APPENDIX 2

Central Lake Ontario Conservation

Port Darlington Community Shoreline Management Plan: Report on Flooding

November 2018

D R A F T

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1.0 Overview

The Port Darlington Community consists of homes and businesses nestled along the Lake Ontario shoreline in the Municipality of Clarington. Mr. J.B. Fairbairn wrote in his History of Bowmanville that "…Port Darlington was for years a great centre of attraction during the summer. Many resorted there to get the invigorating breezes from the lake during the heated term. Picnic parties and pleasure seekers of all kinds assembling in such numbers gave it quite a lively appearance. There was a good hotel and the arrival of the steam boats was quite an attraction." During the first half of the 20th century, cottage lots were created in the community, and over time, the cottages have become all-season homes.

As floodplain mapping and natural hazard assessments were completed, portions of the Port Darlington community were recognized as Flood Damage Centres; areas where buildings are likely to experience damage in the event of a major flood. The purpose of this study is to provide a critical assessment of the flooding conditions, and to investigate the potential for improvements that could be made to reduce the flood risk within the community.

The Central Lake Ontario Conservation Authority (CLOCA) competed a Flood Risk Assessment in March 2017 for all identified Flood Damage Centres (FDC) in the CLOCA watershed, including the West Beach Road and Cedar Crest Beach Road flood damage centres. The Risk Assessment looked at the flood conditions as reported in the Westside Creek Floodplain Mapping Study, the Bowmanville/Soper Creek Floodplain Mapping Study, and the Lake Ontario Shoreline Management Plan. Based on these modelled flood conditions, the Flood Risk estimated the impact of flooding on public safety, structural damage, social impacts, business interruption, and environmental impacts. These two communities scored with higher than average risk scores, with the West Beach Road community ranked as the 6th and Cedar Crest Beach Road ranked tied with other FDC's as 14th highest risks out of the 92 flood damage centres in the CLOCA watershed.

According to the Ontario technical Guide for River and Stream Systems: Flooding Hazard Limit (OMNR 2002):

The management of flood susceptible lands involves a combination of three main program components:

- *Prevention of harm through land use planning and regulation of development*
- *Protection by applying structural and non-structural measures and acquisition, and*
- *Emergency response by flood forecasting/warning and flood/erosion disaster relief*

This report will review the flood conditions impacting the Port Darlington community, and assess potential protection measures and emergency response measures. Land use planning and regulation of development will be addressed through the Aqua Solutions report for the Port Darlington shoreline community.

2.0 Flood Hazard Conditions

The Port Darlington community is within the floodplains of the Bowmanville/Soper Creek, the Westside Creek, and the flood limits of Lake Ontario, as shown on the regulatory floodplain maps contained in Appendix 1.

Generally, on a scale of least severe to most severe, the hazards associated with flooding escalate as flood depth and the velocity of the flowing flood water increases. The hazards include:

- **homes are inundated with water and property damage occurs, well and septic systems impacted**
  Water damage to home and property begin as water seeps into basement and crawl spaces through window and door openings, cracks in the foundation, and any other path that allows water to penetrate the foundation. Where wells and septic tanks and beds are relied upon for water and waste water, flood water can inundate septic systems and contaminate wells, leading to failure of these systems and possible resident health impacts. Water damaged home contents including furniture, flooring, and drywall may need to be replaced. Electrical hazards may be created.
- **inability to access or egress (escape) the community because flooding on roads prevents personal vehicle passage**
  At or above 0.3 meters depth, typical personal vehicles will be limited in the ability to pass through floodwater on roadways, as car exhaust systems and electrical systems will be prone to failure. At this flood depth, vehicles should not attempt to navigate roads because roads are no longer visible, and the possibility of roads being washed out exists. At greater depths, vehicles may become buoyant and be swept away. Evacuation of the area that would become isolated from flooded roads would be advisable prior to depths exceeding this limit.
- **structural damage to homes**
  Hydrostatic pressure caused by floodwater against buildings has the potential to cause structural damage. Typical residential framed structures can withstand about 0.8m of water depth before structural damage occurs. Structural damage may be deflection, cracking, or complete and sudden failure.
- **threat to life from buoyancy and instability**
  Water depth and velocity of flowing water pose buoyancy and lateral forces that pose a hazard to public safety. Water depths greater than 1 metre would be sufficient to float young children, and a product of water depth by water velocity of more than 0.4 metres squared per second will pose a risk of sweeping people away.

Table 2.0: Flood related hazards

Flood		Hazard
Depth	Depth x Velocity	
d>0.1m	n/a	Interior property damage, electrical hazards
d>0.3m	n/a	no access or egress by personal vehicles
d>0.8m	n/a	structural damage to homes
d>1.0m	d x v >0.4m2/s	personal safety

2.1 Lake Ontario Flood Limit

Flood limits for the Great Lakes systems are calculated by combining the 100 year extreme water level, and the wave runup expected from a 100 year storm event. The 100 year extreme water level includes both a static water level and a storm surge component. These values were calculated in the 1990 Lake Ontario Shoreline Management Plan (Sandwell, Swan, Wooster, Inc.) and the 100 year flood limit for the Port Darlington shoreline reach was determined to be 76.27m. At this elevation, many of the homes on Cedar Crest Beach Road and West Beach Road would experience property damage, septic systems would be inundated, and well water contamination would be probable. Furthermore, the flood depth on the roadways would prevent access and egress to the homes, and evacuation would be recommended.

Table 2.1 Lake Ontario Flood Limit

Storm	Elevation	Depth
100Year	76.3m	0.3m

Notes: 100 Year includes extreme water level, surge, and wave runup
West Beach Rd elevation approximately 76.0m
Cedar Crest Beach Rd low point elevation approximately 75.8m

CLOCA is working in partnership with the Ganaraska Region Conservation Authority and Lower Trent Region Conservation Authority to update the 1990 Shoreline Management Plan through funding provided by the Region of Durham and a National Disaster Mitigation Program grant. The project will review and update flood levels for the Lake Ontario shoreline from Ajax through to Brighton. It is not anticipated that the updated flood levels would significantly change the expected impacts from flooding, as described above.

During the spring of 2017, Lake Ontario reached the highest water levels in recorded time, with the maximum static water level of 75.8 meters. On calm days, the high water level did not overtop the shoreline, although it is likely the prolonged high water level saturated the waterfront sand spit, and created problems with seepage into basements /crawl spaces, and fouled septic and well water systems. On stormy days, the combination of surge and wave runup pushed water over the sand spit at Cedar Crest Beach with water flowing from the lake to the Westside Marsh. These water levels were approaching but slightly less than the calculated 100 year Lake Ontario Flood Limit.

Cedar Crest Beach - May 25, 2017

2.2 Bowmanville/Soper Creek Floodplain

The Bowmanville/Soper Creek watershed drains an area of 169 square kilometres, and extends into the Oak Ridges Moraine in the Enniskillen area. The majority of the watershed is rural, although the urban community of Bowmanville is within the watershed also. As it nears Lake Ontario and the Port Darlington community, the Creek is connected to the Bowmanville Marsh, a large provincially significant wetland. Historical alterations have resulted in the arrangement of an open channel connecting the wetland to the creek, and the creek flowing through jetties that project into Lake Ontario. These alterations were historically necessitated to provide suitable conditions for marine traffic into the harbour area. The area continues to be used for recreational boating, with boat launching, repair, and marina services provided.

The southern portion of West Beach Road is situated on the sand spit that separates the Bowmanville Marsh from Lake Ontario. A historic cottage community, portions of the spit have been acquired by the Municipality of Clarington, and converted to a public beach amenity. The remaining homes on the spit are within the floodplain of the Bowmanville/Soper Creek.

The most recent floodplain mapping study for this watershed was completed in 2009 (Bowmanville/Soper Creeks Floodpain Mapping Study, (Aquafor Beech Ltd). As directed through provincial technical guidelines, the floodplain mapping does not include an analysis of the benefits of the coastal wetland for storage, and assumes a long term

average Lake Ontario water level. Table 2.2 provides the flood elevations computed through the study.

Table 2.2 Bowmanville/Soper Creek Flood elevations at West Beach Road
*West Beach Road elevation: approximately 75.8m

Storm	Flood			
	Elevation (m)	Depth (m)	velocity (m/s)	depth x velocity
2 year	75.2	0	1.3	0.0
5 year	75.5	0	1.7	0.0
10 year	75.7	0	1.9	0.0
25 year	76.0	0.2	1.3	0.3
50 year	76.2	0.4	0.5	0.2
100 year	76.5	0.6	0.5	0.3
Regional	78.1	2.3	0.7	1.6

Roadway flooding
No safe access
Public safety concern

In this area, flooding events ranging from a 25 year return period storm (4% probability of occurring in any year) will impact the West Beach Road residents. A survey would be required (with owner consent) to establish the exact ground elevation around the homes and the elevation of the lowest openings into the homes, but generally, topographic mapping shows the ground elevations around the homes in the range of 76 metres to 77 metres. At the 100 year storm (1% chance of occurring in any year) level, water depth on West Beach Road would prevent access and egress by personal vehicles. At the Regional storm flood level, depths would structurally damage buildings and loss of life would become a significant risk for anyone within the southern portion of West Beach Road

2.3 Westside Creek Floodplain

The Westside Creek watershed is much smaller than the Bowmanville/Soper Creek watershed and has a drainage area of 5.4 square kilometres. The watershed includes residential and commercial land uses on the western edge of Bowmanville, and extending just north of the Highway No. 2 areas.

As it nears Lake Ontario and the Port Darlington community, the creek flows into the Westside Marsh, a provincially significant wetland. Historical alterations since 1990 have resulted in the diversion of the Westside Creek around the north and east limits of the St Marys licensed aggregate extraction area, and into a reconfigured wetland. The wetland size has been reduced to accommodate the aggregate pit, and a flood overflow channel has been provided at the south west limit of the wetland to balance the impact of the reduced flood storage volume in the wetland. For further information on the alterations to the wetland and the impact on flooding, please refer to the appendices for the Hydrotechnical Report and Functional Understanding of Westside Marsh.

The Westside Creek has a barrier beach outlet to Lake Ontario. A barrier beach is created by wave activity on Lake Ontario moving sand and stone into the creek and wetland outlet. The outlet may be open and allow water to freely flow from the wetland into Lake Ontario at some times, while at other times the accumulation of sediments may be a barrier to the flow of water. Barrier beaches are common to coastal wetlands, and are important to sustain healthy conditions for wetland plants within the wetland. See Appendix 3 for more information on the function and importance of the barrier beach.

Figure 2.3: Barrier beach at the mouth of the Westside Creek.

CLOCA utilized water level monitoring data for the Westside Marsh and federal Lake Ontario water level data to study the situations where apparent barrier beach breaks occurred. See the Westside Marsh Barrier Beach Function report in Appendix 3 for full details. The study looked for sudden drops in marsh water level over a period of years. These sudden drops were assumed to represent "break" events of the barrier beach. Each event was analysed to determine if there was consistency in the water surface elevation difference between the wetland and the lake. The water elevation difference, known as a hydrostatic head, creates the force to push away the sediments and break the barrier beach. The study looked at more than 15 apparent barrier beach break events between 2006 and 2015. The head at the time of the barrier beach break varied on these events from 0.2m through 0.7m with an average value of 0.4m.

The study further examined the relationship of rain events near the time of the barrier beach break event and determined that the break events are usually preceded by a rain event or series of rain events in days prior to the break.

Although there are general conditions around barrier beach break events, there is also a great deal of variability. This is logical, as the strength of the barrier beach may vary greatly depending on the severity of beach forming events and the length of time between break events.

On occasion, the barrier beach has been opened mechanically because of the threat of flooding in the Cedar Crest Beach community. The elevation of Cedar Crest Beach Road is approximately 75.9m. Using our finding that the barrier beach typically breaks with heads of 0.2m through 0.7m, it can be assumed that under average Lake Ontario water levels (winter low of 74.5m and summer high of 75.1m), the barrier beach would break before the water level in the wetland would overtop the Cedar Crest Beach Road elevation (summer lake level of 75.1m plus 0.7m head = 75.8m). It is only when lake levels exceed 75.1m that the barrier beach may present a risk for flooding. In recent times, a water level alarm has been developed for the Westside Marsh, and e-mail alerts are sent to CLOCA, Clarington, and St Marys Cement staff to alert of wetland levels exceeding 75.5m. Staff from these agencies will assess conditions and take actions as appropriate.

The floodplain mapping study for the Westside Creek watershed was completed in 2013 by CLOCA. As directed through provincial technical guidelines, the floodplain mapping does not include an analysis of the benefits of the coastal wetland for storage, and assumes a long term average Lake Ontario water level as a boundary condition. Table 2.2 provides the flood elevations computed through the study.

Table 2.3 Westside Creek Flood elevations at Cedar Crest Beach Road
*Cedar Crest Beach Road elevation: approximately 75.9m

Storm	Flood			
	Elevation (m)	Depth (m)	velocity (m/s)	depth x velocity
2 year	75.9	0	0.6	0.0
5 year	76.0	0.1	0.8	0.1
10 year	76.0	0.1	0.9	0.1
25 year	76.1	0.2	1.0	0.2
50 year	76.1	0.2	1.0	0.2
100 year	76.4	0.5	1.1	0.6
Regional	76.4	0.5	1.5	0.8

Roadway flooding
No safe access
Public safety concern

In this area, flooding events larger than the 5 year return period storm (20% probability of occurring in any year) will result in flooding of Cedar Crest Beach Road. A survey would be required (with owner consent) to establish the exact ground elevation around the homes and the elevation of the lowest openings into the homes, but generally, topographic mapping shows the ground elevations around the homes in the range of 76 metres to 77 metres. At the 25 year storm flood level (4% chance of occurring in any year), water depth on Cedar Crest Beach Road would prevent access and egress by personal vehicles. During a 50 year, 100 year, and regional storm flood events, the combination of depth and velocity of flood water would create conditions that could result in people being swept away and risk to public safety.

3.0 Flood Mitigation Measures

The Flood Damage Centres of Cedar Crest Beach Road and south limit of West Beach Road are impacted by both riverine floodplains of the creek systems, and the flood limit of Lake Ontario. This situation makes flood mitigation measures challenging, as flooding may occur from either side of the sand spit that the homes are situated upon. Flood mitigation can be provided by floodproofing individual homes. This may involve structural changes elevate or protect the main floor and living space from the flood levels, waterproofing foundation walls, and removing all valuables and utilities from basements and crawl spaces.

Providing flood mitigation on a community scale could involve placement of berms or dykes to hold flood waters away from homes. Berming between the homes and Lake Ontario may not be

feasible because of the lack of space between the homes and shoreline and because of the obstruction of drainage from the homes towards the lake. Berming to provide enhanced flood protection from the riverine flood threat may be possible by raising the elevation of the existing roadways.

3.1 Lake Ontario Flooding Mitigation

Community scale flood mitigation measures are limited for lake based flooding events. Berming to protect homes from high lake levels is not practical due to space constraints, obstruction of lot drainage, and loss of use of the rear yards.

It is possible that the wave uprush component of lake flooding can be reduced with structures that are able to dissipate wave energy. The Port Darlington Shore Protection Concepts (Baird, November 2018) provides concepts for works that could protect the shoreline from erosion, and notes potential of some of the concepts to reduce the wave uprush component of lake flooding, however high water level and storm surge components of lake flooding cannot be mitigated.

The Central Lake Ontario Conservation Authority, Ganaraska Region Conservation Authority, and Lower Trent Conservation Authority have retained coastal engineering firm Zuzek Inc. to complete a Lake Ontario Shoreline Hazards Management Plan. This Plan will update the 1990 Sandwell Report, and will revisit Lake Ontario flood levels with more current information including the record setting 2017 lake levels.

3.2 Bowmanville/Soper Creeks Flood Mitigation

CLOCA completed an analysis of possible flood mitigation measures for the West Beach community and Bowmanville/Soper Creek floodplain. A technical report on the flood mitigation assessment is provided as Appendix 4. The analysis first added more detail into the existing floodplain model for the study area by adjusting model cross-sections to providing better representation of West Beach Road based on surveyed ground elevation data. The adjusted model did not affect computed flood levels from the previously reported values.

Flood mitigation scenarios were analysed using West Beach Road as a flood protection berm. Although it is not practical to significantly elevate the road profile, slight elevation changes may provide some flood protection by preventing creek flows from overtopping the road during frequent return period events.

A survey of centerline grades along West Beach Road completed by CLOCA shows the lowest point in the road is approximately 75.8m. The road is thus overtopped during a 10 year flood event, according to floodplain models, and would be impassable to personal vehicles during a 25 year flood event and greater flood events.

Two flood mitigation scenarios were run to determine the benefit of raising the existing roadway to minimum elevations of 76.0m and 76.2m. The analysis is iterative because

raising the road will impact upstream flood elevations, which in turn affects the level of protection provided. The flood elevations which would result from increasing the minimum West Beach road grade are provided in Table 3.2 below.

Table 3.2: West Beach Road Modifications

	West Beach Road - Minimum Elevation (m)		
Flood Event	**Existing (75.8m)**	**76.0m**	**76.2**
2 year	75.2	75.2	75.2
5 year	75.5	75.5	75.5
10 year	75.7	75.7	75.7
25 year	76.0	76.0	76.0
50 year	76.2	76.2	76.2
100 year	76.5	76.5	76.5
Regional	78.1	78.1	78.1

Roadway flooding
No safe access
Public safety concern

The analysis shows that the raising of West Beach Road provides some benefit by providing greater access during flood events. The first scenario (minimum road elevation: 76.0m) resulted in the roadway being flood-proofed up to the 25 year flood event, but still impassable at the 100 year flood event and regional event. The second scenario (minimum road elevation: 76.2m) provided the added benefit of having West Beach Road flood proof for the 50 year flood event. These modest flood benefits reduce the risk associated by flooding by providing better access during the more frequent flood events.

Raising the road profile has a small negative impact on upstream flood levels. The two scenarios resulted in upstream flood level increases of 0.1m to 0.2m for upstream areas during 25 through 100 year flood events (see appendix 4 for details). If these options are to be further investigated, detailed surveys should be completed or detailed elevation data obtained for lands along Port Darlington Road to determine if these flood elevation increases would impact existing development and property. If these flood increase negatively impact these upstream lands, the flood mitigation option should not be pursued.

The flood mitigation options for the Bowmanville/Soper Creek system may provide some reduction of flood risk, but the alternatives will have no impact on the regulatory flood conditions and flood vulnerability of the community.

3.3 Westside Creek Flood Mitigation

CLOCA completed an analysis of possible flood mitigation measures for the Cedar Crest Beach community and Westside Creek floodplain. A full report on the flood mitigation assessment is provided as Appendix 4. The analysis first added more detail into the existing Westside Creek floodplain model for the study area by providing surveyed ground elevation data for Cedar Crest Beach Road, extending flood model cross-sections, and providing more detailed information for the overflow channel. The assessment determined that the added detail provided in the model resulted in slightly lower flood elevations, although the general conditions of the flooding would continue to be as described in section 2.3 of this report.

The assessment also looked at the impact of elevated Lake Ontario water levels on riverine flooding conditions. As anticipated, the elevated lake levels impacted the flood levels of frequent return period flood events, but had less impact on major flood events. Please refer to Appendix 4 for detailed results.

Two flood mitigation scenarios were analysed using Cedar Crest Beach Road as a flood protection berm. Although it is not practical to significantly elevate the road profile, raising the existing low points of the roadway may provide some flood protection by preventing creek flows from overtopping the road during frequent return period events.

A survey of centerline grades along Cedar Crest Beach Road completed by CLOCA shows the elevation of the lower portions of the road is approximately 75.9m. The road is thus overtopped during a 5 year flood event, according to floodplain models.

A preliminary analysis was completed to determine the approximate level of protection which could be provided should it be possible to raise the existing roadway low points between 76.0m and 76.15m. The analysis is iterative because raising the road will impact upstream flood elevations, which in turn affects the level of protection provided. The flood elevations which would result from increasing the minimum Cedar Crest Beach road grade are provided in Table 3.3 below.

Table 3.3: Cedar Crest Beach Road Modifications

	Cedar Crest Beach Road - Minimum Elevation (m)			
Flood Event	**Existing (75.9m)**	**76.0m**	**76.15**	
2 year	75.9	75.9	75.9	
5 year	76	76	76	
10 year	76	76	76.1	
25 year	76.1	76.1	76.2	
50 year	76.2	76.1	76.2	
100 year	76.4	76.4	76.4	
Regional	76.4	76.4	76.4	

Roadway flooding
No safe access
Public safety concern

As shown in the table above, it appears it is possible to increase the level of flood protection from riverine events by raising Cedar Crest Beach Road. The potential level of protection which could be provided to the adjacent homes would increase from a frequent 2 year flood event level to a less frequent 10 year storm event. Furthermore, safe access would be provided up to the 50 year storm level (76.0m road minimum elevation) or 100 year flood level (76.15m road minimum elevation).

If this flood mitigation concept is pursued, a detailed design process would need to be completed to ensure lot drainage is not obstructed with proposed road profile adjustments, and there are no other negative impacts to the existing lots.

This flood mitigation measure will not protect against regulatory events or lake flooding events. There is also potential that raising the road may make lake events worse should shoreline flooding reach Cedar Crest Beach Road. The elevated road structure would prevent lake water from flowing freely across the road and into the Marsh.

