RC, WM, TC-2A, TC-3A and TC-4, existing rock armouring is present intermittently along the shoreline, and opportunities for conservation gains or habitat improvement are potentially possible at select locations without compromising shoreline stability. It was recognized that nature-based approaches for shoreline rehabilitation, where feasible, could take advantage of the following opportunities:

- Habitat enhancement especially the enhancement of turtle habitat and the establishment of aquatic and coastal riparian vegetation.
- Limiting the potential for human access to the water to reduce human exposure from a health risk perspective.

The objective of the shoreline improvement design is to preserve existing shoreline features that provide protection against shoreline erosion and provide habitat for turtle and fish species, while introducing additional natural or nature-based features (NNBF) that improve shoreline resilience and enhance natural habitat.

Appendix F provides plan view and representative cross sections for the conceptual design for management areas TC-RC, WM, and TC-4, which consist of scattered Large Woody Debris (logs and rootwads) to be placed on the bed in the buffer zone between the shoreline toe and dredged area and be held down by boulders.

12.1.5.1 Existing Shoreline Protection

A qualitative analysis of the existing shoreline protection features along TC-RC, WM, TC-2A, TC-3A and TC-4 was conducted using shoreline photographs taken during a site visit on 7 October 2021 (Appendix G), where the daily maximum water level recorded was 74.7 m (IGLD85), as well as a digital elevation model (DEM) containing the topography and bathymetry data.

Units TC4, TC-3A, and the southern portion of TC-2A showed similar shoreline characteristics. Existing rock armouring is present intermittently along the shoreline as bank protection, which typically consists of approximately 0.3 to 0.5 m diameter rocks on an approximately 15:1 (horizontal:vertical) slope. Existing vegetation is established between the gaps in the armour rocks. In the absence of as-built drawings or detailed condition assessment, it is assumed existing rock protection covers the bank from above the maximum water level of 76 m, to below the average water level of 74.5 m elevation. The shoreline along the northern portion of TC-2A is lined with a vertical stacked rock wall, however, this section of the shoreline is not a part of the proposed design at this time.

Management unit WM exhibits a typical shoreline slope of approximately 10:1, and intermittent coverage by existing rock armour with a diameter of approximately 0.3 to 0.8 m as shoreline protection. Existing vegetation is established between the gaps in the armour rocks. In the absence of as-built drawings or detailed condition assessment, it is assumed existing rock protection covers the bank from above the maximum water level of 76 m, to below the average water level of 74.5 m elevation.

The section of the shoreline along unit TC-RC outside of the existing boat docks typically consists of existing rock armour with a diameter of approximately 0.2 to 0.8 m on an approximately 6:1 slope. Some existing vegetation is established between the gaps in the armour rocks. In the absence of as-built drawings or detailed condition assessment, it is assumed existing rock protection covers the bank from above the maximum water level of 76 m, to below the average water level of 74.5 m elevation.

Qualitative analysis of the shoreline of these management units suggests that existing shoreline protection features (armour rocks, vegetation) have previously remained effective at maintaining shoreline stability and protecting against erosion. No evidence of bank failure was observed along the existing shoreline from the field photos. Therefore, no additional upgrade to the existing shoreline protection features is proposed for shoreline stability; however, detailed shoreline condition assessment (to evaluate the assumption made) and detailed analysis of future water levels and wave conditions will need to be conducted to verify that the existing shoreline protection is sufficient under selected design scenarios within the design life.

Some additional upgrades to the existing shoreline protection features may be considered to enhance existing habitat. Large interlocking armour rocks may present obstacles for turtle hatchlings to reach the water after hatching, through either trapping between the large interstitial voids, or the steep slope and tall ledge formed by stacked armour rocks. Due to the intermittent nature of the rock armouring along the shoreline observed on field photos, a targeted approach focusing on locations with high concentrations of large interlocking armour rocks is recommended, as most of the shoreline currently consists of armour rocks that are spaced far enough apart to not present a trapping hazard or obstruction for turtle hatchings.

12.1.5.2 Proposed Dredging Exclusion Zone

To achieve the objective of preserving the existing shoreline protection features, a five to ten metre width dredging exclusion zone is proposed that begins from the toe of the existing shoreline. The toe of the existing shoreline is defined as the limit of the rock protection and break line in shoreline slope. This would avoid oversteepening of the existing shoreline slope due to dredging that could lead to slope failures.

Existing submergent vegetation in the 5-10 m dredging exclusion zone will also be preserved to maintain existing habitat. Additionally, and as noted earlier, scattered rootwads and/or logs held down by boulders will be added as basking features for habitat enhancement. To avoid creating a separation between the foreshore and offshore habitat, the rootwads and/or logs will be spaced apart with gaps in between as pathways. The rootwads and/or logs will also be placed at a minimum distance of one metre from the toe of the rock protection, to avoid creating an obstacle between the shoreline and the water for turtle hatchings.

A larger dredging exclusion zone has been incorporated for some management units as follows:

- 10 m from the north of PC-E and PC-W to protect [redacted] and the landfill management system for the former Belle Park Landfill.
- 10 to 35 m area from Belle Island (PC-E) to align with the City of Kingston jurisdictional boundary.

12.1.5.3 Riparian Vegetation

Existing riparian zone along the backshore consists of a mixture of grasses, shrubs, and herbaceous vegetation, with scattered tree cover. The width of the riparian zone varies from approximately 3 to 10 m between the crest of the shoreline and an existing paved path. It is assumed that the existing paved path for shoreline recreational access will remain. The approach is to preserve the existing vegetation in the riparian zone as much as possible as it provides turtle hatching habitat. However, additional planting would be required to limit the potential for human access to the water. Given the limited space available in the riparian zone, a single row of native species will be planted such as native roses (e.g., *Rosa acicularis*; *R. blanda*), prickly ash (*Zanthoxylum americanum*), blackberry (*Rubus allegheniensis*), and black raspberry (*Rubus occidentalis*) to deter human access, while minimizing the reduction to existing turtle habitat.

12.2 Risk Reduction Methods

The Conceptual Constraints and Impact Considerations document (CCIC) (SNC Lavalin 2023b) highlighted several design considerations, which include timing, processes, or physical elements that can be considered for incorporation into the detailed design of the SMP (i.e., relating directly to how sediment management is staged and/or carried out) to avoid or minimize potential adverse environmental effects to valued components[12] within the Project area. The design considerations from the CCIC are summarized in Table 8, along with a brief detail on how these were incorporated into the SMP and/or where they are discussed in this report. The design considerations listed in Table 6 are based on high-level and conceptual scenarios, which will be further evaluated and potentially mitigated as part of the DIA.

[12] Valued Components are defined as environmental, health, social, economic, or additional elements or conditions of the natural and human environment that may be impacted by a proposed project and are of concern or value to the public, Indigenous groups, federal authorities and interested parties.

Table 8: Summary of Design Considerations to Reduce Risk

Conceptual Scenario	Design Considerations to Reduce Risk	Incorporated into SMP?
Aquatic Life (Fish, Amphibians, Invertebrates and Vegetation)		
In-water works such as dredging results in accidental capture of fish and amphibians.	Smaller sub-units isolated by turbidity curtain within management unit to be dredged to enhance detectability and capture of aquatic wildlife.	Yes; isolation measures are included in Tables 1 and 2, Sections 7.3, 7.4
In-water works such as wetland vegetation removal, dredging, capping, and shoreline stabilization during the spring spawning period in high quality spawning habitat where spawning has been confirmed result in disturbance to spawning fish.	Timing windows to conduct in-water work in confirmed spawning habitat. Maintain spawning habitat with confirmed spawning during spring spawning period while conducting in-water work in other areas. During 15 March to 1 June, avoid conducting in-water work concurrently in management units with spawning habitat.	Yes; timing windows for in-water works are considered to protect most fish species (refer to Section 7.4; Table 2).
In-water works such as dredging, capping, and shoreline stabilization in fish spawning habitat result in loss of fish habitat.	Where possible, avoidance of disturbance to confirmed spawning habitat via exclusion zones. Backfilling dredged area with clean substrate of similar composition to surroundings. Stockpiling and replacement of cover habitat components such as boulders and logs.	Yes; Section 7.3 discusses standard mitigation measures for application during remediation and appropriate sediment compositions.
In-water works such as dredging and capping that alter benthic biophysical habitat attributes result in loss of benthic invertebrate communities.	Translocation of nearby sediments below PELs (or an equivalent level of protection) for benthic re-colonization of dredged areas without capping where the lacustrine clay is left exposed. In locations where dredging has progressed to the stiffer native clay that may require longer time for benthic recolonization, recovery could be assisted by application of a 15-30 cm thick sand layer mixed with 20% organics. In areas previously noted as having high benthic diversity (or no impairment), instead of dredging, employ lower intrusion methods such as very thin placement (1−2 inches) of activated carbon.	Yes; Section 7.3 discusses the appropriate sediment compositions for benthic recolonization. These compositions will require further refinement in detailed design stages.
In-water works such as wetland vegetation removal, dredging, and capping result in biophysical changes that reduce the quality of Greater Cataraqui Marsh Provincially Significant Wetland.	Stockpiling of removed aquatic vegetation (free of invasive species) for replanting or translocation of nearby aquatic vegetation from “clean” sediments for re-colonization. Schedule or phase dredging to conclude by spring when water temperatures are more favourable for plant growth to re-establish vegetation.	Yes; Section 7.3 discusses the standard mitigation measures for application during remediation and appropriate sediment compositions.
In-water works such as dredging that fragment submergent and floating invasive plants result in spread of invasive aquatic vegetation during sediment management activities and post-sediment management.	Sediment containment design and materials for each management unit that prevent the spread of fragmented aquatic plants (floating and submerged) from spreading at all levels of the water column.	Yes; Section 7.3 discusses the standard mitigation measures for application during remediation for invasive species prevention.

Conceptual Scenario	Design Considerations to Reduce Risk	Incorporated into SMP?
In-water works such as vegetation removal, dredging, capping, and shoreline stabilization that disturb sediments and transport and operation of vehicles and equipment result in introduction or spread of invasive emergent aquatic plant species.	Stockpiling of removed native emergent aquatic vegetation (e.g., lilies, cattails) for replanting; or translocation of nearby aquatic vegetation from sediments with concentrations below PELs (or an equivalent level of protection) for re-colonization. Temporary disturbance areas will be reclaimed as soon as possible after completion of the sediment management activity in that area.	Yes; Section 7.3 discusses the standard mitigation measures for application during remediation for stockpiling of native plants and aquatic vegetation and revegetation of disturbed areas post remediation.
Species at Risk Turtles		
In-water works such as dredging, capping, and shoreline stabilization that disturb thermoregulatory habitat result in the disruption of follicular development in reproductive female SAR turtles.	Timing windows to restrict work , such as during the spring critical follicular development period (and nesting period) from May through mid-July along the shorelines [redacted] Exclusion zones around high-quality basking habitat. Temporary or permanent (to be determined) provision of alternative and/or enhanced basking habitat in adjacent (undisturbed) area with adequate thermal exposure prior to commencement of in-water works. This should take into consideration the type of basking structures (e.g., log, fallen tree/branch, rock, vegetation) becoming disturbed/inaccessible in the in-water work area and should also consider providing new structures at a 2:1 ratio as practicable. Locations near nesting habitat should be the highest priority. Salvage and replacement of basking logs/structures/floating vegetation in disturbed areas following completion of sediment management activities.	Yes; timing windows for in-water works are considered to protect most species (refer to Section 7.4; Table 2). Exclusion zones will be implemented to protect basking habits as discussed in Section 2.1.5, 3.1.1, 7.2, 11.2.12 and Table 2.
In-water works such as dredging results in accidental capture of turtles.	Smaller sub-units isolated by turbidity curtain within Management Unit to be dredged to enhance detectability and capture of aquatic wildlife. Turbidity curtain designed with large, round floats covered in High Density Polyethylene (HDPE) to exclude turtles from in-water work areas by preventing them from crossing over top. Minimum height is recommended to be 60 cm above water level (MNRF 2016). HDPE cover also prevents semi-aquatic wildlife such as muskrats from chewing and burrowing into floats. Mammal and herptile exclusion fencing along terrestrial access points to in-water work areas.	Yes; exclusion zones/fencing are discussed in Section 7.2. Use of turbidity curtains are presented in Sections 2.1.5, 6.2, 6.3, 7.2, 7.4, Table 2 and Table 6.
Terrestrial works such as site preparation and mobilization and shoreline stabilization in management units TC-RC, WM, TC-2A, TC-3A, and TC-4 result in disturbance to nesting movements of female SAR turtles.	Timing windows. Locate mobilization, laydown and stockpile areas away from known nesting habitat. Exclusion zones for terrestrial migration corridors between nesting habitat and aquatic habitat. Prior to the nesting period and under the guidance of a Qualified Biologist, construct temporary (or permanent) artificial nesting mounds or beaches in areas where work is completed or not taking place.	Yes; timing windows for in-water works are considered to protect most species (refer to Section 7.4; Table 2). Exclusion zones and stockpiling are discussed in Section 7.2 and Table 2.

Conceptual Scenario	Design Considerations to Reduce Risk	Incorporated into SMP?
Terrestrial works such as site preparation and mobilization and shoreline stabilization in management units TC-RC, WM, TC-2A, TC-3A, and TC-4 result in disturbance to hatchlings dispersing from nests to aquatic habitats.	Timing windows. Locate mobilization, laydown and stockpile areas away from known nesting habitat. Exclusion zones for terrestrial migration corridors between nesting habitat and aquatic habitat.	Yes; timing windows for in-water works are considered to protect most species (refer to Section 7.4; Table 2). Exclusion zones and stockpiling are discussed in Section 7.2 and Table 2.
SAR turtles are attracted to suitable nesting opportunities within terrestrial work areas associated with site preparation, mobilization and shoreline stabilization.	Locate mobilization, laydown and stockpile areas away from known nesting habitat.	Yes, stockpiling mitigations are discussed in Section 7.2 and Table 2.
In-water works such as dredging, capping, and shoreline stabilization during the turtle overwintering period causes disturbance to overwintering individual SAR turtles.	Timing windows. Exclusion zones and movement corridors around and to turtle overwintering habitat. Prior to the turtle overwintering period (e.g., before end of September), isolation of in-water work areas with aquatic wildlife rescue led by a Qualified Biologist. Aquatic and semi-aquatic megafauna relocated to suitable habitat outside of isolated work areas. In-water work areas remain isolated until completion of remediation work. Turbidity curtain used for isolated in-water work areas designed with large, round floats covered in HDPE to exclude turtles from in-water work areas by preventing them from crossing over top. Minimum height is recommended to be 60 cm above water level (MNRF 2016). HDPE cover also prevents semi-aquatic wildlife such as muskrats from chewing and burrowing into floats. Mammal and herptile exclusion fencing along terrestrial access points to in-water work areas.	Yes; timing windows for in-water works are considered to protect most species (refer to Section 7.4; Table 2). Exclusion zones and stockpiling are discussed in Section 7.2. Use of turbidity curtains are presented in Sections 6.2, 6.3, 7.3, and Table 1.
In-water works such as dredging, capping, and shoreline stabilization that occur in turtle overwintering habitat result in destruction of overwintering habitat *(including Snapping Turtle, Midland Painted Turtle, Northern Map Turtle, Eastern Musk Turtle)*	Where possible, avoidance of disturbance to known overwintering habitat via exclusion zones.	Yes, exclusion zones and mitigations are discussed in Section 7.2 and Table 2. Alternative overwintering habitats are available upstream and downstream of the rehabilitation areas and will be further evaluated in the DIA. Timing windows will be implemented to avoid overwintering period (see Section 7.4; Table 2).
Dredging, capping, and shoreline stabilization result in the removal or alteration of turtle habitat features used for thermoregulation. *(species of interest include Snapping Turtle, Midland*	Maintenance of existing basking structures in-situ. Exclusion zones around high-quality basking habitat. Temporary or permanent (to be determined) provision of alternative and/or enhanced Snapping Turtle basking habitat in adjacent (undisturbed) area with adequate thermal exposure prior to commencement of in-water works. This should take into consideration the type of basking structures	Yes, exclusion zones and stockpiling mitigations are discussed in Section 7.2 and Table 2. This is potentially achieved through alternative overwintering habitats being available upstream and downstream of the rehabilitation areas and will be further evaluated

Conceptual Scenario	Design Considerations to Reduce Risk	Incorporated into SMP?
Painted Turtle, Northern Map Turtle, Eastern Musk Turtle)	(e.g., log, fallen tree/branch, rock, vegetation) becoming disturbed/inaccessible in the in-water work area and should also consider providing new structures at a 2:1 ratio as practicable. Salvage and replacement of basking logs/structures/vegetation in disturbed areas.	in the DIA. Timing windows will be implemented to avoid overwintering period (see Section 7.4; Table 2).
Species at Risk Birds		
Noise from terrestrial and in-water works such as site preparation and mobilization, dredging, and capping result in the disturbance of breeding SAR birds.	Timing windows for work that exceeds noise level threshold. Noise abatement. Staging noisy equipment away from breeding bird habitat features such that noise diminishes to 50 dB or below at the habitat edge.	Yes; timing windows for in-water works are considered to protect most species (refer to Section 7.4; Table 2) and Table 2.
Terrestrial and in-water works such as site preparation and mobilization, dredging, capping, and wetland remediation that remove vegetation result in destruction of undetected breeding and foraging habitat for SAR birds.	Timing windows.	Yes; timing windows for in-water works are considered to protect most species (refer to Section 7.4; Table 2). Exclusion zones surrounding nests and sensitive habitats is presented in Section 7.2 and Table 2.
Terrestrial works involved in site preparation and mobilization that remove vegetation in proximity to nesting Barn Swallows result in destruction of breeding and foraging habitat for Barn Swallow.	Exclusion zones established surrounding confirmed Barn Swallow habitat, including the Barn Swallow artificial nesting structure.	Yes; timing windows for construction works are considered to protect most species (refer to Section 7.4; Table 2). Exclusion zones surrounding nests and sensitive habitats is presented in Section 7.2 and Table 2. Barn swallow habitat has been down listed to special concern recently. A habitat kiosk is available with the study area and will be protected by the exclusion zone.
Terrestrial and in-water works in wetlands such as site preparation and mobilization, dredging, capping, and wetland remediation that remove vegetation result in destruction of Least Bittern breeding habitat.	If habitat is confirmed prior to commencement of works: Exclusion zones around confirmed Least Bittern breeding habitat.	Yes, exclusion zones surrounding nests and sensitive habitats is presented in Section 7.2 and Table 2.
Migratory Birds		
Terrestrial works such as site preparation and mobilization and shoreline stabilization that remove vegetation during the breeding bird season result in harm to nesting migratory birds.	Timing windows for terrestrial vegetation removal. Minimize need for vegetation removal by situating staging areas and access routes in existing open areas (e.g., parking lot, trails).	Yes; timing windows for in-water works are considered to protect most species (refer to Section 7.4; Table 2).

Conceptual Scenario	Design Considerations to Reduce Risk	Incorporated into SMP?
Noise from heavy equipment used for terrestrial and in-water works such as site preparation and mobilization and sediment management and intervention activities result in the disturbance of breeding migratory birds.	Timing windows for work that exceeds noise level threshold. Noise abatement. Staging noisy equipment away from breeding bird habitat features such that noise diminishes to 50 dB or below at the habitat edge.	Yes; timing windows for in-water works are considered to protect most species (refer to Section 7.4; Table 2).
Species at Risk Bats		
Terrestrial works involved in site preparation and mobilization that remove vegetation result in destruction of undetected maternity roosting habitat for SAR bats during site preparation and sediment management activities.	Timing windows	Yes; timing windows for in-water works are considered to protect most species (refer to Section 7.4; Table 2).
Terrestrial works involved in site preparation and mobilization that remove or alter trees in SAR bat maternity roosting habitat result in the destruction of SAR bat maternity roosting habitat.	If habitat is confirmed prior to commencement of works: • Exclusion zones for confirmed maternity roosting habitat. • Potential for compensation of Little Brown Myotis habitat under ESA approval or permit if removal of roost(s) is required by installation of bat house(s) in nearby suitable habitat under the direction of a Qualified Biologist. • Any roosting habitat removed will be replaced with suitable tree species to the bat species affected (and local soils/climate): - Little Brown Myotis: Trembling Aspen (*Populus tremuloides*), Red Oak (Quercus rubra), Large-tooth Aspen (Populus grandidentata), and Red Maple (Acer rubrum). - Northern Myotis: Red Maple, Red Oak - Tri-colored Bat: White Oak (Quercus alba), Red Oak - Eastern Small-footed Myotis: not applicable (roosts in rocky habitats).	Yes; timing windows for in-water works are considered to protect most species (refer to Section 7.4; Table 2). Exclusion zones surrounding sensitive habitats is presented in Section 7.2 and Table 2. A dredging exclusion zone will be applied to the project to protect treed habitats along the shoreline that may be providing bat maternity roost habitat.
Non-SAR Bats		
Terrestrial works such as site preparation and mobilization and shoreline stabilization that remove vegetation result in destruction of undetected Big Brown Bat and Silver-haired Bat maternity colonies.	Timing windows for terrestrial vegetation removal. Minimize need for vegetation removal by situating staging areas and access routes in existing open areas (e.g., parking lot, trails).	Yes; timing windows for in-water works are considered to protect most species (refer to Section 7.4; Table 2).

Conceptual Scenario	Design Considerations to Reduce Risk	Incorporated into SMP?
Snakes		
No terrestrial works such as site preparation and mobilization and shoreline stabilization in management unit TC-RC are expected to alter or remove the snake hibernaculum resulting in the destruction of snake overwintering habitat and disturbance to overwintering snakes.	Work exclusion zone around snake hibernaculum that does not impede snake access and egress. Timing windows for terrestrial work near hibernaculum (avoided between 1 October and 31 March).	Yes; timing windows are considered to protect most species (refer to Section 7.4; Table 2). Exclusion zones are presented in Section 7.2.
Terrestrial Vegetation		
Terrestrial works such as site preparation and mobilization and shoreline stabilization that remove vegetation result in changes to vegetation community classification.	Minimize areas of vegetation removal.	Yes; vegetation removal will be minimized and avoided to the extent practicable and is presented in Section 7.3 and 12.2.
Water Quality		
Baseline water quality present within KIH prior to remediation should not reflect on-going sources of contamination.	Implementation of mitigation measures at identified sources if on-going sources identified. Design engineer to work with City of Kingston to align shoreline works with current understanding of upgradient sources (e.g., storm sewer outfalls, soil erosion controls for shoreline areas). Enhancement of existing upgradient municipal source control initiatives, including public education, if ongoing sources of COCs or CECs identified at levels of concern.	Yes; source control measures are discussed in Section 5.7. Further work is recommended to confirm source controls are adequate for storm sewer management and the Former Davis Tannery erosion controls.
In-water works involving dredging, dewatering and/or capping resulting in the re-suspension of sediments and associated contaminants at the point of departure.	EMP will detail project requirements following BMPs, which may include the use of a turbidity curtain during dredging, positioning of equipment to avoid propeller wash, placement of barge spuds to avoid sediment disturbance, and additional filtration during dewatering.	Yes; Section 6.3 discusses this as a water quality considerations for the EMP.
In-water works involving dredging, dewatering and/or capping resulting in the re-suspension of sediments and associated contaminants within the Receiving Environment.	An EMP will detail project requirements following BMPs, which may include the use of a turbidity curtain during dredging, positioning of equipment to avoid propeller wash, placement of barge spuds to avoid sediment disturbance, and additional filtration during dewatering.	Yes; Section 6.3 discusses this as a water quality considerations for the EMP.
Long-term impacts of sediment re-suspension following in-water works	If it is determined that the elevated COCs in water are the result of the Project and not other sources, additional remedial measures may be considered (e.g., capping within sediment management units that have elevated COCs).	Yes; Section 6.3 discusses this as a water quality considerations for the EMP.

