APPENDIX G: Flood Risk Assessment

1.0 Purpose and Objectives

There are two primary reasons for conducting the Special Policy Area (SPA) review: (1) incorporating revised flood data as a result of land use changes in the watershed and (2) pressure to change land use designations, mainly in the Woodbridge Core area, for higher densities. While the flood risk assessment is a key component of the comprehensive SPA review, it is one of several appendices supporting the main SPA Justification Report. The results of the comprehensive SPA review have been incorporated into the revised land use designations, land use policies and SPA policies in the Woodbridge Centre Secondary Plan, which is part of Volume 2 of the City of Vaughan Official Plan.

The flood risk assessment provides the technical information as the basis for any recommended changes to land use and policies affecting land use designations in the Special Policy Area. This analysis is summarized in the main SPA Justification Report. Information related to development scenarios, flood depths, and flow velocities is quantified here to assess potential risk. The Woodbridge Centre Secondary Plan is provided as an appendix to the overall SPA Justification Report.

1.1 Policy Context

In addition to Section 3 of the Provincial Policy Statement and the Natural Hazards Technical Guides, the main policy document for the SPA review is the "*Procedures for Approval of New Special Policy Areas (SPAS) and Modifications to Existing SPAS Under the Provincial Policy Statement 2005 (PPS, 2005), Policy 3.1.3 – Natural Hazards – Special Policy Areas*" (MNR 2009). Five scenarios for changes to SPA boundaries and/or policies are identified in the *Procedures* document:

- Deletions due to permanent flood plain reduction;
- Deletions due to flood depth reduction;
- Major adjustments due to flood plain enlargement;
- Minor adjustments (minor increase in risk to public health and safety and minimal property damage); and
- Boundary the same but increase in flood depth/velocities.

The "*Procedures for Approval of New Special Policy Areas (SPAS) and Modifications to Existing SPAS Under the Provincial Policy Statement 2005 (PPS, 2005), Policy 3.1.3 – Natural Hazards – Special Policy Areas*" (MNR 2009) also lists the information requirements for a change to SPA policies. This can include any proposed changes to the existing land use designations/densities as well as policies specific to the SPA requirements. The information requirements are listed as follows.

Technical (flood related)

- documentation on any new flood information for the SPA (flood lines, flood depths, flow velocities, access/egress);
- if there have been changes, explain why and whether there are any opportunities for remediation;
- any changes to floodproofing measures;
- analysis of extent to which any flood risk has increased since the SPA was first approved and any subsequent formal reviews;
- explanation as to how emergency response will be provided;
- all mapping should include digital files in geographical information system (GIS) format and be georeferenced.

Land use planning

- a copy of the current SPA approvals by the Province along with OP policies and schedules;
- background information related to land uses in the SPA – how successful has the SPA been functioning – have issues arisen that need to be addressed?
- estimation of the range of any proposed population increases, and structural investment in the flood plain over the planning horizon of the OP;
- explanation of the proposed OPA policy changes to the SPA policies themselves and/or to the land use policies;
- justification report as to why any new or intensified uses need to be located in the SPA;
- demonstration of how the revised policies and land uses are consistent with the PPS and other provincial plans if applicable;
- draft OPA policies and/or revised OP schedule to be submitted;
- any necessary zoning by-law provisions;
- any relevant planning studies that may have been done for the area.

Section 1.0 of the main SPA Justification Report provides a history of official plan amendments and land use designation changes affecting the SPA. Section 3 and Appendix B provide a history of the SPA boundary and policy changes.

Section 5.0 of the main SPA Justification Report includes required technical information and a rationale for SPA boundary adjustments while Appendix D provides a table summarizing SPA deletions and additions.

Sections 6.0 and 7.0 of the main SPA Justification Report include a summary of risk to life from recent policy and land use changes in the SPA and a summary assessment of the proposed land use designations in the Woodbridge Centre Secondary Plan.

1.2 Relevant Flood Events

The flood risk assessment for the SPA review is based on the Regulatory Flood. This is considered to be the Hurricane Hazel event of 1954 (the Regional Storm) and is described in more detail below. However, several flood events are described in this section. At issue is the variability of flood events and the need to incorporate appropriate margins of safety in the assessment of risk. Rainfall amounts and storm duration vary considerably in the examples below, with Hurricane Hazel resulting in 285 mm of rainfall over 48 hours, the 2004 Peterborough flood resulting from 190 mm of rainfall over about 12 hours, and the August 2005 storm in the GTA resulting in 100 to 150 mm of rainfall in just one hour.

1.2.1 Hurricane Hazel, October 15, 1954

Hurricane Hazel was projected to dissipate, but instead re-intensified unexpectedly and rapidly when it reached southern Ontario on October 15, 1954. Winds reached 110 kilometres per hour (68 mph) and 285 millimetres (11.23 inches) of rain fell in the region in 48 hours. Bridges and streets were washed out and an estimated 32 homes and trailers were washed into Lake Ontario. 81 people were killed. The total cost of the destruction in Canada was estimated at $100 million (about $1 billion today).

1.2.2 July 15, 2004 Severe Thunderstorms, Peterborough

In the early morning of July 15, 190 mm of rain fell in the Peterborough area over approximately 12 hours and causing extensive damage to public and private properties. According to reports, most of the rainfall (150 mm) occurred in a 4 to 5 hour period in the early morning. The affected areas included the City of Peterborough, the County of Peterborough, and the Townships of Smith-Ennismore-Lakefield, Otonabee-South Monaghan and Duoro-Dummer.

The Province of Ontario provided $5 million for speedy assistance under the Ontario Disaster Relief Assistance Program (ODRAP). The amount was based on advance assistance of $500 per household for emergency living needs and cleanup. For family income less than $24,000, the program also provided help of up to $6,000 for extreme financial hardship situations. Small businesses were provided with advance assistance of up to $2,500 for cleanup and emergency repairs.

1.2.3 August 19, 2005 Severe Rainfall Event, Greater Toronto Area

Excerpts from a document prepared by the TRCA (June 2006) are provided below to describe the severe rainfall event of August 19, 2005.

“Following one of the driest and warmest summers on record, a cold front passed across the region on the afternoon of Friday, August 19, 2005. The front created severe weather, including tornadoes, along a relatively thin line across most of southern Ontario prior to entering the TRCA region. The collision of the warm air along the front with the cool air at the western end of Lake Ontario created a change in the storm and resulted in a series of extremely intense thunderstorms which moved west to east across the TRCA watersheds, centered over the Highway 401 to Highway 7 corridor. “

“Rainfall amounts of 100 to 150 mm were generally recorded between 3:15-4:15 p.m. exceeding any previously recorded in TRCA's jurisdiction for a one hour storm. Widespread urban flooding occurred which consisted of flooded roads and interchanges,

> roadway underpasses and basement flooding. Traffic within the north portion of Toronto and in southern York Region was in chaos as most major street interchanges were flooded to depths in excess of one metre. Many motorists were stranded after being caught in flooded areas. Finch Avenue at the Black Creek was washed away after the upstream end of the culvert collapsed and the Black Creek tributary of the Humber River overtopped the roadway. "

1.3 Climate Change Adaptation

Changing weather patterns as a result of global warming requires a consideration of potential natural hazards in addition to flooding and erosion (Auld et al. 2007). Environment Canada's Atmospheric Hazards Web Site (www.hazards.ca) was reviewed to determine likelihood of additional hazards in the Woodbridge study area. Hail, ice storms, wind storms and tornados are all additional natural hazards that can be considered for "no regrets" adaptation actions as part of the Woodbridge Focused Area Study.

Wider margins of safety for flood events given likely greater variability of storm events in the future constitute another approach to considering climate change adaptation.

Given the lack of data regarding local variability for these weather events, the SPA Review Working Group concluded that it is not appropriate to consider additional weather events at this time. Furthermore, the SPA Review Working Group agrees that the margins of safety used in the hydrologic modelling employed by TRCA is sufficient to address climate change adaptation for flood events.

2.0 Flood Risk Assessment Methodology

Two general approaches are taken to assess flood risk for the SPA review component of the Woodbridge Focused Area Study. First, flood events were considered part of hazard risk identification following the direction provided in the Emergency Management and Civil Protection Act, 2006. Hazard risk identification is at a broad scale and is described in more detail below in Section 2.1. This is aligned with operational risk and emergency preparedness to reduce risk to life.

Hazard risk identification as mandated under the Emergency Management and Civil Protection Act, 2006 is most useful for preparing for hazard response, particularly since multiple hazards are common as a result of one main natural event. However, the approach does not assess site-specific risk or geographic risk. Hence, a second site-specific assessment was undertaken using information regarding potential future growth together with flood depth and flow velocities. This information is analyzed to quantify risk for specific parts of the SPA. The second approach to quantify geographic risk is described in Section 2.2 below and is consistent with the data requirements outlined in the "*Procedures for the Approval of New Special Policy Areas (SPAS) and Modifications to Existing SPAS Under the Provincial Policy Statement 2005 (PPS, 2005), Policy 3.1.3 – Natural Hazards – Special Policy Areas*" as well reflecting the policy direction in the Section 3.1 of the Provincial Policy Statement and the Natural Hazards Technical Guides.

As a result, a comprehensive assessment of risk to life is provided by considering both operational risk and geographic risk. Operational risk addresses issues of emergency preparedness and response to reduce risk in the event of a hazard under the City-wide Emergency Plan. Assessing geographic risk identifies areas to avoid to minimize placement of people and structures in harms way.

The TRCA is currently undertaking a comprehensive update to the hydrologic modelling of the Humber River, anticipated to be completed in 2014. Pending the outcome of this work, there may be a future update of the hydraulic modelling of the Humber River.