Based on the preliminary analysis outlined above, it is not anticipated there will be any impacts to the existing “Regulatory” flood limits, therefore the current floodplain mapping (Attachment 1) will remain the same.

The flood mitigation would reduce the riverine flood risk for the community, by reducing the frequency of flooding events, although the community flood vulnerability would still be high because of the potential for significant flooding from regulatory riverine and lake based events.

4.0 Emergency Response to Flooding

The responsibility for dealing with flood contingency planning in Ontario is shared by municipalities, Conservation Authorities (CAs) and the Ministry of Natural Resources and Forestry (MNRF), on behalf of the province. As with all emergencies, municipalities have the primary responsibility for the welfare of residents, and incorporate flood emergency response into municipal emergency planning. The Ministry of Natural Resources and Forestry and the Conservation Authorities are primarily responsible for operating a forecasting and warning system, and the province may coordinate a response in support of municipal action.

The Conservation Authorities of the Greater Toronto Area (GTA) have developed a Flood Forecasting and Warning program for the municipalities and residents within their collective watersheds and the shoreline of Lake Ontario and Georgian Bay. The purpose of this service is to reduce risk to life and damage to property by providing local agencies and the public with notice, information and advice so that they can respond to potential flooding and flood emergencies.

The Flood Contingency Plan is intended for all public officials and agency staff likely to play a role in the prevention, mitigation, preparedness, response and recovery pertaining to flood events. The Flood Contingency Plan provides general information on the Flood Forecasting and Warning program for CLOCA, as well as specific information and contacts for municipalities within CLOCA's jurisdiction.

Municipalities have the primary responsibility and authority for response to flooding and flood emergencies, and also for the welfare of residents and protection of property. They will determine the appropriate response to a flood threat and, if warranted, deploy municipal resources to protect life and property. Municipalities may also, if required, declare a flood emergency and implement their Emergency Procedures Plan.

The Municipality of Clarington has a Flood Response Plan included with their Clarington Emergency Plan, and has specific reference to Waterfront Flooding.

Conservation Authorities have several areas of responsibility for flooding and flood emergencies, but act primarily in an advisory capacity:

1. Maintain a local network of stream and rain gauges, and snow courses; collect data, and monitor watershed and weather conditions daily in order to provide timely warning of anticipated or actual flood conditions (i.e., operate a flood forecasting and warning system). Provide updated forecasts and other supporting technical data pertaining to flood conditions under their jurisdiction during an event.

2. Issue flood messages to municipalities and other appropriate agencies, including the media and the public, to advise of potential flooding when appropriate.

3. Maintain communications with municipalities and the MNRF Surface Water Monitoring Centre during a flood event.

4. Support municipal flood emergency planning by providing technical advice pertaining to flood risk (e.g., hydrology, hydraulics, flood vulnerable areas, etc.) and where possible, engage in flood mitigation projects to reduce flood risk prior to flood events.

St Marys Cement has also worked with CLOCA and the Municipality of Clarington to establish a monitoring and maintenance plan for the Westside Marsh overflow channel, and have installed a water level gauging system with remote communication abilities in the west portion of the marsh, owned by CLOCA, that is close to the northern portion of the emergency overflow channel. St. Marys has donated the remote system to CLOCA for operating as an additional component of the flood warning program. St. Marys, CLOCA, and Clarington staff will all receive email alerts from the remote system when the water elevation at the location of the remote system in the Marsh reaches a certain elevation, to be determined periodically by CLOCA (the "preset elevation") as a warning of high marsh water levels. CLOCA also installed manual staff gauges in the marsh closer to Cedar Crest Beach Road which will act as a verification and back-up for the remote system.

Both the barrier beach for the Westside Marsh and the St Marys overflow channel will be assessed by the agencies, and measures including removing accumulated lake sediments will be taken when determined necessary.

Flood emergency preparedness is also a responsibility of everyone living in a flood damage centre. Homeowners within the flood damage centres should review and implement flood preparedness measures including, installing flood shields or barriers for basement windows, ensuring that the grading around the home provides the maximum possible protection from flood waters, removing valuables and services out of the basement, and even preparing for the possibility of sandbagging and/or evacuation. Information sources such as Environment Canada's Flood Ready website (www.canada.ca/en/campaign/flood-ready.html) provide good advice for preparing for a flood.

5.0 Conclusions and Recommendations

The Port Darlington community has a long history including a known attraction for summer retreats and cottages. Over time, the cottage community has developed into all season homes and permanent residences. Two areas of the community, Cedar Crest Beach Road and the southern limit of West Beach Road, are located on the Lake Ontario sand spits, and are backed by the Westside Marsh and Bowmanville Marsh coastal wetlands.

The West Beach Road and Cedar Crest Beach Road communities are flood damage centers with significant flood risk. These areas are exposed to flooding from Lake Ontario and the riverine systems that drain into the coastal wetlands. The CLCOA Flood Risk Assessment (April 2017) ranked these communities as 6th and 14th greatest risk out of the 92 flood damage centres within the CLOCA watershed. Flooding conditions have the potential to cause property damage, prevent access, cause structural damage to homes, and threaten safety of residents.

Mitigation of flooding for these communities is difficult given the severity of the flood conditions. The wave runup component of the Lake Ontario flooding can be somewhat dissipated with on or off-shore structures, however, the benefit is small, and the communities will still face the high water level and storm surge components of Lake Ontario. Berming to protect against lake flooding is impractical because of limited space, and the need to provide drainage from the residential lots towards the lake.

There is some ability to reduce flood risk associated with riverine flooding. CLOCA investigated berming options and suggest that West Beach Road and Cedar Crest Beach Road could be elevated slightly to act as a flood protection berm. This proposed mitigation measure will reduce flood risk by providing an improved level of access and protection against more frequent storm/flood events. These measures will not, however, provide protection against the severe flood events.

If flood mitigation options are to be pursued, more detailed survey, design, and flood modeling will be required. For the West Beach Road flood mitigation, the possible impacts to upstream property must be assessed as part of the analysis. Cost/benefit and feasibility assessments should also be completed.

Flood mitigation also includes floodproofing individual homes and properties, and each property owner should carefully evaluate all possible options to provide greater flood resiliency.

Home owners should also ensure they are prepared for a flood emergency, and should follow suggestions from sources such as Environment Canada's flood ready website. CLOCA provides flood forecasting and warning duties, and has worked with St Marys Cement to establish a water level monitoring and warning station within the West Side Marsh. The Municipality of Clarington is responsible for emergency response during flooding conditions, and have completed a Waterfront Flooding Flood Emergency Response Plan.

The management of flood susceptible lands involves a combination of three main program components:

- Prevention of harm through land use planning and regulation of development
- Protection by applying structural and non-structural measures and acquisition, and
- Emergency response by flood forecasting/warning and flood/erosion disaster relief

Given the severity of the flood hazard, a concerted effort on all program components may be required to manage the flood risk for the Port Darlington community.

Environment Canada / Environnement Canada

FLOOD AND EROSION RISK MAP
CARTE DES RISQUES D'INONDATION ET D'ÉROSION

Ontario — Ministry of Natural Resources / Ministère des Richesses naturelles

CENTRAL LAKE ONTARIO CONSERVATION AUTHORITY

CENTRAL LAKE ONTARIO CONSERVATION AUTHORITY

CANADA-ONTARIO FLOOD DAMAGE REDUCTION PROGRAM
PROGRAMME DE RÉDUCTIONS DES DOMMAGES DUS AUX INONDATIONS

Ontario

LEGEND - LÉGENDE

Horizontal control	010880173	Point de contrôle horizontal	
Vertical point	V-3 567-26	Point de contrôle vertical	
Spot elevation, water elevation	565-3 EL 423.6	Point coté, élévation du plan d'eau	
Photo centre	260	Centre de photo	
Railway		Chemin de fer	
Building, under construction, ruin	U/C RUIN	Bâtiment, en construction, ruine	
Road: paved, unpaved		Route: pavée, non pavée	
under construction		en construction	
Service road, service lane		Rue de désserte, ruelle	
Driveway, cart track		Entrée privée, chemin de terre	
Bridge, footbridge, culvert		Pont, passerelle, ponçeau	
Parking area: paved, unpaved	PARKING PARKING	Stationnement: pavé, non pavé	
Fence, guard rail		Clôture, garde-fou	
Wall	W W	Mur	
Pylon, pole, light standard, flag pole	FP	Pylône pôteau, lampadaire, mât	
Transmission line		Ligne de transport d'énergie	

Quarry, cliff		Carrière, falaise	
Water course, definite		Cours d'eau, défini	
indefinite		indéfini	
Shoreline		Rive	
Dam, falls, rapids	DAM FALLS RAPIDS	Barrage, chutes, rapides	
Pipeline, ditch	P D	Pipe-line, fossé	
Pool	P	Piscine	
Marsh, swamp		Marais, marécage	
Wooded area, scrub		Région boisée, broussailles	
Hedge	H H	Haie	
Individual tree: minimum size		Arbre: grosseur minimum	
Cemetery	CEMETERY	Cimetière	
Contour	70	Courbe de niveau	
Depression contour		Courbe de cuvette	
Indefinite contour		Courbe de niveau imprécise	
Auxiliary contour	70.5	Courbe de niveau intercalaire	

Shoreline Information / Information sur les lignes de rivage

Regulatory flood level (G.S.C.)		Niveau de crue pour l'application des règlements (L.G.C.)	
Standard wave action offset		Décalage standard attribuable à l'action des vagues	
Regulatory erosion limit		Limite de l'érosion pour l'application des règlements	
Location of photogrammetric cross section	H-810	Emplacement de coupe photogrammétrique transversale	
Regulatory dynamic beach limit		Limite dynamique de plage pour l'application des règlements	

Riverine Information / Information sur les rivières

Regulatory floodline		La crue régulatrice	
Floodway boundary		Limite de canal de crue	
Regulatory flood elevation	114.70 1000	Niveau de la crue régulatrice	
Cross section number		Numéro de la coupe transversale	
Cross section		Emplacement de la coupe transversale	

SHEET INDEX / TABLEAU D'ASSEMBLAGE

ENGINEERING CONSULTANT

Date: _____

MAPPING CONSULTANT

PHOTOMAP AIR SURVEYS LIMITED
Toronto

Date: _____

REGULATION No _____ No DU RÈGLEMENT

SCHEDULE No _____ CÉDULE No

Date	Amendment Revision

COMPILATION NOTE

Production techniques used in the preparation of this map are designed for Class "A" standards. This map was prepared under the auspices of the Canada-Ontario Flood Damage Reduction Agreement signed MARCH 31, 1978 and amended NOVEMBER 14, 1985.

GENERAL INFORMATION

Vertical datum:	mean sea level (G.S.C.)
Horizontal datum:	North American (1927)
Map projection:	Transverse Mercator
Zone:	17
Central Meridian:	81°W
Grid spacing:	200 metres
Aerial Photography:	APRIL 26 1989

SCALE 1:2,000 ÉCHELLE

MÈTRES 40 0 40 80 120 160 200 MÈTRES

FEET 200 0 200 400 600 PIEDS

CONTOUR INTERVAL 1 METER
AUXILIARY CONTOURS 0.5 METER

THE INFORMATION ON THIS MAP IS ALSO AVAILABLE IN DIGITAL FORM.

ÉQUIDISTANCE DES COURBES DE NIVEAU 1 MÈTRE,
COURBES INTERCALAIRE 0,5 MÈTRE

LES RENSEIGNEMENTS SUR CETTE CARTE SONT AUSSI DISPONIBLES SOUS FORME NUMÉRIQUE.

RENSEIGNEMENTS GÉNÉRAUX

Niveau de référence:	niveau moyen de la mer (C.G.C.)
Système géodésique:	Nord-Américain unifié (1927)
Projection:	tranverse de Mercator
Zone:	17
Meridien centrale:	81°0
Quadrillage de:	200 mètres
Photographies aériennes:	26 AVRIL 1989

PHOTOGRAMMÉTRIE

Les normes de production de cette carte se conforment aux standards de première classe. Cette carte a été préparée dans le cadre de l'accord Canada-Ontario de la réduction des dommages dus aux inondations, conclu le 31 MARS, 1978 et modifiée le 14 NOVEMBRE 1985.

Environment Canada / Environnement Canada

FLOOD AND EROSION RISK MAP
CARTE DES RISQUES D'INONDATION ET D'ÉROSION

Ontario Ministry of Natural Resources / Ministère des Richesses naturelles

COMPILATION NOTE

Production techniques used in the preparation of this map are designed for Class "A" standards. This map was prepared under the auspices of the Canada-Ontario Flood Damage Reduction Agreement signed MARCH 31, 1978 and amended NOVEMBER 14, 1985.

GENERAL INFORMATION

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Horizontal datum:	North American (1927)
Map projection:	Transverse Mercator
Zone:	17
Central Meridian:	81°W
Grid spacing:	200 metres
Aerial Photography:	APRIL '86, 1989

SCALE 1:2,000 ÉCHELLE

MÈTRES 40 0 40 80 120 160 200 MÈTRES

FEET 200 0 200 400 600 PIEDS

CONTOUR INTERVAL 1 METER
AUXILIARY CONTOURS 0.5 METER

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Projection:	tranverse de Mercator
Zone:	17
Meridien centrale:	81°0
Quadrillage de:	200 mètres
Photographies aériennes:	26 AVRIL 1989

PHOTOGRAMMÉTRIE

Les normes de production de cette carte se conforment aux standards de première classe. Cette carte a été préparée dans le cadre de l'accord Canada-Ontario de la réduction des dommages dus aux inondations, conclu le 31 MARS, 1978 et modifiée le 14 NOVEMBRE 1985.

CENTRAL LAKE ONTARIO CONSERVATION AUTHORITY

CANADA-ONTARIO FLOOD DAMAGE REDUCTION PROGRAM
PROGRAMME DE RÉDUCTIONS DES DOMMAGES DUS AUX INONDATIONS

Ontario

LEGEND - LÉGENDE

Horizontal control	010880173	Point de contrôle horizontal	
Vertical point	V-3 567-26	Point de contrôle vertical	
Spot elevation, water elevation	565-3	EL 423-6 ±	Point coté, élévation du plan d'eau
Photo centre	260		Centre de photo
Railway			Chemin de fer
Building, under construction, ruin	U/C	RUIN	Bâtiment, en construction, ruine
Road: paved, unpaved			Route: pavée, non pavée
under construction			en construction
Service road, service lane			Rue de désserte, ruelle
Driveway, cart track			Entrée privée, chemin de terre
Bridge, footbridge, culvert			Pont, passerelle, ponçeau
Parking area: paved, unpaved	PARKING	PARKING	Stationnement: pavé, non pavé
Fence, guard rail			Clôture, garde-fou
Wall			Mur
Pylon, pole, light standard, flag pole		FP	Pylône pôteau, lampadaire, mât
Transmission line			Ligne de transport d'énergie
Quarry, cliff			Carrière, falaise
Water course, definite			Cours d'eau, défini
indefinite			indéfini
Shoreline			Rive
Dam, falls, rapids	DAM	FALLS RAPIDS	Barrage, chutes, rapides
Pipeline, ditch	P	D	Pipe-line, fossé
Pool	P		Piscine
Marsh, swamp			Marais, marécage
Wooded area, scrub			Région boisée, broussailles
Hedge			Haie
Individual tree: minimum size			Arbre: grosseur minimum
Cemetery	CEMETERY		Cimetière
Contour	70		Courbe de niveau
Depression contour			Courbe de cuvette
Indefinite contour			Courbe de niveau imprécise
Auxiliary contour	70.5		Courbe de niveau intercalaire

Shoreline Information
Information sur les lignes de rivage

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Information sur les rivières

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Floodway boundary	Limite de canal de crue
Regulatory flood elevation 114.70 1000	Niveau de la crue régulatrice
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Cross section	Emplacement de la coupe transversale

SHEET INDEX

TABLEAU D'ASSEMBLAGE

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Toronto

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REGULATION No _____ No DU RÈGLEMENT

SCHEDULE No _____ CÉDULE No

Date	Amendment Revision

SHEET 32 OF 35
FEUILLE 32 DE 35

Central Lake Ontario Conservation

CENTRAL LAKE ONTARIO CONSERVATION AUTHORITY
100 Whiting Avenue Oshawa, Ontario L1H 3T3 (905) 579-0411

LEGEND

- REGULATORY FLOODLINE
- ROADS
- BOWMANVILLE CREEK AND SOPER CREEK (DRAINAGE STREAM)
- MODEL CROSS SECTION
- 1000 125.00 — STATION NUMBER AND REGULATORY (HAZEL OR 100-YR) FLOOD ELEVATION
- ▲ LOWEST WEIR ELEVATION

REVISIONS

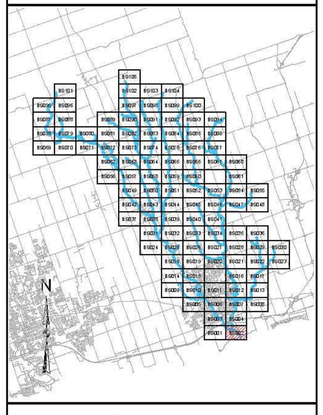
No.	DESCRIPTION	BY:	DATE:
1	Hydrologic Update	AL	05/10

Note:

1. This map is prepared for use in conjunction with the Bowmanville Creek and Soper Creek Floodplain Mapping Report dated May 2009.
2. Floodplain modeling was prepared by Aquafor Beech Limited using HEC-RAS 4.0, March 2008. Input parameters were extracted from base mapping with the use of HEC-GeoRAS.
3. Base mapping has been prepared by Central Lake Ontario Conservation Authority's Geomatics and Information Technology Department. Base Mapping was derived from First Base Solutions Digital Mapping and DEM Mapping produced from Aerial photography carried out in the spring of 2005.

Aquafor Beech Limited

PLEASE NOTE:
THE PROFESSIONAL ENGINEER STAMP VERIFIES THE FLOODLINE AND ASSOCIATED DATA UNLESS OTHERWISE NOTED



Meters
0 12.5 25 50 75 100 125 150
1:2,000

BOWMANVILLE CREEK & SOPER CREEK REGULATORY FLOOD PLAIN MAPPING

Sheet Number: BS002 - 68654862

May, 2009

WS2

Central Lake Ontario Conservation

This map is prepared for use in conjunction with the Hydrologic & Hydraulic modeling for Westside Creek Documentation, 2013.

Floodplain modelling prepared by Engineering Department, CLOCA, using HEC-GeoRAS v10.0, 2013. Input parameters were extracted from base mapping with the use of HEC-Geo RAS.

Base mapping compiled from First Base Solutions Digital Ortho Mapping & DEM Mapping derived from aerial photography (Spring 2010), carried out by Geomatics and Information Technology, CLOCA.

WESTSIDE CREEK FLOODPLAIN MAPPING

- Regulatory Floodplain
- Drainage
- Study Limit
- Contour
- Cross Section
- 3800 49.90 — Station Number and Flood Elevation
- Railway
- Spill Location

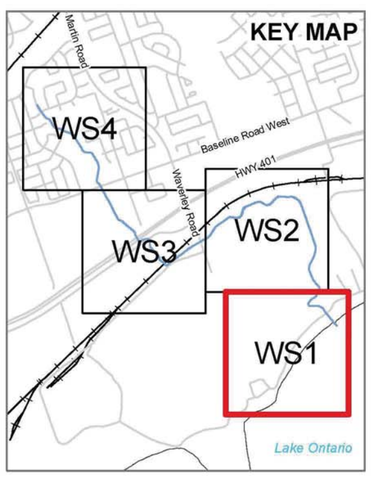
1:2,000

50 25 0 50 100 150 200 250 300

Metres

N

KEY MAP



REVISIONS AND UPDATES

NO.	DATE	REVISION

MAP NUMBER
WS1

March 2013

APPENDIX 2

REPORT ON HYDROTECHNICAL ANALYSIS OF MODIFICATIONS TO WEST SIDE CREEK AND MARSH ASSOCIATED WITH FUTURE OPERATIONS OF BLUE CIRCLE CEMENT

Prepared for

Blue Circle Cement
(formerly St. Mary's Cement Corporation)

April 1998

Marshall
Macklin
Monaghan
CONSULTING ENGINEERS • SURVEYORS • PLANNERS

Marshall
Macklin
Monaghan
CONSULTING ENGINEERS - SURVEYORS - PLANNERS

80 COMMERCE VALLEY DR. EAST
THORNHILL, ONTARIO L3T 7N4
TELEPHONE (905) 882-1100
FAX (905) 882-0055

April 6, 1998
File: 10-92616

Blue Circle Canada Inc.
410 Waverly Road
RR#2, Bowmanville
Ontario, L1C 3K3

Attention: **Mr. Wilson Little, P.Eng.**

Dear Mr. Little,

Subject: **Summary Report - Hydrotechnical Analysis**
Modifications to Westside Creek and Marsh

We are pleased to submit our report providing an up-to-date summary of our hydrotechnical investigations of the proposed modifications to Westside Creek and Marsh to facilitate future operations of Blue Circle Cement in the area. This has been prepared in response to a request from the Central Lake Ontario Conservation Authority (CLOCA) and the Ministry of Natural Resources (MNR) for a compilation of the final results from these investigations. This will facilitate their final approvals for the proposed works.

We trust this submission is satisfactory but if you have any questions please contact the undersigned. We have forwarded copies of this report to CLOCA and MNR on your behalf.