Conceptual Scenario	Design Considerations to Reduce Risk	Incorporated into SMP?
Lacustrine Processes		
Site preparation and removal of existing shore infrastructure and shore protection may result in temporary changes in the stability of the shoreline and substrate with the potential to alter sediment transport processes in KIH.	Structures such as docks and shore protection will be replaced with like structures in the event of temporary removal. Design of dredge prisms will consider slopes and stability of sediment in each management unit. The EMP will detail project monitoring requirements, which will include measures to avoid excessive sediment disturbance.	Yes; unless noted to be structurally unsound all slopes and existing infrastructure will be left unchanged, which will limit changes to the sediment transport processes.
In-water works such as dredging, capping, and shoreline stabilization will result in changes in local depths resulting in alteration of SAV. Temporary or permanent loss of SAV may result in increased frequency of the potential resuspension (increase in TSS/turbidity) by wind waves and currents.	Hydrodynamic (wave and current) modelling and related assessment of sediment transport potential is recommended to compare the existing condition to the post-project (dredged) condition. Evaluate whether risks from temporary loss of SAV are significant in terms of changes to sediment transport potential and develop mitigations as appropriate.	Yes; replanting of SAV is planned in the conceptual design, which will limit the potential for resuspension. Hydrodynamic modelling to assess sediment transport before and after dredging is proposed before detailed design.
In-water works such as dredging, capping, and shoreline stabilization will result in changes in local depths resulting in changes to local hydrodynamics and sediment transport.	In some cases, dredge cuts will be partially backfilled with engineered covers to restore the bed elevation to balance exposure reduction with navigational depth considerations (e.g., Anglin Bay).	Yes; all dredged areas will be partially backfilled with a thin layer mixed cap. Hydrodynamic modelling to assess sediment transport before and after dredging is proposed before detailed design.
Excavation of contaminated material in the upland and riparian zones may contribute to loss of shoreline protection function (e.g., stability) and temporary loss and degradation of habitat.	SMP and detailed designs to consider appropriate site-specific solutions to minimize losses of function.	Yes, the conceptual design shows there is no planned contaminated material removal in the upland and riparian zones, thus preserving the shoreline protection function and the habitat. For management areas TC-RC, WM, TC-2A, TC-3A and TC-4 there is a 5 to 10 m buffer zone from the toe of the existing shore protection to the start of the dredging zones included so that the dredging will not affect the shoreline stability. For all other management areas there is a buffer zone included from the shoreline in order to not damage the stability or habitat. Nature-based shoreline rehabilitation will enhance the existing riparian zones through planting of native vegetation and addition of ecological habitats.

Conceptual Scenario	Design Considerations to Reduce Risk	Incorporated into SMP?
Sediment Quality		
Baseline sediment quality within KIH prior to remediation may be influenced by on-going sources of contamination.	Implementation of mitigation measures at identified sources, if identified. Continuation of municipal source control initiatives, including public education, if ongoing sources of COCs identified at levels of concern.	Yes; source control measures are discussed in Section 5.7. Further work is recommended to confirm source controls are adequate for storm sewer management and the Former Davis Tannery erosion controls.
Baseline sediment quality characterization within KIH identifies gaps in spatial extent of contamination of relevance to remedial design	Consideration of engineered covers or activated carbon where sediment quality is heterogeneous or with potential for free-product coal tar presence.	Yes; Section 5.5.1.3 discusses data gaps related to the sediment baseline data. These will be addressed prior to in water works.
In-water works such as dredging, capping, and shoreline stabilization result in an alteration to existing sediment quality in KIH.	Filtering dredged waters, with effectiveness confirmed through bench testing prior to use. Or use of turbidity curtains. Thin layer capping (RMC) incorporated proactively in design to reduce exposures (i.e., base design elements) or to improve recolonization potential (environmental contingency).	Yes; EMP will address contingency measures if EPOs not met (Section 6.1) RMC for all dredged areas is recommended (Section 14.1.1).
Equipment associated with in-water works that could result in chemical spill into KIH waters.	EMP will detail project requirements following BMPs (e.g., water booms around equipment, spill kit on Site, spill response plan).	Yes; Section 6.3 discusses this as a water quality considerations for the EMP.
In-water works involving dredging, dewatering and/or capping result in the re-suspension of sediments and associated contaminants at the point of discharge.	EMP will detail project requirements, which may include the use of turbidity curtains during dredging, positioning of equipment to avoid propeller wash, placement of barge spuds to avoid sediment disturbance.	Yes; Section 6.3 discusses this as a water quality considerations for the EMP.
In-water works involving dredging, dewatering and/or capping do not meet project objectives for contaminant mass removal or isolation.	Contingency re-dredging may be required if unacceptable dredge residuals or missed inventory. Additional thin layer capping (RMC) as contingency.	RMC for all dredged areas is recommended (Section 14.1.1).
Long-term barriers to recolonization following in-water works	Contingency measures may be considered (e.g., thin-layer capping or activated carbon within sediment management units that have persistent elevated COCs). Incorporation of natural organic carbon sources and mixed particle sizes in capping materials to provide nutrients and substrate for recolonization. Incorporation of natural-based (i.e., ecosystem-based) approaches, such as methods for shoreline management to enhance recovery	Yes; RMC for all dredged areas is recommended (Section 14.1.1). Nature-based shoreline rehabilitation will be implemented where applicable (Section 14.1.5).
Soil and Landform Resources		
In-water and terrestrial works involving the transportation of contaminated sediment result in contamination of soil.	Adequate space is provided for hauling vehicle and turning radius requirements to ensure smooth transfer of contaminated sediments. Implement controls to minimize the loss of sediment during dredging operations.	Yes; dredging controls are provided in Section 12.1.1.

Conceptual Scenario	Design Considerations to Reduce Risk	Incorporated into SMP?
Cultural and Heritage Values		
Terrestrial and in-water works such as mobilization, dredging, capping, and shoreline stabilization, may create temporary or permanent changes in landscape character.	Design temporary works so that no permanent alteration occurs to the features of the affected cultural landscape. Design shoreline stabilization and site rehabilitation to be compatible with the features of the affected cultural landscape.	The City of Kingston Archaeological Master Plan (Archaeological Services Inc. 2008) identifies the entire shoreline on both sides of the river as having potential for pre-contact archaeological significance. The underwater archaeological impact assessment currently being completed will confirm archaeological sensitive areas, which will be incorporated into the DIA. As such, adjustments may be made prior to and/or during the detailed design stage to avoid adverse effects on archeological areas of significance based on these results.
Terrestrial and in-water works such as shoreline stabilization that modify natural ecosystem elements result in loss of landscape character.	Design shoreline stabilization and site rehabilitation to be compatible with valued landscape features.	
Terrestrial works linked to site preparation and mobilization such as temporary access requirements, temporary facilities and laydown area(s), and installation of Erosion and Sediment Controls result in damage or destruction of buried archaeological resources.	Exclusion zones around archeological resources or identification of resources that may require recovery. Works conducted under guidance from licensed consultant archaeologist.	
In-water sediment management activities such as dredging and shoreline stabilization result in disturbance to sediments which contain wrecks and other large submerged archaeological resources.	Exclusion zones around archeological resources or identification of resources that may require recovery. Capping but no dredging at site of archaeological resources. Works conducted under guidance from licensed consultant archaeologist.	
In-water sediment management activities such as dredging and shoreline stabilization result in disturbance to sediments which contain smaller submerged archaeological resources.	Survey and removal of archaeological resources prior to dredging activities. Works conducted under guidance from licensed consultant archaeologist.	

13.0 IMPLEMENTATION CONSIDERATIONS

The next steps for the sediment management plan, including detailed design of the intrusive works, depend on factors outside the scientific and engineering components used to develop the conceptual SMP, such as:

- Funding status—alignment with federal financial cycles, confirmation of federal funding availability, cost-sharing with non-federal lot managers within and adjacent to KIH.
- Partnerships—schedule for activities conducted around the Orchard StreetMarsh area would depend on coordination with brownfield redevelopment, City of Kingston Master Plan development (e.g., recreational corridors), or other synergies with management of the shoreline areas.
- Timelines for the synthesis of input from stakeholders and Indigenous communities (e.g., consultation on impact assessment and offsetting).
- Permit approvals required for project works.

13.1 Project Milestones

Approximate dates for the project milestones are listed below, assuming reasonable schedule factors and no major delays. Due to the volume of sediments targeted for removal, dredging is scheduled to take place over 3 years, with early emphasis placed on the areas of greatest risk reduction. Project milestones include:

- Planning/Pre-Implementation, including biological and archaeological inventories, Indigenous Consultation and Stakeholder Engagement, partnership agreements, Detailed Impact Assessment, detailed design, and permitting—2020 to 2026
- Implementation of Physical Works—2027 to 2029 (assuming efficiencies in scheduling/conducting management activities concurrently)
- Post-Implementation Monitoring—2029 to 2032
- Long-Term Monitoring for Natural Recovery Zones—2029 to 2039

13.2 Construction Schedule

Construction is expected to take place from 2027 to 2029 and the working window for in-water construction is anticipated to be from 1 June to 30 September annually (in order to protect fish spawning and turtle overwintering periods, as described in Section 7.0). WSP has developed a preliminary construction schedule based on these constraints, which is shown in Appendix D.

14.0 PROJECT COSTS

WSP has prepared Indicative (Class C) construction cost estimates, as defined by the Treasury Board of Canada, for the conceptual SMP as described in this report. The Basis of Estimate, which includes a description of the estimate assumptions, exclusions, and limitations, is provided in Appendix D.

Indicative estimates are generally prepared based on limited information, with projects in the pre-feasibility or conceptual design stages. The typical end usage for this level of estimate includes assessment of initial viability, evaluation of alternate options, project screening, evaluation of resource needs and budgeting, and long-range capital planning. The target accuracy range for the cost estimate is +/- 50%.

The technical basis for cost estimation builds on the rationale provided in Section 11.0 and 12.0, while integrating the engineering aspects of the proposed methods. Appendix D also provides unit rate estimates to provide transparency in the calculation of costs for each management unit.

The conceptual SMP accounts for the various management alternatives, incorporates professional judgement, and assumes Indigenous and stakeholder satisfaction for the planned actions. It is anticipated that a revised sediment management design following additional Indigenous Consultation and Stakeholder Engagement will likely remain within the range of costs specified in Appendix D.

15.0 NEXT STEPS

TC and PCA have started to engage with Indigenous communities and stakeholders and are completing various baseline environmental inventory and assessment studies (i.e., archaeological, fish, plant, semi-aquatic wildlife, and habitat studies). The following are also planned for next steps in the planning stage:

- Continue to engage/consult with Indigenous communities, stakeholders (e.g., local community groups, adjacent land managers) and the public.
- Determine regulatory requirements (e.g., *Impact Assessment Act*, *Fisheries Act*, *Canadian Navigable Waters Act*, other permitting), and engage with other government agencies regarding the proposed project.
- Complete any studies needed to fulfill remaining information gaps identified in the CCIC prior to in-water works. This includes establishing an adequate baseline for sediment quality, water quality, and lacustrine processes to assist in the detailed design and the development of EPOs for the Environmental Management Plan.
- Complete a DIA following PCA's Impact Assessment Directive (IAA 2019). This process will be consistent with the requirements of the Canadian *Impact Assessment Act*, to determine whether any aspects of the SMP would be likely to cause significant adverse environmental effects. The DIA will confirm the presence of archeological and biological sensitive areas and any necessary mitigations.
- Explore the potential for partnership with the City of Kingston to coordinate potential work on federal and city lots. A partnership with DND may also be pursued, if DND determines that management action is required on their DND lot (pending confirmation).
- Progress the sediment management plan for the PC-OM management unit through further Indigenous Consultation and Stakeholder Engagement, along with input from the DIA
- Refine project plans based on feedback received from Indigenous communities and stakeholders, seek internal project funding and approvals, and initiate the detailed design and specification stage for physical works.

16.0 CLOSURE

We trust that the information presented in this report addresses your immediate requirements. If you have any questions or concerns, please do not hesitate to contact the undersigned at 519-919-7265.

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APPENDIX A

Species at Risk Status, Habitat Characteristics, Preliminary Presence/Absence Determination, and Habitat Distribution and Risk (SNC Lavalin 2023a)

APPENDIX

Species at Risk Status, Habitat Characteristics, Preliminary Presence/Absence Determination, and Habitat Distribution and Risk for the Kingston Inner Harbour

Species at Risk Status, Habitat Characteristics, Preliminary Presence/Absence Determination, and Habitat Distribution and Risk for the Kingston Inner Harbour

Common Name	Scientific Name	Habitat Characteristics[1,2]	Suitable Habitat within Study Area?[2,3,4]	SARO status[2]	SARA status[1,3]	S-Rank[4]
HERPETOFAUNA						
Blanding's Turtle	*Emydoidea blandingii*	Shallow water, usually in large wetlands and shallow lakes with lots of water plants. Often travels hundreds of metres from water for reproduction. Hibernates in the mud at the bottom of permanent water bodies.	[redacted]	THR	END	S3
Eastern Milksnake	*Lampropeltis triangulum*	Open habitats including rock outcrops and meadows. May also occupy barns, sheds, and houses in rural landscapes.	[redacted]	Not at Risk	SC	S4
Eastern Musk Turtle	*Sternotherus odoratus*	Inhabits littoral zones of waterways such as rivers, lakes, bays, streams, ponds, canals, and swamps with slow to no current and soft bottoms.	[redacted]	SC	SC	S3
Gray Ratsnake (Frontenac Axis population – SARO) (Great Lakes/St. Lawrence population - SARA)	*Pantherophis spiloides*	Found in a wide variety of woodland habitats; prefer a mosaic of forest and open habitat, including fields and bedrock outcrops, with a high amount of edge.	[redacted]	THR	THR	S3
Midland Painted Turtle	*Chrysemys picta marginata*	Aquatic habitats such as ponds, marshes, lakes, and slow-moving creeks, with a soft bottom, abundant basking sites, and aquatic vegetation.	[redacted]	Not at Risk	SC	S4
Northern Map Turtle	*Graptemys geographica*	Lakes and rivers with suitable basking sites, slow moving currents, muddy bottoms, abundant aquatic vegetation, and high-quality water supporting mollusc prey. In winter, deep, slow-moving sections of rivers or lakes are required for hibernation.	[redacted]	SC	SC	S3
Snapping Turtle	*Chelydra serpentina*	Slow-moving water with a soft mud bottom and dense aquatic vegetation. Ponds, sloughs, shallow bays or river edges, and slow streams, or areas combining several of these wetland habitats.	[redacted]	SC	SC	S4
Western Chorus Frog (Great Lakes/St. Lawrence – Canadian Shield)	*Pseudacris triseriata*	Terrestrial habitat consisting of humid prairie, moist woods, or meadows located in close proximity to seasonally dry, temporary ponds devoid of fish predators.	[redacted]	Not at Risk	THR	S4
MAMMALS						
Eastern Small-footed Myotis	*Myotis leibii*	A variety of habitats, including in or under rocks, in rock outcrops, in buildings, under bridges, or in caves, mines, or hollow trees	[redacted]	END	No Status	S2S3
Little Brown Myotis	*Myotis lucifugus*	Caves, quarries, tunnels, hollow trees, buildings, attics, barns, wetlands, forest edges	[redacted]	END	END	S3
Northern Myotis	*Myotis septentrionalis*	Houses, manmade structures, hollow trees, under loose bark, forests.	[redacted]	END	END	S3
Tricolored Bat	*Perimyotis subflavus*	Open woods near water; roosts in trees, cliff crevices, buildings or caves; hibernates in damp, draft-free, warm caves, mines, or rock crevices.	[redacted]	END	END	S3?
BIRDS						
Bank Swallow	*Riparia riparia*	Sand, clay or gravel riverbanks or steep riverbank cliffs; lakeshore bluffs of easily crumbled sand or gravel; gravel pits, road-cuts, grassland or cultivated fields that are close to water.	[redacted]	THR	THR	S4B

Common Name	Scientific Name	Habitat Characteristics[1,2]	Suitable Habitat within Study Area?[2,3,4]	SARO status[2]	SARA status[1,3]	S-Rank[4]
Barn Swallow	Hirundo rustica	Prefer open habitat for foraging: grassy fields, pastures, ROWs, agriculture crops, and wetlands. Post-European settlement - Nest in artificial structures, including barns, garages, houses, bridges, and culverts.	[redacted]	SC	THR	S4B
Black Tern	*Chlidonias niger*	Build floating nests in loose colonies in shallow marshes, especially in cattails.	[redacted]	SC	No Status	S3B,S4M
Bobolink	*Dolichonyx oryzivorus*	Large, open expansive grasslands with dense ground cover; hayfields, abandoned fields, meadows or fallow fields; marshes; requires tracts of grassland >50 ha.	[redacted]	THR	THR	S4B
Chimney Swift	*Chaetura pelagica*	Commonly found in urban areas near buildings; nests in hollow trees, crevices of rock cliffs, chimneys.	[redacted]	THR	THR	S3B
Common Nighthawk	*Chordeiles minor*	Open ground; clearings in dense forests; ploughed fields; gravel beaches or barren areas with rocky soils; open woodlands; flat gravel roofs.	[redacted]	SC	SC	S4B
Eastern Meadowlark	*Sturnella magna*	Generally prefers open grasslands and hay fields. In migration and in winter uses freshwater marshes and grasslands	[redacted]	THR	THR	S4B,S3N
Eastern Whip-poor-will	*Antrostomus vociferus*	Open and forested areas: savannahs, open woodlands, openings in mature deciduous, coniferous, and mixed forests.	[redacted]	THR	THR	S4B
Eastern Wood-pewee	*Contopus virens*	Open, deciduous, mixed or coniferous forest; predominated by oak with little understory; forest clearings, edges; farm woodlots, parks.	[redacted]	SC	SC	S4B
Evening Grosbeak	*Coccothraustes vespertinus*	Open, mature mixed-wood forests dominated by fir species, White Spruce and/or Trembling Aspen.	[redacted]	SC	SC	S4
Grasshopper Sparrow	*Ammodramus savannarum pratensis*	Well-drained grassland or prairie with low cover of grasses, taller weeds on sandy soil; hayfields or weedy fallow fields; uplands with ground vegetation of various densities; requires tract of grassland >10 ha.	[redacted]	SC	SC	S4B
King Rail	*Rallus elegans*	Large marshes with open shallow water that merges with shrubby areas.	[redacted]	END	END	S1B
Least Bittern	*Ixobrychus exilis*	Breeds strictly in marshes dominated by emergent vegetation surrounded by areas of open water. Breeding grounds in Canada are typically dominated by cattails but breeding also occurs in areas with other robust emergent plants and in shrubby swamps.	[redacted]	THR	THR	S4B
Northern Bobwhite	*Colinus virginianus*	Edge and grassland-type habitats, non-intensively farmed agricultural lands.	[redacted]	END	END	S1?
Red-headed Woodpecker	*Melanerpes erythrocephalus*	Open, deciduous forest with little understory; fields or pasture lands with scattered large trees; wooded swamps; orchards, small woodlots or forest edges; groves of dead or dying trees.	[redacted]	END	END	S3

Common Name	Scientific Name	Habitat Characteristics[1,2]	Suitable Habitat within Study Area?[2,3,4]	SARO status[2]	SARA status[1,3]	S-Rank[4]
Wood Thrush	*Hylocichla mustelina*	Second-growth and mature deciduous and mixed forests that have saplings and well-developed understory layers. Large forest mosaics are preferred but may use small forest fragments.	[redacted]	SC	THR	S4B
ARTHROPODS						
American Bumble Bee	*Bombus pensylvanicus*	Open habitats such as farmland, meadow, and grassland with flowers providing pollen and nectar. Nests above ground in dense mats of long grasses, abandoned bird nests, and opportunistically in abandoned rodent burrows.	[redacted]	SC	SC	S3S4
Monarch	*Danaus plexippus*	Exist primarily wherever milkweed (*Asclepius*) and wildflowers (such as Goldenrod, asters, and Purple Loosestrife) exist. This includes abandoned farmland, along roadsides, and other open spaces where these plants grow	[redacted]	SC	SC	S2N,S4B
Nine-spotted Lady Beetle	*Coccinella novemnotata*	Agricultural areas, suburban gardens, parks, coniferous forests, deciduous forests, prairie grasslands, meadows, riparian areas, and isolated natural areas.	[redacted]	END	END	S1
Transverse Lady Beetle	*Coccinella transversoguttata*	A wide range of habitats: agricultural areas, suburban gardens, parks, coniferous forests, deciduous forests, prairie grasslands, meadows and riparian areas.	[redacted]	END	SC	S1
Yellow-banded Bumble Bee	*Bombus terricola*	Habitat generalist, uses a variety of nectaring plants and environmental conditions.	[redacted]	SC	SC	S3S5
FISH AND MOLLUSCS						
American Eel	*Anguilla rostrata*	Fresh water, estuaries, coastal marine waters that are accessible to the Atlantic Ocean.	[redacted]	END	No Status	S1S2
Lake Sturgeon (Great Lakes – Upper St. Lawrence populations)	*Acipenser fulvescens*	Large rivers and lakes.	[redacted].	END	No Status	S2
VASCULAR PLANTS						
Butternut	*Juglans cinereal*	Grows in deciduous forests with moist, well-drained soil, often along streams. Also found on well-drained gravel sites.	[redacted]	END	END	S2?
White Wood Aster	*Eurybia divaricata*	Grows in open, dry deciduous forests that are dominated by Sugar Maple and American Beech trees. Often found mixed in with other asters.	[redacted]	THR	THR	S3

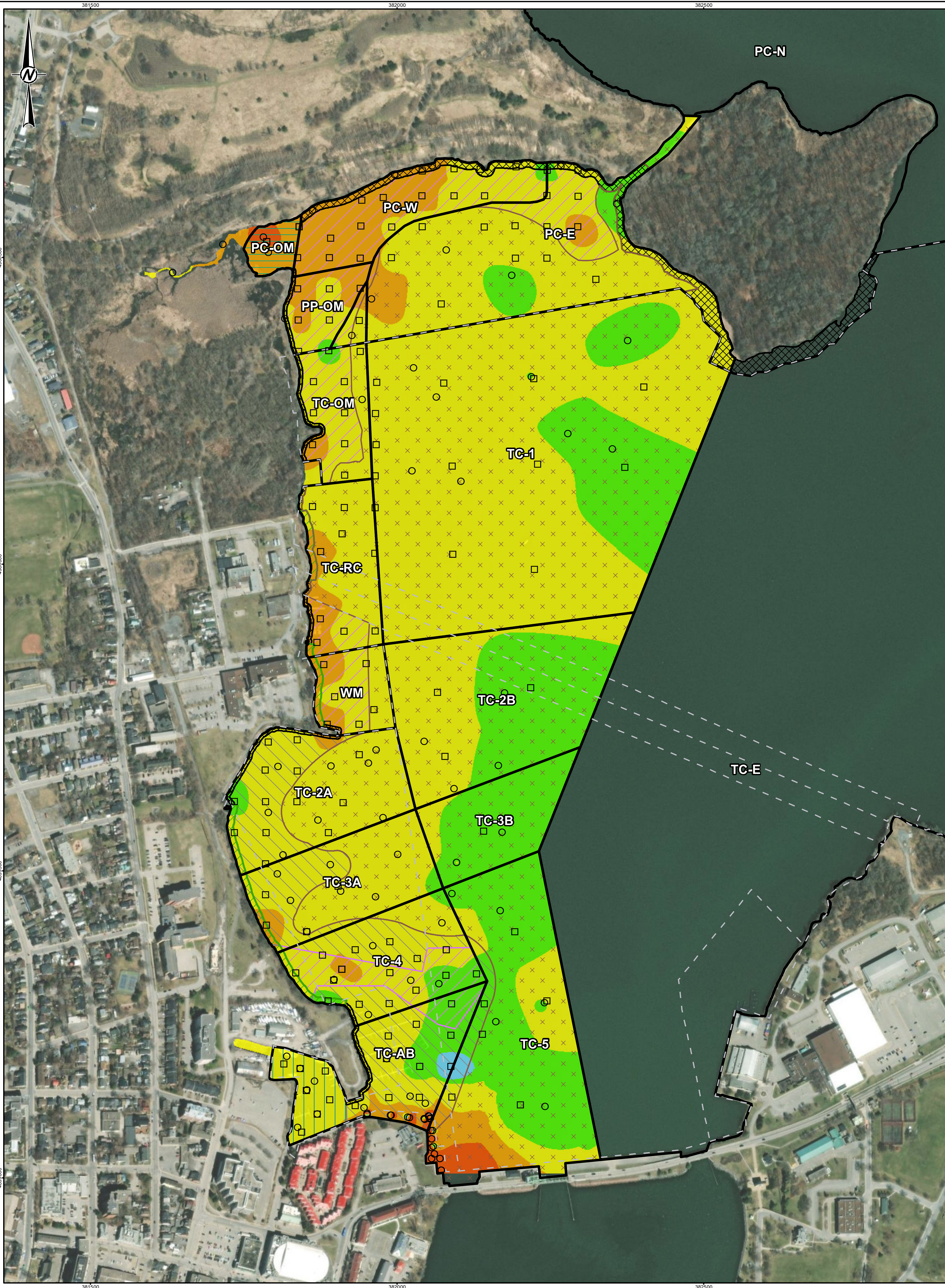
[1] Species at Risk Public Registry. (2023, March 6). Government of Canada. Retrieved March 28, 2023, from https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html
[2] Species at Risk in Ontario List. (2023, January 24). Ministry of the Environment, Conservation and Parks. Retrieved March 28, 2023, from https://www.ontario.ca/page/species-risk-ontario
[3] Natural Heritage Information Centre (NHIC). (2022, December 20). Government of Ontario. Retrieved March 28, 2023, from https://www.ontario.ca/page/get-natural-heritage-information
[4] S-Rank is Subnational Conservation rank within Ontario (https://explorer.natureserve.org/AboutTheData/Statuses); ? = Inexact Numerical Rank

Status
No Status: Species has not been assessed under the Endangered Species Act.
Not at Risk: Species has been assessed as not at risk by the Committee on the Status of Endangered Wildlife in Canada and is not listed under SARA or by the Committee on the Status of Species at Risk in Ontario and is not listed under the ESA.
Special Concern: Species that may become threatened or an endangered species because of a combination of biological characteristics and identified threats.
Threatened: Species that is likely to become an endangered species if nothing is done to reverse the factors leading to its extirpation or extinction.
Endangered: Species that is facing imminent extirpation or extinction.

