Subwatershed Study Phase 3: Management, Implementation, and Monitoring Plan

Smithville Subwatershed Study and Stormwater Management Plan
Township of West Lincoln
TPB198161

Prepared for:

Township of West Lincoln
318 Canborough Street, Smithville, ON L0R 2A0

2/24/2023

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318 Canborough Street, Smithville, ON L0R 2A0

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2/24/2023

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1.0 Introduction

The Township of West Lincoln (The Township) has initiated a Master Community Planning Study to plan for future growth in the Community of Smithville. The Master Community Plan is being developed under the Planning Act and supporting infrastructure planning is being conducted in accordance with the requirements of the Municipal Engineers Association's Municipal Class Environmental Assessment (EA) for Water, Wastewater and Roads (as amended in 2015) Master Plan. This process includes the preparation of a Subwatershed Study (SWS), as a companion study being conducted in parallel with the Master Community Plan Study and Servicing Studies. The overall purpose of this SWS is to:

a. Inventory, characterize and assess natural hazard, natural heritage and water resource features and functions within the study area (i.e., constraints to development);

b. Provide recommendations for the protection, conservation and management of natural hazards, natural heritage, and water resource features within the study area;

c. Provide sufficient detail to support the designation of NHS in Secondary Plans, through the refinement of the Regional NHS; and

d. Provide recommendations for a management strategy, implementation and monitoring plan to be implemented through the Secondary Plan(s) and future site/area specific studies.

The core Work Plan of the SWS process has been structured to be carried out in three (3) phases, which has resulted in three (3) documents/reports, as follows:

- Phase 1: Subwatershed Characterization and Integration,
- Phase 2: Impact Assessment,
- Phase 3: Management, Implementation and Monitoring Plan (this document),

The purpose of Phase 1 (Subwatershed Characterization and Integration) of the SWS is to gain a better understanding of the state, health and general character of the subwatershed. Reviews of existing studies and reports, fieldwork and, where appropriate, modelling has been undertaken, in order to understand the baseline of conditions related to the following key components: Hydrology/Hydraulics, Hydrogeology, Karst Features, Water Quality, Stream Morphology and Aquatic and Terrestrial Resources. These components have been considered and assessed as part of this report to characterize the Subwatershed area's of interest.

Phase 2 (Impact Assessment) involves evaluating the impacts of future planned urbanization of the land use plan, as prescribed by the Master Community Plan. This initial evaluation is intended to provide direction to the Land Use Team, who will then refine the Land Use Plan in accordance with the direction from the first iteration of testing. The refined Land Use Plan (after some integrated consultation amongst all team members) is then advanced for a second round of testing and assessment, as required, as part of Phase 3. Working Targets and preliminary management strategies to address potential impacts associated with future development, as related to the natural environment and stormwater, have been developed. Watercourses and natural heritage features have been assessed and given a constraint ranking, followed by an overall net rating. Any refinements to the Region's NHS have been identified and discussed through this phase.

Phase 3 (Management, Implementation and Monitoring Plan – this report) formalizes the recommendations for water management, including traditional and low impact development practices, as well as specifics related to environmental management, including parameters for stream stability and terrestrial and aquatic system protection and enhancement. This process also includes developing an implementation and monitoring plan, to provide further direction on the implementation procedures related to the plan recommendations, including priorities, specific policies, need for follow-on studies and related study requirements.

In addition to the foregoing, the study includes the preparation of a Stormwater Management Master Plan for the future intensification and infill areas within urban Smithville. This component of the study has built upon the insight and guidance from the three phases of the Subwatershed Study, and has developed the stormwater management plan specific to the future intensification and infill areas, tailored to address local constraints within existing receiving infrastructure in Smithville.

At the conclusion of the SWS, the final reports are to be adopted by Township Council.

2.0 Management Plan

2.1 Introduction

As part of the Phase 2 Impact Assessment, a set of recommendations has been developed to manage the area watercourses, headwater drainage features, and terrestrial features, as well as for managing storm runoff from future urban development. The following section provides details regarding the recommended management plan for the future urban expansion in the community of Smithville.

2.2 Stormwater Management

Stormwater management for the urban expansion area is required to address the following criteria:

- extended detention storage and quantity controls for all future development within the Spring Creek Subwatershed.
- extended detention storage and strategic quantity controls for future development within development areas discharging toward the North Creek and Twenty Mile Creek.
- Provide stormwater quality control to an "Enhanced" standard of treatment, per current Provincial guidelines (ref. MOE, 2003), and address thermal enrichment of urban storm runoff.

The recommended stormwater management strategy based on the criteria is summarized as follows:

- All future development areas are to incorporate extended detention storage within the stormwater management systems for erosion control.
- All future development within the Spring Creek Subwatershed are to incorporate quantity controls to control post-development flows to pre-development levels for all events up to and including the 100 year frequency flow condition.
- The future development areas within the North Creek Subwatershed which drain through private properties external to the development area are to incorporate incorporate quantity controls to control post-development flows to pre-development levels for all events up to and including the 100 year frequency flow condition; those portions of the future development area within the North Creek Subwatershed which discharge directly to the North Creek are not required to incorporate quantity controls above the extended detention storage component of the facility.
- The future development areas within the Twenty Mile Creek Subwatershed which drain through private properties external to the development area are to incorporate incorporate quantity controls to control post-development flows to pre-development levels for all events up to and including the 100 year frequency flow condition; those portions of the future development area within the Twenty Mile Creek Subwatershed which discharge directly to the Twenty Mile Creek are not required to incorporate quantity controls above the extended detention storage component of the facility.
- All future development areas are to incorporate Low Impact Development Best Management Practices (LID BMPs) to maintain water budget and enhance erosion protection within the receiving watercourses.

Various technologies are available to satisfy stormwater management criteria identified herein. The specific technology/technique selected depends upon contributing land use, size of drainage area, and the stormwater management function required. **Table 2.2.1** provides a summary of various practices, and the corresponding function provided by the technology. As the summary above indicates, a variety of stormwater management objectives are required under the recommended plan, hence it is anticipated that a combination of technologies will be required for all future development areas, in order to achieve the requisite objective.

Table 2.2.1. Summary of Stormwater Management Practices and Corresponding Functions

Practice	Flood Control	Erosion Control	Quality Control	Thermal Mitigation	Water Balance	Evapotranspiration	Groundwater Recharge
End-of-Pipe (Wet Pond/Wetland/Hybrid)	X	X	X	X			
Dry Pond	X	X					
Rooftop Detention Storage	X						
Parking Lot Storage	X						
Amended Topsoil		X	X	X	X	X	X
Green Roofs		X	X	X	X	X	
White Roofs				X			
Tree Trench Boxes		X	X	X	X	X	X
Oil/Grit Separators			X				
Rainwater Harvesting		X			X		
Pervious Pipes		X	X	X	X		X
Oversized Pipes	X						
Permeable Pavement		X	X	X	X		X
Soakaway Pits		X	X	X	X		X
Infiltration Trenches		X	X	X	X		X
Bioretention Bumpouts		X	X	X	X	X	X
Grassed Swales			X	X			
Biofilters/Bioswales		X	X	X	X	X	X

In general, the selection of the appropriate stormwater management practice is dependent upon the size (i.e. drainage area) and land use conditions within the proposed development area draining to the specific stormwater management facility. The following general principles have been applied in developing the recommended stormwater management plan:

i. Wet end-of-pipe facilities are preferred, particularly for residential developments, due to their ability to address multiple stormwater management requirements (i.e. quantity, quality, thermal mitigation, and erosion control).

ii. Where drainage areas are insufficient to support an end-of-pipe facility (i.e. generally drainage areas less than 5 ha), source controls (i.e. underground storage, surface storage, LID BMP's, oil/grit separators, vegetated technologies, etc.) are to be applied, with LID BMPs encouraged to address requirements for erosion control and water budget.

iii. LID BMP's are to be applied throughout the urban expansion area, with more passive and distributed LID infiltration BMPs encouraged (i.e. increased topsoil thickness, bioswales), versus LID infiltration BMPs which promote enhanced permeability (i.e. sand columns).

The above long list of stormwater management practices has been reviewed with Township of West Lincoln staff to determine the practices acceptable to the municipality for specific land uses. **Table 2.2.2** provides a summary of the practices acceptable to the Township of West Lincoln.

Table 2.2.2. Summary of Acceptable Stormwater Management Practices Within the Township of West Lincoln

SWM Practice	Land Use				Comments
	Residential	Employment	Commercial	Institutional	
End-of-Pipe (Wet Pond/Wetland/Hybrid)	Y	Y	Y	Y	Not acceptable for grade schools (if assumed by Township); emp/comm/inst. generally privately owned; residential pond assumed by Township unless condo development; preference toward wet pond
Dry Pond	Y	Y	Y	Y	Assumption criteria similar to that of wet ponds
Rooftop Detention Storage[1.]	N	Y	Y	Y	Acceptable to Township if privately owned
Parking Lot Storage[1.]	N	Y	Y	Y	Acceptable to Township if privately owned
Underground Storage Tanks/Superpipes[1.]	N	Y	Y	Y	Acceptable to Township if privately owned
Amended Topsoil	Y	Y	Y	Y	Acceptable to Township; applicable on private property and in public ROWs and public properties
Oil/Grit Separators	Y	Y	Y	Y	
Rainwater Harvesting	Y	Y	Y	Y	Privately-owned
Soakaway Pits	Y	Y	Y	Y	Can be considered as alternative to SWM facility for stormwater quality control, and in combination with other practices for erosion/quantity control, provided they are privately owned
Infiltration Trenches	Y	Y	Y	Y	Can be considered as alternative to SWM facility for stormwater quality control, and in combination with other practices for erosion/quantity control, provided they are privately owned
Bioretention Bumpouts	Y	Y	Y	Y	Can be considered as alternative to SWM facility for stormwater quality control, and in combination with other practices for erosion/quantity control, provided they are privately owned
Grassed Swales	Y	Y	Y	Y	
Biofilters/Bioswales	Y	Y	Y	Y	Can be considered as alternative to SWM facility for stormwater quality control, and in combination with other practices for erosion/quantity control, provided they are privately owned

NOTE: [1.] Rooftop storage, parking lot storage, and underground storage are acceptable if they are under private ownership by a condominium corporation.