Yours Very Truly,

MARSHALL MACKLIN MONAGHAN LIMITED

Robert Bishop

Rob Bishop, P.Eng.
Vice President
Water Resources

c.c. Mr. P. Sisson, P.Eng., CLOCA
Mr. J. Boonstra, MNR
Mr. I. McNaughton, MHBC Planning Ltd

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1.0 INTRODUCTION

1.1 Background

Blue Circle Cement (formerly St. Mary's Cement Corporation) has an existing license for an aggregate mining operation within the West Side Creek drainage area in the Town of Bowmanville. They are preparing to expand their operations into their Phase II & III quarry area. Part of this area is located at the base of the West Side Creek drainage basin within the West Side marsh. A preliminary proposal for aggregate extraction in that area was made in 1992/3. However, the municipality and local community members adjacent to the marsh area had concerns with certain issues associated with mining in the marsh and discussions ensued. The Waterfront Regeneration Trust was asked to help find a resolution to these issues to help identify a plan that is a balance between economy and community.

During the search for an acceptable resolution, there have been many studies, and options investigated. These have has resulted in the proposed "cooperative marsh alternative". This alternative preserves a large section of marsh, provides improvements to portions of the preserved marsh, and allows mining of a reasonable portion of Blue Circle's quarry rights. Drawing DRG1 shows the area in question and the main elements of the proposed scheme which include:

- approximately 25 hectares of preserved and enhanced marsh land with an additional 47 hectares of parkland to buffer the residential communities along Cedar Crest Beach Road and Cove Road
- a berm along the north side of the preserved marsh area which will separate the quarried area from the marsh area
- a 1.8 km long channel designed to divert the flow of West Side Creek around the quarry area and back into the preserved marsh
- a 500 m long overflow channel at the west end of the preserved marsh. This is designed to maintain outflows from the existing outlet of West Side Creek into Lake Ontario at the same levels as today
- a new bridge across the existing outlet of West Side Creek to provide access to Cedar Crest Beach Road west of the outlet. This is required since Waverly Road south of West Side Creek will be closed.

These elements will be discussed in more detail in subsequent sections of this report. However, since they form a significant modification to the West Side Creek south of the CNR tracks, an investigation of their impact upon the hydrology and hydraulics of the water course was required. This included an update of the regulatory flood plain.

1.2 Scope of Current Report

Since 1993, a series of submissions have been made to the Municipality of Clarington, CLOCA and MNR describing the hydrologic and hydraulic analysis of the modified West Side Creek water course and marsh area. These have included a letter report of February 16, 1996, a letter of September 3, 1996 discussing riparian flood issues, a letter of April 24, 1997 updating the analysis after changes to the marsh configuration and a letter of November 4, 1997 providing further information on riparian flooding and suggesting raising Cedar Crest Beach Road. These have addressed the issues raised and have documented the analysis at various stages. However, they have created a lengthy and complex set of documentation which is not all necessarily relevant to the final form of the proposed scheme. Hence the purpose of this report is to provide a final, straight forward description of the proposed modifications to West Side Creek and Marsh between the CNR tracks and Lake Ontario, support for the design of the diversion and overflow channels and documentation of changes to the hydrology and hydraulics and the implications of those changes.

2.0 DESCRIPTION OF PROPOSED MODIFICATIONS

2.1 Modifications to Westside Creek Marsh

To facilitate extraction of aggregate from below part of the existing West Side Creek Marsh, a the area of the existing marsh will be reduced by constructing a separation berm through the area. Drawing DRG1 illustrates the concept. A total of 72 hectares of marsh and upland environmental areas will be retained. Inflow to the upstream end of the marsh will be diverted around the quarry area into the upstream end of the remnant marsh area. Extensive enhancements to the remnant marsh area, the diversion channel and the secondary outlet channel will be included as part of the fisheries compensation plan agreed to with the Federal Department of Fisheries and Oceans and the Ontario Ministry of Natural Resources. This is described in detail in the report, "Phase III Quarry Expansion: West Side Marsh, Fisheries Habitat Compensation Report" (Dillon Consulting, 1996. The design of all modifications within the marsh area including the separation berm was completed by Dillon Consulting. Their drawings should be referred to for details of this area. The impact of changes in this area on the hydrology and hydraulics of the West Side Creek have been reflected in the OTTHYMO and HEC-2 models described in Section 3.

2.2 Proposed Diversion Channel

Before quarrying operations can begin, the area of marsh to be quarried must be drained by re-directing West Side Creek. The Creek will be diverted east after it passes under the Canadian National Railway tracks. Along this section, the diversion channel will be within an Ontario Hydro easement. Flows will then be directed south along the east boundary of the site and back into the remnant wetland area. The proposed route for the diversion channel will require a significant amount of cut and fill to provide appropriate capacity and to match the existing and proposed inverts upstream, downstream and at the tributary (known as Railroad Creek) which currently enters the marsh at its northern boundary.

The diversion channel is proposed to have a relatively natural cross-section consisting of a trapezoidal shape with a meandering low flow channel throughout its length. Upstream of the tributary the bottom width will be 5 meters with a side slope of 3 horizontal to 1 vertical. The longitudinal slope will be 0.43%. In plan view, the channel will meander somewhat within the Hydro easement to mimic approximately the meander length of a natural river of this size near its outlet. Downstream of Railroad Creek, the channel will then change to a linear marsh. The basic shape will be a flooded trapezoid with an 8 meter wide bottom and 2 horizontal to 1 vertical side slopes. The longitudinal slope in this section will be 0.11%.

In the low lying section where Railroad Creek meets the diversion channel, the trapezoidal channel would have to be constructed in fill to contain the entire design flow. However, in order to maintain and enhance fisheries potential, it is proposed that the channel be discontinued

through this section to allow a wetland area to form north of the channel alignment up to the CNR tracks. A berm will be constructed along the edge of the proposed quarry limits to prevent flow from entering the quarry. The berm will have an approximate top elevation of 78 metres and have 3 to 1 side slopes. The berm will keep all flows out of the quarry and effectively create the wetland between it and the CN Rail tracks. The trapezoidal channel will continue in cut to the east of this area.

The geomorphological characteristics and the fisheries aspects of the diversion are described in the report by Dillon Consulting Limited (1996).

2.3 Proposed Secondary Outlet from Remnant Marsh

As discussed in Section 3, a secondary outlet from the remnant marsh is proposed. This will be about 500 m in length and will be routed east from the marsh and then south into the Lake just west of the present Waverly Road alignment. It will have a trapezoidal section with a 12 m bottom width. The first section will have a reverse slope to a high point of 75.68 m at Waverly Road about 250 m west of the edge of the marsh. This is to allow this section to remain flooded during normal water level conditions to provide additional fish habitat. From the high point, the channel will slope down to the Lake. The fisheries compensation aspects of the secondary outlet are described in Dillon (1996).

3.0 DISCUSSION OF HYDROTECHNICAL ANALYSIS

As described in the previous section, significant changes are proposed to the West Side Creek and Marsh between the CNR tracks and Lake Ontario. In order to design these modifications and to understand their impact upon the hydrology and hydraulics of the watercourse, a hydrotechnical analysis was completed. The questions addressed by this analysis were:

i) what are the appropriate flows to use in the design of the diversion channel?

ii) what is the effect of the diversion channel and the reduction in storage in the marsh area upon flows in West Side Creek?

iii) what is the effect of any change in flows upon water levels along the existing outlet channel from the marsh, in the marsh itself and along the diversion channel?

iv) are any mitigating measures required to counter the effects of changes in flows and water levels?

v) what is the extent of the regulatory (Regional Storm) flood plain after the modifications are completed?

An earlier study of West Side Creek investigated the potential impact of proposed future development in the Town of Bowmanville. This was reported in the West Side Creek Master Drainage Study by G.M. Sernas & Associates Limited (September 1992). During that study, hydrologic and hydraulic models of the existing watercourse and marsh were developed. Both the HEC-2 and the OTTHYMO computer models from that study were used as the basis for the current study.

3.1 Hydrologic Modelling

The hydrologic model of West Side Creek developed during the West Side Creek Master Drainage Study (MDS) covers the entire 7.4 km^2 of the watershed. It consists of 18 sub-watersheds (see Drawing 2 of the noted report) of which three are located south of the CNR tracks and are directly affected by the proposed modifications to the creek and marsh within the Blue Circle Cement property. The MDS considered several development conditions within the watershed and models were developed for each case. For the purposes of this report, the base model adopted was for future land use conditions with stormwater management controls included. This reflects the most probable long term watershed condition and is the most appropriate for planning and design of permanent water course modifications.

The West Side Creek MDS OTTHYMO model does not include routing of flows through the

storage in West Side Marsh. This creates conservative discharge values from the existing marsh and correspondingly conservative water levels. This is not significant when considering the Regional Storm and associated flood lines. However, when considering more frequent flows, the effect is important. For example, if the routing is ignored then flooding of buildings adjacent to the outlet channel is predicted during any storm over the 1 year return period. This is not consistent with local observations. Hence, the OTTHYMO model was modified to include a ROUTE RESERVOIR element to model the storage effect.

In order to include the reservoir routing, a storage-discharge curve was required. The discharge-elevation relationship for the marsh outlet was created using the HEC-2 model from the Master Drainage Study. Storage volumes were calculated from contour mapping of the marsh area produced by Brown and Coggan Ltd. in June 1994. The storage-discharge curve for the existing marsh is shown on Table 3.1.

Table 3.1
Storage Discharge Curve for Existing Wetland

Elevation (m)	Storage ha-m (ac-ft)	Discharge m^3/s (cfs)
75.68	12.04 (97.5)	0.57 (20)
75.77	16.13 (130.7)	1.13 (40)
75.83	18.82 (153.3)	1.70 (60)
75.91	23.67 (191.7)	2.83 (100)
76.05	29.52 (239.1)	5.46 (193)
76.11	32.48 (263.8)	7.22 (255)
76.20	37.01 (299.7)	11.50 (406)
76.26	39.56 (320.4)	14.75 (521)
76.35	44.75 (362.5)	19.71 (696)
76.47	51.13 (414.1)	33.13 (1170)

Existing Conditions

Using the modified model, the outflows from the marsh and corresponding water levels in the marsh were computed for the existing conditions. Table 3.2 shows the results for storms between the 1 in 1 year and 1 in 100 year return period and for the Regional Storm. The water levels indicated result in flooding of a few structures around the marsh outlet for storms of 1 in 100 year return period or greater. This more closely corresponds to local experience and hence this modified model was adopted for use in the investigation of changes to the marsh.

Table 3.2
Peak Flows at Marsh Outlet and Water Levels in Marsh
(Existing Marsh)

	No Reservoir Routing		With Reservoir Routing	
Return Period (Years)	**Flow (m^3/s)**	**Elevation (m)**	**Flow (m^3/s)**	**Elevation (m)**
1	5.47	76.04	0.23	75.41
2	7.22	76.09	0.33	75.58
5	11.50	76.21	0.53	75.67
10	14.75	76.27	0.77	75.71
25	19.71	76.35	1.27	75.78
100	33.13	76.48	3.03	75.94
Regional	56.41	76.62	23.90	76.39

Future Conditions

Upon implementation of the proposed modifications to West Side Creek and Marsh, flows from the main watercourse will be diverted around the remnant marsh and the surface area of the marsh will be reduced by about 40%. In order to model the effect of these changes, the OTTHYMO model was modified as follows:

- the discharge-storage curve for the marsh area was modified from that shown in Table

3.1 to that shown in Table 3.3 to reflect the reduction in storage. It should be noted that the stage-discharge component was not modified. Although the proposed scheme requires construction of a new bridge across the outlet of West Side Creek, a HEC-2 analysis of the proposed design indicated that it has no impact upon the upstream water levels in the marsh. Hence the outlet rating curve for the marsh remains the same as for existing conditions (see HEC-2 comparison with and without bridge in Appendix B).

- the configuration of the OTTHYMO model south of the CNR tracks was modified to reflect the realignment of the watercourse. In particular, subwatersheds 17 and 18 of the original model were removed and new subwatersheds 901, 902, 903 and 904 were added to reflect the new drainage pattern into the diversion channel and remnant marsh.

Table 3.3
Storage Discharge Curve for Remnant Wetland

Elevation (m)	Storage ha-m (ac-ft)	Discharge m^3/s (cfs)
75.68	7.75 (62.8)	0.57 (20)
75.77	10.21 (82.7)	1.13 (40)
75.83	11.95 (96.8)	1.70 (60)
75.91	14.91 (120.8)	2.83 (100)
76.05	18.58 (150.5)	5.46 (193)
76.11	20.50 (166.1)	7.22 (255)
76.20	23.38 (189.4)	11.50 (406)
76.26	25.02 (202.7)	14.75 (521)
76.35	28.36 (229.7)	19.71 (696)
76.47	32.24 (261.2)	33.13 (1170)

Table 3.4 shows the peak flows from the marsh and associated water levels in the remnant marsh based upon the modified configuration. As anticipated because of the reduced storage, outflows and water levels would potentially increase significantly. These changes would potentially increase flooding on the properties surrounding the outlet and increase water fluctuations within

the marsh itself with potentially negative impacts on the biological communities. Hence it was necessary to consider ways in which these increases could be reduced and any negative impacts mitigated.

Table 3.4
Comparison of Flows and Water Levels for Existing and Modified Conditions

Return Period (year)	Existing Conditions		Modified Conditions	
	Flow (m^3/s)	Elevation (m)	Flow (m^3/s)	Elevation (m)
1	0.23	75.41	0.33	75.58
2	0.33	75.58	0.46	75.65
5	0.53	75.67	0.98	75.74
10	0.77	75.71	1.54	75.80
25	1.27	75.78	2.40	75.89
100	3.03	75.94	5.44	76.05
Regional	23.90	76.39	31.65	76.46

After considering a number of alternatives (e.g. permitting an overflow into the quarry area under some conditions), it was proposed that a secondary outlet be constructed from the west end of the remnant marsh to Lake Ontario. This would consist of a trapezoidal channel with a bottom width of 12 metres. It would function for storms equal to or greater than a 1 year return period. Drawing DRG1 shows the location and general configuration of the channel. Table 3.5 shows the rating curve for the secondary outlet channel and the combined rating curve for both the main outlet and secondary outlet as input to the OTTHYMO model. The storage-elevation curve remains as shown in Table 3.3.

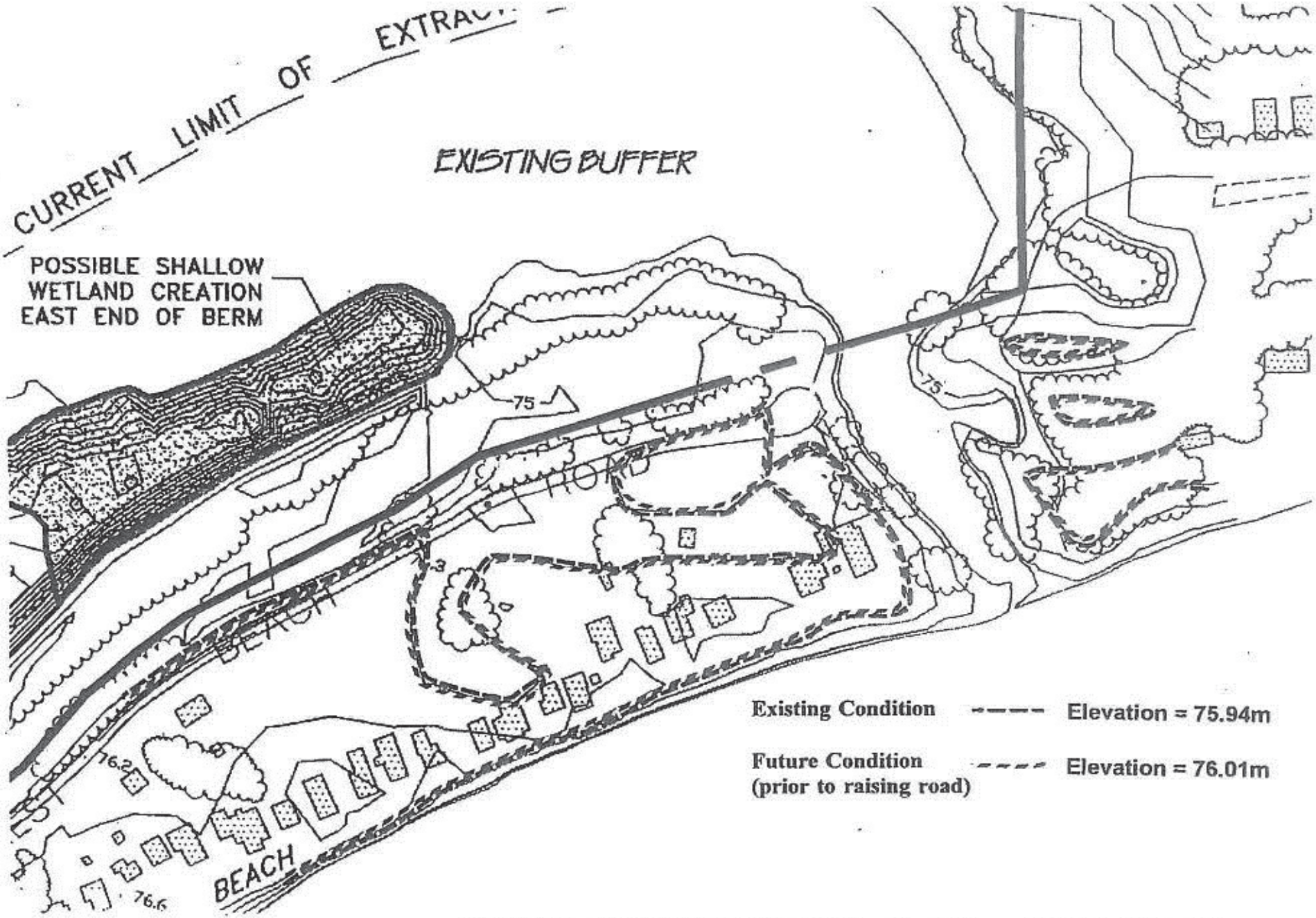


Figure 3.1: Comparison of 1 in 100 Year Flood Lines at Outlet of West Side Marsh

Table 3.5
Rating Curve for Secondary Outlet and Total Combined Outflow from Modified Marsh Area

Elevation (m)	Secondary Outlet m^3/s (cfs)	Combined Outflow m^3/s (cfs)
75.68	0. (0)	0.57 (20)
75.77	0.28 (10)	1.42 (50)
75.83	0.65 (23)	2.35 (83)
75.91	1.36 (48)	4.19 (148)
76.05	3.03 (107)	8.49 (300)
76.11	3.91 (138)	11.13 (393)
76.20	5.44 (192)	16.93 (598)
76.26	6.54 (231)	21.29 (752)
76.35	8.38 (296)	28.09 (992)
76.47	11.18 (395)	44.31 (1565)

The effect of the additional outlet is to release more water from the remnant marsh during high flows preventing any significant increase in water levels above those for existing conditions. Table 3.6 shows the predicted water levels in the marsh and flows at the outlet for the 1 in 1 year to 1 in 100 year storm and the Regional Storm compared to those for the existing conditions. As indicated, the Regional Storm water level is marginally reduced while levels up to the 1 in 100 year storm are potentially raised between 4 and 14 cm. An evaluation of the impact of these increases indicated that a number of structures along Cedar Crest Beach Road are currently within the West Side Creek flood plain. Five structures are in the 1 in 100 year and 21 are within the Regional Storm flood plain. No structures are flooded for the 1 in 25 year or lower return period storms. Under the proposed conditions, the same number of structures are within the Regional Storm flood plain. Similarly, there is no flooding of structures for the 1 in 25 year or more frequent storms. However, for the 1 in 100 year storm, about 3 to 5 additional structures may be subject to flooding to a depth of up to 5 centimetres (it is difficult to be precise given that the contour interval of the available mapping is 0.5 metres). Figure 3.1 shows the limits of the 1 in 100 year flood plain for existing and proposed conditions.

Table 3.6
Comparison of Flows and Water Levels
for Existing and Modified Conditions with Secondary Outlet

Storm Return Period (years)	Existing Flows (m^3/s)	Modified Flows (m^3/s)	Change in Flows (m^3/s)	Existing Water Levels (m)	Modified Water Levels (m)	Change in Levels (m)
1	0.23	0.31	+0.08	75.41	75.55	+0.14
2	0.33	0.45	+0.12	75.58	75.62	+0.04
5	0.53	0.96	+0.43	75.67	75.74	+0.07
10	0.77	1.34	+0.57	75.71	75.79	+0.08
25	1.27	2.17	+0.90	75.78	75.86	+0.08
100	3.03	4.65	+1.62	75.94	76.01	+0.07
Regional	23.90	22.59	-1.31	76.39	76.38	-0.01

The affected structures appear to be predominantly garden sheds or garages not residences. Hence the potential increase in flood damage would seem to be minimal. However, given the criteria of the Lakes and Rivers Improvement Act and Blue Circle's desire to cause no impact on adjacent land owners where feasible, a simple solution to the problem has been formulated. As noted earlier, a bridge is to be constructed over Westside Creek at the east end of Cedar Crest Beach Road. This is to provide access to properties along the road when Waverly Road is removed. By ensuring that the western bridge approach (i.e. along Cedar Crest Beach Road) is constructed at a minimum elevation of 76.1 m., the flooding on the south side of the road for the 100 year event can be prevented. This will eliminate not only the potential flooding of additional structures but also flooding of those structures currently in the 1 in 100 year flood plain. Achieving a minimum elevation of 76.1 m will require raising two low areas on the approach to the bridge by 0.1 to 0.2 m. Hydraulic calculations indicated that this will have no impact on the Regional Storm level.