APPENDIX B

Current Sediment Quality Distributions

PATH: Y:\burnaby\CAD-GIS\Client\PWGSC\Kingston_Inner_Harbour\99_PROJECTS\22523199\02_PRODUCTION\MXD\Report\Appendix\22523199_B-01_KIH_Antimony.mxd



LEGEND

- 2021 SURFACE GRAB LOCATION
- 2011 - 2020 SURFACE GRAB LOCATION
- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- DREDGING EXCLUSION ZONE
- POTENTIAL FOR NATURE-BASED SHORELINE REHABILITATION TO IMPROVE HABITAT/DREDGING EXCLUSION ZONE
- FUTURE WETLAND MANAGEMENT REQUIRING COORDINATION WITH CITY OF KINGSTON, PRIVATE LAND OWNERS AND PARKS CANADA
- DREDGE BOUNDARY WITH (1.0m) CAP WITH CARBON AMENDMENT OR REACTIVE BARIER
- DREDGE BOUNDARY WITH THIN LAYER (UP TO 0.3m) CAP/COVER
- ENHANCED NATURAL RECOVERY (THIN LAYER CAP/CARBON AMENDMENT)
- MONITORED NATURAL RECOVERY

ANTIMONY

- 0 - 0.2 mg/kg
- 0.2 - 0.6 mg/kg (<LAET)
- 0.6 - 1.9 mg/kg (<2LAET)
- 1.9 - 6 mg/kg
- 6 - 20 mg/kg
- > 20 mg/kg

0 120 240

1:6,000 METERS

REFERENCE(S)

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PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PSPC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
ANTIMONY BULK SEDIMENT CHEMISTRY AND INVERSE WEIGHTED DISTANCE SURFACE (2011 - 2021)

CONSULTANT

wsp

YYYY-MM-DD	2023-07-05
DESIGNED	JD
PREPARED	JP
REVIEWED	JD
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
22523199	3000	0	B-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

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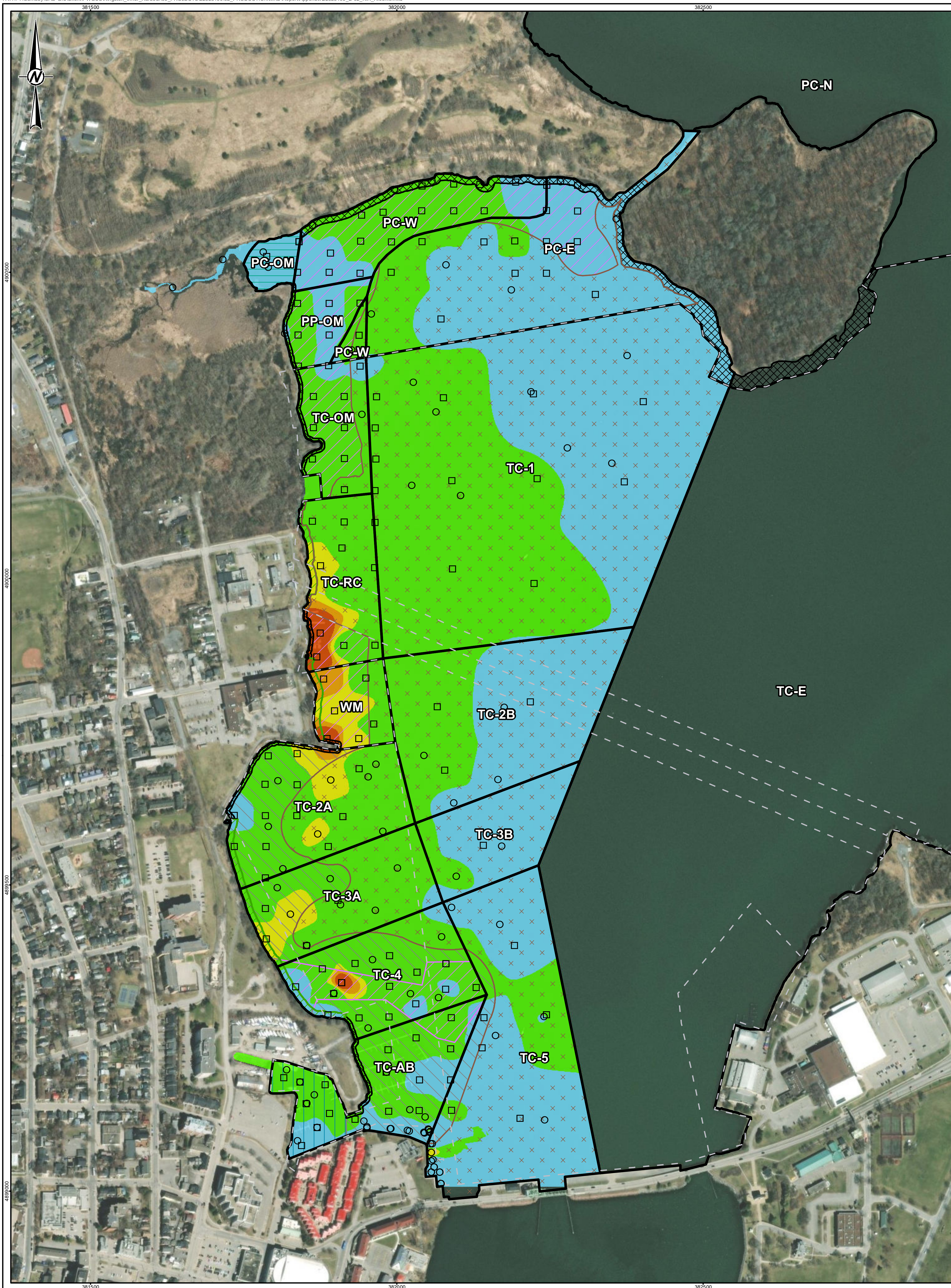

LEGEND

- ☐ 2021 SURFACE GRAB LOCATION
- ○ 2011 - 2020 SURFACE GRAB LOCATION
- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- DREDGING EXCLUSION ZONE
- POTENTIAL FOR NATURE-BASED SHORELINE REHABILITATION TO IMPROVE HABITAT/DREDGING EXCLUSION ZONE
- FUTURE WETLAND MANAGEMENT REQUIRING COORDINATION WITH CITY OF KINGSTON, PRIVATE LAND OWNERS AND PARKS CANADA
- DREDGE BOUNDARY WITH (1.0m) CAP WITH CARBON AMENDMENT OR REACTIVE BARIER
- DREDGE BOUNDARY WITH THIN LAYER (UP TO 0.3m) CAP/COVER
- ENHANCED NATURAL RECOVERY (THIN LAYER CAP/CARBON AMENDMENT)
- MONITORED NATURAL RECOVERY

ARSENIC

- 0 - 5.9 mg/kg (<ISQG)
- 5.9 - 17 mg/kg (<PEL)
- 17- 33 mg/kg (<SEL)
- 33 - 50.9 mg/kg (<2LAET)
- 50.9 - 100 mg/kg
- > 100 mg/kg

0 120 240

1:6,000 METERS

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PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PSPC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
ARSENIC BULK SEDIMENT CHEMISTRY AND INVERSE WEIGHTED DISTANCE SURFACE (2011 - 2021)

CONSULTANT
wsp

YYYY-MM-DD	2023-07-05
DESIGNED	JD
PREPARED	JP
REVIEWED	JD
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

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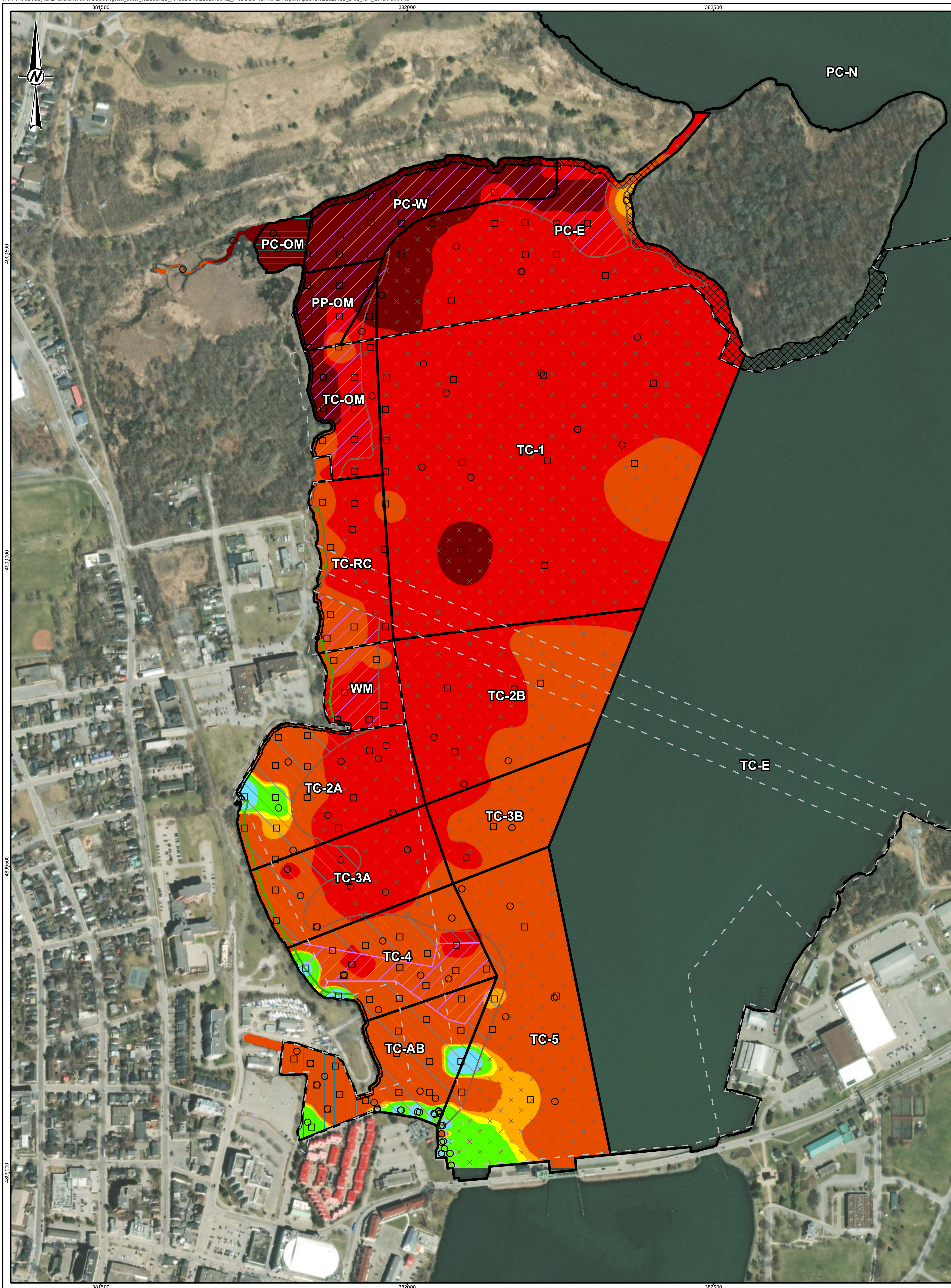

LEGEND

- 2021 SURFACE GRAB LOCATION
- 2011 - 2020 SURFACE GRAB LOCATION
- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- DREDGING EXCLUSION ZONE
- POTENTIAL FOR NATURE-BASED SHORELINE REHABILITATION TO IMPROVE HABITAT/DREDGING EXCLUSION ZONE
- FUTURE WETLAND MANAGEMENT REQUIRING COORDINATION WITH CITY OF KINGSTON, PRIVATE LAND OWNERS AND PARKS CANADA
- DREDGE BOUNDARY WITH (1.0m) CAP WITH CARBON AMENDMENT OR REACTIVE BARIER
- DREDGE BOUNDARY WITH THIN LAYER (UP TO 0.3m) CAP/COVER
- ENHANCED NATURAL RECOVERY (THIN LAYER CAP/CARBON AMENDMENT)
- MONITORED NATURAL RECOVERY

CHROMIUM

- 0 - 37.3 mg/kg (<ISQG)
- 37.3 - 90 mg/kg (<PEL)
- 90 - 110 mg/kg (<SEL)
- 110 - 133 mg/kg (<2LAET)
- 133 - 500 mg/kg
- 500 - 1,000 mg/kg
- > 1,000 mg/kg

0 120 240

1:6,000 METERS

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PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PSPC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
CHROMIUM BULK SEDIMENT CHEMISTRY AND INVERSE WEIGHTED DISTANCE SURFACE (2011 - 2021)

CONSULTANT

wsp

YYYY-MM-DD	2023-07-05
DESIGNED	JD
PREPARED	JP
REVIEWED	JD
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

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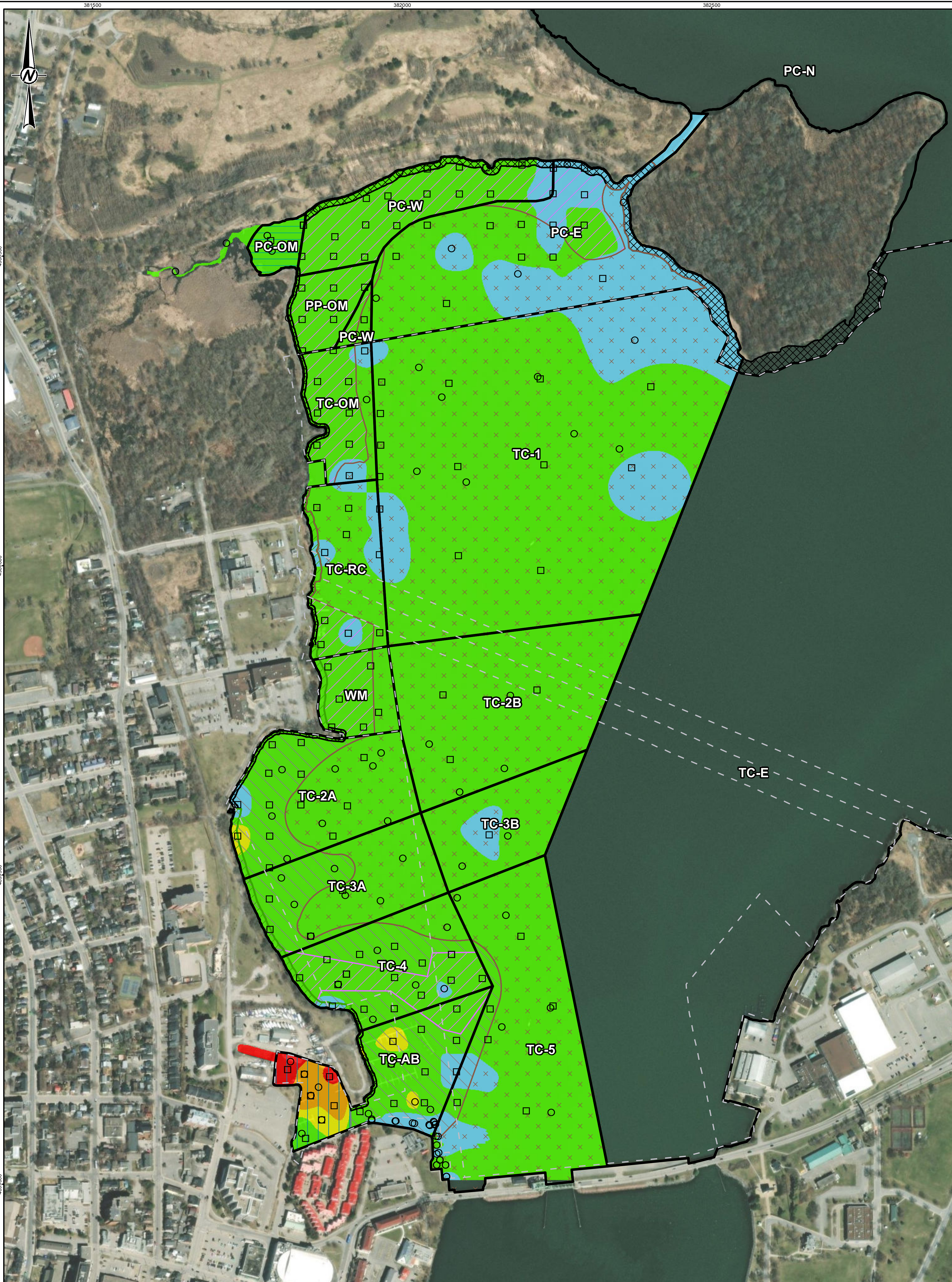

LEGEND

- □ 2021 SURFACE GRAB LOCATION
- ○ 2011 - 2020 SURFACE GRAB LOCATION
- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- DREDGING EXCLUSION ZONE
- POTENTIAL FOR NATURE-BASED SHORELINE REHABILITATION TO IMPROVE HABITAT/DREDGING EXCLUSION ZONE
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- DREDGE BOUNDARY WITH (1.0m) CAP WITH CARBON AMENDMENT OR REACTIVE BARIER
- DREDGE BOUNDARY WITH THIN LAYER (UP TO 0.3m) CAP/COVER
- ENHANCED NATURAL RECOVERY (THIN LAYER CAP/CARBON AMENDMENT)
- MONITORED NATURAL RECOVERY

COPPER

- 0 - 35.7 mg/kg (<ISQG)
- 35.7 - 110 mg/kg (<SEL)
- 110 - 197 mg.kg (<PEL)
- 197 - 619 mg/kg (<LAET)
- 619 - 829 mg/kg (<2LAET)

0 120 240

1:6,000 METERS

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PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PSPC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
COPPER BULK SEDIMENT CHEMISTRY AND INVERSE WEIGHTED DISTANCE SURFACE (2011 - 2021)

CONSULTANT

wsp

YYYY-MM-DD	2023-07-04
DESIGNED	JD
PREPARED	JP
REVIEWED	JD
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

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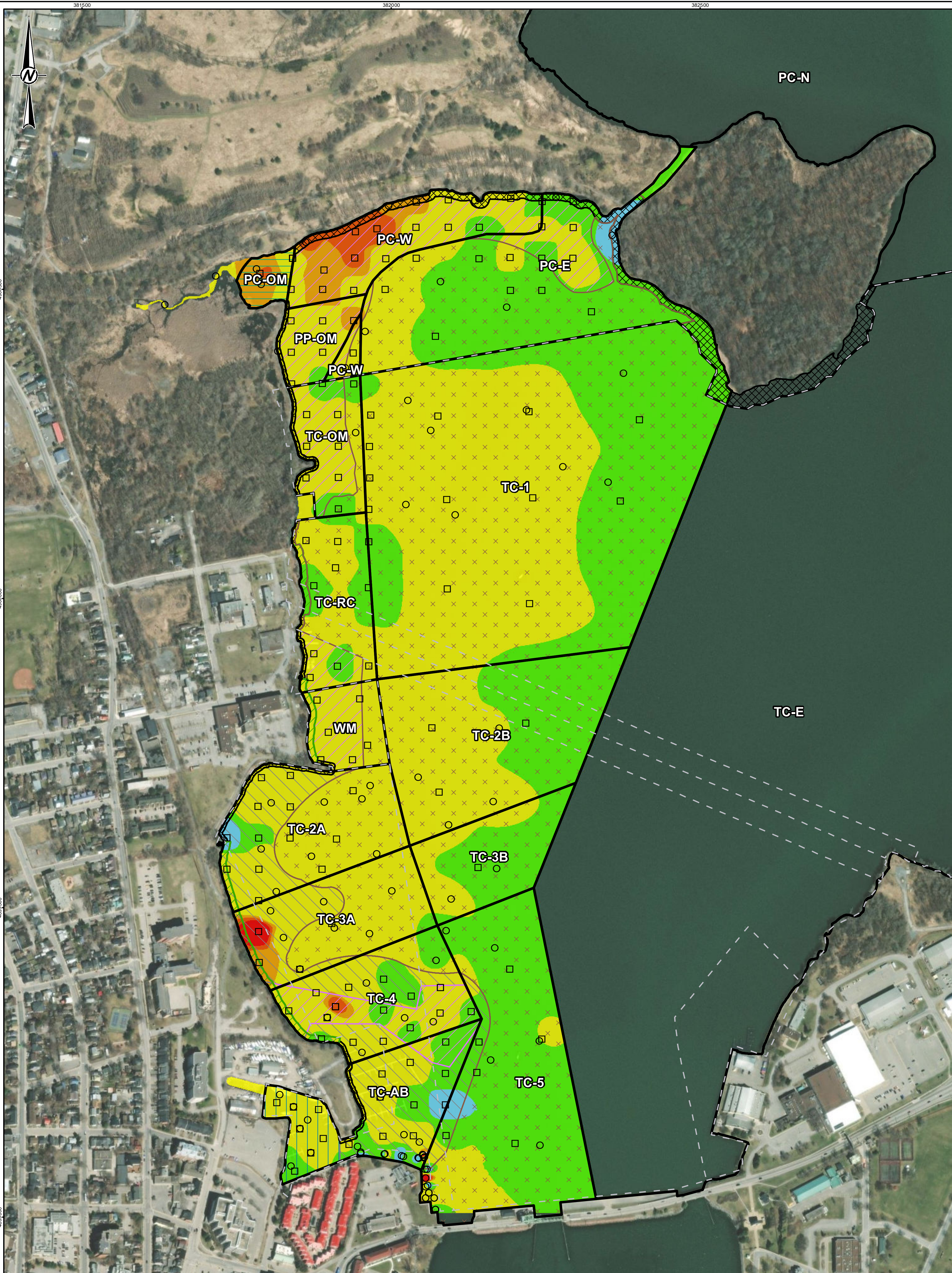

LEGEND

- □ 2021 SURFACE GRAB LOCATION
- ○ 2011 - 2020 SURFACE GRAB LOCATION
- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- DREDGING EXCLUSION ZONE
- POTENTIAL FOR NATURE-BASED SHORELINE REHABILITATION TO IMPROVE HABITAT/DREDGING EXCLUSION ZONE
- FUTURE WETLAND MANAGEMENT REQUIRING COORDINATION WITH CITY OF KINGSTON, PRIVATE LAND OWNERS AND PARKS CANADA
- DREDGE BOUNDARY WITH (1.0m) CAP WITH CARBON AMENDMENT OR REACTIVE BARIER
- DREDGE BOUNDARY WITH THIN LAYER (UP TO 0.3m) CAP/COVER
- ENHANCED NATURAL RECOVERY (THIN LAYER CAP/CARBON AMENDMENT)
- MONITORED NATURAL RECOVERY

LEAD

- 0 - 35 mg/kg (<ISQG)
- 35 - 91.3 mg/kg (<PEL)
- 91.3 - 250 mg/kg
- 250 - 335 mg/kg (<LAET)
- 335 - 431 mg/kg (<2LAET)
- >431 mg/kg

0 120 240

1:6,000 METERS

REFERENCE(S)

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PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PSPC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
LEAD BULK SEDIMENT CHEMISTRY AND INVERSE WEIGHTED DISTANCE SURFACE (2011 - 2021)

