CITY OF HAMILTON

PLANNING AND ECONOMIC DEVELOPMENT DEPARTMENT
Growth Management Division

and

PUBLIC WORKS DEPARTMENT
Hamilton Water Division

TO: Chair and Members Planning Committee	**WARD(S) AFFECTED:** WARD 11
COMMITTEE DATE: April 2, 2013	
SUBJECT/REPORT NO: Binbrook Sanitary and Stormwater Systems Performance (PED12182(a)/PW13016) (Ward 11) (Outstanding Business List Item)	
SUBMITTED BY: Tim McCabe General Manager Planning and Economic Development Department Gerry Davis, CMA General Manager Public Works Department	**PREPARED BY:** Chris Gainham (905) 546-2424 Ext. 3421 Sally Yong-Lee (905) 546-2424 Ext. 1428
SIGNATURE:	

RECOMMENDATION

(a) That the interim report on flooding in Binbrook, including the remedial measures to prevent the potential for flooding in Binbrook, be received;

(b) That AMEC be retained to continue additional studies in Binbrook and Upper Stoney Creek to establish the relationship between the storm run-off and the municipal storm and sanitary conveyance systems and hydraulic analyses of the

minor system and major overland flow systems with associated works to be charged to Capital Budget Account No. 5180855850;

(c) That the item respecting "Binbrook Heights Addition" on lands located at 139 Fall Fair Way (Glanbrook) be identified as complete and removed from the Planning Committee Outstanding Business List.

EXECUTIVE SUMMARY

At the November 6, 2012 Planning Committee meeting, a motion was tabled to defer approval of the recommendations of Report PED12182 - Applications for Amendments to the Township of Glanbrook Official Plan and Zoning By-law No. 464, and Approval of a Draft Plan of Subdivision, known as "Binbrook Heights Addition", on lands located at 139 Fall Fair Way (Glanbrook) (Ward 11) pending the results of the interim report regarding the flooding in Binbrook Village and pending confirmation and corrective action from the Manager of Growth and Management respecting adequate sewer capacity in the development to handle additional flow. This direction was in response to widespread flooding that occurred on July 22, 2012.

July 22, 2012 Storm Overview

In the late afternoon of Sunday, July 22, 2012, a line of persistent slow moving thunderstorms passed through Ontario leaving a swath of damage from Hamilton to Ottawa. The hardest hit areas in Hamilton received torrential rains for an extended duration centralized over the south-east portion of the City. Rainfall gauges at Highland Road (293 Highland Road West) and the Valley Park Community Centre (970 Paramount Drive) recorded 140 and 116 mm of rain respectively, with the most intense rainfall over a three-hour period. Radar maps of this event suggest that rainfall likely reached 250 mm in some areas.

A storm of this magnitude and intensity is unprecedented in the historical record, with an extrapolated return period exceeding 1,000 years. To put this storm into context; the July 26, 2009 storm that caused extensive flooding in the Red Hill corridor delivered approximately 110 mm of rain in about three hours.

Causes of Flooding in Binbrook

In general, mechanisms of flooding are well understood however, existing conditions that exploit these mechanisms require investigation and analysis which staff has undertaken in Binbrook over the last several months. While it remains unclear to what extent each existing condition played a role during the July 22 event, it is staff's opinion

that the cause of flooding in Binbrook on July 22, 2012 was almost exclusively related to the sheer magnitude of this storm. As mentioned above, this storm was unprecedented and it is believed that it overwhelmed the sanitary and storm infrastructure in Binbrook. The storm far exceeded a 100-year return period and, while Hamilton could design for these rare occurrences, this would not be fiscally sound nor in some cases even feasible.

Lot level rainwater run-off and groundwater issues, as well as sanitary and storm sewer system surcharge due to excessive infiltration and inflow, are high on the list of "usual suspects" when flooding occurs, and it appears that during this event every aspect of this list was exploited by flood waters. Additionally, construction management practices associated with on-going residential development that do not exist at full build out may have also played a role.

Based on information gathered from residents, it appears that approximately 60% of basement flooding is believed to have occurred as a result of back-up of the sanitary sewer system while the remaining 40% is more associated with the intrusion of foundation water primarily from the sump pits.

Smoke testing and field reconnaissance identified traditional issues believed to contribute to flooding and include 40 potential examples of infiltration/inflow that may have existed in the Binbrook sanitary system which could have contributed to high wet weather flows. It is not possible to confirm with certainty if, indeed, these sources contributed to the flooding of July 22, 2012 and, if so, to what degree, however, a discussion of these sources is included later in this report.

Corrective and On-going Actions

In response to information revealed through the investigations staff identified measures that are expected to reduce the potential for basement flooding in future. A full discussion of these measures follows later in this report but in summary include:

1. Elimination of extraneous rainfall run-off entering in the sanitary sewer system;
2. Completion of stormwater management facility and storm channel maintenance;
3. Review and potential improvement to engineering standards;
4. Improvements to the affected sewage pump station;
5. Improvement to construction management practices and increased oversight; and,
6. Outreach respecting the mechanisms and root causes of flooding.

Conclusion

Staff concludes that the rainfall intensities and depths associated with this storm likely represents the most severe event experienced on record and is far in excess of any

design standard that is, or can, practically be applied. As a result, flooding on a large scale was likely an inevitable outcome from this storm. The subsequent investigation into the performance of the stormwater and sanitary sewer systems did however reveal a number of issues and practices that, with changes, could have the potential to reduce the impact of future storms. A full discussion of these issues follows later as described above.

A number of actions and modifications were relatively simple and were completed recently to the existing sanitary network and are intended to reduce inflow and infiltration from extreme events. Additionally, actions to be undertaken in the future, discussed later in this report will also contribute to preventing extraneous flows from entering the sewer system.

On-going flow monitoring within the sanitary sewer system will remain for the indefinite future so as to measure the benefits of both completed and planned actions. It is important to note that there has not been sufficient time to confirm with certainty the benefits of the corrective actions described in this report as it relates to extraneous flows entering both the sanitary sewer system and directly into basements.

In considering whether or not the addition of the proposed homes of "Binbrook Heights Addition", on lands located at 139 Fall Fair Way (Glanbrook) can be accommodated in the existing sanitary sewer network, the July 22, 2012 storm event should not be considered as this storm is viewed as an anomaly and as such cannot be considered or planned for under current planning and design standards.

Given the above, analysis has been conducted to confirm the capacity of the sanitary sewer network has been completed using traditional analysis and has confirmed that the necessary reserve capacity is indeed available. The corrective actions identified in this report bring greater confidence that the potential for extraneous flows entering the sanitary sewer system and directly into basements will be significantly reduced.

Alternatives for Consideration – See Page 14

FINANCIAL / STAFFING / LEGAL IMPLICATIONS (for Recommendation(s) only)

Financial: Funding for the additional study by AMEC is available in the following approved Capital Budget Account No. 5180855850.

Staffing: There are no additional staffing requirements as a result of Council's approval of this report's recommendations.

Legal: There are no legal implications.

HISTORICAL BACKGROUND (Chronology of events)

At the November 6, 2012 Planning Committee meeting, a motion was tabled to defer approval of the recommendations of Report PED12182 - Applications for Amendments to the Township of Glanbrook Official Plan and Zoning By-law No. 464, and Approval of a Draft Plan of Subdivision, known as "Binbrook Heights Addition", on lands located at 139 Fall Fair Way (Glanbrook) (Ward 11) pending the results of the interim report regarding the flooding in Binbrook Village and pending confirmation and corrective action from the Manager of Growth and Management respecting adequate sewer capacity in the development to handle additional flow. This direction was in response to widespread flooding that occurred on July 22, 2012.

STORM OVERVIEW

Beginning in the late afternoon of Sunday, July 22, 2012, a line of persistent slow moving thunderstorms passed through Ontario leaving a swath of damage from Hamilton to Ottawa. The hardest hit areas in Hamilton received torrential rains for an extended duration centralized over the south-east portion of the City. Rainfall gauges at Highland Road (293 Highland Road West) and the Valley Park Community Centre (970 Paramount Drive) recorded 140 and 116 mm of rain respectively, with the most intense rainfall over a three-hour period. Radar operated by the United States National Oceanic and Atmospheric Administration (NOAA) Federal Agency estimated that rainfall totals for this storm, just outside the geographic area of the City rainfall gauges, was even greater; 200 – 250 mm, as shown on Appendix "A" of Report PED12182(a)/PW13016. A storm of this magnitude and intensity is unprecedented in the historical record, with an extrapolated return period exceeding 1,000 years. To put this storm into context; the July 26, 2009 storm that caused extensive flooding in the Red Hill corridor delivered approximately 110 mm of rain in about three hours.

The run-off from this storm caused sanitary flooding and overwhelming of the weeping tile systems and sump pits of homes in three primary locations, with Binbrook being impacted the hardest. A media release from the Insurance Bureau of Canada following July 22 pegs the insured damage across Ontario from a combination of torrential rains, overland and basement flooding, large hail and unofficial reports of tornadoes, at $80 M http://www.ibc.ca/en/Media_Centre/News_Releases/2012/08-28-2012.asp.

Staff undertook extensive analysis to verify the reserve sanitary sewer capacity, and identified potential sources of inflow and infiltration of rain run-off into the sanitary sewer network. In addition, the stormwater infrastructure design (stormwater management facilities and conveyance systems) for these developments was reviewed for conformance with the City's policy and stormwater standards.

SANITARY SEWER ANALYSIS

For the sanitary sewer network the following activities and analysis were completed. Detailed explanations of each activity are included in the ANALYSIS/RATIONALE FOR RECOMMENDATION section of the report.

Smoke Testing and Field Observations

Staff engaged Thompson Flow Investigations Inc. (TQI), a hydrotechnical engineering consultant, to smoke test the sanitary sewer system in Binbrook to assist in identifying sources of extraneous inflow and infiltration into the system, with area specific follow-up, visual inspection and reconnaissance to further identify and confirm possible sources of extraneous flow in the sanitary sewer system.

CCTV Video Inspection

Main line sewers were video inspected in the areas where basement flooding was reported, specifically in the vicinity of Southbrook Drive and Etherington Drive to rule out obstructions in the main sewer.

Sanitary Sewer Flow Monitoring

Sanitary sewer flow monitors record actual flow in a sewer continuously reporting five-minute averages. This data allows staff to monitor the impact of growth and ensure that adequate reserve capacity is maintained for future development. This data also allows staff to understand the impact of rainfall on flows in the sanitary sewer system and flags the potential for illicit stormwater infiltration and inflow that can reduce the capacity intended for growth, and in extreme cases, cause sanitary surcharge and basement flooding.

Sanitary sewer flow monitoring instrumentation has been in place at key locations of the sanitary sewer network in Binbrook since late 2006 when two flow monitors were installed as part of a larger program of on-going flow monitoring and infiltration and inflow assessment across the City. In early 2012, and in response to high infiltration and inflow flagged during analysis of the initial monitoring data, three additional monitors were installed in the Binbrook sanitary system with the intention of isolating the sources of extraneous flow.

Assessment of Submerged Sanitary Sewer Manholes

Sanitary manhole covers located within the identified “major overland” flow routes were identified as a potential source of stormwater inflow. Each submerged sanitary manhole cover contains two 25 mm square openings to permit lifting of the cover using a pic axe. Each manhole has a potential of contributing two litres per second of stormwater into the sanitary sewer network through these pic holes.

Existing Sanitary Sewage Pump Station

The preferred approach to reducing the risk of any future surcharging of the sanitary sewer network is to incorporate an "emergency overflow" in the station design, where possible. In the event the sanitary sewer network reaches capacity, the overflows will spill over and are directed to a natural outfall rather than back into residential basements. The Binbrook Pump Station did not include provisions for an "emergency overflow". A high level assessment of the feasibility to establish such a feature at the Binbrook Sanitary Pumping Station was undertaken.

A review of the operation log books and data for the Binbrook Sewage Pump Station showed that the station was functioning as designed. The lead pump was running, as required throughout the duration of the July 22, 2012 storm. A second standby pump was not operational, however only one lead pump is required to be in service.

Building Construction Practice

During the excavation of foundations of homes there is a short window of time when under certain conditions, stormwater may enter into the sanitary sewer network if the cap of the sewer connection is removed and/or dislodged during construction. The number of open excavations on July 22, 2012 was reviewed.

STORMWATER SYSTEM AND DESIGN STANDARDS ANALYSIS

Field Reconnaissance of Surface Drainage Networks and Stormwater Management (SWM) Facilities

Staff investigated the condition of drainage channels and ponds in Binbrook.

An Independent Third Party Peer Review

Staff retained AMEC Environment & Infrastructure to undertake a peer review of the stormwater infrastructure (ie. stormwater management facilities and conveyance systems) for conformance with the City's policy and stormwater standards at the time of the development. The study focused on the Elizabeth Gardens and Southbrook on the Green developments.

Questionnaire and In-Home Inspections

AMEC's report recommended the distribution of a questionnaire to the affected area residents and conducting in-house inspections to better understand the flooding mechanisms from the July 22, 2012 storm. A flood questionnaire was developed and is appended as Appendix "B" of Report PED12182 (a)/PW13016. Some 337 questionnaires were mailed out to residents in Binbrook to obtain information on how they were impacted along with a request for a follow-up site inspection.

POLICY IMPLICATIONS

N/A

RELEVANT CONSULTATION

Staff from both the Planning and Economic Development Department and the Public Works Department collaborated on this report. Various staff from the Storm Event Response Group (SERG) contributed to the investigations and corrective actions to the sanitary sewer system in Binbrook.

ANALYSIS / RATIONALE FOR RECOMMENDATION

(include Performance Measurement/Benchmarking Data, if applicable)

Staff undertook extensive analysis to verify the reserve sewer capacity, corrective action to the sanitary sewer system, and changes to the design standards for stormwater infrastructure.

SANITARY SEWER ANALYSIS

For the sanitary sewer network the following analysis and action was completed.

Smoke Testing and Field Observations

Staff engaged Thompson Flow Investigations Inc. (TQI), a hydrotechnical engineering consultant, to have the entire Binbrook sanitary system “smoke” tested to assist in identifying sources of extraneous inflow and infiltration into the system, with area specific follow-up, visual inspection and reconnaissance to further identify and confirm possible sources of extraneous flow in the sanitary sewer system. Theatre “fog” was introduced into every sanitary sewer pipe in Binbrook. The smoke escapes the network through normal residential plumbing appurtenances and also through illicit connections which unintentionally convey stormwater run-off into the sanitary sewer network.

The smoke testing did uncover a number of issues which would have contributed to the basement flooding such as an incorrect sanitary manhole frame and cover, open joints in temporary manhole adjustment rings, and a possible illicit connection of a sump pump to the sanitary lateral.

CORRECTIVE ACTION

(a) Corrective action to date includes the replacement of a non-standard manhole cover at 222 Fall Fair Way (private condo complex) which will reduce the amount of extraneous rainfall run-off entering into the sanitary sewer system in the past;
(b) The temporary manhole adjustment rings will be removed at the time when the final surface course asphalt is placed on the roadways. The temporary rings are replaced with a poured concrete collar to secure the manhole frame and cover to the manhole structure and set to be flush with the road. This will further reduce the amount of rainwater that enters the sanitary sewer network; and,
(c) To mitigate high inflow and infiltration observed in the sanitary sewer system, the City is currently reviewing a new requirement for dye testing of the sanitary drain for each dwelling unit to confirm connection to the correct sewer, prior to the issuance of the occupancy inspection. Staff has consulted with the stakeholders on this new requirement and implementation will likely occur later in 2013.

CCTV Video Inspection

Main line sewers were video inspected in the areas where basement flooding was reported, specifically in the vicinity of Southbrook Drive and Etherington Drive to rule out obstructions in the main sewer. No obstructions in the main sewers were identified.

CORRECTIVE ACTION

As required, staff will undertake further CCTV and/or Zoom Camera inspections to ensure optimal performance of the sanitary sewer system.

Sanitary Sewer Flow Monitoring

Sanitary sewer flow monitoring instrumentation has been in place at key locations of the sanitary sewer network in Binbrook since late 2006 when two flow monitors were installed as part of a larger program of on-going flow monitoring and infiltration and inflow assessment across the City. In early 2012, and in response to high infiltration and inflow flagged during analysis of the initial monitoring data, three additional monitors were installed in the Binbrook sanitary system with the intention of isolating the sources of extraneous flow.

Analysis of the data shows that peak measured flows during dry weather are substantially below the maximum conveyance capacity of the existing pipes. Since July 22, 2012 continued increases in flow due to rainfall has been recorded, however no flow data has been recorded beyond maximum designed conveyance capacity.

Long-term flow monitoring indicates that during dry weather, the average sanitary flow to the Binbrook sanitary pumping station is 40 litres per second. On July 22, 2012 the recorded flow peaked at 530 litres per second causing sanitary surcharge in the lower

reaches of the system and is consistent with reports of sanitary related basement flooding and with post flooding field investigations and interviews. The likely causes of this high wet weather flow include many small to moderate sources of extraneous infiltration and inflow plus the potentially high flows from manholes under surface water flooding during extreme events.