Appendix A contains print outs from the OTTHYMO model corresponding to Tables 3.2 (existing condition with reservoir routing) and 3.6 (proposed conditions with secondary outlet) for the 1 in 100 year storm. A full set of model inputs and outputs for all storms is included on a computer disk in a pocket at the back of this report.

3.2 Hydraulic Modelling

Hydraulic modelling using the HEC-2 model was completed for the following reasons:

- to assist in sizing the diversion channel and associated culverts and ensure that required design criteria were met
- to provide a basis for a revised regulatory flood line from Lake Ontario to the CNR tracks (except within the Marsh itself where the OTTHYMO routing results were used)
- to provide rating curves for the Marsh routing (as described in the previous section)
- to assist in designing the secondary outlet at the west end of the remnant Marsh
- to analyse the effect of the proposed new bridge across the outlet from West Side Marsh at Cedar Crest Beach Road.

The starting point for the analysis was the HEC-2 model developed in the West Side Creek Master Drainage Study by G.M. Sernas & Associates Limited (September 1992). That model was developed on the basis of 1 inch to 200 foot topographic mapping and is coded in Imperial units. Although the model was extensively modified in the present study, the Imperial units were retained because of the need for consistency with the previous work when comparing existing and future water levels and flood plain limits. The present work was based upon topographic mapping in metric units at a scale of 1:2,000 as prepared by Brown and Coggan Ltd. in June 1994. In addition, extensive field surveys were completed along the alignment of the proposed diversion channel. Other field surveys were completed by Marshall Macklin Monaghan Limited, Dillon Consultants and Totten Sims Hubicki in the areas of the marsh and its outlet. Information from these surveys was incorporated into the revised model and was used to ensure the sections of the earlier model which were retained were consistent with the more recent mapping.

The cross-section locations for the revised HEC-2 model of proposed conditions between Lake Ontario and the downstream end of the diversion channel are shown on Drawing DRG1. The section locations for the diversion are shown on the detailed plans (Drawings P1 to P3) of the channel which accompany this report. The input data and summary output for the 1 in 1 year to 1 in 100 year storms and the Regional Storm are included in Appendix B. They are also included on the computer disk in a pocket at the end of this report. A separate HEC-2 model was developed for the secondary outflow channel. Cross-section locations are also shown on Drawing DRG1. Model input and summary output are also included in Appendix B and on the computer disk.

Several points should be noted regarding the HEC-2 model results.

i) flows were obtained from the OTTHYMO modelling. In the downstream reach from Lake Ontario to cross-section 454, the flows are the routed outflows from the remnant marsh area

ii) the diversion channel was designed to convey the Regional Storm flow with the exception of the area at the confluence with Railroad Creek. In that section, spillage from a small pilot channel was encouraged to help preserve and promote a wetland area

iii) flood lines for the Regional storm are shown on Drawing DRG1 for the outlet and marsh areas and on Drawings P1 to P3 for the diversion channel up to the CNR tracks. In the marsh area, the water level corresponding to the maximum level for the hydrologic routing through the marsh (i.e. 76.38 m) has been used to plot the flood line. This is slightly higher than in the HEC-2 model and is therefore a conservative interpretation.

iv) several culverts are required to provide access to Ontario Hydro towers for maintenance purposes and at the crossing of the remaining part of Waverly Road. The sizes required are shown in Table 3.7. The diversion channel and culverts were designed so that there is no increase in water surface elevation upstream of the existing CNR tracks. Velocities and flood elevations calculated by HEC-2 are provided in the attached Appendix B.

Table 3.7
Proposed Culvert Specifications

Culvert	Number	Length (m)	Height (m)	Width (m)
3087	3	73.	3.0	2.4
5066	2	44.	1.8	3.0
6040	2	100.	1.8	3.0

v) channel velocities range from a low of 0.1 m/s to a high of 3.6 m/s. The section of creek that is most affected by high velocities is between the CNR tracks and the junction of the diversion and the tributary where velocities exceed 1.5 m/s at the 5 year storm. Lining of this section of the channel with a heavy coir cloth (eg. Geo-coir Dekowe 900) that can withstand velocities of up to 3.6 m/s is recommended. The same coir cloth can be used at the entrance and exits of the culverts and at the outsides of bends. An alternative type of erosion control which could be used at the bends is 500mm diameter rip rap or rootwads.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The following are the main conclusions and recommendations of this investigation:

i) an OTTHYMO model of the West Side Creek watershed for future land use conditions with stormwater management was chosen as a basis for calculating flows for the proposed diversion channel. A reservoir routing component was added to represent the storage in West Side Marsh. Flows and water levels generated by this model for the outlet of West Side Creek to Lake Ontario more closely agreed with local observations than the model without routing.

ii) the diversion channel and associated culverts have been designed to convey the Regional Storm such that there is no increase in water levels upstream of the CNR tracks

iii) the reduced storage in the marsh after implementation of the proposed modifications could potentially lead to higher flows and water levels at the outlet of the marsh. This could have a negative impact upon adjacent properties. Hence two remedial actions are recommended:

- the construction of a secondary outlet from the west end of the remnant marsh to partially divert high flows away from the existing outlet and minimize changes in water levels in the marsh

- raising of the approach road to the new bridge over the West Side Marsh outlet to a minimum elevation of 76.1 m.

Together, these measures will reduce the flood potential for flows up the 1 in 100 year return period storm for properties along Cedar Crest Beach Road. The number of properties susceptible to flooding for the Regional Storm will be unchanged

iv) flood lines for the regulatory flood (Regional Storm) have been computed for the modified wetland and watercourse downstream of the CNR tracks. These are shown on Drawings DWG1 and P1 to P3 which accompany this report.

v) velocities in the proposed diversion channel will be sufficiently high that heavy coir cloth should be used to protect areas while vegetation becomes established. This will be aided by constructing the channel in the dry and leaving it for 2 years prior to diverting West Side Creek into it.

5.0 REFERENCES

Dillon Consulting Limited. 1996. "Phase III Quarry Expansion: West Side Marsh, Fisheries Habitat Compensation Report" prepared for St. Marys Cement Corporation.

Sernas & Associates Limited. 1992. West Side Creek Master Drainage Study prepared for The Town of Newcastle and Central Lake Ontario Conservation Authority.

Waterfront Regeneration Trust. 1995. West Side Marsh - Final Report.

WS2

Central Lake Ontario Conservation

This map is prepared for use in conjunction with the Hydrologic & Hydraulic modeling for Westside Creek Documentation, 2013.

Floodplain modelling prepared by Engineering Department, CLOCA, using HEC-GeoRAS v10.0, 2013. Input parameters were extracted from base mapping with the use of HEC-Geo RAS.

Base mapping compiled from First Base Solutions Digital Ortho Mapping & DEM Mapping derived from aerial photography (Spring 2010), carried out by Geomatics and Information Technology, CLOCA.

WESTSIDE CREEK FLOODPLAIN MAPPING

- Regulatory Floodplain
- Drainage
- Study Limit
- Contour
- Cross Section
- 3800 49.90 — Station Number and Flood Elevation
- Railway
- Spill Location

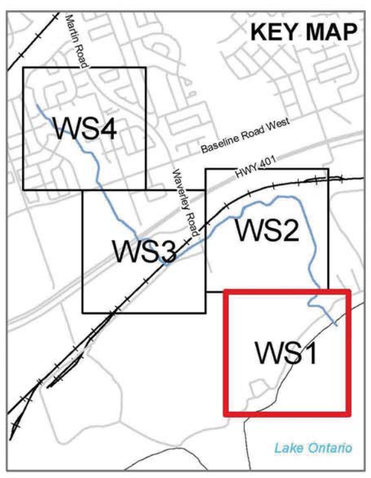
1:2,000

50 25 0 50 100 150 200 250 300

Metres

N

KEY MAP



REVISIONS AND UPDATES

NO.	DATE	REVISION

MAP NUMBER
WS1

March 2013

APPENDIX 2

REPORT ON HYDROTECHNICAL ANALYSIS OF MODIFICATIONS TO WEST SIDE CREEK AND MARSH ASSOCIATED WITH FUTURE OPERATIONS OF BLUE CIRCLE CEMENT

Prepared for

Blue Circle Cement
(formerly St. Mary's Cement Corporation)

April 1998

Marshall
Macklin
Monaghan
CONSULTING ENGINEERS • SURVEYORS • PLANNERS

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April 6, 1998
File: 10-92616

Blue Circle Canada Inc.
410 Waverly Road
RR#2, Bowmanville
Ontario, L1C 3K3

Attention: **Mr. Wilson Little, P.Eng.**

Dear Mr. Little,

Subject: **Summary Report - Hydrotechnical Analysis**
Modifications to Westside Creek and Marsh

We are pleased to submit our report providing an up-to-date summary of our hydrotechnical investigations of the proposed modifications to Westside Creek and Marsh to facilitate future operations of Blue Circle Cement in the area. This has been prepared in response to a request from the Central Lake Ontario Conservation Authority (CLOCA) and the Ministry of Natural Resources (MNR) for a compilation of the final results from these investigations. This will facilitate their final approvals for the proposed works.

We trust this submission is satisfactory but if you have any questions please contact the undersigned. We have forwarded copies of this report to CLOCA and MNR on your behalf.

Yours Very Truly,

MARSHALL MACKLIN MONAGHAN LIMITED

Robert Bishop

Rob Bishop, P.Eng.
Vice President
Water Resources

c.c. Mr. P. Sisson, P.Eng., CLOCA
Mr. J. Boonstra, MNR
Mr. I. McNaughton, MHBC Planning Ltd

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1.0 INTRODUCTION

1.1 Background

Blue Circle Cement (formerly St. Mary's Cement Corporation) has an existing license for an aggregate mining operation within the West Side Creek drainage area in the Town of Bowmanville. They are preparing to expand their operations into their Phase II & III quarry area. Part of this area is located at the base of the West Side Creek drainage basin within the West Side marsh. A preliminary proposal for aggregate extraction in that area was made in 1992/3. However, the municipality and local community members adjacent to the marsh area had concerns with certain issues associated with mining in the marsh and discussions ensued. The Waterfront Regeneration Trust was asked to help find a resolution to these issues to help identify a plan that is a balance between economy and community.

During the search for an acceptable resolution, there have been many studies, and options investigated. These have has resulted in the proposed "cooperative marsh alternative". This alternative preserves a large section of marsh, provides improvements to portions of the preserved marsh, and allows mining of a reasonable portion of Blue Circle's quarry rights. Drawing DRG1 shows the area in question and the main elements of the proposed scheme which include:

- approximately 25 hectares of preserved and enhanced marsh land with an additional 47 hectares of parkland to buffer the residential communities along Cedar Crest Beach Road and Cove Road
- a berm along the north side of the preserved marsh area which will separate the quarried area from the marsh area
- a 1.8 km long channel designed to divert the flow of West Side Creek around the quarry area and back into the preserved marsh
- a 500 m long overflow channel at the west end of the preserved marsh. This is designed to maintain outflows from the existing outlet of West Side Creek into Lake Ontario at the same levels as today
- a new bridge across the existing outlet of West Side Creek to provide access to Cedar Crest Beach Road west of the outlet. This is required since Waverly Road south of West Side Creek will be closed.

These elements will be discussed in more detail in subsequent sections of this report. However, since they form a significant modification to the West Side Creek south of the CNR tracks, an investigation of their impact upon the hydrology and hydraulics of the water course was required. This included an update of the regulatory flood plain.

1.2 Scope of Current Report

Since 1993, a series of submissions have been made to the Municipality of Clarington, CLOCA and MNR describing the hydrologic and hydraulic analysis of the modified West Side Creek water course and marsh area. These have included a letter report of February 16, 1996, a letter of September 3, 1996 discussing riparian flood issues, a letter of April 24, 1997 updating the analysis after changes to the marsh configuration and a letter of November 4, 1997 providing further information on riparian flooding and suggesting raising Cedar Crest Beach Road. These have addressed the issues raised and have documented the analysis at various stages. However, they have created a lengthy and complex set of documentation which is not all necessarily relevant to the final form of the proposed scheme. Hence the purpose of this report is to provide a final, straight forward description of the proposed modifications to West Side Creek and Marsh between the CNR tracks and Lake Ontario, support for the design of the diversion and overflow channels and documentation of changes to the hydrology and hydraulics and the implications of those changes.

2.0 DESCRIPTION OF PROPOSED MODIFICATIONS

2.1 Modifications to Westside Creek Marsh

To facilitate extraction of aggregate from below part of the existing West Side Creek Marsh, a the area of the existing marsh will be reduced by constructing a separation berm through the area. Drawing DRG1 illustrates the concept. A total of 72 hectares of marsh and upland environmental areas will be retained. Inflow to the upstream end of the marsh will be diverted around the quarry area into the upstream end of the remnant marsh area. Extensive enhancements to the remnant marsh area, the diversion channel and the secondary outlet channel will be included as part of the fisheries compensation plan agreed to with the Federal Department of Fisheries and Oceans and the Ontario Ministry of Natural Resources. This is described in detail in the report, "Phase III Quarry Expansion: West Side Marsh, Fisheries Habitat Compensation Report" (Dillon Consulting, 1996. The design of all modifications within the marsh area including the separation berm was completed by Dillon Consulting. Their drawings should be referred to for details of this area. The impact of changes in this area on the hydrology and hydraulics of the West Side Creek have been reflected in the OTTHYMO and HEC-2 models described in Section 3.

2.2 Proposed Diversion Channel

Before quarrying operations can begin, the area of marsh to be quarried must be drained by re-directing West Side Creek. The Creek will be diverted east after it passes under the Canadian National Railway tracks. Along this section, the diversion channel will be within an Ontario Hydro easement. Flows will then be directed south along the east boundary of the site and back into the remnant wetland area. The proposed route for the diversion channel will require a significant amount of cut and fill to provide appropriate capacity and to match the existing and proposed inverts upstream, downstream and at the tributary (known as Railroad Creek) which currently enters the marsh at its northern boundary.

The diversion channel is proposed to have a relatively natural cross-section consisting of a trapezoidal shape with a meandering low flow channel throughout its length. Upstream of the tributary the bottom width will be 5 meters with a side slope of 3 horizontal to 1 vertical. The longitudinal slope will be 0.43%. In plan view, the channel will meander somewhat within the Hydro easement to mimic approximately the meander length of a natural river of this size near its outlet. Downstream of Railroad Creek, the channel will then change to a linear marsh. The basic shape will be a flooded trapezoid with an 8 meter wide bottom and 2 horizontal to 1 vertical side slopes. The longitudinal slope in this section will be 0.11%.

In the low lying section where Railroad Creek meets the diversion channel, the trapezoidal channel would have to be constructed in fill to contain the entire design flow. However, in order to maintain and enhance fisheries potential, it is proposed that the channel be discontinued

through this section to allow a wetland area to form north of the channel alignment up to the CNR tracks. A berm will be constructed along the edge of the proposed quarry limits to prevent flow from entering the quarry. The berm will have an approximate top elevation of 78 metres and have 3 to 1 side slopes. The berm will keep all flows out of the quarry and effectively create the wetland between it and the CN Rail tracks. The trapezoidal channel will continue in cut to the east of this area.

The geomorphological characteristics and the fisheries aspects of the diversion are described in the report by Dillon Consulting Limited (1996).

2.3 Proposed Secondary Outlet from Remnant Marsh

As discussed in Section 3, a secondary outlet from the remnant marsh is proposed. This will be about 500 m in length and will be routed east from the marsh and then south into the Lake just west of the present Waverly Road alignment. It will have a trapezoidal section with a 12 m bottom width. The first section will have a reverse slope to a high point of 75.68 m at Waverly Road about 250 m west of the edge of the marsh. This is to allow this section to remain flooded during normal water level conditions to provide additional fish habitat. From the high point, the channel will slope down to the Lake. The fisheries compensation aspects of the secondary outlet are described in Dillon (1996).

3.0 DISCUSSION OF HYDROTECHNICAL ANALYSIS

As described in the previous section, significant changes are proposed to the West Side Creek and Marsh between the CNR tracks and Lake Ontario. In order to design these modifications and to understand their impact upon the hydrology and hydraulics of the watercourse, a hydrotechnical analysis was completed. The questions addressed by this analysis were:

i) what are the appropriate flows to use in the design of the diversion channel?

ii) what is the effect of the diversion channel and the reduction in storage in the marsh area upon flows in West Side Creek?

iii) what is the effect of any change in flows upon water levels along the existing outlet channel from the marsh, in the marsh itself and along the diversion channel?

iv) are any mitigating measures required to counter the effects of changes in flows and water levels?

v) what is the extent of the regulatory (Regional Storm) flood plain after the modifications are completed?

An earlier study of West Side Creek investigated the potential impact of proposed future development in the Town of Bowmanville. This was reported in the West Side Creek Master Drainage Study by G.M. Sernas & Associates Limited (September 1992). During that study, hydrologic and hydraulic models of the existing watercourse and marsh were developed. Both the HEC-2 and the OTTHYMO computer models from that study were used as the basis for the current study.

3.1 Hydrologic Modelling

The hydrologic model of West Side Creek developed during the West Side Creek Master Drainage Study (MDS) covers the entire 7.4 km^2 of the watershed. It consists of 18 sub-watersheds (see Drawing 2 of the noted report) of which three are located south of the CNR tracks and are directly affected by the proposed modifications to the creek and marsh within the Blue Circle Cement property. The MDS considered several development conditions within the watershed and models were developed for each case. For the purposes of this report, the base model adopted was for future land use conditions with stormwater management controls included. This reflects the most probable long term watershed condition and is the most appropriate for planning and design of permanent water course modifications.

The West Side Creek MDS OTTHYMO model does not include routing of flows through the

storage in West Side Marsh. This creates conservative discharge values from the existing marsh and correspondingly conservative water levels. This is not significant when considering the Regional Storm and associated flood lines. However, when considering more frequent flows, the effect is important. For example, if the routing is ignored then flooding of buildings adjacent to the outlet channel is predicted during any storm over the 1 year return period. This is not consistent with local observations. Hence, the OTTHYMO model was modified to include a ROUTE RESERVOIR element to model the storage effect.

In order to include the reservoir routing, a storage-discharge curve was required. The discharge-elevation relationship for the marsh outlet was created using the HEC-2 model from the Master Drainage Study. Storage volumes were calculated from contour mapping of the marsh area produced by Brown and Coggan Ltd. in June 1994. The storage-discharge curve for the existing marsh is shown on Table 3.1.

Table 3.1
Storage Discharge Curve for Existing Wetland

Elevation (m)	Storage ha-m (ac-ft)	Discharge m^3/s (cfs)
75.68	12.04 (97.5)	0.57 (20)
75.77	16.13 (130.7)	1.13 (40)
75.83	18.82 (153.3)	1.70 (60)
75.91	23.67 (191.7)	2.83 (100)
76.05	29.52 (239.1)	5.46 (193)
76.11	32.48 (263.8)	7.22 (255)
76.20	37.01 (299.7)	11.50 (406)
76.26	39.56 (320.4)	14.75 (521)
76.35	44.75 (362.5)	19.71 (696)
76.47	51.13 (414.1)	33.13 (1170)

Existing Conditions

Using the modified model, the outflows from the marsh and corresponding water levels in the marsh were computed for the existing conditions. Table 3.2 shows the results for storms between the 1 in 1 year and 1 in 100 year return period and for the Regional Storm. The water levels indicated result in flooding of a few structures around the marsh outlet for storms of 1 in 100 year return period or greater. This more closely corresponds to local experience and hence this modified model was adopted for use in the investigation of changes to the marsh.

Table 3.2
Peak Flows at Marsh Outlet and Water Levels in Marsh
(Existing Marsh)

	No Reservoir Routing		With Reservoir Routing	
Return Period (Years)	**Flow (m^3/s)**	**Elevation (m)**	**Flow (m^3/s)**	**Elevation (m)**
1	5.47	76.04	0.23	75.41
2	7.22	76.09	0.33	75.58
5	11.50	76.21	0.53	75.67
10	14.75	76.27	0.77	75.71
25	19.71	76.35	1.27	75.78
100	33.13	76.48	3.03	75.94
Regional	56.41	76.62	23.90	76.39

Future Conditions

Upon implementation of the proposed modifications to West Side Creek and Marsh, flows from the main watercourse will be diverted around the remnant marsh and the surface area of the marsh will be reduced by about 40%. In order to model the effect of these changes, the OTTHYMO model was modified as follows:

- the discharge-storage curve for the marsh area was modified from that shown in Table

3.1 to that shown in Table 3.3 to reflect the reduction in storage. It should be noted that the stage-discharge component was not modified. Although the proposed scheme requires construction of a new bridge across the outlet of West Side Creek, a HEC-2 analysis of the proposed design indicated that it has no impact upon the upstream water levels in the marsh. Hence the outlet rating curve for the marsh remains the same as for existing conditions (see HEC-2 comparison with and without bridge in Appendix B).

- the configuration of the OTTHYMO model south of the CNR tracks was modified to reflect the realignment of the watercourse. In particular, subwatersheds 17 and 18 of the original model were removed and new subwatersheds 901, 902, 903 and 904 were added to reflect the new drainage pattern into the diversion channel and remnant marsh.

