Prepared By:

Master Plan: Brooke Area Basin A3 Outlet

City of Owen Sound

GMBP File: 216301

Version 1: October 25, 2022

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CITY OF OWEN SOUND

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1. INTRODUCTION

1.1 Background

In July 2008, GM BluePlan Engineering Limited (GMBP), on behalf of the City of Owen Sound (City) and the Township of Georgian Bluffs (Township), completed a *'Brooke Area Stormwater Management Study'* (BASWM Study), which investigated drainage issues within seven drainage areas that cross the common municipal border and outlet through the City to Georgian Bay. Brooke Area Basin A3 was identified as one of these drainage areas.

Brooke Area Basin A3 is generally bounded by West Street in the west, 23rd Street West in the north, the Eddie Sargent Parkway (ESP; Grey Road 1) in the east, and the 17th Street West and 18th Street West rights-of-way (ROW) in the south. The specific Study Area includes the outlet portion of the drainage system of Basin A3, which is located entirely within the City's boundaries, east of 8th Avenue West to the outlet at Kelso Beach. The Study Area, which encompasses the geographic limits of Basin A3, is outlined in **Figure 1**.

The BASWM Study identified several drainage deficiencies within the Study Area, including the need for a stormwater management pond to be constructed within Georgian Bluffs to manage an increase in stormwater peak flows due to development within the Township. Subsequently, the Carney Street Stormwater Management (SWM) Pond was constructed by the Township in 2015. The BASWM Study also identified various deficiencies with drainage infrastructure within the City.

Further to the completion of the Carney Street SWM Pond in 2015, the City has chosen to investigate in greater detail the outlet system for Brooke Area Basin A3, by following a Master Plan approach, with the Study Area broken down into the following component Reaches:

Reach #1: Open Channel - East of 8th Avenue West to 6th Avenue West
Reach #2: Culvert - 6th Avenue West and 21st Street West
Reach #3: Open Channel / Culvert - 21st Street West to 20th Street West
Reach #4: Open Channel - 20th Street West to 19th Street West
Reach #5: Culvert Inlet System - 19th Street West near 5th Avenue West
Reach #6: Storm Sewer System - 19th Street West, from Inlet System to ESP
Reach #7: Outlet System - ESP to Kelso Beach

The Reach locations and existing conditions are outlined on General Plan **Drawing No.1**.

1.2 Project Planning and Scope

GMBP was retained by the City of Owen Sound to undertake a planning process towards addressing the drainage deficiencies identified within Brooke Area Basin A3. The City has initiated this Master Plan process, under the Municipal Class Environmental Assessment (EA) process, appropriately to plan various drainage undertakings within the Study Area in a comprehensive manner.

The Master Plan will assist in planning individual projects toward an appropriate overall drainage strategy within the study area. This system wide approach provides for a strategic level of assessment of various options to better address the needs of the overall system and potential impacts and mitigation. Further, this plan identifies specific projects that can be implemented over a period of time.

This Master Plan process is intended to follow Approach #2 (Appendix 4, MCEA Manual 2015), in which the appropriate environmental assessment Schedule 'B' projects will be identified and the investigations, consultation and documentation sufficiently will address the requirements for the Schedule 'B' projects. The Master Plan will be finalized at the conclusion of Phases 1 and 2 of the EA process **(Figure 2)** and the Notice of Completion will fulfill the Schedule 'B' project planning requirements.

The EA planning process develops a Project Statement, considers alternative solutions, and documents the public consultation process toward the selection, by Council, of a *Preferred Solution(s)* to the Project Statement. This Master Plan Report (Version 1) is considered a 'living document', which will be updated as the process advances through various stages. The purpose of this report is to document the master planning process, which will address Phases 1 and 2 of the EA process for the Schedule 'B' projects identified, toward the selection of a preferred Master Plan for drainage systems within Brooke Area Basin A3.

The documentation includes the following:

i. A description of the project background;
ii. Identification of problems and opportunities for component Reaches within the drainage system;
iii. A consolidation of the findings of various background studies;
iv. Identification of alternative solutions to the identified problems and/or opportunities;
v. Evaluation and assessment of alternative drainage solutions;
vi. A summary of public, agency and indigenous community consultation; and
vii. The selection of a preferred set of alternative solutions, which make up the Master Plan.

The recommended Master Plan is contained within this documentation of the process, including Appendices, which contain more specific information.

2. MUNICIPAL CLASS ENVIRONMENTAL ASSESSMENT: MASTER PLANS

Municipal infrastructure projects are subject to the Ontario Environmental Assessment Act (EA Act). The Class Environmental Assessment (Class EA) is an approved self-assessment process under the EA Act for a specific group or "class" of projects. Projects are considered approved subject to compliance with an approved Class EA process. The Municipal Class EA (Municipal Engineers Association October 2000, as amended in 2007, 2011 and 2015) applies to municipal infrastructure projects including roads, water and wastewater.

The Municipal Class EA outlines a comprehensive planning process (illustrated in **Figure 2**) that provides a rational approach to consider the environmental and technical advantages and disadvantages of alternatives and their trade-offs in order to determine a *Preferred Solution* to address an identified problem (or opportunity), as well as consultation with agencies, indigenous communities, directly affected stakeholders and the public throughout the process. The key principles of successful environmental assessment planning include:

- Consultation;
- Consideration of a reasonable range of alternatives;
- Consideration of effects on natural, social, cultural, and economic environments and technical components;
- Systematic evaluation;
- Clear documentation; and
- Traceable decision making.

The classification of projects and activities under the Municipal Class EA is as follows:

Schedule A: Includes normal or emergency operational and maintenance activities, which are limited in scale and have minimal adverse environmental effects. These undertakings are pre-approved and the proponent can proceed without further assessment and approval.

Schedule A+: Introduced in 2007, these minor projects are pre-approved. The public is to be advised prior to the implementation of the project.

Schedule B: Includes projects which have the potential for adverse environmental effects. This includes improvements to, and minor expansions of, existing facilities. These projects are approved subject to a screening process which includes consulting with stakeholders who may be directly affected, relevant review agencies and indigenous communities.

Schedule C: Includes the construction of new facilities and major expansions to existing facilities. These undertakings have the potential for significant environmental effects and must proceed under the planning and documentation procedures outlined in the Municipal Class EA document.

Master Plans are long range plans that recognize the need to integrate infrastructure requirements for existing and future land uses with environmental assessment planning principles. As such, Master Plans address Phases 1 and 2 of the Municipal Class EA process. This Version 1 of the Master Plan Report also includes documentation for the required Schedule 'B' EA processes for identified projects, which is in accordance with the requirements of the Municipal Class EA process and includes Phases 1 and 2, depicted on **Figure 2**:

- Phase 1 consists of identifying the problem or opportunity, and optional (discretionary) public consultation if deemed suitable.

- Phase 2 involves identifying reasonable alternatives to the problem or opportunity, compiling an inventory of the natural, cultural, social, technical and economic environments, evaluating each alternative and recommending a preferred alternative that will address the problem, and provide any measures necessary to mitigate potential environmental impacts. As part of the Phase 2 process, public and agency consultation is required before the preferred solution is selected to ensure all

possible impacts are identified, and assessed, as part of the evaluation process. A summary of the key comments/feedback obtained during the Phase 2 consultation period is provided.

For Schedule 'B' or 'C' projects, a *Notice of Project Initiation* is advertised and the *Preferred Solution* (and for Schedule 'C' projects, the *Preferred Design)* is developed through the process; to be confirmed by Council. The entire process is documented in a Schedule 'B' Project File, or Schedule 'C' Environmental Study Report, which is made available for public, agency and Indigenous Community comment during a 30-calendar day period following the issuance of the *Notice of Completion*. Project Notices are included in **Appendix A**.

The Master Plan Report will be finalized at the conclusion of Phases 1 and 2 of the EA process **(Figure 2)**. Accordingly, the final public notice for the Master Plan will become the *Notice of Completion* for the Schedule 'B' projects addressed within the Plan. However, when using this approach, it is noted that as a Master Plan does not require approval under the EA Act, only the individual projects within the Master Plan must fulfill the EA requirements. Requests for an order to comply with Section 16 of the EA Act are only possible for the specific projects identified in the Master Plan.

For Schedule 'B' and 'C' projects, all comments and concerns raised by the public, stakeholders and/or agencies during the comment period, following advertisement of the *Notice of Completion*, are to be addressed directly to the proponent (i.e., the City) and the project team. However, if concerns are raised during the review period that are specific to aboriginal or treaty rights, that cannot be resolved through discussions with the City, then a Section 16 Order request (formerly a Part II Order request) to the Ministry of the Environment, Conservation and Parks (MECP) may be made.

Requests specific to aboriginal or treaty rights should specify what kind of order is being requested (i.e., additional conditions, higher level of study, individual EA, etc.), how an order may prevent, mitigate or remedy those potential adverse impacts on constitutionally protected Aboriginal and treaty rights, and any information in support of the statements in the request. Requests on other grounds will not be considered. This will ensure that the Ministry is able to efficiently begin reviewing the request. The Section 16 Order request should be sent in writing or by e-mail to the following:

Minister, Ministry of the Environment, Conservation and Parks
777 Bay Street, College Park 5th Floor
Toronto, ON M7A 2J3
minister.mecp@ontario.ca

Copies of the request must also be sent to the Director of the Environmental Assessment Branch at the MECP and the City of Owen Sound at the addresses below:

Director, Environmental Assessment Branch
Ministry of the Environment, Conservation and Parks
135 St. Clair Avenue West, 1st Floor
Toronto, ON M4V 1P5
EABDirector@ontario.ca

Chris Webb, Manager of Engineering Services
City of Owen Sound
808 2nd Avenue East
Owen Sound, ON N4K 2H4
cwebb@owensound.ca

The decision whether (or not) a Section 16 Order is appropriate or necessary rests with the Minister of the MECP. If a Section 16 Order request is not outstanding by the end of the 30-calendar day comment period, the project is considered to have met the requirements of the Class EA, and the City may proceed to design and construct the project subject to resolving any commitments documented in this Project File Update (and the associated Project File) during the subsequent design phases and obtaining any other outstanding environmental approvals.

For further information regarding Section 16 Order requests and process, please go to:
Class environmental assessments: Section 16 Order | ontario.ca

3. STUDY PROCESS

The process toward selecting a preferred Master Plan involves two steps. The first step is generally to identify the broad issue(s) that the Master Plan process is intended to address, the general environmental conditions and constraints within the Study Area, and the parameters against which alternatives are to be measured. The second step is to identify specific problems, develop and assess alternative solutions within each of the identified Reaches along the outlet route, in a 'top → down' approach, and to identify a *Recommended Solution* for each Reach. Following the required consultations and confirmation by Council of the *Preferred Solutions* established as part of this Master Planning process, the individual solutions will be incorporated into a system wide Master Plan for implementation of individual projects, in a planned stepwise manner, as opportunity permits.

4. PLANNING CONSIDERATIONS

As an upper tier government, Grey County establishes land use planning policies in the Grey County Official Plan (GCOP June 6, 2019). The GCOP Secondary Schedule Map, provided in **Appendix B**, identifies land uses with a broad area perspective. An upper portion of the Basin A3 outlet system is designated as 'Hazard Lands' while the remainder of the drainage basin is designated as 'Primary Settlement Area' within the Owen Sound portion of Basin A3.

As a lower tier government, the City establishes more local land use planning policies in the City of Owen Sound Official Plan (OSOP December 18, 2012 – office consolidation January 2017). The Schedule A Land Use Plan, provided in **Appendix B**, identifies a significant portion of the Basin A3 outlet system as 'Hazard Lands' while the remainder of the drainage basin is predominately designated as 'Residential' within the Owen Sound portion of Basin A3. Some lands adjacent to the Eddie Sargent Parkway are planned as 'Open Space' or 'Mixed Waterfront Use'. Based on the Official Plan and existing land uses within the Study Area, the potential for additional development is considered unlikely. Therefore, the Study Area is assumed to be in a 'built-out' condition.

While the westerly, upstream portions of Basin A3 are designated under the Niagara Escarpment Planning and Development Act, no lands within the Study Area are subject to any designation under the Act.

5. EXISTING CONDITIONS

The following background studies were reviewed, or prepared, to assist in establishing the existing development conditions and to identify potential problem flooding areas within the Study Area. This information was used to help inform the identification of drainage related issues within the Study Area that may be resolved through the Master Plan and will be used in the assessment of alternatives within each of the identified Reaches along the outlet route, discussed herein.

5.1 Brooke Area Stormwater Management Study (BASWM Study, 2008)

The BASWM Study modelled the Study Area using MIDUSS hydraulic computer software and determined the design flows and capacities throughout system under three development conditions and evaluated each condition in two different system states, as outlined in the following **Table 5-1**:

TABLE 5-1: BASWM Study - Development Conditions and System States Evaluated

Development Condition	Description of Study Area	System States Evaluated
Pre-Development	In a 'natural' state prior to any level of development	1. Existing Works 2. Proposed Capital Works
Existing Development	As it existed at the time of the BASWM report	
Ultimate Development	Area fully 'built-out' (i.e., developed)	

Proposed Capital Works:

In achieving the 'Proposed Capital Works' system state, the BASWM Study recommended the construction of the Carney Street SWM Pond within the Township of Georgian Bluffs to mitigate peak flow increases due to development within the Township.

With the construction of the Carney Street SWM Pond in 2015, the 'as-built' state of the Pond was re-evaluated using the modelling of the BASWM Study. From a GMBP letter dated November 2, 2015 to the Township, included in **Appendix C**, it was concluded that *'the Carney Street SWM Facility in its as-built state is expected to function as intended in the BASWM Study'*.

Therefore, considering the current 'built-out' development condition within the Study Area, and the appropriate function of the Carney Street SWM Pond, the design flows to be considered within the master planning of the Study Area are those associated with the Proposed Capital Works under an Ultimate Development Condition (proposed ultimate development design flows) as shown in Drawing No. 11 of the BASWM Study, which is included in **Appendix C**.

While the Carney Street SWM Pond provides a degree of attenuation for a range of design flows from upstream runoff, the SWM pond has little impact on peak flows from a Regional storm event, since the volume of runoff from such an event would be considerable. The BASWM Study notes that the subject drainage route through the City does not have a suitable alternate high flow overland flow route and, therefore, the system must convey the Regional flood flow, without adverse effect to existing properties.

5.2 Flood Line Mapping Study (2017)

A Flood Line Mapping Study, which conservatively considered a subcritical flow regime along the subject Reaches to demonstrate the extent of potential flooding under Regional flood flow conditions, was prepared to identify potential flooding problems within the Study Area.

Hydraulic modelling of the system, based on the updated Regional flood flows, was completed to establish flood line elevations under existing conditions from the open channel to east of 8th Avenue West (Reach #1) to immediately upstream of the inlet system at 19th Street West near 5th Avenue West (Reach #5). **Drawing No. 2** shows the extent of the flood line throughout the subject Reaches (i.e., #1 through #5), as per the Regional flood flows determined in the BASWM Study. The key points of this analysis are discussed below, and modelling results are provided in **Appendix D**.

Reach #1:

The flood line mapping study determined that the open channel to the east of 8th Avenue West (Reach #1) does not have sufficient capacity to convey the full Regional flood flow to the culvert at 6th Avenue West (Reach #2). Flow is conveyed in the main channel and also in the shallow overbank areas within the rear-yard area of House Nos. 2168, 2164 and 2130 on 6th Avenue West, resulting in a relatively wide flood flow cross-section. The flood flow cross-section constricts as it approaches the culvert at 6th Avenue West and is conveyed in a well-defined channel between House Nos. 2164 and 2130 on 6th Avenue West. While the Regional flood flow would overflow from the main channel, the modelled flood elevations would not threaten existing residences. The maximum flood elevation adjacent to the residences is approximately 0.78 m below the lowest main floor elevation of either residence. Further, a spill elevation across 6th Avenue West is about 0.4 metres lower than the grades adjacent to the buildings, so additional flood relief is available.

Reach #2:

From 6th Avenue West to 21st Street West (Reach #2), an outlet control condition governs flow through the existing culvert. The Regional flood flow at this Reach is entirely conveyed by the existing twin 1500 Ø CSP culverts and is not adversely restricted by the box culvert at the inlet.

Reach #3:

Flood line mapping along the open channel between 21st Street West and 20th Street West (Reach #3) determined that a majority of the Regional flood flow is conveyed outside of the main channel portion; within the easterly/northerly overbank area since the westerly/southerly overbank area is well-defined and relatively steep. Within this Reach, a flood elevation of approximately 188.30 m is expected to occur near House No. 585 on 21st Street West. This is approximately 0.04 m higher than the basement floor elevation, where an entrance door exists. No risk due to flooding is anticipated for any other residence adjacent to this Reach.

The culvert at 20th Street West (Reach #3), presents a restriction to the Regional flood flow. The existing culvert lacks sufficient flow area fully to convey the design flow under outlet control conditions. Consequently, the expected flow depth at the inlet to the culvert is above the top of the culvert, which contributes to a backwater effect upstream. The culvert has sufficient capacity to convey the design flow, under surcharge, prior to overtopping 20th Street West or posing a risk to adjacent residences.

Reach #4 and Reach #5:

Reach #4 is situated between 20th Street West and 19th Street West. Within this Reach the open channel has a deeper cross-section. Flood line mapping demonstrates a relatively narrow extent of flooding along most of this Reach under Regional flood flow conditions, with no impact to adjacent buildings. The flood line, immediately upstream of the existing 2740 mm x 1220 mm concrete culvert inlet to the 19th Street West storm sewer system, significantly widens easterly at 19th Street West, as the easterly bank slope becomes less steep.

The 19th Street West culvert (Reach #5) has an inlet capacity of about 5.069 m^3/s, which is 0.973 m^3/s less than the Regional flood flow of 6.042 m^3/s at this location. Consequently, although the geometry of the Reach #4 is capable of conveying the Regional flood flow, a backwater effect would be produced by insufficient inlet capacity at 19th Street West, and excess flow would spill overland, in an easterly direction on 19th Street West. Based on Ontario Base Mapping, this spill location would be approximately 55 m east of the culvert inlet, about 4th Avenue West, at an elevation of approximately 184.50 m. At this location, a spill would occur to the 19th Street West road surface.

The extent of the flood line at 19th Street West is relative to the spill elevation. For conservative analysis, the portion of the Regional flood flow required to be conveyed by the overland flow route should be considered for two scenarios, as follows:

i. Sufficient capacity exists within the 19th Street West storm sewer system to receive the capacity of the culvert inlet, and
ii. Insufficient capacity exists within the 19th Street West storm sewer system to only partially receive the capacity of the culvert inlet.

As identified in the BASWM Study, the 19th Street West storm sewer system does not have adequate capacity to convey the Regional flood flow. Therefore, for the purpose of modelling a "worst case" flood elevation, the entirety of the Regional flood flow at the location of Reach #5 can conservatively be considered to flow overland with no portion of Regional flood flows being conveyed by the culvert.

To fully convey the Regional flood flow of 6.042 m^3/s overland, a water level elevation of approximately 185.30 m would be necessary to convey this Regional flood flow as weir flow. At this starting elevation, the flood line mapping for Reaches #4 and #5 indicates that no risk is posed to any adjacent residence. A minimum vertical distance of approximately 1.70 m would be available between the flood line elevation at the spill point and the nearby residence with the lowest elevation (House No. 1914-4th Avenue West).

5.3 High Water Level Mapping

High water level mapping was completed to support the Master Planning process. This was used to identify lands below the 1:100 year flood elevation and was simply based on the topographical contour mapping available. These areas are outlined on **Drawing No.3**. Areas where potential flooding may occur are subject to change, based on site specific surveys which may be recommended for some areas.

6. PROBLEM / OPPORTUNITY DEFINITION

6.1 Definition of Problem

The City of Owen Sound, as proponent, is taking a pro-active approach in assessing a variety of drainage related issues within the Study Area. The original natural watercourse has been modified by development over the years and, currently, the system includes a combination of open watercourses and closed storm sewers, which will require maintenance or replacement in the near future. The proponent wishes to consider an overall appropriate and cost-effective approach in planning the entire system.

6.2 Drainage Issues Identified

The broad issues related to the system include the following:

i. A safe overland flow route is not readily available in some sections and, therefore, in some areas the system must convey the entirety of the flow associated with a Regional storm event.
ii. The drainage system has been modified by development and, therefore, its status as a natural watercourse is altered, also to include a public drainage function, with associated maintenance responsibilities.
iii. While the recently constructed Carney Street SWM Pond is expected to achieve its objective in attenuating peak flow rates from the Township of Georgian Bluffs portion of Basin A3 (reducing the effects of stormwater flooding downstream and reducing the peak flow rates discharging through the City), drainage issues still exist within the Study Area as identified in the BASWM Study. Existing drainage issues within the Study Area, to be addressed in this Master Plan, are described in **Table 6-1** and are identified on **Drawing No.4**:

TABLE 6-1: Identified Drainage Issues to be Addressed

Reach	Issue		Description
1	**A**	Erosion and Sediment Control	The points of confluence between the main watercourse east of Carney Street and two (2) watercourses from other A3 sub-basins may be susceptible to erosion which could result in sedimentation within the infrastructure downstream and impairment to their function. Similar risks are posed by the bends of these watercourses in the surrounding area.
1	**B**	Insufficient Channel Capacity	The common watercourse from the confluence of these watercourses, located about 7th Avenue West, lacks the necessary capacity to convey the greater Regional flood flows to the box culvert that exists at 6th Avenue West.
1	**C**	Discharge to Private Property	A 300 mm Ø storm sewer on 7th Avenue West discharges down the bluff at 22nd Street West, with flow ultimately making its way to the subject watercourse. Presumably, the installation intended flow to be maintained within the 7th Avenue West road allowance, but it is more likely that flows travel overland across the rear yards of House Nos. 2168 and 2164 6th Avenue West before entering the watercourse about 7th Avenue West. The bluff beneath the outfall of the storm sewer is highly eroded.
2	**D**	Structural Deficiencies	The existing 6th Avenue West box culvert and storm sewer along 6th Avenue West, while providing adequate capacity to inlet modelled flows, suffers from physical / structural deficiencies and requires replacement.
3	**E**	Low Opening Elevation	A low basement door elevation, at House No. 585 -21st Street West, may be susceptible to flooding.
3	**F**	Shallow Channel Gradient	The watercourse south of 21st Street West to 20th Street West does not provide adequate capacity to convey modelled flows throughout this Reach. The flat gradient permits sediments to settle under low flow conditions, thus impairing the capacity of the channel.
4	**G**	Potential for Watercourse Obstruction (i.e., Deadfall Trees)	No municipal easement exists over the watercourse Reaches which traverse private properties. Consequently, the City has no access for maintenance along these watercourses, when required.
5	**H**	Structural Deficiency and Inadequate Inlet Capacity	The inlet structure at 19th Street West is aging and may need to be replaced in the foreseeable future. It also has inadequate capacity to inlet the Regional flood flow.
6	**I**	Inadequate Storm Sewer Capacity	The existing corrugated steel pipe (CSP) system on 19th Street West is aging and should be considered for replacement in the short term.
7	**J**	Inadequate Outlet Capacity	The 1500 mm Ø outlet to this system, through Kelso Beach Park, has insufficient capacity to convey the 1:2-year design flow under existing conditions.
7	**K**	Road Flooding	Flooding conditions occur along the west side of the Eddie Sargent Parkway, which should be addressed.

Notes:
1. No municipal easement exists for Reaches 1, 3 and 4, consequently the City currently has no access, when required.
2. **Drawing No.4** illustrates the locations of 'Issues to be Addressed'

The proponent intends to address drainage deficiencies throughout the Owen Sound portion of Brooke Drainage Basin A3, including the identified drainage constraints and flooding issues within the Study Area, to an appropriate outlet(s).

7. BACKGROUND STUDIES

The following background studies were prepared to inventory the technical social, natural, cultural and economic 'environments', and to inform the impacts of the alternative solutions. Copies of these background reports are provided in the Appendices.

Appendix E

i. Stage 1 Archaeological Assessment for Brooke Basin A3 – City of Owen Sound, Grey County, Ontario. Prepared by Scarlett Janusas Archaeology Inc. (April 25, 2018).
ii. Cultural Heritage Evaluation Report: Brooke Area Basin A3. Prepared by Scarlett Janusas Archaeology Inc. (April 26, 2018).

Appendix F

iii. Natural Heritage Feature Analysis: Part Brooke Area Basin A3 – Watercourses between 8th Avenue West to Kelso Beach Park, and 19th Street West to 22nd Street West, City of Owen Sound, County of Grey. Prepared by Aquatic and Wildlife Services (AWS) Environmental Consulting Inc. (April 2019).