2.1 Hazard Risk Identification and Operational Risk

Emergency Management Ontario (EMO), the provincial agency responsible for ensuring implementation of the Emergency Management Act, 2003 (now the Emergency Management and Civil Protection Act), requires that municipalities undertake a Hazard Identification and Risk Assessment (HIRA) process. A modified HIRA process of ranking probability and consequences of hazards was undertaken specific to flood, erosion and slope instability hazards for the study area of the Woodbridge Focused Area Study.

An analysis of different flood events that have occurred in Canada, the United States and globally in areas that had similar characteristics to the Woodbridge study area was conducted. The events analyzed included: the rain storm of August 19, 2005; floods in the Eastwood and Terry's Creek floodplain (Australia); Hurricane Hazel (1954); Peterborough Flood (2004); the 49th Parallel Storm (2002); Okotoks Flood (Alberta 2008); and the Stump Lake Flood (North Dakota, 2001). The purpose of the analysis was to determine the degree of consequences experienced by these local municipalities in relation to the criteria identified in the Hazard Risk Analysis Matrix. The analysis also included identifying secondary threats along the course of the Humber and East Humber Rivers that would exacerbate the impact of flooding on the Woodbridge Core.

Regional storm/flood events are infrequent and no two emergencies manifest exactly the same. The data collected from the past flood events can provide a suitable range and averages for assessing impacts when applied to the municipality's spatial data. An additional component of the process was determining damage estimates in dollars. The City's spatial data was a key component in determining the real direct and indirect costs of a flood emergency. It is important to note that larger municipalities have more resources than smaller municipalities to warn the population, respond to and recover from an emergency situation. The level of available resources plays significantly in the costs of responding to an emergency.

The criteria selected for the hazard risk analysis is based on the Provincial model and on the data provided by the Zeta Group who conducted the overall Hazard Identification Risk Assessment (HIRA) for the City of Vaughan and York Region. The premise of the HIRA is to use information regarding the historical events of the municipality, community memory and events occurring in neighbouring municipalities to determine the probability of occurrence of an emergency. The probability of occurrence is then multiplied by the sum of the consequences (impacts) the event has on the community. Probability and consequence measurements are on a scale of 1 to 4: 1 represents low probability and consequence while 4 represents high probability and consequence.

The probability scoring criteria used is from the Community Emergency Management Coordinator Handbook Version 1.0 (April 2009) and Version 2004-01 (November 2004) provided by Emergency Management Ontario Program Delivery Section.

1. No incidents in the last 15 years,
2. Last incident occurred in the past 5-15 years,
3. One incident occurred in the last 5 years,
4. Multiple incidents in the last 5 years.

The consequence scoring criteria is based on the criteria used by the Zeta Group in performing the overall City HIRA. The consequence category headings of fatalities, injuries, damage to property/vehicles, environment, lifelines, economic, infrastructure, reputation and media were the same as those used by the Zeta Group. The specific scoring and associated definitions were developed in collaboration with the City of Vaughan Emergency Planning Working Group and more specific to a flood emergency.

As a result, flooding is ranked 12th out of 24 identified hazards in the City's overall HIRA. Furthermore, the analysis of flooding events demonstrates that advanced warning and emergency response dramatically reduces loss of life, such that property damage is the more prevalent impact of flooding. Given that the spatial area of potential flooding is known and that early warning is available, the HIRA approach addresses operational risk and emergency preparedness with regards to flood risk. Assessing geographic risk within the SPA requires a more detailed quantification of risk, as explained in Section 2.2 below.

2.2 Approaches to Quantifying Geographic Risk

The primary sources of information used to quantify geographic risk include the residential capacity assessment undertaken by the City of Vaughan (see Appendix E and Appendix F), the City-wide drainage study prepared by Clarifica Inc. for the City of Vaughan (City of Vaughan 2009), and flood depth and flow velocity data provided by the TRCA.

An assessment of the likelihood of ice jam locations has not been considered separately in the risk assessment. Similarly, a slope study has not been undertaken to determine erosion risk in conjunction with flood risk. Thresholds to maintain stable slopes are included in policies in the new City of Vaughan Official Plan that is currently available for public review.

The City-wide drainage study (City of Vaughan 2009) includes data concerning Flood Vulnerable Roads (FVRs) and Flood Vulnerable Areas (FVAs). The drainage study also identifies surface ponding areas or “sinks”. These preliminary surface ponding areas have been identified using the surface elevation data from the DEM. The approach identifies ponding areas by analyzing surface topography and cross-referencing locations of stormwater management facilities and major river road crossings. Surface ponding areas are not considered in the risk assessment in the Woodbridge Focused Area Study.

Two main approaches are taken to quantify flood risk. In the first approach, dwelling unit counts from the capacity analysis are used to quantify development scenarios within the SPA and within the flood depths zones of the SPA. Damage costs from flooding events can also be estimated based on the residential dwelling unit counts. The approach using dwelling units as the unit of quantification is described in subsections 2.2.1 and 2.2.2 below. In the second approach, flood depth and flow velocity provided by TRCA are used to assess risk thresholds in relation to safe access and flooding as a threat to life as defined in the Natural Hazards Technical Guides. This approach is described in subsection 2.2.3 below.

2.2.1 Capacity Assessment and Build-Out Scenarios

A capacity assessment was undertaken to quantify the existing parcels and buildings in the SPA and determine the residential unit count. Intensification scenarios were developed to assess the level of risk associated with various degrees of development. The scenarios and results of the capacity assessment are provided in Appendix E and the capacity assessment methodology is explained in Appendix F.

The capacity assessment results can be used to estimate future population based on residential unit count. Average costs associated with a flooding hazard can also be determined based on residential unit counts.

Population is estimated using 3.1 persons per residential unit (ppu). This is based on York Region’s 2031 Land Budget report which notes that 3.1 ppu is the region-wide average for 2016. A high estimate of 3.6 ppu and low estimate of 2.8 ppu, also noted in the York Region Land Budget report, may also be used to estimate population based on residential unit count.

The following general costs (Table G.1) have been derived from real-world examples. Hence, overall costs associated with the residential unit counts for the various build-out scenarios can be estimated and applied to the evaluation of risk.

Table G.1 Estimated private property repair costs from flood damage.

Property Damage Private	Unit Cost	Duration
Home	$17,000	one time
Commercial	$23,550	one time
Vehicle	$12,000	one time
Clean-up	$4,000	one time

It is important to note that the development scenarios used in the capacity assessment do not represent preferred land use scenarios. The development scenarios are based on development densities in existing policy documents and a scan of existing development applications and submissions to the Official Plan review process. However, the development scenarios are designed to determine the degree of risk in parts of the SPA and to recommend land use changes. The preferred land use scenario is the land use schedule provided in the Woodbridge Centre Secondary Plan.

2.2.2 Capacity Assessment Results and Flood Depths

TRCA has provided the flood depth data in a geo-referenced format. This allows for a spatial analysis of the capacity assessment results, which are based on parcels, against the flood depth ranges. Taking into consideration the assumptions of the flood depth modelling, this analysis illustrates risk trends of the build-out scenarios. That is, this will quantify to what extent the additional residential units in the build-out scenarios are located inside or outside of the SPA, and whether they are in less sensitive or more sensitive parts of the SPA in relation to flood depth.

The flood depth data includes ranges from 0 to 1 metre, 1 to 2 metres, 2 to 3 metres, and greater than 3 metres. This information is illustrated thematically in Figure G.1 in which the existing and proposed SPA boundaries are shown in relation to the flood depth intervals. Ideally, the flood depth ranges would align with the flood depth thresholds interpreted from Appendix 6 of the River and Stream Limits: Flooding Hazard Limit Technical Guide (MNR and Watershed Science Centre 2002), contained in the subsection, Flooding as a Threat to Life. As shown in the discussion below in subsection 2.2.3 of this report, flood depth thresholds of 0.3 metres, 0.8 metres and 1.2 metres are noted in Appendix 6 of the River and Stream Limits: Flooding Hazard Limit Technical Guide (MNR and Watershed Science Centre 2002). However, this level of precision is not available in the data provided by TRCA from the regional flood modelling. Given the information cited below from Appendix 6 of the River and Stream Limits: Flooding Hazard Limit Technical Guide (MNR and Watershed Science Centre 2002), flood depths less than 1 metre are generally the less sensitive parts of the SPA. This is distinct from the attempt to identify the low risk areas of the SPA based on an analysis combining flood depth and flow velocities in subsection 2.2.3 below.

2.2.3 Preliminary Flow Velocities and Flood Depths

The City of Vaughan commissioned a City-wide drainage study undertaken by Clarifica Inc. The drainage study includes an assessment of Flood Vulnerable Areas (FVAs) and Flood Vulnerable Roads (FVRs) for various storm events, including the regional storm event. This data provides flood depths at various building locations and road locations and can be summarized for sub-areas of the SPA.

Preliminary flow velocities have been provided by the TRCA based on existing development conditions and existing and proposed SPA boundaries. Given thresholds for flow velocity and depth in the Natural Hazards Technical Guide, the information provided by TRCA can be used to identify general areas of higher and lower risk within the SPA. An excerpt from Appendix 6 of the River and Stream Limits: Flooding Hazard Limit Technical Guide (MNR and Watershed Science Centre 2002), contained in the subsection, Flooding as a Threat to Life, is provided below illustrating thresholds to determine lower and higher risk areas.

> "Although no product rule exactly defines this region, a reasonable approximation of the low risk area can be made with a product rule that includes some constraints on the domain of depth and velocity. For example, a product of depth and velocity less than or equal to 0.4 m^2/s (4 ft.2/s) defines the low risk area providing that depth does not exceed 0.8 m (2.6 ft.) and that the velocity does not exceed 1.7 m/s (5.5 ft/s). By contrast, in a situation where the depth and velocity are 1.1 m (3.5 ft.) and 0.3 m/s (1 ft./s) respectively, the product is less than 0.4 m^2/s (4 $ft.^2/s$) but the depth limit is exceeded. Hence, these conditions define a high risk area for some individuals."