Infiltration is considered during the design of the sanitary infrastructure and is calculated based on the contributing area and an allowable infiltration rate value of 0.4 litres per second per hectare for areas with no storm sewers or shallow storm sewers, and 0.2 litres per second per hectare for areas with deep storm sewers. All storm pipes within the Community of Binbrook appear to have been constructed at relatively shallow depth and, therefore, the sanitary infiltration value of 0.4 litres per second per hectare was applied. Prior to the July 22, 2012 storm, flow monitoring analysis indicated infiltration and inflow is a problem and two storms in late 2011 indicated significant exceedance of the City's 0.4 litres per hectare per second infiltration limit with rates of 0.6 and 0.7 litres per second per hectare respectively. The July 22, 2012 storm produced an infiltration rate (including inflow) of nearly 4.0 litres per second per hectare, or ten times the design standard. This can be considered the peak potential infiltration and inflow in Binbrook.

CORRECTIVE ACTION

The sanitary sewer flow monitors will remain in place to monitor reserve capacity and assess the effectiveness of remedial measures to reduce future rainfall run-off entry into the sanitary system.

Follow-up study identified in Recommendation (c) of Report PED12182(a)/PW13016 to establish the relationship between the storm run-off on the storm and sanitary conveyance system focusing on inflow/infiltration will be completed.

Assessment of Submerged Sanitary Sewer Manholes

Although not standard practice, in circumstances where excessive rainwater run-off is entering a sanitary sewer network, the identification of and subsequent plugging of the pic axe holes in sanitary sewer manhole covers will reduce the quantity of rainwater that illicitly enters.

CORRECTIVE ACTION

The 95 manholes in the Binbrook area have been sealed since July 22, 2012. During the most extreme storms this corrective action has been calculated to eliminate approximately 190 litres per second and will potentially reduce extraneous rainfall run-off that will no longer reach the sanitary sewer system, thus substantially reducing future risk of basement flooding from the sanitary sewer system.

Existing Sanitary Sewage Pump Station

The preferred approach to reducing the risk of any future surcharging of the sanitary sewer network is to reduce the entry of rainwater run-off entering the sewers. However, many existing and new sanitary sewage pumping stations have "emergency overflow" provisions where geographically and topographically possible, that allow the sanitary sewer system to direct excessively high flows to a natural outfall, rather than residential basements.

CORRECTIVE ACTION

An assessment to determine the feasibility of finding an outlet low enough to provide gravity relief for high flows will commence in 2013. Should it be determined that this is physically possible, implementation can be pursued. Approval of funding, Environmental Assessment, design and permitting, and construction can, however, take years to complete.

Building Construction Practice

During the excavation of foundations of homes there is a short window of time when under certain conditions, heavy rain and run-off might accumulate inside the excavations and enter into the sanitary sewer network if the cap of the sanitary connection is removed and/or dislodged during construction. Staff is investigating the protocol by which these excavations are drained to ensure the water is not discharged into the existing sanitary sewer system either intentionally or unintentionally.

CORRECTIVE ACTION

Should it be determined that rain and run-off from excavated foundations is entering the sanitary sewer system, provisions must be invoked to discourage this practice. Builders should not be leaving the end of the sanitary connection open.

Building Services staff will verify to ensure the end of the sewer connection is capped off as part of their inspections.

STORMWATER SYSTEM AND DESIGN STANDARDS ANALYSIS

For the stormwater management system, the following analysis and action was completed.

Field Reconnaissance of Surface Drainage Networks and SWM Facilities

Staff investigated the condition of drainage channels and SWM Facilities in Binbrook.

CORRECTIVE ACTION

Vegetation and sedimentation in the drainage channel and stormwater management facility, located east of Regional Road 56, was removed returning its conveyance capacity to the originally designed capacity. Ponds were scheduled for rehabilitation in 2013, however this work was accelerated. The maintenance work on the three SWM facilities was completed in February 2013. Channel cleaning work was completed in early March 2013.

An Independent Third Party Peer Review

Staff engaged AMEC Environment & Infrastructure to undertake a peer review of the stormwater infrastructure (ie. stormwater management facilities and conveyance systems) for conformance with the City's policy and stormwater standards at the time of the development. The study focused on the Elizabeth Gardens and Southbrook on the Green developments.

The study (Appendix "C" of Report PED12182(a)/PW13016) concluded the storm drainage system design approach is consistent with the design criteria of the day (pre-2007). It should be noted that the affected homes are not serviced with foundation drains connecting to the storm sewers. The report also further recommended the distribution of a questionnaire to the affected area residents and conducting in-house inspections to better understand the flooding mechanisms from the July 22, 2012 storm.

CORRECTIVE ACTION

Additional study identified in Recommendation (c) of Report PED12182(a)/PW13016 to establish the relationship between the storm run-off and the municipal storm and sanitary conveyance systems and hydraulic analyses of the minor system and major overland flow systems.

Questionnaire and In-Home Inspections

AMEC's report recommended the distribution of a questionnaire to the affected area residents and conducting in-house inspections to better understand the flooding mechanisms from the July 22, 2012 storm. The 337 questionnaires were mailed out to residents in Binbrook to obtain information on how they were impacted along with a request for a follow-up site inspection.

Of the 337 questionnaire mail outs in Binbrook, 36 questionnaires were returned (less than 11% return rate) with 23 agreeing to a follow-up inspection. Of these 23, 16 were ultimately coordinated for an inspection. The remaining seven uninspected homes either did not reply to direct correspondence or it was determined that a sufficient level of information had been gathered through previous inspections in those areas that an inspection was not required.

Through the follow-up inspections, AMEC's report, attached as Appendix "D" of Report PED12182 (a)/PW13016, concludes:

(a) Majority of homes have a sump pump connection that discharges to grade or discharges to the gravity storm connection over the foundation;

(b) The majority of residents east of Regional Road 56 that experienced flooding was associated with the back-up of the municipal sanitary sewer system; and,

(c) The majority of residents west of Regional Road 56 that experienced flooding was a result of an overwhelming amount of water entering the sump pits.

CORRECTIVE ACTION

The report recommends the development of a municipal standard for sump pump discharge connections to include a secondary relief, specify minimum rating for the pump, and a back-up power unit.

A secondary relief on the sump pump line will allow for the surface discharge in the event the capacity of the gravity connection is reached. A battery back-up power for sump pumps will allow continual operation of the pump should they experience a power outage during a storm.

This has been implemented in new developments in areas where the groundwater level is high. The City is currently updating the Engineering Guidelines and will be incorporating these recommendations as part of the update to be implemented City wide.

OTHER DRAINAGE IMPROVEMENTS

Revised Grading Policy

The recently approved revised Grading Policy incorporates improved surface drainage by requiring an appropriate overland flow route and minimizing ponding depths on rear yard catch basins.

Stormwater Infrastructure Design Criteria

Since 2007, new stormwater infrastructure design criteria requires a continuous overland flow route on roadways with no ponding on arterial and no more than 150 mm on local roads. It also requires channel designs and structures crossing the creek to a higher standard to be able to convey the greater of the Regulatory Storm or Hurricane Hazel event.

Lot Grading - Maintenance

Poor lot grading can also be a cause of basement flooding. Over time the ground may settle and cause the ground to slope towards the house or openings may develop in the soil or adjacent to the foundation, resulting in surface run-off to travel towards the house, down the outside foundation wall and enter the weeping tile surrounding the home. Sump pumps can become overwhelmed with extra water due to poor grading.

CORRECTIVE ACTION

It is important to educate homeowners on lot grading and their home drainage system (ie. weeping tiles, downspouts, sump pit/pump, etc.) as they can help protect against flooding through proper maintenance of grading of the lot.

ALTERNATIVES FOR CONSIDERATION

(include Financial, Staffing, Legal and Policy Implications and pros and cons for each alternative)

The alternative for consideration is not to approve the recommendations in Report PED12182 (a)/PW13016 and this is not recommended for the following reasons:

(a) the technical analysis undertaken by staff including a peer review by a Consulting Engineer has identified remedial measures to address the flooding in Binbrook;

(b) in its final analysis, staff is satisfied that there is sufficient sanitary sewer capacity within the existing system to accommodate future developments in Binbrook; and,

(c) that given there is sufficient capacity available to accommodate future developments there is no servicing constraint preventing the approval of the “Binbrook Heights Addition” subdivision.

ALIGNMENT TO THE 2012 – 2015 STRATEGIC PLAN:

Strategic Priority #1
A Prosperous & Healthy Community

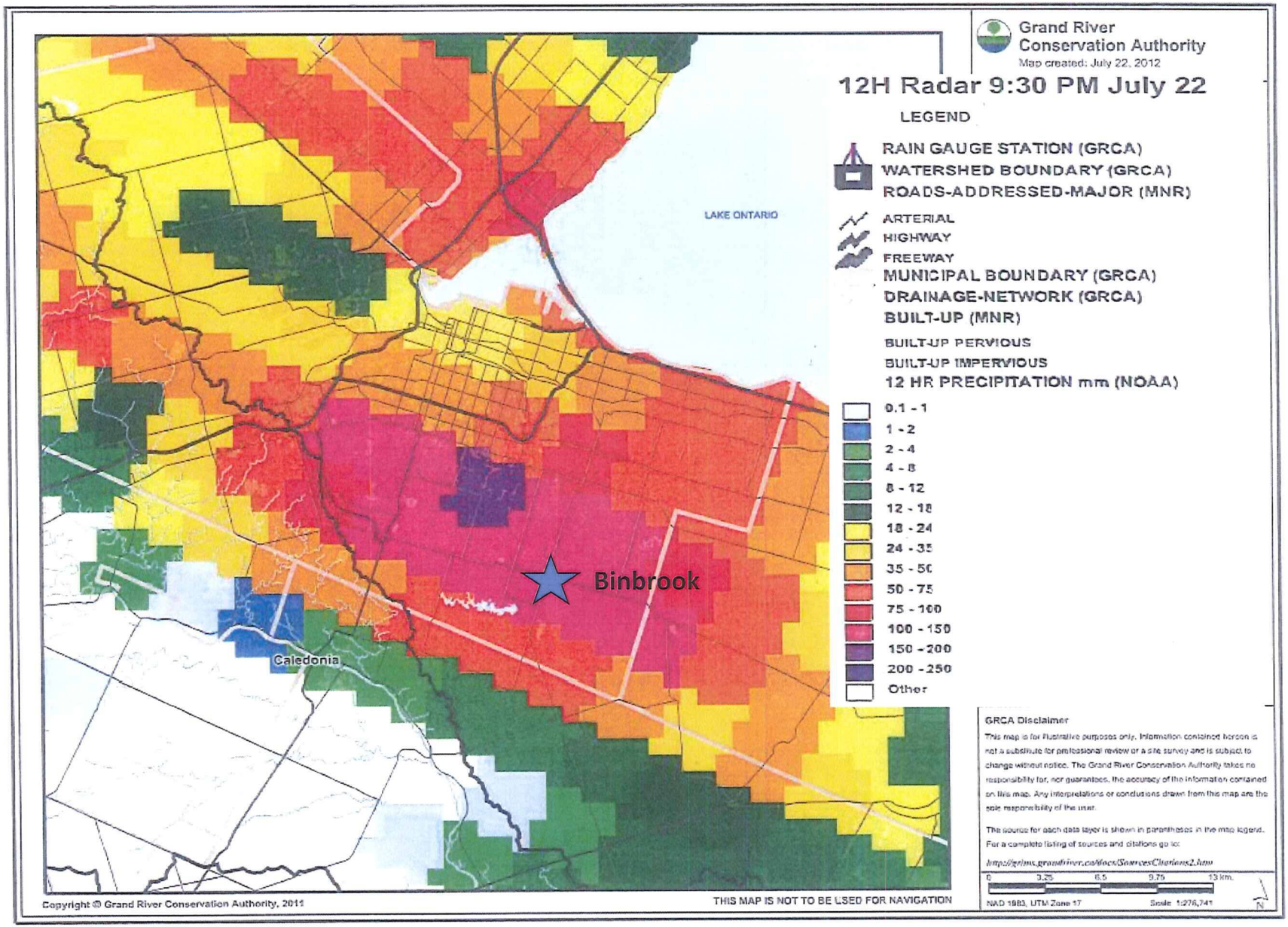
WE enhance our image, economy and well-being by demonstrating that Hamilton is a great place to live, work, play and learn.

Strategic Objective
1.2 Continue to prioritize capital infrastructure projects to support managed growth and optimize community benefit.

APPENDICES / SCHEDULES

- Appendix "A": Rainfall Gauge Map, National Oceanic and Atmospheric Administration (NOAA)
- Appendix "B": City of Hamilton Residents Questionnaire related to Storm Event of July 22, 2012
- Appendix "C": Peer Review of Storm Drainage Design for Elizabeth Gardens Phase 1, AMEC (September 22, 2012)
- Appendix "D": Report on Binbrook and Stoney Creek Mountain Survey and In-House Inspections related to July 22, 2012 Storm, AMEC (March 2013)

SYL/CG:mh


Grand River
Conservation Authority
Map created: July 22, 2012
12H Radar 9:30 PM July 22
LEGEND
RAIN GAUGE STATION (GRCA)
WATERSHED BOUNDARY (GRCA)
ROADS-ADDRESSED-MAJOR (MNR)
ARTERIAL
HIGHWAY
FREEWAY
MUNICIPAL BOUNDARY (GRCA)
DRAINAGE-NETWORK (GRCA)
BUILT-UP (MNR)
BUILT-UP PERVIOUS
BUILT-UP IMPERVIOUS
12 HR PRECIPITATION mm (NOAA)
0.1 - 1
1 - 2
2 - 4
4 - 8
8 - 12
12 - 18
18 - 24
24 - 35
35 - 50
50 - 75
75 - 100
100 - 150
150 - 200
200 - 250
Other
LAKE ONTARIO
Binbrook
Caledonia
GRCA Disclaimer
This map is for illustrative purposes only. Information contained hereon is not a substitute for professional review or a site survey and is subject to change without notice. The Grand River Conservation Authority takes no responsibility for, nor guarantees, the accuracy of the information contained on this map. Any interpretations or conclusions drawn from this map are the sole responsibility of the user.
The source for each data layer is shown in parentheses in the map legend. For a complete listing of sources and citations go to:
http://grims.grandriver.ca/docs/SourcesCitations2.htm
0 3.25 6.5 9.75 13 km.
NAD 1983, UTM Zone 17
Scale: 1:276,741
Copyright © Grand River Conservation Authority, 2011
THIS MAP IS NOT TO BE USED FOR NAVIGATION

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CITY OF HAMILTON RESIDENTS QUESTIONNAIRE
RELATED TO STORM EVENT OF JULY 22, 2012

Last Name: _____

First Name: _____

Street # and Name _____

Postal Code: _____ Phone Number: _____

How long have you lived at this address: _____

This questionnaire is intended to assist the City in better understanding the type and characteristics of flooding which occurred July 22, 2012. This information can then be used to develop solutions.

If you experienced interior flooding to your dwelling, please complete Section 1 and 3 only; if you experienced flooding outside on your property, complete Sections 2 and 3 only; in the event you had both interior and exterior flooding, complete all sections.

SECTION 1 – INTERIOR FLOODING QUESTIONS (mark appropriate answers with an X)

(1) Was the water in your home?
- a) Clear ___
- b) Brown/Dirty ___
- c) Other: (describe) _____

(2) Where did the observed flooding occur?
- a) Basement ___
- b) Main Floor ___
- c) Second Floor ___

(3) Where did the water originate from?
- a) Floor Drain ___
- b) Bottom of foundation wall ___
- c) Through openings (windows, doors, sump hole, etc.) ___
- d) Other: _____

(4) If flooding occurred in the basement, where in the basement did it occur?
- a) North Side ___
- b) East Side ___
- c) South Side ___
- d) West Side ___

(5) Have you experienced flooding within the home before?
- a) Yes ___
- b) No ___

When? (state all known dates) _____

If “Yes”, was it similar to the flooding experienced as described above in Questions 1–4?
- a) Yes ___
- b) No ___

Please describe: _____

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SECTION 2 – EXTERIOR FLOODING QUESTIONS

(6) Where did the observed flooding occur?

a) Street / Front Yard ___
b) Side Yard (i.e. between your property and your neighbours) ___
c) Rear Yard ___
d) Abutting Creek/Watercourse/Stormwater Pond ___

Complete the following ONLY IF you answered "**Street / Front Yard**".

(7) What best describes the flooding observed on the street in front of your property?

a) I could clearly see the street curb. ___
b) I couldn't clearly see the street curb, but I could clearly see the sidewalk. ___
c) I couldn't clearly see the sidewalk (i.e. the flooding was beyond the sidewalk) ___

Complete the following ONLY IF you answered "**Side Yard**".

(8) Have you installed a walkway along the side of your house?
If Yes, is it within 1.0 m (3 ft) of the property line?

a) Yes ___
b) No ___

Complete the following ONLY IF you answered "**Rear Yard**".

(9) Do you have a rear yard catch basin (i.e. grate/drain)?

a) Yes ___
b) No ___

If "Yes", do you know if the catch basin grate was free of debris (i.e. yard waste, leaves, dirt, trash) before the storm?

a) Yes ___
b) No ___

SECTION 3 – GENERAL

Have you ever conducted flood protection works inside or outside of your home? __ Yes __ No
If yes, please describe: _____

_____

_____

(10) Do you have a finished basement?

a) Yes ___
b) No ___

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(11) Do you have a sump pump?

a) Yes ___
b) No ___

If "Yes", what best describes the operation of your sump pump?