Table 3.3
Storage Discharge Curve for Remnant Wetland

Elevation (m)	Storage ha-m (ac-ft)	Discharge m^3/s (cfs)
75.68	7.75 (62.8)	0.57 (20)
75.77	10.21 (82.7)	1.13 (40)
75.83	11.95 (96.8)	1.70 (60)
75.91	14.91 (120.8)	2.83 (100)
76.05	18.58 (150.5)	5.46 (193)
76.11	20.50 (166.1)	7.22 (255)
76.20	23.38 (189.4)	11.50 (406)
76.26	25.02 (202.7)	14.75 (521)
76.35	28.36 (229.7)	19.71 (696)
76.47	32.24 (261.2)	33.13 (1170)

Table 3.4 shows the peak flows from the marsh and associated water levels in the remnant marsh based upon the modified configuration. As anticipated because of the reduced storage, outflows and water levels would potentially increase significantly. These changes would potentially increase flooding on the properties surrounding the outlet and increase water fluctuations within

the marsh itself with potentially negative impacts on the biological communities. Hence it was necessary to consider ways in which these increases could be reduced and any negative impacts mitigated.

Table 3.4
Comparison of Flows and Water Levels for Existing and Modified Conditions

Return Period (year)	Existing Conditions		Modified Conditions	
	Flow (m^3/s)	Elevation (m)	Flow (m^3/s)	Elevation (m)
1	0.23	75.41	0.33	75.58
2	0.33	75.58	0.46	75.65
5	0.53	75.67	0.98	75.74
10	0.77	75.71	1.54	75.80
25	1.27	75.78	2.40	75.89
100	3.03	75.94	5.44	76.05
Regional	23.90	76.39	31.65	76.46

After considering a number of alternatives (e.g. permitting an overflow into the quarry area under some conditions), it was proposed that a secondary outlet be constructed from the west end of the remnant marsh to Lake Ontario. This would consist of a trapezoidal channel with a bottom width of 12 metres. It would function for storms equal to or greater than a 1 year return period. Drawing DRG1 shows the location and general configuration of the channel. Table 3.5 shows the rating curve for the secondary outlet channel and the combined rating curve for both the main outlet and secondary outlet as input to the OTTHYMO model. The storage-elevation curve remains as shown in Table 3.3.

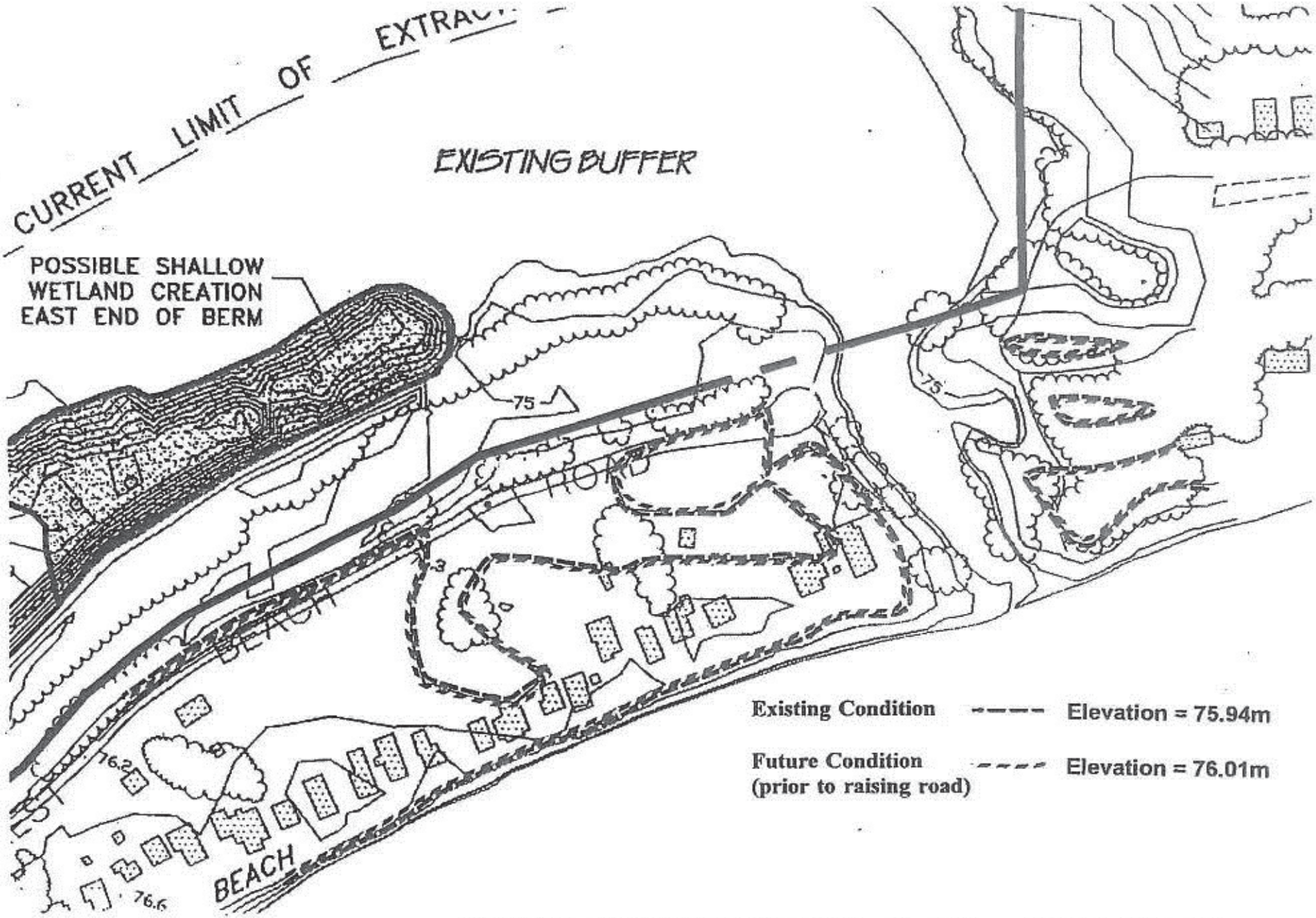

Figure 3.1: Comparison of 1 in 100 Year Flood Lines at Outlet of West Side Marsh

Table 3.5
Rating Curve for Secondary Outlet and Total Combined Outflow from Modified Marsh Area

Elevation (m)	Secondary Outlet m^3/s (cfs)	Combined Outflow m^3/s (cfs)
75.68	0. (0)	0.57 (20)
75.77	0.28 (10)	1.42 (50)
75.83	0.65 (23)	2.35 (83)
75.91	1.36 (48)	4.19 (148)
76.05	3.03 (107)	8.49 (300)
76.11	3.91 (138)	11.13 (393)
76.20	5.44 (192)	16.93 (598)
76.26	6.54 (231)	21.29 (752)
76.35	8.38 (296)	28.09 (992)
76.47	11.18 (395)	44.31 (1565)

The effect of the additional outlet is to release more water from the remnant marsh during high flows preventing any significant increase in water levels above those for existing conditions. Table 3.6 shows the predicted water levels in the marsh and flows at the outlet for the 1 in 1 year to 1 in 100 year storm and the Regional Storm compared to those for the existing conditions. As indicated, the Regional Storm water level is marginally reduced while levels up to the 1 in 100 year storm are potentially raised between 4 and 14 cm. An evaluation of the impact of these increases indicated that a number of structures along Cedar Crest Beach Road are currently within the West Side Creek flood plain. Five structures are in the 1 in 100 year and 21 are within the Regional Storm flood plain. No structures are flooded for the 1 in 25 year or lower return period storms. Under the proposed conditions, the same number of structures are within the Regional Storm flood plain. Similarly, there is no flooding of structures for the 1 in 25 year or more frequent storms. However, for the 1 in 100 year storm, about 3 to 5 additional structures may be subject to flooding to a depth of up to 5 centimetres (it is difficult to be precise given that the contour interval of the available mapping is 0.5 metres). Figure 3.1 shows the limits of the 1 in 100 year flood plain for existing and proposed conditions.

Table 3.6
Comparison of Flows and Water Levels
for Existing and Modified Conditions with Secondary Outlet

Storm Return Period (years)	Existing Flows (m^3/s)	Modified Flows (m^3/s)	Change in Flows (m^3/s)	Existing Water Levels (m)	Modified Water Levels (m)	Change in Levels (m)
1	0.23	0.31	+0.08	75.41	75.55	+0.14
2	0.33	0.45	+0.12	75.58	75.62	+0.04
5	0.53	0.96	+0.43	75.67	75.74	+0.07
10	0.77	1.34	+0.57	75.71	75.79	+0.08
25	1.27	2.17	+0.90	75.78	75.86	+0.08
100	3.03	4.65	+1.62	75.94	76.01	+0.07
Regional	23.90	22.59	-1.31	76.39	76.38	-0.01

The affected structures appear to be predominantly garden sheds or garages not residences. Hence the potential increase in flood damage would seem to be minimal. However, given the criteria of the Lakes and Rivers Improvement Act and Blue Circle's desire to cause no impact on adjacent land owners where feasible, a simple solution to the problem has been formulated. As noted earlier, a bridge is to be constructed over Westside Creek at the east end of Cedar Crest Beach Road. This is to provide access to properties along the road when Waverly Road is removed. By ensuring that the western bridge approach (i.e. along Cedar Crest Beach Road) is constructed at a minimum elevation of 76.1 m., the flooding on the south side of the road for the 100 year event can be prevented. This will eliminate not only the potential flooding of additional structures but also flooding of those structures currently in the 1 in 100 year flood plain. Achieving a minimum elevation of 76.1 m will require raising two low areas on the approach to the bridge by 0.1 to 0.2 m. Hydraulic calculations indicated that this will have no impact on the Regional Storm level.

Appendix A contains print outs from the OTTHYMO model corresponding to Tables 3.2 (existing condition with reservoir routing) and 3.6 (proposed conditions with secondary outlet) for the 1 in 100 year storm. A full set of model inputs and outputs for all storms is included on a computer disk in a pocket at the back of this report.

3.2 Hydraulic Modelling

Hydraulic modelling using the HEC-2 model was completed for the following reasons:

- to assist in sizing the diversion channel and associated culverts and ensure that required design criteria were met
- to provide a basis for a revised regulatory flood line from Lake Ontario to the CNR tracks (except within the Marsh itself where the OTTHYMO routing results were used)
- to provide rating curves for the Marsh routing (as described in the previous section)
- to assist in designing the secondary outlet at the west end of the remnant Marsh
- to analyse the effect of the proposed new bridge across the outlet from West Side Marsh at Cedar Crest Beach Road.

The starting point for the analysis was the HEC-2 model developed in the West Side Creek Master Drainage Study by G.M. Sernas & Associates Limited (September 1992). That model was developed on the basis of 1 inch to 200 foot topographic mapping and is coded in Imperial units. Although the model was extensively modified in the present study, the Imperial units were retained because of the need for consistency with the previous work when comparing existing and future water levels and flood plain limits. The present work was based upon topographic mapping in metric units at a scale of 1:2,000 as prepared by Brown and Coggan Ltd. in June 1994. In addition, extensive field surveys were completed along the alignment of the proposed diversion channel. Other field surveys were completed by Marshall Macklin Monaghan Limited, Dillon Consultants and Totten Sims Hubicki in the areas of the marsh and its outlet. Information from these surveys was incorporated into the revised model and was used to ensure the sections of the earlier model which were retained were consistent with the more recent mapping.

The cross-section locations for the revised HEC-2 model of proposed conditions between Lake Ontario and the downstream end of the diversion channel are shown on Drawing DRG1. The section locations for the diversion are shown on the detailed plans (Drawings P1 to P3) of the channel which accompany this report. The input data and summary output for the 1 in 1 year to 1 in 100 year storms and the Regional Storm are included in Appendix B. They are also included on the computer disk in a pocket at the end of this report. A separate HEC-2 model was developed for the secondary outflow channel. Cross-section locations are also shown on Drawing DRG1. Model input and summary output are also included in Appendix B and on the computer disk.

Several points should be noted regarding the HEC-2 model results.

i) flows were obtained from the OTTHYMO modelling. In the downstream reach from Lake Ontario to cross-section 454, the flows are the routed outflows from the remnant marsh area

ii) the diversion channel was designed to convey the Regional Storm flow with the exception of the area at the confluence with Railroad Creek. In that section, spillage from a small pilot channel was encouraged to help preserve and promote a wetland area

iii) flood lines for the Regional storm are shown on Drawing DRG1 for the outlet and marsh areas and on Drawings P1 to P3 for the diversion channel up to the CNR tracks. In the marsh area, the water level corresponding to the maximum level for the hydrologic routing through the marsh (i.e. 76.38 m) has been used to plot the flood line. This is slightly higher than in the HEC-2 model and is therefore a conservative interpretation.

iv) several culverts are required to provide access to Ontario Hydro towers for maintenance purposes and at the crossing of the remaining part of Waverly Road. The sizes required are shown in Table 3.7. The diversion channel and culverts were designed so that there is no increase in water surface elevation upstream of the existing CNR tracks. Velocities and flood elevations calculated by HEC-2 are provided in the attached Appendix B.

Table 3.7
Proposed Culvert Specifications

Culvert	Number	Length (m)	Height (m)	Width (m)
3087	3	73.	3.0	2.4
5066	2	44.	1.8	3.0
6040	2	100.	1.8	3.0

v) channel velocities range from a low of 0.1 m/s to a high of 3.6 m/s. The section of creek that is most affected by high velocities is between the CNR tracks and the junction of the diversion and the tributary where velocities exceed 1.5 m/s at the 5 year storm. Lining of this section of the channel with a heavy coir cloth (eg. Geo-coir Dekowe 900) that can withstand velocities of up to 3.6 m/s is recommended. The same coir cloth can be used at the entrance and exits of the culverts and at the outsides of bends. An alternative type of erosion control which could be used at the bends is 500mm diameter rip rap or rootwads.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The following are the main conclusions and recommendations of this investigation:

i) an OTTHYMO model of the West Side Creek watershed for future land use conditions with stormwater management was chosen as a basis for calculating flows for the proposed diversion channel. A reservoir routing component was added to represent the storage in West Side Marsh. Flows and water levels generated by this model for the outlet of West Side Creek to Lake Ontario more closely agreed with local observations than the model without routing.

ii) the diversion channel and associated culverts have been designed to convey the Regional Storm such that there is no increase in water levels upstream of the CNR tracks

iii) the reduced storage in the marsh after implementation of the proposed modifications could potentially lead to higher flows and water levels at the outlet of the marsh. This could have a negative impact upon adjacent properties. Hence two remedial actions are recommended:

- the construction of a secondary outlet from the west end of the remnant marsh to partially divert high flows away from the existing outlet and minimize changes in water levels in the marsh

- raising of the approach road to the new bridge over the West Side Marsh outlet to a minimum elevation of 76.1 m.

Together, these measures will reduce the flood potential for flows up the 1 in 100 year return period storm for properties along Cedar Crest Beach Road. The number of properties susceptible to flooding for the Regional Storm will be unchanged

iv) flood lines for the regulatory flood (Regional Storm) have been computed for the modified wetland and watercourse downstream of the CNR tracks. These are shown on Drawings DWG1 and P1 to P3 which accompany this report.

v) velocities in the proposed diversion channel will be sufficiently high that heavy coir cloth should be used to protect areas while vegetation becomes established. This will be aided by constructing the channel in the dry and leaving it for 2 years prior to diverting West Side Creek into it.

5.0 REFERENCES

Dillon Consulting Limited. 1996. "Phase III Quarry Expansion: West Side Marsh, Fisheries Habitat Compensation Report" prepared for St. Marys Cement Corporation.

Sernas & Associates Limited. 1992. West Side Creek Master Drainage Study prepared for The Town of Newcastle and Central Lake Ontario Conservation Authority.

Waterfront Regeneration Trust. 1995. West Side Marsh - Final Report.

MEMO

TO: St. Marys Cement Inc. (Canada) ("St. Marys")
FROM: Chris Gibbons (Dillon Consulting Limited)
DATE: March 2018
SUBJECT: Functional Understanding of Westside Marsh
OUR FILE: 18-7051

Dillon Consulting Limited (Dillon) has been retained by St. Marys to compile relevant background information and provide a general understanding of the hydraulic functionality of Westside Marsh. This memorandum provides a brief description of the assembled background literature, a detailed summary of the various design elements of the hydraulic realignment of Westside Marsh, and a general understanding of how the Marsh is integrated with Westside Creek and Lake Ontario as a coastal wetland system.

Background Literature Assembly and Review

The purpose of this task is to assemble relevant technical information (reports, drawings, surveys, etc.) pertaining to the design of Westside Marsh and the Overflow Channel. An important component of this task is to ensure that the most current version of all information is provided, as superseded and draft versions have been circulated to various stakeholders. The relevant assembled information is provided in the appendices to this memorandum. Brief descriptions of each information source are provided below.

Assembly of the information associated with this project has been challenging, mostly due to the age of the project. It is noteworthy that several people involved in the original design and approval stages are no longer with their respective companies or agencies and are not reachable. As a result, several key reports and drawing sets have not yet been located and included in this literature assembly. Several official data requests have been issued; however, these may take weeks or months to come through if information is even available. This information will be provided should it become available, and this report will be revised and updated accordingly.

Appendix A (Dillon, 1997) - Phase III Quarry Expansion: West Side Marsh, Fisheries Habitat Compensation Report prepared by Dillon Consulting Limited. 1997.

This report provides detailed descriptions of the marsh hydraulics, watershed characteristics, the aquatic and terrestrial ecology, and the general history of the project, all in support of the development of additional fish habitat within Westside Marsh. Sections 2, 3, and 4 are of particular importance to the understanding of the hydraulic functionality of the marsh.

Appendix B (MMM, 1998) – Report on Hydrotechnical Analysis of Modifications to West Side Creek and Marsh Associated with Future Operations of Blue Circle Cement prepared by Marshall Macklin Monaghan (MMM)

This report provides a comprehensive description of the marsh hydraulics. In particular, the report provides a detailed description of two numerical models of the marsh that were developed to evaluate flooding impacts in the marsh. This report and the numerical models demonstrate that the proposed marsh redevelopment, with the inclusion of the main spillway and overflow channels, can sufficiently convey inflowing water from Westside Creek to Lake Ontario through Westside Marsh without significant adverse flooding impacts along the shoreline. It is noted that several key drawings referenced in this report are missing and not yet provided.

Appendix C (Dillon, 2002) – Westside Marsh Design Drawings - Issued For Tender

These drawings are reproductions of the design drawings issued for tender in 2002. It is important to recognize that neither physical, nor digital plots of the original tender drawings were available, and that these drawings are reproductions (i.e. they were re-plotted from their native CAD format). It is also important to recognize that the focus of these drawings is mainly ecological (e.g. fish habitat, planting species, etc.). The original engineering drawings by MMM could not be located as part of this exercise; however, key hydraulic information should be accurately represented in these drawings.

Appendix D – Various Environmental Monitoring Reports (2006-2017)
D1 – (Dillon, 2006) - 2006 Post-Construction Monitoring Report
D2 – (Dillon, 2009) - Fisheries and Oceans, Canada Compliance Monitoring Report Year 2 of 10
D3 – (Dillon, 2012) - Fisheries and Oceans, Canada Compliance Monitoring Report Year 5 of 10
D4 – (Dillon, 2017) - Westside Marsh and Creek Monitoring Year 10 of 10

Dillon conducted annual monitoring of the marsh ecology for ten years (2007-2017) following construction. Several of these monitoring reports are provided in Appendix D. These reports provide detailed summaries of measurements, observations, population surveys, etc. in an effort to evaluate the wildlife productivity and diversity, water quality, and overall ecological health of the wetland.

Appendix E (CLOCA, 2017) - Central Lake Ontario Conservation Watershed Flood-Risk Assessment

In 2017, as part of the National Disaster Mitigation Program (NDMP), CLOCA conducted a watershed flood risk assessment. This assessment evaluates the level of flood risk posed to the properties surrounding various watercourses within the jurisdiction of CLOCA. Westside Marsh falls within the jurisdiction of this assessment.

Appendix F (MMM, 2004) – As-Built (Record) Surveys

Several as-built (record) surveys of elements of the Marsh were conducted following construction (2004-2005). These as-built drawings provide a surveyed record of the post-construction conditions. Plan and cross-sections of this survey data are provided in this appendix.

Missing Data

Only some of the record (as-built) drawings are available at this time. Not all could be obtained. Record drawings provide a surveyed record of the post-construction conditions. Copies of as-built surveys may have been distributed to the various regulatory agencies involved at the time, including CLOCA, the Municipality of Clarington, Fisheries and Oceans Canada (FOC, formerly Department of Fisheries and Oceans), the Ontario Ministry of the Environment and Climate Change (MOECC), and the Ontario Ministry of Natural Resources (MNR). Formal requests for these drawings have been submitted to these agencies.

Another key piece of missing information is the engineering drawings issued for tender. The drawings provided in Appendix C contain some of the information that would have been included in the engineering drawings; however, these drawings focus on the environmental treatment of the wetland, and not the hydraulic engineering of the marsh. Several of these drawings are referenced in the Hydrotechnical Report; however, they too are missing. WSP (formerly MMM) is current searching their archives for these drawings. Formal requests for these drawings have also been issued to CLOCA, FOC, MOECC, and MNR.

Future Data

St. Marys and CLOCA are currently developing a Monitoring and Maintenance Plan for the Overflow Channel. This plan defines the roles of the Municipality of Clarington, CLOCA, and St. Marys to keep the overflow channel in a good and substantial state of repair. It is expected that this plan will be publically available later in 2018.