Additional discussion in Appendix 6 regarding appropriate thresholds suggests certain margins of safety.

> "As a guide for personnel involved in stream flow/depth monitoring, the simple "3 x 3 rule" was developed in the U.S. based on 3 ft depth and 3 ft/s velocity values. The rule suggests that people would be at risk if the product (multiple) of the velocity and the depth exceeded 0.8 m^2/s (9 ft.2/s)."

> "As a result, it is likely that the simple rule of 3 x 3 product (1 m^2/s or 9 ft. $^2/s$) represents an upper limit for adult male occupants in the flood plain and that it would be reasonable to consider something lower as being more representative of a safe upper limit for most flood plain occupants."

> "The 3 x 3 line encloses a large area of depth and velocity conditions which would lead to instability for most individuals. The 3 x 2 line represents a general average, but it too encompasses areas of instability for many individuals."

> "The 2 x 2 line excludes most of the unstable conditions for most individuals and would appear adequate at first glance. However, the 2 x 2 rule also has limitations as shown on the graph. At low velocity but depths greater than 0.9 - 1.2 m (3 - 4 ft.), most individuals would become buoyant. Similarly, in areas where flood plain depths may be less than 0.3 m (1 ft.) but where velocities exceed 1.5 - 1.8 m/s (5 - 6 ft./s) encountered on roadways or bridge crossings, for example, stability conditions would be exceeded and some individuals would be swept off their feet."

> "Flow velocities which will cause erosion of grass covered slopes or erosion around foundations are difficult to determine. Factors such as type of cover, slope and soil conditions must be taken into account. For most common situations, the range lies between 0.8 m/s and 1.2 m/s (2.5 ft/s and 4 ft/s) for easily eroded soils and 1.1 m/s to 1.5 m/s (3.5 ft./s to 5 ft./s) for more erosion resistant soils."

Given the information in Appendix 6 of the River and Stream Limits: Flooding Hazard Limit Technical Guide, and subsequent discussions with the Ministry off Natural Resources, the following thresholds are used to rate low and high flood risk areas, which is depicted on Figure G.4:

> Low risk: Product of depth and velocity less than or equal to 0.37 m^2/s providing that depth does not exceed 0.8 m and that the velocity does not exceed 1.7 m/s.
>
> High risk: Product of depth and velocity greater than 0.37 m^2/s, or where flood depth exceeds 0.8 metres or flow velocity exceeds 1.7 m/s.

3.0 Results and Discussion

The SPA in the Woodbridge community of Vaughan can be described as 10 disjunct parts (Figure G.4). Figure G.2 depicts the existing SPA in relation to the flood limit modelled at that time while Figure G.1 depicts the proposed SPA boundaries in relation to the current flood limit. Table G.2 provides a brief description of each of the 10 sub-areas of the existing SPA.

Table G.2 Brief description of the Woodbridge Special Policy Area.

SPA ID	Predominant Land Uses	Number of Parcels	Number of Existing Residential Units
1	Open Space, Rural Residential and Employment	10	4
2	Residential Single Detached	71	71
3	Mostly Residential Single Detached with 1 Multi-residential Building	24	177
4	Commercial	5	*
5	Townhomes	1	24
6	Residential Single Detached and Open Space	8	6
7	Commercial	6	-
8	Open Space – Community Centre	1	-
9	Residential Single Detached, Mixed Use Commercial and Multi-residential (4 to 6 storeys)	169	736
10	Open Space (Golf Course) and Residential Single Detached	5	2
TOTAL		300	1020

* A small part of a parcel that includes a 30 unit seniors' residence overlaps the SPA. The building footprint of the seniors' residence is located outside of the SPA and the floodplain.

As noted in subsection 2.2, two approaches to quantifying geographic risk are described based on the unit of measure. One approach uses dwelling unit counts to assess risk as this metric can be used to estimate population and damage costs. In the second approach, thresholds for safe access and threat to life are interpreted from the River and Stream Limits: Flooding Hazard Limit Technical Guide (MNR and Watershed Science Centre 2002) using flood depth and flow velocity data. The approaches use differing metrics and no attempt has been made to normalize the data and combine the approaches to provide a final risk summary or rating. Rather, the results of the two approaches, together with the FVR and FVA ranking by Clarifica Inc. (2009), are summarized in subsections 3.1 to 3.4 below. Land use and policy recommendations are interpreted from the results of the risk assessment.

3.1 Capacity Assessment and Build-out Scenarios

The results of the capacity assessment, including the build-out scenarios, are provided in Appendix E.

The build-out scenarios only apply to the parts of the SPA identified as SPA #1, SPA #3, SPA #6, SPA #7, and SPA #9. Parcels in SPA #3 and SPA#6 were considered for higher density in the Islington Avenue Corridor Study (OPA 597). Redevelopment potential is likely in SPA #9, which includes the Woodbridge Commercial Core, according to policies in OPA 440. SPA #7 was considered given that there are development applications in this part of the SPA. SPA #1 was only considered in Scenario 5 of the capacity assessment (see Appendix E) as it was not identified for intensification in OPA 597, but there are existing multi-residential buildings close to the western boundary of the SPA.

In this subsection, the capacity assessment results are further described in relation to potential flood risk for parts of the SPA. Developable area is adjusted by removing parts of parcels with > 3 metres flood depth and > 2 metres flood depth under a Regulatory Flood event. As these are clearly high risk parts of the SPA, a significant decline in potential dwelling units when removing these parts of the SPA suggests that the risk of potential development in these parcels is not warranted. Recall that the risk thresholds for flood depths noted in Appendix 6 of the River and Stream Limits: Flooding Hazard Limit Technical Guide (MNR and Watershed Science Centre 2002) are 0.8 metres and 1.2 metres, such that including lands that could flood up to 2 metres reflects considerable risk. Subsection 3.2 provides a more detailed breakdown of dwelling unit counts for the full range of flood depths.

3.1.2 SPA Sub-Area #1

Only two parcels, 201 and 229 Pine Grove Road, located at the western boundary of SPA #1 are considered in Scenario #5. The combined area of the parcels is 6,670 square metres (0.67 hectares). Assuming 70% coverage and 0.5 FSI results in a Gross Floor Area of 2,335 square metres and approximately 23 dwelling units. Excluding areas > 3 metres flood depth results in a developable area of 3,857 square metres and 13 potential dwelling units. Excluding areas > 2 metres flood depth results in a developable area of 3,093 square metres and 11 potential dwelling units. Assuming 1.0 FSI results in 47 potential dwelling units for the entire lot area. This is reduced to 27 units and 22 units if the developable portion avoids areas in flood depths > 3 metres and > 2 metres, respectively.

3.1.3 SPA Sub-Area #3

The part of the SPA labelled SPA #3 currently includes 177 residential units, most of which (155 units) are in one multi-residential building. Building to recommended policies in OPA 597 (Scenario 2 - Intensification A) would add 62 residential units, resulting in 239 units in SPA #3.

Removing parts of the parcels in SPA #3 greater than 3 metres flood depth results in an additional 54 units, rather than 62 units, when using the parameters from Scenario 2 (Intensification A) to predict capacity, indicating that only a small percentage of the area is at risk of the deepest flooding. Removing parts of the parcels in SPA #3 greater than 2 metres flood depth for the same scenario provides only an additional 17 units. This suggests that most of this part of the SPA is at considerable risk if reducing the net developable area to the portion where flood waters would be less than 2 metres results in a 70% reduction in potential build-out.

Increasing the density of the Residential Medium Density designation according to Scenario 3 (Intensification B) results in an additional 187 units. Note that this scenario has also included more parcels in the build-out scenario that adds 17,606 square metres of gross site area.

Removing parts of the parcels in SPA #3 greater than 3 metres flood depth results in an additional 165 units, rather than 187 units, when using the parameters from Scenario 2 (Intensification A) to predict capacity. This represents a change of only 12%. Removing parts of the parcels in SPA #3 greater than 2 metres flood depth for the same scenario provides only an additional 83 units, which is a change of 56%. As above, this reflects a significant change in potential build-out if the net developable area is reduced only to those parts where flood waters would be less than 2 metres.

3.1.4 SPA Sub-Area #6

There are currently only 6 residential units, all single detached homes, in the part of the SPA labelled SPA #6. Building to recommended policies in OPA 597 (Scenario 2 - Intensification A) would add 125 residential units.

Removing parts of the parcels in SPA #6 greater than 3 metres flood depth results in an additional 69 units, rather than 125 units, when using the parameters from Scenario 2 (Intensification A) to predict capacity. This is only 55% of the original build-out estimate and indicates much of SPA #6 is in a part of the floodplain at considerable risk from flooding. Indeed, removing parts of the parcels in SPA #6 greater than 2 metres flood depth for the same scenario provides only an additional 40 units, or only 30% of the original build-out estimate. This suggests that most of this part of the SPA is at considerable risk if reducing the net developable area to the portion where flood waters would be less than 2 metres results in a 70% reduction in potential build-out.

Increasing the density of the Residential Medium Density designation according to Scenario 3 (Intensification B) results in an additional 147 units. Removing parts of the parcels in SPA #6 greater than 3 metres flood depth results in an additional 93 units, rather than 147 units, when using the parameters from Scenario 3 (Intensification B) to predict capacity. This represents a change of 37%. Removing parts of the parcels in SPA #6 greater than 2 metres flood depth for the same scenario provides only an additional 54 units, which is a change of 63%. As above, this reflects a significant change in potential build-out if the net developable area is reduced only to those parts where flood waters would be less than 2 metres.