The recommended stormwater management plan is presented in Drawing WR-1. It should be noted that the facility locations presented in Drawing WR-1 are conceptual in nature, and may be revised as part of subsequent stages of planning and environmental study. The following sections provide further details regarding the stormwater management plan for urban expansion area. The unitary sizing criteria and corresponding stormwater management facility sizing is to be verified and refined as part of future studies.

2.2.1 Erosion Control

Unitary storage and discharge criteria have been established as part of the Phase 2 Impact Assessment to mitigate erosion impacts at key locations within Twenty Mile Creek Watershed, North Creek Watershed, and Spring Creek Watershed. These criteria have been developed, premised upon providing extended detention storage within the end-of-pipe facilities to maintain the volume of runoff above the critical flow rate at existing levels, i.e. <5% residual increase in duration and volume of critical flow exceedance, and facility drawdown times generally five days or less. The unitary storage and discharge requirements within the end-of-pipe facilities for erosion control are presented in **Table 2.2.3**.

Table 2.2.3. Stormwater Management Facility Sizing Criteria for Erosion Control – Twenty Mile Creek, North Creek, and Spring Creek

Quantity Component	Cumulative Unitary Volume (m^3/impervious ha)	Unitary Discharge (m^3/s/ha)
Erosion	400	0.001

2.2.2 Flood Control

Unitary storage and discharge criteria have similarly been established as part of the Phase 2 Impact Assessment to mitigate increased flood potential at key locations along the Twenty Mile Creek Main Branch as well as along minor tributaries within Twenty Mile Creek Watershed downstream of the urban expansion area, including within the North Creek Subwatershed and the Spring Creek Subwatershed, resulting from the future development, for all events up to the 100 year return period storm. The unitary storage and discharge for flood control is presented in **Table 2.2.4**.

Table 2.2.4. Unitary Storage and Discharge Criteria for Flood Control

Node	Location	25 year		100 year	
		Cumulative Unity Volume (m3/imp.ha)[1.]	Unitary flow (m3/s/ha)	Cumulative Unity Volume (m3/imp.ha)[1.]	Unitary flow (m3/s/ha)
Twenty Mile Creek					
JS26D	Young Street	700	0.017	900	0.028
WC17	confluence; north of CNR	1000	0.017	1200	0.028
WC20	trib, South of West Street	600	0.016	900	0.037
WC116	810m+/- West of S Grimsby Rd 6	700	0.013	900	0.030
JS43US; DICBMH_418	Las Road; Nornak Road	700	0.024	1000	0.040
JS32D	D/S of Townline Road	700	0.053	950	0.095

Node	Location	25 year		100 year	
		Cumulative Unity Volume (m3/imp.ha)[1.]	Unitary flow (m3/s/ha)	Cumulative Unity Volume (m3/imp.ha)[1.]	Unitary flow (m3/s/ha)
WC11; WC12	130 m+/- U/S of Hwy 20; 140 m+/- D/S of Hwy 20	800	0.012	1000	0.017
North Creek					
OF6	east of Port Davidson Rd	800	0.025	1000	0.037
OF7 +OF15	trib, west of Shurie Road	750	0.038	950	0.081
Spring Creek					
WC15	200m+/- S/E of South of Spring Creek Rd	800	0.012	1000	0.025

NOTE: [1.] Cumulative unitary volumes are inclusive of extended detention storage requirements for erosion control (ref. Table 2.2.3).

2.2.3 Stormwater Quality Control

Stormwater quality control for the future development is required to control runoff to an "Enhanced" standard of treatment, per current Provincial standards (ref. MOE, 2003). Wet ponds have been advanced, as the Township's preferred type of end-of-pipe facility for providing stormwater management, due to the opportunities to incorporate multiple stormwater management functions within the facility (i.e. stormwater quality, erosion, and quantity/flood control). In addition, areas recommended to incorporate source controls for stormwater management have been identified, where the size of contributing drainage area and/or impervious coverage is anticipated to be too small to support wet pond facilities. The estimated permanent pool and extended detention storage volumes for the end-of-pipe wet pond facilities are presented in **Table 2.2.5** based upon current Provincial Criteria (ref. MOE 2003) for stormwater quality control, and the sizing criteria for flooding and erosion control presented in **Table 2.2.3** and **Table 2.2.4**. The total storage volumes for areas incorporating source controls are summarized in **Table 2.2.6**.

Table 2.2.5. Stormwater Management Facilities Characteristics

Facility Reference ID[3.]	Estimated Imp. Coverage (%)	Drainage Area (ha)	Required Volume (m^3)					Estimated Facility Area Requirements (ha)[2.]
			Permanent Pool	Water Quality	Erosion[1.]	Flood Control	Total	
Twenty Mile Creek								
SU10	59%	38.9	7,680	7,824	9,235	11,545	20,780	1.41
SU16	48%	10.3	1,552	1,784	1,963	2,700	4,663	0.35
SU17	58%	15.3	2,926	3,025	3,538	-	3,538	0.28
SU18	84%	6.3	1,843	1,555	2,093	3,140	5,233	0.39
SU19	80%	13.4	3,764	3,254	4,301	6,452	10,753	0.76
SU20	76%	15.9	4,162	3,716	4,797	7,195	11,992	0.84
SU21	30%	13.2	1,123	1,650	1,580	3,090	4,740	0.36
SU22	59%	8.8	1,726	1,760	2,076	3,115	5,191	0.39
SU24	49%	14.5	2,255	2,561	2,836	5,672	8,508	0.61

Facility Reference ID[3.]	Estimated Imp. Coverage (%)	Drainage Area (ha)	Required Volume (m^3)					Estimated Facility Area Requirements (ha)[2.]
			Permanent Pool	Water Quality	Erosion[1.]	Flood Control	Total	
SU28	30%	9.7	826	1,213	1,162	2,272	3,485	0.27
SU3	54%	20.0	3,491	3,758	4,290	5,363	9,653	0.69
SU33	85%	5.3	1,603	1,338	1,817	2,271	4,088	0.31
SU4	64%	20.0	4,289	4,207	5,088	6,360	11,448	0.80
SU5	62%	17.0	3,574	3,542	4,255	6,383	10,638	0.75
SU7	46%	17.1	2,469	2,897	3,152	-	3,152	0.25
SU8	62%	15.7	3,244	3,240	3,873	-	3,873	0.30
North Creek								
SU11	58%	16.6	3,195	3,297	3,861	-	3,861	0.30
SU12	60%	7.3	1,454	1,477	1,746	-	1,746	0.15
SU13	63%	29.8	6,303	6,224	7,495	-	7,495	0.54
SU14	65%	10.2	2,236	2,169	2,643	-	2,643	0.21
SU15	57%	13.3	2,468	2,584	2,999	4,499	7,498	0.54
SU9	40%	28.7	3,476	4,424	4,623	-	4,623	0.35
Spring Creek								
SU1	80%	17.5	4,889	4,228	5,588	8,381	13,969	0.97
SU2	80%	31.4	8,804	7,613	10,062	15,093	25,155	1.68
SU6	58%	20.4	3,896	4,032	4,712	7,069	11,781	0.83
SU23	70%	5.3	1,272	1,185	1,484	2,227	3,711	0.29
SU29	30%	39.1	3,335	4,899	4,692	6,832	11,731	0.82

NOTE:
1. Erosion control volumes calculated based upon sizing criteria presented in Table 2.2.3; the greater of the extended detention storage for water quality or erosion control has been used to calculate total facility volume requirements.
2. Facility footprints for end-of-pipe facilities providing 100 year control only (i.e. no Regional Storm control) have been estimated assuming 2.5 m total detention storage above the permanent pool water level, assuming side slopes of 3V:1H.
3. Reference Drawing WR-1 for location of proposed facilities

Table 2.2.6. Source Control Storage Volume Summary

Site Reference ID[2.]	Estimated Imp. Coverage (%)	Drainage Area (ha)	Required Volume (m^3)			
			Water Quality	Erosion[1.]	Flood Control	Total
Twenty Mile Creek						
SU26	30%	4.2	100	506	1,012	1,518
SU27	30%	3.9	92	465	581	1,046
SU30[3.]	85%	4.4	178	1,509	-	1,509
SU41[3.]	85%	1.0	40	337	422	759
North Creek						

SU25	66%	4.4	147	1,152	1,584	2,736
SU31	60%	3.3	103	782	1,077	1,859
SU34	66%	2.7	91	718	1,076	1,794

NOTE:
1. Erosion control volumes calculated based upon sizing criteria presented in Table 2.2.3; the greater of the extended detention storage for water quality or erosion control has been used to calculate total facility volume requirements.
2. Reference Drawing WR-1 for location of proposed facilities
3. LID infiltration not recommended due to potential karst hazards

2.3 Karst and Groundwater

The proposed development is anticipated to reduce groundwater recharge and increase surface runoff volume. Green infrastructure and LID BMPs are critical to also maintaining the karst water budget. This would necessarily include LID BMPs which promote infiltration, in order to maintain the groundwater recharge component of the water budget.

The most significant karst sinkholes (pertaining to size and flow) lie within the western portion of study area, and due to potential karst hazards, more passive and distributed LID infiltration BMPs are encouraged (i.e. increased topsoil thickness, bioswales), versus LID infiltration BMPs which promote enhanced permeability (i.e. sand columns). These areas are presented on Drawing WR3 of the Phase 2 report. As noted further in this report, all karst features identified as part of this Subwatershed Study, as well as any new features identified through the subsequent stages of planning and design, are to be assessed as part of future MESPs, and management recommendations established accordingly in consultation with NPCA.

Seven karst sinkholes have been identified and described within the urban expansion area. Three of these - NW 2, NW 3 and SW 2 have been designated as high constraint; two have been designated as moderate constraint – NW 1 and SW 1; and two – SE 1 and SE 3 – have been designated as having a low constraint. In general, management alternatives range from retaining in-situe to continue their surface water and karst roles and applying a protective buffer to restrict development impacts, to either removing the feature or bypassing flows to the feature. High constraint features are recommended to remain in place but applying stormwater management measures to ensure future development does not result in higher peak flows which would exacerbate flood potential, and also managing change to water budget to prevent potential expansion of the facture on the landscape, and maintain existing flows otherwise local flooding will be exacerbated.