It runs…

a) Continuously ___
b) Intermittently ___
c) Rarely ___
d) Only when it rains ___

(12) Where does your sump pump discharge to? Please describe the location: _____

_____

a) Grass ___
b) Sewer ___
c) Unsure ___

(13) During the storm on July 22, 2012, did you experience a power outage?

a) Yes ___
b) No ___

If you have any photos or videos of the flooding that you wish to share, please contact the City Representative or Consultant.

Your participation in this survey is greatly appreciated.

Please note that you may be contacted by City and/or AMEC representatives for a follow up inspection to document and confirm details of your property and the flooding experienced as reported within this questionnaire. This activity will require access to the interior and exterior of your home and property. Please find attached a "Voluntary Follow-Up Inspection Form". By filling out this form, you are voluntarily granting permission for, or declining, a follow-up inspection. Once again, this information would only be used to develop a better understanding of the flood and to assist in developing a solution.

We thank you for your assistance. If you have any questions the following persons can be contacted for further information.

City Representative
Sally Yong-Lee, P.Eng.
Manager of Infrastructure Planning
City of Hamilton, City Hall
71 Main Street West, 6th Floor
Hamilton, ON
(905) 546-2424 Ex. 1428
Email: Sally.Yong-Lee@hamilton.ca

City Consultant
Ryan Moore, P.Eng.
Design Engineer
AMEC Environment & Infrastructure
3215 North Service Road
Burlington, ON
(905)-335-2353 Ex. 1293
Email: Ryan.Moore@amec.com

Hamilton

VOLUNTARY FOLLOW-UP INSPECTION FORM

To provide the City a better understanding of the factors related to the flooding of July 22, 2012, the City has chosen to undertake follow-up inspections to further document key information inside and outside affected homes.

Please mark your answer to the following question with an X.

__ I volunteer to the follow-up site inspection
__ I decline the follow-up site inspection

The site inspection will involve the following:

Photo documentation of:

- House front
- Side yards
- Rear yards
- Downspouts
- Sump pump outlet
- Interior part of the home where flooding occurred
- Basement sump pump

If you have volunteered to the Follow-up Inspection Program, when is the best time to arrange a visit?

__ Morning (7 a.m. to 11 a.m.)
__ Mid-day (11 a.m. to 4 p.m.)
__ Evening (4 p.m. to 7 p.m.)

What is the best number or e-mail address to contact you at to arrange a date and time?

Phone: _____ Email: _____

Your co-operation is greatly appreciated; the *Questionnaire* and *Voluntary Follow-up Inspection Form* can be returned by mail, email, or simply by contacting the City or AMEC representative.

City Representative
Sally Yong-Lee, P.Eng.
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Email: Ryan.Moore@amec.com

September 20, 2012
Our File: TP112123-10

City of Hamilton
Planning & Economic Development
71 Main Street West, 5th Floor
Hamilton ON L8P 4Y5

ATTENTION: Monir Moniruzzaman, P.Eng.
Project Manager, Development Engineering Dept.

Dear Sir:

RE: Peer Review of Storm Drainage Design for Elizabeth Gardens Phase 1, Community of Binbrook, City of Hamilton

The City of Hamilton has retained AMEC Environment and Infrastructure to conduct a peer review of the drainage design for Elizabeth Gardens Phase 1 specifically and related (but not detailed) aspects of Southbrook on the Green. The scope has focused on a review of stormwater infrastructure (i.e. stormwater management facilities and conveyance systems) ensuring conformance with the City's policy and stormwater standards of the day.

1. Background

A Stormwater Management Master Plan was prepared by A.J. Clarke & Associates Ltd. in 2000 (ref. "Stormwater Management Report, Binbrook Urban Settlement Area and Southbrook on the Green", A.J. Clarke, (June 2000, Revised November 2000) (BUSA Stormwater Management Report)). In support of the development of the Binbrook Urban Settlement Area (BUSA), the Stormwater Management Master Plan outlines the stormwater policy of the day, existing constraints within the developable lands and provides recommendations on engineering design in support of future development. The report also provides engineering recommendations for the design of stormwater infrastructure in support of the proposed Southbrook on the Green subdivision.

In June 2004, the City received a stormwater management report in support of Elizabeth Gardens, Phase 1 subdivision, prepared by Lamarre Consulting Group Inc. (ref. "Stormwater Management Report, Elizabeth Gardens, Phase 1", Lamarre Consulting Group Inc. (June 2004)). The stormwater management report cited the Binbrook Urban Settlement Area, Stormwater Management Report (A. J. Clarke, 2000), as a basis for the governing criteria for of the engineering stormwater management design.

On July 22, 2012, a significant rainfall event occurred within the City of Hamilton. The areas which were impacted most significantly were Glanbrook, upper Stoney Creek, and Binbrook, all

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of which experienced significant flooding. The City received numerous complaints in regards to the storm event for locally affected residents.

As a result of the July 22, 2012 storm event and associated flood complaints, the City has commissioned this Peer Review investigation to better understand the events which took place on July 22, 2012, which lead to AMEC being retained for professional consultation services.

In support of this Peer Review the following documents have been provided by the City and reviewed by AMEC:

Policy & Standards

- Township of Glanbrook Municipal Engineering Standards, (March 1987)
- City of Hamilton Storm Drainage Policy, Philips Engineering Ltd. (May 2004)
- City of Hamilton Engineering Guidelines, A.J. Clarke (June 19, 2006)
- Stormwater Criteria and Guidelines for Stormwater Infrastructure Design, Philips Engineering Ltd. (September 2007)

Stormwater Management Reports

- "Stormwater Management Report, Binbrook Urban Settlement Area and Southbrook on the Green", A.J. Clarke, (June 2000, Revised November 2000) (BUSA Stormwater Management Report)
- "Stormwater Management Report, Elizabeth Gardens, Phase 1", Lamarre Consulting Group Inc. (June 2004)
- "Stormwater Management Report, Elizabeth Gardens, Phase 3", Lamarre Consulting Group Inc. (November 2005)

Engineering Drawings

- Elizabeth Gardens, Phase 1, S. Llewellyn and Associates
- Elizabeth Gardens, Phase 3, S. Llewellyn and Associates
- Southbrook on the Green, Phase 1, 2 ,3 & 4, S. Llewellyn & Associates

General Data/Information

- Historical Rainfall Gauge Data, City of Hamilton, 2012
- Rainfall Gauge Map, City of Hamilton
- Map of Resident Complaints on July 22, 2012, City of Hamilton
- Residents Photos/Video documentation of rainfall event, City of Hamilton
- Aerial Orthographic Images of Binbrook Urban Settlement Area, City of Hamilton
- GRCA GRIM Mapping, Total Rainfall Depth, AMEC (July 2012)

2. Comparative Assessment of Design Elements

AMEC has carried out a comprehensive review of the approved Elizabeth Gardens Phase 1 stormwater management report. The stormwater management methodology used for the assessment and mitigation of development impacts is considered consistent with the standards of the day, in that, stormwater management controls for water quantity and quality were designed and implemented prior to surface runoff discharging from the development site to the receiving watercourse.

(a) Water Quality Control

As discussed within the Elizabeth Gardens Phase 1 Stormwater Managment Report (2004), the stormwater management facility has been designed based on the guidelines presented in the "Stormwater Management Practice Planning and Design Manual" 1994. However, the original Stormwater Management Master Plan (A. J. Clarke, 2000) refers to the Stormwater Management Practice, Planning and Design Manual, 1994. The MOE released a revised document titled "Stormwater Management Planning and Design Manual" in March 2003, which superseded the previous design manual. However, the wet pond design parameters are unchanged between the March 2003 and 1994 documents. A review of the calculations provided within the text of the Elizabeth Gardens Phase 1 Stormwater Management Report for the permanent pool and extended detention is considered to satisfy the requirements of the MOE guideline document. However, the following supporting calculations were not provided:

- Forebay sizing
- Dispersion length
- Settling length
- Deep zone bottom width
- Sediment accumulation
- Removal efficiency

As noted in the following Section (b), Water Quality Controls, the level of impervious coverage observed versus the planned imperviousness for the Elizabeth Gardens Phase 1 is significantly greater. Therefore, the constructed water quality treatment system is considered to be inadequately designed to effectively t5reat surface runoff for the contributing drainage area.

(b) Water Quantity Controls

According to available documentation, quantity control of stormwater runoff was designed and achieved by implementing a stormwater quantity control facility prior to the point of discharge to the receiver. The stormwater management facility was designed to detain post-development peak flows to pre-development rates. The SWMHYMO (Ver. 4.02) model was used to model two hydrologic conditions: (1) Existing land use conditions, (2) Future Controlled land use conditions.

Rainfall parameters applied in the hydrologic modeling are consistent with those parameters prescribed by the City of Hamilton intensity-duration-frequency (IDF) rainfall curves, at the time (ref. Table 2.1).

Table 2.1. – City of Hamilton IDF Parameters

IDF-Parameter	Rainfall Return Frequency Events (Years)					
	2	5	10	25	50	100
A	646	1049.5	1343.7	1719.5	1954.8	2317.4
B	6.0	8.0	9.0	10.0	10.0	11.0
C	0.781	0.803	0.814	0.823	0.836	0.836

The hydrologic modeling parameters were obtained from the hydrologic model output provided in the Appendix of the approved stormwater management report. The modeling parameters have been compared against those parameters established by the BUSA Stormwater Management Master Plan (A. J. Clarke, 2000), since the Elizabeth Gardens Phase 1 Stormwater Management Report referenced this document as establishing the framework for these developable lands (ref. Table 2.2).

Table 2.2. – Hydrologic Modeling Parameters

Land Use Condition	Pervious Surfaces			Impervious Surfaces				
	SCS Curve Number (CN)	Initial Abstraction, Ia (mm)	Manning's Roughness	SCS Curve Number (CN)	Initial Abstraction, Ia (mm)	Manning's Roughness	Imperviousness	
							% Directly Connected (XIMP)	% Total, (TIMP)
Binbrook Urban Settlement Area, MIDUSS 98 (A. J. Clarke, 2000)								
Existing	70	10.9	0.25	98	0.5	0.015	-	-
Future	70	5	0.25	98	0.5	0.015	-	-
Elizabeth Gardens, Phase 1 Development, SWMHYMO (Lamarre, 2004)								
Existing	74	10	-	98	-	-	-	-
Future	70	5	0.25	-	1.5	0.013	15	40

The modeling parameters applied in the Elizabeth Gardens SWMHYMO model are largely consistent with the modeling parameters established by the BUSA Stormwater Management Master Plan. Marginal differences occur between the SCS CN (Soil Conservation Society Curve Number) value, initial abstraction for pervious/impervious surfaces, and roughness coefficient for impervious surfaces. Although there are marginal differences between the modeling parameters, the values applied within the Elizabeth Gardens modeling are considered consistent with anticipated values based on the existing and future land use conditions, with the exception of the SCS CN value and imperviousness.

Typical hydrologic modeling convention is that the CN value is maintained or increased relative to the existing land use condition, unless soil amendments are proposed. The effect of reducing

the CN-value for the future land use model may impact the amount of storage required to achieve control of future land use peak flows; higher CN values provide greater runoff volumes and peak flow rates as the surface becomes more impervious to infiltration. The inference would be that pervious surfaces (lawns) would have less runoff potential than pre-development surfaces (agricultural / fallow), which could occur but is atypical and less conservative.

The conveyance of surface water runoff and the quantity and quality control of runoff were designed based on a total imperviousness of 40%, with a directly connected impervious ratio of 0.375 resulting in an overall directly connected imperviousness of 15%. Using the aerial imagery provided by the City, the imperviousness of the site has been estimated to be 55%, with a directly connected ratio of 0.53, resulting in an overall directly connected imperviousness of 29%. Therefore, the sizing of quantity and quality control systems and storm conveyance systems are considered undersized based on the characteristics of the contributing drainage area which is an emerging trend observed by City staff across its developing areas, including most recently the North Waterdown Master Drainage Plan Update.

(c) Storm Sewer and Major Overland Flow Route Design

AMEC has reviewed the design of the storm sewers for the Elizabeth Gardens Phase 1 development. The storm sewer design approach is considered consistent with design criteria of the day, specifically the Township of Glanbrook Municipal Engineering Standards (1987). In accordance with engineering standards, conveyance of runoff is to be provided by a minor and major system. The minor system, typically a piped storm sewer, is required to convey the 5 year storm (i.e. no surface ponding) and a major, overland system, designed to convey the 100 year event. Parameters for the basis of design are based on the IDF-parameters from the Mount Hope Airport rain gauge station. Table 2.3 summarizes the design parameters and provides the comparison to the current design parameters.

Table 2.3. – Pipe Sizing Parameters

Parameters	Glanbrook (1987)	City of Hamilton (2007)
IDF-Parameters		
A	904	1049
B	5	8
C	0.788	0.803
Inlet Time, t (mins)	15 min	10 mins
Pipe Capacity Limits		
Maximum Flow Capacity (Design)	100%	85%
Pipe Velocity (m/s)		
Minimum	0.8	0.9
Maximum	4.6	3.65

As expected, the design parameters are not consistent between the Glanbrook 1987 municipal standard in comparison to the City of Hamilton's (2007) current design standard. The notable difference between the two standards is the IDF-parameters; these parameters were updated as a part of the 2004 City of Hamilton Storm Drainage Policy, and were generated from a

greater range of historical rainfall data, including years from 1987 - 2000. A comparative assessment was carried out to assess the impact to peak flow estimation. It was concluded that the revised (2007) values would result in 17% higher peak flow than using the 1987 criteria, suggesting slightly smaller sewers than would be designed today. A sample calculation is provided in Attachment 1. Although the peak flows would be affected by the IDF relationship, this does not directly impact the sizing of the storm sewer system, as the pipe slope and total conveyance capacity require consideration.

Neither a hydraulic gradeline assessment of the storm sewer system, nor major overland flow route calculations were received by the City, as a part of the Elizabeth Gardens Phase 1 Stormwater Management Report. It should be noted that the residential lots are not serviced with foundation drainage leads to the storm sewer, hence diminishing the need for a hydraulic gradeline analysis. Rather, each lot is serviced by a sump pump which discharges to grade. Evidence of this discharge to grade was observed on a site walk (August 9, 2012).

Nevertheless, a review of the major overland conveyance system has been carried out. The major overland flow route is comprised of the municipal right-of-way graded with a saw-tooth pattern due to very flat local grades. Based upon a review of the engineering drawings, it has been determined that there are several areas of concern where the major overland system does not have sufficient gradient between the highpoints in the roadway, (in some cases it is flat) to effectively drain without ponding. As a result, surface runoff captured between the highpoints within these areas will remain ponded until such time there is capacity within the minor system to allow it to safely drawdown. Therefore, the major overland conveyance system is considered in some locations to be inadequately designed to effectively convey major storm events.

3. Storm Event Review

The City of Hamilton, on July 22, 2012, experienced a significant storm event which was centralized over the south-east portion of the City's regional boundary, encompassing the areas of Glanbrook, Binbrook, and Stoney Creek.

(a) Rainfall

Rainfall data has been obtained from four (4) of the area's rain gauge stations nearest to Binbrook. Table 3.1. below summarizes the rainfall totals obtained from the collected data.

Table 3.1. Rainfall Summary

Gauge Station Location	Identifier Name	Distance from Binbrook (km)	Storm Duration (hrs)	Total Rainfall Depth (mm)
Highland Road & Second Road West	HD-007	7.5	2.75	140.4
Rymal Road & Upper Wellington	CALDER 001	11.2	2.75	66.6
Stone Church & Upper Ottawa	CALDER 002	9.7	3.25	169.4
Mount Hope Airport	HC-019	10.5	3.17	92.8

Rainfall depths have been compared against radar precipitation totals obtained through the Grand River Conservation Authority's, Grand River Information Network (GRIN) (ref. Attachment 2). The source of the data is provided by the National Oceanic and Atmospheric Administration (NOAA) located in the United States.

A frequency assessment of the observed rainfall data has been carried out, in order to estimate the return period of the July 22, 2012 rainfall event. The results of the assessment are provided in Table 3.2. Supporting calculations are provided in Attachment 3.

Table 3.2. Rainfall Frequency Assessment Summary

Gauge Station Location	Identifier Name	3 Hour Rainfall Depth Observed (mm)	3 Hour Return Period Estimate (Years)
Highland Road & Second Road West	HD-007	140.4	+1,000*
Rymal Road & Upper Wellington	CALDER 001	66.6	23*
Stone Church & Upper Ottawa	CALDER 002	102.8	329*
Mount Hope Airport	HC-019	92.6	155*

* - based on extrapolated values

In comparison, the theoretical 100 year rainfall depth over 3 hours, based on the IDF parameters from the City of Hamilton Storm Drainage Policy (based on historical rainfall from Mount Hope rainfall gauge station), is 86.1 mm.

(b) *Observed Flooding*

Observed accounts of the flooding as a result of the July 22, 2012 storm have been provided to the City in the form of photos and videos taken by local residents. Additionally, residents have contacted the City through the City's flood reporting phone-in centre.