3.1.5 SPA Sub-Area #7

The General Commercial designation at the southwest corner of Avenue 7 and Islington makes up most of this part of the SPA. SPA #7 is not considered in Scenarios 1 and 2 of the capacity assessment as the policies of OPA #661 do not cover these lands. Rather, Scenarios 3 and 4 (Intensification B and C) consider extending the Transit Stop Centre policies of OPA #661 to this area. This results in an additional 87 units and 116 units, respectively, when the parameters for Scenarios 3 and 4 are applied to the lands.

Given that only Scenarios 3 and 4 are applied to the lands, the modified capacity assessment by including only net developable area below the 2 metre and 3 metre flood depth also only considered these Scenarios. Removing parts of the parcels in SPA #7 greater than 3 metres flood depth results in an additional 12 units, rather than 87 units, when using the parameters from Scenario 3 (Intensification B) to predict capacity. This represents a change of 86%. Removing parts of the parcels in SPA #7 greater than 2 metres flood depth for the same scenario provides only one additional unit. Hence, most of this part of the SPA includes lands where flood depths from a Regulatory Flood would be 2 metres or greater.

The change in capacity assessment for Scenario 4 (Intensification C) is similar. Considering only net developable area in lands that would experience less than 3 metres flood depth reduces the additional units from 116 units to 17 units. Considering only lands that would experience less than 2 metres flood depth reduces the additional units from 116 to 1.

3.1.6 SPA Sub-Area #9

The part of the SPA labelled SPA #9 includes 613 residential units. Building to policies in OPA 440 (Scenario 1) would add 199 residential units. Additional units in SPA #9 according to build-out parameters for Scenarios 3 and 4 (Intensification B and C) would add 348 and 411 units, respectively.

Removing parts of the parcels in SPA #9 greater than 3 metres flood depth results in an additional 165 units, rather than 199 units, when using the parameters from Scenarios 1 and 2 to predict capacity. This is a change of 17% and indicates that only small percentage of the redevelopment area is at risk of the deepest flooding. Removing parts of the parcels in SPA #9 greater than 2 metres flood depth for the same scenario provides an additional 142 units. This represents a fairly modest change of less than 30% and suggests that the likely redevelopment area in SPA #9 is less susceptible to the deepest flooding.

Removing parts of the parcels in SPA #9 greater than 3 metres flood depth results in an additional 306 units, rather than 348 units, when using the parameters from Scenario 3 (Intensification B) to predict capacity. This represents a change of only 12%. Removing parts of the parcels in SPA #9 greater than 2 metres flood depth for the same scenario provides only 266 units, which is a change of 24%.

The scenario results have not been revised since the approval of 125 dwelling units (Z.08.045 and DA.11.071) in SPA sub-area 9a2.

3.2 Capacity Assessment Results and Flood Depths

A second approach to determine the level of risk associated with parts of the SPA is to categorize the residential unit counts from the build-out scenarios according to flood depths (Table G.3). A modified parcel fabric layer was developed by intersecting the flood depth data provided by TRCA. The area of each parcel is calculated within each the following flood depth ranges: 0 to 1 metre depth; 1 to 2 metre depth; 2 to 3 metre depth; and >3 metres depth. A single parcel can overlap several flood depth ranges. Hence, the flood depth range representing the highest proportion of the parcel is the flood depth used for the purpose of this analysis. Parcels in which the highest areal proportion are in the 0 to 1 metre flood depth range or outside of the SPA are grouped together in the 0 to 1 metre flood depth range in the tables below.

Table G.3 Build-out scenario results categorized by flood depth for parts of the SPA with a major residential component.

Flood Depth/ Scenario	**SPA #1**	**SPA #2**	**SPA #3**	**SPA #6**	**SPA #7**	**SPA #9**
Flood Depth 0–1 metre						
Existing	*1*	*71*	*166*	*2*	*-*	*516*
Scenario 1 (Approved OPA 440 and 597)			-			147
Scenario 2 - Intensification A (Deferred OPA 597)			7	26		-
Scenario 3 - Intensification B			54	24		286
Scenario 4 - Intensification C			62	25		343
Flood Depth 1-2 metres						
Existing			*1*		*-*	
Scenario 1 (Approved OPA 440 and 597)			-			-
Scenario 2 - Intensification A (Deferred OPA 597)			-			-
Scenario 3 - Intensification B			5	-		-
Scenario 4 - Intensification C			6	-		-
Flood Depth 2-3 metres						
Existing			*8*	*3*	*-*	*23*
Scenario 1 (Approved OPA 440 and 597)			-			-
Scenario 2 - Intensification A (Deferred OPA 597)			55	69		-
Scenario 3 - Intensification B			115	86	10	-
Scenario 4 - Intensification C			134	92	13	-
Flood Depth > 3 metres						
Existing	*2*		*2*	*1*	*-*	*74*
Scenario 1 (Approved OPA 440 and 597)			-			51
Scenario 2 - Intensification A (Deferred OPA 597)				30		-
Scenario 3 - Intensification B			13	38	78	64
Scenario 4 - Intensification C			13	40	104	68

Table G.4 Total private residence repair costs based on residential unit counts for build-out scenarios.

Flood Depth/ Scenario	**Unit Count (#)**	**Dwelling Unit Repair Cost ($) ($17K/unit)**	**Vehicle Repair Cost ($) ($12K/unit)**	**Clean Up Cost ($) ($4K/unit)**	**Total Private Residence Repair Costs ($)**
Flood Depth 0–1 metre					
Existing	*812*	*13.8 M*	*9.7 M*	*3.2 M*	*26.7 M*
Scenario 1 (Approved OPA 440 and 597)	147	2.5 M	1.8 M	588 K	4.9 M
Scenario 2 - Intensification A (Deferred OPA 597)	33	561 K	396 K	132 K	1.1 M
Scenario 3 - Intensification B	364	6.2 M	4.4 M	1.5 M	12.1 M
Scenario 4 - Intensification C	430	7.3 M	5.2 M	1.7 M	14.2 M
Flood Depth 1-2 metres					
Existing	*24*	*408 K*	*288 K*	*96 K*	*792 K*
Scenario 1 (Approved OPA 440 and 597)	-				
Scenario 2 - Intensification A (Deferred OPA 597)	-				
Scenario 3 - Intensification B	5	85 K	60 K	20K	165 K
Scenario 4 - Intensification C	6	102 K	72 K	24 K	198 K
Flood Depth 2-3 metres					
Existing	*11*	*187 K*	*132 K*	*44 K*	*363 K*
Scenario 1 (Approved OPA 440 and 597)	-				
Scenario 2 - Intensification A (Deferred OPA 597)	124	2.1 M	1.5 M	496 K	4.1 M
Scenario 3 - Intensification B	211	3.6 M	2.5 M	844 K	6.9 M
Scenario 4 - Intensification C	239	4.0 M	2.9 M	956 K	7.9 M
Flood Depth > 3 metres					
Existing	*79*	*1.3 M*	*948 K*	*316 K*	*2.6 M*
Scenario 1 (Approved OPA 440 and 597)	50	850 K	600 K	200 K	1.7 M
Scenario 2 - Intensification A (Deferred OPA 597)	30	510 K	360 K	120 K	990 K
Scenario 3 - Intensification B	193	3.3 M	2.3 M	772 K	6.4 M
Scenario 4 - Intensification C	225	3.8 M	2.7 M	900 K	7.4 M

This analysis is not intended to describe risk at the scale of each individual parcel since the capacity assessment is based on build-out assumptions and the flood depth data is based on regional modelling. Rather, trends in build-out results toward lower flood depths illustrates residential capacity in less sensitive parts of the SPA while build-out trends in greater flood depths indicates higher risk if residential capacity is identified for these areas.

Using the repair costs from Table G.1 of this report, the total private residence repair costs for each of the build-out scenarios is provided in Table G.4. Note that this is an underestimate of repair costs for dwellings in the deeper flood depths as an average dwelling unit repair cost was used. The Flood Damage Estimation Guide (OMNR 2007) can provide much more detail on potential damage costs for individual buildings and a plan area. However, this type of GIS-based analysis is not required to demonstrate trends in increasing or decreasing damage costs. It may be more appropriate to evaluate potential future remediation measures, which are not considered in this SPA review.

The data in Table G.3 indicate that build-out to current approved policies (Scenario 1) largely adds dwelling units either outside the SPA or in the 0 to 1 metre flood depth range. However, there is a high likelihood that over 50 dwelling units may be built in parcels characterized by the deepest flood depths.

Build-out to the densities and in the parcels identified in the deferred policies of OPA 597 (Scenario 2) mostly adds dwelling units in the 2 to 3 metre flood depth range. The two additional intensification scenarios (Scenarios 3 and 4) also appear to add most of the dwelling units in the 2 to 3 metre flood depth range.

As shown in Table G.3, only the build-out to current approved policies meets the intent of Section 3 of the PPS and the direction in the Terms of Reference for the Woodbridge Focused Area Study to direct growth to areas outside of the SPA or to less sensitive parts of the SPA.

Total private residence repair costs based on existing buildings is estimated to be over $30 M (Table G.4). This could increase by an additional $6.6 M for build-out according to current approved policies. Total private resident repair costs could further increase by $6.5 M if build-out occurs according to the deferred policies of OPA 597. Additional intensification as described in Scenarios 3 and 4 would increase total private residence repair costs by over $25 M and $29 M, which represents almost a doubling of repair costs in comparison to the current situation.

3.3 Flow Velocities and Flood Depths

TRCA further subdivided the SPA (Figure G.4) for the purposes of providing flow velocities and average flood depths. The SPA was subdivided into areas with similar hydraulic characteristics in order to provide more appropriate averaging of the flood depths and flow velocities. The results are shown in Table G.5 along with the risk ranking as described in Section 2.2.3.