CONSULTANT

wsp

YYYY-MM-DD	2023-07-04
DESIGNED	JD
PREPARED	JP
REVIEWED	JD
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
22523199	3000	0	B-5

25mm

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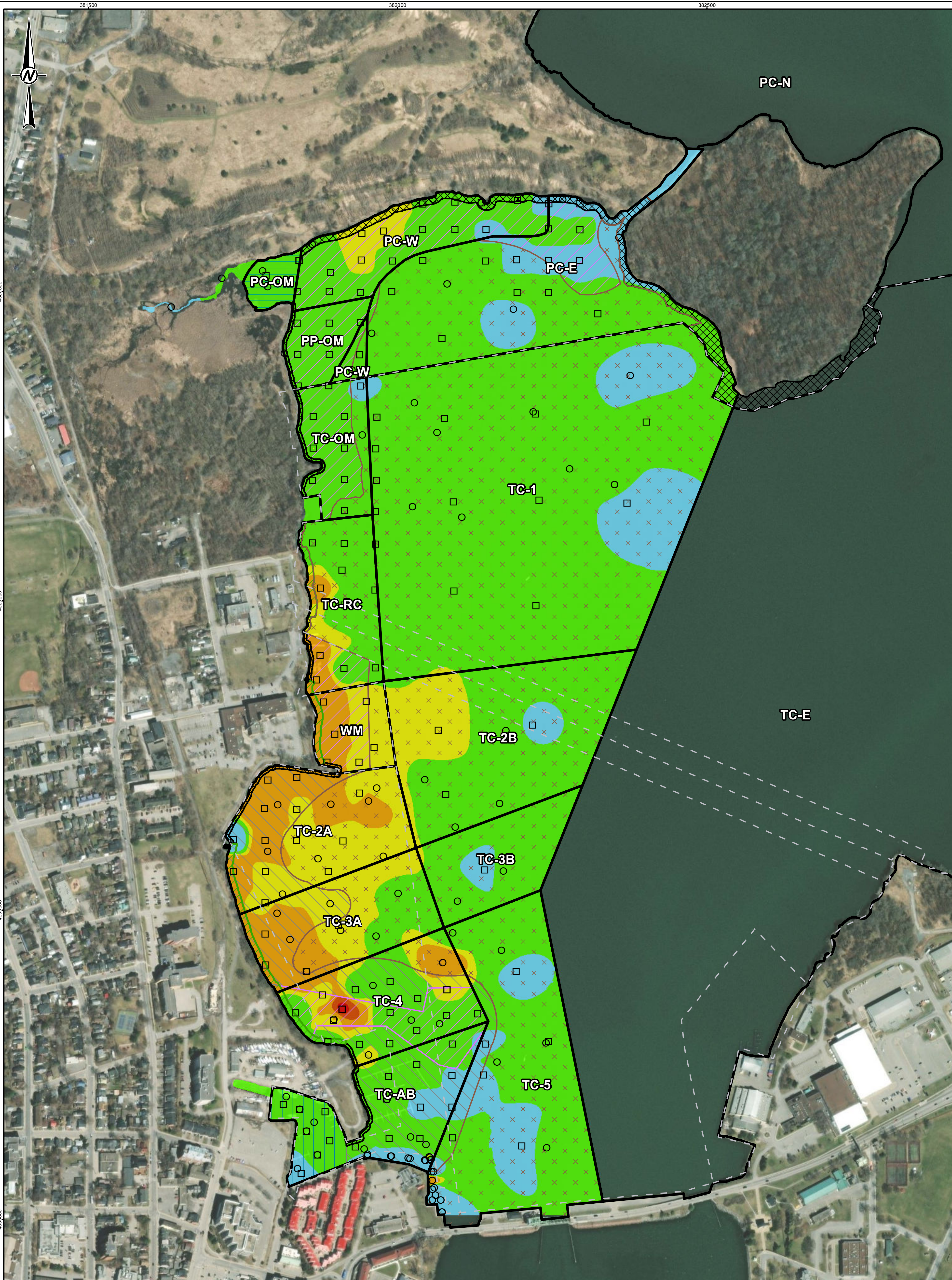

LEGEND

- 2021 SURFACE GRAB LOCATION
- 2011 - 2020 SURFACE GRAB LOCATION
- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- DREDGING EXCLUSION ZONE
- POTENTIAL FOR NATURE-BASED SHORELINE REHABILITATION TO IMPROVE HABITAT/DREDGING EXCLUSION ZONE
- FUTURE WETLAND MANAGEMENT REQUIRING COORDINATION WITH CITY OF KINGSTON, PRIVATE LAND OWNERS AND PARKS CANADA
- DREDGE BOUNDARY WITH (1.0m) CAP WITH CARBON AMENDMENT OR REACTIVE BARIER
- DREDGE BOUNDARY WITH THIN LAYER (UP TO 0.3m) CAP/COVER
- ENHANCED NATURAL RECOVERY (THIN LAYER CAP/CARBON AMENDMENT)
- MONITORED NATURAL RECOVERY

MERCURY

- 0 - 0.17 mg/kg (<ISQG)
- 0.17 - 0.486 mg/kg (<PEL)
- 0.486 - 0.8 mg/kg (<LAET)
- 0.8 - 2 mg/kg (<SEL)
- 2 - 3.04 mg/kg (<2LAET)
- > 3.04 mg/kg

0 120 240

1:6,000 METERS

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PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PSPC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
MERCURY BULK SEDIMENT CHEMISTRY AND INVERSE WEIGHTED DISTANCE SURFACE (2011 - 2021)

CONSULTANT
wsp

YYYY-MM-DD	2023-07-05
DESIGNED	JD
PREPARED	JP
REVIEWED	JD
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
22523199	3000	0	B-6

25mm

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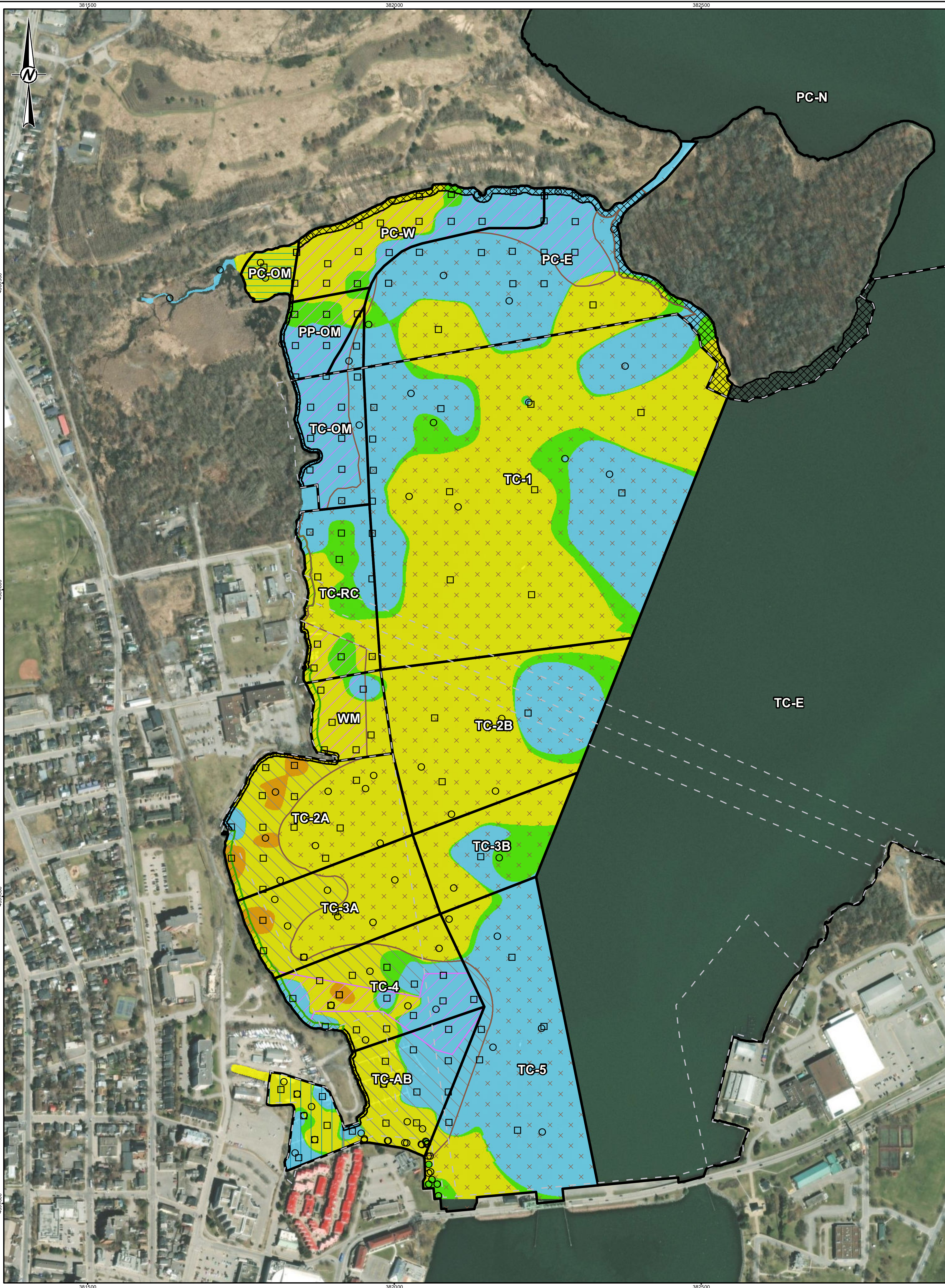

LEGEND

- 2021 SURFACE GRAB LOCATION
- 2011 - 2020 SURFACE GRAB LOCATION
- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- DREDGING EXCLUSION ZONE
- POTENTIAL FOR NATURE-BASED SHORELINE REHABILITATION TO IMPROVE HABITAT/DREDGING EXCLUSION ZONE
- FUTURE WETLAND MANAGEMENT REQUIRING COORDINATION WITH CITY OF KINGSTON, PRIVATE LAND OWNERS AND PARKS CANADA
- DREDGE BOUNDARY WITH (1.0m) CAP WITH CARBON AMENDMENT OR REACTIVE BARIER
- DREDGE BOUNDARY WITH THIN LAYER (UP TO 0.3m) CAP/COVER
- ENHANCED NATURAL RECOVERY (THIN LAYER CAP/CARBON AMENDMENT)
- MONITORED NATURAL RECOVERY

SILVER

- 0 - 0.5 mg/kg
- 0.5 - 0.545 mg/kg (<LAET)
- 0.545 - 2 mg/kg
- 2 - 3.5 mg/kg (<2LAET)
- 3.5 - 4.5 mg/kg
- > 4.5 mg/kg

0 120 240

1:6,000 METERS

REFERENCE(S)

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2. INSET BASE OBTAINED FROM ESRI CANADA.
PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PSPC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
SILVER BULK SEDIMENT CHEMISTRY AND INVERSE WEIGHTED DISTANCE SURFACE (2011 - 2021)

CONSULTANT

YYYY-MM-DD	2022-07-05
DESIGNED	CP
PREPARED	JP/MH
REVIEWED	JD
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
22523199	8007	0	B-7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
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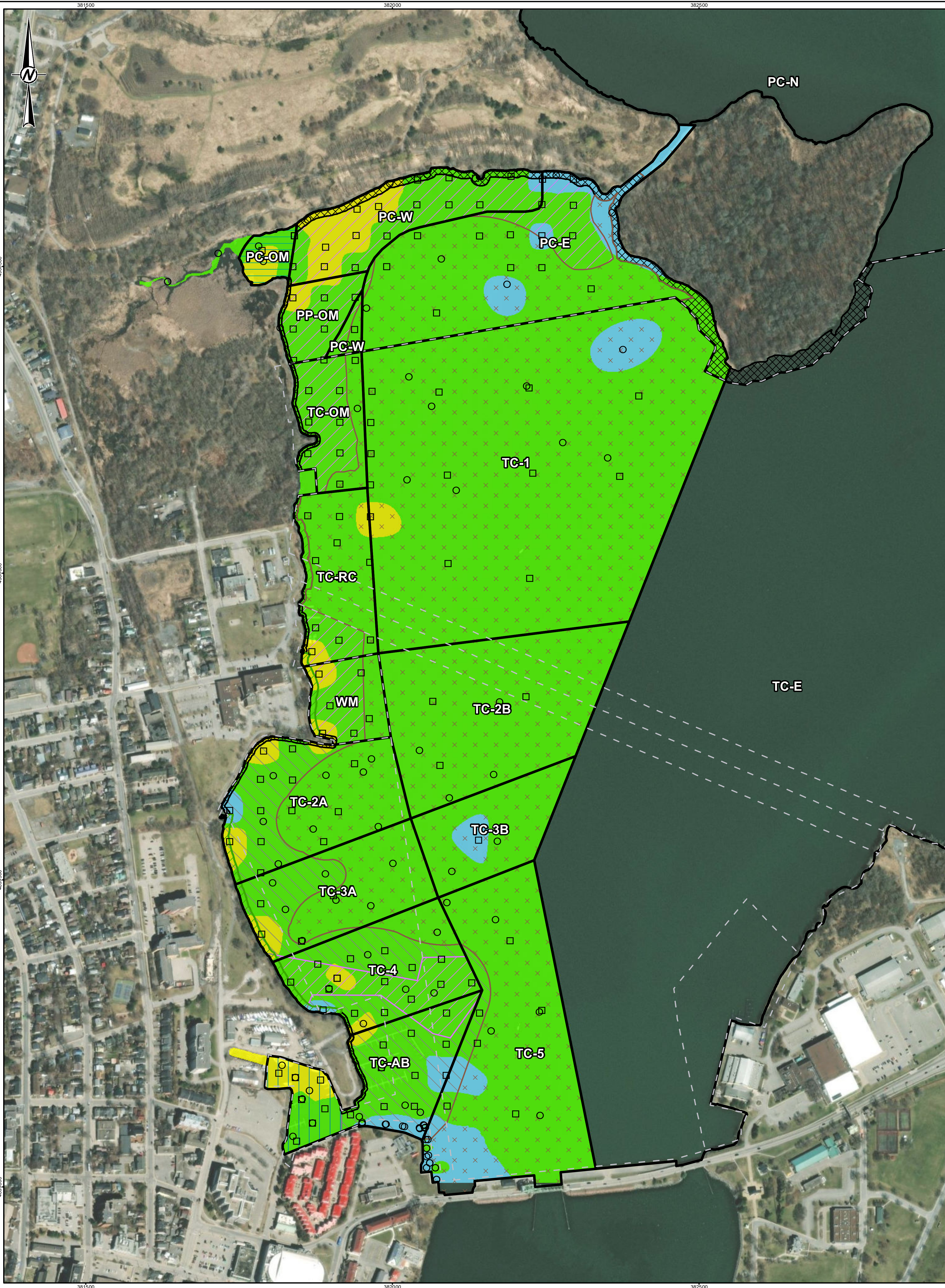

LEGEND

- 2021 SURFACE GRAB LOCATION
- 2011 - 2020 SURFACE GRAB LOCATION
- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- DREDGING EXCLUSION ZONE
- POTENTIAL FOR NATURE-BASED SHORELINE REHABILITATION TO IMPROVE HABITAT/DREDGING EXCLUSION ZONE
- FUTURE WETLAND MANAGEMENT REQUIRING COORDINATION WITH CITY OF KINGSTON, PRIVATE LAND OWNERS AND PARKS CANADA
- DREDGE BOUNDARY WITH (1.0m) CAP WITH CARBON AMENDMENT OR REACTIVE BARIER
- DREDGE BOUNDARY WITH THIN LAYER (UP TO 0.3m) CAP/COVER
- ENHANCED NATURAL RECOVERY (THIN LAYER CAP/CARBON AMENDMENT)
- MONITORED NATURAL RECOVERY

ZINC

- 0 - 123 mg/kg (<ISQG)
- 123 - 315 mg/kg (<PEL)
- 315 - 683 mg/kg (<LAET)
- 683 - 820 mg/kg (<SEL)
- 820 - 1080 mg/kg (<2LAET)
- > 1080 mg/kg

0 120 240

1:6,000 METERS

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PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PSPC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
ZINC BULK SEDIMENT CHEMISTRY AND INVERSE WEIGHTED DISTANCE SURFACE (2011 - 2021)

CONSULTANT

YYYY-MM-DD	2023-07-05
DESIGNED	JD
PREPARED	JP
REVIEWED	JD
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
22523199	3000	0	B-8

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

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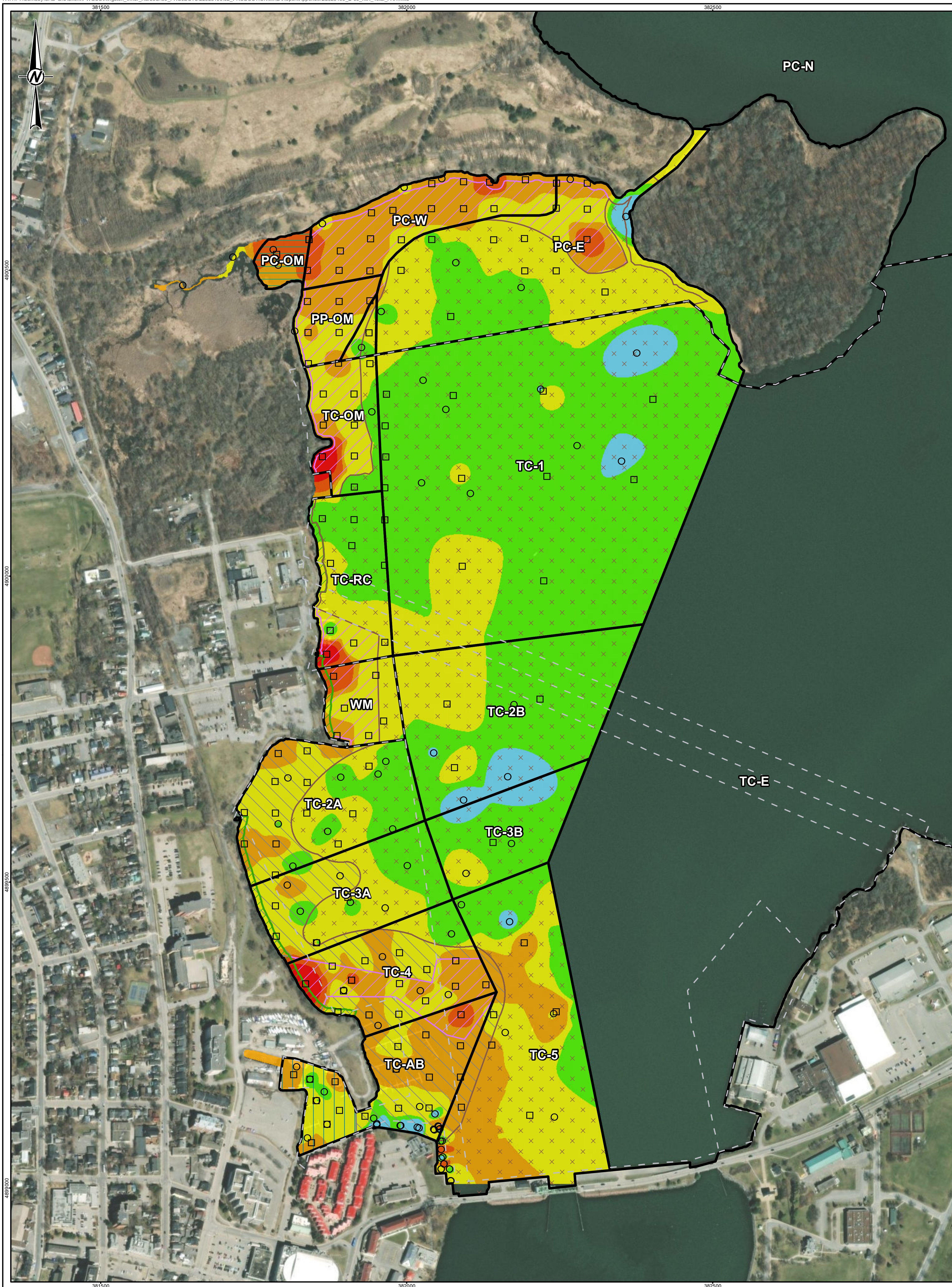

LEGEND

- 2021 SURFACE GRAB LOCATION
- 2011 - 2020 SURFACE GRAB LOCATION
- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- DREDGING EXCLUSION ZONE
- POTENTIAL FOR NATURE-BASED SHORELINE REHABILITATION TO IMPROVE HABITAT/DREDGING EXCLUSION ZONE
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- ENHANCED NATURAL RECOVERY (THIN LAYER CAP/CARBON AMENDMENT)
- MONITORED NATURAL RECOVERY

TOTAL PAH

- 0 - 1.61 mg/kg (<TEC)
- 1.61 - 4 mg/kg (<LEL)
- 4 - 10 mg/kg
- 10 - 22.8 mg/kg (<PEC)
- 22.8 - 100 mg/kg
- 100 - 750 mg/kg

0 120 240

1:6,000 METERS

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PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT

PSPC

PROJECT

KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE

TOTAL PAH BULK SEDIMENT CHEMISTRY AND INVERSE WEIGHTED DISTANCE SURFACE (2011 - 2021)

CONSULTANT

wsp

YYYY-MM-DD	2023-07-05
DESIGNED	JD
PREPARED	JP
REVIEWED	JD
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
22523199	3000	0	B-9

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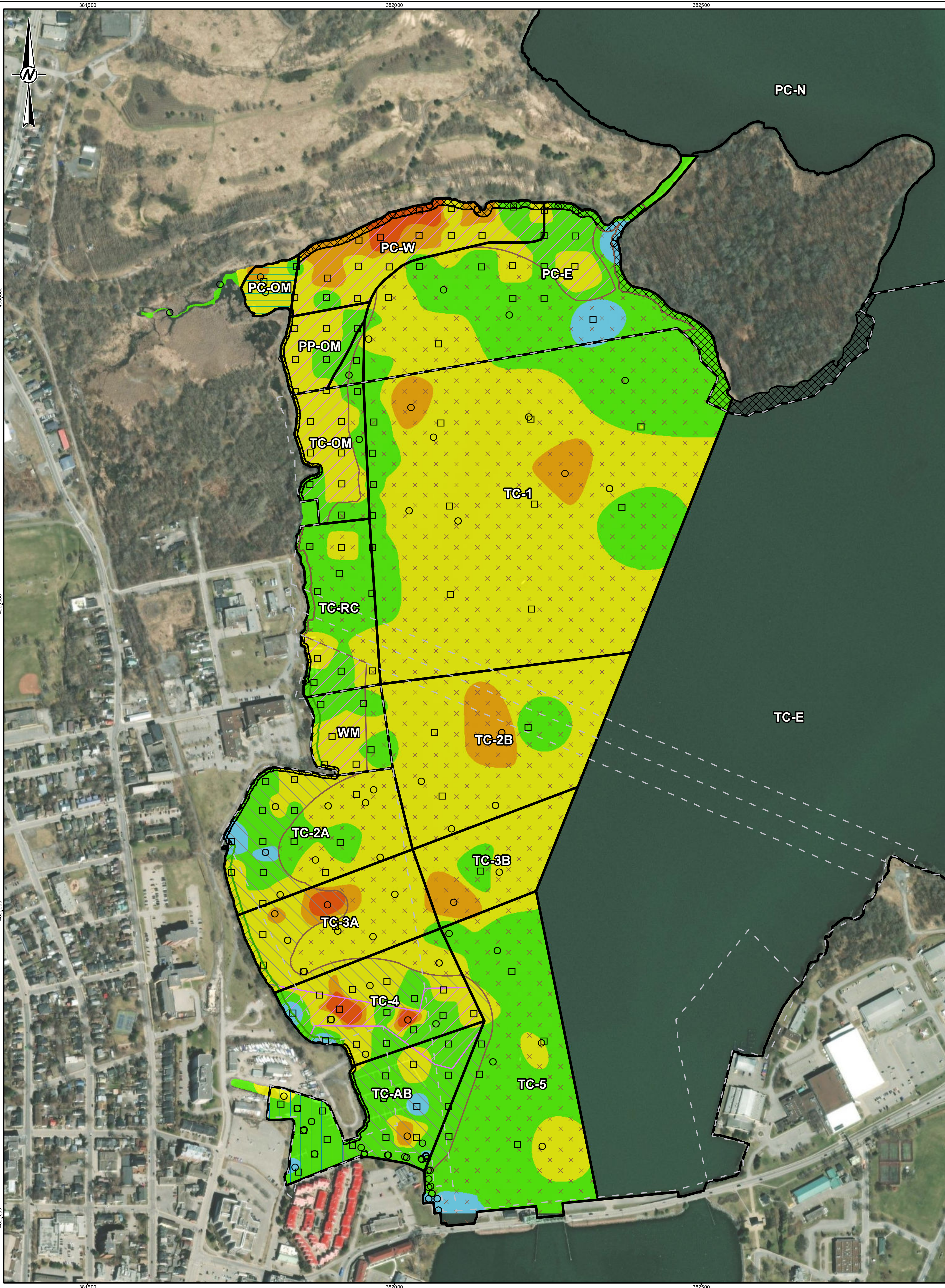

LEGEND

- 2021 SURFACE GRAB LOCATION
- 2011 - 2020 SURFACE GRAB LOCATION
- FEDERAL WATER LOT BOUNDARY
- MANAGEMENT UNIT
- DREDGING EXCLUSION ZONE
- POTENTIAL FOR NATURE-BASED SHORELINE REHABILITATION TO IMPROVE HABITAT/DREDGING EXCLUSION ZONE
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- DREDGE BOUNDARY WITH THIN LAYER (UP TO 0.3m) CAP/COVER
- ENHANCED NATURAL RECOVERY (THIN LAYER CAP/CARBON AMENDMENT)
- MONITORED NATURAL RECOVERY

TOTAL PCB

- 0 - 0.07 mg/kg (<LEL)
- 0.07 - 0.3 mg/kg (<PEL)
- 0.3 - 0.6 mg/kg (<LAET)
- 0.6 - 1 mg/kg
- 1 - 5.3 mg/kg (<SEL)
- > 5.3 mg/kg

0 120 240

1:6,000 METERS

REFERENCE(S)

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PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PSPC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
TOTAL PCB BULK SEDIMENT CHEMISTRY AND INVERSE WEIGHTED DISTANCE SURFACE (2011 - 2021)

CONSULTANT

YYYY-MM-DD	2023-07-05
DESIGNED	JD
PREPARED	JP
REVIEWED	JD
APPROVED	GL

PROJECT NO.	PHASE	REV.	FIGURE
22523199	3000	0	B-10

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APPENDIX C

Basis of Design for Shoreline Protection Concepts

UNCLASSIFIED / NON CLASSIFIÉ

TECHNICAL MEMORANDUM

DATE 19 September 2023

Reference No. 22523199-010-TM-Rev0

TO Pravina Singh
Public Services and Procurement Canada

CC Jennifer Daley, Gary Lawrence

FROM Keyvan Mahlujy [redacted]

KINGSTON INNER HARBOUR – BASIS OF DESIGN FOR SHORELINE PROTECTION CONCEPTS

WSP Canada Ltd. (WSP) was retained by Public Services and Procurement Canada (PSPC), on behalf of Transport Canada and Parks Canada (the Client), to prepare this technical memorandum documenting a coastal engineering basis of design for shoreline protection concepts to be considered in refinements to the conceptual Sediment Management Plan (SMP) for the Kingston Inner Harbour (KIH) Sediment Management Project in Kingston, Ontario (the Project). The first draft of the SMP was prepared by Golder (amalgamated under WSP Canada Inc. in January 2023) in 2021 and included consideration of several environmental (biological, chemical, and toxicological), hydrological, and preliminary design considerations for the implementation of a sediment remediation project (Golder 2021). This basis of design document is being prepared as a component of the second draft SMP.