NW 2 is located within the uppermost reach of a small drainage channel (stream reach TM4[5]1-2-3) near the local height of land. Its location suggests the possibility of the presence of a paleokarst feature. If so, this could be an area of higher instability. It is recommended to leave this sinkhole in place and buffer. Although ideally it should be traced to its outlet, this is anticiapted to be extremely difficult given its upstream location and lack of significant flow during the snowmelt period. This feature is considered to be a hazardous site, and hence should follow NPCA policies for hazardous sites. It is thus recommended that this feature be protected in-situ with a 50 m buffer. Stormwater management within the upstream development area should maintain pre-development peak flows and water balance.

NW 3 is located at the downstream end of a tributary that flows primarily under snowmelt conditions and much of the spring period (reach TM4[5]2). It is located within a treed valley, hence has natural vegetation occupying its immediate riparian zone. This feature is considered to be a hazardous site, and hence should follow NPCA policies for hazardous sites. It is recommended that this feature be protected in-situ with a 50 m buffer, to fulfil its current watershed and karst role. Furthermore, stormwater management within the upstream development area should maintain pre-development peak flows and water balance. Dye tracing is also recommended and should have a greater chance of success given its flow regime,

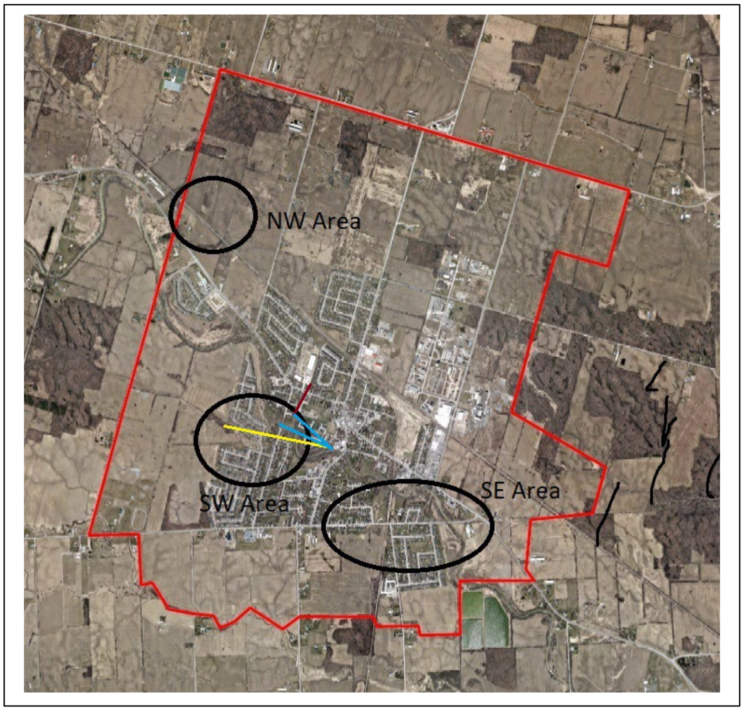
SW 2 is also located within an active, naturally vegetated stream channel and likely has the greatest flow volume and period of all sinkholes in the study area (reach TM4[2]2). This should result in a successful dye trace which may have already been undertaken by the developer's karst consultant. This feature is considered to be a hazardous site, and hence should follow NPCA policies for hazardous sites. It is recommended that this feature be protected in-situ with a 50 m buffer, to fulfil its current watershed and karst role. Furthermore, stormwater management within the upstream development area should maintain pre-development peak flows and water balance.

NW 1 is a small streamsink at the lower end of a small channel within the study area (reach TM4[5]1-2). It is interpreted to be a relatively recent feature formed due to back-flooding from an under-sized culvert beneath the rail line. Not considered to be a structural hazard, it is of concern because it is located within the road allowance for South Grimsby Rd 6 which could lead to flooding hazards The recommended management action at this location is to enlarge the culvert beneath the tracks and fill-in the existing depression.

It is further recommended that all culverts beneath the railway in the development area should be analyzed for peak flow conveyance to determine whether they represent a hydraulic constraint generating backwater conditions which could trigger karst drainage in the future. Should this be confirmed, the culverts should be resized to improve conveyance and mitigate the backwater condition; these analyses may be completed as part of future studies as noted below.

SW 1 is also interpreted to be a relatively recently formed sinkhole related to original forest removal and conversion to open fields. It is currently expanding and reveals significant instability as shown by active sloughing of soil into a prominent vertical throat. This feature is considered to be a hazardous site, as it is potentially dangerous to humans, and is an active system potentially contributing contaminants to the receiving watercourse. As such, it is recommended that this feature be excavated and grouted, subject to following NPCA policies for hazardous sites. Stormwater management within the upstream development area should maintain pre-development peak flows and water balance.

Sinkholes of low constraint (SE 1 and SE 3) can be left in-place or grouted. In either case, the features should not continue to receive surface water flows.


NW Area
SW Area
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NW 1
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SW 2
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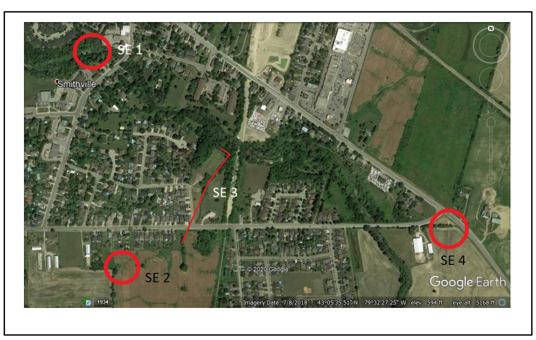
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The potential impacts from the reduction in infiltration and subsequent reduction in groundwater levels, groundwater recharge and groundwater discharge are mitigated through various stormwater management techniques where the groundwater component of the water budget is functionally significant. Employing Low Impact Development infiltration techniques will aid in maintaining existing overburden quantity and quality of recharge, associated groundwater levels, potential groundwater discharge as well as recharge to the lower aquifers. Specific infiltration techniques will be provided depending on the characteristics of the more local surface water catchment area. These may include more passive infiltration and distributed infiltration practices (i.e. amended/increased topsoil thickness, rain gardens), which can manage potential impacts to both groundwater quailty and quantity. Infiltration type measures such as bioswales, pervious pipes and permeable pavements would require the water table to be lower than the bottom of the structure. A 1 m separation is generally required. Site specific design will be addressed at future stages which would take into account the height of the water table and soil characteristics.

The construction of buried services below the water table has the potential to capture and redirect groundwater flow through more permeable fill materials typically placed in the base of excavated sewer and utility trenches. Best management practices may involve the use of anti-seepage collars or clay plugs surrounding the pipes to provide barriers to prevent groundwater flow along granular bedding material and erosion of the backfill materials. It is noted that backfill for decommissioning of any existing sewer lines should consider low hydraulic conductivity material to prevent preferential groundwater flow.

Dewatering is typically expected for construction of services where the excavations occur below the water table. Over much of the study area, the surficial soils encountered during servicing are expected to be predominantly silty clay till and typically this is low hydraulic conductivity material and may not produce much water. There may, however, be areas where the weathered overburden may produce more significant volumes of groundwater seepage or there may be locations where coarser-grained sand or gravel layers could be encountered. The dewatering requirements may vary significantly depending on the type of geologic materials encountered at the excavation, the season and climate conditions, and the depth and size of the excavations. Shallow, highly fractured bedrock may require higher dewatering quantities. The potential impacts may be more significant where infrastructure is in close proximity to wetland features or water courses. Dewatering systems where the volume of water collected exceeds 50,000 L/day require a Permit to Take Water (PTTW) from the MECP. Even for areas where the construction is only expected to encounter till soils, as a contingency, it is generally recommended that the contractor apply for and obtain a PTTW prior to construction activities in the event that unexpectedly high flows are encountered. The MECP will require a detailed groundwater management plan for the permit application to address local impacts to groundwater levels and for the management of the quantity and quality of the discharge water.

2.4 Watercourses and Headwater Drainage Features

Characterization and evaluation of area drainage features has been a key component of this Subwatershed Study to develop a characterization of the features, establish associated constraints, and direct opportunities and recommended practices for management. Management recommendations for watercourses and headwater drainage features (HDFs) have been developed based on the Impact Assessment results (quantitative and qualitative), and through the application of Table 1 in Appendix C.

2.4.1 Surface Water Feature Definition, Classification, and Management

Stream morphology is a key aspect that has been considered in developing the definitions and management opportunities for watercourses and HDFs as detailed in Table 1 of Appendix C. Through Phase 1, Reach and HDF evaluations led to the determination of appropriate constraints and management recommendations, respectively, from which impacts due to proposed land uses were evaluated (Phase 2), with general preferred management recommendations. In addition to geomorphology, this classification and management structure integrates the findings and recommendations from the other study disciplines for: Surface Water, Fisheries, and Terrestrial Ecology. The following provides feature definitions used in the current subwatershed study.

***Watercourses*:**

Watercourses are defined as permanently to intermittent flowing drainage features with defined bed and banks. They exhibit clear evidence of active channel process including planform, profile, and material sorting, with evidence of a balance between erosion and deposition throughout the reach. They are often second-order or greater, but may be first order when verified by the practitioner(s). Watercourses are currently identified as regulated features by the NPCA, and fish are typically found within these features.

NPCA watercourse mapping (Contemporary Watercourse Mapping) was used to identify watercourses and HDFs as a scoping exercise, and field confirmation confirmed and/or updated feature identification and extents. In general, their drainage area exceeds 50ha.

***Headwater Drainage Features (HDFs)*:**

Non-permanently flowing drainage features that may not have defined bed or banks have been designated as HDFs. The presence of bed and bank definition within these features may be attributed to anthropogenic intervention (e.g. cutting a drainage feature into the surface), or seasonally as spring freshet concentrates flows in depressions, causing channel development into surfaces lacking vegetated cover. HDFs are first order intermittent and ephemeral channels, swales and connected headwater wetland, but do not include rills or furrows. They are currently not identified as a regulated feature, and fish may or may not be found within the feature. The contributing drainage area is less than 50 ha.