The results of the risk rating show that only three parts of the SPA (SPA #2, SPA #4b2, and SPA #9a2), would experience a combination of flow velocities and flood depths that do not exceed the risk thresholds recommended in the Natural Hazards Technical Guides (Figure G.4). SPA #2 is a stable residential area and is not likely to experience intensification. Furthermore, the flood plain for this area has been reduced, which is documented in more detail in the final SPA justification report. As a result, the modified SPA is likely to include a smaller number of existing residences.

SPA #4b2 is designated commercial and open space and will not include residential units.

SPA #9a2 includes the part of the SPA bounded to the south by Woodbridge Avenue, to the north by Arbors Lane and to the east by Clarence Street. It is characterized by shallow flood depths, which is the main factor resulting in a product of flood depth and velocity that is below the 0.37 m^2/s threshold recommended in the Natural Hazards Technical Guides. This part of the SPA is likely to be affected by most of the residential intensification according to approved policies in OPA 440.

Parts of SPA #3 and SPA #6 are identified for residential intensification in OPA 597. However, these areas are identified as being at high risk according to the average flood depth and preliminary flow velocities.

Table G.5 Flow velocities and average flood depths for the SPA. The risk rating is described in Section 2.2.3, where low risk areas are defined where the product of depth and velocity is less than or equal to 0.37 m^2/s providing that depth does not exceed 0.8 m and that the velocity does not exceed 1.7 m/s.

SPA Subdivision Id:	Representative Cross Sections	Average Depth of Flooding (m)	Velocity (m/s)	Average Velocity (m/s)	Product Depth and Velocity (m^2/s)	Risk Rating
1a1	21.12	1.63	0.69	0.71	1.15	High
	21.11		0.55			
	21.10		0.88			
1a2	21.10	0.99	0.88	0.88	0.87	High
2b1	21.10	N/A	1.21	1.21		N/A
2b2	21.10	0.18	1.21	0.97	0.17	Low
	21.09					
	21.08		0.73			
3a1	21.08	1.92	1.08	0.82	1.57	High
	21.07		0.56			
3a2	21.08	2.06	0.62	0.54	1.10	High
	21.07		0.45			
3a3	21.07	1.31	0.38	0.54	0.70	High
	21.06		0.69			
4b1	21.04	1.82	0.64	0.65	1.18	High
	21.03		0.62			
	21.02		0.68			
4b2	21.041	0.67	0.62	0.56	0.37	Low
	21.04		0.56			
	21.03		0.54			
	21.02		0.50			
5	21.01	2.04	0.59	0.59	1.20	High
6b1	27.58	2.60	0.53	0.53	1.38	High

SPA Subdivision Id:	Representative Cross Sections	Average Depth of Flooding (m)	Velocity (m/s)	Average Velocity (m/s)	Product Depth and Velocity (m^2/s)	Risk Rating
6b2	27.572	3.08	0.34	0.37	1.14	High
	27.571		0.40			
7	27.531	3.59	2.57	1.27	4.57	High
	27.52		0.82			
	27.51		0.43			
8	27.54	2.50	1.10	1.13	2.81	High
	27.532		1.15			
9a1	13.03	1.94	0.40	0.33	0.65	High
	13.02		0.37			
	13.01		0.34			
	27.58		0.23			
9a2	27.58	0.54	0.15	0.19	0.10	Low
	27.572		0.23			
9a3	27.57	1.56	0.71	0.63	0.99	High
	27.56		0.66			
	27.55		0.53			
9a4	27.58	0.95	0.56	0.59	0.56	High
	27.572		0.61			
9a5	13.03	1.79	0.47	0.48	0.85	High
	13.02		0.52			
	13.01		0.36			
	27.58		0.56			
9a6	13.03	2.06	0.47	0.50	1.02	High
	13.02		0.52			
10	13.06	1.08	0.86	0.60	0.65	High
	13.043		0.63			
	13.042		0.31			

TRCA also provided complementary data on flood frequency for a portion of the SPA in the Woodbridge commercial core, parts of which are likely to redevelop. TRCA assessed water levels and flows related to various return period flows for SPA sub-areas 9a2, 9a3 and 9a4, which are ranked in Table G.5 as low, high and moderate risk, respectively. While the flood depth and flow velocity information remain the same in the modelled approach as for the Regulatory Flood, a return period is assumed for the flood event. TRCA does not normally identify a return period for the Regulatory Flood as it reflects the maximum historical event and plots as an outlier on any statistical analysis of flood frequency. However, assuming a specific return period for the flood event allows for an assessment of a return period for which flooding first begins for specific parts of the flood zone. Hence, a longer return period at which flooding first begins for a specific geographic area reflects decreasing risk.

Results are provided in Table G.6 below for SPA sub-areas 9a2, 9a3 and 9a4 considering a 500 year return period for the flood event. The 500 year return period is an appropriately conservative flood management approach to reflect the risk of flooding for events between the 100 year event and Regulatory Flood.

Table G.6 Additional hydraulic analysis of flood frequency for a portion of the Special Policy Area in the Woodbridge commercial core. A 500 year return period for the flood event is assumed.

SPA Sub-area	Interpolated Return Period at which Flooding First Begins	Risk of Exceedance on a Yearly Basis
9a2	1 : 450 year	0.22%
9a3	1 : 195 year	0.51%
9a4	1 : 360 year	0.28%

Of the SPA sub-areas assessed in the approach above, sub-area 9a2 shows the least risk based on the interpolated return period at which flooding first begins. The information is supportive of the analysis using average flood depths and flow velocities (Table G.5), which identifies sub-area 9a2 as an area in which risk thresholds are not exceeded. By contrast, sub-area 9a3 includes the area in closer proximity to the Humber River to the south of Woodbridge Avenue and has a much shorter interpolated return period at which flooding first begins, signifying a higher risk.

3.4 Flood Vulnerable Areas and Flood Vulnerable Roads

The City-wide drainage study (City of Vaughan 2009) includes databases of Flood Vulnerable Areas (FVAs) and Flood Vulnerable Roads (FVRs) for various storm events, including the regional storm. A summary of the FVAs and FVRs for the regional storm event is provided below.

The flood vulnerability analysis involves calculation of the Flood Emergency Response Index (FERI). The FERI approach was developed to prioritize the planning and emergency response at Flood Vulnerable Areas (FVAs) and Flood Vulnerable Roads (FVRs) based on various vulnerability criteria. The FERI approach yields a priority list based on risk prior to and during large storm events.

Relevant factors considered in the index have been defined separately for buildings (FVAs) and road crossings (FVRs). Weights have been used to assign relative values to each criteria factor. At this stage of plan development, response priority focuses on the risk to public safety rather than the property damage. The initial Flood Emergency Response Index (FERI) was developed from basic assumptions for buildings and crossings as described below. While the FERI provides a baseline for conditions, it is important to note that the City's response protocols are much more stringent with a focus on the highest possible level of safety during an emergency.

FVAs are centered on building lots and criteria to determine FERI scores for FVAs include:

1. Land Use: The land use is the most important component in the vulnerability analysis as it relates the potential number of people and their response to critical flood conditions.

2. Private Vehicle Access: Private vehicle access is one mode of evacuation. This assumes that the vehicle is serviceable and reachable from the building, and that the road is safe. Flooded roads may wash-out and the degraded road may not be visible under flood waters. Hence, the vehicle could be swamped or float downstream. Flood waters can enter the exhaust system and short out the vehicle's electrical system, which would place residents at unnecessary risk. To reduce the level of risk to the public, the City would initiate the evacuation plan in advance of flooding and advise those who refuse to leave to take refuge in upper levels of the building.

3. Emergency Vehicle Access: This approach is used to evacuate people at key locations. Typically, because of the size, weight and height, an emergency vehicle would have greater access to a flooded site than a private vehicle. Emergency Services would implement their standard operating procedures to stage at a safe location from the hazard. While it can be assumed that the size, weight and height of an emergency vehicle (Fire Apparatus) would give it greater access to a flooded site, the design of the mechanical components of the vehicle would render the vehicle inoperable if it entered flood waters. Many Vaughan Fire and Rescue Service (VFRS) vehicles have low exhaust systems (30 cm from the road surface) and the engine is not an enclosed system. Flood waters would be drawn in through the exhaust and other mechanical systems, severely damaging the apparatus. VFRS SOG OP 0021 requires fire vehicles to park at a safe and appropriate distance from the scene based on proper size-up, in the best location to facilitate safe traffic flow and to enhance the safety of personnel while mounting and dismounting the vehicle and removal/replacement of equipment. Ambulances and police cars do not have the weight, size or height to enter flooded areas and would also stage in a safe location. VFRS crews would utilize boats such as zodiacs or heavy construction equipment such as front end loaders to affect rescue in flooded areas.

4. Human Access: This is a measure of the ability for people to walk out of a vulnerable site. However, debris, hazardous materials and water velocity can create an unsafe situation for people to walk through flood waters.

The flood vulnerability analysis approach developed for road crossings (FVRs) is similar to buildings. The FERI score for each stream crossing must be identified using GIS tools together with the predicted water level, flood mapping, and building location layer. The analysis then incorporates two key factors:

1. Type of road usage; and
2. Overtopping depth.

Two important considerations must be recognized in conjunction with the FERI approach.

- The conditions that must be in place for the Humber and East Humber to flood are such that early notification and evacuation of the population in the potentially affected area would be initiated and completed in advance of the rivers breaching their banks.
- Public awareness and education on actions residents and property owners should take during an evacuation due to a potential flood emergency is a critical component of reducing risk.

Of the 494 FVAs identified in the City of Vaughan, 196 are located in the Woodbridge study area and most of these FVAs (193) are located in the existing SPA (Table G.7 and Figure G.5). Only two FVAs are removed from the proposed SPA (Table G.7). Of the 100 highest-ranked (most at risk) FVAs, according to the FERI score, 91 are located in the study area.