This basis of design document summarizes several constraints to the implementation of a successful remediation project, focusing on aspects related to the management of physical shoreline elements. As the draft conceptual design entails intervention in several shoreline-adjacent areas, either through dredging, thin-layer capping, or other physical works, the feasibility and effectiveness of the shoreline interventions is a critical component of the overall SMP. As such, the conceptual design objectives, constraints, and preliminary design criteria for shoreline works are described herein. These elements provide ground rules for the implementation of the conceptual options, with emphasis on the geotechnical, coastal engineering, and hydrological considerations. In addition, several biological design features are discussed (e.g., constraints around sources and properties of materials used for shoreline design) that link to habitat requirements. These considerations are combined with other environmental, economic, and social considerations in the ongoing revisions to the SMP, including the consideration of recent stakeholder feedback as appropriate.

1.0 INTRODUCTION

Kingston Harbour is located at the eastern end of Lake Ontario and includes an Inner Harbour (i.e., water lots north of Lasalle Causeway) and an Outer Harbour. Sediment in KIH, which includes several water lots south of Belle Island and Cataraqui Park, is known to contain contamination of historical origin, much of which has been characterized in terms of spatial extent and magnitude of sediment contamination and the effects of those contaminants to organisms (Golder 2016). Transport Canada is responsible for the management of most sediment areas in the southern and central sections of KIH. Parks Canada is responsible for sediments in the water lot immediately south of Belle Park Fairways (i.e., southwest of Belle Island) and in the portion of KIH north of Belle Island (i.e., the reference area with lower concentrations of contaminants). A small percentage of the southern half of KIH is owned by other parties, including a square water lot adjacent to the former Woolen Mill owned by the City of Kingston, small areas of foreshore near the Kingston marina owned by the City of Kingston, a Military Reserve in the southeastern corner of KIH owned by the Department of National Defence (DND), and small areas of foreshore near Anglin Bay owned by DND. Figure 1 provides a spatial overview of KIH including the following management units defined by the ownership within the waterlot including:

- Parks Canada (PC)—includes management units coded as: Parks Canada West subunits of PC-W, PC-OM, and East (PC-E)
- Transport Canada (TC) —includes management units coded as: Orchard Street Marsh (TC-OM), Rowing Club (TC-RC), Units 1 to 5 (i.e., TC-1, TC-2A, TC-2B, TC-3A, TC-3B, TC-4 and TC-5), and Anglin Bay (TC-AB)
- Other Parties – includes management units under municipal, or unverified ownership coded as Woolen Mill (WM) and PP-OM

In 2019, Golder prepared a conceptual remedial design describing an overall level of intervention that is intermediate between the low and moderate intervention levels identified in the conceptual remedial options analysis (CROA) (Golder 2017a), reflecting assumptions regarding the practicality, cost, proportional risk reduction, site constraints, and anticipated stakeholder input. In 2020, a preliminary remedial action plan (RAP), later renamed as the Conceptual Sediment Management Plan (Golder 2021; SMP) was prepared by Golder. The document provided an analysis of the scientific issues, estimates of indicative liability costs, alternatives evaluation, and a recommended approach for sediment management within the aquatic portions of the harbour. Targeted stakeholder engagement and Indigenous community consultations have been underway since fiscal year 2020/21.

Based on initial stakeholder feedback, revisions have been made to the proposed shore protection options for management units TC-RC, WM, TC-2A, TC-3A and TC-4, which formerly included a revetment structure placed over a sediment cap. Specifically, nature-based approaches for shoreline rehabilitation are being considered as a complement to engineering approaches, where suitable, to take advantage of the following opportunities:

- Habitat enhancement especially the enhancement of turtle habitat and the establishment of aquatic and coastal riparian vegetation
- Limiting the potential for human access to the water to reduce human exposure from a health risk perspective

Golder (2022) outlined potential nature-based shoreline rehabilitation principles and concepts that may be appropriate for application in management units TC-RC, WM, TC-2A, TC-3A and TC-4. The nature-based shoreline rehabilitation concepts offer the potential for habitat improvement and are also compatible with both the City's Master Plan for shoreline development and with regulatory requirements (permitting) for habitat alteration. This memorandum provides an updated basis of design for the shore rehabilitation and nearshore river bed components prior to the development of more detailed concepts for application in the respective management units. This document is not intended to provide detailed design or costing elements, but rather to identify the constraints that will apply to those design elements.

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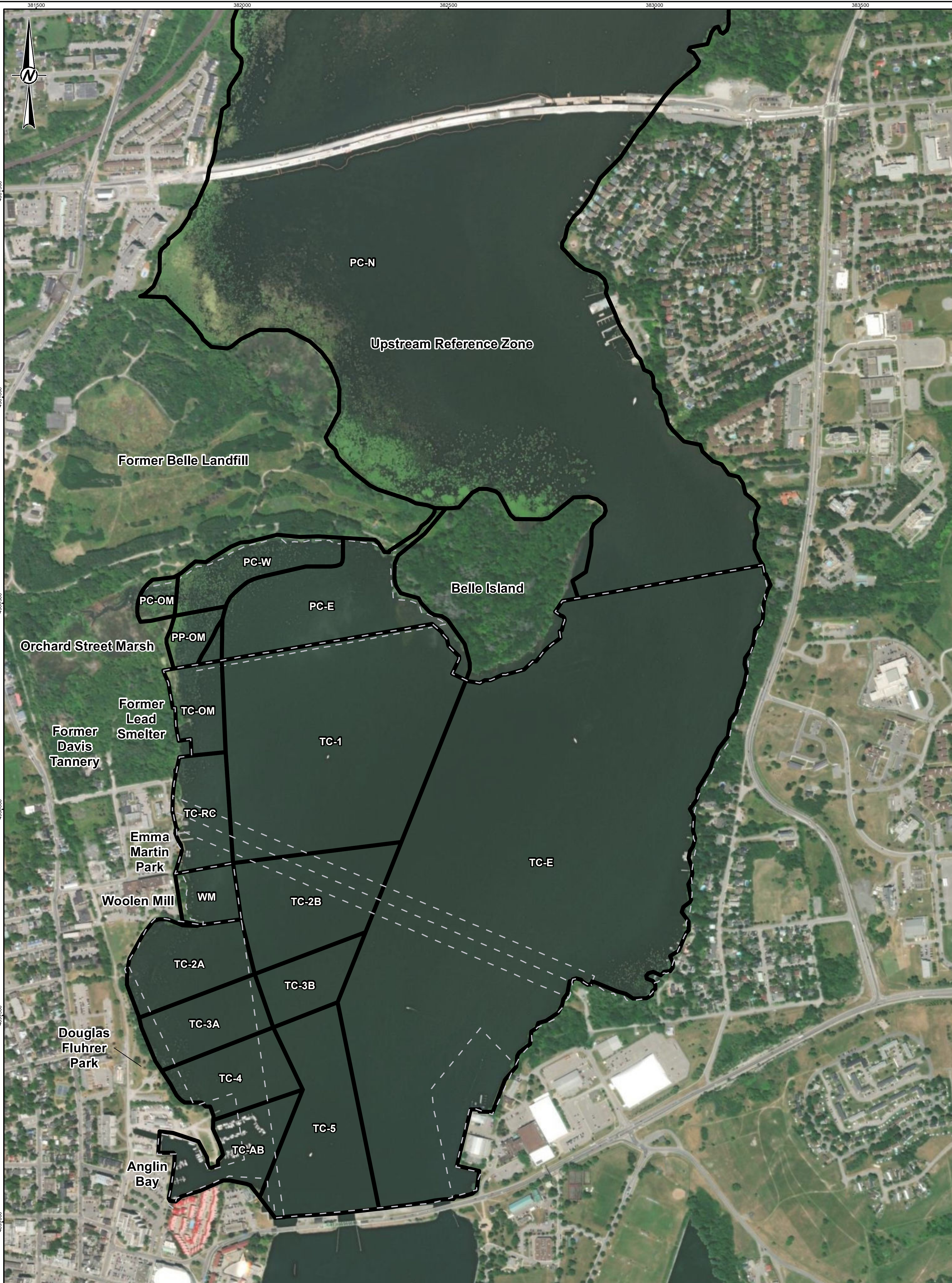

LEGEND

FEDERAL WATER LOT BOUNDARY

MANAGEMENT UNIT

FOR DISCUSSION PURPOSES ONLY

0 200 400

1:9,000 METERS

REFERENCES

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PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PSPC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
SPATIAL DOMAIN OF KIH STUDY AREA AND MANAGEMENT UNITS

CONSULTANT

YYYY-MM-DD	2022-12-08
DESIGNED	LF
PREPARED	JP
REVIEWED	
APPROVED	

PROJECT NO.	PHASE	REV.	FIGURE
2253199	4000	0	1

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25mm

2.0 BASIS OF DESIGN

This section of the technical memorandum summarizes the conceptual design objectives, constraints, and preliminary design criteria to be used as a basis for development of shoreline rehabilitation and protection concepts. In the final design, the configurations of some design elements can be modified (e.g., the specific areas of shoreline requiring intervention can be modified, or details of specific materials refined) provided that the primary constraints and design criteria are respected.

2.1 Design Objectives

Overall, the objective of the shoreline improvement design is to preserve existing shoreline features that provide protection against shoreline erosion and provide habitat for turtle and fish species, while introducing additional natural or nature-based features (NNBF) that improve shoreline resilience and enhance natural habitat.

The sediment management options are expected to reduce contaminant-based hazards but also align well with urban redevelopment, recreation, and aesthetic values. These objectives include alignment with the City's Master Plan for shoreline development and with regulatory requirements (permitting) for habitat alteration. Monitoring will need to be implemented to evaluate shoreline protection and rehabilitation performance.

Maintaining public access for recreational purposes is not seen as desirable in the design objectives, partly to limit the potential for direct contact human exposure to any remaining contaminants, and partly to avoid human interference with natural habitat process (e.g., trampling of aquatic habitat or disruption of life cycles). However, this objective is not applicable to existing areas used as boat access within private properties such as the Kingston Rowing Club and Cataraqui Canoe Club (where no/minimal disruption to boat access will be made). It is noted that these areas are not included in the shoreline enhancement conceptual design.

In general, shoreline protection concepts may include addition of fill material to shape the shoreline profile and provide long-term risk reduction. The degree of intervention will vary as a function of the current habitat values, requirement for chemical risk reduction, and requirement for erosion controls. To this end, a cover layer consisting of granular materials (e.g. gravel or cobble) may need to be added over parts of the shoreline, working within the constraints of the existing physical and ecological conditions of the shoreline. The cover layer typically serves either to reduce the shoreline slope to decrease the risk of slope failure under gravity from oversteepening; or increase the size and roughness of the surficial material along the shoreline to improve energy dissipation and reduce the risk of erosion from wave action. Selective placements of large granular (rock) materials may also be included, if applicable, to provide additional shoreline stability, but will be balanced with a stakeholder desire to maintain the shoreline in as natural a condition as practicable (i.e., aquatic habitat and with native aquatic and riparian vegetation, where feasible, to maintain the aesthetics of the shoreline).

From the draft SMP, several management units along the western shoreline of KIH were initially identified as suitable for Nature Based Shoreline Rehabilitation that balance physical remediation methods with natural shoreline protection measures. These areas currently include artificial shoreline features, but also have sub-habitats of ecological value. The following specific sediment management actions (approaches, assumptions, constraints) apply to these management units, which include units TC-RC, WM, TC-2A, TC-3A and TC-4:

- Up to 3.5 ha of contaminated sediments will be dredged to a depth of up to 1 m below the harbour bed. Dredging will not take place along land, and will start in water after a minimum 5 m buffer zone from the edge of the toe of the existing shoreline protection
- Up to 9.2 ha of thin-layer sediment cover (up to 0.3 m thickness) will be placed along the shoreline protection and nearshore rehabilitation areas; the cover will include natural organic carbon amendment and/or reactive materials such as activated carbon to reduce chemical exposure
- Shoreline protection and rehabilitation (generally consistent with existing shoreline character) features will be implemented to provide a stable or dynamically stable physical barrier to exposure.
- The implementation of the shoreline protection features will not interfere with adjacent upland remediation techniques, such as those at Emma Martin Park (zero-valent ion remedial controls) or Belle Park Landfill but rather be complementary
- Disruptions in shoreline uses, including existing boat docks, will be accommodated within the construction designs, and some features may be enhanced long-term through engineering

A high-level condition assessment of the KIH shoreline utilizing site photos and Digital Elevation Model (DEM) showed that the existing shoreline appears to be stable and no notable degradation or damage/reshaping was observed. In order to preserve the existing shoreline and the associated ecosystem comprising of vegetation and above/below water habitats, WSP in consultation with TC, PC and PSPC, has proposed the following approaches for the conceptual design in units TC-RC, WM, TC-2A, TC-3A and TC-4 :

- Preventing damage/removal of the vegetation on top of the shoreline. All construction in the water will be completed from the water, with no access needed from land, thus preserving the existing habitats
- Maintaining the existing shoreline protection unless there are signs of degradation
- Allocating a minimum 5 m buffer zone from the toe of the slope protection to the start of the dredging/capping areas to prevent affecting/undermining the existing shoreline protection
- Placing large logs/woody debris to be stabilized using boulders in the buffer zone between the shoreline toe and dredged area, except in areas of archaeological significance or where boat access needs to be accommodated. The proposed approach is expected to enhance freshwater habitat and also reduce wave impact on the existing shoreline.

A more detailed evaluation of the shoreline will be completed in the next phase of the Project and the proposed approaches revisited, if needed.

In the conceptual design, desktop design methods (e.g., reviewing available literature and previously completed analyses, and utilizing recommendations and formulae provided by design guidelines) will be utilized to select the median mass (M_{50}) of rock required to withstand environmental conditions (e.g storm wave event with repairable damage, and consideration of potential ice impact on the shoreline protection).

2.2 Design Standards

2.2.1 Units

All dimensions on the engineering, calculations and drawings will be in SI (metric) units.

2.2.2 Standards and Design Guidance

Traditional coastal engineering guidance has been obtained from the following:

- U.S. Army Corps of Engineers (2002), 'Coastal Engineering Manual (CEM). Engineer Manual 1110-2-1100'
- EurOtop 2018 – Wave Overtopping of Sea Defences and Related Structures
- FEMA, 2016 – Guidance for Flood Risk Analysis and Mapping
- CIRIA-CUR, 2007 – The Rock Manual, The Use of Rock in Hydraulic Engineering
- Relevant project and case study experience

The use of natural and nature-based features (NNBF) for shoreline management in various forms has been growing and maturing for several decades, and there is a growing body of relevant guidance to support the design of NNBF for application to beach and shoreline rehabilitation projects. The primary NNBF guidance documents used as reference in this report, with respect to the KIH shoreline design, include the following:

- International Guidelines for Natural and Nature-Based Features for Flood Risk Management (Bridges et al. 2021)
- Nature-Based Solutions for Coastal and Riverine Flood and Erosion Risk Management (CSA 2021)
- Rising Seas and Shifting Sand: Combining Natural and Grey Infrastructure to Protect Canada's Eastern and Western Coastal Communities (Intact Centre on Climate Adaptation 2021)
- Green Shores for Shoreline Development Credits and Ratings Guide (Stewardship Centre of British Columbia 2020)

2.3 Project Datum

All horizontal coordinate systems shall refer to Universal Transverse Mercator Zone 18 North (UTM-18N) North American Datum 1983 (NAD83) coordinates. All elevations shall be referenced vertically in metres in the International Great Lakes Datum of 1985 (IGLD85), with 74.2 m as the Chart Datum, based on the Low Water Datum (LWD) for Lake Ontario reported by the Canadian Hydrographic Service (CHS 2007), with zero reference point at Rimouski, Quebec.

2.4 Design Life

WSP recommends considering a design life of 30 years for the shoreline protection design for the KIH project. This is in line with existing industry design life recommendations for shoreline protection structures.

Within this 30-year design period, it is likely that some extreme events, such as high-water levels, strong winds, and large waves, will occur. For evaluating the existing condition or developing a new design, it is necessary to select a return period, for example 100-year represents a 1 in 100-year condition, for the design event.

Extreme Value Analysis and estimation of design conditions are expected to be less reliable for return periods larger than 3−4 times of the length of available data. A return period of 100 years has been selected based on the Extreme Value Analysis that have been previously completed for water level and wind/wave conditions. In a 30-year design life, there is ~25% probability that a 1 in 100-year level event occurs or exceeds.

If a longer design life is considered, it is more likely that more frequent and more intense extreme events will occur at the shoreline; such would negatively affect the stability of the shoreline, and the shoreline will likely need more frequent maintenance and/or repair. NNBF feature designs require a regular monitoring program over the life of the project, and also after extreme events so that project performance can be evaluated and, maintained or adapted to changing conditions if required.

During the next stages of the Project, updates to the water levels, wind, and wave condition studies and Extreme Value Analysis should be completed as needed.

2.5 Site Conditions

2.5.1 Topography and Bathymetry

Bathymetry and topography data sources used for conceptual design include:

- Bathymetric survey conducted by Golder at the Site in October 2021 and May 2022.
- Digital Terrain Model (DTM) with 1 metre resolution from LIDAR Eastern Acquisition Project (LEAP) collected by The Ontario Ministry of Natural Resources (2009).

A Digital Elevation Model (DEM) was assembled from the above topography and bathymetry sources and is shown in Figure 2. The assembled DEM will be used as a project baseline from which to establish a set of representative cross-shore transects.

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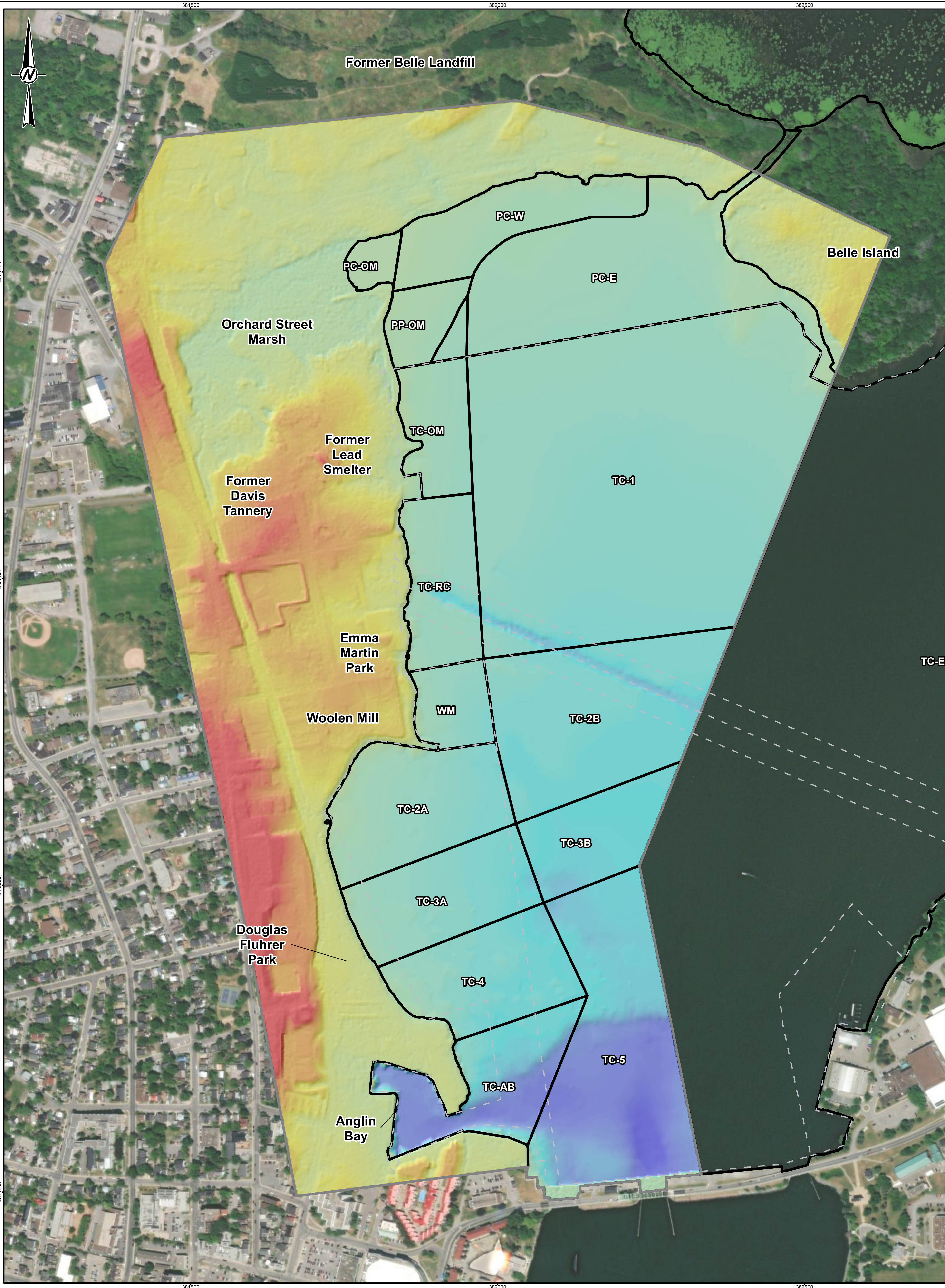

LEGEND

FEDERAL WATER LOT BOUNDARY

MANAGEMENT UNIT

ELEVATION (m, IGLD85)

85.25

76.5

67.75

FO DISCUSSIONPU POSESONLY

0 120 240

1:6,000 METERS

REFERENCES

1. IMAGERY COPYRIGHT © 20220711 ESRI AND ITS LICENSORS. SOURCE: MAXAR VIVID WV02. USED UNDER LICENSE, ALL RIGHTS RESERVED.
2. LIDAR DATA OBTAINED FROM NRCAN, ONTARION LEAP PROJECT.
PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PSPC

PROJECT
KINGSTON INNER HARBOUR – BASIS OF DESIGN - SHORELINE PROTECTION CONCEPTS

TITLE
LIDAR AND BATHYMETRIC ELEVATIONS (IGLD85)

CONSULTANT

YYYY-MM-DD	2023-06-01
DESIGNED	EC
PREPARED	JP
REVIEWED	
APPROVED	

PROJECT NO.	PHASE	REV.	FIGURE
22523199	3000	0	2

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25mm

2.5.2 Existing Structures

The KIH shorelines are used for a variety of commercial, industrial, and recreational activities, and require maintenance of physical works. These zones, if considered for physical management of sediments, would require setbacks (determined safe distances away from physical structures that work cannot take place in) which may limit access to some areas of contamination. For some features, such as the municipal wastewater utility corridor connecting the west and east shorelines, physical setbacks will be respected. Other features may require temporary dismantling followed by reconstruction after remediation, or relocation of the infrastructure to a nearby location where beneficial uses could be maintained.