The flooding within in the Elizabeth Gardens Phase 1 development was comprised of surface flooding (streets and overland routes) and residential basement flooding. In one resident report, residential basement flooding was described to be originating from where the wall of the basement meets the basement floor, and was described as being colourless; consistent with surface rainwater. The water entered at the joint, where the foundation walls of the building and basement floor rest upon the footings for the building (commonly referred to as a 'cold joint'). Located on the exterior side of the wall is the weeper drain for the foundation. This type of flooding mechanism is typical when the weeper and sump pump system discharge capacity is exceeded by the inflow of surface water. No flooding was reported as coming through surface openings (i.e. windows and doors).

Flooding within Binbrook was also observed within the Southbrook on the Green residential development and was similarly comprised of surface flooding and residential basement flooding. The source of the residential basement flooding was, in some instances, reported to be originating from the floor drains and was described as being brown and black; consistent with

sanitary sewer system surcharge. Surface flooding of the municipal right-of-way, conveyance channel and stormwater management facility was also observed.

In addition to the flooding reported by the local residents, the City of Hamilton maintains flow monitors on the sanitary sewer system, for those pipes discharging to the sanitary pump station, located a Southbrook Drive and Regional Road 56. It was noted that the sanitary sewer system responded rapidly to the storm event, with the inlet flow exceeding the capacity of the sanitary pump station. It was also noted that the flow monitor for the sanitary flows discharging from the Southbrook on the Green flowing within Southbrook Drive, reported reverse flow within the pipe. As observed by residents within the Southbrook on the Green subdivision, basement floor drains and basement showers were reportedly backed-up, which is consistent with the reverse flow and surcharged condition within the sanitary sewer system.

The primary conveyance channel is located between Regional Road 56 and Southbrook Drive. According to Figure 6 ("Schematic of Site: Future (Developed) Conditions") (BUSA, A. J. Clarke 2000), the channel conveys surface runoff from 150.8 ha of developed lands to the west of Regional Road 56. The water surface elevation within the channel, observed immediately upstream of the 2.4 m x 1.5 m twin-cell culvert at Southbrook Drive, was at the limit of the channel block, suggesting a top width of 25 m (+/-). Furthermore, the water surface elevation located upstream of the 2.4 m x 1.5 m twin-cell culvert at Southbrook Drive was marginally higher than the top of the culvert, suggesting a geodetic water surface elevation of 206.0 m (+/-), based on the Engineering design drawings (ref. Dwg.K-00-046-6, A. J. Clarke, June 2000), which corresponds with the geodetic elevation at the property limits of the channel. Stormwater Management Facility No. 5, located downstream of the Southbrook Drive culvert crossing, was observed to be inundated with surface runoff. The water surface elevation at the inlet of the two water quality facilities, 5A and 5B, was observed to be marginally higher than the inlet headwall, suggesting a geodetic water surface elevation of 204.75 m (+/-). The field visit carried out on August 9, 2012, confirmed that the emergency spillways for both water quality facilities were activated, as 'fresh' debris was noted to be strewn across the spillway and suspended within the surrounding vegetation. Heavy staining from turbid water of the vegetation surrounding the stormwater management facility was also noted which corresponded with the height of the suspended debris. Based on the engineering drawings (ref. Dwg K-00-046-2 & K-00-046-5, A. J. Clarke, 2000), the elevations of the top of the two stormwater quality management facilities, 5A and 5B, is 204.50 m, and the 100 year water surface elevation is 204.57m. Therefore, the observations made in the field suggest that stormwater quality management facilities were overtopped by about 0.25 m (+/-) and that the storm event was greater than the 100 year design event which, is consistent with the event's magnitude (ref. Section 3). It should be noted that the Stormwater Management Master Plan prepared for the BUSA was completed without hydrologic modeling of the Regional Storm event. Therefore at this time, it is not conclusive if the July 22, 2012 storm event produced water surface elevations less than or greater than the Regional Storm event. In addition, the emergency spillway calculations typically prepared by the proponent were not included in the design information provided to us by the City. The eastern berm acted as spillway during the July 22, 2012 storm event. As a result, the berm has failed at different locations and the maintenance access has been washed out in various locations.

Furthermore, the City of Hamilton currently does not record the type of flooding (i.e. flooding mechanism), when recording phone complaints from residents. Therefore, the City does not have a complete record of the flooding mechanics for the July 22, 2012 event. The reported flooding within this report is based on observations submitted by individual residents to the City.

4. Conclusions

The following can be concluded based on the information collected and made available by the City for this Peer Review of the Elizabeth Gardens Phase 1 Development in Binbrook:

1) The end-of-pipe stormwater management wet pond and has been designed in accordance with the MOE guidelines providing 'Normal' water quality treatment of surface runoff.

2) Stormwater infrastructure has been designed using the appropriate parameters from the Guidelines and Standards of the day (Township of Glanbrook, Municipal Engineering Standards, March 1987).

3) The foundation drains for the subject development are connected into sump pumps hence there is *no* direct hydraulic connection between the storm sewers and the foundation drains. Notwithstanding, the storage volume associated with stormwater quantity and quality control systems (storm water management facilities), as well as the capacity of conveyance infrastructure (storm sewers and overland flow routes), are considered somewhat under -sized based on the characteristics (i.e. land cover) of the contributing drainage area. The measured lot coverage (% impervious) is higher than the assumptions used in the design (i.e. 60% coverage or more verses typical design assumption of about 40%); this is an emerging issue which has been identified in several Hamilton area developments. The anticipated results of this would be more frequent storm sewer surcharge and more frequent use of the major overland flow routes (roadways). Another possible impact could be higher downstream discharge to receiving streams.

4) Supporting documentation for the major overland flow route and hydraulic analysis of the storm sewer system were not provided for the subdivision development.

5) The Binbrook area received greater than 140 mm of rainfall over a 3 hour period and this magnitude of event is characterized to be greater than the depth of a 1 in 100 year design storm as per the City of Hamilton IDF parameters.

6) Significant flooding was observed by local residents with over 40 residents reporting flooding in the Binbrook area.

7) The observed flooding can be characterized in to three (3) mechanisms: (1) Foundation drainage related, (2) Sanitary (sewer) related, (3) Surface (major system) related.

City of Hamilton
September 20, 2012

5. Recommendations

The current Peer Review scope has focused on a review of existing information, comparison of standards and a field reconnaissance; no additional data has been collected nor any supplemental analysis conducted. As such, the following is recommended in order to better establish the cause(s) which resulted in the severe flooding experienced by the residents of Elizabeth Gardens and Southbrook on the Green developments:

1) Collect information on the specific flooding mechanisms from area residents, to establish a comprehensive record of the flood event of July 22, 2012.

2) Consider modifying the protocols associated with the City of Hamilton flood data collection process to include obtaining the "flooding mechanism" when retrieving information from property owners.

3) Carry out additional hydraulic study of the minor system and major overland flow system, as well as the open channel network to confirm performance.

4) Carry out an additional study to establish the relationship between storm runoff and the municipal storm and sanitary conveyance system, focused on potential inflow/infiltration with an emphasis on inflow due to reported rapid response as well as potential for cross connections.

Yours truly,

AMEC ENVIRONMENT & INFRASTRUCTURE
A division of AMEC Americas Limited

Per: Ron Scheckenberger, M.Eng., P.Eng.
Principal Consultant

Per: Ryan R. Moore, P.Eng.
Design Engineer

RM/RBS/ll

c.c. Sally Yong-Lee, City of Hamilton
Tony Sergi, City of Hamilton

ATTACHMENT 1

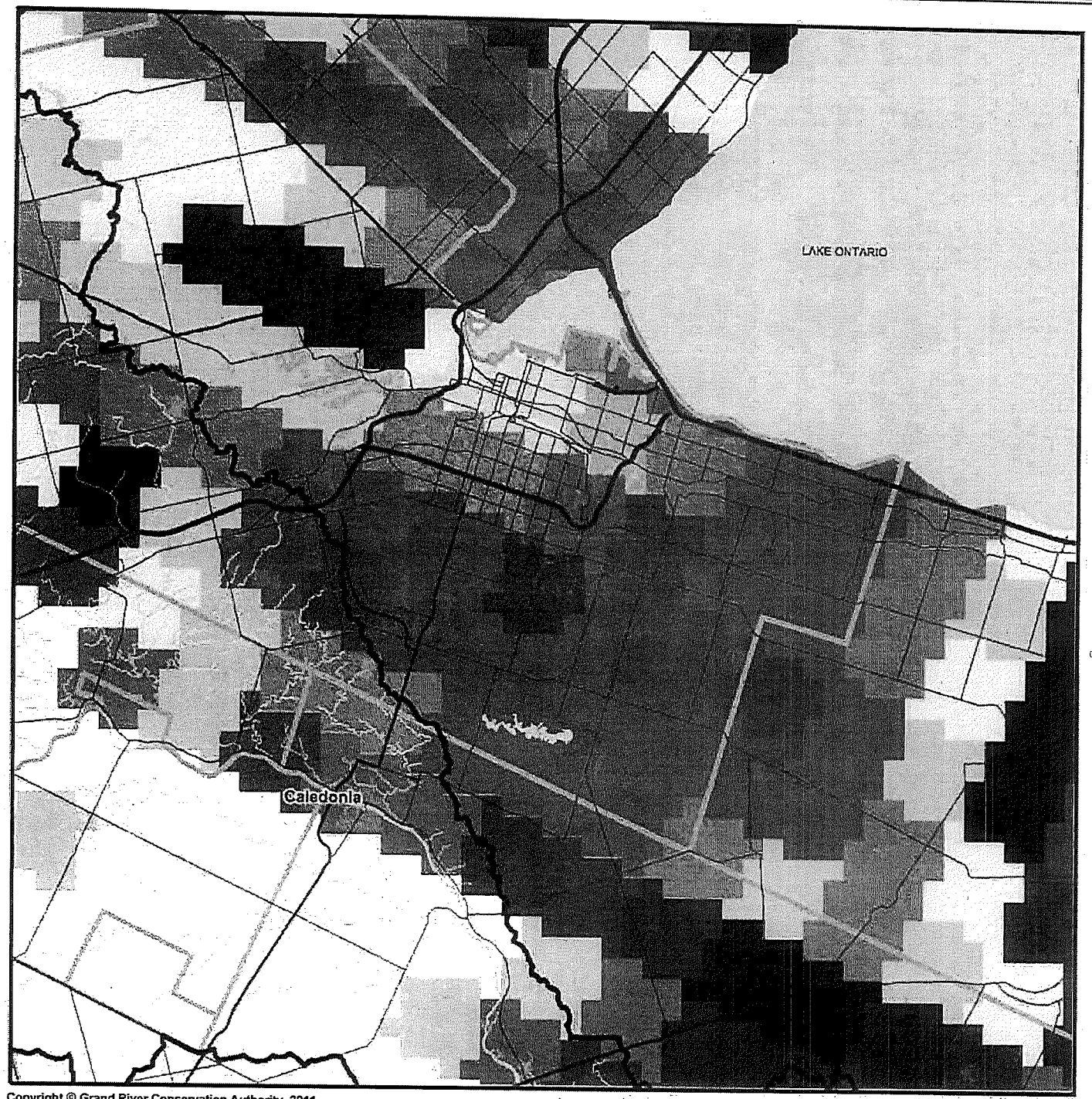
PEER REVIEW - STANDARDS COMPARISON

RUNOFF COEFFICIENT	Glanbrook Standards March 1987	City of Hamilton September 2007
Park	-	0.25
less than 4.0 ha	0.20	-
greater than 4.0 ha	0.25	-
Single Family	0.40	0.40
Semi Detached	0.50	0.50
Interlink	-	0.55
Quatroplex	-	0.60
Townhouse Apartments, Maisonettes	0.60	-
Medium Density	-	0.60
High Density	-	0.70
Institutional	0.70	0.75
Industrial and Central Business District	-	0.75
Commercial	0.90	0.90
Paved Areas	0.95	0.90 - 1.00

PIPE SIZING IDF-PARAMETERS	Glanbrook Standards March 1987 IDF-Parameters 5 - Year	City of Hamilton September 2007 IDF-Parameters 5 - Year	Glanbrook Standards March 1987 IDF-Parameters 100-Year	City of Hamilton September 2007 IDF-Parameters 100-Year
A	904	1049.5	1799	2317.4
B	5	8	5	11
C	0.788	0.803	0.81	0.803
t	15min	10 min	15min	10 min
	Intensity, I (mm/hr)	Intensity, I (mm/hr)	Intensity, I (mm/hr)	Intensity, I (mm/hr)
t = 15 min	85.3	103.0	158.9	201.0
Example Calculation	Q (cms)	Q (cms)	Q (cms)	Q (cms)
C = 0.40, A = 1.0 ha	**0.095**	**0.114**	**0.177**	**0.223**

PIPE PARAMETERS	Glanbrook Standards March 1987	City of Hamilton September 2007
Pipe Velocity		
Minimum, (m/s)	0.80	0.90
Maximum, (m/s)	4.60	3.65
Hydraulic Losses for Drop Transitions	Drop (m)	Drop (m)
0° (straight run)	0.03	grade of sewer
1° - 45°	0.03 - 0.07	0.03
90°	0.07	0.06

ATTACHMENT 2



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THIS MAP IS NOT TO BE USED FOR NAVIGATION

Grand River Conservation Authority
Map created: July 22, 2012

12H Radar 9:30 PM July 22

LEGEND

RAIN GAUGE STATION (GRCA)
WATERSHED BOUNDARY (GRCA)
ROADS-ADDRESSED-MAJOR (MNR)
ARTERIAL
HIGHWAY
FREEWAY
MUNICIPAL BOUNDARY (GRCA)
DRAINAGE-NETWORK (GRCA)
BUILT-UP (MNR)
BUILT-UP PERVIOUS
BUILT-UP IMPERVIOUS
12 HR PRECIPITATION mm (NOAA)

- 0.1 - 1
- 1 - 2
- 2 - 4
- 4 - 8
- 8 - 12
- 12 - 18
- 18 - 24
- 24 - 35
- 35 - 50
- 50 - 75
- 75 - 100
- 100 - 150
- 150 - 200
- 200 - 250
- Other

GRCA Disclaimer

This map is for illustrative purposes only. Information contained hereon is not a substitute for professional review or a site survey and is subject to change without notice. The Grand River Conservation Authority takes no responsibility for, nor guarantees, the accuracy of the information contained on this map. Any interpretations or conclusions drawn from this map are the sole responsibility of the user.

The source for each data layer is shown in parentheses in the map legend. For a complete listing of sources and citations go to:

http://grins.grandriver.ca/docs/SourcesCitations2.htm

0 3.25 6.5 9.75 13 km

NAD 1983, UTM Zone 17 Scale 1:276,741

N

Appendix "C" to Report PED12182(a)/PW13016
(Page 14 of 19)

ATTACHMENT 3

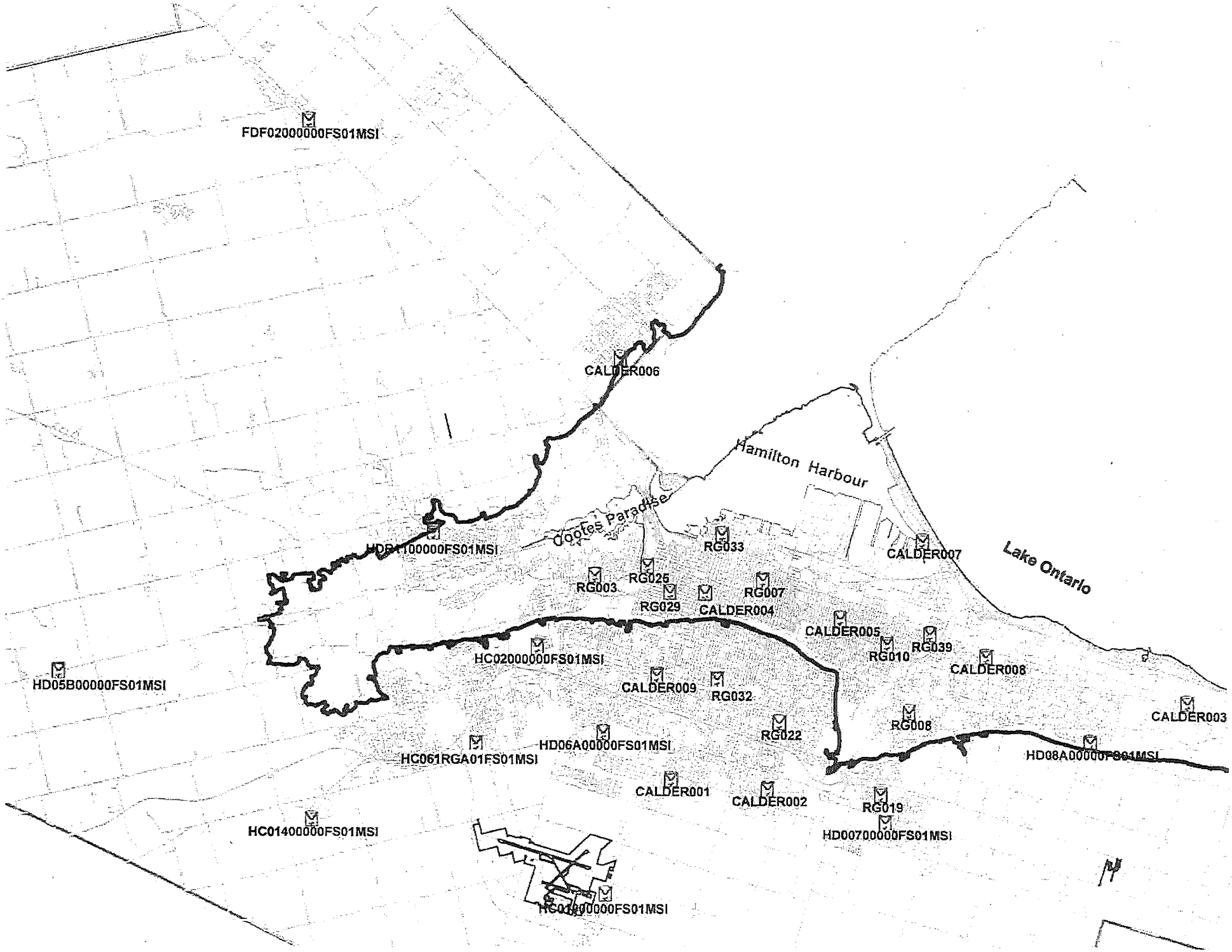
Gauge/Storm	Maximum Rainfall (mm) for Specified Duration						
	5 Minute	10 Minute	15 Minute	30 Minute	1 Hour	2 Hour	3 Hour
Calder001	8.8	15.2	21.4	31.6	49.0	63.6	66.6
Calder002	11.0	21.6	27.0	47.4	78.6	92.4	102.8
Highland Rd	21.0	29.4	39.8	53.8	92.6	115.2	137.4
Mt Hope	10.0	16.4	24.4	36.8	55.2	82.0	92.6
2	8.6	12.0	14.6	19.8	24.7	30.0	32.7
5	11.7	16.7	20.3	27.6	36.2	44.3	47.0
10	13.7	19.9	24.1	32.8	43.8	53.9	56.5
25	16.4	23.8	28.9	39.3	53.4	65.9	68.7
50	18.3	26.7	32.4	44.1	60.6	74.8	76.9
100	20.2	29.6	35.9	49.0	67.7	83.7	86.1