Of the 120 FVRs identified in the City of Vaughan, only 12 are located in the study area. Only 4 FVRs are located in the existing SPA (Figure G.6): 2 FVRs in sub-area #2; and 2 FVRs in sub-area #9. The FVRs in sub-area #9 are removed from the proposed SPA boundaries, leaving only 2 FVRs in the proposed SPA.

Five of the FVRs in the Woodbridge study area are in the top 20 ranked (most at risk) FVRs. In addition, the highest ranked FVR is located just to the south of the study area where the Humber River is adjacent to Islington Avenue near 7471 Islington Avenue (south of Highway 7).

Table G.7 Count of Flood Vulnerable Areas (FVAs) in the existing and proposed SPA.

Current (Old) SPA	**Count**	**New SPA**	**Count**
1	6	1a1	2
		1a2	3
2	11	2b1	-
		2b2	6
3	2	3a1	-
		3a2	-
		3a3	2
4	3	4b1	2
		4b2	1
5	2	5	4
6	4	6b1	1
		6b2	3
7	7	7	7
8	1	8	1
9	153	9a1	84
		9a2	7
		9a3	15
		9a4	3
		9a5	40
		9a6	7
10	4	10	3
TOTAL	193	TOTAL	191

3.5 Infrastructure in the SPA

The area of the SPA is fully serviced and new infrastructure is not proposed. Table G.8 provides an inventory of existing infrastructure in the existing and proposed SPA. The decrease in the amount of infrastructure in the proposed SPA is only partly a result of the overall reduced area of the SPA. For the most part, the decrease in infrastructure is a result of the alignment of the proposed SPA boundaries along property boundaries and, hence, avoiding roads and road allowances.

Figure G.7 shows the infrastructure locations with respect to the existing SPA.

Table G.8 Inventory of infrastructure in the existing and proposed SPA.

Infrastructure Type	Unit	Existing SPA	Proposed SPA
Water	Length (km)	5.33	1.78
Storm	Length (km)	4.53	2.45
Sanitary	Length (km)	4.99	1.59
Sidewalk	Length (km)	7.62	3.23
Barrier	Length (m)	162.33	106.5
Pole	No.	90	33
Street Light	No.	90	33
Catchbasin	No.	72	30
Culvert (< 1.2 m)	No.	18	3
Culvert (> 1.2 m)	No.	1	1
Geodetic Control Survey Monument	No.	3	1
Hydrant	No.	33	10
Inlet / Outlet	No.	2	1
Bridge Structure	No.	5	5

4.0 Conclusions

Categorizing the build-out scenarios by flood depth shows that only the current approved policies direct development to the less sensitive parts of the SPA. Similarly, estimates of private residence repair costs increase 20% from existing conditions assuming build-out to current approved policies. A further 20% increase results if build-out occurs to the deferred policies of OPA 597. The additional intensification scenarios result in potential 80% and 90% increases in private residence repair costs over existing conditions.

Finally, consideration of both average flood depth and flow velocities shows that risk to life thresholds, as noted in the Natural Hazards Technical Guides, are not exceeded in only three parts of the SPA. Of these, only the area to the northwest of Clarence Street and Woodbridge Avenue, coded as SPA #9a2, will include residential redevelopment within the 2031 planning horizon.

5.0 Recommendations Regarding SPA Boundaries and Policies

Consistent with policies in Section 3 of the Provincial Policy Statement, it is important to recognize that intensification potential exists outside of the SPA along Kipling Avenue. An estimated 1,022 additional dwelling units can be provided as described in the Kipling Avenue Corridor Secondary Plan (formerly OPA 695).

It is recommended that residential and commercial development in the Woodbridge Commercial Core can proceed according to approved policies in OPA 440 and consistent with the Woodbridge Heritage Conservation District Plan. This generally represents the less sensitive parts of the SPA, although not always limited to only the low risk parts of the SPA.

Residential intensification for the SPA along Islington Avenue is not recommended as these parts of the SPA are at high risk from a flood event. This constitutes a change from the recommendations in OPA 597. However, the Region of York deferred approval of the policies regarding the SPA in OPA 597.

Risks to existing and proposed infrastructure and an analysis of infrastructure replacement costs are not provided in this assessment. Only a small change in land use is recommended from the risk assessment. As these land use changes do not require expanded infrastructure requirements, a further risk assessment of infrastructure is not warranted.

5.1 Deletions Due to Flood Plain Reductions

Most changes to SPA boundaries reflect reductions due to revised flood plain mapping. These changes are summarized in Section 5.0, Special Policy Area Boundary Adjustments and Policy Modifications, of the main SPA Justification Report. Furthermore, all SPA additions and reductions are summarized in Appendix D (Summary of Special Policy Area Boundary Modifications).

5.2 Required Municipal Policy Changes

Section 3.0 of the *Procedures for the Approval of New Special Policy Areas (SPAS) and Modifications to Existing SPAS Under the Provincial Policy Statement 2005 (PPS, 2005), Policy 3.1.3 – Natural Hazards – Special Policy Areas*" (MNR 2009) also lists the information requirements for a change to SPA policies. This can include any proposed changes to the existing land use designations/densities as well as policies specific to the SPA requirements.

All land use designations in the Woodbridge Centre Secondary Plan are changing to reflect the designations in the new City-wide Official Plan, VOP 2010 (adopted by Council in September 2010). However, the residential densities are only changing for the part of the SPA in the Woodbridge Commercial Core (SPA sub-areas 9a2, 9a3 and 9a4). This is described in more detail in Section 6 of the main SPA Justification Report. There are two other parts of the SPA worth noting, as provided below.

5.2.1 Market Lane Area (Northwest corner of Woodbridge Avenue and Clarence Street

Current development in the Mixed Use Commercial designation in the Woodbridge Core has generally been at higher densities than permitted in OPA 440. This is the only low risk part of the SPA with redevelopment potential. Hence, it is recommended that this minor increase in risk is acceptable and in keeping with the original justification for the "central" part of the SPA as described in OPA 145. This area is described in more detail in Section 6.0, Summary of Flood Risk, in the main SPA Justification Report.

5.2.2 Parcels at 145 and 153 Woodbridge Avenue

Parts of these parcels are included in the proposed SPA boundary. The lands are designated Low-Rise Mixed-Use in the Woodbridge Centre Secondary Plan with an FSI of 1.0. This allows for residential development as the parcels redevelop. Applications for redevelopment should demonstrate that the building footprint is outside of the SPA in order not to trigger the SPA policies.

5.2.3 Parcel at 8265 Islington Avenue

The parcel at 8265 Islington Avenue is part of a group of parcels recommended to allow an increase in density up to 1.0 FSI in the Low Rise Residential (2) designation. However, the Low Rise Residential (2) designation only applies to the part of the parcel outside of the SPA. The balance of the lands are designated Low-Rise Residential.

5.3 Alternative Floodplain Management Approaches

The SPA boundary modifications maintain the original intent of the SPA, which is to maintain the continued viability of the historic Woodbridge Commercial Core that would otherwise be limited by the one zone flood plain management approach. Specifically, the existing policies allow for a scale of redevelopment that could not be achieved through a one zone approach. Additionally, the flood depths within the SPA, particularly along Islington Avenue, would severely limit or preclude viable redevelopment, renewal, and consistent management of these floodprone areas, if a one zone management approach was to be applied.

The Province has also established procedures for assessing the suitability of applying the Two Zone Concept as an alternative flood plain management approach to the One Zone or SPA Concepts. The Two Zone Concept separates the flood plain into two zones: the floodway and the flood fringe. Using this approach, development and site alteration may be permitted within the flood fringe, subject to specific conditions, including the requirement to floodproof new development and redevelopment to the Regulatory Flood elevation. New development in the floodway is to be prohibited or restricted. The Special Policy Area concept allows for selective development and redevelopment to occur in the flood fringe and floodway, (in which development already exists particularly in urbanized areas), that would be otherwise precluded by the application of the Two Zone Concept. In order to allow for a scale of development and redevelopment and renewal to maintain continued viability of the Woodbridge Commercial Core, and in keeping with the original intent, the SPA remains the most reasonable flood plain management approach. Notwithstanding this, the City of Vaughan has incorporated the principles of the Two Zone Concept in its comprehensive risk management approach to the SPA review and update by directing modest additional dwelling units to the low risk, accessible area of the flood plain and maintaining existing development permissions within the deeper, less accessible areas of the flood plain.

6.0 References

Auld, H., D. MacIver, J. Klaasen, N. Comer and B. Tugwood. 2007. Planning for atmospheric hazards and disaster management under changing climate conditions. Occasional Paper 12, Adaptation and Impacts Research Division (AIRD), Environment Canada. 16 pp.

City of Vaughan. 2009. City-wide Drainage and Stormwater Management Criteria Study. Prepared by Clarifica Inc.

Ontario Ministry of Natural Resources. 2007. Flood Damage Estimate Guide. Prepared by Water's Edge, W.F. Baird and Associates and Planning Solutions Inc. May 2007. 72 pp.

Ontario Ministry of Natural Resources and Watershed Science Centre. 2002. Adaptive Management of Stream Corridors in Ontario including Natural Hazards Technical Guides. Queen's Printer for Ontario. ISBN: 0-9688196-0-51

York Region. 2009. York Region 2031 Land Budget. York Region Planning and Development Services. January 2009. 48 pp.