Appendix G

iv. Ontario Structure Inspection Manual – Inspection Forms (OSIM, 2018 and 2020). Prepared by GMBP.

In addition, the previously discussed *'Brooke Area Stormwater Management Study' (July 2008)*, which investigated drainage issues on a larger scale and identified Brooke Area Basin A3 as one of the drainage areas, and Flood Line Mapping Study is considered relevant to this Master Plan and was used to inform the impacts of the alternative solutions.

A summary discussion of the background information, including the findings for each study, is provided in the following sections.

8. INVENTORY OF ENVIRONMENTS

The Study process includes preparation of an inventory of environments. The inventory establishes the criteria against which alternative solutions for each specific project (or Reach) will be assessed. Alternative solutions to specific problems or opportunities are considered and assessed within this Master Plan.

8.1 Cultural Environment

8.1.1 Archaeological Assessment

In consideration of Section 1.3.1 of the 2011 Standards and Guidelines for Consultant Archaeologists (S&G) administered by the Ministry of Heritage, Sport, Tourism and Culture Industries (MHSTCI), which lists criteria that are indicative of archaeological potential, the study area meets the following criteria indicative of archaeological potential:

- Water sources (primary, secondary, features indicating past water sources, accessible or inaccessible);
- Early historic transportation routes; and
- Proximity to early settlements.

Scarlett Janusas Archaeology Inc. was retained to complete a Stage 1 Archeological Assessment for the area that may be impacted by drainage improvements within Brooke Area Basin A3. A copy of the Report (April 25, 2018) is provided in **Appendix E**. The assessment was conducted under the S&G. In a letter dated March 11,

2019, the MHSTCI confirmed the entry of the Stage 1 Assessment Report into the Ontario Public Register of Archaeological Reports (**Appendix E**).

The Stage 1 work included a review of historical background information and a site inspection of the Study Area. The Study Area encompassed a 5-meter area on either side of the existing storm drainage system, limited to Reach #1 through Reach #6. The Stage 1 assessment concluded that the study area exhibits archaeological potential based on its proximity to early transportation routes, its association with an area of both Indigenous and early Euro-Canadian settlement and the presence of the glacial Lake Nipissing shoreline in the Region. The Stage 1 assessment determined that approximately 56% of the Study Area retains archaeological potential, while the remaining 44% was considered to have low or no archaeological potential based on slopes in excess of 20 degrees and/or deep and extensive development disturbance.

Stage 2 archaeological assessments, using test pitting methodology, were recommended for the area(s) considered to retain archaeological potential. A summary of the findings of the Stage 1 archaeological assessment and the recommendations are summarized in **Table 8-1**. Areas considered to have archaeological potential and recommended for Stage 2 test pit survey, are outlined on **Figure 3**.

TABLE 8-1: Summary of Stage 1 Archaeological Assessment – Findings and Recommendations

Reach	Stage 1 Assessment Findings	Recommended Stage 2 Assessment
#1	Previously subject to development in the form of two 1500 mmØ culverts, with large utility services on the east side. West side of culvert remains undisturbed.	With the exception of routine maintenance, if there is any development along the west side of the existing culvert, the west side of Reach 1 should be the subject of Stage 2 Assessment.
#2	Significant disturbance associated with the municipal sewer and water main beneath 6th Avenue West and two – 1500mmØ culverts under the east boulevard. West side of the waterway retains archaeological potential.	The west side of Reach 2 exhibits potential and will require additional assessment if developed.
#3	Includes a watercourse which has been previously dredged. The majority of this Reach remains undeveloped, therefore retains archaeological potential.	Should any development in this area be proposed, Stage 2 archaeological assessment is recommended.
#4	Low Archaeological Potential: North end: concrete culvert and utility disturbance. Slopes in excess of 20 degree develop towards the south. Areas of archaeological potential exist in the remaining areas where past works has been limited to the removal of deadfall.	Should any development within the areas identified to retain archaeological potential be proposed, a Stage 2 archaeological assessment would be recommended.
#5	Previously disturbed through utility and roadway development.	None: No archaeological potential
#6	Previously subject to development disturbance.	None: No archaeological potential

Figure 3 outlines the Recommended Stage 2 Assessment Areas (Map 15 of the CHER)

8.1.2 Built Heritage Resource and Cultural Heritage Landscape Assessment

Scarlett Janusas Archaeology Inc. was retained to conduct a Cultural Heritage Evaluation Report (CHER) for Brooke Area Basin A3. A copy of the CHER dated April 26, 2018 is included in **Appendix E**. The assessment encompassed the area along the drainage basin, including the lots adjoining the drainage features, as well as buildings within lots situated adjacent to the drainage basin. The assessment was completed to satisfy Section 2(d) of the Planning Act which necessitates 'the conservation of features of significant architectural, cultural, historical, archeological or scientific interest'. Further, the County of Grey provides cultural heritage policies in

Section 3 of its Official Plan (2013) and the City of Owen Sound also provides cultural heritage policies in Section 7.2 of its Official Plan (2014).

The CHER determined that there were no structures within the Study Area itself deemed to have cultural heritage value or interest. However, of the thirty (30) structures located immediately adjacent to the Study Area, a total of 10 heritage buildings were determined to be heritage buildings or retain heritage elements. In consideration of the anticipated area of impact, the CHER determined that the proposed Brooke Area Basin A3 development will not have a direct impact on the built heritage resources located within (or adjacent to) the Study Area.

In addition, the area was identified as a cultural heritage landscape primarily due to its association with early settlement in the original Town Plot of Brooke. However, as stated in the CHER, *'although the landscape of the Study Area has been deemed to have cultural heritage value or interest, the proposed development project will not negatively impact or further alter the integrity of the landscape, including its viewsheds'*.

Therefore, based on the limited geographical extent of the proposed drainage improvement project, impacts to built heritage resources and/or cultural heritage landscapes are not anticipated and will not be considered further in the assessment of alternatives discussed herein.

8.2 Social Environment

The social environment includes the interests of directly and indirectly affected public members in the usage of the built facility. Potential construction impacts to directly affected public members will be addressed as part of the consultation process, to be completed as part of this Master Plan. The following summarizes an inventory of the Social Environment:

- Impacts to private property, such as potential flooding threats to residences, access limitations and implications on land use.
- Land acquisition and/or municipal easements.
- Aesthetic impacts of drainage improvements.

8.3 Natural Environment

8.3.1 Natural Heritage Features

A *'Natural Heritage Feature Analysis'* (NHFA) was completed for the subject portion of Part of Brooke Area Basin A3, by Aquatic and Wildlife Services (AWS) Environmental Consulting Inc., in April 2019. A copy of the NHFA Report is provided in **Appendix F**. The report addressed the seven Natural Heritage Features, as identified by Provincial Policy Statement 2.1, with a review of available federal, provincial and municipal literature. This background literature review and data search was augmented with Stage 1 field observations/findings for the General Study Area. The purpose of the assessment was to identify any significant natural heritage features and key ecological functions within the *Study Lands* and the adjacent *Site Lands,* considered to be situated within 120 meters of the Study Lands. This information is intended to aid in the review of alternatives and potential design mitigation measures.

Through the significant feature analysis, the following Natural Heritage Features were identified by AWS within the General Study Area, or within the 120 m adjacent lands to the focused water course features. The Natural Heritage Features are depicted on **Figure 4** (Copy of NHFA Report Figure 8).

i. Habitat for Species-At-Risk (SAR) Species:

a. Confirmed presence for Butternut
b. Candidate suitable habitat for bats, barn swallow, gypsy cuckoo bumble bee and rusty patched bumble bee.

ii. Fish Habitat: Confirmed fish habitat present for warm-water resident population of common Cyprindae Family (minnows, dace) species.

iii. Significant Woodlands: Confirmed forest stands of significant woodlands within the western portion of the NHFA Study Area (Polygon No.'s 1 and 2 on **Figure 4**).

iv. Significant Wildlife Habitat (SWH):
a. Confirmed presence of snapping turtle
b. Candidate for bat maternity colonies, specialized habitat and flora species of conservation concern.

It is further noted that a Natural Environment Impact Study (EIS), prepared for the Carney Street SWM Pond, indicated an upstream limit of fish habitat at the westerly end of Reach #1.

In general, the NHFA concluded that *'with confirmed SAR and candidate other SAR habitat along with the confirmed Fish Habitat, Significant Woodland and Significant Wildlife Habitat within the general study area, site alterations will require further natural heritage impact assessment review. Such works shall be required to demonstrate compliance with the Endangered Species Act 2007, Fisheries Act and applicable Official Plan policies with survey works focused on site alteration impact zones with possible species or habitat related mitigation measures required'*. Therefore, additional natural environment study may be required to support individual projects within the Study Area.

8.3.2 Regulations and Requirements

Grey Sauble Conservation Authority

The watercourse system within the Study Area is regulated by the Grey Sauble Conservation Authority (GSCA) under Ontario Regulation 151/06: Regulation and Development, Interference with Wetlands and Alterations to Shorelines and Watercourses. As indicated in correspondence from the GSCA dated February 14, 2016, under this regulation a permit (or permits) will be required from the GSCA prior to undertaking any alterations or development within the regulated areas. A copy of this correspondence is included in **Appendix F**.

Within the aforementioned GSCA correspondence, the GSCA has more specifically stated the following:

- In general, the GSCA has no objection to the City upgrading the drainage system.
- The GSCA would require that the portions of the system that can currently convey a Regional storm event must continue to do so. However, those portions at the Kelso Beach outlet that currently struggle with the 2-year storm event will be required to be upgraded to handle regional flows.
- Overall the GSCA prefers the City to provide whatever additional relief is feasible through the system to protect the existing built environment without undue damage to the existing natural environment.
- Depending on the nature of the proposed works, approvals may also be required from the Department of Fisheries and Oceans Canada (DFO), the Ontario Ministry of Natural Resources and Forestry (MNRF) and/or the Ministry of the Environment, Conservation and Parks (MECP).

Department of Fisheries and Oceans Canada (DFO)

A DFO letter of authorization is required for any project alternative that may result in a permanent alteration to fish habitat.

8.3.3 Source Water Protection

Recent amendments to the EA process require proponents to consider whether the project is located within a Source Water Protection Area and, if so, to document whether any project activities are a prescribed drinking water threat. As part of the EA process, this project was reviewed with respect to the requirements under the Clean Water Act, 2006. The Study Area is located within the Grey Sauble Source Protection Area and falls under the Saugeen-Grey Sauble-Northern Bruce Peninsula Source Protection Plan. Based on the Saugeen, Grey Sauble and Northern Bruce Peninsula Source Protection Vulnerable Areas Mapping Application, the Study Area is situated within an Intake Protection Zone, with a 2-hour time of travel capture zone (IPZ-2) and has a highly vulnerable aquifer vulnerability score of 6. Brooke Basin A3 is also situated within an Events Based Area (EBA) where the threshold for on-site storage of fuel is in the range of 25,000L to 50,000L.

The GSCA Risk Management Office has been consulted via the *Notice of Project Initiation and Public Information Centre*. GSCA comments specific to Source Water Protection will be included in **Appendix F**. Based on previous consultation efforts associated with other projects in the area, it is not anticipated that Source Water Protection will be considered to be a significant issue for projects planned within this Master Plan.

8.3.4 Climate Change

The natural environment also includes potential impacts of the project on Climate Change, and of Climate Change on the project. Provided that individual projects intend to address and improve upon existing drainage issues, provisions for improvements to the drainage system may simultaneously address the effects of climate change on the project, such as potential increase in flows.

8.4 Technical Environment

Storm sewer systems are typically designed as a “minor system” intended to convey the 1:5 year design flows. Overland flow routes generally are considered as a “major system” to convey the 1:100 year design or Regional flood flow. The drainage infrastructure must provide sufficient capacity for the continued conveyance of the Regional flood flow downstream to an appropriate outlet.

The technical environment includes consideration of design standards and constructability. Maintenance and asset ownership may also be considered. Improvements proposed to the drainage system are also evaluated based on flood and erosion protection. The following summarizes an inventory of the technical environment:

- Technical considerations, such as the capacity of the proposed drainage infrastructure, protection from flooding and erosion and/or relative maintenance requirements of drainage system, as applicable.
- Efficacy of design: project constructability and minimization of drainage infrastructure while addressing the identified issues and/or opportunities.
- Ability to address identified drainage issues.
- Project Timing.

8.5 Economic Environment

The economic environment includes the capital costs associated with construction, professional fees and application fees. Long-term costs associated with the operation and maintenance are also typically considered. Other project related costs, such as land acquisition costs and legal costs, are not usually included. The following summarizes an inventory of the Economic Environment:

- Relative construction costs.
- Operation and Maintenance costs.

It is noted that cost estimates provided herein were prepared with limited design details and are based on probable conditions affecting the project(s). Therefore, they are intended to reflect the approximate magnitude of the project costs. A more detailed assessment of overall project costs would be evaluated during the design development phases, as appropriate.

Further, project funding may be reviewed by the City, as opportunities permit.

9. ALTERNATIVE SOLUTIONS AND ASSESSMENTS

The Municipal Class EA outlines a comprehensive planning process (illustrated in **Figure 2**) that provides a rational approach to consider the advantages and disadvantages of various alternatives and the trade-offs in order to determine a *Preferred Solution*, or set of *Preferred Solutions*, to address an identified problem (or opportunity), as well as consultation with the public, directly affected stakeholders, agencies and indigenous communities throughout the process.

In the following Sections, a set of alternative solutions is considered for each Reach. The potential benefits and impacts of each alternative are assessed against various 'environments' including primarily social, natural, technical and economic. As discussed later in this Section, the cultural environment is considered 'net neutral' for the alternatives considered for each Reach.

The background studies were prepared to help inform the impacts each alternative would have on each of the environments. The process toward the selection of a *Recommended Solution,* or combination of *Recommended Solutions,* for each Reach involved the following:

i. Identification of the impacts and mitigation measures of an alternative solution on each environment;
ii. An assessment of the degree of impact each alternative would have on each environment; and
iii. An evaluation based on comparative analysis of the alternative which best addresses the Project Statement.

In essence, the evaluation is carried out using the Reasoned Argument method, comparing differences in impacts and providing a clear rationale for the selection of the *Recommended Solution(s)* for each Reach. It is noted that for a given alternative a specific 'environment' may be discussed in more detail, where appropriate. However, a summary of the impacts and an assessment of each of the alternative solutions on each of the environments is provided within a comparative summary Table, where deemed appropriate, prepared for each Reach. The summary Tables provide a ranking of each of the identified potential impacts on each of the alternatives considered, as follows:

Red = Least Favoured
Yellow = Partially Favoured / Net Neutral
Green = Favoured

It is noted that within each of the assessments a net neutral impact is assumed for the cultural environment, in other words the cultural environment is considered not likely to have an effect on the overall assessment of alternatives considered for each Reach. This approach is based on the findings of the cultural heritage evaluation which concluded that impacts to built heritage resources and/or cultural heritage landscapes are not anticipated. Further, although areas with archaeological potential were identified within parts of the watercourse, which would require Stage 2 investigations, the overall impact of the additional investigations, where necessary, would not likely affect the overall approach (i.e., the *Recommended Solution*). Therefore, while the cultural environment is not considered further herein, the proponent may be required to complete additional archaeological investigations as part of the subsequent planning for a given Reach. The findings of these investigations would need to be considered during the design phase, including potential consultation with indigenous communities, as appropriate.

As previously noted, depending on the nature of the proposed works, approvals may be required from the Grey Sauble Conservation Authority, the Department of Fisheries and Oceans Canada (DFO), the Ontario Ministry of Natural Resources and Forestry (MNRF) and/or the Ministry of the Environment, Conservation and Parks (MECP). However, it is noted that the potential requirement for approvals is not considered a factor in the ranking of the alternatives, therefore approval requirements are not considered further within the assessment of alternatives.

For each identified problem (or opportunity), the 'Do Nothing' alternative is not typically carried forward into the evaluation of alternatives because it typically does not address the problem and/or opportunity. In general, only alternatives that address the problem are carried forward into the evaluation process. However, for comparison purposes, the 'Do Nothing' alternative is carried forward in the evaluation and assessment for each Reach. Based on the potential drainage issues identified, alternative solutions are reviewed for each Reach in the following Sections of this Master Plan Report.

10. REACH #1: OPEN CHANNEL – 7TH AVENUE WEST TO 6TH AVENUE WEST

The Carney Street Stormwater Management (SWM) Pond was constructed by the Township of Georgian Bluffs in 2015. Prior to that time, concerns had been raised by area residents that rear-yard flooding had become more frequent and severe. To address these concerns, hydraulic floodline mapping was completed by GMBP in May 2015 to investigate the degree of flooding in this area. This included the completion of a topographic survey and a field review of Reach #1, from 8th Avenue West, easterly to 6th Avenue West; a distance of approximately 235m. The investigations concluded that the main watercourse channel was capable of conveying limited flows, equivalent to a 1:2 year rainfall event, before spilling its banks, and that seasonal spill from the main channel would be expected.

Following the construction of the Carney Street SWM Pond, a Flood Line Mapping Study was completed for Reaches #1 to #5 to reflect the present flooding conditions to the adjacent properties north and south of the watercourse, including the rear-yard of No. 2164 6th Avenue West (a property previously impacted by flooding).

10.1 Existing Conditions

The outflow from the Carney Street SWM Pond is conveyed to the east by a ravine system across the municipal boundary at 8th Avenue West, approximately 60 meters north of 21st Street West and, ultimately, to Reach #1 which extends to 6th Avenue West. Additional flows from several tributary channels also confluence enroute, including the 300 mm Ø storm sewer outlet on 7th Avenue West that discharges down the bluff at 22nd Street West immediately upstream of the subject Reach.

As the ravine system transitions into Reach #1 and approaches the rear-yards of the properties fronting onto 6th Avenue West, the channel geometry becomes shallower with more moderate banks, becoming a very shallow channel within a wide and gradual flood plain spread across the rear-yards of House Nos. 2130, 2164 and 2168 on 6th Avenue West. The channel remains relatively constant in size as it approaches the 6th Avenue West culvert, but its overbanks become increasingly narrow and steep as the watercourse passes between the adjacent residences (i.e., 2130 and 2164 6th Avenue West).

From topographic survey data, the longitudinal profile of the channel is relatively straight, and the gradient is relatively flat, at about 0.5%. Generally, the open channel can be described as having a bottom width of 1.0 m and a depth of 1.0 m with vertical side slopes.

10.2 Design Flows and Capacities

The BASWM Study identified the following design flows for Reach #1:

TABLE 10-1: Reach #1 Design Rainfall Events (Existing Conditions)

Rainfall Event	Flow Volume
1:2 Year	0.606 m^3/s.
1:100 year design flow	2.992 m^3/s
Regional flood flow	**4.952 m^3/s**

The bank full capacity of the open channel is about 0.97 m^3/s and the bank full velocity of the subject open channel was calculated to be about 0.97 m/s, assuming a Manning's Roughness Coefficient of n = 0.035. Generally, a flow of 0.6 m/s is considered adequate to provide self-cleaning, and a flow velocity of about 1.0 m/s may initiate erosion, depending on the vegetation and soil type. However, no significant silt deposition or scour holes along the subject watercourse were noted during the field review.

The BASWM Study, which was completed without the benefit of field investigations of the subject watercourse, identified potential erosion and sediment control issues for Reach #1. Based on the subsequent field review,

the present risk of sedimentation may not be as prevalent as previously identified. However, the possibility for erosion should still be addressed in consideration of an alternative solution. Therefore, consistent with the recommendations of the BASWM Study, a City easement could be established for the open channel of Reach #1 to permit any improvements or maintenance necessary in providing appropriate capacity for design flows through the Reach, as required **(Drawing No.4; Drainage Issue A)**.

Further, based on modelling completed as part of the BASWM Study, the 7th Avenue West storm sewer outfall which is located immediately upstream of the subject Reach, discharges a 1:100 year design flow of 0.201 m^3/s and a Regional flood flow of 0.104 m^3/s. A greater 1:100 year design flow rate may be the result of peak flow timing from upstream lands runoff and related superposition effects. Based on field observations, the bluff beneath the outfall of the storm sewer is highly eroded **(Drawing No.4; Drainage Issue C)**.

10.3 Definition of Problem

With the development of upstream Georgian Bluffs lands, the open channel of Reach #1 evolved from a basic natural system to one that also includes a public drainage function, the effects of which have been mitigated with the construction of the Carney Street SWM Pond. Therefore, the watercourse should either be managed to ensure it serves the intended, or actual present day, function, or be restored to a more natural stream flow condition better to reflect its original state.

The BASWM Study identified that runoff from Georgian Bluffs carries eroded materials from the ravine systems east of Carney Street to the open channel of Reach #1. The subsequent topographic survey and study determined that the low-flow channel achieves self-draining flow velocities. Sedimentation and erosion within the low-flow channel were noted as not being evident.

The watercourse provides sufficient capacity to convey runoff from a 1:2 year rainfall event. Flows with greater return periods would surcharge the channel and spread out across the rear yards of the adjacent properties. In summary, based on previous investigations, it was identified that the open channel watercourse of Reach #1 would require additional capacity to convey the range of design flows **(Drawing No.4; Drainage Issue B)**.

10.4 Alternative Solutions: Reach #1

Considering the inadequate capacity of the main channel, and the potential for erosion, sedimentation and flooding onto private property, the following alternative solutions are considered for Reach #1:

Alternative 1-1: Do Nothing
Alternative 1-2: Increase Open Channel Capacity
Alternative 1-3: Diversion of 7th Avenue West Storm Sewer Outlet Flows
Alternative 1-4: Construct a SWM Pond

10.5 Assessment of Alternatives: Reach #1

10.5.1 Alternative 1-1: Do Nothing

Based on design flows calculated in the BASWM Study, and the findings of the May 2015 field review, the existing open channel of Reach #1 provides sufficient capacity to convey the 1:2 year storm flows but insufficient capacity to convey flows associated with storm events of greater return periods. This leads to the nuisance flooding observed in the rear-yards of the adjacent properties. A 'Do Nothing' approach would therefore not address the conveyance issues of Reach #1 under the conditions of the previous Study and 2015 observations.

However, since that time, the Carney Street SWM Pond has been constructed and is expected to reduce a range of flows (1:2 year to 1:100 year return frequency) through the Reach to about the 1992 levels; at which time the system was reportedly functioning without issue. Flow hydraulics, under the Regional flood flow condition, are assumed to be not affected by the Carney Street SWM pond.

Although the relatively low channel capacity may result in occasional surface flooding of the adjacent properties, it is believed that it would be of relatively short duration, since runoff flows generally build to the peak flow and then gradually subsided over the duration of the storm event.

The Flood Line Mapping Study determined that the Regional flood flow elevation would not pose a threat to the residences adjacent to this Reach.

In terms of sedimentation risks, given the calculated full bank flow velocity of the open channel watercourse and observations of the field review, the existing watercourse can generally be considered self-cleaning and just below the threshold velocity for erosion.

If the channel banks are prone to erosion, the geometry of the open channel can maintain only a maximum flow before it is surcharged and spills. Therefore, it is believed that the existing open channel section would ultimately be maintained, as opposed to widening to accommodate the increase in flow.

Considering that the hydraulic conditions through Reach #1 are expected to be improved for the range of design flow conditions, as a result of the Carney Street SWM Pond construction, that the Regional flood flow condition would not impact on adjacent dwellings, and that erosion and sedimentation do not appear to be an issue, a 'Do Nothing' approach is considered to be a viable alternative.

10.5.2 Alternative 1-2: Increase Open Channel Capacity

This alternative is considered to increase the capacity of the existing open channel to fully convey the Regional flood flow through Reach #1 to the inlet of Reach #2. In general, the capacity of the open channel section would be increased by steepening its longitudinal slope and/or expanding its cross-sectional flow area.

Longitudinal Slope Increase:

An increase in the longitudinal slope could be achieved by re-grading the channel bottom along its current alignment such that the slope is uniform between the upstream and downstream ends. However, since the existing longitudinal slope is relatively uniform, no significant grade increase would be achievable. Therefore, a re-grading effort would essentially require a full reconstruction of the open channel.

Expansion of Cross-Sectional Flow Area:

The cross-sectional flow area of the channel could also be increased to attain the required capacity to convey the design flows. The side slopes of the existing open channel are almost vertical. Flattening the side slopes to a ratio of 3:1 (H:V) would yield a capacity of 5.339 m^3/s by increasing the flow area. Erosion protection should be considered for high flow conditions, since all of the flow would be contained within the re-constructed channel. Conveyance of the Regional flood flow through this Reach with a flow velocity of less than 1.0 m/s, in an attempt to mitigate the potential for erosion, would require a considerably large cross-sectional flow area. It would be infeasible to design the channel by this objective as it would be considerably land-intensive and take a large portion of the adjacent properties to implement.