Stream management is to be approached on a reach or feature basis as these units display relative homogeneity with respect to form, function, and habitat. Key management practices, in terms of stream morphology, are recommended according to the geomorphic constraint rating, or HDF management recommendation. Management strategies may include several options, or specific guidance. **Table 2.4.1** summarizes the geomorphological components of the management strategy for watercourses, while management recommendations for HDFs generally follow that of the TRCA/CVC protocols as summarized in the following subsection.

Table 2.4.1. Watercourse Classification – Geomorph9ology Component

Watercourse Classification	Geomorphological Definition	Proposed Management Strategy
Red Classification (Solid Red Line on Map) – High Constraint	These corridors contain a defined active channel with well-developed channel morphology (i.e., riffle-pool), material sorting, floodplain development, and/or a well-defined valley. These corridors offer both form and function and have been identified as 'no touch' reaches that must be maintained undisturbed in their present condition. They have	Watercourse to be protected with meander belt in current form and location. Minor modification through rehabilitation/enhancement may be acceptable in select location where it is a benefit to the system. Options • Do nothing: Corridors must remain where they are in the landscape. Delineate meander belt or erosion hazard corridor depending on valley classification.

Watercourse Classification	Geomorphological Definition	Proposed Management Strategy
	usually been deemed high-quality systems that could not be re-located and replicated in a post-development scenario.	Determine additional regulatory setbacks as required. • Channel adjustments may be permitted at select locations given sufficient rationale (e.g. addressing an immediate high-risk erosion hazard, or a critical servicing issue). Natural channel design to be implemented for any adjustments. • Degraded (channelized and straightened) portions may by realigned using natural channel design, if realignment does not negatively impact rehabilitation.
Blue Classification (Solid Blue Line on Map) – Medium Constraint	These reaches have well-defined morphology (defined bed and banks, evidence of erosion/sedimentation, and sorted substrate). These reaches maintain geomorphic function and have potential for rehabilitation. In many cases, these reaches are presently exhibiting evidence of geomorphic instability or environmental degradation due to historic modifications and land use practices.	Watercourse to be protected with applicable meander belt and setbacks. Realignment may be acceptable when deemed appropriate for restoration and enhancement. Options • Do nothing: Leave the corridors in their present condition and develop outside of their boundaries: Delineate appropriate meander belt or erosion hazard corridor depending on valley classification. Determine additional regulatory setbacks as required. • Enhance existing conditions: maintain the present location of the corridor but enhance the existing conditions (e.g. bank stabilization, re-establish a meandering planform, connect channel to functioning floodplain). Natural channel design to be implemented for any adjustments. • Re-locate and enhance existing conditions: many of the reaches within the study area have undergone extensive straightening and modification for agricultural drainage purposes. As such, they are not as sensitive to re-location and would benefit from enhancements such as the re-establishment of a meandering planform with functioning floodplain and development of a riffle-pool morphology (i.e. natural channel design). In the event that these reaches are re-located, the corridor width (meander belt width/hazard corridor) associated with each

Watercourse Classification	Geomorphological Definition	Proposed Management Strategy
		reach must, at a minimum, be maintained. For reaches that have been straightened, appropriate surrogate reaches or empirical methods should be applied to determine the meander belt corridor. Natural channel design to be implemented for any realignment or adjustments.

It should be noted that the constraint ranking for each reach my vary between disciplines, however the final constraint ranking represents the most limiting classification (high, medium). During the Phase 1 characterization, any features were documented to be of 'low' constraint were evaluated as an HDF where timelines permitted. The integrated multi-disciplinary constraint assessment of the area drainage features is presented in Table 2 Appendix C.

Headwater Drainage Features

The classification and evaluation methodology in this Subwatershed Study first classifies individual HDFs, then applies a management recommendation. The approach first applies the guidelines set by TRCA/CVC (2014) to determine a feature classification ("**HDFA Classification**"), which may then be carried forward to "**Final Management**" or altered based on site opportunities, or other constraints that the protocol may not capture (e.g. feature protection based on location within a significant valley or terrestrial feature). There are several instances where HDFs could not be evaluated during the course of this study due to site access, however, final management recommendations have been provided based on the feature presence (as mapped) within a valley or terrestrial feature, or to maintain continuity of upstream function at a minimum (e.g. applying a 'conservation' recommendation for an unevaluated HDF in order to maintain a surface ecological linkage). The following briefly summarizes management strategies for HDFs, with details available in Table 1 of Appendix C:

- **Protection feature** (red-white dashed streams) – Protect in place and maintain contributions to and from feature, to be incorporated into the NHS
- **Conservation feature** (yellow streams) – where a linkage has been identified without any alternative opportunities, conservation features can be incorporated into the NHS. Realignment permitted provided linkages are maintained. Also, realignment may be permitted within existing buffer areas, provided that the feature realignment/creation supports the objectives of the buffer.
- **Mitigation feature** (green streams) – maintain function to downstream features. These features are typically highly modified but provide some downstream function (e.g. supply of sediment and water, or seasonal fish habitat). Some complexities like tile drains can be replicated through SWM, while fish habitat may be replicated within another nearby feature, or downstream in the floodplain (e.g. pond creation).
- **No management required** (green-dashed streams) – feature can be removed from the surface without any implication to the system.

Some drainage features have been identified as requiring additional evaluation at the MESP stage as access (i.e. Permission to Enter) for certain locations was not available during the Subwatershed Study process, or because additional environmental study (e.g. wetland evaluations) are required to confirm and/or update their management recommendation. These features are identified in Table 3, Appendix C, and Drawing FG-2.

Management recommendations for HDFs within the study area range from 'no management' to 'protection', which distinguish the different functions and management requirements. The headwater drainage feature summary table in Appendix C (Table 3) provides an overall review of feature evaluation, recommendations, and rationale. The "Final Management" recommendation determines the strategy and opportunities for each. which may or may not differ compared to the HDFA Classification (feature characterization) based on site specific rationale. Final Management recommendations were developed for some HDF reaches based on criteria described below.

HDFs within Linkages: Final Management Recommendations for HDFs that *form* Linkages were assigned a 'Conservation' status to ensure the features are retained within the linkage (e.g., SC1(6)1, SC1(6)2, TM4(3)1 and TM4(3)2). For Unevaluated HDFs that form Linkages, "Conservation - Further Evaluation Required" applied as the feature should at a minimum be retained as part of the linkage but the specific hydrological, terrestrial, aquatic or riparian conditions need to be assessed in the field (e.g., SC1(7)1 and SC1(7)2)). For HDFs that do not form the ecological linkage (e.g., perpendicular to linkage) the Final Management Recommendation was not altered.

If a linkage corridor is recommended for relocation to a more ecologically preferred location on the landscape, and it is determined that a surface water (hydrological) function is not required for the linkage, then the HDF in the origional location should be managed based on the original HDF classification and the inherent management recommendation(s) (i.e. "HDFA Classification").

HDFs within high-constraint watercourse valleys: HDFs located within the erosion hazard limits of High constraint watercourses were assigned a Final Management Recommendation of 'Protection' by virtue of their location within a higher constraint terrestrial feature. New reach breaks were introduced at the lateral limit of watercourse corridors to facilitate this distinction. Where a feature Final Management recommendation has been modified from 'no management required' to 'protection', the feature will remain on the landscape, however, there is no requirement for the provision of water to the feature.

The Final Management Recommendations for HDFs within the meander belts of Medium Constraint watercourses were not altered. It is recommended that the downstream function of HDFs within Medium Constraint meander belts be maintained to maintain watercourse conditions.

HDFs and Karst features: Following a TAC meeting and subsequent consultation with the Township and SWS team, it was agreed that the Subwatershed Study would classify HDFs connected to karst features as 'Mitigation' or 'Conservation' (i.e., cannot be 'No Management'), with the caveat that subsurface connections are to be determined as part of future studies to finalize the feature classification. This is applicable to HDFs connected to Medium or High Constraint karst features. Management recommendations for HDFs connected to Low Constraint karst features are not impacted (i.e., may be 'No Management') as Low Constraint karst features may be filled in.

Erosion Hazard Corridors

Watercourse features and associated erosion hazard limits (i.e., meander belts for unconfined systems, and stable top of slopes for confined systems) should be incorporated into the development of the NHS in order to protect the feature and resident aquatic habitat, as well as to mitigate risk associated with the hazard. Should a medium constraint watercourse be realigned or relocated, a design meander belt and appropriate setbacks should be developed and then incorporated into the NHS. Where necessary, natural channel design may be used for high-constraint (red) watercourses to address localized issue or permit the construction of essential infrastructure. In cases where corridor enhancements are recommended, including realignment of medium constraint streams, it will be necessary to refine hazard limits for confined and unconfined systems as part of future studies (i.e., MESPs) based upon refinements to the anticipated flow regime, design channel geometry and degree of stability (i.e. migration). Hazard delineations are not required for existing or realigned/enhanced HDFs, and the Provincial Policy Statement (2020) does not identify HDFs as erosional features, or features which require a hazard setback. Erosion hazard corridors for watercourse reaches within the study area are presented in Drawing FG-1.

Corridor Enhancements and Rehabilitation

Enhancements of watercourse corridors should include the removal of barriers to the movement of water and sediment in the downstream direction, and fish in the upstream direction (e.g. severe debris jams/dams, weirs), provided they do not serve a necessary function (e.g. grade control). In the case of grade control weirs, opportunities to replace the structure with natural channel design features (e.g., a series of riffles) should be explored.

Rehabilitation options to improve the geomorphic function of watercourses, primarily those of medium constraint classification that been previously channelized or modified by agricultural practices, may include:

- **Re-establish a functioning floodplain:** Creating a bankfull channel with better connectivity to a wider floodplain, or terrace, allows flows and fine sediment to overtop the banks during periods of high-water levels. This excess water would then travel across the floodplain, dissipating energy across a much larger surface area. Vegetation would also decrease velocity, promoting deposition, while also reducing erosion issues downstream
- **Provide a low-flow channel:** Creating a low-flow channel will provide storage and refugia for aquatic organisms during drought conditions as well as reducing the potential for sedimentation within the channel.
- **Re-establish a 'natural' meander planform:** Using reference reaches as an indication of channel planform prior to agricultural influences; it is obvious that historical ditching and straightening has removed the natural meander planform of many reaches within the study area. This channelization effectively increases stream gradient and, consequently, the energy available to erode bed and banks. The restoration of a more 'natural' meandering planform can help to re-establish more natural geomorphological processes and increase geomorphological diversity.
- **Re-establish riparian vegetation:** Re-establishing a healthy riparian vegetation community can help increase bank stability in addition to creating shading and improving fish and wildlife habitat. The provision of bank vegetation also provides a source of woody debris and organic matter for the stream, as well as providing a natural buffer to reduce fine sediment input from tilled agricultural fields.