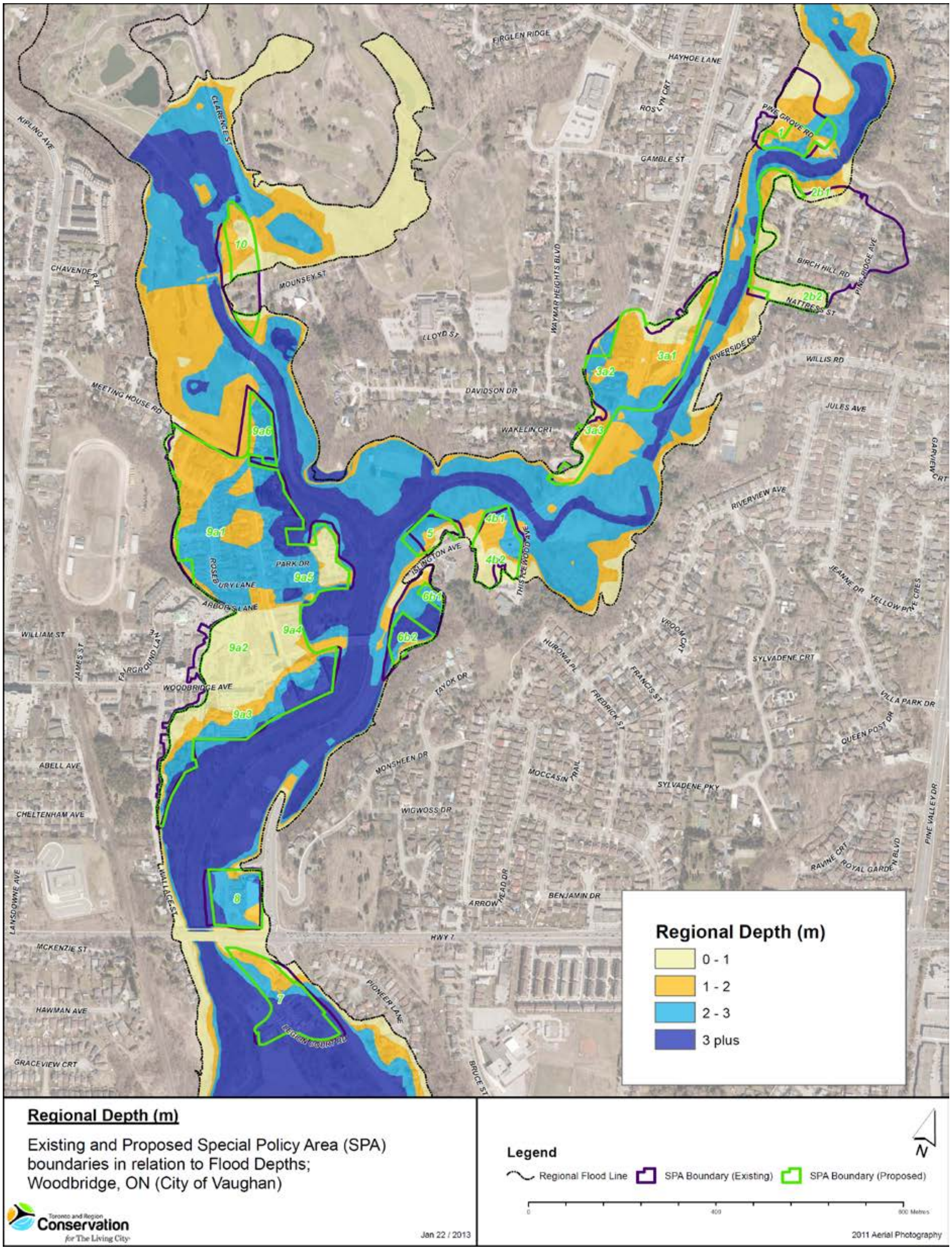

Figure G.1 Existing and proposed Special Policy Area (SPA) boundaries in relation to the flood depths, at 1 metre intervals, from a Regulatory Flood event. Prepared By: TRCA, 2013.

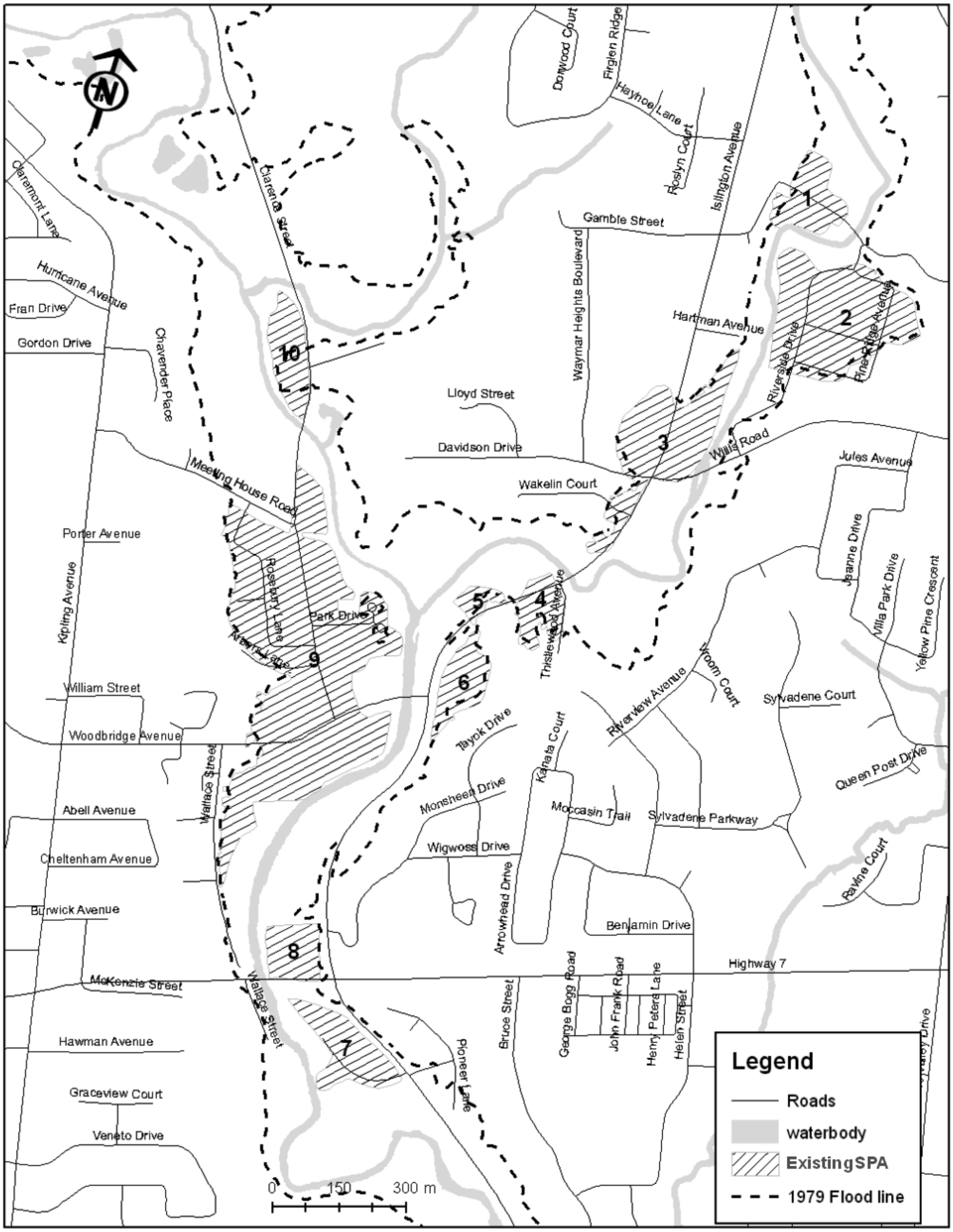

Figure G.2 Existing Special Policy Area (SPA) boundaries as delineated in OPA 440 in relation to the flood limit (derived from 1979 data). Number codes are used to identify disjunct parts of the SPA.
Prepared By: City of Vaughan. Data Source: TRCA, 2011.