If this alternative solution was favoured, a City easement could be instated, as required, to allow not only for the construction of the open channel, but also for future associated maintenance works.

10.5.3 Alternative 1-3: Diversion of 7th Avenue West Storm Sewer Outlet Flows

Under existing conditions, the storm sewer outlet from 7th Avenue West discharges down the bluff at 22nd Street West. This runoff contributes a minor amount to the design flows conveyed through Reach #1. Based on the BASWM Study, the modelled flows discharging from the 7th Avenue West storm sewer outlet account for approximately 7% and 2% of the total design flows for Reach #1 during the 1:100 year design storm event and Regional flood event, respectively. Therefore, the discharge from the 7th Avenue West storm sewer outlet does not contribute significantly to the total design flows for Reach #1, and a diversion from 7th Avenue West would not substantially change the design conditions along Reach #1.

With a relatively minor discharge rate and considering that this outlet existed long before nuisance flooding observations were reported (i.e., circa 2002), it is not considered to be a significant contributor to the occasional flooding experienced, nor the persistent wet conditions noted on the flood plain lands of Reach #1.

About 2003, a review of the 22nd Street West storm sewer was completed to investigate the potential to divert the 7th Avenue West storm sewer flows easterly to the 22nd Street West storm sewer system at 6th Avenue West. That review concluded that a 60-metre-long section of storm sewer on 22nd Street West from 5th Avenue West to 60 metres westerly would be undersized to accommodate the 1:5 year design flow including the diverted flow. Additional capacity deficiencies were noted in the storm sewer system further downstream in that system around 24th Street West, based on a 1:5 year design flow. Further, several capacity deficiencies were identified considering a 1:100 year design flow condition. Ultimately, this diversion alternative was considered to be not feasible.

Subsequently, in 2013, a storm sewer at 7th Avenue West and 22nd Street West was designed to extend easterly to 6th Avenue West, then southerly to connect to a planned culvert reconstruction on 6th Avenue West, pertaining to Reach #2. While this minor diversion would reduce surface discharge across private lands, it would not affect flood line elevations along Reach #1. This proposed design has not yet been constructed.

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Therefore, as the extension and connection of the 7th Avenue West storm sewer to the 6th Avenue West storm sewer at 22nd Street West would not affect conditions along Reach#1, it should be considered as its own alternative solution and implemented as per the preliminary design for the 6th Avenue West culvert replacement.

10.5.4 Alternative 1-4: Construct a SWM Pond

The purpose of a SWM pond at the upper limit of Reach #1 would be to provide attenuation to upstream inflow and reduce peak flows throughout the downstream system. Reduced peak flows would decrease the size of downstream storm drainage infrastructure required to convey the design flow. The effectiveness of this SWM pond alternative would be dependent upon the amount of runoff storage provided by the facility.

The feasibility of the alternative is assessed on a cost-benefit basis, with consideration for the technical aspects, by reviewing the required storage volume in relation to the pipe material costs downstream. The difference in installation costs is considered to be negligible between the options. The following **Table 10-2** summarizes this review by demonstrating the storage volume necessary to reduce the downstream storm sewer section of the most restrictive capacity by one and two nominal size(s) and the corresponding percent reduction in material costs downstream of the SWM pond location.

Table 10-2: Effects of SWM Pond on Downstream Infrastructure Material Costs

Reduction in Limiting Section Size	SWM Pond		Downstream Infrastructure	
	Pond Size	Construction Cost	Cost Reduction	Percent Savings
One Nominal Diameter Size	20,000 m^3	$400,000	6.9 %	$39,000
Two Nominal Diameter Size	37,000 m^3	$740,000	15.3 %	$86,000

Based on the above cost comparison, a SWM pond in this location is not considered to provide a cost-effective solution as a SWM pond of relatively large storage volume would be required to yield a relatively minor reduction in the required pipe sizes downstream and associated minor cost savings. Further, a SWM pond at this location would also require a large land area. For reference, the Carney Street SWM Pond was designed to provide approximately 10,000 m^3 of storage volume and has a footprint of approximately 18,500 m^2. Therefore, additional land costs for a SWM Pond in this location may be significant.

Furthermore, relocating the SWM pond alternative farther downstream in the system is also not considered feasible as it would:

i. Increase the design flow that the pond receives, increasing the SWM pond storage volume required to maintain the same effectiveness; and
ii. Reduce the amount of storm drainage infrastructure which may benefit from a possible reduction in size.

Therefore, as the construction of a stormwater management pond further downstream is not considered feasible, it is not considered to be viable alternative for the downstream Reaches. As such, a SWM pond is not considered as a favourable solution within the Master Plan.

10.6 Recommended Solution: Reach #1

Based on the above review of alternatives and the results of the relative ranking presented in **Table 10-3**, Alternative 1-1, 'Do Nothing' is the recommended alternative for Reach #1, at least for the short-term. The effects of the construction of the Carney Street SWM Pond on Reach #1 have yet to be fully realized, although recent evidence shows a favourable improvement within Reach #1. The design of the Carney Street SWM Pond is expected to improve the drainage conditions for a range of design flows, to past levels, at which time no nuisance flooding problems were observed.

Continued monitoring of flows in this Reach #1 should verify if the Carney Street SWM Pond is achieving the objectives for Reach #1. No flooding threat to the residences adjacent to the open channel is expected to be present under the existing Regional flood flow conditions.

The 7th Avenue West storm sewer diversion to 6th Avenue West should be constructed as planned in 2013. It is recommended that this be implemented concurrently with the recommended alternative for Reach #2.

TABLE 10-3: ASSESSMENT OF STORMWATER MANAGEMENT ALTERNATIVES
REACH #1: Open Channel - East of 8th Avenue West to 6th Avenue West

ENVIRONMENT	ALTERNATIVE 1-1 Do Nothing	ALTERNATIVE 1-2 Increase Open Channel Capacity	ALTERNATIVE 1-3 Diversion of 7th Avenue West Storm Sewer Outlet Flows	ALTERNATIVE 1-4 Construct a SWM Pond
CULTURAL				
Ranking	**Net neutral for all alternatives considered.**			
SOCIAL				
1. Impacts to Private Property (i.e. flooding, access, land use)	The design of the previously constructed Carney Street SWM Pond is expected to improve drainage conditions for a range of design flows. Therefore no nuisance flooding issues to adjacent properties are anticipated.			
2. Aesthetic Impacts of Drainage Improvements	No impact: maintains existing condition.	Would increase the watercourse area and require significant re-construction efforts. The larger drainage channel would change the overall aesthetics.	No impact: maintains existing condition.	The significant land area required for the pond and construction efforts would impact the existing landscape.
3. Land Acquisition (including easements)	The City may consider the establishment of an easement within this 'natural watercourse', if and when required.	The area required would extend beyond the current watercourse. The City would need to establish an easement for construction and maintenance of the open channel.	Intended to divert flows. Therefore, no land acquisition would be required.	Land acquisition would be required. This may not be supported by the landowners.
Ranking	**Favoured**		**(Previously Addressed)**	
NATURAL				
1. Natural Heritage Features & Species at Risk	No impact: maintains existing condition.	Construction required to increase the capacity of the existing drainage system would impact the identified Fish Habitat.	Diversion via storm sewer system would eliminate impacts to existing drainage swale (beyond limit of Reach #1).	Required land area would likely encompass 'significant woodlands'.
2. Storm Water Treatment: Runoff Water Quality	Water quality within the drainage channel can be addressed, as required.	Water quality within the drainage channel could be addressed as part of the design, potentially using the treatment train approach.	Water quality treatment could be addressed as part of the storm sewer system design.	Water quality treatment could be incorporated into the design of a stormwater management pond.
Ranking	**Favoured**		**(Previously Addressed)**	
TECHNICAL				
1. Technical Considerations (i.e. Ability to Satisfy Required Capacity)	Subsequent to the completion of the Carney Lane SWM Pond upstream of Reach #1, the channel capacity requirements appear to be sufficient under existing conditions.	Provide that there is a lack of sufficient grade, a considerable land area would be required. Designing a channel to convey additional flows is not considered a viable solution.	A design and plan to divert drainage from the sewer outlet at 7th Avenue West has already been proposed. Construction is pending.	Could be designed to manage stormwater quantity and stormwater quality requirements.
2. Efficacy of Design	Existing natural watercourse sufficiently accomodates the design flows.	Increasing the open channel capacity would require a considerable re-grading effort and/or would be very land-intensive.	A design and plan to divert drainage from the sewer outlet at 7th Avenue West has already been proposed. Construction is pending.	A large storage volume would be required to yield a relatively minor reduction in the required downstream storm drainage infrastructure required to convey the design flow.
3. Abitlity to Address Idenfied Drainage Issues	Drainage isssues identified have essentially been previously resolved, as follows: A. Carney Lane SWM Pond upstream of Reach #1 has reduced the channel capacity requirements. B. Field investigations noted that the present risk of sedimentation may not be as prevalent as identified in the BASWM Study. C. As per a previous design solution, the storm sewer at 7th Avenue/22nd Street West has been designed to extend southerly to a planned culvert reconstruction on 6th Avenue West. It is recommended that this be implemented concurrently with the Preferred Alternative for Reach #2.			
4. Timing	Maintains existing condition. No further work required.	Establishment of an easement would need to be arranged and administered by the City, adding time (and costs) to the project.	It is recommended that this diversion opportunity be implemented concurrently with the Preferred Alternative for Reach #2.	Pre-purchase of lands by the City required for the Pond would add time (and cost) to the project.
Ranking	**Favoured**		**(Previously Addressed)**	
ECONOMIC				
1. Relative Construction Costs	Maintains existing condition	$$	$	$$$
2 Operation & Maintenance	Existing watercourse can generally be considered self-cleaning.	Routine maintenance along the open channel would likely be required.	Flows would be diverted through storm sewer system. Limited operation and maintenance costs.	Stormwater management pond would require routine maintenance for ongoing operations.
Ranking	**Favoured**		**(Previously Addressed)**	
OVERALL RANKING	**Recommended**		**(Previously Addressed)**	
Relative Ranking of Environments:		Favoured and/or Positive Impact	Net Neutral	Least Favoured / Negative Impact

Environmental Assessment Schedule for Recommended Solution: Not Applicable

11. REACH #2: CULVERT – 6TH AVENUE WEST; NORTH OF 21ST STREET WEST

Reach #2 represents the culvert system that conveys flows between the open channels of Reach #1 and Reach #3. The culvert receives inflow from the westerly side of 6th Avenue West, north of 21st Street West, and discharges to the southerly side of 21st Street West, east of 6th Avenue West.

GMBP was retained by the City in 2013 to design a replacement for the existing aging culvert system associated with Reach #2. The project, as planned, qualified as a Schedule 'A+' activity under the Municipal Class EA. Project implementation of the preliminary design was delayed due to poor founding soils identified during the geotechnical investigations. Mitigating for the poor soil conditions resulted in a more costly foundation system than initially was anticipated. This previous work is considered within the assessment of alternatives for Reach #2.

11.1 Existing Infrastructure

In general, the existing culvert system is comprised of twin 1500 mm Ø CSP culverts acting as the main conveyance elements, with open-footing concrete box culvert structures, located at each end of the CSP culverts, acting as the inlet and outlet structures under the roadway areas.

The inlet open-footing box culvert is 2700mm x 1500mm in size and is oriented in an east-west manner across 6th Avenue West. At the east end of the box culvert, a concrete box structure extends, and ultimately encloses twin 1500 mm Ø CSP culverts on the east side of 6th Avenue West, maintaining the same flow area throughout. The twin CSP culverts, oriented in a north-south direction, are installed into the southerly face of the upstream concrete box portion of the inlet structure. From this location, the twin CSP culverts extend approximately 54 m to the south, to the outlet structure that crosses 21st Street West.

The outlet structure, similar to the inlet structure, consists of a box culvert section open at the south end with a concrete structure supporting the entrance of the twin CSP culverts at the north end. The outlet concrete structure portion itself is approximately 3150 mm x 1500 mm in size and is attached to the upstream end of the 2700 mm x 1500 mm open-footing box culvert. As a result, one of the twin CSP culverts is partially blocked but the transition is mitered such that flow does not appear to be significantly impeded by the overlap. The outlet portion of the culvert system discharges via the open-footing box culvert to the open channel of Reach #3.

Recent structural inspection reports indicate that some of these individual elements are in fair to poor condition. Copies of the OSIM Inspection Reports (2018 and 2020) are included in **Appendix G**.

11.2 Design Flows and Capacities

Under design conditions, the BASWM Study identified the following Regional and design flows for Reach #2:

TABLE 11-1: Reach #2 Design Rainfall Events (Existing Conditions)

Rainfall Event	Flow Volume
1:2 Year	0.787 m^3/s.
1:100 year design flow	2.952 m^3/s
Regional flood flow	**5.005 m^3/s**

Based on the modelling completed as part of the BASWM Study, the twin 1500 mm Ø CSP culverts are believed to provide the most restrictive capacity within the subject Reach, with a combined capacity of approximately 6.200 m^3/s.

Although the twin CSP culvert outlet is located immediately upstream from an obstruction caused by the mismatched structure openings within the outlet system, the capacity of each of the 1500 mm Ø CSP culverts is not considered to be adversely influenced by this obstruction.

Since there is no overland flow route and no upstream storage available at this location, the capacity of this system should be no less than the existing capacity and the Regional flood flow is considered to be the design flow.

The existing outlet of Reach #2 is located at the northerly end of the open channel watercourse within Reach #3. At this location, the Flood Line Mapping Study identified that the Regional flood flow poses a potential flooding risk to House No. 585 21st Street West. While consideration should be given to the effects of the alternative solution for Reach #2 on the Reach #3 open channel watercourse, ultimately, the flooding risks to House #525 21st Street West will be the focus of the alternative solutions for Reach #3. However, alternative solutions considered for Reach #2 should provide adequate capacity to the next downstream Reach.

11.3 Definition of Problem

Based on modelling completed as part of the BASWM Study, the existing culvert system is expected to provide sufficient capacity to convey the Regional Design flood flow. Therefore, the main concern with the Reach #2 infrastructure is poor structural integrity under existing conditions (**Drawing No.4: Drainage Issue D**).

The findings and recommendations of recent structural inspections (i.e., Ontario Structure Inspection Manual (OSIM) Inspection Forms, 2018 and 2020), are as follows:

i. The inlet box culvert that crosses 6th Avenue West has deteriorated to a point where load posting restrictions and replacement have been recommended. At this time, Structure OS-9c is under consideration for replacement, however due to lack of funding the replacement has been postponed. Further reduction of the current load posting of 12 tonnes will limit the City's ability to provide winter maintenance and emergency services to the residences which it serves.
ii. The twin CSP culverts are in overall 'good' condition, however repairs to the barrels and foundation have been recommended.
iii. The outlet box culvert is in overall fair to poor condition with several elements requiring major rehabilitation.

Therefore, in consideration of the replacement of the inlet and outlet structures, it was further recommended within the OSIM Forms that, although the twin CSP culverts are in overall 'good' condition, the entire culvert system within Reach #2 be replaced in simultaneously to save on overall replacement costs.

11.4 Alternative Solutions: Reach #2

GMBP was retained by the City in 2013 to design a replacement for the existing aging culvert system within Reach #2. However, project implementation was deferred due to poor founding soils identified during the geotechnical investigations, which resulted in a more costly foundation system than initially was anticipated. Based on the previous design work completed for this Reach, and the soil conditions identified, the following alternatives were reviewed for technical compliance and cost to determine an appropriate solution:

Alternative 2-1: Do Nothing
Alternative 2-2: Repair Existing System
Alternative 2-3: Remove and Replace Existing System

11.5 Assessment of Alternatives: Reach #2

11.5.1 Alternative 2-1: Do Nothing

Currently, there is no Regional flood flow conveyance issue related to the culvert system. Therefore, the City could choose to postpone the replacement of the culvert with no issue related to drainage. However, the 'Do Nothing' approach would not address the poor structural condition of the 6th Avenue West crossing. Ultimately, the longer the deteriorating culvert structure remains in service, the greater the risk of a structural failure.

The 2018 and 2020 OSIM Inspection Reports recommend replacement of the entire culvert system within three years of the reporting date. To date, load posting reductions have been recommended for this water crossing. In addition, it has been recommended that the City implement a monitoring program until the structure can be replaced. Follow up structural reviews should consider if the culvert should be closed to traffic.

The structure crosses 6th Avenue West, north of 21st Street West, and provides access to five private properties situated to the north of the water crossing. Further, 6th Street West is a dead-end road and potential access from the north (i.e., 22nd Street West) is considered to be impractical. Therefore, a closure of the deteriorated culvert would eliminate access to these five properties.

Due to an inevitable need for replacement of the deteriorating culvert structure, at least in terms of hydraulic capacity if not for public safety, the 'Do Nothing' alternative is not considered further. While postponing replacement for the short-term will permit appropriate project planning and coordination with other improvements to upstream and downstream Reaches, which may reduce overall construction costs and duration of property access interruption, the replacement of this structure in the near future is recommended.

11.5.2 Alternative 2-2: Repair Existing System

The OSIM Inspection Reports (2018/2020) provide valuable and comprehensive information for the culvert system where the integrity of the structures are methodically inspected, issues are identified, replacement/repair alternatives are considered and, ultimately, a recommendation is made for the specific structure. OSIM Inspection Forms, which identify the specific elements requiring repair, are included in **Appendix G**.

To maintain the use of the culvert system, the OSIM Inspection Reports for Reach #2 recommend that a replacement of the entire culvert system is favoured over repair or rehabilitation. Based on this recommendation, it is inferred that a replacement of the culvert system would be expected to be more economical than rehabilitation. Therefore, replacement of the culvert system is favoured over a repair alternative.

11.5.3 Alternative 2-3: Remove and Replace Existing System

Culvert Replacement (GMBP 2013): Design Considerations

Replacement of the culvert system within Reach #2 was previously investigated. Initially, the preliminary design proposed the construction of a 2400 mm x 1200 mm concrete box culvert at a grade of approximately 0.5%. The inverts of the box culvert were proposed at an elevation of approximately 187.65 m on the upstream end and 187.05 m on the downstream end of the structure. However, the identification of poor founding soils would require that the installation of a foundation, in addition to the concrete box, be considered in the design.

The installation of a foundation would require a flow by-pass system during construction. Considering the extent of work anticipated, the local residential neighbourhood, and the significant distance between the system's inlet and outlet, a pumped by-pass system may not be practical and, therefore, a piped by-pass system may be more appropriate for this undertaking. However, since the cost to install and remove this

length of temporary flow by-pass system would be significant, once installed, a flow by-pass system may be considered as part of a permanent system.

A flow by-pass system is typically designed to convey runoff, at a minimum, from a 2-year design storm event, which is a flow of 0.787 m^3/s at this location as per the BASWM Study. A 750 mm Ø HDPE culvert at 0.5% grade would provide a capacity of 0.787 m^3/s, which would be the minimum by-pass pipe size required.

Replacement Schemes:
In achieving the recommendations of the OSIM Inspection Forms, and in consideration of the poor founding soils identified as part of previous culvert replacement efforts, removal and replacement of the existing culvert system is further investigated as part of this Master Plan. In consideration of the culvert replacement alternative for Reach #2, the following replacement schemes were examined:

Scheme 2-3A: 2400 mm x 1500 mm Concrete Box with Foundation
Scheme 2-3B: 2 x 1500 mm Ø Culverts (within 6th Avenue ROW)
Scheme 2-3C: 2 x 1500 mm Ø Culverts (with diversion through rear yards)
Scheme 2-3D: 4 x 900 mm Ø HDPE Storm Sewers
Scheme 2-3E: 2 Bridges with Open Channel Flow
Scheme 2-3F: Continuous Corrugated Steel Arch Bridge

Economic Considerations:
The preliminary design submission for the 6th Avenue West culvert replacement project included a Class B Construction Cost Estimate in the amount of $741,000 (2013 costs). Using this is as a basis, additions or deletions to this estimate are considered to compare a relative construction costs for each of the considered alternatives. In addition, the estimated costs for all schemes considered do not include costs associated with contingencies or engineering.

A. Scheme 2-3A: 2400 mm x 1500 mm Concrete Box Culvert with Foundation

The cross-sectional area of the subject concrete box culvert (2400mm x 1200mm) is 2.88 m^2, which is slightly smaller than the cross-sectional area of the existing twin 1500 mm Ø CSP culverts (3.54 m^2), although the centroid of flow is lower and the Manning's Roughness Coefficient is lower.

Geotechnical data at the time of the preliminary design indicated that a soil layer, suitable to support a raft foundation, exists at an elevation of 185.0 m, or about 2.5 metres below the planned invert elevations. This option is considered to be the most costly alternative, since it would require significant excavation, dewatering and engineered fill above the raft foundation to the underside of the box culvert. In addition, the geotechnical data also indicates that end-bearing piles could be founded at depths ranging from 14.3 m to 15.8 m. This system may also require grade beams on top of the piles to support all of the concrete box sections, to prevent differential settlement.

The construction costs for this replacement alternative are estimated in the following **Table 11-2**.

TABLE 11-2: Construction Cost Estimate for Scheme 2-3A

Description	Estimated Cost
Piles and Grade Beams	$250,000
By-Pass Piping System (85m - 750 mmØ + 2 x 1800 mmØ manhole)	$53,000
Dewatering Measures	$10,000
Permit to Take Water	$7,000
Estimated Total Additional Construction Cost	**$320,000**
Estimated Total Construction Cost	**$1,061,000**

Note: It is assumed that utility poles would not require relocation with this Scheme.

B. Scheme 2-3B: 2 x 1500 mm Ø Culverts (within 6th Avenue ROW)

Based on discussions with the geotechnical engineer, round plastic pipe would not impart the same loading on the poor subsurface soils. Based on outlet control conditions, two 1500 mm Ø pipes (i.e., polypropylene or PP), at a grade of 0.5%, would convey the 5.005 m^3/s Regional flood flow. Product specifications would have to be verified for use of a 1500 mm Ø PP pipe in this application. This system is envisioned as two separate pipes within the 6th Avenue West ROW. Pipes could either be placed side by side along the east side, along the existing alignment, or be placed with one on each side of 6th Avenue West.

While a pumped by-pass system could be used to divert flows during construction, a flow by-pass piping system could be considered as an alternative. The type of system best-suited for the installation of 2 x 1500 mm Ø PP pipes would be determined during the design phase.

Should a piped flow by-pass system be considered most practical for construction, the first pipe may be constructed along the west side of the 6th Ave West ROW, also to act as the flow by-pass during construction of the second pipe, which would entail the replacement of the existing piping system on the east side of 6th Avenue West. Cast-in-place box manholes (four [4] in total) would be required at the inlet, outlet and at each of the two bends. The box manholes may potentially have to be supported on piles to prevent differential settlement. Details would be resolved through the design development process.

The construction costs for this replacement alternative are estimated in the following **Table 11-3**.

TABLE 11-3: Construction Cost Estimate for Scheme 2-3B

Description	Estimated Cost
Reduction for cost of box section	($315,000)
1500 mm Ø pipe (x2), such as polypropylene	$160,000
4 x Cast-in-Place Box Manholes	$120,000
Dewatering	$10,000
Permit to Take Water	$7,000
Utility Relocation (Hydro Poles) – Subject to detailed design	$50,000 (±Allowance)
Estimated Total Additional Construction Cost	**$32,000**
Estimated Total Construction Cost	**$773,000**

Notes:
1. Cost estimate does not include cost for piles potentially required to support manholes and is generally limited to the costs for the replacement of the drainage infrastructure.
2. Installation of a pipe along the west side of the 6th Ave W ROW would likely require relocation of utility pole lines and, possibly, gas and bell utilities.

If a flow by-pass along the west side of the 6th Street ROW is considered further during the design phase, the two flow streams would confluence perpendicular to each other at the outlet, which would yield hydraulic losses and, resultantly, increased flow depths. The Flood Line Mapping Study identifies a potential existing flooding risk at House No. 585 -21st Street West so the hydraulic losses resulting from this confluence would not create a new concern but may increase the severity of the existing risk when compared to parallel flows (i.e., both pipes along the east side of the 6th St W ROW). This risk has been identified for consideration in the Reach #3 review in **Section 12** and is intended to be addressed in the consideration of Reach #3 alternatives.

Further, if a flow by-pass along the west side of the 6th Street ROW is considered further during the design phase, another variation would be to extend the westerly by-pass culvert southerly to where the downstream channel bends; an additional distance of about 75 metres. This variation would also require one additional manhole, additional hydro pole relocation and, likely, replacement of at least one traffic lane on 6th Avenue West between 21st Street West and 20th Street West. Full reconstruction of the 2000 Block of 6th Avenue East should be considered if this variation is preferred. This variation is considered further in **Section 12**.