CLOCA is currently working with both Aqua 5 Solutions and W.F. Baird & Associates Ltd. to complete a coastal assessment of the Lake Ontario shoreline in an effort to revise and update policies pertaining to natural hazards such as erosion and flooding. It is expected that this report will be available in the autumn of 2018. A public meeting on this subject is scheduled for March 3, 2018.

CLOCA, Lower Trent Conservation, and the Ganaraska Conservation Authority are providing an update to the Lake Ontario Shoreline Management Plan throughout their combined jurisdictions. The updates to this plan are commencing this year, but the finalized plan will not likely be available until 2020.

Functional Understanding

The purpose of this task is to provide a general understanding of the hydraulic functionality of the realigned Westside Marsh and its integration with Westside Creek and Lake Ontario as a coastal wetland system. The background reports and drawings from the previous task have been referenced throughout this section.

General Description

Westside Marsh is a 45 hectare coastal wetland located on the shoreline of Lake Ontario in the municipality of Clarington. Westside Creek drains to Lake Ontario through Westside Marsh. St. Marys operates a limestone quarry adjacent to the marsh. The third phase of the quarry expansion involved the hydraulic realignment of Westside Creek and ecological restoration of Westside Marsh. The design and approval stages for this expansion occurred between 1996 and 2002, and the construction and restoration occurred between 2002 and 2007. Ecological monitoring was completed between 2007 and 2017.

This realignment involved relocating Westside Creek to the east side of Westside Marsh through a low flow channel and a series of deep water basins before emptying into Lake Ontario through a main floodway channel. A map showing key elements of the hydraulic realignment of Westside Marsh is provided in Figure 1.

Figure 1 – Key elements of Hydraulic Realignment of Westside Marsh

Barrier Beach

A barrier beach, which restricts the marsh water from draining into Lake Ontario through the main floodway channel, frequently builds up along the shoreline of Lake Ontario. For reference, a barrier beach is a gravel or shingle bar which forms along the shoreline, typically above the high lake level. The barrier beach acts as a berm which isolates the wetland from the coastal waters. The barrier beach is mainly formed by material deposited by wave energy during storms. The lake level can also be temporarily increased during these storms. This phenomenon is known as storm surge. The combination of increased wave energy during periods of higher lake levels can result in larger beach material being deposited higher up the beach profile. The lake level will decrease as the storm subsides, and the normal wave conditions can no longer reach the accreted material and transport it offshore. The formation of a barrier beach, similar to the one at Westside Marsh, is common to coastal wetlands on the Great Lakes (Dillon, 1997).

The elevation difference between the level in the marsh and the level in the lake can be referred to as the “difference in head.” The water level can fluctuate both in the marsh and the lake. It is therefore

important to recognize that this difference in head is a relative difference, and not based on defined (absolute) elevations. The barrier beach is mostly sand, gravel, and cobbles, which are generally porous materials. During low flow periods (e.g. summer months) the outflow of the marsh can infiltrate through the porous barrier beach (Dillon, 1997). The water levels in the marsh are typically not much higher than the lake levels (less than 0.2 m difference) during these low flow periods. During periods of higher precipitation and higher flow through the marsh, the barrier beach can restrict the outflow of the marsh, causing water levels in the marsh to rise (increased difference in head). The flow through the marsh exceeds the infiltration rate through the barrier beach, and the result is an increase in water levels in the marsh. Once the difference in head reaches a certain threshold, the built up pressure can exert enough force to breach the barrier beach through a phenomenon known as "head cutting." This head cutting typically occurs when the difference in head reaches 40-50 cm (Dillon, 1997).

Figure 3.2 from the Fish Habitat Compensation Report (Dillon, 1997) shows a series of water level, and precipitation observations from 1996, prior to the marsh redevelopment. For convenience, a copy of this figure is provided in Figure 2. The figure shows sudden drops in the recorded water level in the marsh, typically following a heavy rain event. These sudden drops in the marsh level are associated with breaches in the barrier beach caused by head cutting.

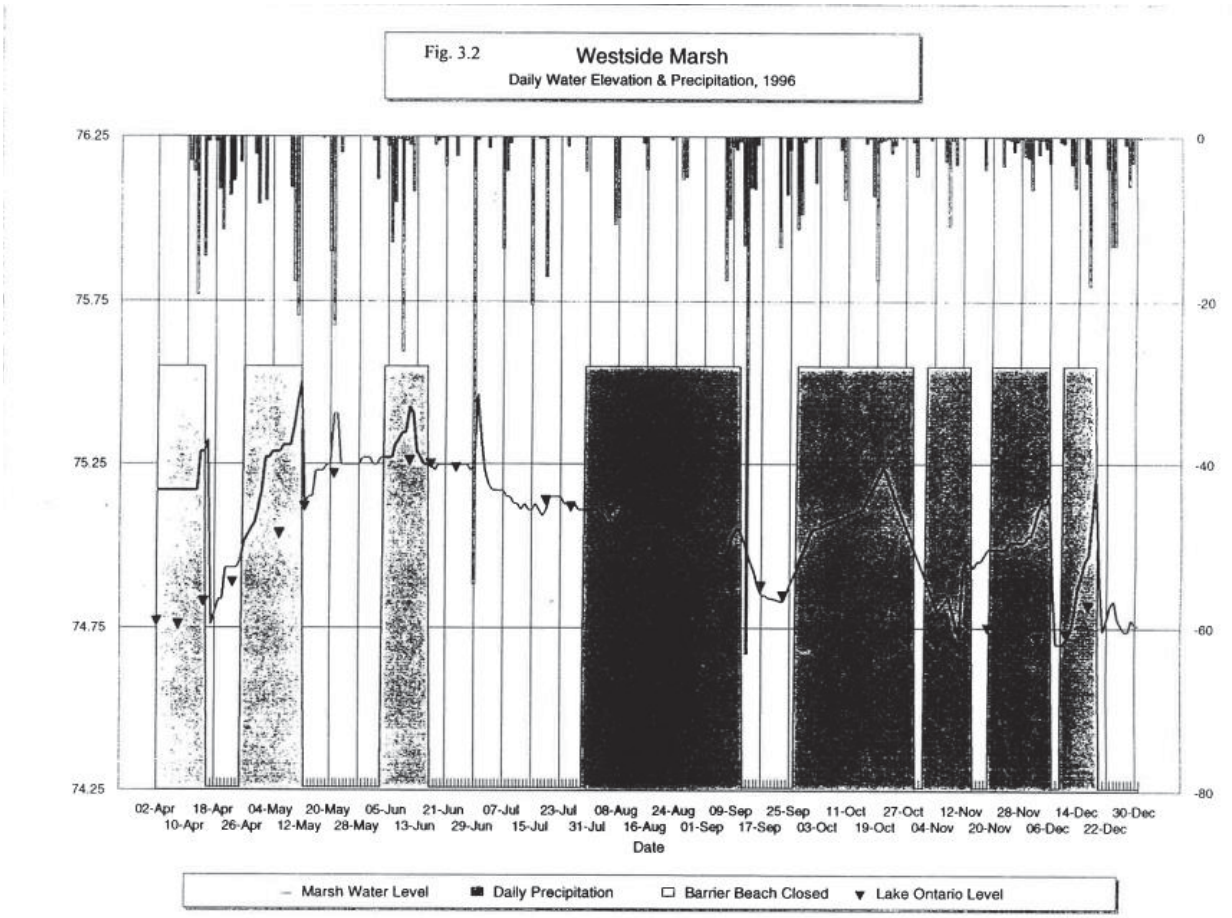

Figure 2 – Water Level and Precipitation Observations in Westside Marsh Prior from 1996 (Dillon, 1997)

The accumulation of the barrier beach and the breaches due to head cutting are natural processes, which occurred both before and after the hydraulic realignment of Westside Marsh. The breaches in the barrier beach provide a linkage between the Marsh and Lake Ontario, which provides an opportunity for migration of fish between the two environments. This linkage is essential to the overall health of the Marsh.

It is also noted that residents of Cedar Crest Beach Road have previously arranged to have heavy machinery open the barrier beach through the main floodway channel in an effort to lower the water levels in the marsh and prevent potential flooding conditions (Dillon, 1997). This manual removal of the barrier beach was done both before and after the redevelopment of Westside Marsh. Manually opening the barrier beach may interfere with natural processes and may prevent water levels in the marsh from rising sufficiently to naturally breach the barrier beach.

Storage and Flooding

During the design and approval stages, it was recognized that the quarry expansion would reduce the overall flood storage volume of the marsh and that this reduction in storage would potentially increase the outflow from the Marsh. This increase in outflow of the Marsh could have, if not addressed, potentially exacerbated flooding conditions along the Lake Ontario shoreline and Cedar Crest Beach Road.

One of the conditions of the permit and approval for the Marsh redevelopment is outlined in Section 5.1.1 of the Fish Habitat Compensation Report (Dillon, 1997). It states that *"Although properties on Cedar Crest Beach Road currently experience flooding under the 100-year return storm event, this condition cannot be exacerbated without the consent of the landowners."* In other words, the marsh redevelopment must not make flooding conditions along Cedar Crest Beach Road worse than they were prior to any work in the Marsh. However, it is also important to recognize that prior to any work in the Marsh the properties along Cedar Crest Beach Road were already exposed to potential flooding conditions during various storm events. It is also important to recognize that no regulatory body imposed or sought to impose a requirement that the marsh hydraulic realignment decrease the existing flooding conditions or risks.

The Report on Hydrotechnical Analysis of Modifications to West Side Creek and Marsh Associated with Future Operations of Blue Circle Cement (MMM, 1998) provides a comprehensive analysis of the hydraulics through Westside Marsh under various conditions, including an evaluation of any potential flooding conditions along the Lake Ontario shoreline and Cedar Crest Beach Road. This report includes detailed descriptions of the hydraulic modeling completed in support of this analysis. The OTTHYMO and HEC-2 numerical models were used to estimate the hydraulics in the Marsh (MMM, 1998).

The University of Ottawa Hydrologic Model (OTTHYMO) is a hydrologic management model developed at the University of Ottawa that can been used for various simulation analyses such as: Watershed Studies, Sub---watershed Studies, Master Drainage Plans, Functional Stormwater Management Plans, Site Plans, and Stormwater Management Pond Designs. HEC-2 is a numerical model used for computing water surface elevations for rivers, streams, and other open channel networks. HEC-2 was developed by the Hydraulic Engineering Center (HEC) of the United Army Corps of Engineers (USACE). Both the OTTHYMO and HEC-2 models are appropriate numerical models for their intended use to simulate the physical processes of a coastal wetland at the time the Hydrotechnical analysis was completed. The

model parameters and boundary conditions described in the Hydrotechnical Report seem both reasonable and appropriate to estimate the hydraulics in the marsh.

One of the conclusions from this analysis showed that the reduction in storage after the proposed modifications could have resulted in potential flooding impacts along Cedar Crest Beach Road, were preventative measures not taken. To alleviate these flooding impacts, two remedial actions were proposed and implemented:

i. A secondary (overflow) channel at the west end of the marsh was designed and constructed;
ii. The elevation of the approach road to the bridge over West Side Marsh was raised.

The combination of these two remedial measures was intended and implemented to reduce potential flooding for events up to the 1 in 100 year return period (MMM, 1998), bringing the risk of flooding down to the level existing prior to the marsh redevelopment. Outflow from the Marsh would not be routed through the secondary overflow channel for events with a return period lower than the 1 in 25 year event (Dillon, 1997).

In 2017, as part of the National Disaster Mitigation Program (NDMP), CLOCA conducted a watershed flood risk assessment (CLOCA, 2017). Westside Marsh and the Lake Ontario shoreline were both within the jurisdiction of this assessment. This assessment identifies Cedar Crest Beach Road as a community that has always had high vulnerability and potential frequency of flooding as a result of being located between the marsh and Lake Ontario and due to its low elevations relative to the water levels in both the lake and marsh (CLOCA, 2017).

Lake Levels

The water level on Lake Ontario used as the downstream boundary condition in the HEC-2 modeling was set to 75.25 m, which is the long-term average of Lake Ontario. This lake level is also referred to as the “normal persistent lake level” in the Tender Drawings (Dillon, 2002) and the Hydrotechnical Report (MMM, 1998). For comparative purposes, the spring-high water level is approximately 30 cm higher than the long-term mean (75.55 m).

Lake Ontario water levels fluctuate over the long-term, seasonally, and in the short-term. Long-term variations are mostly the result of climatic conditions (precipitation, evaporation); other factors, such as regulation also play a role. Over the past 100 years or so, the mean monthly lake level has varied over a range of approximately 2.0 m (from elevation 73.75 m to 75.75 m). The long-term lake level records demonstrate a gradual oscillation in lake levels. Periods of lake level rise are typically followed by periods of decline. Alternatively, periods of declining lake levels are typically followed by periods of rising lake levels. These periods of lake level rise or decline can last several years before shifting.

The lake level fluctuation over any given year can also vary. The water level typically peaks during June of each year. The lowest levels generally occur during December and January. Both the Canadian Hydrographic Services (CHS, 2018) and the United States Army Corps of Engineers (USACE, 2018) provide long-term records of measured water levels on the Great Lakes. Both agencies also provide monthly bulletins outlining historic highs, recent trends, and future projections (CHS, 2018) and (USACE, 2018).

Overflow Channel

The overflow channel is approximately 300 m long, 12 m wide, trapezoidal in shape, with a gradually sloping channel invert The channel mimics the design of the main floodway channel in Westside Creek. At the north limit of the overflow channel, a rock weir acts as the relief point for the overflow channel. The elevation of the crest of this weir was designed to 75.68 m, (Table 3.5 - MMM, 1998). The water level just upstream of this point during the regional flood is 76.8 m (Dillon, 2002). The as-built drawings in Appendix F do not clearly provide any surveyed record of the elevation of this weir (MMM, 2004).

The Hydrotechnical report states *"the effect of the additional outlet is to release more water from the remnant marsh during high flows preventing any significant increase in water levels above those for existing conditions,"* (MMM, 1998.*)* Essentially, the overflow channel was designed to provide additional outflow capacity during peak events to reduce potential flooding conditions in the Marsh. The overflow channel was not designed to completely eliminate potential flooding conditions in the Marsh; it was designed to provide relief capacity when the main floodway channel reaches its maximum capacity.

The majority of the overflow channel is owned and maintained by St. Marys, under the direction of CLOCA.

Ecology

One of the objectives of the Marsh redevelopment work was to reestablish the ecological function of the wetland. Dillon conducted annual monitoring of the marsh ecology for ten years following construction (2007-2017). Several of these monitoring reports are provided in Appendix D.

Prior to the work in Westside Marsh there was "poor connectivity" between the wetland and Lake Ontario. This poor connectivity led to inconsistent spring high water levels and poor water quality in the wetland. This all led to a lack of adequate fish habitat, and aquatic diversity in the Marsh (Dillon, 1997).

The diversity of the wildlife in the marsh has increased, and now includes species such as osprey and otter. The fish habitat that was created as part of the redevelopment has also led to a more productive and more diverse fish population. Species such as largemouth bass and southern pike have been observed in the wetland. Since pike do not typically spawn in a wetland such as Westside Marsh, the presence of pike in the wetland suggests that they enter through the main floodway during a period where the barrier beach has been breached (Dillon, 2007-2017, Appendix D). Water quality has been improved and measured turbidity throughout the marsh is lower than the pre-construction conditions (Dillon, 2007-2017, Appendix D).

This ongoing monitoring has demonstrated that the ecological health of Westside Marsh has been improved, and it has become a more productive wetland as a result of the marsh redevelopment. The ecological condition of the Marsh has generally been enhanced from its condition prior to construction.

Approvals

The detailed design of the creek realignment, the main floodway channel, and the overflow channel were approved by multiple agencies including CLOCA, MOECC, MNR, and FOC.

References

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APPENDIX 3

Central Lake Ontario Conservation

WESTSIDE MARSH BARRIER BEACH FUNCTION

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Introduction

During storms the higher wave energy allows the waters of Lake Ontario ("the Lake") to move sediments that would otherwise be immobile. The waves force sand gravel and cobbles to the mouth of Westside Marsh ("the marsh") where they are then deposited; this forms a barrier beach. This barrier beach allows the water levels of the marsh and the lake to fluctuate independently whereas they would generally be the same with no barrier beach present. When there is a small difference in head between the lake (0.2 m difference) the marsh water can infiltrate through the porous media to prevent flooding of the marsh (Dillon, 2018). During storm events, flow out of the marsh is restricted by the beach, which causes an increase in water level in the marsh. Once the difference in head is large enough, the water on the marsh side has enough energy to breach the barrier beach; this phenomenon is called "head-cutting". Once the barrier beach has been breached, water from the marsh can freely flow into Lake Ontario allowing the water levels to return to equilibrium.

The barrier beach of interest is located just south of the bridge crossing the marsh on Cedar Crest Beach Road directly east of 149 Cedar Crest Beach Road.

The function of this barrier beach is to be analyzed, so that future breaches can potentially be predicted. This knowledge will also help predict periods when the marsh levels will rise enough to cause overtopping of Cedar Crest Beach Road.

Figure 1: Barrier beach at the mouth of the main floodway channel of the marsh.

Methodology

Water level data for Westside Marsh was obtained from a logger located in the west part of the marsh which can be seen in the figure below.

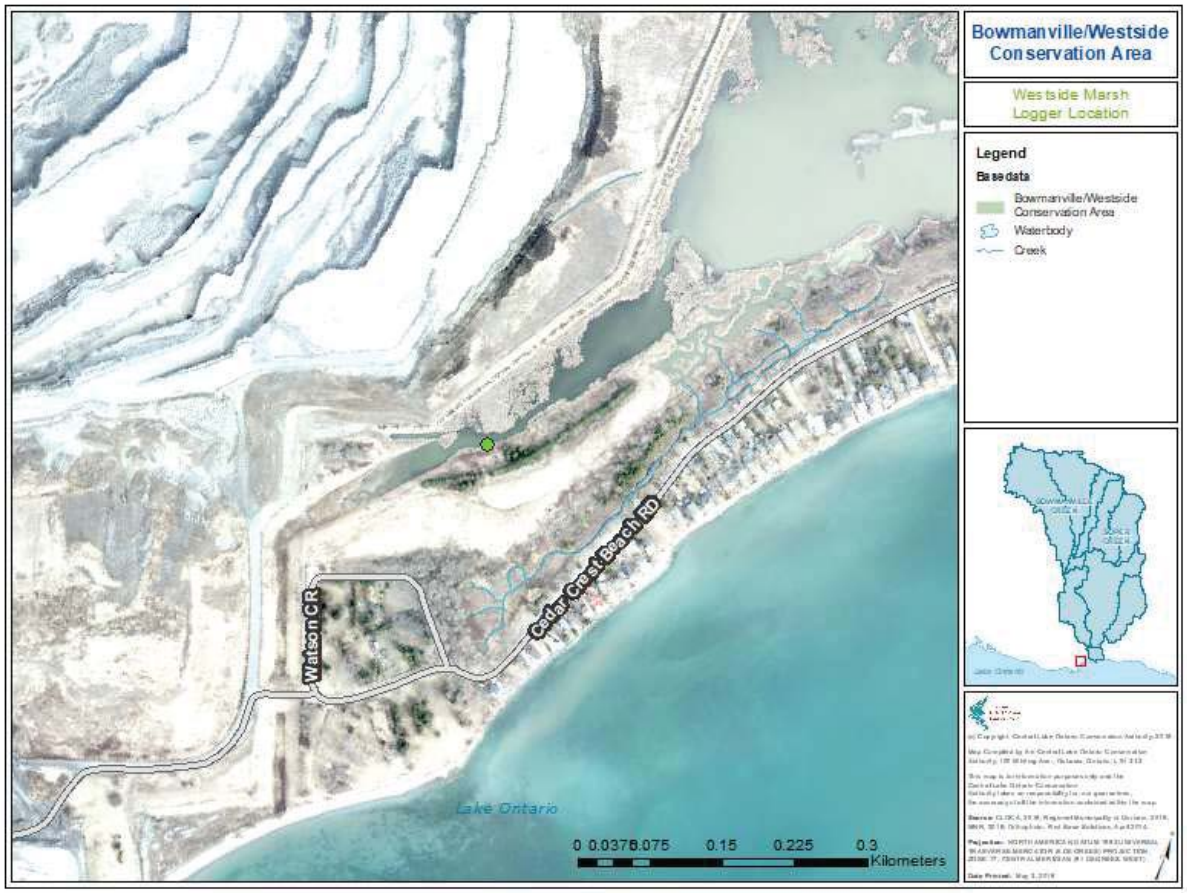

Figure 2: Westside marsh logger location (shown in green).

Water levels in Lake Ontario were obtained from Fisheries and Oceans Canada station number 13320 located in Toronto, ON. This data could then be plotted and dates which the barrier beach broke were easily distinguishable by sharp drops in the marshes water level.