Maintenance of Channel Length, and Sediment Supply

Stream length and sinuosity should be maintained at a minimum unless rationale is provided where a balance cannot be maintained between pre- and post- development conditions. HDF assessments and management recommendations for each act to maintain the functional role of each feature to supply water and sediment in the downstream direction. However, it is also noted that sediment supply / transport under existing conditions is influenced by human activities, including agricultural land management and potential inputs from road surface drainage, and therefore does not represent "natural" conditions. 'Conservation' and 'Mitigation' management recommendations maintain connectivity, and the supply role of each feature. Some features may be replicated with LID practices or swales to maintain the primary function(s).

Channel design and subsequent channel management practices will be required to encourage the delivery of natural sediment supply. Streams in corridors should be designed such that natural erosion may occur in keeping with the nature of the channel, thereby replicating the natural potential to generate sediment for transport downstream. Naturalization of swales in urban areas should be encouraged where possible to facilitate natural sediment generation.

It should be noted that it is not necessarily desirable to replicate current sediment supply conditions in the headwaters since these are heavily impacted by agricultural practices, resulting in potential higher volumes of fine sediment conveyance of poor quality than would occur under more "natural" conditions during periods when the surface is bare and vegetation has yet to establish. Otherwise, these features are controlled by vegetation and in general, not considered erosive.

Roads and Road Crossings

Road and road crossing designs should avoid requiring alteration to high-constraint watercourses wherever possible. Interactions, primarily at crossings, should be oriented perpendicular to the watercourse. Similarly, 'protection' HDFs should be avoided in the planning and design of roadways. Road crossings should be oriented and sized appropriately with consideration of geomorphic risk factors (e.g., bankfull width, channel stability, erosion rates, meander amplitude). For more detail, refer to "Road Crossings and Alignments" in Section 4.5.2 in the Phase 2 report. The following provides general guidance for crossing siting and sizing includes:

- Geomorphic considerations above (e.g., minimum span based on erosion risk)
- Size appropriately based on hydraulic criteria for freeboard, clearance, and 100 year storm conveyance.
- Wildlife passage (aquatic and terrestrial)
- Minimum spacing of 100 m between crossings, with two channel wavelengths between each crossing (design or existing)
- Avoid or minimize grading within the erosion hazard

Erosion Thresholds and Stormwater Management

Critical discharges determined through the erosion threshold analysis should be applied as stormwater management targets to mitigate adverse erosion downstream following development. At the MESP stage, erosion thresholds should be confirmed or updated as appropriate, based on any revisions to the SWM plan (e.g. pond locations and changes to grading). This may include the selection and evaluation of additional sites.

2.4.2 Drainage Feature Management Recommendations

Recommendations for managing drainage features within the future development areas have been developed based on the Impact Assessment (Phase 2) results (quantitative and qualitative). Several reach boundaries were revised following Phase 2, and mapping and tables have been updated accordingly. In general management recommendations should follow those opportunities in Table 2.4.1. However, site-specific recommendations may be provided in the notes/rational column of the management recommendations tables for watercourses and HDFs (insert reference). There are instances where drainage feature management recommendations have been deferred to subsequent stages of study (i.e. MESP or later), due to a lack of field verification or further field requirements (confirmation/update of findings). Features for which management recommendations are to be determined are identified within the management tables (Appendix C), and within the mapping (Drawing FG-2).

Drawing FG-1 and FG-2 present the hazard corridors and HDF final management recommendations for the Smithville SWS study area, respectively. Full Watercourse and HDF management recommendations (tabular) for the study area are available in Tables 1 and 2 of Appendix C, respectively.

2.5 Natural Heritage System

The Smithville NHS has been developed and identified through Phases 1 and 2 of the SWS, in consultation with the Township, Region, NPCA, TAC, and input from the public. The recommended Smithville NHS comprises 26.3% of the Community of Smithville and 29.6% of the new community expansion lands. It is comprised of Core Areas, Linkages, Conceptual Buffers, and Recommended Restoration Areas, as shown on Map NH-11. Core Areas are comprised of Significant Wetlands, Significant Woodlands, Significant Valleylands, Significant Wildlife Habitat, fish habitat, and habitat for endangered and threatened species. Although there is flexibility in the precise identification of Linkages, Buffers, and Restoration Areas, the size of these as identified through this SWS is required to come close to the 30% cover target aspired to in the Township Official Plan, as well as recommended through this SWS. Policy 10.3.2.a)i. of the West Lincoln OP states that the Township shall *encourage efforts* to achieve the protection of 30% of the land area in forest and wetland cover. The Smithville NHS includes additional areas within it, not just woodlands and wetlands. The complete Smithville NHS is shown on Map NH-12.

Linkages are connections between natural heritage features that provide movement opportunities for species between habitat patches that would otherwise be isolated. They enhance and maintain the viability of specific species populations by providing habitats for various life processes (e.g. breeding habitat vs summer foraging habitat), preserving genetic variability, and allowing populations to recolonize areas where they are no longer found. Linkages also provide some foraging and breeding habitat, as well as provide a buffer function along watercourses and other features. Linkages within the study area are generally mapped as Primary Linkages (200m wide) and Secondary Linkages (50m wide). High constraint watercourses typically require a buffer of 30m, thereby leading to a 60m wide Linkage. Linkage function can be enhanced by locating compatible land uses within or adjacent to them, such as open space, passive recreational parkland, or naturalization and restoration areas. Land uses within the Linkage should consider the function of the Linkage, which is primarily wildlife connectivity. Open space or parkland with passive recreational use may be compatible with Linkages and provide appropriate habitat diversity within the Linkage. Linkage lengths should be minimized and any remnant natural heritage features and areas should be incorporated into the linkage to the greatest extent possible (e.g. hedgerows, thickets). Where a linkage crosses a road, an appropriate wildlife crossing should be designed. Linkages should be naturalized to provide wildlife habitat.

A secondary linkage, 50m in width, is mapped (Map NH-11) connecting the North Creek and Twenty Mile Creek corridors along a former railway line west of Shurie Road. An alternative linkage concept was presented to the SWS team on June 2, 2022, which suggests the be linkage moved to the east alongside the Smithville sewage lagoons; documentation submitted by the proponent (Jonathan Kingma) is included in Appendix A. That linkage concept has been reviewed at a high level, and is considered to meet the objective of connecting the two main creek corridors and reduces the length of the total linkage from 1.5km (Shurie linkage) to 0.87km (lagoon linkage). Both linkage options connect the valleylands through woodlands and Provincially Significant Wetlands. The linkage concepts are to be further reviewed through the Block Plan and MESP process at the next stages of study.

Linkage locations may conflict with other elements of planning for the urban boundary expansion. Where this occurs, linkages may be moved where feasible and where they continue to meet the objectives of the original linkage as shown on Map NH-11, by connecting larger components of the Natural Heritage System.

Buffers are generally recommended to be 30m wide, but may be refined at the MESP stage. Wide buffers provide better protection to the Core Areas they surround and provide additional wildlife habitat, thereby contributing to the natural heritage cover target of 30% as per the Township's current policy 10.3.2.a)i., as well as providing for better climate change resiliency.

Restoration Areas have been identified and recommended where woodlands have been removed in the past, or where a conversion of the land to natural communities is seen as providing a benefit to the NHS as a whole. These areas contribute to the enhancement of existing Core Areas, the natural heritage cover target, and climate change resiliency, leading to a system that is robust and sustainable. Precise restoration area boundaries are to be identified at the MESP stage. Larger restoration blocks are considered more beneficial than smaller areas as these can provide larger blocks of habitat. For instance, certain Recommended Restoration Areas may be best naturalized by creating grassland habitat, which, if large, can provide habitat to some species that require large grassland habitats which are otherwise rare on the landscape. Existing natural heritage features may benefit from enhancement, such as invasive species removal, removal of fish barriers, garbage removal, etc. Restoration of existing natural heritage features should be identified at the MESP stage and beyond.

Linkages, buffers, and Restoration Areas (Map NH-11) are to be naturalized. Naturalization can occur through active restoration of these areas by planting and seeding of native species. Through the development approval processes, it is recommended that detailed planting plans be established for the restoration of these areas adjacent to the proposed development. It is recommended that the active agricultural areas identified for restoration be graded appropriately and amended with additional topsoil. A variety of habitats may be restored, depending on the adjacent natural areas, such as woodlands, wetlands, or watercourses, as well as providing some meadow and thicket habitats. Providing habitat for significant species should be considered. For instance, Milkweed should be included in most seeding plans to benefit Monarch. Native seed mixes should be used along with plantings in a range of sizes (caliper stock, whips, plugs). As noted, it is recommended that the Linkage aligned with the hydro corridor be naturalized in a similar fashion to The Meadoway located in Toronto (TRCA 2019).

Additional areas may be added to the Smithville NHS through the Block Plan/MESP process and/or site specific study, as in the further identification of Significant Wildlife Habitat or habitat for Species at Risk, and the integration of small wetland units, karst, floodplain, or erosion hazard sites. It is recommended that compatible land uses be situated next to the Smithville NHS that will contribute to the protection of natural heritage features and the overall enhancement of the natural environment within the community. For instance, locating stormwater management facilities, Low Impact Development, parks, and schools next to the Smithville NHS can provide further opportunities to enhance the NHS even further, while also providing the public with access to natural areas for their enjoyment, recreation, and nature appreciation. The Smithville NHS provides an opportunity to design the proposed development in an environmentally sensitive way that mitigates climate change, protects and enhances the natural heritage features, and benefits the adjacent development.

A trail network should be considered at the outset of development. Creating a network of trails within the Smithville NHS, especially within the buffer areas, will provide residents with walking trails right away, which will discourage the creation of ad hoc trails. Trails will foster nature appreciation and allow for passive recreation opportunities, which is part of a sustainable community.