C. Scheme 2-3C: 2 x 1500 mm Ø Culverts (with diversion via rear yards)

Similar to Scheme 2-3B, this scheme considers that a flow by-pass piping system may be required and envisions two separate flows 'systems' (i.e., pipes). As an alternative to the installation of two separate pipes within the 6th Avenue West ROW, this scheme would replace the proposed installation of one of the 1500 mm Ø PP pipes with the diversion of flows via a channel and pipe through the backyards of 2110 and 2130 6th Avenue West properties and along 21st Street East – ultimately to the intersection of 21st Street and 6th Avenue West.

The diversion of flows through the backyards to the end of Reach #2 would act as the flow by-pass during construction of the second pipe which, similar to Scheme 2-3B, would entail the replacement of the existing piping system on the east side of 6th Avenue West. Cast-in-place box manholes (four [4] in total) would still be required at the inlet, outlet and at each of the two bends. A general comparison and assessment of Schemes 2-3B and 2-3C is provided in the following **Table 11-4.**

TABLE 11-4: Comparison and Assessment of Scheme 2-3B and Scheme 2-3C

Comparison Criteria	Scheme 2-3B All flow along 6th Ave W, within ROW (2x 1500 mm Ø PP pipes)	Scheme 2-3C Some diversion within channel/pipes via rear yards
REACH 1	Continued flow through the natural watercourse (all flows).	Baseflow would continue to flow to 6th Avenue West through the natural watercourse.
REACH 2	Flows would be directed via 2 1500 mm Ø PP pipes (or hydraulic equivalent), within the 6th Avenue West Right-of Way.	Baseflow conditions would be maintained along the existing open channel to 6th Avenue West and would then be directed via a 1500 mm Ø PP pipe along the east side of 6th Avenue West. Additional flows would be directed via an open channel through the backyards of 2110 and 2130 6th Avenue West into a 1500 mm Ø PP pipe to the outlet of Reach #2.
7th Avenue West Flows	Would be directed to 1500 mm Ø along east side of 6th Avenue West	
Roadway 'Crossings'	1. Across 6th Avenue East, north of 21 Avenue East (at inlet to Reach #2) 2. Across 21st Street West, immediately east of 6th Avenue West (at Outlet to Reach #2) 3. To accommodate flows that remain to the west of 6th Avenue West across the intersection of 21st Street and 6th Avenue West to the outlet of Reach #2.	
Length of Pipe (Estimated)	75 to 80 meters	60 to 70 meters
Additional Channel Length	Existing	65 to 75 meters
Hydro Poles (Utility Relocation)	The removal of one hydro pole would be required for the replacement of the box culvert across 6th Ave W. If installation of one of the pipes along the west side of the 6th Ave W ROW is considered, the removal of 2 additional hydro poles may be required. May impact existing gas and utilities.	The removal of one hydro pole would be required for the replacement of the box culvert across 6th Ave W. The removal of 1 additional hydro pole would be required. Potential impacts to gas and utilities could be avoided.
Impacts to Private Property	Limited Works could be completed with the existing ROW.	Significant A portion of the drainage would be diverted through a new channel that would extend through two private residential lots. Drainage easements would be required.
Constructability / Cost	Would remain in the existing ROW, which will be disturbed for construction regardless.	Part would pass through a hill. Significant additional excavation or directional drilling would add significant cost.

Based on a review of these two culvert replacement alternatives, Scheme 2-3B is favoured over Scheme 2-3C as the works can be completed within the existing 6th Street ROW, limiting impacts to private property. In addition, Scheme 2-3C would result in greater impacts to the natural environment and higher costs.

D. Scheme 2-3D: Multiple 900 mm Ø HDPE Culverts

Although a single 900 mm Ø HDPE pipe at 0.5% grade can convey 1.280 m^3/s under gravity flow conditions, the outlet control conditions at this site would limit the capacity per pipe to about 0.7 m^3/s. Therefore, about seven (7) pipes would be required to convey the 5.005 m^3/s Regional flood flow. Providing 1 m separation between the pipes for compaction would require a single trench width of at least 14 meters, which is considered impractical due to the lack of available land area.

The construction costs for this replacement alternative are estimated in the following **Table 11-5**.

TABLE 11-5: Construction Cost Estimate for Scheme 2-3D

Description	Estimated Cost
Reduction for cost of box section	($315,000)
900 mm Ø HDPE pipes (x7)	$270,000
4 x Cast-in-Place Box Manholes	$200,000
Dewatering	$10,000
Permit to Take Water	$7,000
Utility Relocation (Hydro Poles)	$50,000 (±Allowance)
Estimated Total Additional Construction Cost	**$222,000**
Estimated Total Construction Cost	**$963,000**

E. Scheme 2-3E: 2 Bridges with Open Channel Flow

The concept of restoring a portion of this drainage system to open channel flow was conceived in the BASWM Study. Under this Scheme, bridge structures would be constructed across 6th Avenue West and across 21st Street West, with an open channel connecting between the two structures. Based on the channel profile and the road profile, the depth of an open channel would range from about 2.5 m to 3.0 m. Assuming a 0.5 m bottom width and 3:1 side slope, the top width of an open channel would be approximately 15.5 m to 18.5 m, which cannot fit within the 20 m right-of-way alongside a road. In consideration of the poor soil conditions identified, steeper side slopes are not considered appropriate. Therefore, this alternative is not considered further.

Another variation on this scheme would be to provide a new access from the north (23rd Street West) and eliminate the existing road crossing at this location, however, the 6th Avenue West road allowance to 23rd Street West is too steep to fit a road design.

F. Scheme 2-3F: Continuous Corrugated Steel Arch Bridge

This alternative investigates an open-footing structural plate corrugated steel arch bridge. Although lighter in weight than a concrete box culvert, piles and strip footings would be required to provide a stable foundation for the structure. The alignment would be similar to the concrete box section considered in Scheme 2-3A.

The construction costs for this replacement alternative are estimated in the following **Table 11-6**.

TABLE 11-6: Construction Cost Estimate for Scheme 2-3F

Description	Estimated Cost
Reduction for cost of box section	($315,000)
Corrugated Steel Arch	$130,000
Piles and Strip Footings	$250,000
By-Pass Piping System (85m - 750 mmØ + 2 x 1800 mmØ manhole)	$53,000
Dewatering	$10,000
Permit to Take Water	$7,000
Estimated Total Additional Construction Cost	**$135,000**
Estimated Total Construction Cost	**$876,000**

Note: It is assumed that utility poles would not require relocation with this Scheme.

11.6 Recommended Solution: Reach #2

Based on a review of the culvert replacement alternatives, including the economic and technical environments, the preferred culvert removal and replacement alternative is Scheme 2-3A, which includes replacement with a 2400 mm x 1500 mm box culvert. While this replacement solution is the least economical, it is preferred from a technical perspective as it incorporates the most robust foundation and may ultimately be the provide for a longer-term solution. As this replacement solution is considered the to be most technically feasible, it and was carried into the overall review of alternatives and relative ranking presented in **Table 11-7**. Based on the assessment of alternatives, Alternative 2-3A to remove and replace the existing system with a 2400 x 1500 mm box culvert is considered the *Recommended Solution* for Reach #2.

The replacement of a “sewage facility” on a watercourse is considered as a Schedule ‘B’ EA activity. It is noted that the 7th Avenue West storm sewer diversion previously discussed in conjunction with the review and assessment of alternative for Reach #1, could be constructed concurrently with this culvert replacement project.

In addition, the effects of the by-pass outlet location on the hydraulic flood line adjacent to 585 on 21st Street West are considered as part of the alternative considered for Reach #3, presented in Section 12 and are needed to confirm the feasibility of the Recommend Solution for Reach #2.

TABLE 11-7: ASSESSMENT OF STORMWATER MANAGEMENT ALTERNATIVES
REACH #2: Culvert - 6th Avenue West and 21st Street West

ENVIRONMENT	ALTERNATIVE 2-1 Do Nothing	ALTERNATIVE 2-2 Repair Existing System	ALTERNATIVE 2-3A Remove and Replace Existing System
CULTURAL			
Ranking	**Net neutral for all alternatives considered.**		
SOCIAL			
1. Impacts to Private Property (i.e. flooding, access, land use)	Eventual structural failure/collapse would elimate access to five (5) properties to the north of the water crossing.	Access to the properties to the north of the crossing would be maintained. More frequent works and construction efforts would be more interuptive to the nearby landowners.	Access to the properties to the north of the crossing would be maintained, with limited interuption (i.e.construction efforts).
2. Aesthetic Impacts of Drainage Improvements	No impact in the short term. Eventual collapse would significantly impact the landscape.	Would maintain existing condition.	Would maintain existing condition.
3. Land Acquisition (including easements)	Culvert system is situated within existing Right-of-Ways.		
Ranking			**Favoured**
NATURAL			
1. Natural Heritage Features & Species at Risk	Existing buried culvert, which is considered fish habitat for movement, would be maintained. A structural failure would impact these movements.	Existing buried culvert, which is considered fish habitat for movement, would be maintained. Ongoing repairs and eventual replacement would more frequently impact fish movements.	Replacement would maintain the buried fish habitat in the long-term, with minimal disruption compared to other alternatives.
2. Storm Water Treatment: Runoff Water Quality	Impacts to water quality, including increased sedimentation related to increased flow velocities, are not considered to be directly affected by the culvert system itself.		
Ranking			**Favoured**
TECHNICAL			
1. Technical Considerations (i.e. Ability to Satisfy Required Capacity)	Currently there is no flow conveyance issue related to Reach #2 of the drainage system. Reach #2 should provide adequate capacity to the next downstream Reach.	Currently there is no flow conveyance issue related to Reach #2 of the drainage system. Reach #2 should provide adequate capacity to the next downstream Reach.	System capacity would be designed to continue to convey the Regional flood flows, which is considered to be the design flow for this system. Reach #2 should provide adequate capacity to the next downstream Reach.
2. Efficacy of Design	Would maintain existing condition. Eventual collapse could negatively impact the entire drainage system	Would maintain existing condition, with culvert system limited to the east side of the 6th Street West. However, the existing system may eventually be impacted by the poor soil conditions (i.e. differential settlement).	System is envisioned as a 2400 x 1500 mm box culvert. This design best addresses the potential effects the poor soil conditions could have on the system.
3. Abitlity to Address Idenfied Drainage Issues	Drainage issues identified poor structural integrity under existing conditions. The 'Do Nothing' approach would not address this identified drainage issue.	Drainage issues identified poor structural integrity under existing conditions. Culvert repairs would not sufficiently address this identified drainage issue.	Drainage issues identified poor structural integrity under existing conditions. Replacement of the entire culvert system within Reach #2 would address this problem.
4. Timing	Maintains existing condition. No further work required in the short-term. Emergency work associate with a collapse is not considered preferable (or cost effective).	OSIM Reports indicate replacement should be completed by 2021. Repairs may provide additional time required for design and approvals.	Based on the condition of the inlet culvert, OSIM Reports suggest that the replacement of this culvert system be completed by 2023. Therefore, this would need to be considered a priority project.
Ranking			**Favoured**
ECONOMIC			
1. Relative Construction Costs	$	$$$$	$$$
2 Operation & Maintenance	By definition, the 'Do Nothing' approach would mean costs would be negligible. However, costs associated with eventual structural failure and emergency replacement would be high.	Routine repairs and more frequent maintenance would likely be required. Eventual culvert replacement would need to be considered.	With the complete replacement of the culvert system, the routine operations and maintenance costs will be limited.
Ranking			**Favoured**
OVERALL RANKING			**Recommended**
Relative Ranking:	Favoured and/or Positive Impact	Net Neutral	Least Favoured / Negative Impact

Environmental Assessment Schedule for Recommended Solution: Schedule 'B'

12. REACH #3: OPEN CHANNEL / CULVERT – 21ST STREET TO 20TH STREET WEST

During 2008 and 2009, GMBP was retained by the City to assist with efforts to improve the flow hydraulics of the open channel Reach situated to the east of 6th Avenue West, between 21st Street West and 20th Street West, where shown on **Drawing No.1**. The process was proposed to be completed in two Phases:

Phase 1: Deposits of sediment were to be cleaned out of the Reach.
Phase 2: A revised channel profile was considered to achieve a self-cleaning velocity, to reduce the effects of sedimentation and to provide Regional flood flow conveyance.

Phase 1 of the process was completed as a maintenance item in 2008, and the full length of the open channel Reach was cleaned out, its banks stabilized, and the area restored with grass seed.

Phase 2 of the process was initiated in 2009. As part of the planning for this Phase, GMBP prepared a revised channel profile which would maximize the available gradient between the existing culvert ends at 21st Street West and 20th Street West along the existing alignment. An alternative with a straighter alignment was also considered to further increase the channel gradient and further to promote self-cleaning flow that would further reduce the effects of sedimentation. However, as alternative solutions that considerably alter an existing open channel watercourse are required to be planned as a Schedule 'B' process under the Municipal Class EA, the design direction for Phase 2 was not resolved at that time. The alternatives previously developed as part of Phase 2 of this process are considered herein as Alternatives 3-2 and 3-3.

12.1 Existing Infrastructure

From the downstream end of the Reach #2 culvert to the south of side of 21st Street West, the existing open channel drains in a southerly direction, generally parallel to 6th Avenue West, for a distance of approximately 70m. From this location, the Reach takes a sharp 90° bend and drains easterly for a distance of approximately 45m, generally parallel to 20th Street West, to another 45° bend. The final open channel segment of ±50m extends from this bend to the northerly inlet of the 20th Street West culvert.

With the exception of the most downstream segment of the Reach, the existing open channel has an inconsistent gradient that is relatively flat along much of its length. At the most downstream location, immediately upstream of the northerly 20th Street West culvert end, the grade drops by about 0.4 metres over a distance of approximately 5 meters.

The downstream limit of Reach #3 is considered to be the 1800 mm x 1200 mm box culvert across 20th Street West located approximately 85m east of 6th Avenue West. The culvert traverses 20th Street West at an angle of approximately 40° from the northwest to the southeast. The culvert discharges to the open channel watercourse of Reach #4 directly to the east of the unopened 5th Avenue West ROW. Recent OSIM Inspection Forms (2018 and 2020) for the 1800 mm x 1200 mm culvert note that the structural integrity of the culvert is acceptable, and no replacement or repair is foreseen in the short-term.

As previously discussed, the Flood Line Mapping Study identifies a potential existing flooding risk at the existing residence at 585 - 21st Street West **(Drawing No.4; Drainage Issue E)**, which is located approximately 30 m east of the upstream segment of Reach #3. This residence has a basement walk-out door that faces the open channel with a door tread elevation of approximately 188.26 m.

12.2 Design Flows and Capacities

Under design conditions, the BASWM Study identified the following Regional and design flows throughout Reach #3:

TABLE 12-1: Reach #3 Design Rainfall Events (Existing Conditions)

Rainfall Event	Flow Volume
1:100 year design flow	3.291 m^3/s
Regional flood flow	**5.151 m^3/s**

Based on the modelling completed as part of the BASWM Study, the capacity of the existing main channel is calculated as 1.451 m^3/s and no overland flow route is available. Flows not accommodated by this system would flood easterly across the private residential properties adjacent to the watercourse.

The capacity of the downstream 1800 mm x 1200 mm culvert is approximately 4.480 m^3/s, under free-flow conditions. The Hydraulic Flood Line Mapping Study determined that the culvert can convey all of the Regional flood flow through this Reach. However, to facilitate a greater conveyance through the culvert, the headwater within Reach #3 immediately upstream rises above the top of the culvert opening.

Since there is no overland flow route and no upstream storage available at this location, the capacity of this system should be no less than the Regional flood flow.

The Flood Line Mapping Study identifies a potential existing flooding risk at the residence at 585 - 21st Street West. Under existing conditions, during the Regional flood flow event the water surface elevation immediately upstream and downstream of the walk-out basement door is expected to be approximately 188.30 m and 188.20 m, respectively. When compared to the basement door tread elevation of 188.26m, a flooding risk may exist, under existing conditions.

12.3 Definition of Problem

Reach #3 has been identified as providing insufficient capacity to convey the Regional flood flow within the main channel (BASWM Study). The insufficient capacity results in overtopping of the main open channel and flooding onto adjacent private lands. The modelled Regional flood water surface elevation, within the section of Reach #3 adjacent to House No. 585 - 21st Street West, is about the same as the elevation of the existing walk-out basement door. Therefore, there is a potential risk of flood damage to the residence as at this location under high flow conditions **(Drawing No.4: Drainage Issue E)**.

For Reach #3, the watercourse is not necessarily required to convey the entirety of the Regional flood flow within the main channel portion. However, sufficient capacity must be provided within the main portion such that the elevation of flood flows conveyed in the overbanks are an acceptable distance below the elevation of adjacent buildings. Similarly, the 1800 mm x 1200 mm box culvert outlet of the subject Reach is not required to convey the entirety of the Regional flood flow through the Reach under free-flow conditions. However, the backwater effects of should be considered, and should not adversely impact adjacent buildings.

In addition, the relatively flat channel gradient promotes suspended materials to settle out and choke the channel, thereby reducing the conveyance capacity **(Drawing No.4: Drainage Issue F)**. In general, increasing the capacity and flow velocity of the channel within Reach #3, will reduce the extent of the flood line and risk of sedimentation. However, the free-flow capacity of the 1800 mm x 1200 mm box culvert, regardless of the upstream conditions, is still less than the Regional flood flow through the Reach. Therefore, regardless of the considered improvements to the open channel, the existing culvert will produce a backwater effect on the watercourse, to some degree, which should be considered.

In terms of public liability, the use of this watercourse, especially in its existing open channel form, as a public drainage system, imparts some responsibility on the City to maintain this system.

12.4 Alternative Solutions: Reach #3

Due to the insufficient capacity of the open channel Reach and the potential for sedimentation and flood damage to private property, as well as the acceptable structural integrity of the culvert at 20th Street West, the following alternative solutions are considered:

Alternative 3-1: Do Nothing
Alternative 3-2: Channel Improvements along Current Alignment
Alternative 3-3: Re-alignment along Straighter Route
Alternative 3-4: Piped Diversion System
Alternative 3-5: Increase Flow Area Across 20th Street West
Alternative 3-6: Flood Protection

12.5 Assessment of Alternatives: Reach #3

12.5.1 Alternative 3-1: Do Nothing

The 'Do Nothing' alternative would reflect the conditions of the Flood Line Mapping Study within the Reach #3 area. The Flood Line Mapping Study determined that the existing geometry of the channel and overbanks is capable of conveying the Regional flood flow through the subject Reach. Given the relatively low capacity of the main channel portion of the watercourse, a majority of the Regional flood flow is conveyed within the overbanks, which subjects the residence at 585 - 21st Street West to a potential risk of flooding.

Flooding within Reach #3 is expected to be of relatively short duration since runoff flows generally build to the peak flow and then gradually subside over the duration of the design storm event. In addition, Regional flood flow events are of relatively rare frequency. Due to these factors, it may be reasoned that a level of risk is acceptable. Alternatively, the cost of improvements that could mitigate this risk may possibly be much less than the cost to compensate for building damage with the occurrence of a Regional flood event.

In addition, the 'Do Nothing' alternative would not address the effects of sedimentation within the open channel watercourse, which may further reduce channel capacity. Due to the potential financial implications associated with the flooding risk and the unresolved concerns related to sediment build-up in the channel, the 'Do Nothing' alternative is not considered appropriate and is not carried forward into the assessment of Alternatives for Reach #3.

12.5.2 Alternative 3-2: Channel Improvements Along Current Alignment

As part of the previous efforts to improve the flow hydraulics within Reach #3, one of the Phase 2 preliminary design options included a revised channel profile within the current alignment, namely improvements to the gradient and banks of the open channel watercourse that would be sufficient to convey Regional flood flow.

Under the Phase 2 plan, it was recommended that the watercourse be reconstructed to achieve a more uniform gradient along its length. In other words, the relief that exists within the steepest downstream section of Reach #3 would be evenly distributed along its entire length. Additional improvements would include a widening of the cross-sectional geometry to permit a better-defined watercourse and a flood plain with a greater flow area. As this work would be completed on private property, and routine maintenance would be required, the establishment of permanent easements along the watercourse could be established, as required.

By increasing both the flow area and longitudinal slope of the open channel, the overall capacity of the Reach can be increased to convey the Regional flood flow within the main channel portion of the watercourse. A partial conveyance of the Regional flood flow within the overbanks is acceptable as long as it does not pose a flood risk to the adjacent residences. These proposed improvements would also increase the velocity of flow within the watercourse and reduce the potential for sedimentation.

The proposed design for Phase 2 reconstruction provided a capacity of approximately 6.582 m^3/s; well above the Regional flood flow of 5.151 m^3/s through Reach #3. However, while the capacity of the channel would be increased, the free-flow capacity of the 3200 mm x 1000 mm box culvert downstream would remain less than the Regional flood flow through the Reach. Therefore, the backwater effects of the culvert must also be considered.

An HEC-RAS model was completed to examine the flood line extent throughout Reach #3 under the design conditions of the Phase 2 channel design. The model output is provided in **Appendix D.** For conservative analysis purposes, sub-critical flow conditions were modelled to represent the maximum expected water surface elevations throughout the Reach.

Based on the modelling of the Phase 2 design, a backwater effect from the 1800 mm x 1200 mm box culvert at 20th Street West is evident. Further, the water surface elevation during the Regional flood flow event immediately upstream and downstream of the residence at 585 - 21st Street West is expected to be approximately 187.96 m and 187.91 m, respectively. Therefore, in consideration of the basement door elevation of approximately 188.26 m, the highest water surface elevation within the watercourse at the point adjacent this residence is expected to be about 0.30 m below the elevation of the walkout basement door.

12.5.3 Alternative 3-3: Re-Alignment Along Straighter Route

Following the completion of the Phase 1 channel clean-out in 2009, the City was advised that the owner of House No. 585 21st Street West may consider the re-alignment of the watercourse across the rear-yard. It is noted that prior to the construction of House No. 560 20th Street West, the subject open channel watercourse of Reach #3 crossed the northeasterly corner of that property, along a similarly shorter flow path. At that time, no adverse effects were noted upstream or downstream of the Reach.

In consideration of the potential support of the property owner, an alternative Phase 2 preliminary design option was considered at that time as part of the efforts to improve the flow hydraulics within Reach #3, which included a revised channel profile within a straighter alignment, to further increase the channel gradient and to promote self-cleaning flow, ultimately reducing the effects of sedimentation. The straighter alignment may require an access across the channel to the balance of the rear yard, or a property acquisition.

The re-alignment of this watercourse would be designed to eliminate the existing sharp bends, replacing them with more gradual bends while maintaining the existing inlet and outlet points of the Reach. Generally, more gradual bends reduce the potential for erosion experienced at points of transitioning flow directions. Further, in a re-aligned configuration, the total length of the open channel watercourse would be reduced, allowing for a slightly steeper channel gradient through Reach #3. Based on the field data, it is expected that a longitudinal slope of approximately 1.0% could be achieved.

Similar to Alternative 3-2, coupled with wider banks, the capacity of the open channel could be increased to accommodate the Regional flood flow through the Reach. Moreover, the velocity of flow through the watercourse would be increased to permit self-cleaning and to reduce the effects of sedimentation. However, the free-flow capacity of the 1800 mm x 1200 mm box culvert is less than the Regional flood flow of 5.151 m^3/s throughout Reach #3. Therefore, while the open channel design of this alternative addresses the capacity

issue and sedimentation issues identified for Reach #3, the open channel portion of the Reach would still be subject to the backwater effects of the downstream box culvert.

In function, Alternatives 3-2 and 3-3 would be expected to be similar. About a 0.3m free board could be achieved between the Regional flood elevation and the basement door elevation for the residence at 585 - 21st Street West. With a steeper channel gradient, the alignment of Alternative 3-3 would improve the potential for self-cleaning flow velocity and reduce the effects of sedimentation. However, the benefit of a steeper channel slope is only marginal relative to maintaining the current alignment (i.e., 1.00% vs. 0.76%). In consideration of the greater construction costs and the more significant impacts to private property associated with re-aligning Reach #3, Alternative 3-2 is considered to be more favoured than Alternative 3-3.

12.5.4 Alternative 3-4: Piped Diversion System

Assuming the 2 x 1500 mm Ø pipe alternative is advanced, as recommended in **Section 11**, a piped diversion system which diverts upstream flows from Reach #2 to a point further downstream of the residence via a piped system may be considered to reduce the flood risk to the residence at 585 - 21st Street West. The effectiveness of the piped diversion alternative is, in part, dependent on the influence of downstream drainage infrastructure in reducing, or negating, benefits through possible backwater effects. In general, the farther downstream the outlet of the subject diversion is proposed, the lesser degree of influence there may be at the point of diversion. However, the farther downstream the outlet of the diversion is proposed, the greater the costs associated with the installation of the diversion system.