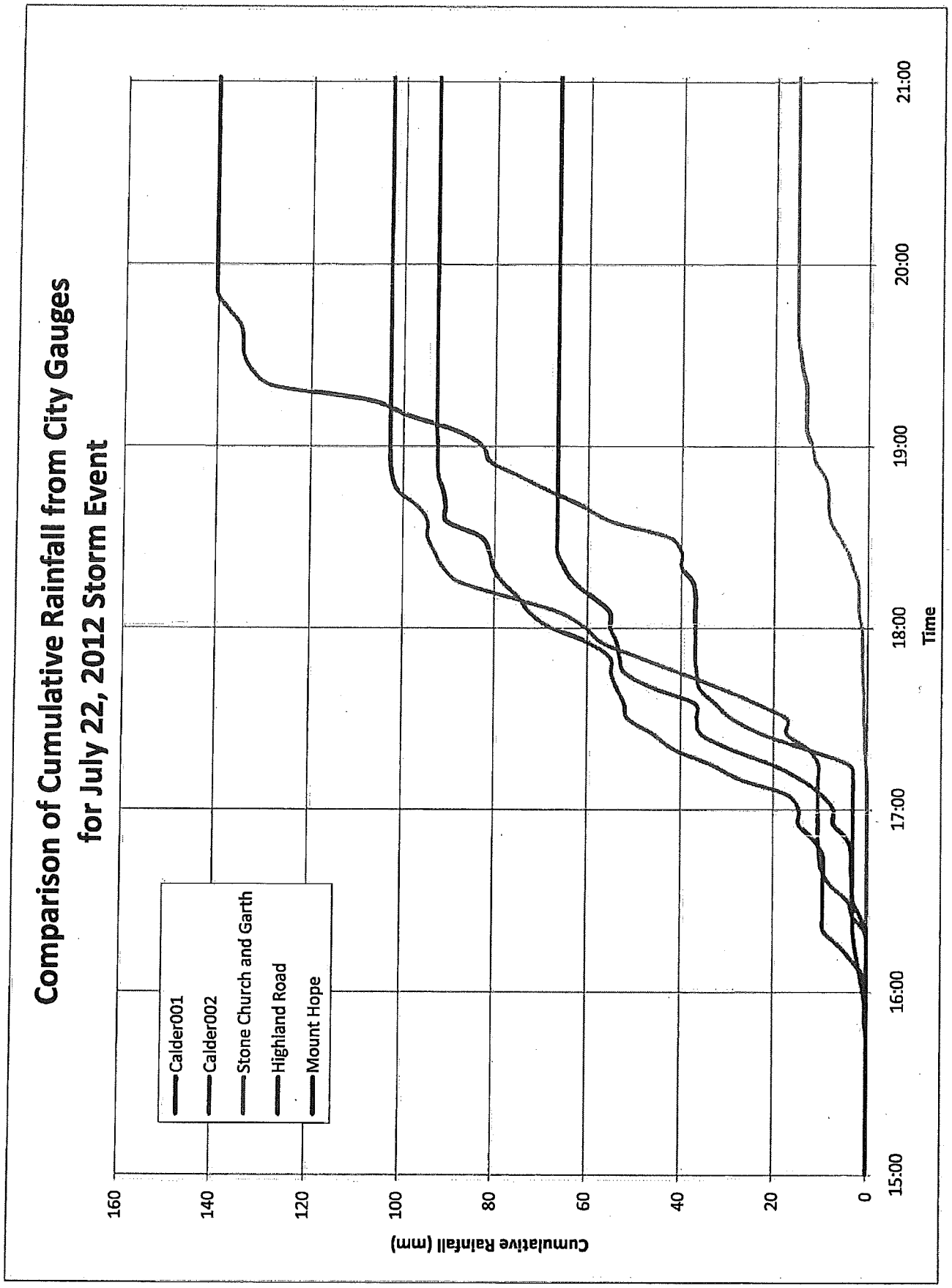
A	B	C	1H Using Equation	2H Using Equation
646.0	6.0	0.781	24.5	29.6
1049.5	8.0	0.803	35.4	42.7
1343.7	9.0	0.814	42.8	51.4
1719.5	10.0	0.823	52.1	62.6
1954.8	10.0	0.826	58.5	70.1
2317.4	11.0	0.836	65.7	78.7

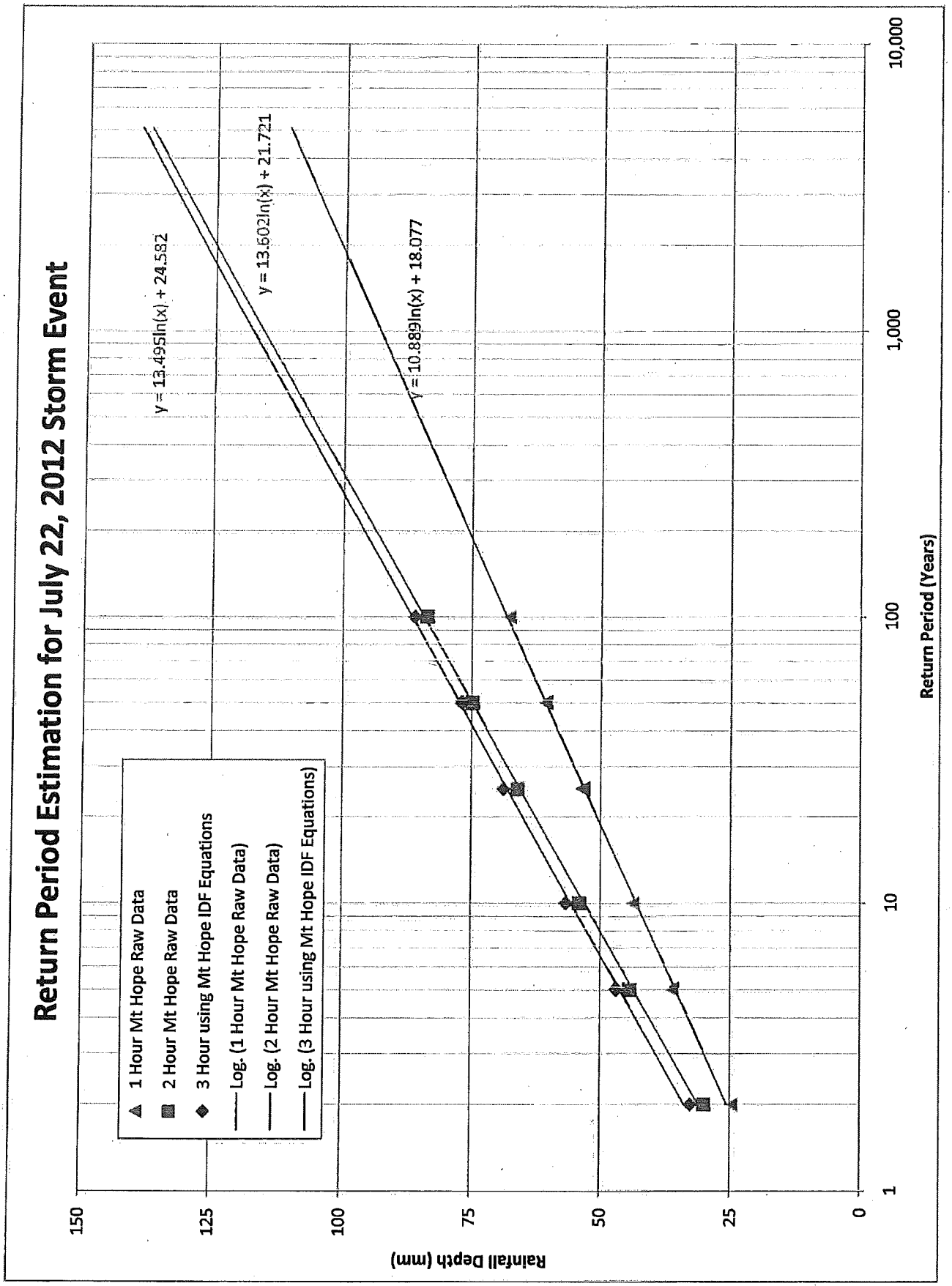
Rain gauge amounts and patterns don't really match the radar accumulation - higher amounts are seen where lesser accumulations shown on radar map and vice versa
Why does highland rd gauge show a different accumulation pattern than all the other gauges? Most of its volume is from second phase of storm which other gauges don't have

Return Period values for everything but 3 hour storm directly from frequency analysis results, 3H results based on IDF curve equation. This will give slight differences as curve is fit to raw data points
All IDF parameters and depths based off of Hamilton Mount Hope (as per January 2007 Criteria and Guidelines document - Appendix A)

Gauge	1 Hour Total (mm)	1 Hour Return Period Estimate (Years)	2 Hour Total (mm)	2 Hour Return Period Estimate (Years)	3 Hour Total (mm)	3 Hour Return Period Estimate (Years)
Calder001	49.0	17	63.6	22	66.6	23
Calder002	78.6	259	92.4	181	102.8	329
Highland Rd	92.6	938	115.2	965	137.4	4,273
Mt Hope	55.2	30	82.0	84	92.6	155


FDF02000000FS01MSI
CALDER006
Hamilton Harbour
Cootes Paradise
HDR1100000FS01MSI
RG033
CALDER007
Lake Ontario
RG003
RG025
RG029
CALDER004
RG007
CALDER005
RG039
RG010
HC02000000FS01MSI
CALDER008
HD05B00000FS01MSI
CALDER009
RG032
CALDER003
RG008
RG022
HD06A00000FS01MSI
HC061RGA01FS01MSI
HD08A00000FS01MSI
CALDER001
CALDER002
RG019
HC01400000FS01MSI
HD00700000FS01MSI
HC01800000FS01MSI


Comparison of Cumulative Rainfall from City Gauges
for July 22, 2012 Storm Event
Calder001
Calder002
Stone Church and Garth
Highland Road
Mount Hope
Cumulative Rainfall (mm)
0
20
40
60
80
100
120
140
160
15:00
16:00
17:00
18:00
19:00
20:00
21:00
Time


Return Period Estimation for July 22, 2012 Storm Event
y = 13.495ln(x) + 24.582
y = 13.602ln(x) + 21.721
y = 10.889ln(x) + 18.077
1 Hour Mt Hope Raw Data
2 Hour Mt Hope Raw Data
3 Hour using Mt Hope IDF Equations
Log. (1 Hour Mt Hope Raw Data)
Log. (2 Hour Mt Hope Raw Data)
Log. (3 Hour using Mt Hope IDF Equations)
Rainfall Depth (mm)
150
125
100
75
50
25
0
1
10
100
1,000
10,000
Return Period (Years)

REPORT ON BINBROOK AND STONEY CREEK MOUNTAIN SURVEY AND IN-HOUSE INSPECTIONS JULY 22, 2012 STORM

CITY OF HAMILTON

Submitted to:

City of Hamilton

Submitted by:
AMEC Environment & Infrastructure
a division of AMEC Americas Limited
3215 North Service Road
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March, 2013

Project No. TP112123

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1.0 BACKGROUND

On July 22, 2012 a significant rainfall event occurred in the City of Hamilton, focused on the Stoney Creek Mountain and the Binbrook area. Rainfall gauges in the affected areas recorded between 90 mm and 140 mm of rainfall over a 4-hour time period, during which time as many as 100 area residents reported flooding to the City.

In response to this significant rainfall and flooding event, the City initiated an Engineering Peer Review of the engineering design for the Elizabeth Gardens and Southbrook on the Green developments in Binbrook. This review was undertaken by AMEC and a report on the findings was provided to the City in September 2012.

Recommendations from the September 2012 report identified the need for the City to better define flooding mechanisms from the July 22, 2012 storm event, which AMEC suggested could be ascertained through the distribution of a questionnaire to the affected area residents and by conducting in-home inspections. The following provides a summary of the respective findings for the subject study areas along with associated recommendations, as well as a more detailed review of available design information for the Shady Glen development in Stoney Creek.

2.0 STUDY AREA

2.1 Binbrook

Development within the Binbrook urban boundary has intensified over the past decade with several new and current developments under construction, providing a mix of townhomes and single detached dwellings (ref. Drawing 1 – Binbrook Study Area). Dwellings typically are serviced by a direct connection through a sanitary lead and indirect storm sewer connection. The indirect storm sewer connection consists of a sump pump discharging either to (1) grade, or (2) to a gravity storm lead which is directly connected to the storm sewer system.

2.2 Stoney Creek Mountain

Development on the Stoney Creek Mountain, more specifically, the area bounded by Highland Road (north), First Road West (east), Rymal Road (south) and Second Road West (west), is characterized as an established neighbourhood with very few infill areas remaining (ref. Drawing 2 – Stoney Creek Study Area). Dwellings typically are serviced by a sanitary and storm lead directly connected to their respective sewers.

3.0 SCOPE AND METHODOLOGY

The scope of this study has been focused on the acquisition of information from residents impacted by the July 22, 2012 storm event by conducting a questionnaire along with follow-up in-house inspections.

In support of this assessment, the following documents have been provided by the City of Hamilton for review:

- City of Hamilton, Engineering Guidelines (2006);
- Township of Glanbrook, Municipal Engineering Standards (1987);
- City of Stoney Creek Stormwater Management Policy (1989);
- City of Stoney Creek Municipal Engineering Standards (1982);
- Stormwater Management Report, Binbrook Urban Settlement Area and Southbrook on the Green Development, (Revised November 2000);
- Elizabeth Gardens, Phase 3, Engineering Plans (May 2006);
- Functional Servicing and Stormwater Management Assessment, Shady Glen Development (June 1998); and
- Shady Glen, Phase 1-3, Engineering Plans (March 2000, August 2000, Sept. 2004).

The City of Hamilton conducted a mass mail-out to some 800 area residents split between Binbrook and Stoney Creek Mountain (i.e. the affected areas) with a questionnaire developed jointly by AMEC and City of Hamilton.

The purpose of the questionnaire was to gather data related to interior and exterior flooding observed by the individual residents during the July 22, 2012 storm event in order to better define the flooding mechanics and thereby provide an opportunity to develop a mitigation strategy. The questionnaire was divided into to three sections related to questions about, (1) interior flooding, (2) exterior flooding, and (3) general questions. The questionnaire provided to residents along with the results is provided in Appendix A of this report. Also included in this questionnaire was a volunteer request form for a follow up inspection. The purpose of the follow up inspection was to photo document where the flooding occurred within the home, review flood protective measures (i.e. sump pumps, backflow preventers, etc.), identify surface drainage concerns, and examine the overall lot coverage.

During the follow up inspection, additional inquiries were made with affected residents to validate field data collected by the City of Hamilton’s various gauges (i.e. sewer flow gauges, rain gauges).

4.0 RESULTS

In order to achieve its objectives, this study relied largely on the response rate of the affected area residents who were requested to: (1) return a completed copy of the questionnaire, and (2) agree to a follow up inspection. Without this information, any conclusions on the mechanics of the flooding experienced by area residents would be speculative at best. Of the 800 mail-outs, 73 questionnaires were returned (less than 10% return rate) with 42 of the 73 residents agreeing to a follow up inspection. Of these 42 residents, 29 residences were ultimately co-ordinated for inspections. The remaining 12 uninspected homes either did not reply to direct correspondence or it was determined that a sufficient level of information had been gathered through previous inspections in those areas that an inspection was not required.