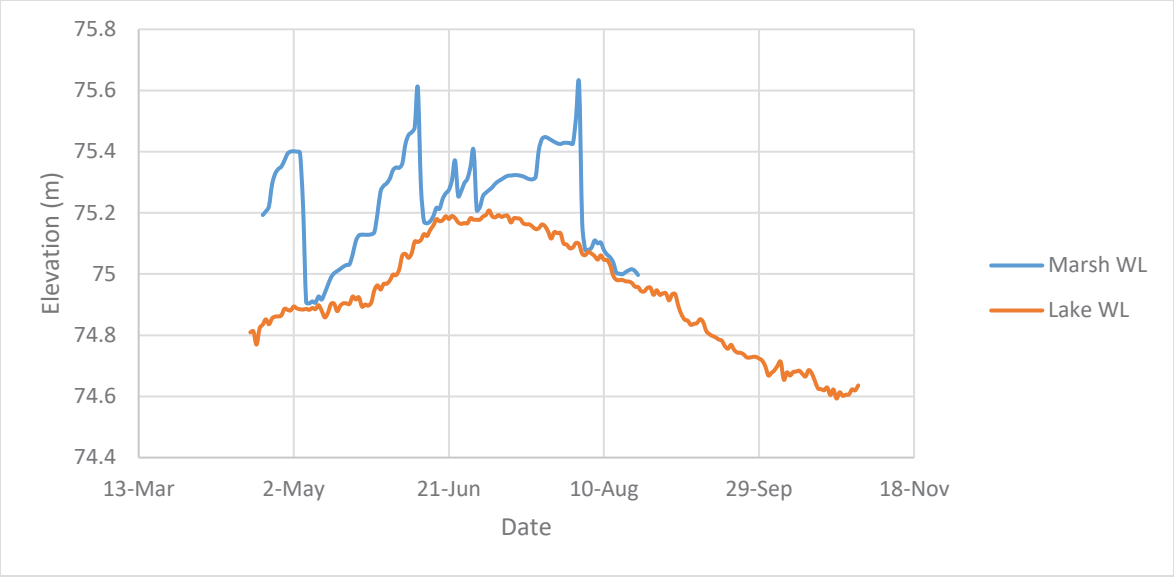

Figure 3: Marsh and Lake water levels between the 18th of April and the Nov. 4th, 2013.

Such drops can be seen above in Figure 3. In some cases marsh levels appeared to drop below lake levels which should not possible. A correction factor had to be applied to this data so that the lake levels and marsh levels were approximately equal when there was no barrier beach present.

To calculate the difference in head that caused the barrier beach to breach, lake elevations were subtracted from the marsh elevation at the point of the breach (point at the top of the sharp marsh water level decline).

Precipitation data was obtained in order to plot hyetographs corresponding to each barrier break. This data was obtained from www.worldweatheronline.com using their weather history for Bowmanville, ON.

To determine periods of time when Cedar Crest Beach Road may flood due to rising marsh levels elevations obtained from a 2017 survey of the road were compared to marsh water surface elevations for multiple years. These surveys can be seen in the Appendix of this document.

Results

Several breaches of the barrier beach have been analyzed to attempt to determine a relationship between difference and head and when the barrier beach will break. The drawdown dates below represent when the drawdown was completed (i.e. the marsh water level and lake water level reached equilibrium). The drawdown time represents the number of days between when the beach broke and when the levels reached equilibrium.

Drawdown Dates	Drawdown time (days)	WSE difference (m)
1-Aug-06	1	0.347
11-Sep-06	2	0.6623
30-May-09	3	0.399
3-Aug-09	1	0.74

9-May-10	2	0.243
8-Jun-10	1	0.306
20-Jun-10	2	0.3376
29-Apr-11	2	0.409
22-May-11	2	0.2144
13-Aug-11	2	0.336
7-May-13	3	0.5105
15-Jun-13	2	0.4979
5-Aug-13	2	0.5239
19-May-14	1	0.432
31-Jul-14	2	0.289
1-Jul-15	2	0.392
12-Aug-15	1	0.2793

Table 1: WSE difference required to break barrier beach, as well as time required for marsh water level to drawdown.

Upon analyzing the data it is evident that there is no direct relationship between difference in head and barrier beach failure, so other factors had to be investigated.

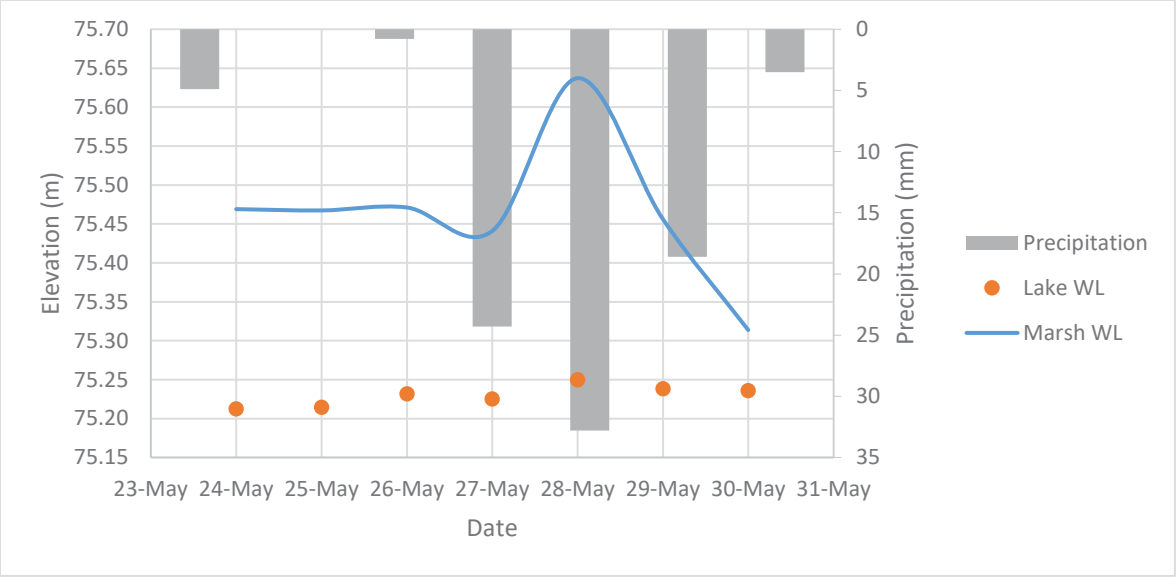

Figure 4: Marsh and Lake levels along with precipitation amounts around the breach that occurred on May 28th, 2009.

Figure 4 shows that the beach broke during the heavy rainfall event, after about 62.8mm of rainfall over a period of 5 days. In some cases the failure does not occur until days after the heavy rainfall has finished, an example of this can be seen below in Figure 5.

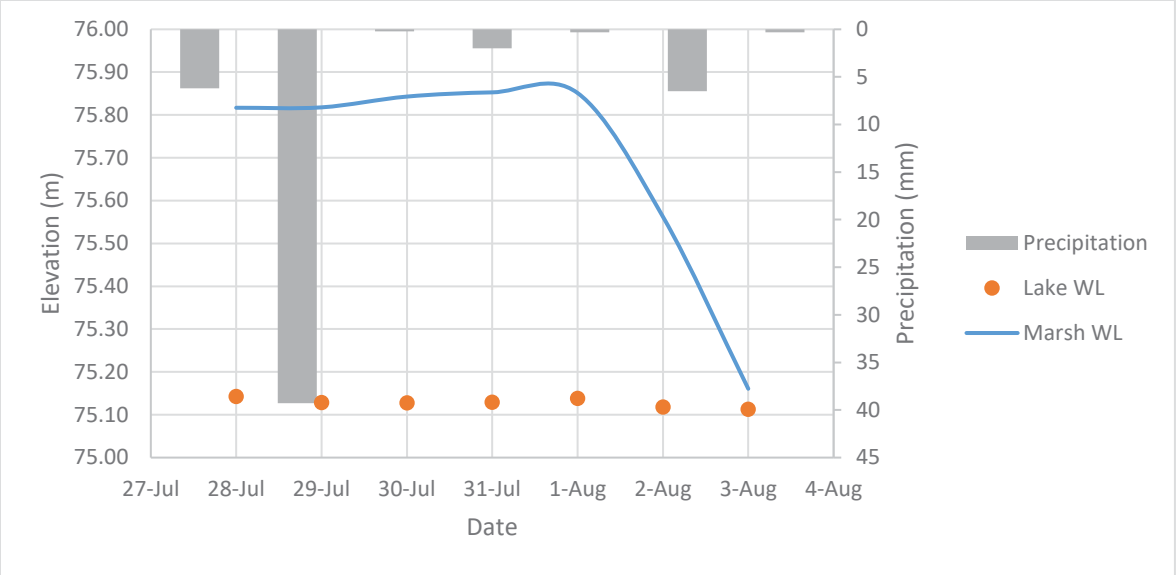

Figure 5: Marsh and Lake levels along with precipitation amounts around the breach that occurred on August 1, 2009.

The breach that occurred on May 3rd, 2013 happened under interesting circumstances as there was no reported rain in the area for more than a week prior. Although, something within the watershed added enough water to Westside marsh to create a difference in head of half a meter.

Overtopping of Cedar Crest Beach road starts when the marsh water levels reach 75.839m, as this is the lowest elevation along the road. Two periods of time within the analyzed data showed evidence of road overtopping, These periods were July 30th-August 1st, 2009, and early May (logger started on May 18th but overtopping had already begun) -June 29th , 2017.

Conclusions and Recommendations

The inconsistency in results shows that there are many factors that determine when the barrier beach will break that can't be easily quantified. Since the formation of this barrier is a natural coastal process, physical properties such as the strength and height of the barrier may change with variables such as wind speed. Wind gives the waves their energy, which in turn pushes the sediments into the mouth of the marsh. Higher wind speeds would allow the waves to transport larger cobbles which would form a stronger barrier than one formed by low wind speeds. Time between breaches may also be a variable that determines the strength of the barrier, as the beach would have more time to build up and compact. In order to accurately predict when a breach will occur more monitoring would need to take place until a pattern is observed. It is also recommended that higher resolution marsh level data is collected since currently only daily data was available. This causes problems because the exact difference in head that caused the barrier beach to fail could not be determined. In some cases the logger may have recoded data hours after the beach broke, which would lead us to believe that a lower difference in head caused this.

References

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Appendix

Figure 6: Cedar Crest Beach Road survey (Part 1).

Figure 7: Cedar Crest Beach Road survey (Part 2).

COASTAL WETLANDS AND BARRIER BEACHES

Life is a beach, if you are a coastal wetland.

Great Lake coastal wetlands like this one, form at the mouths of rivers and in bays along the shoreline. Many coastal wetlands in the Durham Region are separated from Lake Ontario by a barrier beach system. These beaches are naturally very dynamic, which means they shrink and grow depending on wave action, wind direction and water levels in Lake Ontario and the wetland. Occasionally they open up when wetland water levels rise above the Lake. They can also close completely when wind and waves push the sand and cobble into the opening. When, where, and how long these barrier beaches remain open and closed varies among wetlands and ongoing weather conditions.

Barrier beach open at McLaughlin Bay

As the barrier beach changes, water levels in coastal wetlands can rapidly move up or down by more than 50 cm. Coastal wetlands actually require these water level fluctuations to sustain higher biodiversity levels. The wetland plants and animals here have adapted to these extreme changes. Periods of sustained low water levels in the wetland expose the bottom sediment and its diverse bank of native emergent plant seed which germinate and re-establish an important plant community. This prevents expansion of aggressive emergent plants like cattails into drier meadow marsh plant communities. By contrast, when the wetland experiences higher than normal water levels, the aquatic zone around the shoreline expands preventing the establishment of upland woody plants. Fluctuations between these high and low water level periods maintains plant species diversity and the balance between shallow aquatic, shallow marsh, and meadow marsh vegetation communities. It is this diversity that attracts a variety of wildlife providing critical habitat for many wetland dependent species.

Since 1959, Lake Ontario water levels have been regulated so extreme high and low water level periods are now uncommon. The result is conditions that favour cattails as the dominant vegetation species, further reducing plant diversity and meadow marsh communities.

COASTAL WETLAND MONITORING

The Central Lake Ontario Conservation Authority (CLOCA) values the natural dynamic role of coastal wetland barrier beaches and the resulting fluctuating water levels that contribute to the ecological function and health of these important ecosystems. CLOCA and our partners collect data on several indicators including the biological communities, water quality and barrier beach conditions of 18 coastal wetlands along the north shore of Lake Ontario. For more information about the Durham Region Coastal Wetland Monitoring Project or to learn more about wetlands visit our website at www.cloca.ca or contact

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Central Lake Ontario Conservation

Central Lake Ontario Conservation

Technical Report: Flood Mitigation for Cedar Crest Beach Road

DRAFT

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Introduction

The Cedar Crest Beach Road Flood Damage Centre encompasses approximately 40 homes located along the south side of the road. These homes are impacted by both riverine flooding from Westside Creek and shoreline flooding from Lake Ontario.

In 2013, floodplain mapping was developed by CLOCA for Westside Creek. The Regulatory Floodplain in the vicinity of Cedar Crest Beach Road is depicted on Westside Creek Floodplain Mapping Sheet WS1 (***Attachment 1***). Details are outlined in the study entitled Westside Creek Hydrologic and Hydraulic Modeling, prepared by CLOCA (March 2013), here within referred to as the Westside Creek study.

Shoreline flood mapping was developed and reported in the Lake Ontario Shoreline Management Plan (Sandwell Swan Wooster Inc, December 1990). An update is currently underway.

The following brief provides a high level analysis of the existing flood condition at Cedar Crest Beach Road and investigates the feasibility of raising Cedar Crest Beach Road to prevent creek flows from overtopping the road and impacting the community during frequent storm events. It is recognized that this measure may potentially reduce flood risk associated with the creek system, but will not reduce the flooding risk associated with Lake Ontario flooding.

Existing Condition

Regulatory Floodplain Mapping and Flood Model Updates

The Westside Creek study completed in 2013 focused on the entire 500 hectare watershed. As such, a focused review of the latest flood model and mapping in the vicinity of Cedar Crest Beach Road was undertaken.

It should be noted that the models developed for the study were not calibrated. As a result, the models may overestimate actual flows.

It should be noted that the 100 Year and Regional storm scenarios do not consider any existing storage within upstream stormwater management facilities (SWMFs). These are the "Regulatory Events" on which the floodplain mapping shown on ***Attachment 1*** is based. The 2 through 50 Year Scenarios, however, do consider storage available in SWMFs. Flood storage available within Westside Creek marsh is not considered in the models.

The following is a list of modifications undertaken to the flood model in order to more accurately reflect the existing flood limits within the area shown on ***Attachment 1***.

1. Cross-sections 53 to 156 (see ***Attachment 1***) were extended west beyond the limits of the floodline to capture the available conveyance capacity along the western portion of Cedar Crest Beach Road and the adjacent properties within the flood model.

2. In the flood model, cross-sections 53, 111 and 131 include 'levees' on the west bank of the creek. The levees prevent the model from utilizing the conveyance capacity of the west overbank areas (ie. properties on the west side of the creek) until the 'levee' or bank elevation is overtopped. This does not reflect the actual conditions as nearly the entire length of Cedar Crest Beach Road is shown to overtop during all storm events. As such, it is clear that the properties fronting Cedar Crest should be modeled as 'conveyance' areas. These levees were therefore removed from the flood model.

3. The 'road deck' cross-section which represents Cedar Crest Beach Road in the flood model was extended (similar to the cross-section extension - see note 1 above). The elevations were also updated according to a survey of centerline grades along Cedar Crest Beach Road completed by CLOCA in July, 2017 (***Attachment 2***).

4. Westside Creek Marsh is located immediately upstream of Cedar Crest Beach Road. In the 1990's, a flood overflow channel from the wetland to Lake Ontario was constructed at the south west limit of the study area. The overflow channel was sized to compensate for development of an aggregate extraction area which reduced the size of the wetland. The design of the overflow channel was documented within the Hydrotechnical Report and Functional Understanding of Westside Marsh, prepared by MMM (April 1998). Conveyance of flood flows through the overflow channel is not considered in the 2013 flood model. For the purpose of this site specific analysis, the conveyance values for the overland flow channel have been incorporated into the revised 2018 existing condition scenario. The total flow through the Hec-Ras cross-sections has been reduced by the corresponding flow capacity of the overflow channel for the corresponding water surface elevation of each storm profile (using the overflow channel rating curve [Table 3.5] provided in the Hydrotechnical report).

The flood elevations resulting from the above model refinements are slightly lower than the current regulatory flood elevations and are summarized in Table 1 below. The flood elevations vary at cross-sections (XS), therefore flood elevation results are reported for three cross-sections within the study area (XS's 141 Cedar Crest Beach Road, 111 residential homes/lots, & 53 beach/Lake Ontario Shoreline).

The revisions to the existing condition flood model do not result in any appreciable difference to the mapped floodline depicted on ***Attachment 1***.

Table 1: Existing Flood Model Update Results

		Existing Flood Elevations (m)		
Cross-Section	**Return Period Event**	**2013 Existing**	**2018 Existing**	**Change in Flood Elevation (m)**
141 Cedar Crest Beach Road	2 Year	75.91	75.85	-0.06
	5 Year	76.05	75.95	-0.10
	10 Year	76.14	76.01	-0.13
	25 Year	76.23	76.07	-0.16
	50 Year	76.30	76.12	-0.18
	100 Year*	76.67	76.37	-0.30
	Regional	76.66	76.36	-0.30
111 Residential homes/lots	2 Year	75.88	75.80	-0.08
	5 Year	76.02	75.89	-0.13
	10 Year	76.11	75.95	-0.16
	25 Year	76.21	76.01	-0.20
	50 Year	76.28	76.06	-0.22
	100 Year*	76.69	76.32	-0.37
	Regional	76.67	76.31	-0.36
53 Beach / Lake Ontario Shoreline	2 Year	75.55	75.35	-0.20
	5 Year	75.66	75.41	-0.25
	10 Year	75.72	75.44	-0.28
	25 Year	75.79	75.48	-0.31
	50 Year	75.85	75.51	-0.34
	100 Year*	76.17	75.66	-0.51
	Regional	76.15	75.66	-0.49

** Regulatory Event*

Lake Ontario Water Level Impacts on Existing Condition

The flood model used to determine the flood elevations along Westside Creek is a one-dimensional backwater flow model. As such, an initial starting water surface elevation is entered in the model at the furthest downstream cross-section based on the long term average Lake Ontario water level (74.7m) as per provincial technical guidelines.

Lake Ontario experienced record high water levels during the Spring of 2017 (75.87m – May 26) which were over 1 metre higher than the starting water elevation assumed in the 2013 flood model. In order to determine the impact the record high water levels have on the flood elevations, the model was run using the high water level reached in 2017. For the purposes of this analysis, it was assumed that the overflow channel (see note 4 above) does not function during high lake levels.

The results of the analysis are shown below in Table 2. As shown in the table, the high lake levels have a large impact adjacent to the shoreline. There is a much smaller impact upstream of Westside Creek adjacent to Cedar Crest Beach Road.

Table 2: Impact of 2017 High Lake Level on Existing Riverine Flood Elevations

Cross-Section	Return Period Event	Flood Elevations (m)		Difference in Flood Elevation (m)
		2018 Existing (Lake Ontario Water Level =74.7m)	2018 Existing (Lake Ontario Water Level =75.9m)	
141 Cedar Crest Beach Road	2 Year	75.85	75.93	+0.08
	5 Year	75.95	76.00	+0.05
	10 Year	76.01	76.05	+0.04
	25 Year	76.07	76.11	+0.04
	50 Year	76.12	76.15	+0.03
	100 Year*	76.37	76.43	+0.06
	Regional	76.36	76.42	+0.06
111 Residential homes/lots	2 Year	75.80	75.90	+0.10
	5 Year	75.89	75.95	+0.06
	10 Year	75.95	75.99	+0.04
	25 Year	76.01	76.04	+0.03
	50 Year	76.06	76.08	+0.02
	100 Year*	76.32	76.36	+0.04
	Regional	76.31	76.35	+0.04
53 Beach / Lake Ontario Shoreline	2 Year	75.35	75.87	+0.52
	5 Year	75.41	75.87	+0.46
	10 Year	75.44	75.87	+0.43
	25 Year	75.48	75.87	+0.39
	50 Year	75.51	75.87	+0.36
	100 Year*	75.66	75.87	+0.21
	Regional	75.66	75.87	+0.21

* *Regulatory Event*

The analysis also shows that the elevated Lake Ontario water levels has greater impact on the more frequent smaller storm flood events, and has less of an impact during large infrequent events. It could be assumed that the barrier beach at the outlet of Westside Creek to Lake Ontario, could have similar impacts (see Westside Marsh Barrier Beach Function report).

Flood Mitigation Measures

Raising Cedar Crest Beach Road may provide some flood protection by preventing creek flows from overtopping the road during frequent return period events.

A survey of centerline grades along Cedar Crest Beach Road was completed by CLOCA in July, 2017 (***Attachment 2***). The survey shows the lowest point in the road is approximately 75.8m.

The road is thus overtopped during a 2 year event, according to Table 1 above (see Cross-Section 141). The results shown in Table 1 for Cross-Section 141 provides a basis for determining the level of protection which may be afforded the homes on Cedar Crest Beach Road by raising the road. The analysis is iterative because raising the road will impact upstream flood elevations, which in turn affects the level of protection provided.

A preliminary analysis was completed to determine the approximate level of protection which could be provided should it be possible to raise the road with a minimum low point between 76.0m and 76.15m. The flood elevations which would result from increasing the minimum Cedar Crest Beach road grade are provided in Table 3 below.