The Smithville NHS must be managed and maintained following implementation, to ensure long-term sustainability. This includes stewardship and management opportunities such as the following:

- Managing informal access to the NHS (i.e. rear yards backing on to the NHS should be fenced).
- Establishing a trail network through the NHS will provide for recreational opportunities and discourage footpaths and dumping.
- Removal of invasive species and control of invasive species in the future, to the extent possible.
- Removal of trash and debris, including farm dump sites of vehicles, fencing, and farm implements.
- Nature interpretive signs for education purposes, especially along trails.
- Nest box installation for birds, bats, and pollinators.
- Restoration of buffers, Linkages, and Restoration Areas.
- Naturalization and stewardship of school yards, as these may be linked to the Smithville NHS in the future and will foster an appreciation of nature in children, as well as provide physical and psychological benefits. Naturalization and stewardship of other open spaces is also encouraged as much as possible, such as of parkland, trail corridors, areas of stormwater management, and private property.

Monitoring of the Smithville NHS and adaptive management as required, such as removal of garbage, closure of ad-hoc trails, management of invasive species, planting of native species, etc.

2.6 Climate Change Risk Assessment

It is recognized that the climate patterns have changed over the past decades. As a result, it is generally accepted that the frequency and intensity of the strom events would increase and extreme events and would be more frequently seen. In combination with the future development and increased impervious coverages, the capacity of the storm infrasturctures would potentially be reduced. As well, the impact on flood levels within watercourses would potentailly lead to higher flood risks.

Regulated Watercourses

Potential climate change impacts along regulated watercourses have been evaluated, specifically related to potential impacts to the Regulatory Flood Hazard along the regulated watercourses within the study area. The assessment has been conducted to apply a high-level evaluation of potential impacts, hence is not intended to be binding at this time. This assessment has applied the 12 hour AES synthetic design storms, consistent with the NPCA's HEC-RAS currently approved hydraulic modelling and flood hazard mapping. Simulated frequency flows generated by the continuous simulation and frequency analysis for the Subwatershed Study have been reviewed to develop peak flows for the 250 year return period for the flood hazard mapping. The 250 year return period storm has been applied for the purpose of conducting a sensitivity analysis of potential climate change impacts, and is not intended to be applied for establishing new stormwater management criteria. Based upon a review of the frequency flows generated from the continuous simulation and frequency analysis, the ratio of the 200 and 500 year frequency flow to the 100 year frequency flow has been determined and used as a scaling factor to establish the corresponding return period peak flow rate, for interpolation to determine the scaling factor for the 250 year return period. The results of this assessment have determined that interpolated 250 year frequency flows are approximately 1.2 times the 100 year frequency flows. Scaling factors applied by Wood in other studies, have accounted for peak flow increases ranging from 15% - 25% to account for the climate change impact. Although the scaling factor of 1.2 is considered to be consistent with the approach applied in other studies, the assessment completed for this Subwatershed Study has applied a 25% increase to the 100 year peak flow rate to estimate the 250 year return period peak flow for the climate change assessment

Three regulated watercourses within the study area limits have been assessed for the climate change impact, i.e. the watercourse running west from South Grimsby Road 5 and joining the Twenty Mile Creek Main Branch at Regional Road 20, the watercourse running east from South Grimsby Road 6 and joining Twenty Mile Creek Main Branch west of Wade Road, and the Spring Creek Tributary running south from Industrial Park Road to Townline Road. The comparison of floodlines for the regulated watercourses have been presented on Drawing WR-2. The mapping illustrates that the climate change would have insignificant impact along the regulated watercourses within the study area. the floodline limits are identical for the three regulated watercourses between the future land use condition and the future land use condition with climate change influences.

Stormwater Management Facilities (SWMF)

Potential climate change impacts to stormwater management facility sizing for quantity control has been determined. The PCSWMM model developed for the Phase 2 study has been executed using the 100 year 12 hour AES synthetic design storm, with an additional 25% increase to the IDF to account for the climate change impact. The resultant storage volumes for the proposed storage units have been compared with the required storage volumes based on the SWM criteria established during the Phase 2 study. **Table 2.6.1** indicates that an increase of 19% in storage volumes would be required to accommodate the additional flows due to climate change.

Table 2.6.1. Climate Change Assessment of SWMF Required Volumes

Parameter	Provided	Climate Change Req.	Additions	Percentage Changes
Total Developed Area (ha)	485	485	-	-
Total Impervious Area (ha)	279	279	-	-
SWM Footprint Area (ha)	16.4	19.4[1.]	3.0	18%
Total Storage Volume (m^3)	227,173	269,106	41,933	18%
Note: [1.] Based on the ratio of provided storage volume and footprint				

Minor System Requirement

Potential climate change impacts to minor system design have been determined. A scoped assessment of a typical major and minor system has been completed to assess the change in minor system design (i.e. storm sewer size) required to accommodate the 25 year 12 hour Chicago storm event based upon current IDF relationships. The subcatchments along Brock Street between the rail tracks and the outfall at Twenty Mile Creek have been selected, as they are considered to represent the mixed types of land uses anticipated within future development. The total drainage area of the selected subcatchments include 10.31 ha with 56% of impervious coverage. The size of storm sewer required to convey the peak flow for the 25 year 12 hour Chicago storm event has been determined for this drainage area, and compared against the size of storm sewer currently within the area. The result is summarized in **Table 2.6.2**. The assessment shows that the current storm sewers would need to be upsized by 4 to 5 pipe sizes to accommodate the 25 year peak flows without causing surcharging within the pipes.

Table 2.6.2. Minor System Requirement for the 25 Year Storm Event

Sewer	Current Pipe Diameter (mm)	Current Surcharge Condition	Improvement Pipe Diameter (mm)	Improvement Surcharge Condition	Upsize
STM1186	300	above ground	600	within in pipe	4
STM1185	300	above ground	600	within in pipe	4
STM1182	300	surcharged	600	within in pipe	4
STM1181	300	surcharged	600	within in pipe	4
STM1180	300	surcharged	600	within in pipe	4
STM1233	450	above ground	825	within in pipe	5
STM1231	450	above ground	825	within in pipe	5
STM1232	450	above ground	825	within in pipe	5
C69	450	above ground	825	within in pipe	5

It should be noted that minor and major system designs are to be in accordance with current Town standards (typically 5 year for minor system and 100 year for major system), with allowance for flooding of municipal right-of-way during 100 year storm event for major system conveyance.

A high-level cost-benefit analysis has been completed based upon the findings of scoped analysis of climate change impact. Based on similar previous projects conducted by Wood, $60/m^3 has been assumed for the unitary storage cost for SWM facilities and $2,000,000/ha has been assumed for the unitary land value. The SWM Facility Capital Cost has been calculated as the product of required storage volume and unitary storage cost. The SWM Facility Land Cost has been calculated as the product of SWM Footprint Area and the unitary land value. The approach considers the costs of land and additional upsized infrastructure versus benefits in terms of high-level damages averted. The high-level cost assessment of SWMFs has been presented in **Table 2.6.3**. The comparison shows that the additional storage volumes required for the SWMFs to accommodate the climate change impact would lead to19% increases in cost.

Table 2.6.3. Cost Assessment and Comparison of SWM Facilities Under Existing Conditions and Potential Climate Change Conditions

Parameter	Provided	Climate Change Req.	Additions	Percentage Changes
Total Developed Area (ha)	485	485	-	
Total Impervious Area (ha)	279	279	-	
SWM Footprint Area (ha)	16.4	19.6[1.]	3.2	19%
Total Storage Volume (m^3)	227,173	271,454	$ 44,281	19%
SWM Facility Capital Cost ($)	$ 13,630,380	$ 16,287,264	$ 2,656,884	19%
SWM Facility Land Cost ($)	$ 32,800,000	$ 39,193,497	$ 6,393,497	19%
Total Cost ($)	**$ 46,430,380**	**$ 55,480,761**	**$ 9,050,381**	**19%**
Note: 1. Based on ratio				

The high-level cost assessment of storm sewers has been presented in **Table 2.6.4**. For the scoped area with 56% of impervious coverage and pipe diameters of 300 mm to 450 mm, the cost of upsizing the storm sewers by 4-5 levels has been estimated at approximately 0.7 million, which is approximately 2.5 times the cost for the existing infrastructure.

Table 2.6.4. Cost Assessment and Comparison of Storm Sewers Under Existing Conditions and Potential Climate Change Conditions

Parameter	Existing	Upsized	Diff	Perc_diff
Total Developed Area (ha)	10.31	10.31	-	-
Total Impervious Area (ha)	5.79	5.79	-	-
Impervious Coverage	56%	56%	-	-
Length of Pipe (m)	584	584	-	-
Supply Cost	$75,599	$ 193,186	$117,587	156%
Supply and Install Cost (2.5 times Supply Cost)	**$188,998**	**$ 482,966**	**$293,968**	**156%**
25% Contingency	$47,249	$120,741	$73,492	156%
2.5% Construction Mobilization (Survey, Markup, Hoarding, Laydown Area)	$4,725	$12,074	$7,349	156%
6% Traffic Controls (Signage, Flagmen, Barriers, Permits)	$11,340	$28,978	$17,638	156%
10% Engineering	$18,900	$48,297	$29,397	156%
Total Cost	**$271,211**	**$693,055**	**$421,844**	**156%**

3.0 Implementation Plan

3.1 Introduction

The following section provides an overview of the future study requirements to accompany subsequent stages of planning and design within the urban expansion area for the Community of Smithville, as well as considerations and mechanisms for the phasing and financing of the development.

3.2 General Implementation Process

The urban expansion area for the Community of Smithville has been subdivided into contiguous blocks, representing areas with common infrastructure for servicing and transportation. At the next stage of planning, the land use for the blocks will be refined to develop more detail for the respective Block Plans. These Block Plans may represent the individual blocks identified, or encompass contiguous groups of blocks, depending upon the timing of development for the respective blocks and serivicing and transportation infrastructure. The Block Plans are to be supported by Master Environmental Servicing Plans (MESPs), which is described further below.