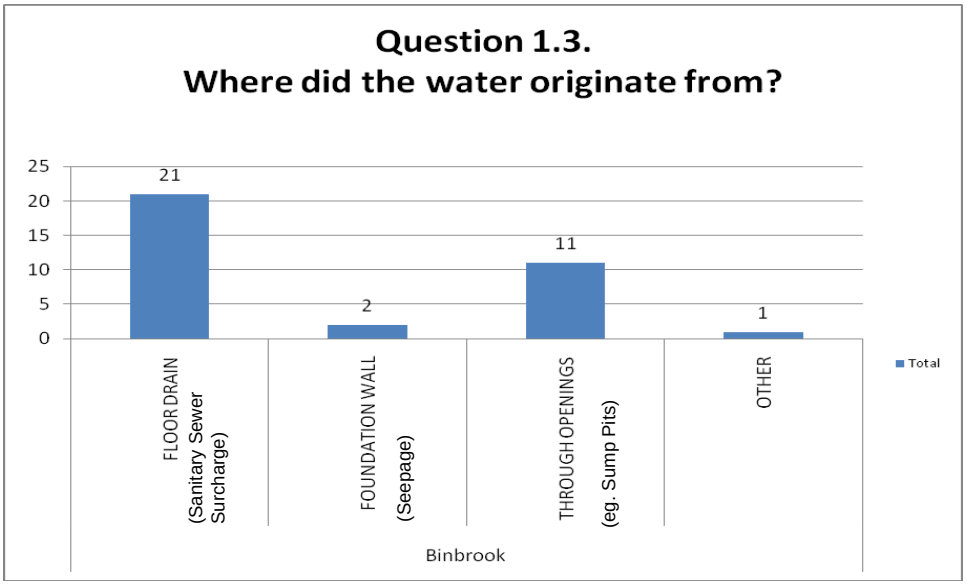
4.1 Binbrook

Based on the results, two different types of flooding were characterized by respondents. For the lands west of Regional Road 56 (Elizabeth Gardens Phase 3), the flood water was characterized to be clear/clean and orginating from floor drains and sump pits. For the lands east of Regional Road 56 (Southbrook on the Green) the flood water within the home was characterized to be as follows (ref. Drawing 3 – Binbrook Residential Flood Mapping):

(1) For those homes extending from the intersection of Regional Road 56 and Southbrook Drive, eastward to the intersection of Southbrook Drive and Etherington Cresent, the flood water was characterized as dirty/brown in colour with a strong odour which flooding orginating from the basement floor drain or basement fixture (i.e. toilet, shower stall, bath tub, etc.).
(2) For those homes north of the intersection of Southbrook Drive and Etherington Cresent, the flooding within the home was characterized to be clear/clean and associated with overwhelming of the sump pit.

The majority of the respondents across Binbrook (89%) reported that this was the first flooding in the home. Figure 1 identifies the location where the flooding orginated from within the homes.

Figure 1 – Flooding Origin for Homes in Binbrook



Many residents experienced what can be characterized as surcharge of the sanitary sewer. The homes inspected from Regional Road 56 and 290 m along Southbrook Drive noted that there was a significant amount of muddy debris which originated from the floor drain suggesting a sanitary sewer system surcharge. Additionally, for those homes within 100 m of the 290 m boundary, or in proximity to the intersection of Southbrook Drive and Etherington Crescent (at the upstream limit), basement flooding originated from the floor drain which was characterized as liquid only, and in some instances was described as being a 5"-15" geyser with basement flooding reaching depths of 4"-6".

In addition to the flooding related to floor drains, respondents reported clear/clean water flooding related to the "foundation wall" and "through openings" (i.e. sump pit opening). During the follow up inspections, residents noted that they have had to replace their sump pumps several times (i.e. 2 and 3 times) noting that they have a tendency to "burn-out". In particular one resident had their sump pump burn-out during the storm event of July 22, 2012, which resulted in basement flooding as the sump pit became overwhelmed with water collected by the dwelling's perimeter weeping tile system. Additionally, residents interviewed along Voyager Pass, west of the intersection with Bradley Avenue, reported that during the July 22, 2012 storm event, area residents were disconnecting their sump pump discharge line from the gravity storm lead so that it would discharge to surface to flow away from the home, through the use of hoses and piping.

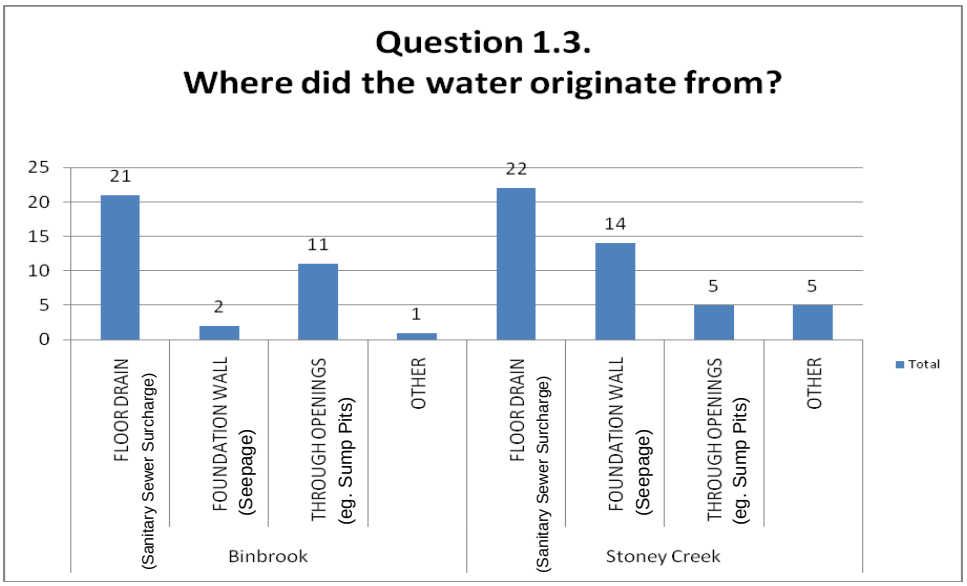
Flooding beyond the respondents' property was also reported with a majority of responses identifying flooding within the municipal right-of-way to depths greater than the curb height (typically 0.15 m) with the sidewalk being clearly visible. Based on field observations, the constructed roadways, in general, have a low gradient with little variation in slope; Through a thorough review of the engineering design of a near zero (0 +/-) gradient in the overland flow route has been identified at the intersection of Great Oak Trail and Windwood Drive, and Great Oak Trail and Voyager Pass (ref. Elizabeth Gardens Phase 1 Grading Plan (Sheet 14)). Given this site condition, there would have been the potential for 0.09 m of ponding water to be above

the sanitary and storm sewer manholes located in the intersection of Great Oak Trail and Windwood Drive; this would not have included the additional depth component of the major overland flow. Similarly, this condition would also result in 0.29 m (+/-) of ponding above the catch basin grates located at the curb face within the same intersection.

4.2 Stoney Creek Mountain

Based on the results from the survey and inspections, two different flood mechanisms were characterized by respondents. However, unlike the data collected in Binbrook, there were more reported cases (14 of 46 responses) of flooding related to water originating from the foundation wall, though there was a similar amount of responses related to water originating from floor drains. A comparison of these results is provided in the following graph.

Figure 2 – Flood Origin Comparison, Binbrook v. Stoney Creek



It should be noted that there were less occurrences of flooding related to “Through Openings” in the Stoney Creek area, which is to be expected as the majority of the homes and all of those which were inspected, do not have sump pumps.

It was determined through the responses that a number of residents had experienced flooding within the home prior to the July 22, 2012 event. Of those who experienced flooding previously, a small percentage identified the flooding as being similar in nature, which is presented in Figures 3 and 4.

Figure 3 – Residents with flooding prior to July 22, 2012 comparison, Binbrook v. Stoney Creek

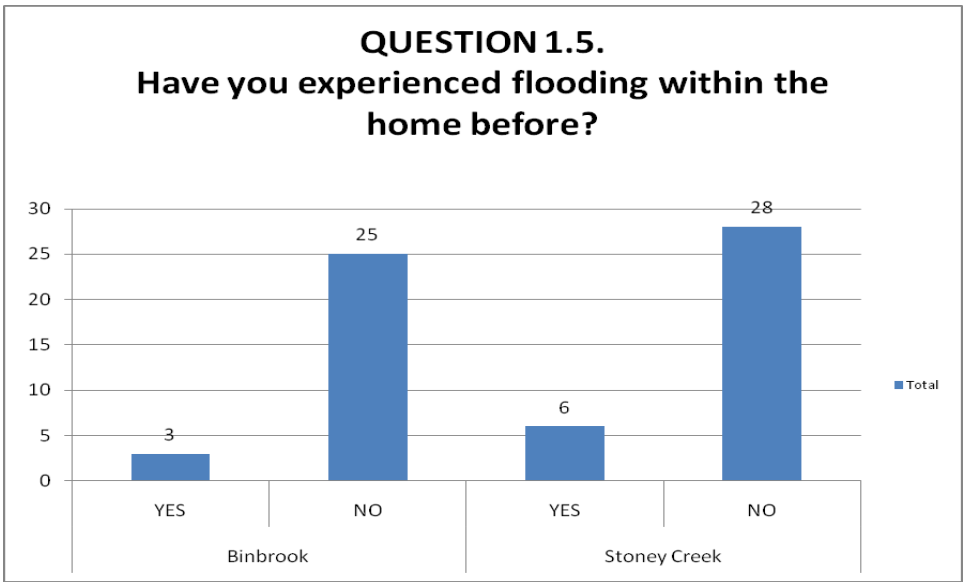
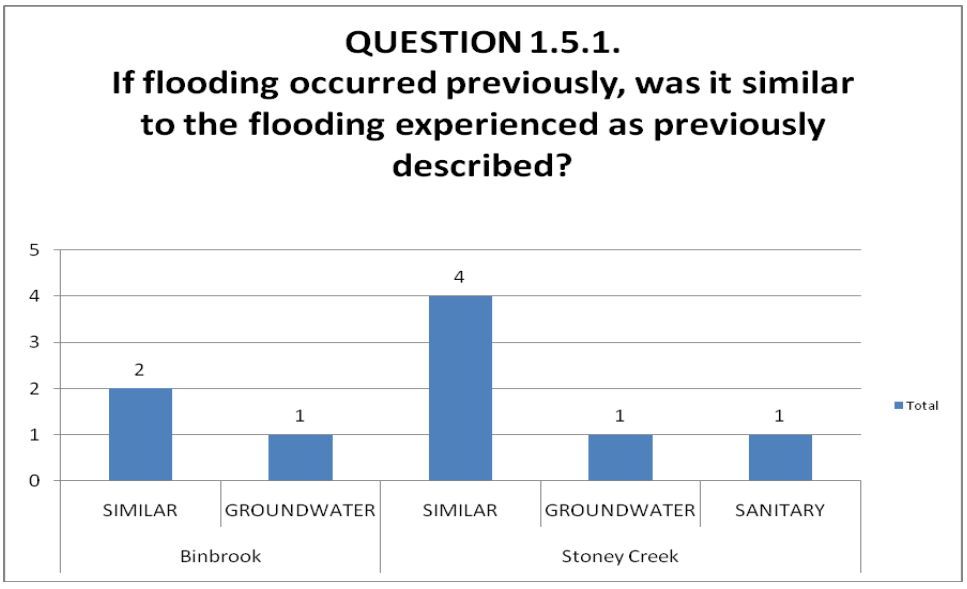


Figure 4 – Flooding type for residents with flooding prior to July 22, 2012



Based on mapping of those residents that reported flooding (ref. Drawing 4), either clear or dirty, the majority of the flood reports appear to be centralized, or are adjacent, to the Gatestone Open Space corridor, specifically in the area of Eringate Drive and the Gatestone Open Space corridor (i.e. the Shady Glen development) and First Road West and the Gatestone Open Space corridor.

4.2.1 Review of Shady Glen Design Information

A review of the Shady Glen, Phase 1 and 3, plan and profiles has been undertaken as a complement to the survey and inspections, to specifically focus on the location of flooding including Fairhaven Drive (Phase 1), immediately upstream of the stormwater management facility and Eringate Drive (Phase 2), a primary area of concern (ref. Shady Glen, Phase 1-3, Engineering Plans (March 2000, August 2000, Sept. 2004)) (ref. Drawing 2).

Fairhaven Drive is a 20 m right-of-way graded from east to west having a gradient of 0.50%, to a low-point adjacent to the stormwater management facility. The street is serviced by a 375 mm sanitary sewer and a 1350 mm storm sewer, having gradients of 0.40% and 0.30%, respectively. It should be noted that the storm sewer was designed to have 1.5 m cover (i.e. shallow system). Dwellings fronting Fairhaven Drive have directly connected sanitary leads and indirect storm foundation connections provided by sump pumps, as indicated on Drawing 5 of the Shady Glen Phase 1 engineering plans. It should be noted that the plan and profile drawing also provides the elevation of the 100-Year hydraulic gradeline. A copy of this plan has been provided with this report (ref. Appendix B).

In the review of the Shady Glen FSR (A.J. Clarke and Associates, June 1998) the following statement is made:

"In the area of the proposed stormwater management pond, the rock elevation is close to the surface. To minimize the amount of excavation for the stormwater management pond in the proposed location, shallow storm sewers (1.5 m below centre line of road) are proposed throughout this development. Since the shallow storm sewers will not provide gravity drainage for the dwelling footing drains, sump pumps shall be required for all dwellings in this development and discharge from these sump pumps will drain to a shallow private storm connection."

The statement suggests the use of sump pumps and shallow storm sewer systems throughout the entire development. As such, it is inferred that sump pumps should have been mandatory for all dwellings. This condition though is not the case, as only those dwellings located in the vicinity of the stormwater management facility (i.e. fronting Fairhaven Drive) were ultimately required to have sump pumps, as residential storm leads in this location connect to a shallow storm sewer system, with the remaining homes upstream of Fairhaven Drive having a direct connection to a deep storm sewer system.

Eringate Drive is characterized by a 20 m right-of-way, graded in an east to west direction having a gradient of 0.50%, with storm and sanitary sewers having gradients of 0.25% and 0.50% and 3.0 m or more cover, respectively. It should be noted that the plan and profile drawing does not indicate the location of the 100-Year hydraulic gradeline or the requirement for sump pumps. Although similar in nature to Fairhaven Drive, there were several accounts of flooding reported by respondents along Eringate Drive, and no reports of flooding by those residents on Fairhaven Drive. A copy of this plan has been provided at the rear of this report (ref. Appendix B).

Additionally, the storm sewer infrastructure located 32.0 m west of the intersection of Eringate Drive and Willowridge Way has been reviewed with respect to the standards of the day. The storm sewer system makes use of several 45-degree bends, a wye and a tee. The use of these sewer elements is not consistent with the former Town of Stoney Creek Municipal Engineering Standards (1982). The former municipal Town standards, Section 5.2.2.(c), identifies that "where applicable, a curved pipe may be used in sewers 675 mm in diameter or larger", where as the current plan identifies the use of "bends". Additionally, the standards identify the required minimum drops across maintenance holes when a storm sewer alignment is deflected, which has been provided in the following table.

Table 4.1. Stoney Creek Municipal Engineering Standards
Section 5.2.2(c) Minimum Drop Required through a Maintenance Hole

Pipe Alignment	Minimum Drop
Straight Run (0˚)	30 mm
1˚ to 45˚ deflection	60 mm
45˚ to 90˚ deflection	150 mm

Notwithstanding the above cited standards, the sewer elements in some of the locations may be suitable, based on the diameter of the transition between two pipes and the amount of drop through the transition, thus satisfying the cited municipal standard.

A secondary area of concern was identified as bounded by Hillgarden Drive (north), Foxtrot Drive (south), First Road West (east) and Holyoake Drive (west) (ref. Drawing 4). Based on the questionnaire responses, flooding in this area was primarily related to water entering the home through the floor drains, with reports of water entering the home through the foundation wall. Water entering the home through the floor drains was characterized as dirty, where water entering the home through the foundation wall was characterized as clear.

The majority of homes which experienced flooding associated with the foundation wall were located along Foxtrot Drive. Based on field observations and review of the available engineering plans (Heritage Green Highland, Stage 2, Grading Plan, Sheet 15) there exists a major overland flow route in close proximity to these homes. This major overland flow route provides conveyance of surface runoff from Highbury Drive, Holyoake Drive, and Foxtrot Drive right-of-ways to the south and through a side yard swale to the Gatestone Open Space to the north. It should be noted that the major overland flow route is partially obstructed by a wooden fence, which provides separation between the neighbouring properties.

It should be noted that the side yards of the inspected homes that reported flooding associated with the foundation wall were altered, which would have inhibited the conveyance of surface runoff promoting ponding. Photos of the site conditions with this condition are provided in Appendix C.

In addition to the questionnaire and follow up inspection program, AMEC has reviewed the design of the storm sewer system for the Shady Glen, Phase 2, development. The storm sewer design approach is considered consistent with design criteria of the day, specifically the Town of Stoney Creek Municipal Engineering Standards (Rev.1982). In accordance with the engineering standards, conveyance of runoff was to be provided by a minor and major system. The minor system, typically a pipe storm sewer, was required to convey the 5 year storm (i.e. no surface ponding) and a major overland system was designed to convey the 100 year event. Parameters for the basis of design were based on the IDF-parameters from the Mount Hope Airport rain gauge station. Table 4.2 summarizes the design parameters and provides the comparison to the current design parameters.