Examples of existing shoreline infrastructure include: Kingston Marina, Davis Drydock, Anglin Bay South Shore, Kingston Rowing Club and Emma Martin Park and Douglas Fluhrer Park Waterfront. Included in these areas are boat launches, floating docks, drydock, retaining walls, embankments, and engineered paths set back from the shoreline (Golder 2017a).

An underground utility corridor across KIH exists that may limit access to some areas of contamination; this corridor is indicated by the Transport Canada federal water lot units that transect the harbour diagonally (Figure 1), connected west from the River Street pumping station property to the eastern shore of KIH. These utilities (sewer and water lines) have been placed within a trench dredged into the harbour sediments and are at a shallow depth, such that mechanical dredging of sediments would be problematic in these areas (Golder 2017a).

2.5.3 In Situ Material / Sediments

Depth to bedrock ranges from 3 m on the western side of the harbour to 22 m on the eastern side. Boreholes from previous investigations show a shallow valley within the bedrock where the river channel flows.

Alternating layers of fine grained organically enriched materials including peat and gyttja were found to be overlying the native lacustrine clay in KIH. Peat materials within KIH contain an organic content of 70–75% and the inorganic content is silt and clay with mean grain sizes of 0.0155 mm to 0.0055 mm. KIH gyttjas are soft, water rich, bioturbated sediments with the same mean inorganic grain sizes as peat (Dalrymple and Carey 1990). Peat is still present along the surface in the shallow portions of KIH as well as in the marshy areas (ESG 2014). The surficial layer of sediment in deeper waters (>0.7 m) is composed of gyttja which has a lower organic content than underlying layers.

Figure 3 (ESG 2014) displays a distribution of fine-grained surface sediments across KIH, which are consistent with Golder's studies (Golder 2014). It shows a fining of material from the western side of KIH to the east. An area of silty sand is present offshore of Douglas Fluhrer Park north towards the rowing club. Sandy silt occupies the area east of the silty sand followed by the dominant surface sediment deposit of silty clay as well as a smaller area southeast of Belle Island covering part of the navigation channel. Silty clay covers approximately 60% of the bed within KIH. These grain sizes can help to assess sediment transport patterns within the harbour, with fine grained material indicative of low-energy areas of deposition and coarser material in areas of higher-energy.

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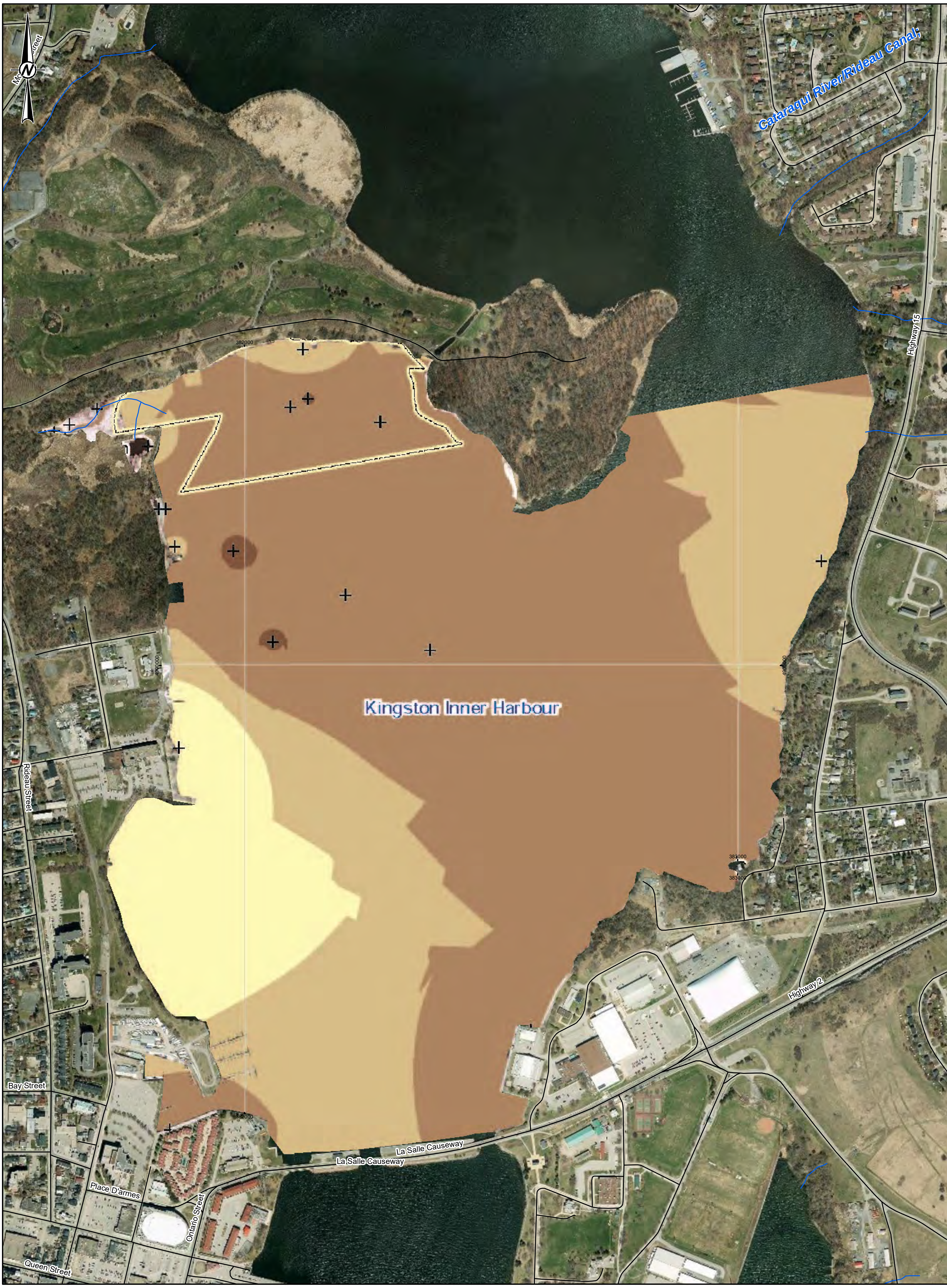

LEGEND

- HIGHWAY
- ROAD
- RAILWAY
- WATERCOURSE
- PARKS CANADA BOUNDARY

GRAIN SIZE

- < 63 SILTY SAND
- 63-81 SANDY SILT
- 81-96 CLAYEY SILT
- >97 SILTY CLAY
- KINGSTON INNER HARBOUR GRAIN SIZE SAMPLE

0 150 300

1:7,500 METERS

REFERENCES
1. IMAGERY COPYRIGHT © 20101103 ESRI AND ITS LICENSORS. SOURCE:DIGITALGLOBE WV02. USED UNDER LICENSE, ALL RIGHTS RESERVED.
2. TRANSPORTATION FEATURES, WATER FEATURES OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
3. FINE-GRAINED SEDIMENT DATA OBTAINED FROM THE ROYAL MILITARY COLLEGE OF CANADA. RMC-ESG. 2014. APPLICATION OF THE CANADA-ONTARIO DECISION-MAKING FRAMEWORK FOR CONTAMINATED SEDIMENTS IN THE KINGSTON INNER HARBOUR. PREPARED BY ENVIRONMENTAL SCIENCES GROUP, ROYAL MILITARY COLLEGE, KINGSTON, ONTARIO. FEBRUARY 2014.
4. PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
PWGSC

PROJECT
KINGSTON INNER HARBOUR
KINGSTON, ONTARIO

TITLE
DISTRIBUTION OF FINE-GRAINED SEDIMENTS IN KINGSTON INNER HARBOUR

CONSULTANT

YYYY-MM-DD	2017-01-11
DESIGNED	SS
PREPARED	JP
REVIEWED	
APPROVED	

PROJECT NO.	PHASE	REV.	FIGURE
1661792		0	3

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2.5.4 Longshore Planform

TC-RC and WM occupy a straight section of shoreline while TC-2A, TC-3A and TC-4 occupy an embayment that approximates a pocket beach.

2.5.5 Cross-Shore Profile

There is a direct linkage between sediment size and average beach slope, with coarser material generally sustaining steeper slopes (CIRIA 2010). Typical beach slopes that can occur in the upper foreshore and shallow nearshore environment are shown in Table 1. For a given grain size, beaches will tend to adopt flatter slopes in areas more exposed to wave (CIRIA 2010). Steeper storm waves cause a beach of a given sediment type to flatten and become more dissipative, whereas small amplitude (with relatively long period waves) tend to build steeper and more reflective beaches. Wider beach material gradations typically result in flatter slopes than narrowly graded (i.e., more uniform) material but may also develop composite slopes when material sorting by waves occurs.

Table 1: Typical beach slopes for various median sediment sizes (CIRIA 2010)

Sediment Type	Median Sediment Size D50 (mm)	Mean Beach slope (V:H) Minimum	Mean Beach slope (V:H) Maximum
Sand	0.2	1:50	1:100
	0.3	1:25	1:50
	0.5	1:20	1:40
Gravel	5.0	1:8	1:15
	10.0	1:7	1:12
	35.0	1:4	1:8

Note: V and H refer to vertical and horizontal, respectively.

Existing slopes measured from the representative profiles are summarized in Table 2. The extent and depth of backshore excavation and nearshore dredging will be established in the conceptual design.

Table 2: Representative beach and nearshore slopes in the Project area

Management Unit	Minimum Slope (V:H)	Maximum Slope (V:H)
TC-RC	1:6	1:10
WM	1:6	1:12
TC-2A	1:4	1:12
TC-3A	1:6	1:8
TC-4	1:8	1:10

2.5.6 Terrestrial and Aquatic Vegetation and Habitats

Much of the terrestrial lands adjacent to the study area is dominated by anthropogenic disturbances and uses, including buildings, streets and parking, and manicured areas. The terrestrial and wetland natural areas within the study area are concentrated in the northern portion of KIH, particularly adjacent to the Orchard Marsh brownfield area. Terrestrial and wetland vegetation within the study area will be impacted by the proposed works in the short-term; however, the proposed post-remediation rehabilitation aims to maintain, improve, or re-establish the ecological community classification of each disturbed area. Disturbance to natural vegetation will be limited to the extent feasible while also satisfying the contaminant risk reduction goals.

Terrestrial work areas are to be restored to original condition, or enhanced for turtle nesting. Detailed surveys of turtle nesting activity in the study area have been completed and have identified nesting areas along most of the terrestrial areas adjacent to the study area, excluding areas of tree cover and dense vegetation.

General improvements to turtle habitat within the study area proposed as part of the remediation works include:

- Softening the existing bank slopes in select areas to make it easier for turtles to travel between water and land (e.g., mitigating hazards such as boulder shorelines where hatchlings may become trapped in crevices)
- Adding nodes and line segments of boulders, logs, and root wads within 5 m of the shoreline in selected areas to increase cover and basking opportunities for turtles
- Improving shoreline vegetation in selected areas to provide cover in heavily disturbed or otherwise human-influenced areas

These improvements may be further refined in detail design and upon completion of the Detailed Impact Assessment.

Most of the aquatic portion of the study area is dominated by anthropogenic disturbances and uses, including historical contamination, water outfalls, navigational routes, and harbour use. The aquatic natural areas within the study area include KIH and associated riparian areas.

The impact of aquatic vegetation on reducing current speeds and wave energy has been well documented and can significantly increase sediment deposition and bed stability due to increased friction and root binding. Golder (2011) reported presence of the following primary aquatic vegetation types in KIH: Eurasian watermilfoil, coontail, pondweeds, and eelgrass. The increased presence of cattails and Eurasian watermilfoil are associated with the accumulation of sediments related to human-induced hydrological changes. Dalrymple and Carey (1990) indicate that portions of KIH deeper than 1.7 m water depth are typically devoid of vegetation. The northern two thirds of the harbour (north of the harbour limits), and east of the navigation channel are well covered with aquatic vegetation and not significantly affected by physical disturbance through vessel activity (Golder 2017b). Additional aquatic vegetation surveys and collection of samples is scheduled for late summer/fall 2023.

SNC Lavalin (2020) showed observations of aquatic vegetation during the open water season in 2018 and reported significant difficulties in navigating the study area west of the navigational channel, with repetitive clogging and fouling of the propeller by aquatic vegetation. SNC Lavalin (2020) further classified a September 2015 aerial image for floating, submerged, and mixed (floating and submerged) aquatic vegetation types (Figure 4).

Based on SNC Lavalin (2020) analysis of satellite images, the northern two-thirds of KIH and the area west of the navigation channel were well covered with aquatic vegetation. The water lots in KIH requiring sediment management cover a total surface area of 85 ha. Of this, 81 % (69 ha) is covered by extensive macrophyte beds (floating: 14 ha, submerged: 9 ha; mixed: 46 ha). The water lot management units with limited presence of vegetation are in the deeper reaches at the south end of KIH (TC-5, TC-AB, and part of TC-4).

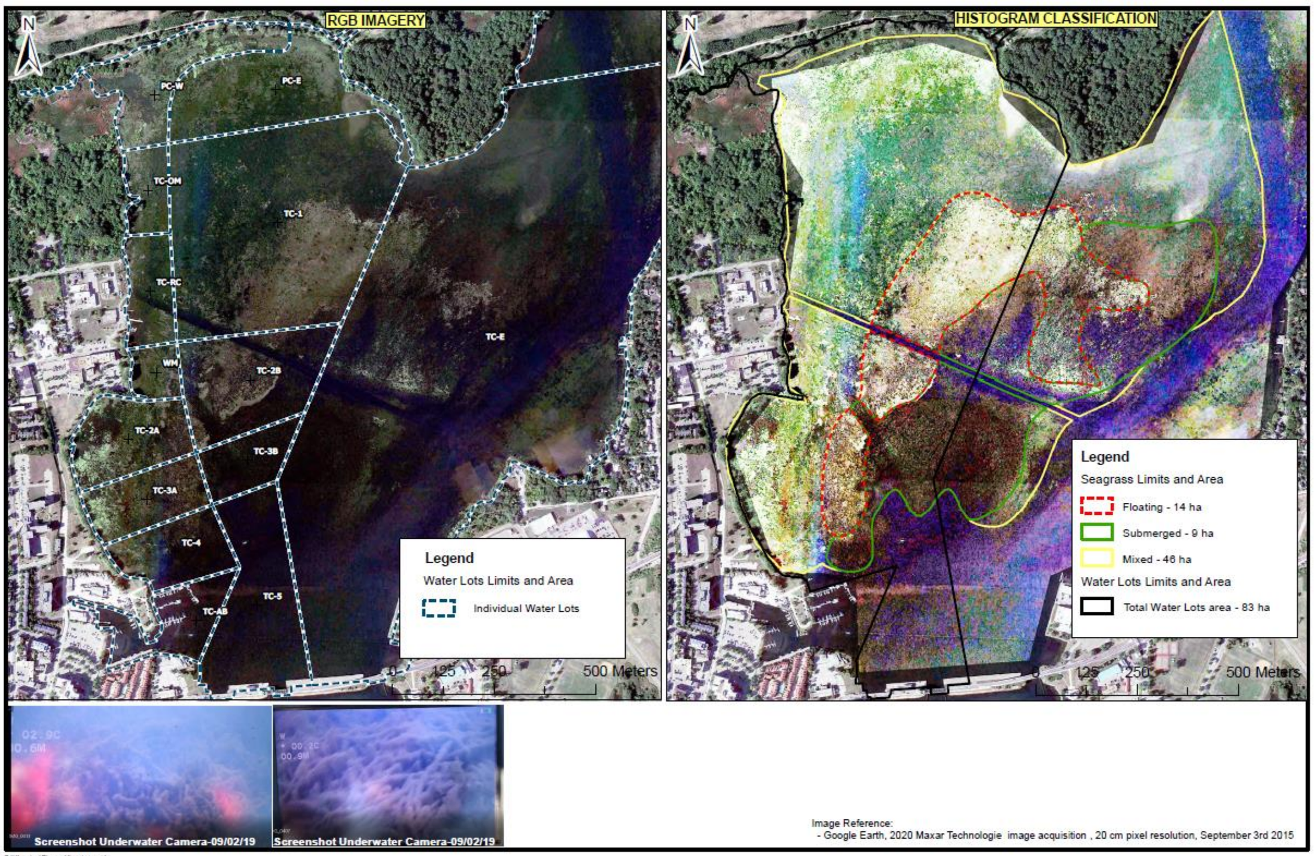

Figure 4: Macrophyte beds in the KIH basin using delimitation from satellite imagery (September 2015) and underwater camera imagery (February 2019) Source: SNC 2020

Based on community consultation, where practicable, the shoreline should be maintained as natural aquatic habitat suitable for turtles and with native aquatic and riparian vegetation to maintain ecological status and the aesthetics of the shoreline. This consideration must be balanced with the requirements for contaminant exposures (i.e., removals, isolation, and/or bioavailability reduction). The conceptual design for nature-based shoreline rehabilitation currently includes three vegetation zones integrated with the beach berm from backshore to offshore as follows:

- Riparian zone – this includes above ground plants in the backshore region of the rehabilitation area. It is intended that a single row of native species be planted along the existing pathway to deter human access. Existing vegetation will be kept intact to minimize disturbance to existing turtle hatching habitat. Riparian vegetation including larger trees and shrubs are intended to serve the following functions:

  - Discourage direct access to the beach and foreshore; it is expected to include native trees, shrubs, grasses including species such as native roses (e.g., *Rosa acicularis*; *R. blanda*), prickly ash (*Zanthoxylum americanum*), blackberry (*Rubus allegheniensis*) and black raspberry (*Rubus occidentalis*) to further deter human access.
  - Stabilize the land surface and reduce potential for soil erosion during precipitation events
  - Provide topographic wind blocking to reduce wind energy
  - Provide overhead cover and shading for fish and fish habitat (e.g., trees, shrubs, long grasses, woody debris along the shoreline)
- Cobble beach or large woody debris (LWD) vegetation zone – this includes above-ground plants that includes beach grasses and large woody debris (e.g. logs and rootwads) that serve the following functions:
  - Maintain, and where possible enhance, turtle habitat
  - Adapt to changing water levels and periodic inundation and drying
  - Provide additional beach stabilization and wave attenuation function
- Aquatic vegetation zone – this includes aquatic vegetation plant structure that includes emergent, submerged, and floating plants such as water lily (*Nymphea odorata*), pondweeds (*Potamogeton* spp.), coontail (*Ceratophyllum demersum*), marsh grasses (e.g., *Calamagrostis canadensis; Leersia oryzoides*), sedges (e.g., *Carex lacustris;* C. *aquatilis; Scirpus cyperinus*) and cattails (*Typha latifolia*; *T. angustifolia*) that serve the following functions:
  - Enhance turtle and fish habitat
  - Reduce nearshore wave heights and nearshore current
  - Stabilize the lakebed to reduce sediment mobility and transport
  - Provide resilience to changing water levels
  - Provide cover, refugia, and spawning surfaces for fish

The Nature Based Shoreline Concepts Memo provided addition information regarding plant selection criteria for restoring backshore to offshore vegetation zones (Golder 2022b). The species and concepts described above are examples rather than prescriptive decisions and can be customized to specific shoreline areas during detailed design. Additional information on species at risk, terrestrial and aquatic vegetation and habitats can be found in Section 7 of the Conceptual SMP and will be further refined during the detailed design and Detailed Impact Assessment processes.

2.5.7 River Hydrology

The Kingston Inner Harbour includes a 5 km length of the Great Cataraqui River. The sediment management area within KIH includes an approximate 1.7 km length of the Great Cataraqui River. The trajectory of the suspended sediments carried by the Cataraqui River is influenced by the La Salle Causeway, with some discharges to Lake Ontario and the remaining sediment redirected toward Anglin Bay (Golder 2017b).

The Cataraqui River discharge regime is dominated by a spring (February to March) increase in flows due to snowmelt. Cataraqui River typical flows range from 4 m^3/s to 17 m^3/s up to a maximum estimated flow of 50 m^3/s recorded during a heavy storm (HCCL 2011). These flows cause the harbour to flush out approximately 76 times per year (ESG 2014).

Even though the harbour is located at the mouth of the Cataraqui River, its water levels are dictated by those of Lake Ontario. Golder's 2017 sediment transport study concluded that the dominant source of sediments to KIH is a combination of fine-grained sediments delivered via Cataraqui River flows and resuspension of localized bed sediments through wave/wind, current, and contributions from local stormwater flows (Golder 2017b). The hydraulic influence on water velocities and subsequent sediment resuspension from the Cataraqui River is very limited (Golder 2017b).

2.5.8 Water levels

Water levels in KIH are generally consistent with Lake Ontario levels (Dalrymple and Carey 1990). Water levels in the Great Lakes system are usually defined with respect to IGLD85. Low Water Datum for Lake Ontario is defined 74.2 m above the zero reference point at Rimouski, Quebec, and is used as the Chart Datum for the bathymetry data. The minimum, mean and maximum historic water levels in Lake Ontario were 73.7, 74.8 and 75.8 m (IGLD85) (overall range 1.9 m) respectively (Golder, 2017b). These calculations were based on the monthly lake-wide average water levels from January 1960 through December 2016. Water supplies to Lake Ontario surpassed the historical maximum during Spring 2017 and water levels remained high throughout the summer. In 2018, peak Lake Ontario water levels decreased to approximately the 1960–2016 seasonal average but spiked again in spring 2019 (new maximum of 75.9 m) and remained high through late summer. These record setting levels were followed by recent stable water levels that have remained near historical seasonal averages from January 2021 to January 2023. An extreme value analysis for water level has been proposed by WSP for the conceptual design for the KIH area to inform the design water level, using data for Lake Ontario published by CHS.

The climate change impact on water level, if any, has not been considered, and should be assessed during later phases of the Project via literature search and post-processing of available water level data. In the absence of further information, a design water level of 75.8 m IGLD85 will be used.

2.5.9 Winds

Figure 5 shows wind roses summarizing all wind data collected at the Kingston Airport, located approximately 10 km west of the site, from May 1967 to July 2016 (50 years) for summer and winter seasons (Golder 2017b). Summer and winter seasons are broadly defined as the intervals from April to September and from October to March, respectively. Wind roses indicate the direction from which the wind is blowing. Wind direction at the Kingston Airport is primarily from the south during summer and from the west during winter. Wind from the westerly and southerly quadrants (from 135 to 315°) represent 68% and 60% of all wind directions during summer and winter, respectively. Average wind speed during winter is approximatively 20% stronger than in summer (3.9 m/s in summer; 4.8 m/s in winter), but the frequency of wind stronger than 10 m/s in winter is approximatively 5 times greater over the winter months than in summer.