3.3 Master Environmental Servicing Plan (MESP) Process

3.3.1 MESP Requirements

Master Environmental Servicing Plans (MESPs) are to be completed in support of the Block Plans for the future development areas encompassed in this Subwatershed Study. The MESPs are intended to build upon the Subwatershed Study recommendations, and refine the analyses and recommendations as appropriate based upon additional study and investigation, particularly for non-participating lands during the Subwatershed Study process.

Key outcomes from the MESP include:

i. Stormwater management facility siting and refined sizing criteria,

ii. Requirements to acquire legal storm pond outlets with proper approvals or easements are to identified as part of the MESPs, and all legal outlets acquired prior to detailed design

iii. Updated and refined water budget assessment and LID capture targets and general guidance for siting LID BMPs.

iv. Update formal Regulatory floodline mapping

v. HDF and watercourse management recommendations

vi. Staked top-of-bank for confined watercourse systems

vii. Establish the NHS to ensure proper delineation of natural hazard lands (flooding and erosion hazards) and regulatory allowances, and the application of appropriate buffer/setbacks to the natural features; additional studies will need to be completed as part of the MESP to establish/refine buffers/setbacks to NHS Features

viii. Confirm/reflect SWH and Significant Woodlands from Subwatershed Study

ix. Provide guidance regarding principles and objectives where salvage of natural features can occur

x. Linkage and enhancement area refinements to be completed.

xi. Establish watercourse/valley crossing locations, and corresponding sizes and geometry of structure for morphological criteria, hydraulic design criteria of freeboard and clearance, regulatory peak flow conveyance, and wildlife passage.

xii. Identify general guidance and requirements for holistic monitoring program and principles for developing local monitoring programs.

xiii. Detailed assessment of karst features NW-3 and SW-2, including dye tracing (to the extent possible), to verify and refine the characterization and management recommendations advanced herein for the features (to the satisfaction of NPCA), and to demonstrate no impacts or hazard to the adjacent development.

xiv. For karst feature NW-1, additional analyses should be completed to demonstrate that the management recommendation advanced in the MESP would not increase flood risk to the adjacent development, and would not increase the risk of structural failure within the adjacent development.

xv. All identified karst features, as well as any new features identified through the subsequent stages of planning and design, are to be assessed as part of the MESPs, and management recommendations established accordingly in consultation with NPCA

Pre-consultation with the Township, Region, and the NPCA is recommended to develop Terms of Reference for MESPs. The MESPs are to provide a refinement to the SWS by providing more detail through site specific study.

From a natural heritage perspective, the MESPs shall include the following:

- Site specific terrestrial field surveys to provide detailed and updated review of MESP study areas, including standard anuran, breeding bird, and vegetation surveys, where appropriate.
- Site specific aquatic field surveys to provide detailed and updated review of MESP study areas, including standard habitat assessments and fish community surveys, where appropriate.
- Assessment and evaluation of “wetlands for further review” and other such areas to determine whether or not they meet the Conservation Authority Act definition of wetland.
- Wetland water balance assessment to ensure the water balance for each wetland unit is maintained to pre-development conditions
- Staking and survey of wetland boundaries with the Township and NPCA. Consultation with NPCA and/or the relevant approval authority around wetlands and potential provincial significance.
- Staking and survey of woodland boundaries with the Township and Region.
- Assessment of Significant Wildlife Habitat (SWH) through more detailed surveys and review of MESP study areas. This is also to include the following:
    - Snake emergence surveys where there is potential for a snake hibernaculum, especially in the area of the rail line and former woodland west of Shurie Road.
    - Assessment of Raptor Wintering Areas SWH east of Industrial Park Road and north of the rail line within the milieu of woodland, forest, meadow, and thicket habitat.
    - Assessment of Turtle Nesting Areas SWH along North Creek and Twenty Mile Creek, as well as adjacent to any ponds that provide suitable habitat for turtles.
- Identification of appropriate buffers from natural heritage features, including woodlands, wetlands, and watercourses. Appropriate justification for changes from the buffers recommended through the SWS.

- Consideration of non-significant woodlands and treed areas for retention or compensation.
- Surveys for bat Species at Risk where habitat is proposed for removal, including woodlands and buildings, in accordance with MECP guidance documents.
- Site specific surveys for Species at Risk, including Bobolink, Eastern Meadowlark, and Barn Swallow.
- Address compensation requirements if natural heritage features are proposed for removal.
- Assessment and refinement of Recommended Restoration Areas. Justification for changes from the Restoration Areas recommended through the SWS.
- Assessment and refinement of Linkages. Justification for changes from the Linkages recommended through the SWS.
- Refinement of the Smithville NHS to meet SWS objectives. Justification for changes from the NHS recommended through the SWS ensuring the intent, objectives, and targets of the overall study area are met.
- Monitoring plan for pre-construction, during construction, and post-construction.
- A preliminary feature-based water balance assessment to ensure the water balance of features that may be impacted by development can be maintained to pre-development conditions. This includes wetlands, HDF, and watercourses.
- Provision of spatial data relating to the Smithville NHS to be provided to the reviewing agencies at the conclusion of each MESP, which is to include natural heritage feature boundaries, Linkages, Buffers, and Restoration Areas.

It is expected that additional data will be collected at MESP stage to support local scale characterization of the hydrogeologic system with specifics documented in the individual MESPs. The additional data would include all the various types of hydrogeological field data necessary to define the site specific hydrogeologic setting and associated groundwater surface water connections (ie borehole logs, monitoring wells, groundwater levels, discharge areas). The number and location would need to be determined by proponent's consultant at the MESP stage. Where substantive differences in current conditions are identified in soil type (e.g. sand vs. till), subsurface geology, overburden thickness, groundwater depth, groundwater flow direction, groundwater discharge locations, the local characterization should be refined and include a discussion of how these local refinements may influence or change the hydrogeological characterization presented in the Subwatershed Study. Where the refinements in the local characterization are interpreted to have potential to substantively change in potential infiltration, recharge, groundwater levels, groundwater flow direction, gradients or groundwater discharge, it is recommended that the groundwater management plan presented in Section 2.3 and associated stormwater management plan in Section 2.2 be assessed accordingly.

The predominance of fine-grained material and thickness of the overburden provides a high level of water quality protection to the shallow bedrock aquifer from typical urban runoff and infiltration. Areas where the overburden is thinners, less than 6 m, currently mapped on Figure GW-5b (Appendix XX), would be more hydrogeological sensitive. Water quality management for storm water is discussed in Section XX.

In addition, the following should be considered at the MESP stage to minimize potential water quality impacts:

- Hydrogeological sensitivity for locating underground storage tanks (ie surficial sand unit, proximity to water course or wetland). Require associated groundwater monitoring for storage tanks.
- Spills management plans.

- Minimize application of fertilizer, pesticides and herbicides.
- Maintain a contaminant threats inventory.

To prevent potential contaminants from entering the groundwater flow system through abandoned private domestic wells or unused monitoring wells it is necessary that they be properly decommissioned as per MECP Ontario Regulation 903.

The existence and potential removal of tile drainage may increase the local water table and could potentially reduce short term groundwater discharge to local surface features. Dewatering and construction considerations along with any related site specific water management practices should take this into account.

Management direction and consideration for site specific feature-based water balance assessments are expected to address and the extent of assessment determined based on any future refinements to the ecological connection or the current requirements from the NPCA. Areas recommended for further study are expected to carry out a groundwater field program to refine the groundwater function and provide appropriate groundwater management options.

The MESPs would be submitted to the Township, NPCA, and Niagara Region for review and approval.

3.4 Class EA Schedules

Once OPA 63 is approved under the Planning Act (subject to no appeals) select Schedule B projects (e.g. new SWMF, where property is required) are automatically approved as Schedule A projects. This also aligns with MCEA document Appendix 1 Project Schedules, (Schedule A Wastewater Protect # 17) "the construction of stormwater facilities establishment which are required as a condition of site plan , consent plan, plan of subdivision or condominium which come into effect under the Planning Act prior to construction of the facility" are automatically approved. It is also important to note that any change in infrastructure location (example SWMF) would be documented in a Master Environmental Servicing Plan and MCEA Addendum process in conjunction with block plan process.

3.5 Timing and Phasing

Details regarding the timing and phasing for implementation are provided by AECOM under separate cover.

4.0 Monitoring and Adaptive Management Plan

4.1 Introduction

Monitoring and Adaptive Management Plans are generally developed as part of MESPs, Environmental Impact Studies, and/or as conditions of approval for stormwater management plans and watercourse reconstructions/realignments. The information collected as part of these plans is intended to verify the performance of the environmental and stormwater management system, as well as to provide guidance for potential modifications to the management plan to satisfy the objectives of the Subwatershed Study.

Overall, the baseline monitoring program would extend 2-3 years, then annual during-construction monitoring (pre-80% build out), followed by three years of monitoring spread over 5 years post-construction (80 to 100% build out). This is to be confirmed on a site by site basis through the development of an Environmental Monitoring and Adaptive Management Plan as approved by NPCA/Town/Region, and may include scoping various components of the program based upon site-specific conditions and findings from the initial years of monitoring. Additional details regarding the framework for various components of the monitoring and adaptive management plan are provided below.

4.1.1 Groundwater

During development, groundwater monitoring associated with dewatering activities related to watercourses or wetlands should consider monitoring of groundwater levels, groundwater discharge, hydraulic gradients, baseflow and discharge quantity and quality.

Post-construction performance monitoring of hydrogeological conditions should focus on the performance of the proposed LID BMPs that are intended to maintain the functional pre-development rate and distribution of groundwater recharge.

An appropriate spatial discretization groundwater monitoring is needed to represent functional linkages and potential hydrostratigraphic variation. Pre-construction and post-construction performance monitoring requirements should include:

- A spatially representative network of water table monitors and multi-level monitoring wells to assess any potential change to the water table, vertical gradients and larger scale groundwater flow directions;
- A number of multi-level drive point piezometers to assess vertical gradient trends in wetland features and watercourses;
- Seasonal groundwater level measurements are likely adequate for monitoring locations intended to represent general conditions, with a number of other sites instrumented with data loggers to monitor shorter term trends;
- Groundwater level and vertical gradient monitoring at selected natural features where the need for post-construction mitigation is identified, such as the wetlands. Continuous data collection would also be important in these monitoring locations;
- Spot baseflow measurements;
- Annual water quality sampling of selected monitoring wells and spot baseflow sites.