Table 4.2. Comparison of Pipe Sizing Parameters

Parameters	Stoney Creek (1982)	City of Hamilton (2007)
IDF-Parameters		
A	2463.8	1049
B	16	8
C	1	0.803
Inlet Time, t (mins)	10 mins	10 mins
Pipe Capacity Limits		
Maximum Flow Capacity	100%	85%
Pipe Velocity (m/s)		
Minimum	0.80	0.90
Maximum	3.60	3.65

Table 4.3 below summarizes the parameters used in the hydrologic model for Shady Glen from the Functional Servicing Report versus the approved storm sewer design sheet.

Table 4.3. Summary of Storm Sewer Design Parameters
Shady Glen FSR and Storm Sewer Design

Parameters	FSR	Sewer Design Sheet
IDF-Parameters		
A	760.878	2463.8
B	5.571	16
C	0.775	1.0
Inlet Time, t (mins)	10 mins	10 mins
Sample Intensity, I (mm/hr), at t=10 min	90.62	94.76

As noted in Table 4.3, the sample calculation demonstrates that the storm sewer design sheet provides a slightly greater intensity, lending to a slightly more conservative pipe size. This is the case as the calculated pipe size, determined based on conveyance requirements (Q) is directly proportional to the intensity (I) parameter (i.e. Q = C*I*A / 360).

A sampling of runoff coefficients for the Shady Glen development was carried out, by calculating the amount of hardened (impervious) and soft (pervious). The areas analyzed evaluated a single lot and the municipal right-of-way space fronting the selected lot by projecting the side-lot lines to the municipal right-of-way centerline of road.

It was determined that the runoff coefficient (C) for the constructed condition was greater than 0.59, where as the designed condition is based on C = 0.4. It should be noted that the runoff coefficient value of 0.4 was consistent with the Stoney Creek Municipal Design standards of the day. This difference results in a minimum increase of 47%, in terms of runoff volume and peak flow, which can have a significant impact on the designed conveyance function of the receiving storm sewer system. Sample calculations are provided in Appendix D.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The current study and resident survey including follow-up inspections has focused on the review of existing information, collection of resident observations and a field reconnaissance of affected properties; no supplemental analyses have been conducted. The following summarizes the conclusions and recommendations for the two areas based on the level of effort to-date:

5.1 Binbrook

The following can be concluded from the assessment of existing information as well as input from area residents and home inspections:

- The majority of respondents east of Regional Road 56 experienced flooding associated with the back-up of the municipal sanitary sewer system.
- The majority of respondents west of Regional Road 56 experienced flooding associated with the intrusion of clear water primarily to the sump pits.
- There are two distinct sump pump connections; those that (1) discharge to grade, (2) discharge to the gravity storm lead over the foundation.
- Sump pumps discharging to a gravity storm drain generally did not have a back-up relief system (i.e. overflow to grade).

The following action is recommended:

(1) Consider developing a Municipal standard for sump pump installation, specifically:

- Pump discharge lines having a secondary relief to grade
- Minimum Pump rating (horsepower, GPM)
- Back-up power.

(2) Consider developing a home-owner brochure with drawing/schematic demonstrating to residents how their dwelling connects to the municipal services. It is suggested that optional flood protective measures that can be carried out by the home-owner to minimize their flooding potential be included. This would include an explanation of the following standard flood protective measures:

- Sanitary backflow check valves
- Sump pumps
- Sump pump backflow check valves
- Sump pump battery backup
- Secondary (backup) relief on the sump pump discharge line

(3) Investigate the performance of the storm conveyance system, including storm sewers, major overland conveyance systems (road allowance and naturalized channels) for the purpose of identifying existing service levels.

(4) Carry out an additional study to establish the relationship between storm runoff and the municipal storm and sanitary conveyance system, focused on potential inflow/infiltration with an emphasis on inflow due to reported rapid response which suggests unusual levels of inflow.

(5) Conduct a condition assessment of residential storm and sanitary laterals, including video inspection and air testing.

(6) Conduct a condition assessment of municipal storm and sanitary sewers, including video inspection and air testing.

5.2 Stoney Creek Mountain

The following can be concluded from the assessment of existing information as well as input from area residents and home inspections:

- Flooding experienced by respondents was largely associated with:
  i. Back-up of the municipal sanitary sewer system,
  ii. Intrusion of clear water along the base of the basement walls.
- None of the inspected homes had sump pumps.

- Runoff coefficients applied to the storm sewer design (i.e. C = 0.4) are less than the observed existing field conditions (i.e. greater than C = 0.6), suggesting greater storm runoff volume and higher peak flow rates.
- The layout/configuration of the storm sewer (minor) conveyance system within Eringate Drive and Willowridge Way does not meet present day standards with respect to current construction practices and City standards regarding pipe (drop) transition.

The following action is recommended:

(1) As for Stoney Creek, consider developing a home-owner brochure with drawing/schematic demonstrating to residents how their dwellings connect to the municipal services.

(2) Carry out an additional study to confirm the current 100-Year hydraulic grade line from the Shady Glen stormwater management facility to Second Road West and establish the 100-Year hydraulic gradeline from Second Road West to the Shady Glen Phase 2 & 3 development.

(3) Analyze the hydraulics and consider re-constructing the storm sewer configuration, immediately west of the intersection of Eringate Drive and Willowridge Way, to meet current day practices should this be determined to be deficient and a cause of local backwater/surcharge..

(4) Carry out an additional study to establish the relationship between storm runoff and the municipal storm and sanitary conveyance system, focused on potential inflow/infiltration with an emphasis on inflow due to reported rapid response.

Report prepared by,

AMEC ENVIRONMENT & INFRASTRUCTURE,
a division of AMEC Americas Limited

Per: Ryan R. Moore, P. Eng.
Project Engineer

Per: Ron Scheckenberger, M. Eng., P. Eng.
Office Manager

RM/RBS/kf

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APPENDIX A

Questionnaire

Hamilton

CITY OF HAMILTON RESIDENTS QUESTIONNAIRE RELATED TO STORM EVENT OF JULY 22, 2012

Last Name: _____

First Name: _____

Street # and Name _____

Postal Code: _____ Phone Number: _____

How long have you lived at this address: _____

This questionnaire is intended to assist the City in better understanding the type and characteristics of flooding which occurred July 22, 2012. This information can then be used to develop solutions.

If you experienced interior flooding to your dwelling, please complete Section 1 and 3 only; if you experienced flooding outside on your property, complete Sections 2 and 3 only; in the event you had both interior and exterior flooding, complete all sections.

SECTION 1 – INTERIOR FLOODING QUESTIONS (mark appropriate answers with an X)

(1) Was the water in your home?
- a) Clear ___
- b) Brown/Dirty ___
- c) Other: (describe) _____

(2) Where did the observed flooding occur?
- a) Basement ___
- b) Main Floor ___
- c) Second Floor ___

(3) Where did the water originate from?
- a) Floor Drain ___
- b) Bottom of foundation wall ___
- c) Through openings (windows, doors, sump hole, etc.) ___
- d) Other: _____

(4) If flooding occurred in the basement, where in the basement did it occur?
- a) North Side ___
- b) East Side ___
- c) South Side ___
- d) West Side ___

(5) Have you experienced flooding within the home before?
- a) Yes ___
- b) No ___

When? (state all known dates) _____

If “Yes”, was it similar to the flooding experienced as described above in Questions 1–4?
- a) Yes ___
- b) No ___

Please describe: _____

Hamilton

SECTION 2 – EXTERIOR FLOODING QUESTIONS

(6) Where did the observed flooding occur?

a) Street / Front Yard ___
b) Side Yard (i.e. between your property and your neighbours) ___
c) Rear Yard ___
d) Abutting Creek/Watercourse/Stormwater Pond ___

Complete the following ONLY IF you answered "**Street / Front Yard**".

(7) What best describes the flooding observed on the street in front of your property?

a) I could clearly see the street curb. ___
b) I couldn't clearly see the street curb, but I could clearly see the sidewalk. ___
c) I couldn't clearly see the sidewalk (i.e. the flooding was beyond the sidewalk) ___

Complete the following ONLY IF you answered "**Side Yard**".

(8) Have you installed a walkway along the side of your house?
If Yes, is it within 1.0 m (3 ft) of the property line?

a) Yes ___
b) No ___

Complete the following ONLY IF you answered "**Rear Yard**".

(9) Do you have a rear yard catch basin (i.e. grate/drain)?

a) Yes ___
b) No ___

If "Yes", do you know if the catch basin grate was free of debris (i.e. yard waste, leaves, dirt, trash) before the storm?

a) Yes ___
b) No ___

SECTION 3 – GENERAL

Have you ever conducted flood protection works inside or outside of your home? __ Yes __ No
If yes, please describe: _____

_____

_____

(10) Do you have a finished basement?

a) Yes ___
b) No ___

Hamilton

(11) Do you have a sump pump?

a) Yes ___
b) No ___

If "Yes", what best describes the operation of your sump pump?

It runs…

a) Continuously ___
b) Intermittently ___
c) Rarely ___
d) Only when it rains ___

(12) Where does your sump pump discharge to? Please describe the location: _____

_____

a) Grass ___
b) Sewer ___
c) Unsure ___

(13) During the storm on July 22, 2012, did you experience a power outage?

a) Yes ___
b) No ___

If you have any photos or videos of the flooding that you wish to share, please contact the City Representative or Consultant.

Your participation in this survey is greatly appreciated.

Please note that you may be contacted by City and/or AMEC representatives for a follow up inspection to document and confirm details of your property and the flooding experienced as reported within this questionnaire. This activity will require access to the interior and exterior of your home and property. Please find attached a "Voluntary Follow-Up Inspection Form". By filling out this form, you are voluntarily granting permission for, or declining, a follow-up inspection. Once again, this information would only be used to develop a better understanding of the flood and to assist in developing a solution.

We thank you for your assistance. If you have any questions the following persons can be contacted for further information.

City Representative
Sally Yong-Lee, P.Eng.
Manager of Infrastructure Planning
City of Hamilton, City Hall
71 Main Street West, 6th Floor
Hamilton, ON
(905) 546-2424 Ex. 1428
Email: Sally.Yong-Lee@hamilton.ca

City Consultant
Ryan Moore, P.Eng.
Design Engineer
AMEC Environment & Infrastructure
3215 North Service Road
Burlington, ON
(905)-335-2353 Ex. 1293
Email: Ryan.Moore@amec.com

Hamilton

VOLUNTARY FOLLOW-UP INSPECTION FORM

To provide the City a better understanding of the factors related to the flooding of July 22, 2012, the City has chosen to undertake follow-up inspections to further document key information inside and outside affected homes.

Please mark your answer to the following question with an X.

__ I volunteer to the follow-up site inspection
__ I decline the follow-up site inspection

The site inspection will involve the following:

Photo documentation of:

- House front
- Side yards
- Rear yards
- Downspouts
- Sump pump outlet
- Interior part of the home where flooding occurred
- Basement sump pump

If you have volunteered to the Follow-up Inspection Program, when is the best time to arrange a visit?

__ Morning (7 a.m. to 11 a.m.)
__ Mid-day (11 a.m. to 4 p.m.)
__ Evening (4 p.m. to 7 p.m.)

What is the best number or e-mail address to contact you at to arrange a date and time?

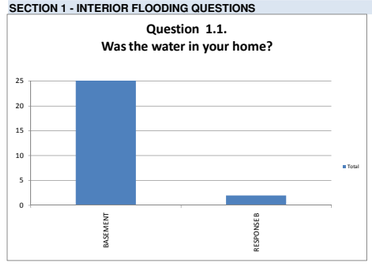
Phone: _____ Email: _____

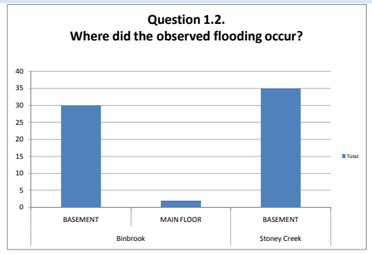
Your co-operation is greatly appreciated; the *Questionnaire* and *Voluntary Follow-up Inspection Form* can be returned by mail, email, or simply by contacting the City or AMEC representative.

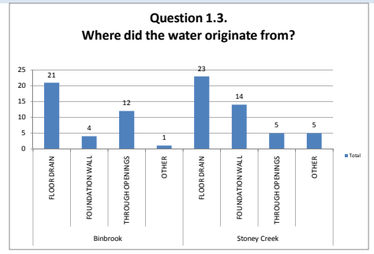
City Representative
Sally Yong-Lee, P.Eng.
Manager of Infrastructure Planning
City of Hamilton, City Hall
71 Main Street West, 6th Floor
Hamilton, ON
(905) 546-2424 Ex. 1428
Email: Sally.Yong-Lee@hamilton.ca

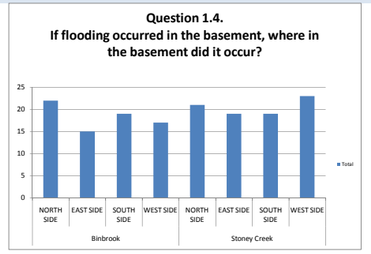
City Consultant
Ryan Moore, P.Eng.
Design Engineer
AMEC Environment & Infrastructure
3215 North Service Road
Burlington, ON
(905)-335-2353 Ex. 1293
Email: Ryan.Moore@amec.com