In considering a diversion of flow from the outlet for Reach #2 (i.e., at 21st Street West), bypassing the portion of Reach #3 adjacent to 585 21st Street West to a point farther downstream in Reach #3, three diversion options were assessed, assuming the existing channel condition remains:

Option 1: Diversion to ±75m downstream to the first 90° bend of Reach #3.
Option 2: Diversion to immediately upstream of the existing Reach #3 box culvert at 20th Street West.
Option 3: Diversion to immediately downstream of the existing Reach #3 box culvert at 20th Street West.

For each of the three diversion options, in consideration of the potential for fish habitat along Reach #3, base flows would have to be maintained in the open channel, with a potential diversion of high flows within the piped system. Since sedimentation occurs with low flow conditions the issue of reduced channel capacity over time would not be resolved. Further, modelling results indicate that the flood line elevation at 585 21st Street West may be lowered, but only to a minor degree.

HEC-RAS modelling was used to inform the assessment of these alternatives. Based on the modelling completed, the difference in water surface elevation between Option 1 and Option 2 was negligible. The backwater effect of the downstream box culvert at 20th Street West, and the relatively small additional cross-sectional area provided for piped flow, negated any benefits that could be achieved via the greater diversion. Therefore, neither of these piped diversion options for Reach #2 is considered further.

For Option 3, the installation depth at the 19th Street and 16th Avenue West intersection, and associated costs, would be considerable. Further, minimal flood level improvements would be accomplished at 21st Street West and sedimentation issues would not be addressed. Therefore, while the costs to install a piped diversion system would be significant, the diversion of flow from the outlet of Reach #2 to immediately downstream of the existing Reach #3 box culvert at 20th Street West would not address all of the drainage issues identified within Reach #3. Therefore, this alternative would need to be considered in considered in conjunction with open channel improvements (i.e., Alternative 3-2) in order to mitigate the risk of sedimentation, while preserving fish habitat, thereby fully addressing all of the identified drainage issues within Reach #3. This would add unnecessary cost and complexity to the project.

12.5.5 Alternative 3-5: Increase Flow Area Across 20th Street West

Within Reach #3, it is evident that the existing 1800 mm x 1200 mm box culvert located at 20th Street West influences flood level conditions within the upstream open channel watercourse. In general, the Regional flood flow exceeds the capacity of the culvert. This results in a higher upstream water surface elevation, the effects of which can be diminished with distance upstream.

This Alternative considers that the restrictive influence of the existing culvert could be reduced, or eliminated, by increasing the conveyance capacity across 20th Street West. Generally, a wider cross-sectional area would convey a greater flow (at the same depth) within the channel, lowering the upstream water surface elevations and reducing the risk of flooding. This could be achieved by either replacing the existing culvert with a larger sized culvert (i.e., provides for a larger flow area) or by installing an additional culvert. However, in order simultaneously to address the issue of sedimentation, this alternative would also be required to include a level of improvements to the open channel watercourse upstream.

In consideration of culvert replacement, it is noted that recent OSIM Inspections (2018 and 2020) indicate that the culvert is in good condition and that replacement or rehabilitation of the culvert is not expected to be required within the foreseeable future. Therefore, it may be an ineffective use of funds to replace the existing culvert at this point in its service life.

The modelling completed to assess the option to install an additional culvert indicated that no amount of additional flow area at 20th Street West would affect the flood line elevation upstream at 21st Street West. This suggests that, further to the backwater effects at 20th Street West, the existing channel upstream also restricts flood flows and contributes to the flood line elevation at 21st Street West. Since this Alternative 3-5 would not achieve the required lowering of the upstream surface elevations, it is not considered to be a technically viable solution. Consequently, it is not carried forward into the assessment of Alternatives for Reach #3.

12.5.6 Alternative 3-6: Flood Protection

One of the two principle drainage issues identified for Reach #3 is flood protection for the residence at 585 – 21st Street West. Flood line mapping of existing conditions indicates that Regional flood flows would rise to a similar elevation as the existing basement walk-out door. While this alternative would not address the issue of sedimentation within the channel, this drainage issue specific to the private residence could be addressed separately with an access agreement for maintenance purposes.

For the protection of private property and public safety, and depending on the Recommended Solution, flood control measures such as the construction of berms and lot grading of the private property at 585 - 21st Street West may be required. Therefore, Alternative 3-6 may be considered in addition to a specific alternative. Further, this Alternative could be completed in advance of other improvements to pre-emptively address the flooding risk associated with the existing basement door elevation at 585-21st Street West. While the owners of this property have been receptive to such improvements in the past, their consent would be essential to the implementation of any alternative that would affect their property.

Although it is acknowledged that flood protection measures specific to the property would require the cooperation of the home owner, options for flood protection were considered as follows:

Option 1: Eliminate Basement Door

This option would require the removal of the existing basement door and installation of a new water-proofed wall. In addition, the side yard would need to be re-graded to raise the grade along the west side of the existing residence. A cut-fill balance through this area would be necessary to maintain flood storage. In essence, this option would basically eliminate the potential for flood damage to the dwelling during a Regional flood event, however it would be considerably intrusive to the dwelling.

Option 2: Localized Flood Protection

Considering that the modelled Regional flood elevation is similar to the basement floor elevation, the existing basement door could be afforded a degree of flood protection by installing a +/-200 mm high curb, to enclose an area of ±1.5m x 1.5m outside the basement door. In addition, a small awning over the door would help to prevent rain water from accumulating within the enclosed area, adjacent to the door. A small drain from the area could ensure the area remains dry. This option would be less intrusive than Option 1.

12.6 Recommended Solution: Reach #3

Based on the above review of alternatives and the results of the relative ranking presented in **Table 12-2**, Alternative 3-2: channel improvements along the current alignment, addresses the identified problems associated with Reach #3. This alternative is preferred primarily due the economic and social considerations and implications. However, it is noted that while the hydraulic modelling for Alternative 3-2 is considered to represent the Regional flood flow within the open channel watercourse to sufficient accuracy, some degree of uncertainty exists from the hydraulic losses experienced by the confluence of the Reach #2 outlets, at the upstream end of Reach #3, and within the natural systems themselves. Consequently, additional flood protection measures for the residence at 585 21st Street West, as outlined in Alternative 3-6, should be considered, more specifically Option 2: Localized Flood Protection.

It should be noted that, while the *Recommended Solution* for Reach #3 is a combination of Alternative 3-2 and Alternative 3-6, the final design may be subject to local landowner consultation, as well as the preferred solution for Reach #2 upstream. It may be possible that Alternative 3-6 on its own, with planned channel maintenance, could achieve an acceptable level of service at a much lower cost. Based on the relative cost of the flooding prevention measures compared to the potential cost implications associated with property damage due to flooding, this Alternative 3-6 could be implemented in the short-term to address the risk of flooding.

Implementation of Alternative 3-2 is subject to the Schedule 'B' EA process and would require the establishment of an easement for access. Implementation of Alternative 3-6 alone would not be subject to the EA process.

TABLE 12-2: ASSESSMENT OF STORMWATER MANAGEMENT ALTERNATIVES
REACH #3: Open Channel / Culvert - 21st Street West to 20th Street West

ENVIRONMENT	ALTERNATIVE 3-2 Channel Improvements along Current Alignment	ALTERNATIVE 3-3 Channel Re-Alignment along Straighter Route	ALTERNATIVE 3-4 Piped Diversion System	ALTERNATIVE 3-6 Flood Protection
CULTURAL				
Ranking	**Net neutral for all alternatives considered.**			
SOCIAL				
1. Impacts to Private Property (i.e. flooding, access, land use)	The surface elevation within the watercourse at the point adjacent to the residence at 585-21 Avenue West is expected to be lowered to a level of about 0.3 m below the basement door elevation.	The surface elevation within the watercourse at the point adjacent to the residence at 585-21 Avenue West is expected to be lowered to a level of about 0.3 m below the basement door elevation.	Minimal flood risk improvements for the residence at 585 21st Avenue West would be achieved.	The implementation of flood protection measures would address drainage issues specific to flooding risk at the private residence. An access agreement would be required.
2. Aesthetic Impacts of Drainage Improvements	Would increase the watercourse area and require a level of re-construction efforts. The larger drainage channel would change the overall aesthetics.	Would increase the watercourse area and require significant re-construction efforts. The larger drainage channel would change the overall aesthetics.	No impact: maintains existing condition within channel.	No impact: maintains existing condition within channel.
3. Land Acquisition (including easements)	The establishment of permanent easements along the open channel of Reach #3 is required to permit maintenance, as necessary. Widening of the channel may require a slightly greater area.	In addition to an easement along the open channel, the re-alignment may require an access across the channel to the balance of the yard, or property acquisition.	The establishment of permanent easements along the open channel of Reach #3 is required to permit maintenance, as necessary.	The establishment of permanent easements along the open channel of Reach #3 is required to permit maintenance, as necessary.
Ranking				**Favoured**
NATURAL				
1. Natural Heritage Features & Species at Risk	The increased capacity and flow velocity achieved would decrease sedimentation. A reduction in the required drainage clean-out frequency is considered beneficial to fish and snapping turtle habitat.	The increased capacity and flow velocity achieved would decrease sedimentation, reducing the required drainage clean-out frequency. However, the development of a new channel would have a significant impact on fish and snapping turtle habitat.	Maintaining existing conditions would avoid the larger scale construction effort associated with channel profile upgrades, however more frequent routine maintanence would be more disruptive.	Maintaining existing conditions would avoid the larger scale construction effort associated with channel profile upgrades, however more frequent routine maintanence would be more disruptive.
2. Storm Water Treatment: Runoff Water Quality	Long-term water quality treatment provisions could be considered as part of the design development phase.	Long-term water quality treatment provisions could be considered, as appropriate, as part of the design development phase.	Water quality within the drainage channel could be addressed, as required.	Water quality within the drainage channel could be addressed, as required.
Ranking	**Favoured**			
TECHNICAL				
1. Technical Considerations (i.e. Ability to Satisfy Required Capacity)	Overall capacity of the Reach can be increased to convey the design flow within the main channel portion of the watercourse. Would reduce the backwater effects from the downstream culvert at 20th Street West, reducing the flooding risk.	Overall capacity of the Reach can be increased to convey the design flow within the main channel portion of the watercourse. Would reduce the backwater effects from the downstream culvert at 20th Street West, reducing the flooding risk.	Considered to address backwater effects from culvert at 20th Street West. Minimal flood level improvements would be realized. Sedimentation issues would be maintained, possibly increased, due to reduced flow velocities within existing channel.	No improvements to the drainage system were considered as part of this alternative. However, flooding protection can be implemented in conjunction with another alternative.
2. Efficacy of Design	The required improvements to the flow hydraulics can be acheived within the existing channel. This alternative effects a minimal disruption to the overall system.	Re-aligning the channel would require more considerable construction efforts and/or would be more land-intensive.	Pipe length and required installation depth at the 19th Street and 16th Avenue West intersection is considerable.	Considered a simple and cost effective alternative to address the flooding risk issues in the short-term.
3. Abitlity to Address Idenfied Drainage Issues	Drainage issues identified, including flooding risk and sedimentation which reduces channel capacity, are both addressed.	Drainage issues identified, including flooding risk and sedimentation which reduces channel capacity, are both addressed.	Modelling results indicate that the flood line elevation at 585 21st Street West would be lowered, but only to a minor degree. Further, drainage issues associated with sedimentation would not be addressed.	Would address flooding risk. However, drainage issues associated with sedimentation would not be addressed.
4. Timing	Easements would need to be established prior to construction. While this would add time (and cost) to the project, easements are recommended for all alternatives that maintain a drainage channel within private property(ies).	Access agreements and/or pre-purchase of lands by the City required to re-align the channel would add time (and cost) to the project.	Maintains exisitng condition within drainage channel. Extension of pipe further to the south would need to be completed concurrently with the culvert installation recommended for Reach #2.	Could be implemented at any time. However, timing (and implementation) would be dependent on the negotiations and consent from the homeowners.
Ranking	**Favoured (Long-Term)**			**Favoured (Short-Term)**
ECONOMIC				
1. Relative Construction Costs	$$$	$$$$	$$$$	$
2 Operation & Maintenance	Watercourse, as designed and constructed, would be considered self-cleaning.	Watercourse, as designed and constructed, would be considered self cleaning.	Watercourse would require routine maintenance. Additional operational costs would be associated with the drainage pipe extension.	Watercourse would continue to require routine maintenance to address on-going sedimentation issues.
Ranking	**Favoured**			**Favoured**
OVERALL RANKING	**Recommended (Long-Term)**			**Recommended (Short-Term)**

Note: Based on technical and/or economic considerations, Alternatives 3-1 and 3-5 were not carried forward into this assessment.

Relative Ranking of Environments: Favoured and/or Positive Impact | Net Neutral | Least Favoured / Negative Impact

Environmental Assessment Schedule for Recommended Solution: Schedule B (Alt 3-2) and Not Applicable (Alt 3-6)

13. REACH #4: OPEN CHANNEL – 20ST STREET WEST TO 19TH STREET WEST

Reach #4 consists of a deep gully-like watercourse draining generally in a northwest to southeast direction from the box culvert at 20th Street West southerly across the unopened 5th Avenue West ROW to 19th Street West. As such, Reach #4 crosses both private and municipal properties in its course.

No issues were previously identified; or recommendations made, for Reach #4 within the BASWM Study and, with the exception of deadfall trees that can restrict flow, no issues within this Reach are known. The removal of deadfall trees is considered a maintenance item and can be completed at any time, provided access is permitted by the affected property owners.

13.1 Existing Infrastructure

Immediately beyond the 20th Street West culvert, the well-defined, open channel also receives flows from the storm sewer system on 5th Avenue West, where shown on **Drawing No.1**. The open channel then drains southerly at a longitudinal slope of approximately 1% for a distance of approximately 19 meters where it then receives additional flows from a tributary channel that extends approximately 600 m to the west with its own tributaries. This tributary receives flows from a large additional portion of the Basin A3 lands.

The open channel continues to drain approximately 43 meters to the south at a longitudinal slope of approximately 1% to 2% before draining southeasterly for a distance of approximately 49 meters where the longitudinal slope becomes steeper to an average gradient of approximately 2.5% over this section. Adjacent to this section of the Reach is an apartment building (550 19th Street West), which has an approximate elevation of at least 189.5 m (OBM).

From this point, the channel drains southerly again for a distance of approximately 32 meters at a longitudinal slope of approximately 2% where it drains to the culvert inlet of Reach #5 at 19th Street West. In the downstream section of the watercourse, the easterly bank becomes more gradual until it extends approximately 50 m to the east from the main channel portion when it meets 19th Street West. Adjacent to this section of the Reach is a private residence (1914 4th Avenue West) which has an approximate elevation of 187.0 m (OBM).

The open channel is relatively deep, typically varying between 2.5 and 4 meters in depth throughout the Reach. The surrounding area is densely vegetated and has been designed as a Woodland (i.e., a Natural Heritage Feature), where shown on **Figure 4**.

13.2 Design Flows and Capacities

Under design conditions, the BASWM Study identified the following Regional and design flows at the inlet to Reach #4 and, as the tributary watercourse confluences with the subject open channel watercourse, throughout the remainder of the Reach downgradient of this confluence.

TABLE 13-1: Reach #4 Design Rainfall Events (Existing Conditions)

Rainfall Event	Flow Volume
INLET to Reach	
1:100 year design flow	3.288 m^3/s
Regional flood flow	5.221 m^3/s
Beyond Tributary Watercourse Confluence	
1:100 year design flow	4.965 m^3/s
Regional flood flow	6.043 m^3/s

From the modelling of the BASWM Study, a channel capacity of 7.105 m^3/s and 8.255 m^3/s is identified as the capacity of the watercourse to the north and to the south of the tributary channel, respectively. These capacities reflect a flow with no backwater effects as a result of the existing downstream infrastructure.

The Flood Line Mapping Study determined that water surface elevations within the watercourse are influenced by an insufficient capacity of the 19th Street West culvert (i.e., Reach #5). However, water surface elevations within the existing watercourse, as defined by Reach #4, pose no risk to adjacent residences.

While the Regional flood flow may currently be sufficiently conveyed through this Reach, there is a potential for deadfall trees to restrict flow. Similarly, the use of this watercourse as a public drainage system may impart some responsibility on the City to maintain the subject Reach.

13.3 Definition of Problem

There does not appear to be any specific problem associated with Reach #4 at this time as sufficient capacity is provided by the open channel watercourse and the effects of sedimentation or erosion have not been observed. Although the culvert at 19th Street West is inadequate to inlet all of the Regional flood flow, there is no flood risk to adjacent buildings.

As the watercourse of Reach #4 spans municipal and private lands, coordination and consultation efforts with local property owners would be necessary to implement any alternative solution.

While the Regional flood flow through Reach #4 is greater than the capacity of the 19th Street West culvert, resulting in a backwater effect from the downstream culvert inlet at 19th Street West, the manner in which the Regional flood flow discharges from the watercourse at 19th Street West is a consideration of the Reach #5 discussion.

13.4 Alternative Solutions: Reach #4

Due to a potential for the City to consider the preservation of the system as a functioning public drainage system, and the risk posed by vegetative obstruction, the following alternative solutions are considered:

Alternative 4-1: Do Nothing
Alternative 4-2: Provide Maintenance to the Open Channel Watercourse
Alternative 4-3: Fully or Partially Piped System along ROWs

13.5 Assessment of Alternatives: Reach #4

13.5.1 Alternative 4-1: Do Nothing

The 'Do Nothing' alternative would reflect the conditions of the Hydraulic Flood Line Mapping Study within the Reach #4 area. Based on the mapping study, it is demonstrated that the existing geometry of the open channel watercourse is capable of conveying the Regional flood flow through the subject Reach.

While the presence of deadfall trees in the open channel would obstruct flows and result in higher flood line elevations, given the considerable depth of the watercourse, deadfall trees are not expected significantly to increase the flood risk to existing structures adjacent to the Reach. However, the open channel of Reach #3, even after the implementation of its corresponding *Recommended Solution*, would be influenced by backwater effects in the downstream Reach and is an area subject to potential flooding risks.

Since the 'Do Nothing' approach does not address the potential flooding risks posed by deadfall trees that could be realized in Reach #3, the 'Do Nothing' alternative is not considered favourable.

13.5.2 Alternative 4-2: Remove Deadfall Trees

An alternative to complete maintenance on the watercourse, as the need arises, is considered to address the potential for deadfall trees within the open channel flow area from dis-lodging and obstructing the drainage system inlet at 19th Street West. Although this may, in part, be a private property matter, the City may still wish to obtain easements, as required, along this Reach to remove existing deadfall trees and to provide further maintenance services as conditions require.

To facilitate the maintenance activities, it would be appropriate for City staff to meet with the landowners to resolve access agreements required to allow for the removal of deadfall trees.

13.5.3 Alternative 4-3: Fully or Partially Piped System along ROWs

In conveying the Regional flood flow from the 20th Street West box culvert to the 19th Street West storm sewer system, a full or partial conveyance of the Regional flood flow could be considered for construction within the City's ROWs. The intention of such an alternative would be to remove the conveyance of public stormwater flows from private lands and onto municipal lands to address the liability associated with using the subject Reach as a public drainage system.

Upon preliminary investigation, the most likely route would follow the unopened ROW of 5th Avenue West between 20th Street West and 19th Street West, since any other route along existing road ROWs (i.e., 6th Avenue West) would require considerable road reconstruction and insufficient relief would be available to achieve an appropriate pipe grade over such a distance.

Between 20th Street West and 19th Street West, a pipe grade of approximately 1.75% may be achieved along the unopened 5th Avenue West ROW. At this slope, a pipe diameter of approximately 1350 mm Ø would be required to fully convey the Regional flood flow. This relatively large pipe diameter would incur considerable construction costs.

To reduce the material costs associated with the pipe, a reduction in the pipe diameter and length could be achieved by partial conveyance through a piped system, with the remainder conveyed via an open channel, either via the existing watercourse or via a new open channel within the 5th Avenue West ROW. However, given the topography and density of vegetation within the Reach, any work on the existing channel, or construction of a new channel in the area, would also incur substantial costs.

In addition to the above referenced economic implications, the installation of a drainage pipe within the relatively undisturbed woodland area through which the watercourse meanders would likely negatively impact the overall aesthetics in the block. Further, a piped system, whether through the entire Reach, or part thereof, would have a significant impact on the confirmed fish habitat.

In consideration of the existing open channel watercourse, in which drainage issues associated with sedimentation, erosion and/or flooding risks are not evident, the alternative to convey the Regional flood flow through Reach #4 via a piped system, in full or in part, is not considered necessary. Further, given the significant costs and minimal, if any, additional benefits that could be achieved by installing a piped system in an undisturbed area, this alternative is not considered to be a practical solution to potential obstructions of the watercourse that may be imposed by deadfall.

13.6 Recommended Solution: Reach #4

Based on the review of the alternatives considered for Reach #4, the Recommended Solution is Alternative 4-2: to remove deadfall trees on an as needed basis. This general maintenance work sufficiently addresses potential drainage issues associated with the location of the watercourse in a highly undisturbed and vegetated area. As part of the implementation of this Alternative, the City of Owen Sound may establish permanent easement(s) along the watercourse situated between 19th Avenue and 20th Avenue West (i.e., Reach #4), as required. Maintenance work is considered to be a Schedule 'A' activity. Depending on future inspections of the Reach, the consideration of additional alternatives may be deemed appropriate in the future.

TABLE 13-2: ASSESSMENT OF STORMWATER MANAGEMENT ALTERNATIVES
REACH #4: Open Channel - 20th Street West to 19th Street West

ENVIRONMENT	ALTERNATIVE 4-1 Do Nothing	ALTERNATIVE 4-2 Remove Deadfall Trees, as Needed	ALTERNATIVE 4-3 Fully or Partially Piped System along ROWs
CULTURAL			
Ranking	**Net neutral for all alternatives considered.**		
SOCIAL			
1. Impacts to Private Property (i.e. flooding, access, land use)	Could subject properties within Reach #3 to potential flooding risk.	Would minimize flooding risk to upgradient properties within Reach #3.	Would minimize flooding risk to upgradient properties within Reach #3.
2. Aesthetic Impacts of Drainage Improvements	Would maintain existing conditions.	Would maintain existing condition.	The construction activities within the relatively undisturbed woodland area would significantly impact the existing landscape.
3. Land Acquisition (including easements)	The conveyance of public stormwater flows from private lands and into a combination of municipal and public lands is not favoured. A permanent municipal easement along this Reach could be sought.	The conveyance of public stormwater flows from private lands and into a combination of municipal and public lands is not Favoured. A permanent municipal easement along this Reach could be sought.	Would prevent the conveyance of public stormwater flows from private lands and onto municipal lands to address the liability associated with using the subject Reach as a public drainage system.
Ranking		**Favoured**	
NATURAL			
1. Natural Heritage Features & Species at Risk	Fish habitat would not be impacted.	Fish habitat would not be impacted.	Would have a significant impact on the confirmed fish habitat and surrounding undisturbed areas.
2. Storm Water Treatment: Runoff Water Quality	No impacts to water quality: Maintains existing condition.	No impacts to water quality: Maintains existing condition.	Would have the potential to impact water quality during construction. Mitigation measures could be evalauted as part of the design phase.
Ranking	**Favoured**	**Favoured**	
TECHNICAL			
1. Technical Considerations (i.e. Ability to Satisfy Required Capacity)	The existing geometry of the open channel watercourse is capable of conveying the design flows through the subject Reach.	The existing geometry of the open channel watercourse is capable of conveying the design flows through the subject Reach.	System capacity would be designed to continue to convey sufficient capacity.
2. Efficacy of Design	Would maintain existing condition.	Would maintain existing condition, with minimal maintenance requirements.	Not considered to be a practicle alternative to address potential obstructions within a well established and sufficient watercourse.
3. Abitlity to Address Idenfied Drainage Issues	Drainage issues identified flloding risk due to obstructions in the watercourse. The 'Do Nothing' approach would not address this identified drainage issue.	The removal of deadfall trees, on an as needed basis, would sufficiently address potential drainage issues associated with the location of the watercourse in a highly undisturbed and vegetated area.	Drainage issues associated with sedimentation, erosion and/or flooding risks are not evident, therefore the alternative to convey the design flow through Reach #4 via a piped system, in full or in part, is not considered necessary. Potential flooding risk due to obstructions can be simply addressed via ongoing maintenance.
4. Timing	Maintains existing condition. No further work required in the short-term. Emergency work associate with a flooding is not considered preferable (or cost effective).	Can be implemented on an as needed basis - with limited time and effort.	Could be implemented in the longer-term, if deemed appropriate. Would require significant planning as part of the design development phase.
Ranking		**Favoured**	
ECONOMIC			
1. Relative Construction Costs	Not Applicable	$	$$$$
2 Operation & Maintenance	By definition, the 'Do Nothing' approach would mean costs would be negligible. However, the compensation costs for building damage due to flooding could be substantial.	Routine costs associated with the maintenance of the watercourse would be minimal.	With the complete replacement of the culvert system, the routine operations and maintenance costs will be limited.
Ranking		**Favoured**	
OVERALL RANKING		**Recommended**	
Relative Ranking:	Favoured and/or Positive Impact	Net Neutral	Least Favoured / Negative Impact

Environmental Assessment Schedule for Recommended Solution: Schedule 'A'

14. REACH #5: CULVERT INLET SYSTEM – 19ST STREET WEST NEAR 5TH AVENUE WEST

14.1 Existing Infrastructure

The culvert inlet structure is located immediately north of 19th Street West approximately 25 meters to the east of 5th Avenue West. The structure is a 2740 mm x 1220 mm open-footing concrete box culvert extending approximately 5 meters to the north of the 19th Street West roadway. The structure has an overall length of approximately 17 meters.