Table 3: Cedar Crest Beach Road Modifications

Cross-Section	Return Period Event	Flood elevations (m)*		
		2018 Existing	Proposed Minimum Road Grade	
			76.00m	76.15m
141 Cedar Crest Beach Road	2 Year	75.85	75.88	75.88
	5 Year	75.95	76.00	76.00
	10 Year	76.01	76.01	76.07
	25 Year	76.07	76.07	76.15
	50 year	76.12	76.12	76.21
	100 Year*	76.37	76.37	76.37
	Regional	76.36	76.36	76.36

* *Regulatory Event*

XX.XX *Spill Elevation*

As shown in the table above, it appears it is possible to increase the level of flood protection from riverine events by raising Cedar Crest Beach Road. The potential level of protection which could be provided to the adjacent homes is summarized in Table 4. In addition to providing flood protection, the raised road profile also improves emergency access for the community.

Table 4: Preliminary Flood Protection Results of Raising Cedar Crest Beach Road

Minimum Road Grade	Potential Level of Protection
Existing: 75.8m	Less than 2 Year Riverine Flood Event
76.00m	5 Year Riverine Flood Event
76.15m	25 Year Riverine Flood Event

The results above are preliminary and subject to a more rigorous analysis and detailed design, including refining the hydraulic model with a detailed survey of the overflow channel, Cedar Crest Beach Road, and existing lot grades. If this flood mitigation concept is pursued, a detailed design process would need to ensure lot drainage is not obstructed and there are no other negative impacts to the existing lots. It is also recommended a cost-benefit analysis is completed to ascertain if this approach provides an overall benefit to the community.

This flood mitigation measure will not protect against regulatory events or Lake flooding events. There is also potential that raising the road may make Lake events worse should shoreline flooding reach Cedar Crest Beach Road.

Based on the preliminary analysis outlined above, it is not anticipated there will be any negative impacts to the "Regulatory" flood limit, however the current floodplain mapping (***Attachment 1***) requires an update based on the results of the existing condition flood model updates outlined under the "Existing Conditions" section above. Due to the complexity in modeling split flows with a one-dimensional model, development of a two-dimensional hydraulic analysis of the creek and overflow channel should be considered.

The flood mitigation would reduce the riverine flood risk for the community, by reducing the frequency of flooding events, although the community flood vulnerability would still be high because of the potential for significant flooding from regulatory riverine and Lake based events.

Lake Ontario Water Level Impacts on Flood Mitigation Scenario

An analysis of the proposed scenarios under the 2017 high lake levels was completed. A comparison between the existing condition and proposed scenarios is presented in Table 5 below. As shown, raising the road has minimal impact on the Riverine flood elevations when compared to the existing condition.

Table 5: Results of Flood Mitigation Scenarios modelled with 2017 High Lake Levels

Cross-Section	Return Period Event	Flood Elevations (m) (Lake Ontario Water Level = 75.9m)		Difference in Flood Elevation (m)
		2018 Existing	Proposed Cedar Crest Beach Road Modifications	
141 Cedar Crest Beach Road	2 Year	75.93	75.98	+0.05
	25 Year	76.11	76.23	+0.12
	100 Year*	76.43	76.43	0
	Regional	76.42	76.42	0
111 Residential homes/lots	2 Year	75.90	75.96	+0.06
	25 Year	76.04	76.20	+0.16
	100 Year*	76.36	76.36	0
	Regional	76.35	76.35	0
53 Beach / Lake Ontario Shoreline	2 Year	75.87	75.87	0
	25 Year	75.87	75.87	0
	100 Year*	75.87	75.87	0
	Regional	75.87	75.87	0

* *Regulatory Event*

N/C = no change

Conclusions

An update to CLOCA's existing flood model was undertaken to more accurately depict the flood conditions within the Cedar Crest Beach Road community. The updates resulted in slightly lower flood elevations than those previously modelled.

The impact of the 2017 high lake level on the flood model was analyzed. It was determined that although the high lake levels significantly increase flooding adjacent to the shoreline, upstream riverine flood levels are not appreciably impacted by high lake levels. More frequent smaller flood events would be most affected by the raised Lake water levels.

An analysis of raising Cedar Crest Beach Road was completed as a possible flood mitigation measure to protect homes from frequent Westside Creek flooding. The existing low point on the road is approximately 75.8m. Based on the current model, the road is overtopped during 2 year return period events, which have a 50% chance of occurrence in any given year. Note flood models are generally conservative, therefore this level of flooding may not occur as frequently as per model predictions.

By raising the road to between 76.00 and 76.15m, it may be possible to provide riverine flood protection for the 5 and 25 year return period events; respectively. These results are

preliminary and subject to further review including an Environmental Assessment and detailed design. The design would need to ensure lot drainage is not obstructed and there are no other negative impacts to the existing lots. It is also recommended a cost-benefit analysis is completed to ascertain if this approach provides an overall benefit to the community. This flood mitigation measure has the potential to reduce flood risk for the community, by reducing the *frequency* of flooding events, and improving emergency access. The community flood *vulnerability* would still be high, however, because of the potential for significant flooding from regulatory riverine and Lake based events.

ATTACHMENT #1

WS2

Central Lake Ontario Conservation

This map is prepared for use in conjunction with the Hydrologic & Hydraulic modeling for Westside Creek Documentation, 2013.

Floodplain modelling prepared by Engineering Department, CLOCA, using HEC-GeoRAS v10.0, 2013. Input parameters were extracted from base mapping with the use of HEC-Geo RAS.

Base mapping compiled from First Base Solutions Digital Ortho Mapping & DEM Mapping derived from aerial photography (Spring 2010), carried out by Geomatics and Information Technology, CLOCA.

WESTSIDE CREEK FLOODPLAIN MAPPING

- Regulatory Floodplain
- Drainage
- Study Limit
- Contour
- Cross Section
- 3800 49.90 — Station Number and Flood Elevation
- Railway
- Spill Location

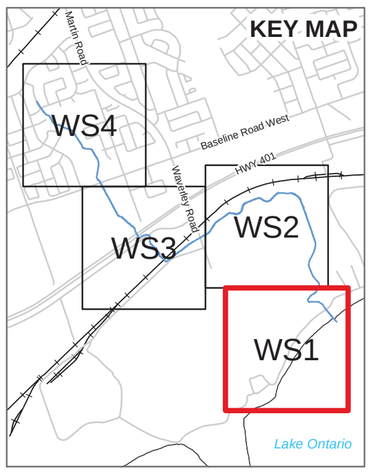
1:2,000

50 25 0 50 100 150 200 250 300

Metres

N

KEY MAP



REVISIONS AND UPDATES

NO.	DATE	REVISION

MAP NUMBER
WS1

March 2013

ATTACHMENT #2

The Central Lake Ontario Conservation Authority

Cedar Crest Beach Road - Section 2

Legend

- Contours 1m Interval
- Surveyed Points ht2_0

20 10 0 20 40

Meters

(c) Copyright. Central Lake Ontario Conservation Authority, 2017.

Map Compiled by the Central Lake Ontario Conservation Authority, 100 Whiting Ave., Oshawa, Ontario, L1H 3T3

This map is for information purposes only and the Central Lake Ontario Conservation Authority takes no responsibility for, nor guarantees, the accuracy of all the information contained within the map.

Source: CLOCA, 2017; Regional Municipality of Durham, 2017; MNR, 2017.

Projection: NORTH AMERICAN DATUM 1983 UNIVERSAL TRASVERSE MERCATOR (6 DEGREES) PROJECTION, ZONE 17, CENTRAL MERIDIAN (81 DEGREES WEST)

Date Printed: July 11, 2017

Central Lake Ontario Conservation

The Central Lake Ontario Conservation Authority

Cedar Crest Beach Road - Section 1

Legend

- Contours 1m Interval
- Surveyed Points ht2_0

20 10 0 20 40

Meters

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This map is for information purposes only and the Central Lake Ontario Conservation Authority takes no responsibility for, nor guarantees, the accuracy of all the information contained within the map.

Source: CLOCA, 2017; Regional Municipality of Durham, 2017; MNR, 2017.

Projection: NORTH AMERICAN DATUM 1983 UNIVERSAL TRASVERSE MERCATOR (6 DEGREES) PROJECTION, ZONE 17, CENTRAL MERIDIAN (81 DEGREES WEST)

Date Printed: July 11, 2017

Central Lake Ontario Conservation

APPENDIX 4

Central Lake Ontario Conservation

Technical Report:
Flood Mitigation for West Beach Road

DRAFT

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Introduction

The residential community on West Beach Road is within the floodplain of the Bowmanville/Soper Creek and is also at risk of flooding from Lake Ontario.

In 2009, floodplain mapping was developed by Aquafor Beech Limited for CLOCA for Bowmanville Creek and Soper Creek. The Regulatory Floodplain in the vicinity of West Beach Road is depicted on Bowmanville Creek & Soper Creek Regulatory Flood Plain Mapping Sheet Number BS002 (***Attachment 1***). Details are outlined in the study entitled Bowmanville Creek & Soper Creek Floodplain Mapping Study, prepared by Aquafor Beech Limited (June 2009), here within referred to as the Bowmanville/Soper Creek study. Shoreline flood mapping for the area was developed and reported in the Lake Ontario Shoreline Management Plan (Sandwell Swan Wooster Inc, December 1990). An update is currently underway.

The following brief outlines a high level analysis completed to investigate the feasibility of raising West Beach Road to prevent creek flows from overtopping the road and impacting the West Beach Road community during storm events. It is recognized that this measure may potentially reduce flood risk associated with the creek system, but will not reduce the flooding risk associated with Lake Ontario flooding.

Existing Condition

The Bowmanville/Soper Creek study completed in 2009 focused on the entire Bowmanville Creek and Soper Creek watersheds. As such, a focused review of the flood model and mapping in the vicinity of West Beach Road was undertaken.

It should be noted that the hydrology model used for the study was not calibrated. As a result, the hydrology model may overestimate actual flows, and therefore the flood model may also overestimate the extent of the floodplain.

The following is a list of modifications undertaken to the flood model in order to determine if raising West Beach Road will provide additional flood protection for the community without impacting upstream properties.

1. In the flood model, there is a cross-section located upstream of West Beach Road (XS 99) and one which crosses through the residential properties (XS 8). See ***Attachment 1*** for details. An additional cross-section was added to the model to represent West Beach Road. This was done by taking a copy of XS 99 and inserting it as a new cross-section approximately 25m south of XS 99. The portion of this new cross-section (XS 76) intended to depict West Beach Road was then raised to the lowest centerline road grade along West Beach Road (75.8m according to a survey completed by CLOCA in July, 2017 – see ***Attachment 2***).

2. Existing cross-sections 9 and 99 include 'levees' on the west bank of the creek. The levees prevent the model from utilizing the conveyance capacity of the west overbank areas (i.e. properties on the west side of the creek) until the 'levee' or bank elevation is overtopped. This does not reflect the actual conditions as the entire length of West Beach Road is shown to overtop during the 25 to 100 year and Regional storm events. As such, it is clear that the properties fronting West Beach Road should be modeled as 'conveyance' areas. These levees were therefore removed from the flood model.

The flood elevations upstream of West Beach Road resulting from the above model updates are slightly higher than the current flood elevations and are summarized in Table 1 below for cross-sections 8 (residential homes/lots), 76 (West Beach Road), and 99 (south limit of Bowmanville Marsh). The revisions to the existing condition flood model do not result in any appreciable difference to the mapped floodline depicted on ***Attachment 1***.

Table 1: Existing Flood Model Update Results

		Existing Flood Elevations (m)		
Cross-Section	**Return Period Event**	**2009 Existing**	**2018 Existing**	**Change in Flood Elevation (m)**
99 Bowmanville Marsh	2 Year	75.27	75.29	+0.02
	5 Year	75.61	75.72	+0.11
	10 Year	75.83	75.97	+0.14
	25 Year	76.08	76.19	+0.11
	50 Year	76.22	76.33	+0.11
	100 Year	76.43	76.50	+0.07
	Regional	78.07	78.07	0
76 West Beach Road	2 Year	N/A*	75.20	N/A
	5 Year		75.53	
	10 Year		75.74	
	25 Year		76.03	
	50 Year		76.24	
	100 Year		76.45	
	Regional		78.06	
8 Residential Homes/Lots	2 Year	74.70	74.70	0
	5 Year	74.93	74.93	0
	10 Year	75.09	75.09	0
	25 Year	75.29	75.29	0
	50 Year	75.44	75.44	0
	100 Year	75.59	75.59	0
	Regional	77.53	77.53	0

** XS 76 is a new cross-section added to the 2018 model. It is not in the 2009 model.*

XX.XX *Elevation at which West Beach Road is overtopped*

Flood Mitigation Measures

Raising West Beach Road may provide some flood protection to the community by preventing creek flows from overtopping the road.

A survey of centerline grades along West Beach Road was completed by CLOCA in July, 2017 (***Attachment 2***). The survey shows the lowest point in the road is approximately 75.8m. The road is thus overtopped during a 25 year event, according to Table 1 above (see Cross-Section 76).

A preliminary analysis was completed to determine the approximate level of protection which could be provided should it be possible to raise the road with a minimum low point between 76.0m and 76.2m. The flood elevations at West Beach Road which would result from increasing the minimum road grade are provided in Table 3 below.

The potential level of protection which could be provided to the adjacent homes is summarized in Table 4. In addition to providing flood protection, the raised road profile would also improve emergency access for the community.

Table 2: West Beach Road Modifications

Cross-Section	Return Period Event	Flood elevations (m)		
		2018 Existing	Proposed Minimum Road Grade	
			76.00m	76.20m
76 West Beach Road	2 Year	75.20	75.20	75.20
	5 Year	75.53	75.53	75.53
	10 Year	75.74	75.73	75.73
	25 Year	76.03	75.98	75.98
	50 year	76.24	76.23	76.16
	100 Year	76.45	76.46	76.45
	Regional	78.06	78.06	78.06

XX.XX *Elevation at which West Beach Road will overtop*

Table 3: Preliminary Flood Protection Results of Raising West Beach Road

Minimum Road Grade	Potential Level of Protection
Existing: 75.8m	10 Year Riverine Flood Event
76.00m	25 Year Riverine Flood Event
76.20m	50 Year Riverine Flood Event

As shown in the table above, it appears it is possible to increase the level of flood protection from riverine events by raising West Beach Road. However, it is necessary to first determine if doing so would impact any upstream properties.

The following table shows the impact of raising the road on upstream flood elevations. Representative upstream cross-sections were chosen to demonstrate the extent of potential impacts. The location of these cross-sections is shown on ***Attachment 1***. The flood elevations for the 2, 5 and 25 year events are not included in the table as impacts to upstream flood elevations are not anticipated during these storm events.

Table 4: Upstream Flood Elevation Impacts of West Beach Road

		Flood Elevations (m)				
Cross-Section	**Return Period Event**	**2018 Existing**	**Road Grade Raised to 76.00m**	**Change in Flood Elevation (m)**	**Road Grade Raised to 76.20m**	**Change in Flood Elevation (m)**
131 Soper Creek Branch	25 year	76.67	76.71	+0.04	76.71	+0.04
	50 year	76.77	76.81	+0.04	76.87	+0.10
	100 year	76.97	76.99	+0.02	77.03	+0.06
	Regional	78.23	78.23	0	78.24	+0.01
340 Bowmanville Creek Branch	25 year	76.71	76.74	+0.03	76.74	+0.03
	50 year	76.82	76.85	+0.03	76.89	+0.07
	100 year	77.00	77.01	+0.01	77.04	+0.04
	Regional	79.52	79.52	0	79.52	0
587 Bowmanville/ Soper Creek	25 year	76.58	76.63	+0.05	76.63	+0.05
	50 year	76.75	76.79	+0.04	76.85	+0.10
	100 year	76.95	76.97	+0.02	77.01	+0.06
	Regional	78.15	78.15	0	78.16	+0.01
271 Bowmanville/ Soper Creek	25 year	76.07	76.18	+0.11	76.18	+0.11
	50 year	76.15	76.26	+0.11	76.39	+0.24
	100 year	76.27	76.33	+0.06	76.43	+0.16
	Regional	78.10	78.11	+0.01	78.12	+0.02
99 Bowmanville Marsh	25 year	76.19	76.29	+0.10	76.29	+0.10
	50 year	76.33	76.42	+0.09	76.53	+0.20
	100 year	76.50	76.55	+0.05	76.63	+0.13
	Regional	78.07	78.08	+0.01	78.09	+0.02

XX.XX *Potential increase in upstream flood elevation identified. Requires further study.*

The table above indicates that raising the road will have impacts on upstream flood elevations. Generally, CLOCA considers increases greater than 5cm as significant. These increases are highlighted above. There are no significant increases to the Regional flood elevations on which the 'Regulatory' flood limit depicted on ***Attachment 1*** is based. Upstream flood increases are expected, however, for the 25, 50 and 100 year storm events up to the north section of east-west running West Beach Road (just south of the CN Railway).

Further study is required to determine if raising West Beach Road is feasible and if the upstream flood elevation increases will impact private properties. The following additional analyses are recommended:

1. Detailed survey of West Beach Road and existing lot grades should be completed to ensure lot drainage is not obstructed and there are no other negative impacts to the existing driveways and lots.
2. West Beach Road should be more accurately modeled. For the purposes of this analysis, the total length of West Beach Road was assumed to have an elevation of 75.8m based on the minimum road grade surveyed by CLOCA. The detailed road survey grades obtained from 1) above should be entered into the model. This should minimize the overflow conveyance capacity of West Beach Road under existing conditions. This may, in turn, show there is less impact with raising the road than estimated in this analysis.
3. Any upstream private properties which may be impacted should be surveyed to confirm the location of the existing floodline and to confirm if any modelled vertical elevation increases will result in a lateral movement of the floodline on the property.
4. It is also recommended a cost-benefit analysis is completed to ascertain if this approach provides an overall benefit to the community.

This flood mitigation measure will not protect against regulatory events or Lake flooding events. There is also potential that raising the road may make Lake Events worse should shoreline flooding reach West Beach Road.

Based on the preliminary analysis outlined above, it is not anticipated there will be any impacts to the existing "Regulatory" flood limits, therefore the current floodplain mapping (***Attachment 1***) will remain the same.

The flood mitigation would reduce the riverine flood risk for the community, by reducing the frequency of flooding events, although the community flood vulnerability would still be high because of the potential for significant flooding from regulatory riverine and Lake based events.

Conclusions

An analysis of raising West Beach Road as a possible flood mitigation measure for the surrounding community has been undertaken. The existing low point on the road is approximately 75.8m. Based on the current model, the road is overtopped during 10 year return period events.

By raising the road to between 76.00 and 76.20m, it may be possible to provide riverine flood protection for the 25 and 50 year return period events; respectively. These results are preliminary and subject to further review including an upstream flood impact analysis, Environmental Assessment and detailed design. The design would need to ensure lot drainage is not obstructed and there are no other negative impacts to the existing lots. It is also recommended a cost-benefit analysis is completed to ascertain if this approach provides an overall benefit to the community. This flood mitigation measure has the potential to reduce flood risk for the community, by reducing the *frequency* of flooding events, and improving emergency access. The community flood *vulnerability* would still be high, however, because of the potential for significant flooding from regulatory riverine and Lake based events.

Central Lake Ontario Conservation

CENTRAL LAKE ONTARIO CONSERVATION AUTHORITY

100 Whiting Avenue Oshawa, Ontario L1H 3T3 (905) 579-0411

LEGEND

- REGULATORY FLOODLINE
- ROADS
- BOWMANVILLE CREEK AND SOPER CREEK (DRAINAGE STREAM)
- MODEL CROSS SECTION
- 1000 125.50 — STATION NUMBER AND REGULATORY (HAZEL OR 100-YR) FLOOD ELEVATION
- LOWEST WEIR ELEVATION

REVISIONS

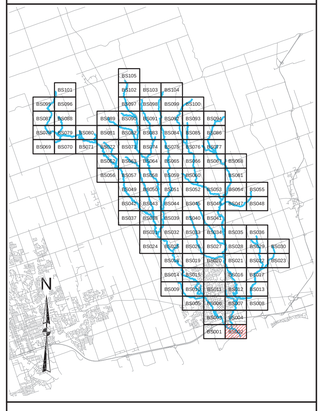
No.	DESCRIPTION	BY:	DATE:
1	Hydrologic Update	AL	05/10

Note:

1. This map is prepared for use in conjunction with the Bowmanville Creek and Soper Creek Floodplain Mapping Report dated May 2009.
2. Floodplain modeling was prepared by Aquafor Beech Limited using HEC-RAS 4.0, March 2008. Input parameters were extracted from base mapping with the use of HEC-GeoRAS.
3. Base mapping has been prepared by Central Lake Ontario Conservation Authority's Geomatics and Information Technology Department. Base Mapping was derived from First Base Solutions Digital Mapping and DEM Mapping produced from Aerial photography carried out in the spring of 2005.

Aquafor Beech Limited

PLEASE NOTE:
THE PROFESSIONAL ENGINEER STAMP VERIFIES THE FLOODLINE AND ASSOCIATED DATA UNLESS OTHERWISE NOTED



Meters
0 12.5 25 50 75 100 125 150
1:2,000

BOWMANVILLE CREEK & SOPER CREEK REGULATORY FLOOD PLAIN MAPPING

Sheet Number: BS002 - 68654862

May, 2009

The Central Lake Ontario Conservation Authority

West Beach Road

Legend

- Contours 1m Interval
- Surveyed Points ht2_0

20 10 0 20 40

Meters

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Map Compiled by the Central Lake Ontario Conservation Authority, 100 Whiting Ave., Oshawa, Ontario, L1H 3T3

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