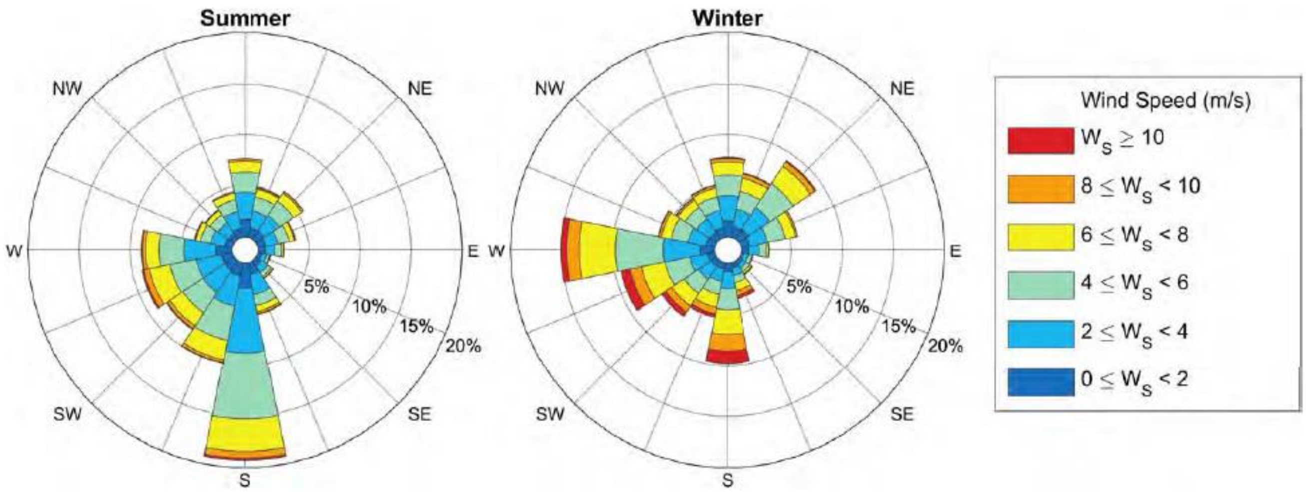

Figure 5: Wind Roses for the Summer and Winter Season from 1967 to 2016 at the Kingston Airport (Golder, 2017b).

A peaks over threshold (POT) extreme value analysis (EVA) was carried out using wind speeds recorded at Kingston Airport to determine wind speeds for a number of return periods, the results of which can be seen in Golder 2017b. The POT analysis identified approximately 3 storms per year in the winter and approximately 13 storms per year in the summer. Based on the analysis of water levels, and assuming a uniform distribution of storm events, at least 2 storm events may be expected to occur coincidentally with high water levels on Lake Ontario in a given year.

2.5.10 Waves

In 2017 wind-waves at the site were calculated by Golder using the Automated Coastal Engineering System (ACES) software (Leenknecht et al. 1992) developed by the United States Army Corps of Engineers (USACE) to estimate wind-wave growth over open water and restricted fetches in deep and shallow water (Golder 2017b). The deep water, restricted fetch condition was used for calculating wind-waves generated over fetches associated with each wind direction sector in the Inner Harbour as follows:

- Southerly: 1.6 km
- Southwesterly: 2.1 km
- Westerly: 1.2 km

Wind speeds calculated in the EVA were used to evaluate significant wave heights and peak wave periods generated along each fetch. Nearshore wind-generated wave estimates (significant wave height and peak wave period) are provided in Table 3 for each wind directional sector (with return periods of 2, 5, 10, 25, 50, and 100 years), respectively. Wave heights for a two year event range from 0.2 m to 0.3 m. For extreme conditions during a 100-year event wave heights range from 0.3 to 0.4 m in summer and 0.3 to 0.5 m in winter under winter open water conditions. Ice is typically present in KIH during the winter months, and the presence of ice cover would minimize or reduce the generation of waves by winds. For the purposes of this analysis, open water conditions in the winter were assumed as this would be conservative. The largest wave height conditions occur with winds from the southwest predominantly due to the larger fetch length. Waves forming along this direction will reach full size in the northeast corner of KIH near the navigation channel and will deflect currents to the north.

Based on the typical estimate wave heights (0.2 to 0.3 m) and periods (1.5 s to 2 s), these waves will interact with the bed in water depths typically less than 2 to 3 m.

Table 3: Estimated Significant Wave Heights (Hs) and Periods (Tp) for Associated Return Periods for Various Fetch Lengths in the Inner Harbour

	RP (yrs)	Summer			Winter (assumes open water)		
		South (157.5-202.5)	Southwest (202.5-247.5)	West (247.5-292.5)	South (157.5-202.5)	Southwest (202.5-247.5)	West (247.5-292.5)
Hs (m)	2	0.2	0.2	0.2	0.3	0.3	0.2
	5	0.2	0.3	0.2	0.3	0.3	0.3
	10	0.3	0.3	0.2	0.3	0.4	0.3
	25	0.3	0.3	0.3	0.3	0.4	0.3
	50	0.3	0.4	0.3	0.3	0.4	0.3
	100	0.3	0.4	0.3	0.3	0.5	0.3
Tp (s)	2	1.6	1.6	1.4	1.7	1.9	1.6
	5	1.7	1.8	1.5	1.8	2.0	1.7
	10	1.7	1.8	1.6	1.8	2.1	1.7
	25	1.8	1.9	1.7	1.9	2.2	1.8
	50	1.9	2.0	1.8	1.9	2.2	1.9
	100	1.9	2.1	1.9	2.0	2.3	1.9

The design winds and waves for this preliminary conceptual design were established by reference to the extreme value analysis of wind records from the Kingston Airport and fetch considerations in KIH. A 100-year design wind speed of 16 m/s was selected for prediction of waves along a north-easterly fetch of 2 km (Golder 2017; SNCL 2020; HCCL 2010). This results in a significant wave height of 0.5 m with peak period of 2.4 s which is consistent with wave parameters suggested by Golder (2017). This wave will arrive at the shoreline at an oblique angle.

These wave parameters have been estimated using high level wave hindcasting tools and low resolution bathymetry information; however, the project site is shallow enough that depth-limited shoaling may occur, affecting wave heights locally. To better understand this, detailed wave hindcasting analysis, simulating propagation/decay of waves into the shallower areas of KIH using numerical modelling. Depending on the results, the collection of data to calibrate and validate these simulations may be needed.

2.5.11 Wakes

Vessel activity, when observed, was confined to the southern portion of KIH, within the harbour limits as well as the navigation channel (Golder 2017b), and the presence of wakes behind observed vessels was minimal. Limited vessel activity was identified north of the harbour limit and west of the navigation channel (Golder 2017b); with vessel activity confined primarily to small non-motorized watercraft. It is unlikely that propeller action contributes significantly to resuspension in the study area due to speed restrictions imposed by navigation requirements and the presence of aquatic vegetation (Golder 2017b). Vessel activities will be revisited in the next phase of the design in consultation with PSPC, and vessel wakes will be considered in the design, if applicable.

2.5.12 Currents

SNC Lavalin (2020) completed a sediment stability study in 2019 within KIH to gain a better understanding of the hydraulic circulation dynamics and sediment dynamics in the areas of concern. Water velocities within the KIH basin were assessed as low, with no strong circulation pattern.

As concluded in Golder 2017b and SNC Lavalin 2020, strong winds can generate localized currents that cause lateral sediment transport within the water lot, with the dominant currents produced from the south and southwest. Large sediment resuspension events are unlikely due to the low mean water velocities and extensive macrophyte bed coverage that has the potential to lower water velocities and hold sediment in place. Modelled currents ranged from 0 up to 0.45 m/s along the navigation channel, the eastern shoreline and the southern (deeper) portion of KIH. These current speeds are capable of re-suspending silts and sands based on the Shield’s criterion. The shallow areas of the northern portion of the Transport Canada Waterlot exhibited currents between 0 and 0.18 m/s while currents were almost 0 in the Parks Canada Waterlot. These current speeds are capable of re-suspending finer sediments but may not re-suspend coarser sediments (e.g., sand-sized sediments) (Golder, 2017b).

In the absence of further information, a design current speed of 0.45 m/s will be used in the conceptual design. It is recommended that further current information be gathered and modelled.

2.5.13 Ice

Ice processes are expected to have a small to negligible effect on sedimentary processes in KIH and similarly, the implementation of the SMP is unlikely to result in significant changes to the ice cover and ice dynamics in the project area. However, ice thickness and movement may be an important design consideration for shallow water capping and shore protection design.

Seasonal ice cover typically occurs from mid to late December until mid to late April depending on severity of winter conditions. Ice cover reduces the effects of wind on currents and circulation and reduces the effects of wave action. Ice formation occurs most often along the shoreline and may freeze from the surface to the sediment bed in shallow water. The latter process may result in ice-related transport of sediments from shallow water areas.

The Detailed Impact Assessment (DIA) for Kingston Third Crossing concluded that the potential for ice jam flooding during either the temporary works or post-construction (bridge in place) was extremely low. This was related to the low velocities within the Project area and lack of supply ice due to Kingston Mills upstream (Hatch 2019).

Overall, there is a lack of quantitative ice thickness and ice movement data for KIH. Further review of ice thickness and ice movement data to better refine the design is recommended.

2.6 Shoreline Protection and Beach Crest Elevation

Due to the presence of a recreational pathway behind the shore protection, which is used for pedestrians/cyclists, the shoreline protection crest elevation will be selected in collaboration with the City of Kingston considering maximum allowable mean overtopping discharge of 1 l/s/m for the design water level and wave condition.

Design beach berm or crest elevations for beach fill projects are typically set based on a combination of evidence from local, natural analogs and wave run-up conditions under extreme and non-extreme wave and tide conditions. The berm should be low enough that some overwash could occur periodically over the life of the project to help nourish the area behind the berm and encourage healthy backshore habitat conditions. Where applicable, the beach crest elevation will be selected based on the following considerations:

- Crest elevation of existing beaches based on topographic LiDAR survey
- A wave runup analysis based on the method of the Coastal Engineering Manual and a typical annual significant wave height, and the 10-year extreme high-water level (in the absence of detailed water level analysis results, design water level of 75.8 m IGLD85 will be used for conceptual design).

Note that it is necessary to monitor beach slope and crest elevation over the life of the project to confirm the beach fill meets expectations and objectives for the Project.

2.7 Beach Fill and Rock Properties

A key performance criterion of any beach fill is the compatibility of the imported beach materials with native (in situ) materials. Typically, it is not practical for imported material to exactly match the native beach particle size distribution. Ideally it should be similar in grain size (or slightly coarser), composition, angularity and colour. The grain size distribution of the beach fill will affect the cross-shore profile of the constructed beaches, mobility of the material, long-term transport rates and losses, and how the beach will respond to storms and high water levels. The grain size distribution should be selected with considerations of the suitability for turtle and fish habitat.

A mixed sand and gravel gradation envelope with upper and lower bounds for beach fill will be selected during conceptual design, where needed, with consideration of the following:

- Existing local beach and nearshore conditions
- Design wave and water level conditions,
- Range of sediment sizes associated with stable beach slope proposed by the conceptual design using CIRIA (2010) (as summarized in Table 1), and beach morphodynamic principles (e.g., Wright et al., 1985)
- Findings based on previous beach rehabilitation projects
- Available materials from local sand and gravel pits.

The design gradation of the beach fill sediment should be determined by coastal engineering analysis during the design phase.

Beach fill material should meet the following specifications:

- Be a mixture of naturally occurring water rounded aggregates and sand, preferably sourced locally. The material may be processed, but should not contain blast rock, crushed rock, ledge rock, aggregates from talus slopes, fly ash, and slag. Material with 10% by weight or more elongated or fractured particles are to be avoided.
- Consists of hard, durable uncoated particles of natural sand, gravel, cobble.
- Not be obtained from sanitary landfill areas or areas exposed to contaminated ground water or other contaminated materials.
- Be clean with limited percentage of fines (to be defined in the detailed design stage), and free of sod, roots, brush, wood, rubbish, oil, metal, chemical contaminants, construction debris, asphalt and other waste materials. The materials shall not contain organic or non-organic substances that may be leached from the material in amounts sufficient to be deleterious or harmful in any way. The material should not interfere with the designated uses of the beach and water, including but not limited to shale, alkali, chert carbonates, mica, clay lumps, coal, or lignite. Materials must also meet Provincial and Federal environmental requirements.

Rock material shall be durable stones, preferably sourced locally, with no/minimal bedding planes/joints and cracks and no foreign, organic material or clay. Rock material needs to have a minimum density of 2.6 t/m^3 and maximum water absorption of 2%, with aspect ratio (ratio of maximum dimension and minimum dimensions of individual rocks) of 2 or less.

3.0 CLOSURE

We trust that this report provides sufficient information for your current needs. Please be advised that the conceptual designs will be provided in the updated SMP. Please contact the undersigned should you have any questions.

WSP CANADA INC.

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https://golderassociates.sharepoint.com/sites/162644/project files/6 deliverables/3.0_issued/22523199-010-tm-rev0/22523199-010-tm-rev0-basis of design 19sep_23.docx

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APPENDIX E

Evaluation of Residual Risks

TECHNICAL MEMORANDUM

DATE 19 September 2023 **Reference No.** 22523199-012-TM-Rev0

TO Pravina Singh
Public Services and Procurement Canada

CC Jennifer Daley

FROM Lindsay Furtado, Gary Lawrence [redacted]

EVALUATION OF RESIDUAL RISKS

WSP Canada Ltd. (WSP) was retained by Public Services and Procurement Canada (PSPC), on behalf of Transport Canada and Parks Canada (the Client), to prepare this technical memorandum regarding residual risks to be considered in refinements to the conceptual Sediment Management Plan (SMP) for the Kingston Inner Harbour (KIH) Sediment Management Project in Kingston, Ontario (the Project). The first draft of the SMP was prepared by Golder (amalgamated under WSP Canada Inc. in January 2023) in 2021 and included consideration of several environmental (biological, chemical, and toxicological), hydrological, and preliminary design considerations for the implementation of a sediment remediation project (Golder 2021). This evaluation of residual risk document is being prepared as a component of the second draft SMP.

The term “residual risk,” as applied in this Appendix, refers to the human and/or ecological risks associated with sediment areas that:

- reflect improvements in long-term sediment quality following Project works, including a stabilization period following dredging;
- recognize that much of the water lot area has been intentionally excluded from the footprint of proposed physical interventions due to acceptably low contaminant risks;
- acknowledge that proposed physical interventions may be adjusted (i.e., deferred or removed from active works) based on future input from the Detailed Impact Assessment, stakeholder engagement and consultation, or detailed design constraints.

As such, residual risk applies to our best estimates of the post-implementation conditions, recognizing some uncertainty in those estimates.

1.0 INTRODUCTION

As discussed in Section 11.0 of the revised SMP, management in place (monitored and enhanced natural recovery) will be a significant component of the recommended sediment management strategy, considering the magnitude of risk and the preferences of stakeholders and Indigenous communities. Therefore, some residual risk tolerance for ecological endpoints (e.g., fish deformities and modest benthic invertebrate community alterations) is required for areas where:

- Sediments would be expensive and/or difficult to physically manage.
- Physical management was determined to be of limited efficiency or effectiveness.
- Physical management would yield significant short-term environmental alteration (e.g., disruption of dense macrophyte beds used for fish foraging).

To evaluate the predicted overall reductions in risk associated with implementation of the conceptual SMP, post-implementation sediment concentrations were calculated for each management unit (or group of management units depending on the receptor being assessed) and used to evaluate residual risks relative to those estimated under existing conditions (i.e., as presented in the Risk Refinement and Synthesis). Residual risks under post-implementation conditions were evaluated using the methods, assumptions, and models used in the Risk Refinement and Synthesis.

2.0 EVALUATION OF RESIDUAL RISK

To calculate post-implementation sediment concentrations, inverse-distance weighted (IDW) concentrations (a spatial averaging technique presented in the Risk Refinement and Synthesis) were calculated for each management unit assuming that material used to cover dredged areas will be less than Canadian Council of Ministers of the Environment (CCME) Probable Effect Levels (PELs) as is typically required for backfill material for such applications. To evaluate residual risks under the post-implementation scenario, exposure point concentrations (EPCs) were calculated using post-implementation IDW sediment concentrations. The statistic used to estimate exposure (i.e., the EPC) varied depending on the receptor being evaluated (i.e., average and 75th percentile concentrations were used to assess residual risks to the benthic community, 75th percentile concentrations were used to assess residual risks to fish health, and 90th percentile concentrations were used to assess residual risks to wildlife receptors), consistent with the approach used in the Risk Refinement and Synthesis.

Although potentially unacceptable risks were identified in the Risk Refinement and Synthesis for human receptors from dermal contact with PAHs in sediment and dietary exposure to mercury and PCBs from the ingestion of fish caught in KIH, administrative and engineering controls will be implemented as part of the SMP to reduce exposure. These controls include nature-based shoreline rehabilitation to deter human access to water, as well as the maintenance of fish consumption advisories to limit exposure to contaminants of concern (COCs) through dietary uptake. Additionally, implementation of the SMP throughout KIH is expected to reduce the weighted average concentrations of these substances by focusing on hot spots. As a result, it was not considered necessary to evaluate residual risks for the protection of human health.

2.1 Benthic Community

For the assessment of residual risks to the benthic community, average post-implementation sediment concentrations were calculated and the potential risk categorized. The management actions for the protection of benthic invertebrates are focused on total PAHs because localized sediment toxicity to benthic invertebrates was observed in sediments with elevated PAH concentrations, and toxicity identification evaluations confirmed PAHs as a plausible causal agent. Therefore, the assessment of residual risks to the benthic community was based on the average post-implementation sediment concentrations for total PAHs and is presented for those management units subject to physical intervention in the SMP. The average post-implementation sediment concentrations and their categorization based on sediment quality guidelines (SeQG) representative of various risk thresholds is provided in Table 1. To facilitate comparison to existing conditions, average pre-implementation sediment concentrations are also presented and the potential risk categorized, using both the average exposure and the 75th percentile exposure. As benthic invertebrates require protection at the community level, and because the study area has been divided into multiple management areas and subareas (i.e., for which spatially explicit risks are provided), the average PAH concentration within each unit is considered an appropriate measure of exposure. Use of average and 75th percentile exposure statistics recognizes that localized areas within each management unit will be higher than the central tendency, and may enter higher risk categories where hot spots are present. However, averaging is appropriate given that the protection goal is for community level protection at a spatial scale broader than an individual sampling location.

Table 1: Assessment of Residual Risks to the Benthic Community based on Total PAH Concentrations

Management Unit	Average Total PAH Surface Sediment Concentrations			
	Pre-Implementation		Post-Implementation	
	Median	75th Percentile	Median	75th Percentile
PC-E	6.40	7.7	4.58	5.25
PC-W (including PP-OM sub-unit) [1]	13.4	18.4	4.03	4.00
TC-OM	16.7	9.7	3.76	3.99
TC-RC	9.63	5.3	3.52	4.00
WM	10.2	12.5	4.02	4.01
TC-2A	6.13	7.4	3.88	4.04
TC-3A	5.62	6.3	4.29	4.48
TC-4	18.1	13.3	3.91	4.00
TC-AB	10.2	13.0	4.03	4.00

Notes:
Concentrations presented in mg/kg dry weight.
1 The original PC-W management unit assessed as part of the risk assessment (Golder 2016) and initial remedial assessments (Golder 2017a and Golder 2019) was subdivided for the SMP into three different sub-units: PC-W, PC-OM, and PP-OM to reflect an updated property survey and a different remedial strategy for the Orchard Street Marsh (PC-OM). As such, PC-OM is not included in the residual risk analysis.

Negligible Risk		Less than the SQG described in the Risk Refinement and Synthesis (Golder 2016) indicative of negligible risks to the benthic community (total PAHs < 4 mg/kg)
Low Risk		Less than the SQG described in the Risk Refinement and Synthesis (Golder 2016) determined to be indicative of low risks to the benthic community (total PAHs < 10 mg/kg)
Moderate Risk		Less than the numerical sediment management criterion derived in Section 10.3 to be protective against significant risks to the benthic community as indicated in site-specific toxicity tests (total PAHs < 22.8 mg/kg)
Moderate to High Risk		Greater than the numerical sediment management criterion derived in Section 10.3 to be indicative of significant risks to the benthic community to the benthic community (total PAHs > 22.8 mg/kg)

Because sediment toxicity and benthic community data are not available under the future post-implementation scenario, the weight of evidence categorization for overall benthic community effects could not be reproduced with high precision to evaluate residual risks to the benthic community upon completion of the SMP. Instead, the results of the categorization of average post-implementation sediment concentrations were extrapolated to make predictions about the residual risks to the benthic community for each management unit subject to physical intervention. For those management units subject to monitored natural recovery or enhanced natural recovery, residual risks are expected to improve gradually over time, mainly due to recirculation of cleaner sediments from adjacent water lot areas. Based on the results presented in Table 1, residual risks to the benthic community are predicted to be negligible to low with implementation of the SMP, and therefore meet the overall protection goal of achieving a level of risk not greater than “moderate” for benthic invertebrates.

2.2 Fish Health

For the assessment of residual risks to fish health, 75th percentile post-implementation sediment concentrations were calculated and the potential risks categorized. A 75th percentile is appropriate for fish because these organisms will be protected at the population level even if a minority of local sediment conditions exceed risk-based benchmarks within a management unit. Fish will integrate their exposures to sediment and dietary items across multiple locations and across management units. Post-implementation sediment concentrations were calculated for all substances and groups of management units (associated with continuous foraging habitat for bottom fish) predicted to have greater than negligible effects to fish health in the Risk Refinement and Synthesis (i.e., for total PAHs and total PCBs in all groups of management units). The 75th percentile post-implementation sediment concentrations and their categorization based on the benchmarks protective of fish health are provided in Table 2. To permit comparison to existing conditions, 75th percentile pre-implementation sediment concentrations are also presented and potential risks categorized.

Table 2: Assessment of Residual Risks to Fish Health

Habitat Area (Management Units)	75th Percentile Pre-Implementation Sediment Concentrations		75th Percentile Post-Implementation Sediment Concentrations	
	Total PAHs	Total PCBs	Total PAHs	Total PCBs
North (PC-E, PC-W [including PP-OM subunit][1], TC-OM)	11.4	0.42	4.14	0.30
North Central (TC-1, TC-RC)	3.63	0.46	3.60	0.46
South Central (WM, TC-2A, TC-2B, TC-3A, TC-3B)	5.02	0.48	4.15	0.45
South (TC-4, TC-5, TC-AB)	11.8	0.31	7.9	0.30

Notes:
Concentrations presented in mg/kg dry weight.
Management units grouped into zones commensurate with the foraging ranges of bottom fish.

Negligible Risk	Equal or less than the low-risk benchmarks derived in the Risk Refinement and Synthesis (total PAHs = 4 mg/kg; total PCBs = 0.3 mg/kg)
Low Risk	Less than the numerical sediment management criteria derived in Section 10.3 to be protective of low risks to fish health (total PAHs = 8 mg/kg; total PCBs = 1 mg/kg)
Moderate Risk	Exceeds the numerical sediment management criteria derived in Section 10.3 to be protective of low risks to fish health (total PAHs = 8 mg/kg; total PCBs = 1 mg/kg)

1 The original PC-W management unit assessed as part of the risk assessment (Golder 2016) and initial remedial assessments (Golder 2017a and Golder 2019) was subdivided for the SMP into three different sub-units: PC-W, PC-OM, and PP-OM to reflect an updated property survey and a different remedial strategy for the Orchard Street Marsh (PC-OM). As such, PC-OM is not included in the residual risk analysis.

Based on the results shown in Table 2, the assessment of residual risks to fish health following implementation of the SMP is summarized below:

- For the north area (i.e., management units PC-E, PC-W, TC-OM), residual risks to fish health from total PAHs are predicted to decrease from moderate to low following implementation of the SMP.
- For the north-central and south-central areas (i.e., TC-1, TC-RC, WM, TC-2A, TC-2B, TC-3A, TC-3B), residual risks to fish health are predicted to decrease but remain negligible to low following implementation of the SMP.

For the south area (i.e., management units TC-4, TC-5, TC-AB), residual risks to fish health from total PAHs are predicted to decrease from moderate to low following implementation of the SMP.