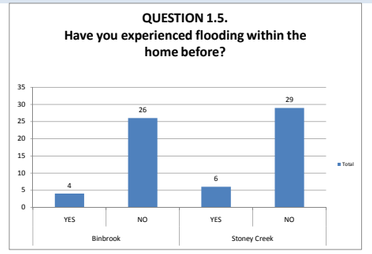
SECTION 1 - INTERIOR FLOODING QUESTIONS

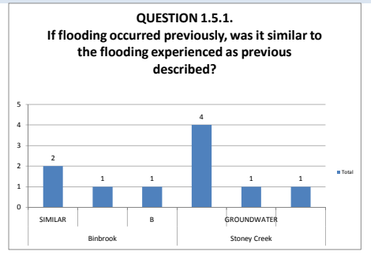




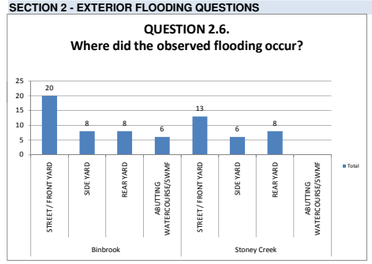


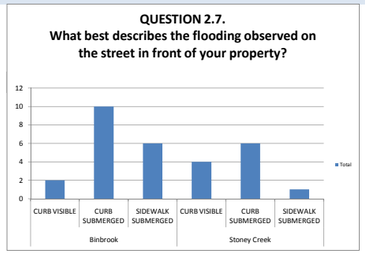


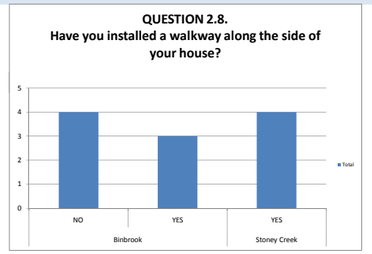


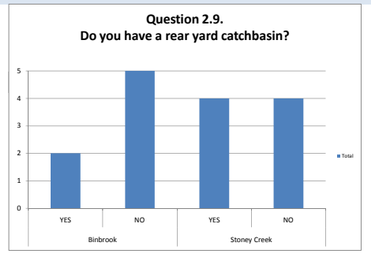


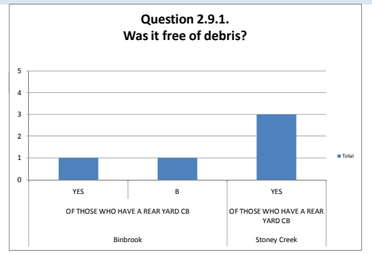
SECTION 2 - EXTERIOR FLOODING QUESTIONS



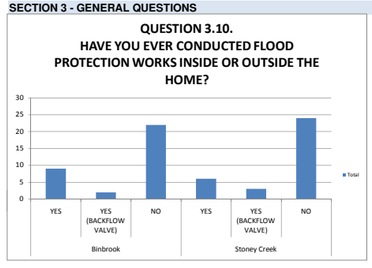


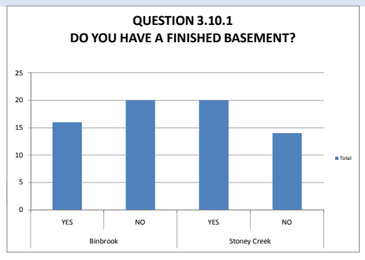


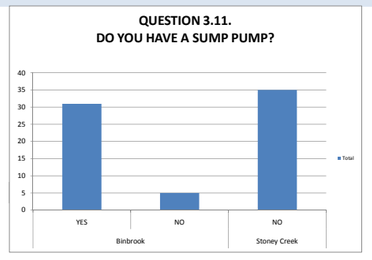


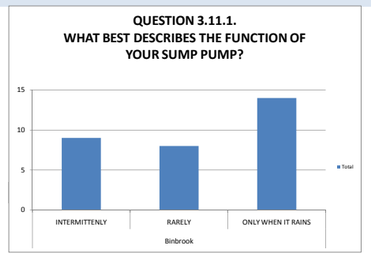


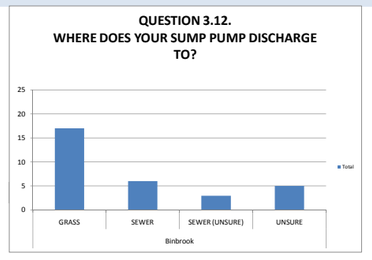
SECTION 3 - GENERAL QUESTIONS

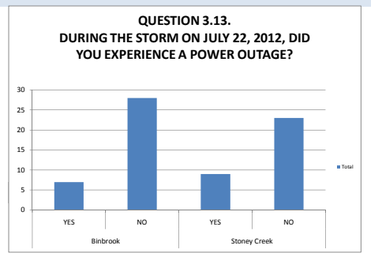






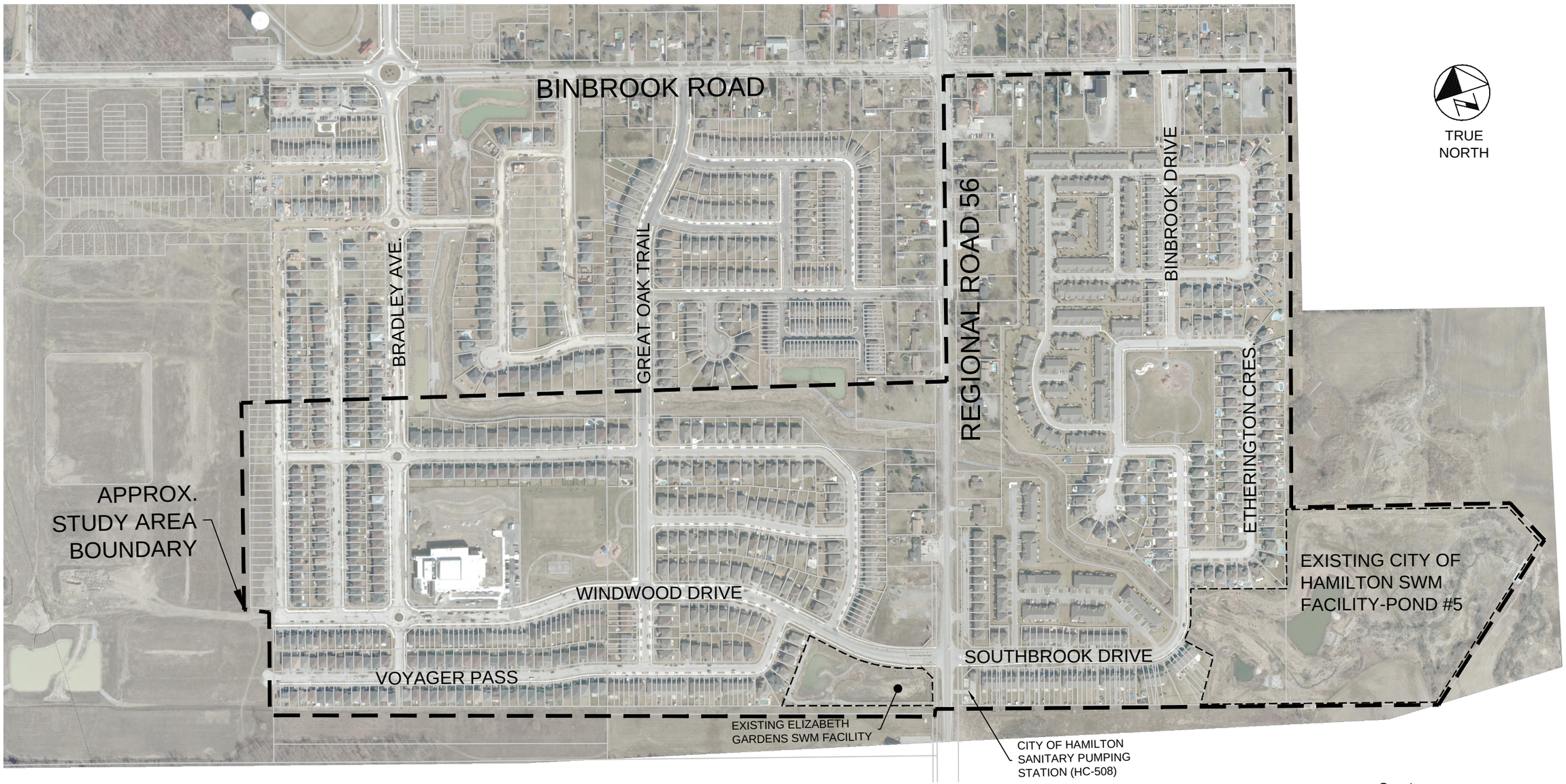






APPENDIX B

Drawings



Scale
0 5 10 20

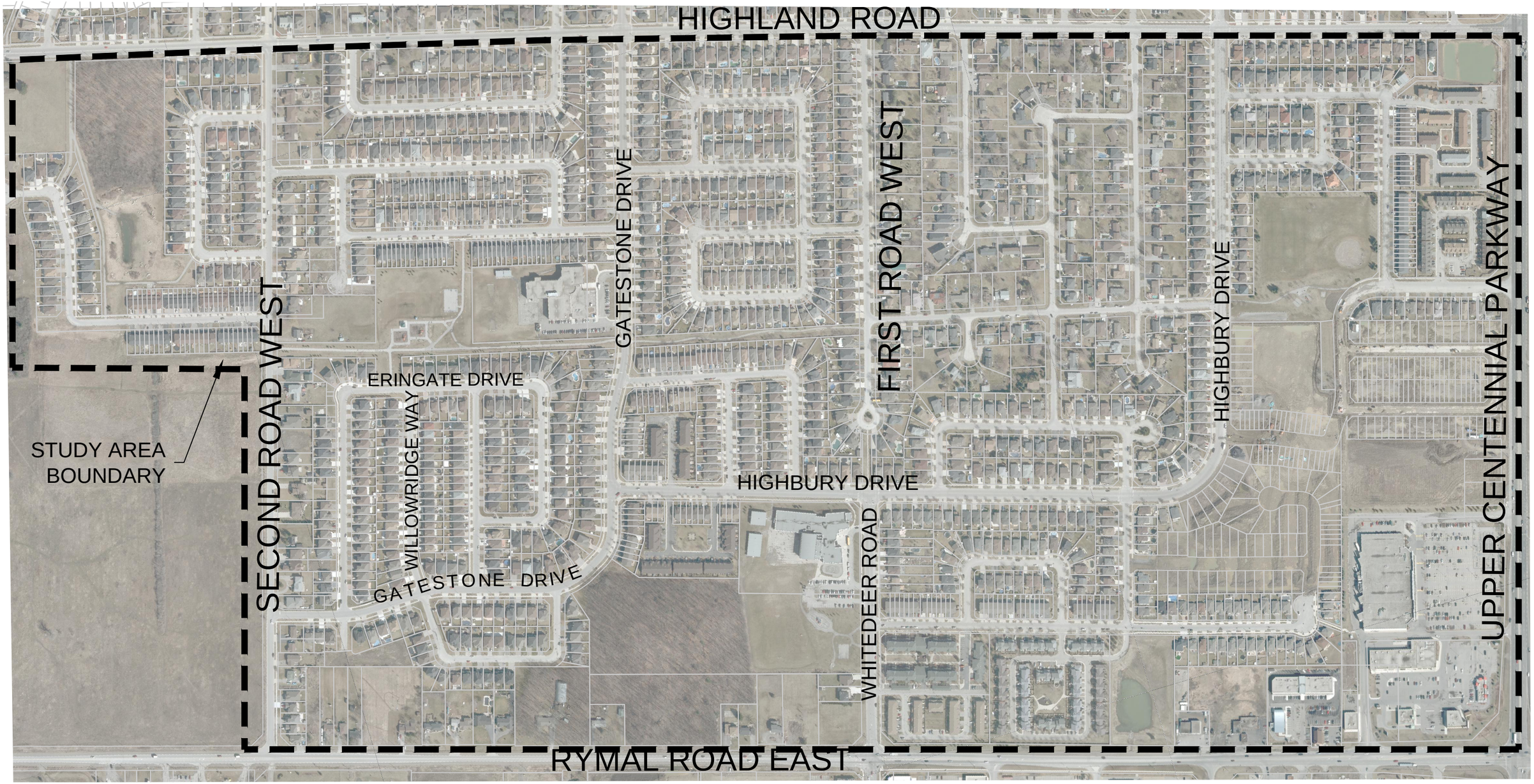
STONEY CREEK & BINBROOK
FLOOD STUDY RELATED TO
JULY 22, 2012 STORM
CITY OF HAMILTON
BINBROOK STUDY AREA

amec

Project No.	TP112123
Date	March 2013
Scale	1:5000
Figure No.	1

P:\Work\TP112123\Water\dwg\01-Binbrook.dwg

Mar 12/13 – peter.dimitroulias



TRUE NORTH

Scale
0 5 10 20

STONEY CREEK & BINBROOK FLOOD STUDY RELATED TO JULY 22, 2012 STORM CITY OF HAMILTON STONEY CREEK MOUNTAIN STUDY AREA	amec
Project No.	TP112123
Date	March 2013
Scale	1:5000
Figure No.	2

P:\Work\TP112123\Water\dwg\02-StoneyCreek.dwg

Mar 12/13 – peter.dimitroulias

BINBROOK ROAD

BRADLEY AVE.

GREAT OAK TRAIL

REGIONAL ROAD 56

BINBROOK DRIVE

ETHERINGTON CRES.

WINDWOOD DRIVE

VOYAGER PASS

SOUTHBROOK DRIVE

TRUE NORTH

APPROX. STUDY AREA BOUNDARY

LEGEND

99 STREET ADDRESS

INSPECTED:

- SUMP PUMP/FOUNDATION WALL FLOODING
- FLOOR DRAIN FLOODING
- NO FLOODING EXPERIENCED

NOT INSPECTED:

- SUMP PUMP/FOUNDATION WALL FLOODING
- FLOOR DRAIN FLOODING
- NO FLOODING EXPERIENCED

Scale 0 5 10 20

STONEY CREEK & BINBROOK FLOOD STUDY RELATED TO JULY 22, 2012 STORM

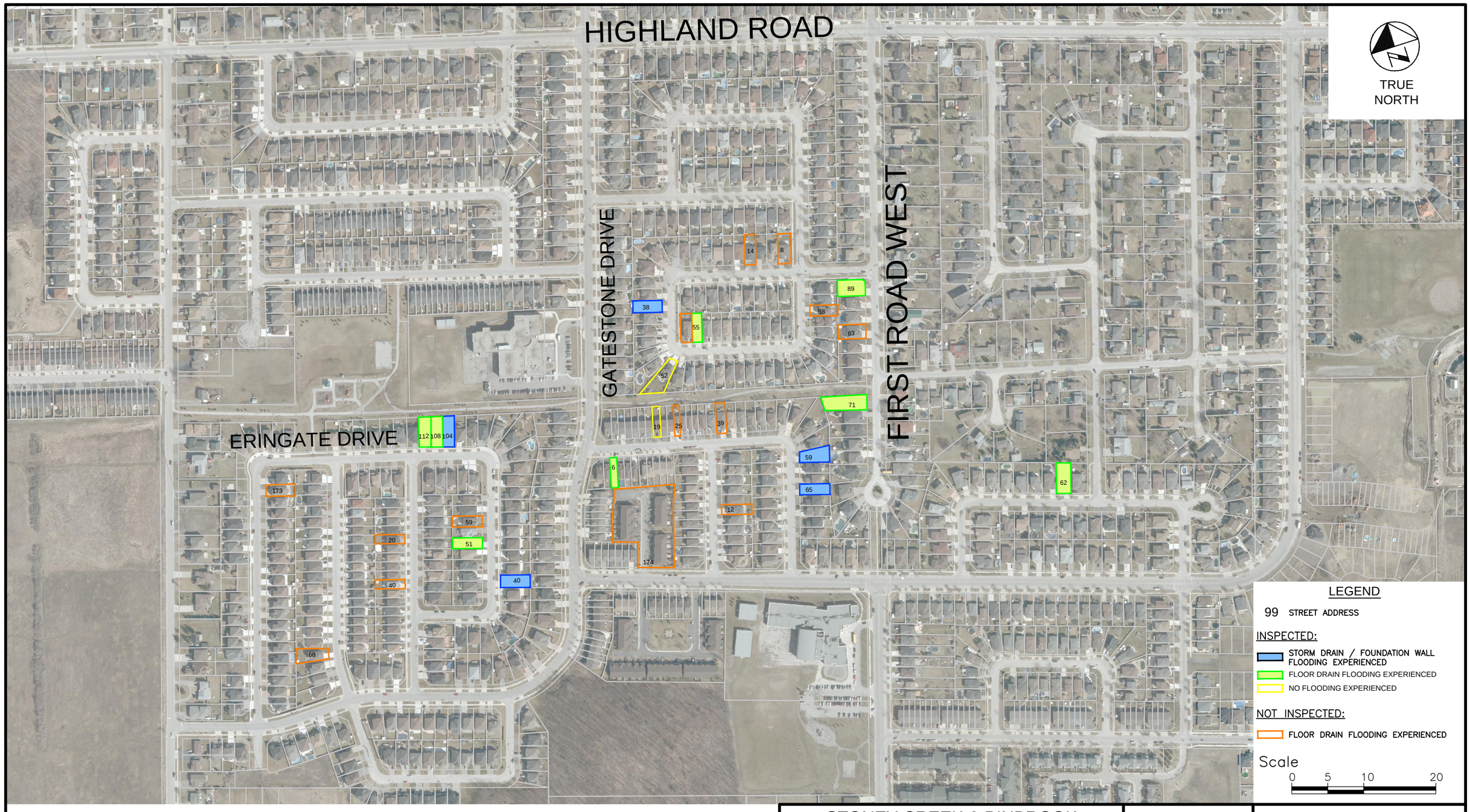
BINBROOK
RESIDENTIAL FLOOD MAPPING

amec

Project No.	TP112123
Date	March 2013
Scale	1:4000
Figure No.	3

P:\Work\TP112123\Water\dwg\03-BinFld.dwg

Mar 12/13 – peter.dimitroulias



STONEY CREEK & BINBROOK
FLOOD STUDY RELATED TO
JULY 22, 2012 STORM
STONEY CREEK
RESIDENTIAL FLOOD MAPPING

amec

Project No.	TP112123
Date	March 2013
Scale	1:4000
Figure No.	4

P:\Work\TP112123\Water\dwg\04-StoneyFld.dwg

Mar 12/13 – peter.dimitroulias

APPENDIX C

Photographs


BEWARE OF DOG
05 . 12 . 2012


05.12.2012

APPENDIX D

City of Stoney Creek & City of Hamilton
Standards Comparison

APPENDIX D - CITY OF STONEY CREEK & CITY OF HAMILTON STANDARDS COMPARISON

RUNOFF COEFFICIENT	Stoney Creek Standards January 1982	City of Hamilton September 2007
Park	0.2	0.25
less than 4.0 ha	-	-
greater than 4.0 ha	-	-
Single Family	0.40	0.40
Semi Detached	0.50	0.50
Interlink	-	0.55
Quatroplex	-	0.60
Townhouse Apartments, Maisonettes	0.65	-
Medium Density	-	0.60
High Density	-	0.70
Institutional	0.75	0.75
Industrial and Central Business District	0.75	0.75
Commercial	0.90	0.90
Paved Areas	0.90 - 1.00	0.90 - 1.00

PIPE SIZING IDF-PARAMETERS	Stoney Creek Standards January 1982 IDF-Parameters 5 - Year	City of Hamilton September 2007 IDF-Parameters 5 - Year	Stoney Creek Standards January 1982 IDF-Parameters 100-Year	City of Hamilton September 2007 IDF-Parameters 100-Year
A	2463.8	1049.5	1322.1	2317.4
B	16	8	3.84	11
C	1	0.803	0.748	0.803
t	10 min	10 min	10 min	10 min
	Intensity, I (mm/hr)	Intensity, I (mm/hr)	Intensity, I (mm/hr)	Intensity, I (mm/hr)
t = 15 min	94.8	103.0	147.1	201.0
Sample Calculation No.1	Q (cms)	Q (cms)	Q (cms)	Q (cms)
C = 0.40, A = 1.0 ha	**0.105**	**0.114**	**0.163**	**0.223**
Sample Calculation No.2	Q (cms)	Q (cms)	Q (cms)	Q (cms)
C = 0.60, A = 1.0 ha	**0.158**	**0.172**	**0.245**	**0.335**

PIPE PARAMETERS	Stoney Creek Standards January 1982	City of Hamilton September 2007
Pipe Velocity		
Minimum, (m/s)	0.80	0.90
Maximum, (m/s)	4.60	3.65
Hydraulic Losses for Drop Transitions	Drop (m)	Drop (m)
0º (straight run)	0.03	grade of sewer
1º - 45º	0.03 - 0.07	0.03
90º	0.07	0.06