4.1.2 Surface Water

Surface water monitoring should include the collection of local stream flow and rainfall data. The selection of the appropriate gauge site should be completed in consultation with NPCA, Niagara Region, and Township of West Lincoln staff. Available flow data from NPCA should be used to inform the monitoring programs.

Each stormwater management facility should be monitored for inflow and outflow and temperature. Given that the inlet and outlet control structures are generally well documented with well-defined hydraulic rating curves, continuous water level recording devices would be considered appropriate. Should the results of the stormwater management facility monitoring program indicate deficiencies with respect to facility performance, including deficiencies related to stormwater quality treatment, requirements for remediation will be the responsibility of the facility owner. Where the facility has not been assumed by the Township, it will be the responsibility of the landowner, and remediation will typically be required as a condition of the ECA.

Regular inspection of the inlets and outlets should be completed to ensure that they are free of debris and sediment, and are functioning in accordance with theory. As a minimum, inspections should be completed every month and following major storms for the first two years of operation. Any problems should be rectified by the consultant or reported to the Township for rectification, if special equipment is required. The gauges should be installed from April 1 to November 30 and be capable of providing data in a minimum of 5 minute increments. All data should be collected in digital format and processed into a tabular inlet/outlet hydrograph form.

Depending on the results of the first year of monitoring, consideration should be given to monitoring the performance of the facilities year round (i.e. inclusive of the December 1 to March 31 period).

4.1.3 Surface Water Quality

Surface Water Chemistry

Chemical sampling using grab sampling should be completed to characterize and verify the stormwater quality management system. Instream monitoring to establish pre-development (i.e. baseline) conditions should be completed for two years prior to development; the location of instream water quality monitoring should be determined in consultation with NPCA, Niagara Region and Township of West Lincoln staff.

Water chemistry monitoring of post-developed conditions should be completed for a minimum of three years post development, and should include monitoring of the inlet and outlet of each stormwater management facility after construction as well as online the receiving watercourse at the same location identified for pre-development monitoring.

Grab sampling is recommended for collecting water quality samples from each facility for the monitoring program. Each site should have 3 events sampled per year, typically representative of an average spring, summer and fall event (rainfall event volumes of over 15 mm depth are preferable).

The following parameters are recommended for monitoring surface water chemistry and water quality:

The parameters to sample for include:

- Oil and Grease
- Total Phosphorus
- Anions (Nitrate, Nitrite, Phosphate, Chloride)

- Ammonia
- Total Kjeldahl Nitrogen (TKN)
- Conductivity
- Total Solids (TS)
- Total Suspended Solids (TSS)
- BOD5
- Dissolved Oxygen
- pH/alkalinity
- Salinity
- Total Coliforms
- Faecal Coliforms
- PAH
- Metals (Al, Sb, As, Ba, Be, B, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Mo, Ni, P, K, Se, Si, Ag, Na, Sr, Tl, Sn, Ti, W, U, V, Zn, Zr).

Surface Water Temperature

Continuous temperature gauges should be installed from June 1 to September 30 at the outlet from all facilities and both upstream and downstream of the facility outlets, to monitor the effectiveness of measures to cool the effluent and the impact on stream temperature. Locations for online monitoring of water temperature should be determined in consultation with NPCA, Niagara Region, and Township of West Lincoln staff.

4.1.4 Stream Morphology

In order to monitor and evaluate channel response at multiple scales, the following channel features should be monitored as part of future studies. The frequency of each monitoring task is also proposed:

- **General channel morphology:** Photographs from a known vantage point and photo logs should be used to document general geomorphic site conditions on an annual basis. An additional site visit will be conducted at each site following a peak storm in excess of the 5-year storm event for the system. These photographs will be used as supplemental information to inform decisions regarding the need for mitigation.
- **Control Cross-sections:** To be monitored twice annually. Once following the spring freshet, and again in the fall. An additional site visit should be conducted at each site following a peak storm in excess of the 5-year storm event for the system;
- **Substrate Composition:** A modified Wolman pebble count should be conducted at each control cross-section on an annual basis. An additional site visit will be conducted at each site following a peak storm in excess of the 5-year storm event relevant to the hydrologic regime. Due to the dynamic nature of substrate composition, no action will be taken until Year 5 unless the adjustment is identified as a potential risk to the function of the channel by a qualified geomorphologist;
- **Lateral Migration:** A series of erosion pins installed in areas of active bank migration as well as areas of anticipated migration should be measured during each monitoring visit to determine rates of bank

adjustment. An additional site visit will be conducted at each site following a peak storm inexcess of the 5-year storm event for the system

Key geomorphic parameters to monitor and record should include but not limited to: Bankfull cross-sectional area (m^2), mean bankfull channel depth, bank migration rates (cm/yr), and substrate distribution (D_{50} and D_{90}).

Baseline Monitoring and Establishing Thresholds of Adjustment

It is recommended that baseline geomorphic monitoring occur twice annually (e.g. spring and fall), over a period of 2 to 3 years to observe trends in the parameters described above for the existing condition. Through an interpretation of baseline monitoring results by a qualified professional, thresholds (or targets) of adjustment to guide the interpretation of during- and post-construction monitoring results should be developed.

Given that channels are naturally active, acceptable rates of change may be difficult to define. Therefore, targets may be recommended as proportional changes between years (e.g. greater than 20% channel width). Monitoring plans and target thresholds may need to be developed on a site-by-site basis depending on the variability of adjustment between site locations (i.e. some channels may be more active than others). Monitoring plans and targets should be confirmed in consultation with NPCA and the Town, and other agencies (e.g. MECP) where appropriate. Baseline monitoring results, target thresholds, and monitoring schedules/plans and responsibilities should be summarized in the monitoring report, and approved by the Town and Agencies.

During- and Post-Construction Monitoring

Annual during-construction monitoring (e.g. pre-80% build out), followed by three years of monitoring spread over 5 years post-construction (e.g. 80 to 100% build out) are recommended, but may be modified as appropriate within the monitoring program. This monitoring should occur twice-annually (e.g. spring and fall), and at least once following a significant precipitation event (i.e. 10 mm within 24 hours). .

Threshold exceedances, if documented, will require an interpretation of site conditions and trends by a qualified Professional Geomorphologist to explore if any adaptive management or remediation recommendations are appropriate.

4.1.5 Ecology and Natural Heritage System

The monitoring conducted for the SWS is baseline data, but additional surveys should be undertaken by MESP/Block Plan study area for more detailed data. This monitoring data provides baseline conditions, prior to development. Monitoring of vegetation (3 season), anurans, breeding birds, and fish, should be undertaken where appropriate. Mammals may be monitored incidentally through other surveys, as well as road mortality searches, and winter wildlife surveys. Surveys for Species at Risk bats should be undertaken where necessary, following the ESA and MECP guidance documents. Reptiles are to be monitored through the placement of snake cover boards, snake emergence surveys where applicable, and basking and nesting surveys for turtles. Odonate and butterfly surveys should be undertaken in spring, summer, and late summer. Areas of degradation that could benefit from restoration should be identified.

The following provides guidance on recommended pre-, during, and post-construction monitoring:

Pre-Construction

Prior to construction, on-site inspections of the sediment and erosion control measures, as well as tree protection measures should be undertaken. Four seasons of recent natural heritage field data should be collected to compare to during and post-development monitoring results.

During Construction

During construction, sediment and erosion control measures and tree protection fencing should be monitored on a regular basis and maintained in good working order to ensure effectiveness. Pruning of any limbs or roots of trees to be retained disrupted during construction should be undertaken.

Mitigation measures recommended for the development process should be adhered to, such as fueling of machinery at designated locations away from woodlands, wetlands, and watercourses; storage of machinery and material, fill, etc. in designated areas; and equipment movement through natural areas and buffers must be controlled.

Natural heritage monitoring is to be completed every second year throughout construction, to the 90% build-out point, at which time post-construction monitoring commences. Monitoring reports should make recommendations to address adaptive management, such as increased sediment and erosion control, garbage removal, signage, fencing, etc.

Post-Construction

Buffer, restoration, and compensation plantings should be monitored after installation. Following planting, it is recommended that the plantings be inspected to ensure that the correct species and number of plants were planted in accordance with the approved planting plan. Two years after planting, the plantings should be inspected again to ensure a good survival rate, and any plants not meeting warranty conditions should be replaced at that time. The target survival rate should be established during the creation of detailed planting plans. To increase survival, it is recommended that new plantings be maintained through watering during the first two years after installation during dry periods of the growing season. Tree staking is to be removed two years after installation. Buffer monitoring should assess whether buffers are providing the protection to the natural heritage features as designed (e.g. monitoring stations are to include buffers) and should include monitoring of encroachment, trampling, ad hoc trails, dumping, litter, invasive species, as well as light and noise impacts.

Post-construction natural heritage monitoring is to commence at 90% buildout of each development block area. Post-construction monitoring should be undertaken in years 1, 3, and 5. Annual monitoring reports are to address adaptive management and the recommended activities shall be undertaken. Adaptive management techniques may include additional plantings, wildlife habitat creation, changes to lighting design, fencing, wildlife crossings, signage, and/or modifications to stormwater management, among others.

4.2 Reporting

Annual reports are to be prepared for all monitoring programs. Annual monitoring reports to verify facility performance prior to assumption by the Township should be submitted to the Township and any other permitting agencies (i.e. MOECC) per the conditions of approval. Annual monitoring reports for the holistic monitoring programs should be submitted to Township of West Lincoln, Niagara Region, and NPCA.

5.0 Policy Conformance

This Phase 3 report represents the final document for the Subwatershed Study, summarizing the key recommendations and process for the next stages of planning and design. The report has built upon the findings and recommendations from the Phase 1 Characterization and Phase 2 Impact Assessment reports. In total, the findings and recommendations presented in this Subwatershed Study have addressed Provincial, Regional, and Municipal policy related to the planning of the natural heritage and water resource systems within the urban expansion area of the Community of Smithville, as well as the stormwater management system for mitigating impacts to natural hazards for flooding and erosion, and managing water budget and hydroperiod to key natural features.

Appendix A

Correspondence

Appendix B

Surface Water

Appendix C

Stream Morphology

Appendix D

Cost Estimates