The culvert inlet system of Reach #5 facilitates the transition from open channel flow to culvert flow, as the inlet to the main storm sewer system along 19th Street West. Based on the OSIM Inspection Forms, it is believed that the current culvert inlet system was built in 1930. In about 1995, the culvert was extended approximately 12 meters to the north towards the open channel watercourse of Reach #4. The extension was completed, since the fill above the structure was determined to be too high and there became a risk of road failure.

The most recent OSIM Reports (2018 and 2020) indicate that the box culvert is in 'overall good condition' and generally recommends the removal and replacement of poor concrete and the clean out of sediment and debris accumulations from the bottom of the culvert.

The box culvert discharges to the 19th Street West storm sewer system, at a confluence with other upstream sewer flows. The 19th Street West storm sewer system services a considerable additional portion of the Basin A3 lands both within the City and Georgian Bluffs as the beginning of the sewer is situated approximately 400 meters west of the Reach #5 culvert inlet, where shown on **Drawing No.1**.

The spill point of Reach #5 for upstream flows would be along the 19th Street West roadway at a point approximately 10 meters to the west of 4th Avenue West and 80 m to the east of the subject box culvert inlet. From OBM data, the overflow elevation at this location is believed to be ±184.50 m.

14.2 Design Flows and Capacities

Under design conditions, the BASWM Study identified the following Regional and design flows throughout Reach #5:

TABLE 14-1: Reach #5 Design Rainfall Events (Existing Conditions)

Rainfall Event	Flow Volume
1:100 year design flow	4.833 m^3/s
Regional flood flow	6.042 m^3/s

Based on the information provided in the BASWM Study, a capacity of 5.069 m^3/s is identified for the subject 2740 mm x 1220 mm box culvert inlet system. Based on a combination of field data and the modelling of the BASWM Study, it is estimated that the capacity of the 19th Street West storm sewer section immediately downstream of the Reach #5 culvert inlet is approximately 4.269 m^3/s. Therefore, the culvert inlet system under consideration has a greater capacity than its receiving outlet drainage system.

Further, the available head on the 2740 mm x 1220 mm box culvert at 19th Street West is considered insufficient to convey the Regional flood flow through the receiving 1350 mm Ø storm sewer downstream on 19th Street West (i.e., Reach #6). Therefore, a spill easterly to the surface of 19th Street West is considered under Regional flood flow conditions.

Generally, it is considered that the greater the inlet capacity of Reach #5, the lesser the backwater effect is experienced on the upstream watercourse of Reach #4.

14.3 Definition of Problem

From the BASWM Study, as well as the Flood Line Mapping Study, it has been identified that the 2740 mm x 1220 mm box culvert of Reach #5 provides inadequate inlet capacity to convey the entirety of the Regional flood flow **(Drawing 4: Drainage Issue H)**. As a result, a backwater effect is experienced in the watercourse immediately upstream of the box culvert inlet at 19th Street West. The backwater effect is influenced as the upstream water surface elevation rises until the flow can discharge at an overland spill point along 19th Street West.

Further, recent OSIM Inspection Forms have noted debris, sediment and poor concrete within the barrel of the box culvert.

14.4 Alternative Solutions: Reach #5

In consideration of the noted sediment and debris, and the insufficient capacity of the box culvert inlet of Reach #5 and its effects on upstream water surface elevations in the open channel, the following alternative solutions are considered:

Alternative 5-1: Do Nothing
Alternative 5-2: Repair and Clean-out Culvert Barrel
Alternative 5-3: Remove and Replace Culvert Structure

14.5 Assessment of Alternatives: Reach #5

14.5.1 Alternative 5-1: Do Nothing

The Flood Line Mapping Study determined that there is no risk of flooding to residences adjacent to the open channel of Reach #4 as a result of the flow constriction at the existing culvert inlet system of Reach #5 under Regional flood flow conditions. The design conditions of the Study conservatively considered that the entirety of the Regional flood flow through Reach #5 is conveyed only by the overland spill route to maximize the starting water surface elevation and to minimize uncertainty associated with the capacities of the downstream 19th Street West storm sewer sections and their effects on the modelled Reaches.

The 'Do Nothing' alternative considered herein reflects the existing infrastructure of the Reach, free and clear of flow obstructions, with less conservatively considered (and more realistic) outlet conditions than those applied to the Flood Line Mapping Study. For the purpose of this assessment, the capacity of the box culvert is considered to convey a portion of the Regional flood flow and, as such, the amount of flow required to be conveyed by the overland spill route is reduced. This analysis showed that the expected water surface elevation of open channel flows within the Reach #4 watercourse would be lower than those considered in the Flood Line Mapping Study. Therefore, under existing conditions, Reach #5 is expected to provide sufficient capacity, in combination of the culvert's conveyance and that discharging via the overland spill route, such that no flood risk is posed to the residences adjacent to the upstream Reach #4 open channel watercourse.

Given the capacity of the 19th Street West box culvert, approximately 0.973 m^3/s of the Regional flood flow would be expected to discharge from the overland spillway at 19th Street West under Regional flood flow conditions. Overland flow on the 19th Street West roadway at this location seems acceptable and not too great of a flow rate as to pose a risk to public health and safety as sheet flow within the urban section roadway.

Structural Deficiency:

The OSIM Inspection Form notes debris, sediment and poor concrete within the barrel of the box culvert, which may reduce the effective flow area of the box inlet. While the current degree of obstruction may result in a negligible reduction in flow area and capacity, the degree of deterioration was sufficient enough that the OSIM

Inspection Form specifically identified this as a concern and provided a recommendation to remedy the situation. Also, the recommendation to address poor concrete is indicative of a potential for continued deterioration to impact the capacity of the Reach in the foreseeable future. Unchecked deterioration may result in structural conditions that require complete removal and replacement of the box culvert sooner than would be expected by implementing minor repairs and rehabilitation in the short-term.

In summary, although the Reach #5 culvert inlet system is currently expected adequately to function hydraulically, when Regional flood flows and acceptable overland flows are considered, alternatives that address the existing condition of the structure and potential deterioration of the aging structure should also be taken into consideration.

14.5.2 Alternative 5-2: Repair and Clean Out Culvert Barrel

From the discussion presented in Alternative 5-1, it is known that the existing culvert inlet system of Reach #5 is expected to provide adequate conveyance of Regional flood flow with an acceptable degree of flood and overland flow risks.

Alternative 5-2 proposes maintaining existing conditions by considering the removal of debris and sediment from the barrel of the box culvert in addition to the removal and replacement of poor concrete. These actions, supported by the findings of the corresponding OSIM Inspection Forms (2020), are not only expected to maintain the capacity of the box culvert but also to extend its service life, providing a significant benefit at a relatively low cost.

14.5.3 Alternative 5-3: Remove and Replace Existing Culvert

In eliminating the need for any portion of Regional flood flow to be conveyed via an overland spill route, the removal of the existing box culvert and its replacement with a culvert of a greater capacity is considered. Removal and replacement of the existing culvert is the costliest alternative under consideration for this Reach.

Generally, bridges and culverts are expected to operate for a service life of approximately 80 to 100 years before requiring replacement. As this structure was reportedly built in 1930, replacement of this culvert could likely be deferred for an estimated 10 years, subject to the findings and recommendations of the OSIM Inspections that are completed every two (2) years. Therefore, while the structure is currently considered to be in ‘overall good condition’ (OSIM, 2018 and 2020), the replacement of the structure may be required in the foreseeable future due to deterioration in its structural integrity, regardless of its current hydraulic properties.

It would be economically beneficial to maintain the existing structure until such a time that significant repairs or replacement are required. Given the infrequency of the Regional flood flow event and the limited risks associated with the existing culvert inlet system during such an event, replacement may best be considered when the conditions of the structure dictate and, at that time, an increased capacity could be considered in the design, as it would relate to downstream infrastructure planning. Further, from a social perspective, maintaining the structure to the end of its service life would be the least disruptive to the flow of traffic along 19th Street West, which services a moderate volume of local vehicular traffic as well as the public transit system.

14.6 Recommended Solution: Reach #5

The discussion for Reach #5 outlines a plan to utilize each of the alternatives considered over a longer-term planning horizon. Therefore, an assessment Table is not considered necessary.

Based on the review and assessment of alternatives considered, at this time the short term *Recommended Solution* for Reach #5 is Alternative 5-2: to repair and clean out the culvert barrel. This alternative provides measures appropriately to mitigate the drainage issues identified at a minimal cost. This maintenance work would be considered a Schedule 'A' EA activity.

However, although the inlet culvert structure is in overall good condition at this time, it is anticipated that it is approaching the end of its service life and may require replacement in the foreseeable future. When the structural conditions of the box culvert dictate replacement, it is recommended that the replacement structure or system provide a minimum capacity of 6.042 m^3/s; to accommodate the Regional flood flow through this Reach. In consideration of the Municipal Engineering EA Manual, last updated in 2015, the recommended replacement a 'sewage facility' on a watercourse, albeit in the medium-term (i.e., less than 10 years), is considered to be a Schedule 'B' EA activity.

15. REACH #6: STORM SEWER SYSTEM – 19ST STREET WEST; 5TH AVENUE TO ESP

Within the overall drainage outlet system, Reach #6 represents the main storm sewer system within the Study Area. It is noted that this storm sewer system encloses a watercourse along its length. In confirming existing conditions of downstream sections of the storm sewer system, GMBP conducted field investigations in the Spring of 2017 by measuring the sizes/diameters and elevations of storm sewer infrastructure, where possible. Further, a camera inspection was completed by the City in the Spring of 2020, along its entire length to a point approximately 30 m east of 3rd Avenue West (i.e., into Reach #7). A copy of the camera inspection report is included in **Appendix G**.

15.1 Existing Infrastructure

The storm sewer system along 19th Street West extends from the culvert inlet system of Reach #5, located approximately 35 m to the east of 5th Avenue West, to immediately east of the Eddie Sargent Parkway (ESP). Directly to the west of the ESP, two ditch inlet storm sewer sections, to the north and the south of 19th Street West, drain into the Reach #6 storm sewer system. A lateral storm sewer also drains to the Reach #6 storm sewer system from 3rd Avenue West, where shown on **Drawing No.1**.

Based on the results of the recent camera inspection, the subject storm sewer system (i.e., corrugated steel pipe) appears to be in overall good condition. In addition, the results of the previous field investigations (2017) indicate that the diameter/size and characteristics of the existing 19th Street West storm sewer system along Reach #6 are summarized in **Table 15-1** below.

Table 15-1: Existing Infrastructure of Reach #6

Street	From	To	Diameter/Size *(Equivalent Diameter)**	Slope
19th St. W.	±80 m west of 4th Ave W	4th Ave W	1350 mm Ø CSP	2.18%
19th St. W.	4th Ave W	±10 m west of 3rd Ave W	1850 mm x 1100 mm CSPA *(1544 mm Ø)*	2.85%
19th St. W.	±10 m west of 3rd Ave W	±20 m west of the ESP	1850 mm x 1100 mm CSPA *(1544 mm Ø)*	0.85%
19th St. W.	±20 m west of the ESP	±10 m east of the ESP	1850 mm x 1100 mm CSPA *(1544 mm Ø)*	0.53%

**Equivalent Diameter as per the modelling of BASWM Study*

The slopes of the storm sewer sections presented in **Table 15-1** are based on field measurements. Given the size and depth of the storm sewer infrastructure along 19th Street West, as well as the inaccessibility to some of the structures, the calculated slopes are approximate. Diameters/sizes could not be confirmed due to accessibility issues for obtaining measurements.

The 19th Street West roadway within Reach #6 generally slopes downward from west to east, until reaching a low point approximately 13 m west of the centreline of the ESP roadway. The elevation of the 19th Street West roadway at its lowest point is approximately 183.30 m.

The north and south ditches, draining to the Reach #6 storm sewer immediately west of the ESP, appear to be graded in such a manner as to permit considerable temporary ponding volume. The confluence of these ditches with the Reach #6 storm sewer system is generally at the location of the low point along the subject section of the 19th Street West roadway.

15.2 Design Flows and Capacities

Under design conditions, the BASWM Study identifies a range of design flows along 19th Street West, generally increasing as it progresses downstream receiving runoff from additional lands en route to the outlet of Reach #7. The design flows of the BASWM Study through Reach #6, for the 1:100 year design storm and Regional flood event, for the storm sewer sections along 19th Street West, are summarized in **Table 15-2**.

TABLE 15-2: Existing Design Flows and Capacities of Reach #6

Along 19th Street West		Design Flow* (m^3/s)		Capacity (m^3/s)	Ratio of Design Flows to Capacity	
From	To	100-yr.	Regional		100-yr.	Regional
±80 m west of 4th Ave W	4th Ave W	5.404	6.298	4.269	**127%**	**148%**
4th Ave W	±50 m east of 3rd Ave W	5.725	6.430	6.982	82%	92%
±50 m east of 3rd Ave. W.	±10 m west of 3rd Ave W	5.737	6.454		82%	92%
±10 m west of 3rd Ave W	±20 m west of the ESP	5.707	6.457	3.813	**150%**	**169%**
±20 m west of the ESP	±10 m east of the ESP	5.940	6.625	2.788	**213%**	**238%**

The ratio of design flow to capacity generally represents the proportion of design flows conveyed via overland flow in comparison to the design flows conveyed via the storm sewer for each section. A ratio of less than, or equal to, 100% would therefore indicate that the design flow is fully conveyed by the storm sewer. A ratio of

greater than 100% would indicate that the design flow is drained via a combination of piped flow and overland flow.

As demonstrated in **Table 15-2**, the most restrictive capacity within Reach #6 is the section of storm sewer that crosses the Eddie Sargent Parkway. It is estimated that approximately 3.152 m^3/s and 3.837 m^3/s, or about 53% and 58%, of the total design flows through this section must be conveyed as overland flow for the 1:100 year design storm and Regional flood event, respectively.

15.3 Definition of Problem

From the modelling of the BASWM Study and the additional information retained as part of field investigations, it is shown that the 19th Street West storm sewer system provides insufficient capacity to convey the entirety of the Regional flood flow via piped flow throughout the full extent of Reach #6. As a result, a portion of the Regional flood flow through some sections of the Reach would be conveyed via overland flow easterly along 19th Street West. The risks to public safety, in terms of both health and property, must be assessed and addressed accordingly.

Other Considerations

Generally, municipal design guidelines dictate that storm sewer systems should provide sufficient capacity to convey peak runoff rates associated with a 1:5 year design storm event. During design storm events of greater return periods, peak runoff rates greater than the capacity of the storm sewer systems would be conveyed as overland flow via the roadway section. Therefore, overland flow conveyance is not necessarily an issue. However, the 19th Street West storm sewer system receives a significant amount of flow. Therefore, the adequacy of the overland flow route, as well as the rate of flow through it, should be considered.

While not all buildings along 19th Street West are situated at an elevation above the adjacent roadway, conditions observed from field investigations seem to be indicative of effective conveyance of overland flow by the roadway and its curbs. Therefore, an overland flow route should be maintained.

The capacity of this outlet system may be influenced by the water level in Georgian Bay. Under high water level conditions, portions of the storm sewer under the Eddie Sargent Parkway would be submerged, thus further reducing flow capacity.

15.4 Alternative Solutions: Reach #6

The following alternative solutions are considered to address the insufficient capacity of the 19th Street West storm sewer system within Reach #6:

Alternative 6-1: Do Nothing
Alternative 6-2: Repair or Rehabilitate the Storm Sewer System
Alternative 6-3: Partial or Full Replacement of the Storm Sewer System

15.5 Assessment of Alternatives: Reach #6

15.5.1 Alternative 6-1: Do Nothing

The 'Do Nothing' approach reflects the existing conditions of Reach #6. Based on the recent camera inspections of the storm sewer, the corrugated steel pipe has been observed to be in good condition. Further, no negative drainage impacts have been identified, observed, or reported within the Reach, of which the City or GMBP is aware.

In a review of **Table 15-2**, a maximum required overland flow of 3.837 m^3/s is expected within Reach #6. This constitutes a large flow rate to be conveyed on a public roadway and occurs around the low-point elevation of the 19th Street West roadway. Further, the ditch systems to the north and south of 19th Street West generally drain to the storm sewer system at this location. However, under high flow conditions, it is believed that whatever runoff is unable to be conveyed by the roadway would be temporarily stored in these ditches until sufficient capacity is available within the storm sewer system for discharge. As the design flow represents a peak flow rate that subsides and is not sustained for any considerable duration, and the depth of the existing ditches provides temporary storage, the adjacent buildings above the elevation of the ESP would be protected from flooding risks. A spill route across the Eddie Sargent Parkway is available about elevation 178.50 m.

The 19th Street West storm sewer system of Reach #6 does not appear to require immediate replacement based on its structural condition. However, the need for replacement of the existing infrastructure may be required in the foreseeable future due to aging materials. At the time of replacement, storm sewer sections of greater capacity could be considered in the design in order to convey more of the Regional flood flow through the subject Reach.

15.5.2 Alternative 6-2: Repair or Rehabilitate the Storm Sewer System

Based on the review provided in Alternative 6-1, the existing storm sewer and overland flow route can provide adequate capacity to convey the Regional Flood flow. The camera inspection provided confirmation that that the existing corrugated steel pipe is in good condition. Alternative 6-2 proposes completing repair and rehabilitation work in order to extend the useful service life of the existing storm sewer system. Conserving material resources, and prolonging the service life of the existing system, would have both financial and social benefits.

Advantages to completing culvert rehabilitation efforts, such as adding a new wearing surface or lining, generally include the following:

- Less costly than pipe replacement.
- The time associated with adding a new wearing surface or lining is typically significantly less than that required for replacement.
- As this is typically considered to be a 'no-dig' solution, there is less disruption to traffic. Keeping roads open, when possible, is preferred over road closures and detours.
- The system is generally stronger and more durable and can result in improved flow.

The financial implications combined with the social impacts associated with the required road closure make significant repairs or replacement impractical. As a result, it is desirable to aim to simultaneously replace the storm sewer system at such a time that significant road repairs and/or upgrades are required, thereby limiting disruptions to traffic (i.e., road closures), particularly on this well travelled road (i.e., 19th Street West). Therefore, culvert rehabilitation efforts, more specifically adding a new wearing surface or lining, provides for an alternative option to restore, or enhance, the structural capacity and integrity of the system while keeping the road open to the public until such a time that replacement can be combined with other infrastructure needs in the area.

Rehabilitation of the inlet culvert section, along with lining the existing storm sewer, are not only expected to maintain the structural integrity of the storm sewer system, but also to extend its service life, providing a significant benefit at a relatively low cost with minimal disruption to traffic and the public. An integral part of this Alternative, to repair or rehabilitate the existing system, would be the completion of routine inspections, at minimum every 5-years, to ensure proper shape, structural integrity and hydraulic efficiency and performance of the system.

15.5.3 Alternative 6-3: Partial or Full Replacement of the Storm Sewer System

To address the insufficient capacity of the 19th Street West storm sewer within Reach #6, the replacement of all, or select, undersized sections of the storm sewer is considered as an alternative solution to reduce, or eliminate, the degree of overland flow.

For Reach #6, the required minimum capacity of the 19th Street West storm sewer system to convey the entirety of the Regional flood design flows through its various sections is shown in the following **Table 15-3**.

TABLE 15-3: Minimum Capacities for Replacement of Reach #6 Storm Sewer

Along 19th Street West		Capacity (m^3/s)
From	To	
Culvert Inlet of Reach #5	4th Ave W	6.298
4th Ave W	3rd Ave W	6.454
3rd Ave W	Ditch Confluence Immediately to the West of the ESP	6.457
Ditch Confluence Immediately to the West of the ESP	Immediately to the East of the ESP	6.625

Replacement of the existing storm sewer system with one of greater capacity would undoubtedly eliminate the majority of the potential flood risks within Reach #6 but at significant cost, both financially and socially. Conveyance of the entirety of the design flow through Reach #6 via storm sewers would require pipe sections of relatively large size. Further, the installation of a replacement storm sewer system would incur considerable construction costs given the required roadway reconstruction of 19th Street West.

As previously noted, 19th Street West has a relatively high traffic volume and hosts a public transit service. Therefore, major construction within the 19th Street West roadway would impede traffic access and public mobility along this route. Additionally, construction near the intersection of 19th Street West and the Eddie Sargent Parkway would significantly impede traffic flow in the area.

Therefore, although inadequate sewer capacity has been identified as an issue for Reach #6, in consideration of the systems good overall structural condition, the ability for the area to adequately manage the overland flows, versus the financial costs and social implications associated with the construction of a replacement storm sewer system along 19th Street West, Alternative 5-3 is not considered to be immediately necessary. However, replacement of this aging infrastructure may need to be considered in the foreseeable future. The timing of such a replacement could be re-evaluated on a routine basis by ensuring inspection of the system is completed every 5-years, at minimum.

15.6 Recommended Solution: Reach #6

Based on the review and assessment of Alternatives presented for Reach #6, it is important to recognize that the existing infrastructure of Reach #6, including the ability of the system to manage overland flows, adequately conveys flows through the Reach. As a result, from a technical perspective, all of the Alternatives could be considered appropriate. Therefore, the discussion for Reach #6 outlines a plan to utilize Alternative 6-2 and Alternative 6-3 considered over a longer-term planning horizon. While Alternate 6-1 (i.e., Do Nothing) could be considered appropriate, it is thought that extending the useful service life of the storm sewer system, with minimal costs and limited impacts to the public, may provide significant additional benefits over the 'Do Nothing' Alternative. Therefore, an assessment Table is not considered necessary.

Depending on the condition of other infrastructure (sanitary sewer, watermain, road surface), the Recommended Solution is Alternative 6-2: to repair or rehabilitate the existing storm sewer system, via the installation of a new wearing surface (or lining), at such a time that routine inspections recommend such efforts. In addition to the financial and social benefits, an extension of the service life of this system could provide the City the opportunity to better align the replacement of this infrastructure with other infrastructure upgrades along this well travelled road. Rehabilitation of the system is recommended only as short- to medium-term solution, dependent on the structural integrity of the system. It is recommended the routine inspections of the storm sewer occur every five years, at minimum.

Further, as part of any alternative, it is recommended that the City develop flood protection standards in areas where low opening elevations of the adjacent and/or nearby residences could result in flooding (i.e., to ensure opening elevations remain greater than the spillway elevation across the ESP), as opportunities permit.

Ultimately, it is anticipated that the existing infrastructure that forms the 19th Street West storm sewer system may potentially require replacement in the foreseeable future due to its age. At such a time, it is recommended that replacement infrastructure within Reach #6 provide a minimum capacity of no less than existing conditions and preferably equal to that of the Regional flood design flow associated with each section as outlined in **Table 15-3.** The replacement of a 'sewage facility' on a watercourse is currently considered to be a Schedule 'B' EA activity.

16. REACH #7: OUTLET SYSTEM – EDDIE SARGENT PARKWAY TO KELSO BEACH

The Eddie Sargent Parkway was constructed in the mid-1970's and included the overall storm sewer system outlet of Reach #7. Since that time, flows from Reach #6 and flows from the Eddie Sargent Parkway drainage system essentially converge at the entrance to Kelso Beach Park, where shown on **Drawing No.1,** and continue through Reach #7 to the Owen Sound Harbour. Therefore, the Reach #7 infrastructure constitutes the drainage outlet for the entirety of Basin A3 to the Owen Sound Harbour.

Following the construction of the Eddie Sargent Parkway, the area to the east between the parkway and the shoreline, through which Reach #7 drains, was redeveloped as the main entrance to Kelso Beach Park and, as such, proper drainage conditions are essential to maintaining operation as a safe and usable recreational area.