2.3 Avian and Mammalian Wildlife

For the assessment of residual risks to avian and mammalian wildlife, 90th percentile post-implementation sediment concentrations were used to calculate residual risks using the food chain model (and associated input parameters) used in the Risk Refinement and Synthesis. Wildlife receptors require protection at the population level at minimum and require protection at the individual level for listed species (if present). As such, the 90th percentile is considered an appropriate measure of exposure for wildlife to avoid potential underestimation of exposure, such as would occur if receptors forage, on a chronic basis, over more contaminated local portions of the exposure unit. Post-implementation sediment concentrations and residual risks were calculated for those substances and groups of management units with suitable foraging habitat predicted to have greater than low effects based on the methods and results of the Risk Refinement and Synthesis (Golder 2016), in consideration of the lower bound toxicity reference values (TRVs) derived by Golder (2012) [1] (see Section 10.3 for further details). The 90th percentile post-implementation sediment concentrations are provided in Table 3 and the calculated hazard quotients (HQs) and categorization of residual risks are presented in Table 4. To permit comparison to existing conditions, pre-implementation HQs are also presented and the potential risks categorized in Table 4.

Table 3: 90th Percentile Sediment Concentrations

<table>
<tr><th rowspan="3">Management Unit</th><th colspan="3">Pre-Implementation 90th Percentile</th><th colspan="3">Post-Implementation 90th Percentile</th></tr>
<tr><th>Mink</th><th>Mallard</th><th>Marsh Wren</th><th>Mink</th><th>Mallard</th><th>Marsh Wren</th></tr>
<tr><th>Total PCBs</th><th>Chromium</th><th>Chromium</th><th>Total PCBs</th><th>Chromium</th><th>Chromium</th></tr>
<tr><td>PC-E</td><td>—</td><td>—</td><td>1378</td><td>—</td><td>—</td><td>1102</td></tr>
<tr><td>PC-W (including subunit PP-OM)[1]</td><td rowspan="2">22</td><td rowspan="2">4295</td><td>3385</td><td rowspan="2">0.3</td><td rowspan="2">581</td><td>278</td></tr>
<tr><td>TC-OM</td><td>1419</td><td>602</td></tr>
</table>

Notes:
Concentrations presented in mg/kg dry weight
— Suitable habitat for receptor not present or negligible risks (i.e., HQ < 1.0) under existing conditions (Risk Refinement and Synthesis)
1 The original PC-W management unit assessed as part of the risk assessment (Golder 2016) and initial remedial assessments (Golder 2017a and Golder 2019) was subdivided for the SMP into three different sub-units: PC-W, PC-OM, and PP-OM to reflect an updated property survey and a different remedial strategy for the Orchard Street Marsh (PC-OM). As such, PC-OM is not included in the residual risk analysis.

[1] The categories used to categorize potential risks were updated from those used in the Risk Refinement and Synthesis as these risks were predicted using TRVs developed using US EPA Eco-SSLs. As described in the Risk Refinement and Synthesis, the US EPA specifically warns that that Eco-SSLs are "not designed to be used as cleanup levels" but rather to identify COC. As a result, Golder (2012) developed mammalian and avian TRVs for total PCBs and chromium using the guidance and principles recommended by Environment Canada that are relied upon for the assessment of risk in this report.

Table 4: Assessment of Residual Risks to Avian and Mammalian Wildlife, Using Hazard Quotients

<table>
<tr><th rowspan="3">Management Unit</th><th colspan="3">Pre-Implementation Hazard Quotients</th><th colspan="3">Post-Implementation Hazard Quotients</th></tr>
<tr><th>Mink</th><th>Mallard</th><th>Marsh Wren</th><th>Mink</th><th>Mallard</th><th>Marsh Wren</th></tr>
<tr><th>Total PCBs</th><th>Chromium</th><th>Chromium</th><th>Total PCBs</th><th>Chromium</th><th>Chromium</th></tr>
<tr><td>PC-E</td><td>—</td><td>—</td><td>5.5</td><td>—</td><td>—</td><td>4.7</td></tr>
<tr><td>PC-W (including subunit PP-OM)[1]</td><td rowspan="2">24</td><td rowspan="2">1.7</td><td>13.5</td><td rowspan="2"><1.0</td><td rowspan="2"><1.0</td><td>1.1</td></tr>
<tr><td>TC-OM</td><td>5.7</td><td>2.4</td></tr>
</table>

Notes:

— Suitable habitat for receptor not present or negligible risks (i.e., HQ < 1.0) under existing conditions (Risk Refinement and Synthesis)

Negligible Risk	(blue)	All HQ values below 1.0 using
Low Risk	(green)	HQ values above 1.0 using Golder (2012) lower bound TRVs but less than 1.0 using Golder (2012) upper bound TRVs; exceedance of lower bound TRVs shown as value in cell
Low to Moderate Risk	(yellow)	HQ values above 5.0 using Golder (2012) lower bound TRVs, but less than 1.0 using Golder (2012) upper bound TRVs; exceedance of lower bound TRVs shown as value in cell
Moderate to High Risk	(orange)	HQ values above 1.0 using Golder (2012) upper bound TRVs

1 The original PC-W management unit assessed as part of the risk assessment (Golder 2016) and initial remedial assessments (Golder 2017a and Golder 2019) was subdivided for the SMP into three different sub-units: PC-W, PC-OM, and PP-OM to reflect an updated property survey and a different remedial strategy for the Orchard Street Marsh (PC-OM). As such, PC-OM is not included in the residual risk analysis.

Based on the results shown in Table 4, the assessment of residual risks to wildlife following implementation of the SMP is summarized below:

- For mammals, residual risks to mink from PCBs decrease from moderate/high to negligible
- For mallards, residual risks from chromium decrease from low to negligible
- For marsh wrens, residual risks decrease from low/moderate to low

3.0 CLOSURE

We trust that this report provides sufficient information for your current needs. Please be advised that the conceptual designs will be provided in the updated SMP. Please contact the undersigned should you have any questions.

WSP CANADA INC.

[redacted]

Lindsay Furtado, MSc, RPBio
Environmental Risk Assessor

Gary Lawrence , MRM, RPBio
Environmental Scientist, Principal

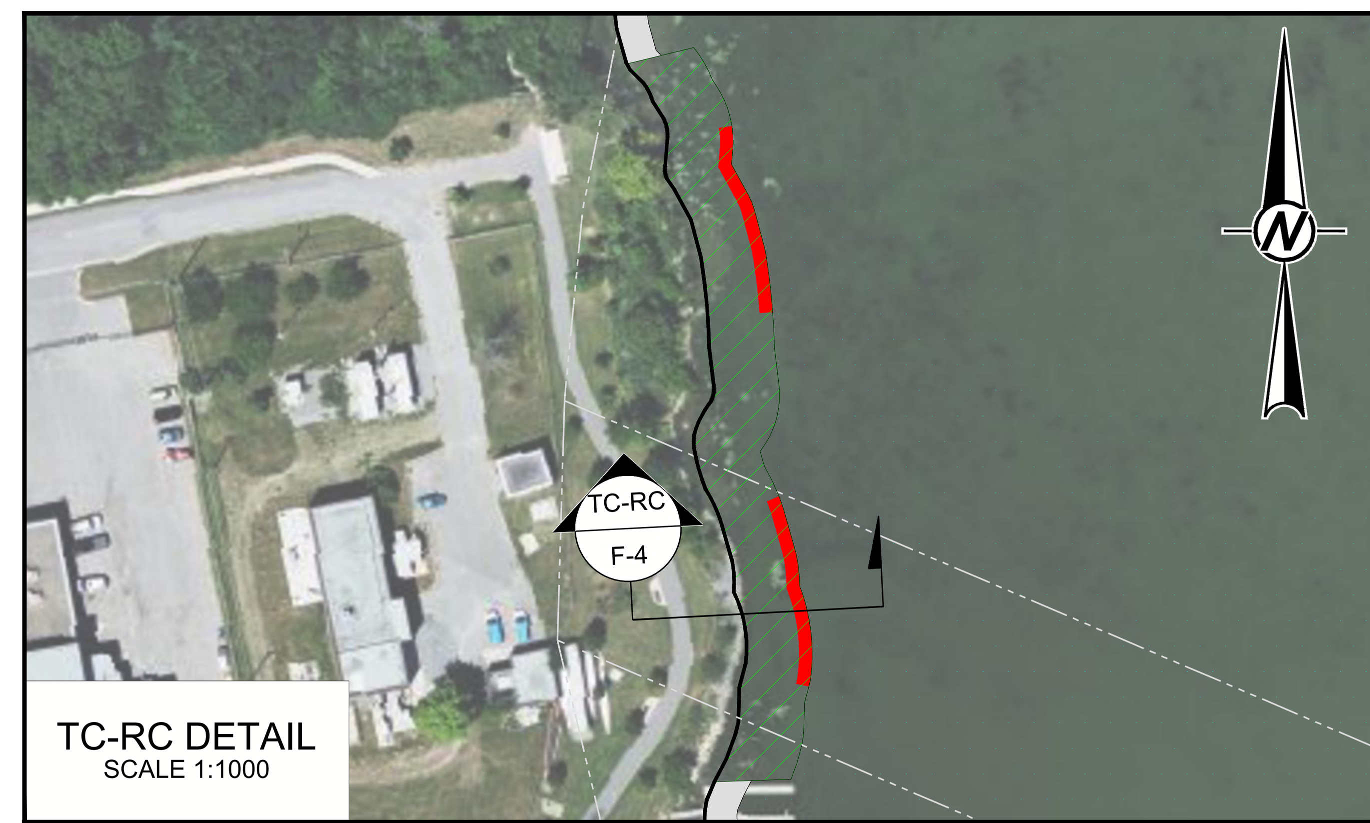
LF/GL/lih

https://golderassociates.sharepoint.com/sites/162644/project files/6 deliverables/3.0_issued/22523199-012-tm-rev0/22523199-012-tm-rev0-residual risk 19sep_23.docx

APPENDIX F

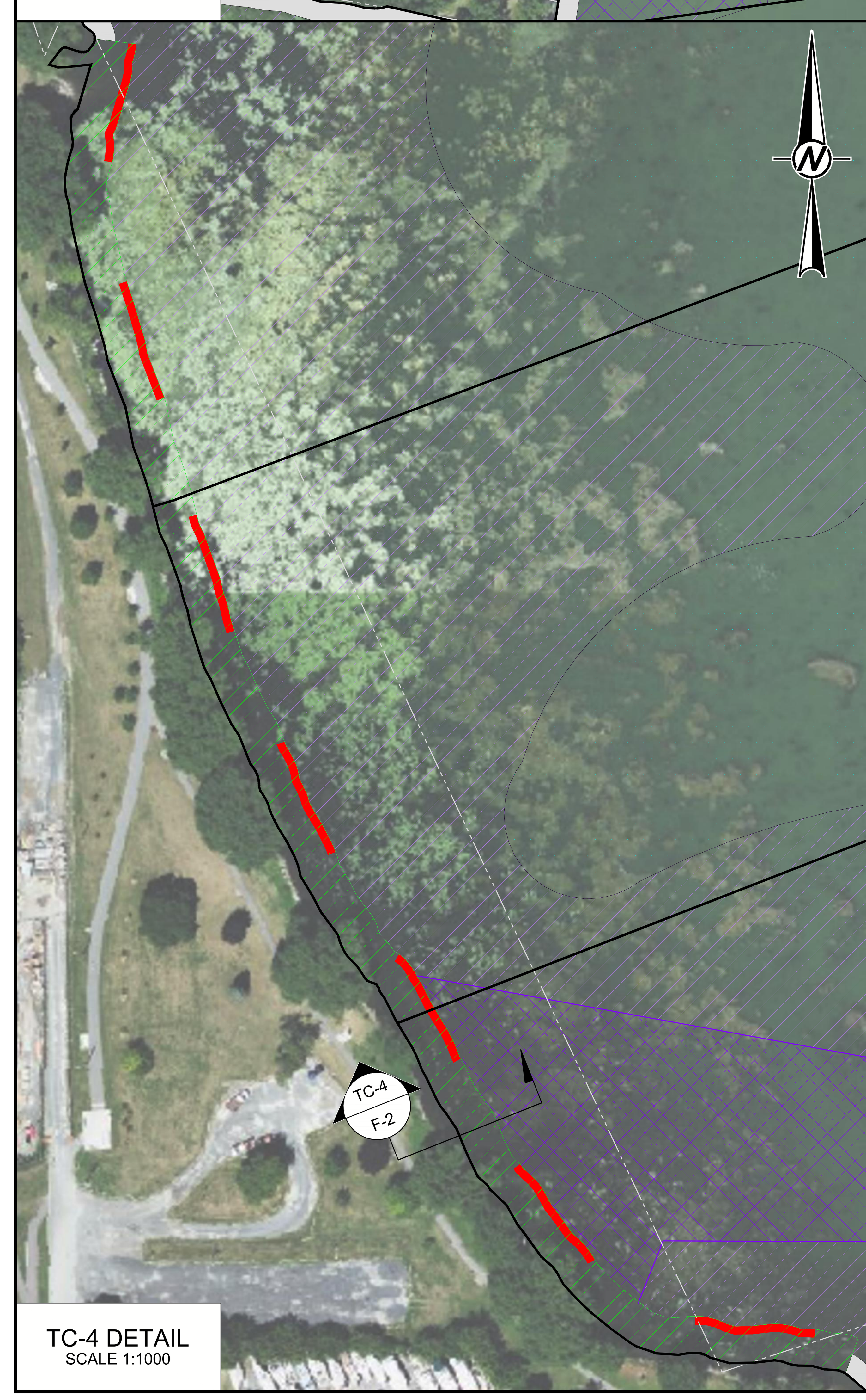
Sediment Management Plan Conceptual Profiles

SITE PLAN
SCALE 1:2500



TC-RC DETAIL
SCALE 1:1000

WM DETAIL
SCALE 1:1000



TC-4 DETAIL
SCALE 1:1000

LEGEND

- DREDGING EXCLUSION ZONE
- DREDGE BOUNDARY WITH THIN LAYER (UP TO 0.3 m) CAP/COVER
- POTENTIAL FOR NATURE-BASED SHORELINE REHABILITATION TO IMPROVE HABITAT/DREDGING EXCLUSION ZONE
- ENHANCED NATURAL RECOVERY (THIN LAYER CAP/CARBON AMENDMENT)
- DREDGE BOUNDARY WITH (1.0 m) CAP WITH CARBON AMENDMENT OR REACTIVE BARRIER
- FUTURE WETLAND MANAGEMENT REQUIRING COORDINATION WITH CITY OF KINGSTON, PRIVATE LAND OWNERS AND PARKS CANADA
- MONITORED NATURAL RECOVERY
- MANAGEMENT UNIT
- FEDERAL WATER LOT BOUNDARY
- PROPOSED WOODY DEBRIS/LOGS AND BOULDER (SEE NOTE 1)

NOTE(S)

1. PLACEMENT OF WOODY DEBRIS/LOGS AND BOULDER IS APPROXIMATE AND INTENDED FOR INDICATIVE PURPOSES ONLY
2. UNITS ARE IN METRES (m) UNLESS OTHERWISE NOTED
3. THIS FIGURE IS CONCEPTUAL ONLY

REFERENCE(S)

1. IMAGERY COPYRIGHT © 2022-07-11 ESRI AND IT'S LICENCSORS. SOURCE: MAXAR VIVID WV02. USED UNDER LICENCE, ALL RIGHTS RESERVED
2. PROJECTION: UTM ZONE 18 DATUM NAD83

0 100 200
1:2,500 METRES

0 50 100
1:1,000 METRES

SEAL

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
----	----	----	----	----	----	----
B	2023-08-29	DRAFT - FOR CLIENT REVIEW	EC	RTJ	KM	JD
A	2023-07-14	DRAFT - FOR CLIENT REVIEW	EC	RTJ	KM	JD

CLIENT
PUBLIC SERVICES AND PROCUREMENT CANADA

PROJECT
KINGSTON INNER HARBOUR SMP

CONSULTANT

OTTAWA
1931 ROBERTSON ROAD
OTTAWA, ONTARIO
CANADA
[+1] (613) 592 9600

TITLE
CONCEPTUAL SITE PLAN

PROJECT NO.	CONTROL	REV.		FIGURE
22523199	0001	0	1 of 6	F-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D
25 mm
0

HORZ. SCALE 1:50 TC-4 TYPICAL CONCEPTUAL PROFILE
VERT. SCALE 1:50 F-1

LEGEND

EXISTING ROCK (CONCEPTUAL)

PROPOSED ROCK (CONCEPTUAL)

NOTE(S)

1. THIS FIGURE IS CONCEPTUAL ONLY

REFERENCE(S)

1. BATHYMETRIC SURVEY CONDUCTED BY WSP AT THE SITE IN OCT 2021 AND MAY 2022.
2. DIGITAL TERRAIN MODEL (DTM) WITH 1 METRE RESOLUTION FROM LIDAR EASTERN ACQUISITION PROJECT (LEAP) COLLECTED BY THE ONTARIO MINISTRY OF NATURAL RESOURCES (2009).
3. ALL ELEVATIONS NOTED ARE IN m IGLD

0 2 4
1:50 METRES

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
A	2023-07-14	DRAFT - FOR CLIENT REVIEW	EC	RTJ	KM	JD

SEAL

CLIENT
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PROJECT
KINGSTON INNER HARBOUR SMP

TITLE
SHORELINE CONCEPTUAL DESIGN PROFILE - TC-4

PROJECT NO.	CONTROL	REV.		FIGURE
22523199	0001	0	2 of 6	F-2

HORZ. SCALE 1:50 | WM | TYPICAL CONCEPTUAL PROFILE
VERT. SCALE 1:50 | F-1

LEGEND

EXISTING ROCK (CONCEPTUAL)

PROPOSED ROCK (CONCEPTUAL)

NOTE(S)

1. THIS FIGURE IS CONCEPTUAL ONLY

REFERENCE(S)

1. BATHYMETRIC SURVEY CONDUCTED BY WSP AT THE SITE IN OCT 2021 AND MAY 2022.
2. DIGITAL TERRAIN MODEL (DTM) WITH 1 METRE RESOLUTION FROM LIDAR EASTERN ACQUISITION PROJECT (LEAP) COLLECTED BY THE ONTARIO MINISTRY OF NATURAL RESOURCES (2009).
3. ALL ELEVATIONS NOTED ARE IN m IGLD

0 2 4
1:50 METRES

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
A	2023-07-14	DRAFT - FOR CLIENT REVIEW	EC	RTJ	KM	JD

SEAL

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PROJECT
KINGSTON INNER HARBOUR SMP

TITLE
SHORELINE CONCEPTUAL DESIGN PROFILE - WM

PROJECT NO.	CONTROL	REV.		FIGURE
22523199	0001	0	3 of 6	F-3

HORZ. SCALE 1:50 | TC-RC | TYPICAL CONCEPTUAL PROFILE
VERT. SCALE 1:50 | F-1

LEGEND

EXISTING ROCK (CONCEPTUAL)

PROPOSED ROCK (CONCEPTUAL)

NOTE(S)

1. THIS FIGURE IS CONCEPTUAL ONLY

REFERENCE(S)

1. BATHYMETRIC SURVEY CONDUCTED BY WSP AT THE SITE IN OCT 2021 AND MAY 2022.
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3. ALL ELEVATIONS NOTED ARE IN m IGLD

0 2 4
1:50 METRES

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
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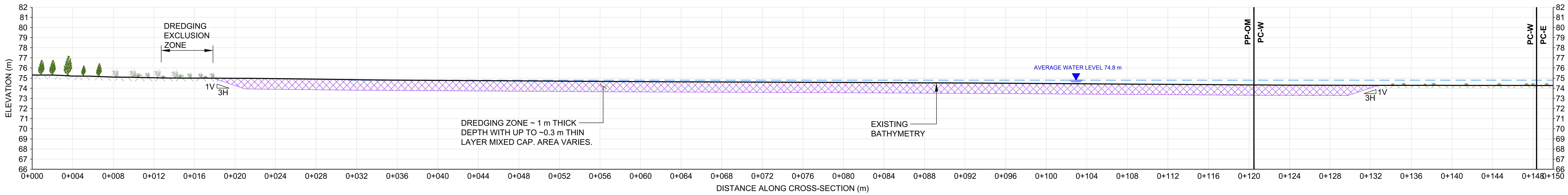
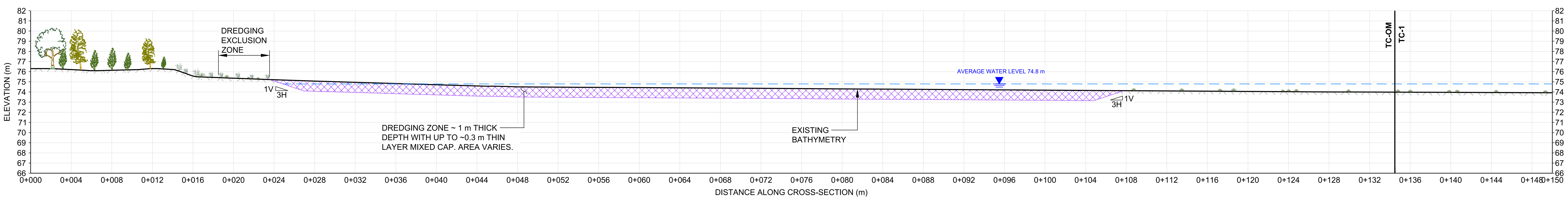
PROJECT
KINGSTON INNER HARBOUR SMP

TITLE
SHORELINE CONCEPTUAL DESIGN PROFILE - TC-RC

PROJECT NO.	CONTROL	REV.		FIGURE
22523199	0001	0	4 of 6	F-4



HORZ. SCALE 1:200 PP-OM TYPICAL CONCEPTUAL PROFILE
VERT. SCALE 1:200 F-1



HORZ. SCALE 1:200 TC-OM TYPICAL CONCEPTUAL PROFILE
VERT. SCALE 1:200 F-1

NOTE(S)
1. THIS FIGURE IS CONCEPTUAL ONLY

REFERENCE(S)
1. BATHYMETRIC SURVEY CONDUCTED BY WSP AT THE SITE IN OCT 2021 AND MAY 2022.
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0 10 20
1:200 METRES

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PROJECT
KINGSTON INNER HARBOUR SMP

TITLE
TC-OM & PP-OM CONCEPTUAL DESIGN PROFILE

PROJECT NO.	CONTROL	REV.		FIGURE
22523199	0001	0	5 of 6	F-5

Path: \\golder.gds\complexdata\office\Ontario\SIM\Clients\PSPC\Kingston_Inner_Harbour\99_PROJ\22523199_PSPC_SMP\40_PROD\0001_ShorelineDesign\ | File Name: 22523199-0001-CW-0001.dwg | Last Edited By: ryjames Date: 2023-07-14 Time:11:50:04 AM | Printed By: RYJames Date: 2023-07-14 Time:11:56:42 AM

HORZ. SCALE 1:100 PC-W TYPICAL CONCEPTUAL PROFILE
VERT. SCALE 1:100 F-1

NOTE(S)
1. THIS FIGURE IS CONCEPTUAL ONLY

REFERENCE(S)
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0 5 10
1:100 METRES

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PROJECT
KINGSTON INNER HARBOUR SMP

TITLE
PC-W CONCEPTUAL DESIGN PROFILE

PROJECT NO.	CONTROL	REV.		FIGURE
22523199	0001	0	6 of 6	F-6

APPENDIX G

Existing Shoreline Photos

Photo 1: TC-4

Existing rock armouring is present intermittently along the shoreline as bank protection. Typically consists of approximately 0.3 to 0.5 m diameter rocks on an approximately 15:1 slope.

Photo 2: TC-3A

Existing rock armouring is present intermittently along the shoreline as bank protection. Typically consists of approximately 0.3 to 0.5 m diameter rocks on an approximately 15:1 slope.

Photo 3: TC-2A

Existing rock armouring is present intermittently along the shoreline as bank protection. Typically consists of approximately 0.3 to 0.5 m diameter rocks on an approximately 15:1 slope.

Photo 4: TC-2A

Northern portion of TC-2A consists of vertical stacked rock wall along the shoreline. This area is not a part of the proposed design at this time.

Photo 5: WM

Causeway at the intersection between TC-2A and WM. Foundation consists of riprap.

Photo 6: WM

Existing rock armouring is present intermittently along the shoreline as bank protection. Typically consists of approximately 0.3 to 0.8 m diameter rocks on an approximately 10:1 slope.

Photo 7: TC-RC

Existing rock armouring is present intermittently along the shoreline as bank protection. Typically consists of approximately 0.2 to 0.8 m diameter rocks on an approximately 6:1 slope.

Photo 8: TC-RC

Existing boat access along the shoreline of TC-RC. Current design will allow for continued boat access.

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