In 2005, GMBP prepared preliminary plans for minor improvements to the Kelso Beach storm sewer outfall within Reach #7. Improvements included minor erosion control measures within a plunge pool at the storm sewer outfall and at the interface between the water's edge and existing stone block wall, via the strategic placement of stone and boulders. A new stone wall was built at the Kelso Beach storm sewer outfall in 2020.

The capacity of this outlet system may be influenced by the water level in Georgian Bay. Under high water level conditions, the piped outlet would be fully submerged and sufficient head would need to be developed upstream to convey flow through the pipe prior to overland flow access to the ESP.

16.1 Existing Infrastructure

Description of Reach #7:
The main storm sewer section of Reach #7 is a 1500 mm Ø CSP, which extends from a manhole immediately east of the ESP to the outfall. The sewer has a grade of approximately 1.03% over a distance of approximately ±50 meters. The downstream invert elevation of the section was measured to be approximately 175.81 m. The upper portion, a section of an estimated ±30 meters, was inspected by camera in the spring of 2020 in conjunction with Reach #6. This inspection indicated that the pipe is still in good condition. It is likely that a concrete section remains at the former railway crossing. Beyond the outfall (i.e., beyond the easterly limits of Reach #7), an open watercourse extends through Kelso Beach Park, about 80 meters to the Owen Sound Harbour.

Catchment Area:
Immediately to the east of the Eddie Sargent Parkway, two ditches, one to the south and one to the north of the entrance to Kelso Beach Park, drain local area surface water runoff to ditch inlet catch basins which then drain into the storm sewer section that forms part of Reach #7. The top of grate elevations of the ditch inlet catchbasin structures immediately to the north and south of the Kelso Beach Park entrance are approximately 177.74 m and 177.21 m, respectively. As shown on **Drawing No.1**, these ditch inlet catch basins also receive flows from local storm sewer systems, as follows:

- The southerly ditch inlet catchbasin receives road runoff from the ESP immediately to the south of its intersection with 19th Street West.
- The northerly ditch inlet catchbasin receives road runoff from the ESP to the north of its intersection with 19th Street West as well as the 2000 Block of 3rd Avenue West. The subject section of 3rd Avenue West is situated in a local low point within Basin A3 and is believed to receive overland flows conveyed by the local roadways from a tributary area of approximately 5.3 hectares. The elevations of the catchbasin top of grates through this Reach vary between approximately 177.61 m and 177.92 m, an estimated 0.06 m to 0.58 m higher than the ESP catchbasins, into which they drain.

Another ditch, approximately 25 m to the east of the northerly ditch along the ESP, drains to the main 1500 mm Ø storm sewer section via a culvert inlet. An overland spillway through Reach #7 is not well-defined but is

believed to be provided by the entrance to Kelso Beach Park, discharging to the location of the storm sewer outfall of the 1500 mm Ø CSP storm sewer.

Owen Sound Harbour:
The outlet conditions for Reach #7 are influenced by water levels in the Owen Sound Harbour. Reported water levels are as follows:

i. The all-time average mean monthly elevation is 176.42 m.
ii. The all-time maximum monthly mean water is 177.50 m.
iii. The Lake Huron 100-year flood elevation is 177.90 m.

In consideration of water levels in the harbour, the BASWM Study recommended that, in addition to the construction of minor improvements to the outfall area within Kelso Beach (completed in 2020), improvements to the storm sewer outlet (i.e., the 1500 mm Ø CSP section of Reach #7) be completed in order to convey design flows associated with a 1:5 year design storm event. At the time of the BASWM Study, the 1500 mm Ø CSP was estimated as having a 0.2% grade. However, recent field investigations have determined that the slope of the pipe section is actually closer to 1.03%.

Under free-flow conditions, the 1500 mm Ø CSP at a grade of 1.03% would provide sufficient capacity to convey runoff from a 1:10 year design storm event. However, since the outlet elevation is about 175.81m, the available capacity would be restricted, to a varying degree, by water levels in the Owen Sound Harbour.

Conditions along Eddie Sargent Parkway:
Recent field investigations noted that the 1500 mm Ø CSP storm sewer outfall was submerged. High water level mapping along the ESP and around the Kelso Beach Park Outlet is illustrated on **Drawing No. 3.** This mapping was supplemented with field survey data, particularly in the area of the 2000 Block of 3rd Avenue West. This mapping suggests that grade elevations at some of the dwellings along the 2000 Block of 3rd Avenue West are below the ESP Parkway grade. Areas depicted as potential flooding zones are subject to change, based on site specific surveys which may be recommended for some areas. Furthermore, as discussed above, the lowest spill point for overland flows appears to be within the 2000 Block of 3rd Avenue West, about elevation 178.50 meters.

16.2 Design Flows and Capacities

Under design conditions, the BASWM Study identified the following Regional and 1:100 year design flows through the outlet storm sewer section of Reach #7 (i.e., the 1500 mm Ø CSP):

TABLE 16-1: Reach #7 Design Rainfall Events (Existing Conditions)

Rainfall Event	Flow Volume
1:100 year design flow	7.244 m^3/s
Regional flood flow	7.404 m^3/s

Based on field measurements, the capacity of the 1500 mm Ø CSP is expected to be approximately 3.886 m^3/s. Therefore, approximately 46% and 48% of the 1:100 year design flow and Regional flood flow, respectively, would be required to be conveyed as overland flow, assuming that flow within the storm sewer system is not pressurized.

As the capacity of the 1500 mm Ø CSP is exceeded, the surcharged flow is expected to be stored within the lateral ditch systems along each side of the Eddie Sargent Parkway. Under more extreme conditions, the storm sewer section within the 2000 Block of 3rd Avenue West would 'back up' and a portion of the flows would be stored in the 3rd Avenue West road right-of-way. Given the elevation of the 3rd Avenue West roadway section in relation to the adjacent ESP roadway, ponding water may have the potential to flood this area before spilling overland across the ESP, unless overland relief flow is available to the south across the campground to

the Pottawatomi River. Based on a recent topographical survey completed in the area, an overland flow route is available southerly across 20th Street West and 19th Street West, leading towards the Pottawatomi River.

16.3 Definition of Problem

The most significant problem associated with Reach #7 is that the 1500 mm Ø outlet to the system has capacity only to convey the 1:10 year design flow under free flow conditions. As a result, there is a risk of flooding to the buildings in the vicinity of the 2000 Block of 3rd Avenue West due to storm sewer 'back-up' as a result of the surcharged 1500 mm Ø CSP outlet at Kelso Beach Park, unless an adequate overland flow route is available either to the east across the ESP or to the south across the campground to the Pottawatomi River.

Further, since the outlet elevation is about 175.81m, which is often below the water surface elevations in the Owen Sound Harbour, the available capacity is further restricted, to a varying degree, by water levels in Georgian Bay.

16.4 Alternative Solutions: Reach #7

Based on the insufficient storm sewer capacity within Reach #7, associated with the 1500 mm Ø storm sewer outlet and the resulting flow 'back-up' effects on the lateral drainage structure(s), which includes potential flooding risks to private residences, the following alternative solutions are considered:

Alternative 7-1: Do Nothing
Alternative 7-2: Backflow Preventers for 3rd Avenue West Storm Sewer
Alternative 7-3: Construct Better Defined Overland Flow Route
Alternative 7-4: Remove and Replace Existing Outlet Pipe
Alternative 7-5: Municipal Flood Protection Standards

16.5 Assessment of Alternatives: Reach #7

16.5.1 Alternative 7-1: Do Nothing

The 'Do Nothing' alternative reflects the existing conditions within Reach #7. Assuming the lack of an alternate overland flow route, other than easterly across the ESP, in combination with the existing 1500 mm Ø CSP storm sewer, flow 'back-up' effects under Regional flood flow conditions would currently create the potential for flooding at residences within the 2000 Block of 3rd Avenue West. Therefore, the 'Do Nothing' alternative does not address the problems identified within Reach #7. Consequently, this alternative is not considered to be favourable.

16.5.2 Alternative 7-2: Back Flow Preventers for 3rd Avenue West Storm Sewer

To mitigate the risk of flows backing up from the Kelso Beach outlet and ponding within the 3rd Avenue West roadway between 20th Street West and 21st Street West, the implementation of backflow prevention devices, such as flap gates on the outlet of the 3rd Avenue West storm sewer draining across the Eddie Sargent Parkway, is considered as an alternative.

The implementation of backflow prevention devices would address the issues of downstream flows backing up into the subject 3rd Avenue West roadway. However, the roadway along the 2000 Block of 3rd Avenue West is located at the low point of a sizeable drainage catchment. Thus, a significant amount of overland flow would be expected to be conveyed to this area. This runoff would have to be stored within the 3rd Avenue West roadway as surface ponding until the flows in the downstream drainage system subsided and the backfill preventers permitted to open.

The Kelso Beach outlet of Reach #7 drains the entire 148-hectare catchment of Basin A3. The runoff associated with the approximately 5.3-hectare tributary area to the subject 3rd Avenue West storm sewer system is relatively small in comparison to that associated with the remainder of the Basin A3 area. However, the available storage volume also is relatively small.

Therefore, it is expected that capacity within the storm sewer sections downstream of 3rd Avenue West may not sufficiently be able to drain surface ponding within the 3rd Avenue West roadway within a reasonable timeframe. The runoff draining to the 3rd Avenue West roadway, while minor in comparison to the overall drainage basin, is still expected to be considerable given the extent of the upstream catchment area.

Therefore, while backflow preventers may prevent surcharge from the main storm sewer outlet, the risk of flooding to the private residences along 3rd Avenue West from upstream lands may still be present from flows within the sub-catchment area.

16.5.3 Alternative 7-3: Construct Better Defined Overland Flow Route

To mitigate downstream flows from backing up into the roadway of the 2000 Block of 3rd Avenue West, an overland flow route is considered as an alternative to promote drainage of surface ponding before potentially rising to the elevation of adjacent private residences. For this alternative, overland flow routes via a lateral ditch system draining to a natural water body outlet, are considered. The intent would be to allow surcharged flows that re-emerge from the 19th Street West storm sewer system to be conveyed overland via a ditch system grading either easterly to the Owen Sound Harbour, or southerly to the Pottawatomi River.

Since the Lake Huron 1:100 year flood elevation of 177.90 m is well above the top of grate elevations of the existing ditch inlet catch basins (i.e., 177.24 m and 177.74 m), under high water levels and extreme flow events, overland flow routes would already be submerged under such conditions. Further, the 1:100 year high water elevation is higher than the 3rd Avenue West road surface, where grate elevations vary between approximately 177.61 m and 177.92 m. Therefore, regardless of a defined overland flow route, the 1:100 year high water level would result in flooding of the 3rd Avenue West roadway (the 2000 Block). Consequently, an appropriate overland flow route cannot fully be achieved. However, establishing or maintaining an overland flow route at a lower elevation than the ESP spill elevation would provide benefit under most conditions. A survey of this area verified the potential to develop an overland flow route to the south across 19th and 20th Street West towards the Pottawatomi River. To ensure that this potential overland flow route to the south is not further inhibited, this area could be recognized in the City's Official Plan and/or Zoning By-Law in such a manner that prevents fill/development along the drainage pathway.

16.5.4 Alternative 7-4: Remove and Replace Existing Outlet Pipe

To convey more of (or the entirety) of the Regional flood flow through Reach #7 as piped flow, the removal and replacement of the existing 1500 mm Ø outlet with an outlet of greater capacity is considered as an alternative. Generally, if the capacity of the outlet was increased to that of the Regional flood flow, there would be no flow restriction within Reach #7 and the "back-up" effect on upstream drainage infrastructure, including the storm sewer sections within the 2000 Block of 3rd Avenue West, would be reduced or eliminated.

However, similar to Alternative 7-3, the 1:100 year flood elevation of Lake Huron (or the Owen Sound Harbour) would impede the conveyance of the Regional flood flow through any storm sewer during a design storm event. The outlet of the Reach #7 section of storm sewer would be expected to be submerged and the free-flow capacity of the replacement outlet would not be available.

To promote free-flow conveyance, the outlet of the Reach #7 storm sewer section would have to be constructed with its invert above the 1:100 year flood elevation of the Owen Sound Harbour. Complete

reconstruction of the ESP in the area of its intersection with 19th Street West, as well as a portion of the 19th Street West roadway to the west of the ESP, would be required to sufficiently raise road grades to fit a large size storm sewer and to achieve this outlet invert elevation. Such an undertaking would be expected to incur a significant construction cost as well as major traffic interruption within this area of the City during the construction.

A more favourable iteration of this alternative, which would still maintain the existing upstream infrastructure, is to replace the existing outlet pipe of Reach #7 with an outlet that is as large in cross sectional flow area as possible, and placed at as high an elevation as possible, while still maintaining necessary cover, conveyance and access to the Kelso Beach Park. Although the outlet for Reach #7 would still be submerged under high lake level conditions, upstream flows generally would be permitted freely to drain more frequently, earlier and ultimately at a greater discharge rate. Additional, and substantial, consideration would be required to maintain the natural aesthetics of the outfall to the watercourse draining through Kelso Beach Park with this alternative.

16.5.5 Alternative 7-5: Municipal Flood Protection Standards

To ensure that future development is not impacted by potential flood event conditions noted, municipally-enforced flood protection standards are considered as an alternative. Alternative 7-5 proposes that future redevelopment of private properties prone to flood risks, such as select private properties within the 2000 Block of 3rd Avenue West and properties adjacent to the Eddie Sargent Parkway, be required to consider the extreme flood elevations of the Owen Sound Harbour and to provide sufficient freeboard to future proposed finished floor elevations. In doing so, future developments would be protected from the flood risks and 'back-up' effects associated with Reach #7.

While Alternative 7-5 addresses the flooding risks of Reach #7 in the long-term, it does not immediately address these risks in the short-term. Therefore, Alternative 7-5 is best applied in conjunction with another alternative, which may be implemented in the shorter term.

16.6 Recommended Solution: Reach #7

Based on the above review of alternatives and the results of the relative ranking presented in **Table 16-2**, the *Recommended Solution* for Reach #7 is Alternative 7-4: to remove and replace the existing outlet pipe. This alternative best addresses the identified drainage issues associated with Reach #7. This alternative is preferred primarily due to its technical feasibility/need as compared to the other alternatives, including its ability to best mitigate the effects of the flood flows through the Reach. Alternative 7-4 would involve the replacement of a 'sewage facility' on a watercourse, which is considered to be a Schedule 'B' EA activity.

Due to the limitations imposed by the elevation of the existing infrastructure and roadways relative to the water levels reported for the Owen Sound Harbour, additional flood protection measures would be recommended to complement Alternative 7-4. Therefore, it is recommended that Alternative 7-5: Municipal Flood Protection Standards, together with Alternative 7-4, would best address the potential risk for residential flooding and could provide the best protection against flooding for buildings. Implementation of Alternative 7-5 would not be subject to the Environmental Assessment process and could be implemented on an opportunistic basis.

Establishing or maintaining an overland flow route either easterly to the Bay or southerly to the Pottawatomi River, at an elevation lower than the ESP spill elevation, should also be considered. Additional topographic survey work completed as part of this Master Planning process suggests that the establishment of an overland flow route to the east towards the Bay may not be technically feasible. Therefore, it is recommended that lands required to establish an overland flow route to the south towards the Pottawatomi River be recognized in the City's Official Plan and/or Zoning By-Law to ensure that future development does not further restrict the overland flow potential in this area.

TABLE 16-2: ASSESSMENT OF STORMWATER MANAGEMENT ALTERNATIVES
REACH #7: Outlet System - Eddie Sargent Parkway to Kelso Beach

ENVIRONMENT	ALTERNATIVE 7-2 Backflow Preventers for 3rd Ave W Storm Sewer	ALTERNATIVE 7-3 Construct Better Defined Overland Flow Route	ALTERNATIVE 7-4 Remove and Replace Existing Outlet Pipe	ALTERNATIVE 7-5 Municipal Flood Protection Standards
CULTURAL				
Ranking	**Net neutral for all alternatives considered.**			
SOCIAL				
1. Impacts to Private Property (i.e. flooding, access, land use)	While backflow preventers may prevent surcharge from the main storm sewer outlet, flooding from upstream lands from flows within the subcatchment area would still pose a risk to private properties.	Since the 1:100 year flood elevation for the harbour is higher than the catchment grate elevations along the ESP and 3rd Ave W, overland flow routes would already be submerged under high water levels and extreme flow events.	Replacement of the outlet pipe of Reach #7, with an outlet that is as large in cross-sectional flow area as possible, and placed at as high an elevation as possible, would best mitigate the effects of flood flows through the Reach (while maintaining existing infrastructure and roadways).	Would ensure that future development is not impacted by potential flood event conditions. However, does not immediately address the flood risks in the short-term.
2. Aesthetic Impacts of Drainage Improvements	No aestetic impact. Backflow preventers would be installed within the existing storm sewer system.	An adddditional overland flow route would change the existing aesthetics.	No impact: with the exception of construction efforts, the storm sewer would remain underground, therefore would not impact the overall landscape. Additional, and substantial, consideration would be required to maintain the natural aesthetics of the outfall to the watercourse draining through Kelso Beach Park with this alternative.	No Impact.
3. Land Acquisition (including easements)	Storm Sewer system is located within existing municipal rights-of way.	Overland flow route would likely be developed within existing rights-of-way or on City property (i.e. Kelso Beach Park).	Storm sewer system would be maintained in existing right-of-way.	Would not require land acquisition or the establishment of permanent easements.
Ranking			**Favoured**	
NATURAL				
1. Natural Heritage Features & Species at Risk	No impact: Maintains existing conditions.	No impact: Overland flow route would likely be directed through a previously disturbed and developed park area.	Replacement would be disruptive to fish habitat in the short-term, but would maintain the buried fish habitat in the long-term.	No impact: Maintains existing conditions.
2. Storm Water Treatment: Runoff Water Quality	No change relative to exisitng condition. However, 'uncontrolled' flows to the east into the Bay could be of reduced water quality.	Overland flow and discharge directly into the Harbour may contibute a greater concentration of total suspended solids to the Bay.	A reduction in overland flows may may improve the overall water quality of the discharges to the Bay.	No change relative to exisitng condition. However, 'uncontrolled' flows to the east into the Bay could be of reduced water quality.
Ranking	**Favoured**		**Favoured**	**Favoured**
TECHNICAL				
1. Technical Considerations (i.e. Ability to Satisfy Required Capacity)	While backflow preventers may prevent surcharge from the main storm sewer outlet, flooding from upstream lands from flows within the subcatchment area would still pose a risk. The capacity of the existing sytsem would remain the same.	Since the 1:100 year flood elevation for the harbour is higher than the catchment grate elevations along the ESP and 3rd Ave W, overland flow routes would already be submerged under high water levels and extreme flow events. Therefore , would not change the capacity of the existing sytsem.	Replacement of the outlet pipe of Reach #7, with an outlet that is as large in cross-sectional flow area as possible, and placed at as high an elevation as possible, would best mitigate the effects of flood flows through the Reach (while maintaining existing infrastructure and roadways) and provide for additional flow capacity through the system.	The capacity of the existing sytsem would remain the same. Flooding risk to existing structures would remain a concern.
2. Efficacy of Design	Typically this preventative measure would require minimal work for the potential prevention of signifcant flooding.	Providing an alternative route for overland flows would require more considerable construction efforts and/or would be more land-intensive.	The recommended installation of a storm sewer, while maintaining the existing infrastructure and roadways, would best mitigate the effects of flow flood with the least disruption to the community (and cost).	Considered a simple and cost effective alternative to address the flooding risk issues in the long-term.
3. Abitlity to Address Idenfied Drainage Issues	Would not address identified drainage issue: While backflow preventers may prevent surcharge from the main storm sewer outlet, the risk of flooding to the private residences along 3rd Avenue West from upstream lands would still be present from flows within the sub-catchment area.	Would not address identified drainage issue: Regardless of a defined overland flow route, the 1:100 year high water level (Lake Huron) would result in flooding of the 3rd Avenue West roadway. Consequently, an appropriate overland flow route cannot be achieved.	Most technically feasible alternative. Best mitigates the effects of flood flows through the Reach.	Preventative measure. Would not address drainage issue identified.
4. Timing	Not Applicable: Not technically feasible.	Not Applicable: Overland flow route can not be achieved.	In the short-term, this alternative best mitigates the drainage issues identified.	In the long-term this alternative provides the best protection against flooding for buildings.
Ranking			**Favoured**	
ECONOMIC				
1. Relative Construction Costs	$$	$$	$$$	$
2 Operation & Maintenance	In general, operations and maintenance costs would be low. However, the compensation costs for building damage due to flooding could be substantial.	In general, operations and maintenance costs would be low. However, the compensation costs for building damage due to flooding could be substantial.	Minimal operations and maintenance costs would be incurred following the installation of a new storm sewer. Further, as this best addressses the conveyance of flows, costs associated with flooding would be reduced.	In general, operations and maintenance costs would be low. The compensation costs for building damage due to flooding could still be substantial. However, with the development of Municipal Flood Protection Standards, these costs would be reduced.
Ranking			**Favoured**	**Favoured**
OVERALL RANKING			**Recommended (Short-Term)**	**Recommended (Short-Term)**

Note: Based on technical and/or economic considerations, Alternatives 3-1 and 3-5 were not carried forward into this assessment.

Relative Ranking of Environments: Favoured and/or Positive Impact | Net Neutral | Least Favoured / Negative Impact

Environmental Assessment Schedule for Recommended Solution: Schedule B (Alt 7-4) and Not Applicable (Alt 7-5)

17. MASTER PLAN: SUMMARY OF RECOMMENDED SOLUTIONS

The intention of the Master Plan process is ultimately to identify a broad level approach toward addressing the identified problems and/or opportunities. Based on the preliminary level of review completed as part of the Master Plan (Version 1), this Version of the Master Plan identifies the recommended infrastructure required to address the drainage deficiencies identified within Brooke Area Basin A3.

Brooke Area Basin A3 is generally bounded by West Street in the west, 23rd Street West in the north, the Eddie Sargent Parkway (ESP; Grey Road 1) in the east, and the 17th Street West and 18th Street West rights-of-way (ROW) in the south. The specific Study Area included the outlet portion of the drainage system of Basin A3, is located entirely within the City's boundaries, east of 8th Avenue West to the outlet at Kelso Beach, where shown on **Figure 1**.

The main components of the Master Plan identified for each subject Reach, as well as follow-up work and/or assessments identified, are summarized below.

i. Reach #1: Monitor effects of the Carney Street stormwater management pond on the open channel watercourse to the west of 6th Avenue West. Evaluate need to improve Reach #1 channel design if erosion or sedimentation effects are observed.

ii. Reach #2: Remove and replace the existing culvert system along 6th Avenue West with a 2400 x 1500 mm Box Culvert. Include the diversion of the 7th Avenue West storm sewer with this project.

iii. Reach #3: Complete gradient improvements and widening of the open channel watercourse between 21st Street West and 20th Street West, as per the previously proposed Phase 2 designs (subject to additional design development review). Maintain existing culvert across 20th Street East.

iv. Reach #3: Localized flood protection improvements should be considered for the residence at 585 21st Street West. This would be subject to consent from the property owner.

v. Reach #3 and #4: A maintenance easement(s) could be established, as required, for the open channel watercourse between 20th Street West and 21st Street West for the removal of potential obstructions within the Reach, such as deadfall trees.

vi. Reach #5: In the short-term, general maintenance of the box culvert located at 19th Street West, to the east of 5th Avenue West, may be completed as recommended in the OSIM Inspection Reports. This would include the clean-out of the culvert barrel and repairs to the deteriorated concrete, as needed. As the box culvert reaches the end of its service life, which is likely to occur in the foreseeable future, it should be replaced with a structure that, at minimum, provides sufficient capacity to accommodate the design flows associated with the Regional flood event.

vii. Reach #6: Ultimately, it is anticipated that other existing infrastructure (i.e., sanitary sewer, watermain, road surface) will eventually also require replacement and that extending the service life of the existing storm sewer by rehabilitating the system, via the installation of a new wearing surface (or lining), could provide the City with the opportunity to delay replacement of the system until such a time that the project can be better aligned with other infrastructure needs along this well-travelled road. Rehabilitation of the system is recommended only as a short- to medium-term solution, dependent on the structural integrity of the system, which could be re-assessed on a routine basis (i.e., once every 5-years, at minimum). Further, it is anticipated that the existing infrastructure may potentially require replacement in the foreseeable future due to its age. At such a time, it is recommended that replacement infrastructure within Reach #6 provide a minimum capacity equal to existing, and preferably to that of the Regional flood flow, for each section. Timing for replacement(s) would be subject to condition assessments and/or other infrastructure needs.

viii. Reach #7: The outlet of 19th Street West storm sewer system at Kelso Beach should be removed and replaced with a pipe section which maximizes the flow area and outlet elevation.

ix. Reach #7: Flood protection, via the establishment of municipally enforceable flood protection standards, is recommended for the future development of private properties along the Eddie Sargent Parkway and the 2000 Block of 3rd Avenue West.

x. Reach #7: Establish and/or maintain an overland flow route to the south towards the Pottawatomi River at an elevation lower than the spill elevation across the Eddie Sargent Parkway.

Drawing No.5 illustrates the main features, and direction for, this Master Plan, resulting from the process. The following **Table 17-1** provides a prioritized schedule for project implementation and associated 'Order of Magnitude' Construction Costs. Priorities are ranked from high to low, with high being the highest priority. Cost estimates may not include for other infrastructure works, which may be associated with the considered drainage infrastructure costs, including such items as watermain relocation etc.

Table 17-1: Prioritized Schedule of Recommended Project Implementation

Reach	Recommended Solution(s)	EA Schedule	Relative Priority	Estimated Cost
1	**Do Nothing** Other: May consider the establishment of an easement, as required, for maintenance of this 'natural watercourse'.	N/A	N/A	N/A
2	**Replacement (2400 x 1500 m Box Culvert with Foundation)** Other: Previously considered 7th Avenue West storm sewer diversion could be completed in conjunction with the replacement.	B Included	**High**	$1.5M Included
3	**Channel improvements along the current watercourse alignment**; **and Localized Flood Protection** (at 585 - 21st Street West). Other: Establish easement for maintenance, as possible.	B N/A	Medium **High**	$100,000 $20,000
4	**Remove Deadfall Trees** Other: Establish easement for maintenance, as possible.	A	Low	$10,000
5	**Short Term: Repair and Clean-Out Culvert Barrel.** Continue to maintain, as necessary; and **Longer-Term: Replace the Culvert**, as it approaches the end of its service life.	A B	**High** Medium	$100,000 $500,000
6	**Short to Medium Term: Rehabilitate** (via installation of a new wearing surface or lining, timing based on recommendations of routine inspections); and **Long-Term: Replacement** of the storm sewer system as it approaches the end of its service life or as other infrastructure needs arise (i.e., sanitary sewer, watermain, roadway).	A B	As Needed Low	$250,000 to $400,000 $2.0M
7	Remove and replace existing outlet pipe; Develop municipal flood protection standards; and Designate existing overland flow route to Pottawatomi River.	B N/A N/A	Medium N/A Medium	$500,000

It is noted that while the Master Plan addresses the need and justification at a broad level, more detailed studies for each of the projects included in the Master Plan will be completed as part of the planning and design process, as necessary. Further, this Master Plan is intended sufficiently to document the investigations, assessments and consultations required to fulfill the requirements of the Schedule 'B' projects identified.

18. PHASE 2 CONSULTATION

Consultation early in and throughout the process is a key feature of environmental assessment planning. This Master Plan is intended sufficiently to document the investigations, assessments and consultations required to fulfill the requirements of the Schedule 'B' projects identified. Schedule 'B' projects have two mandatory points of contact; the *Notice of Project Initiation* (i.e., Consultation - Phase 2) and the *Notice of Completion*. It is noted that the final public Notice for this Master Plan will become the *Notice of Completion* for the Schedule 'B' projects addressed within the report.

18.1 Notice of Project Initiation and Public Information Centre (PIC No.1)

A *Notice of Project Initiation and Public Information Centre (PIC No.1)* was prepared and first issued on October 25th, 2022. The Notice included an invitation to a Phase 2 Public Information Centre to be held on November 8th, 2022. A copy of the Notice is provided in **Appendix A**. The Notice was advertised in the Owen Sound Sun Times on October 25th, 2022, and October 29th, 2022. The Notice was also mailed to property owners within 120 meters of the main drainage corridor. It is noted that while public notice typically requires that notices be mailed to the owners of all properties within and abutting the Study Area, an extended notification area was endorsed, as outlined on the Notification Area Figure provided in **Appendix A**.

The *Notice of Project Initiation and Public Information Centre* invites the public, agencies and Indigenous Communities to review this version of the Master Plan (i.e., Version 1), which includes the background technical reports. Comments received over the course of the Study will be incorporated into the Master Plan (Version 2), which will include a re-assessment of alternatives as required to address comments received, to be issued at a later date.

18.2 Notice of Completion

As previously noted, this Master Plan process is intended to follow Approach #2 (Appendix 4, MCEA Manual 2015), in which the appropriate environmental assessment Schedule 'B' projects are identified and the investigations, consultation and documentation sufficiently addresses the requirements for the Schedule 'B' projects identified. Therefore, the Master Plan will be finalized at the conclusion of Phases 1 and 2 of the EA process and subsequently circulated via the *Notice of Completion* which will fulfill the Schedule 'B' project planning requirements.

19. CONSULTATION: PUBLIC, AGENCY AND INDIGENOUS COMMUNITY

19.1 Public Consultation

With the circulation of this version of the Master Plan, the public are invited to provide comments regarding the set of *Recommended Solutions* identified. Comments received will be summarized in this section. Upon receipt and review of all comments, the review of the alternatives will be re-visited, and any new information will be incorporated into the re-assessment of the *Recommended Preferred Solutions*, for consideration and acceptance (or otherwise) by Council.

19.2 Agency and Indigenous Community Consultation

Agencies with a regulatory role that may require future permits/approvals, or may have a direct interest in the study, are to be contacted at each 'mandatory point of contact' required as part of the EA process to invite feedback. This version of the Master Plan was circulated to select key agencies and indigenous communities on October 25th, 2022, to solicit comments and feedback, which will be incorporated into the assessment of the

Recommended Preferred Solutions, where appropriate, for consideration and acceptance (or otherwise) by Council. A list of the agencies and Indigenous Communities contacted is included in **Appendix A.**

20. NEXT STEPS

This version of the Master is issued under Phase 2 Step 5, as the first mandatory point of contact under the Municipal Class Environmental Assessment process. Next steps in the process include the following:

i. The Master Plan was circulated to directly affected landowners, agency groups, and Indigenous Communities. Comments will be received by the Project Team until November 25th, 2022.

ii. The City will hold a Public Information Centre on November 8th, 2022, which will include an information session followed by a brief presentation of the Study process and findings to date. Public discussion and comments will be encouraged.

iii. Any new information received will be incorporated into the Master Plan, and the assessment of alternatives and the *Recommended Solutions* will be updated for Council to consider as the *Preferred Solutions*.

iv. Upon acceptance (or otherwise) by Council of the *Preferred Solutions*, a *Notice of Completion* (i.e., final public Notice for the Master Plan) will be issued, advising participants of the outcome to the Schedule 'B' EA processes identified.

v. A 30-day Review Period will follow the *Notice of Completion* date to:

- Provide the opportunity for Indigenous Communities to request the Minister to enact Section 16 of the Act, for a specific project (or projects) within the Master Plan, and not the Master Plan itself, which would require additional study to verify the project direction.
- For the Project Team to respond to any remaining concerns raised by the public or agencies.

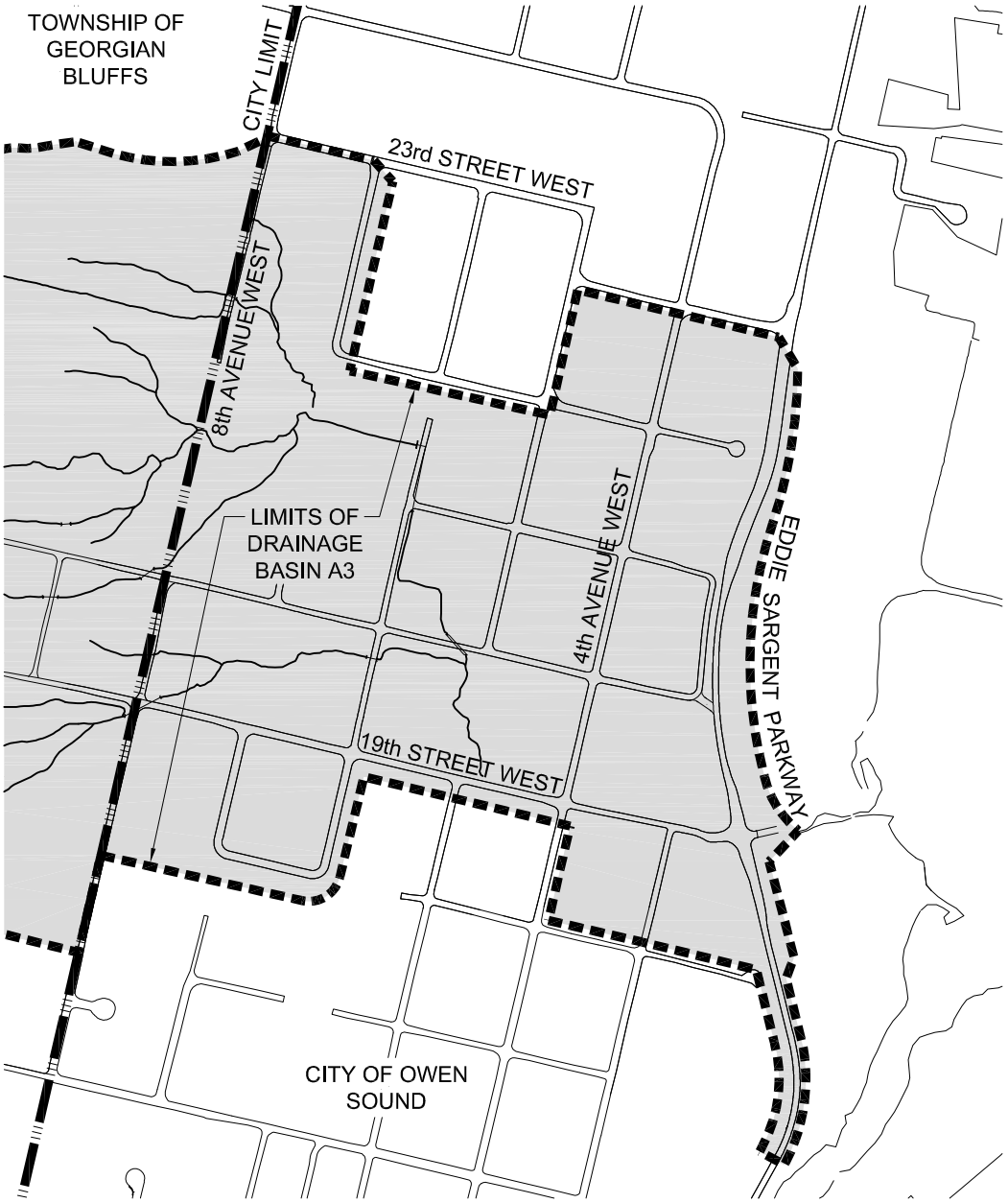
If a Section 16 Order request in not made during the review period, and the City of Owen Sound Council supports the Master Plan, the *Preferred Solution* to the individual projects identified may proceed to implementation (i.e., Phase 5 of the EA process as outlined in **Figure 2**).

vi. Maintain the Master Plan on the City of Owen Sound website for reference purposes.

Depending on the nature of the proposed works, approvals may be required from the Grey Sauble Conservation Authority, the Department of Fisheries and Oceans Canada (DFO), the Ontario Ministry of Natural Resources and Forestry (MNRF) and/or the Ministry of the Environment, Conservation and Parks (MECP). Further, depending on the alternative selected and the nature of the proposed works, additional archaeological assessment may be required within Reach #1 through Reach #4. It is recommended that required approvals be sought, and the potential need for a Stage 2 archaeological assessment be reviewed, in conjunction for the design development phase for a subject Reach, as appropriate. Further, it is noted that depending on the findings of the Archaeological assessment(s), additional consultation with Indigenous Communities may be required.

FIGURES

Brooke Area
City of Owen Sound



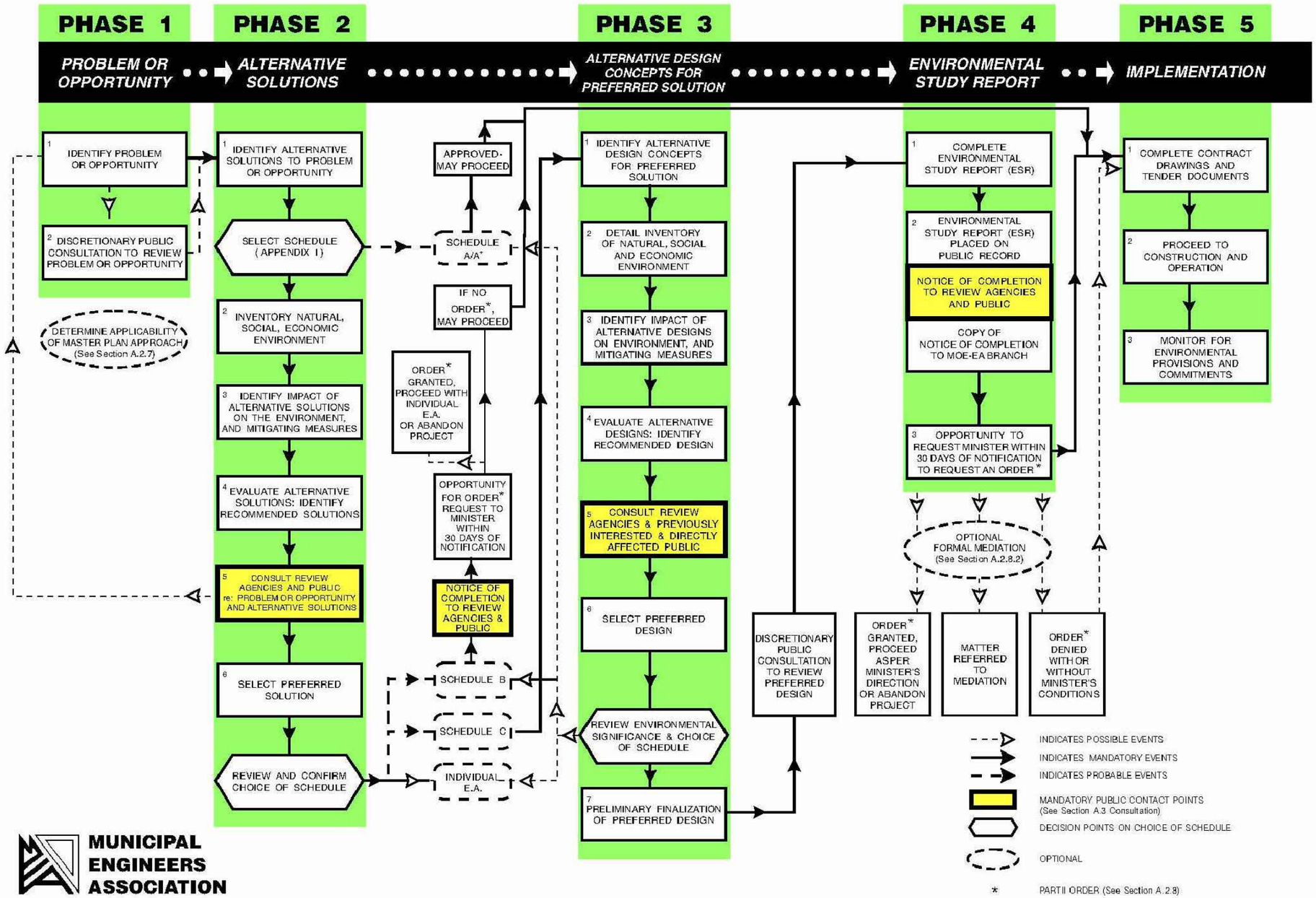
BROOKE AREA
DRAINAGE BASIN A3

Figure No. 1

BluePlan
ENGINEERING

EXHIBIT A.2 MUNICIPAL CLASS EA PLANNING AND DESIGN PROCESS

NOTE: This flow chart is to be read in conjunction with Part A of the Municipal Class EA



MUNICIPAL ENGINEERS ASSOCIATION

216301
BROOKS AREA
BASIN A3 OUTLET
CITY OF OWEN SOUND

NOT TO SCALE

JULY 2017

EA PROCESS

Figure No. 2

BluePlan ENGINEERING

Map 15: Recommended Stage 2 Assessment Methodology

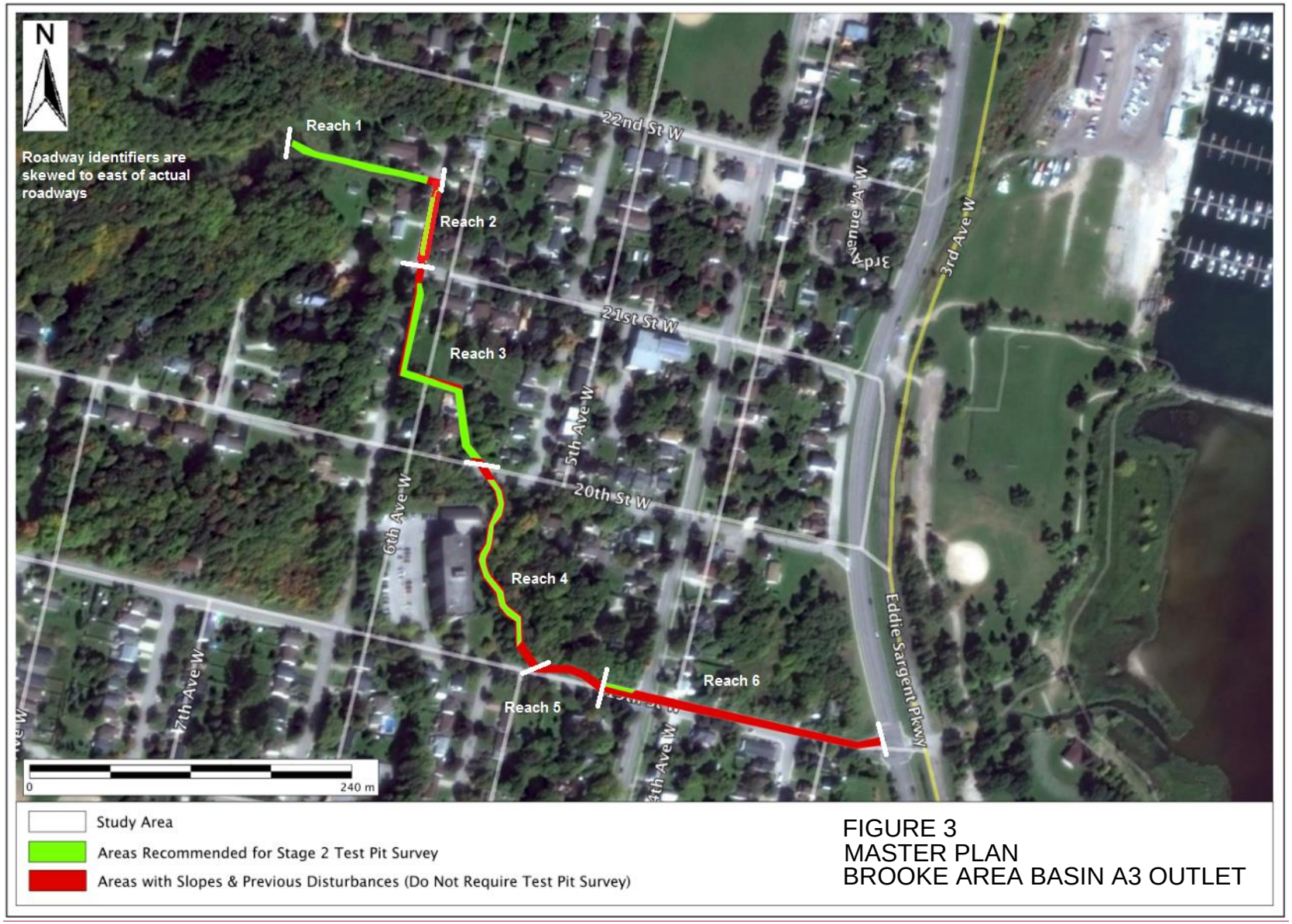
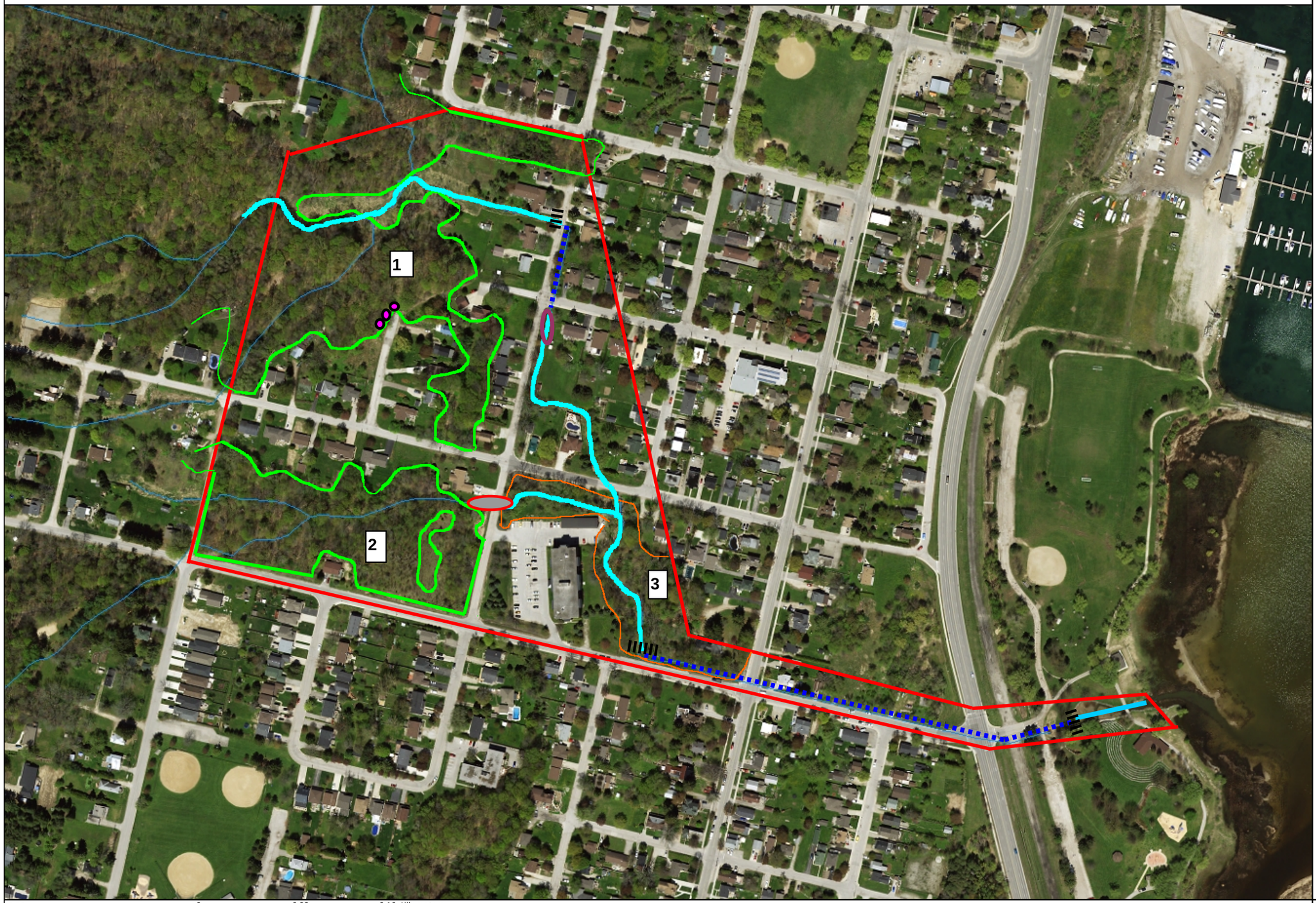


FIGURE 3
MASTER PLAN
BROOKE AREA BASIN A3 OUTLET

Grey County

Figure No. 8: Natural Heritage Features



Legend

- Watercourses
- General Study Area
- Significant Woodlands : Polygon 1 & 2
- Woodland: Polygon 3
- Butternut: ESA Flora
- Snapping Turtle Sighting: Special Concern Species
- Open Waters, Confirmed Fish Habitat
- Buried Pipe Waters, Fish Habitat for Movement
- Grate Barrier: Prevention of Upstream Large Fish Movement
- Other Fish Barriers

Remaining watercourse sections do not directly support Fish Habitat but do provide indirect functions to downstream Fish Habitat

FIGURE 4
MASTER PLAN
BROOKE AREA BASIN A3 OUTLET

0.16 0 0.08 0.16 Kilometers

WGS_1984_Web_Mercator_Auxiliary_Sphere

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THIS MAP IS NOT TO BE USED FOR NAVIGATION

Notes

Part Brooke Area Basin A3
City of Owen Sound