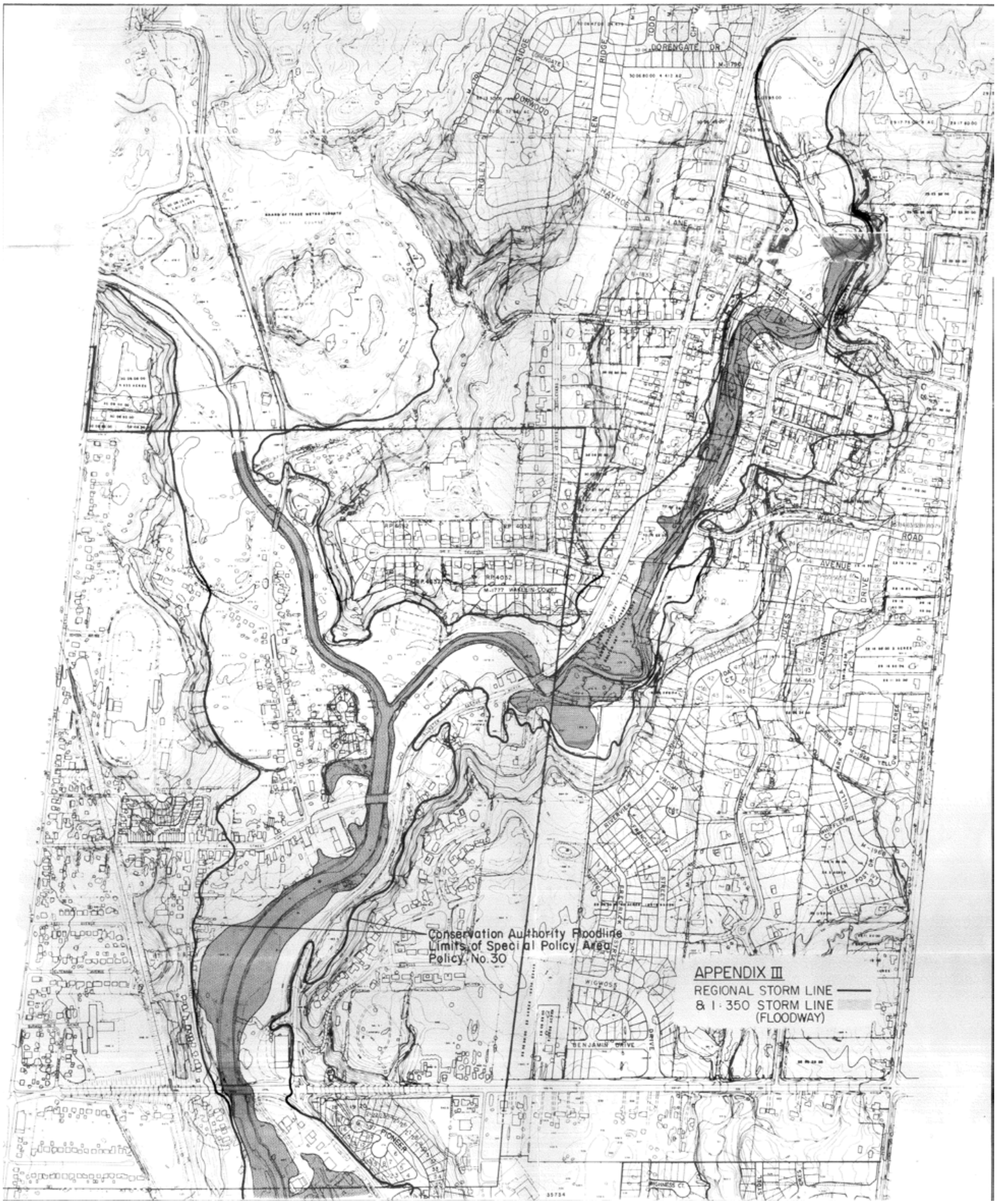

Figure G.3 1979 Floodline and limit of 1:350 year Floodway. Source: TRCA, 1979.

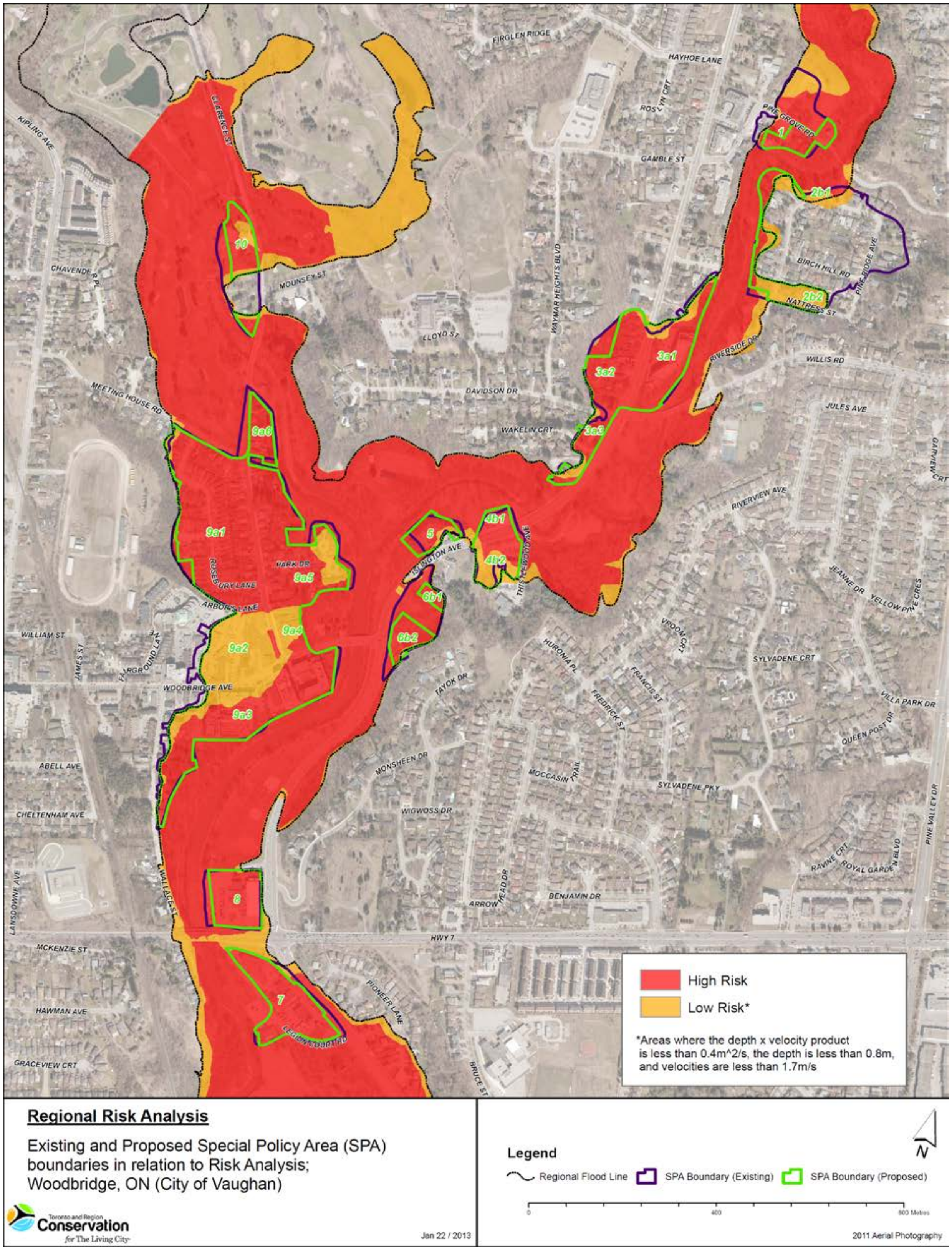

Figure G.4 SPA divisions of the proposed SPA for the purposes of calculating flow velocities and flood depths, in relation to flood risk rating. Source: TRCA, 2013.

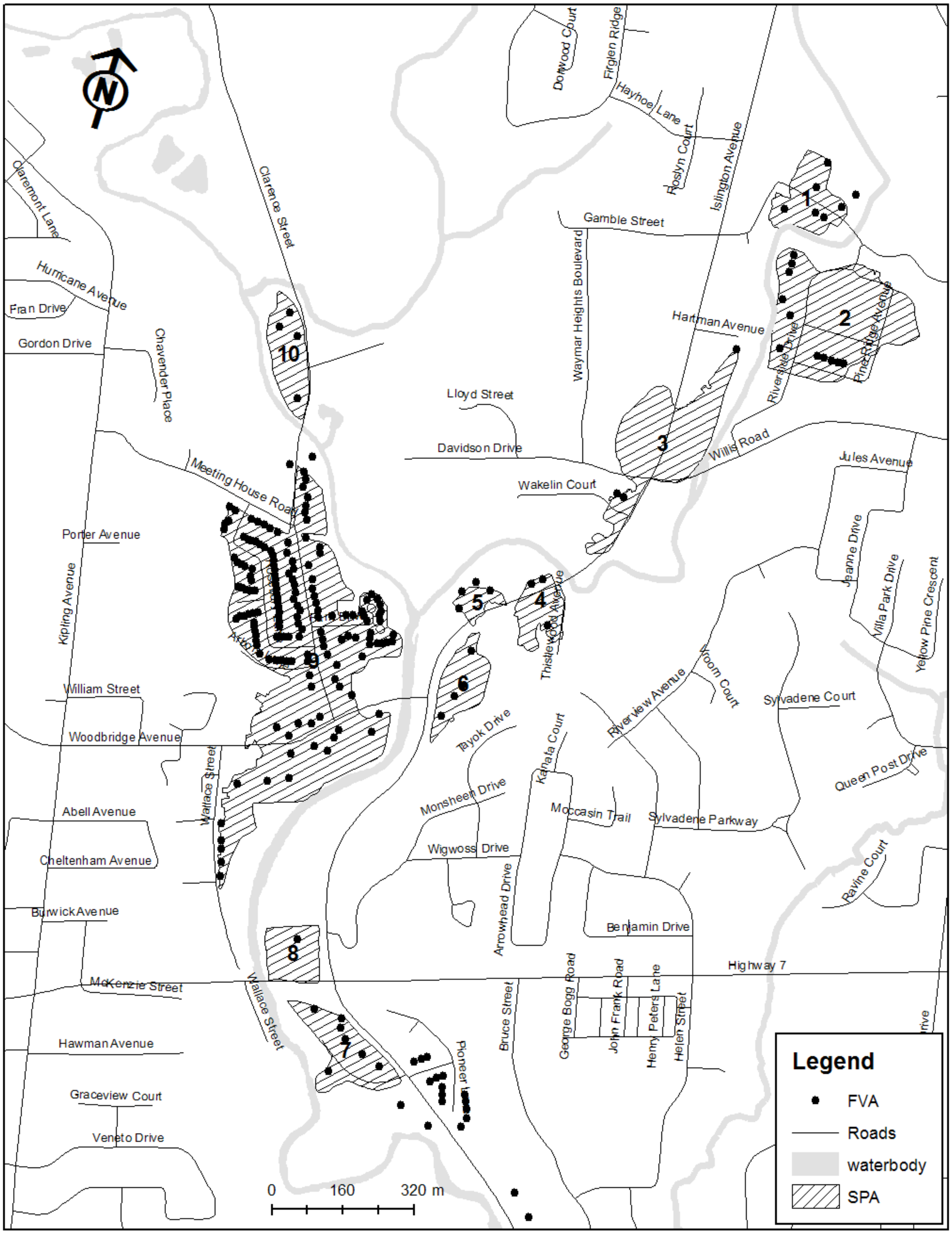

Figure G.5 Flood Vulnerable Areas (FVAs) in relation to the existing SPA. Source: City of Vaughan, 2009, City-wide Drainage and Stormwater Management Criteria Study. Prepared By: City of Vaughan.

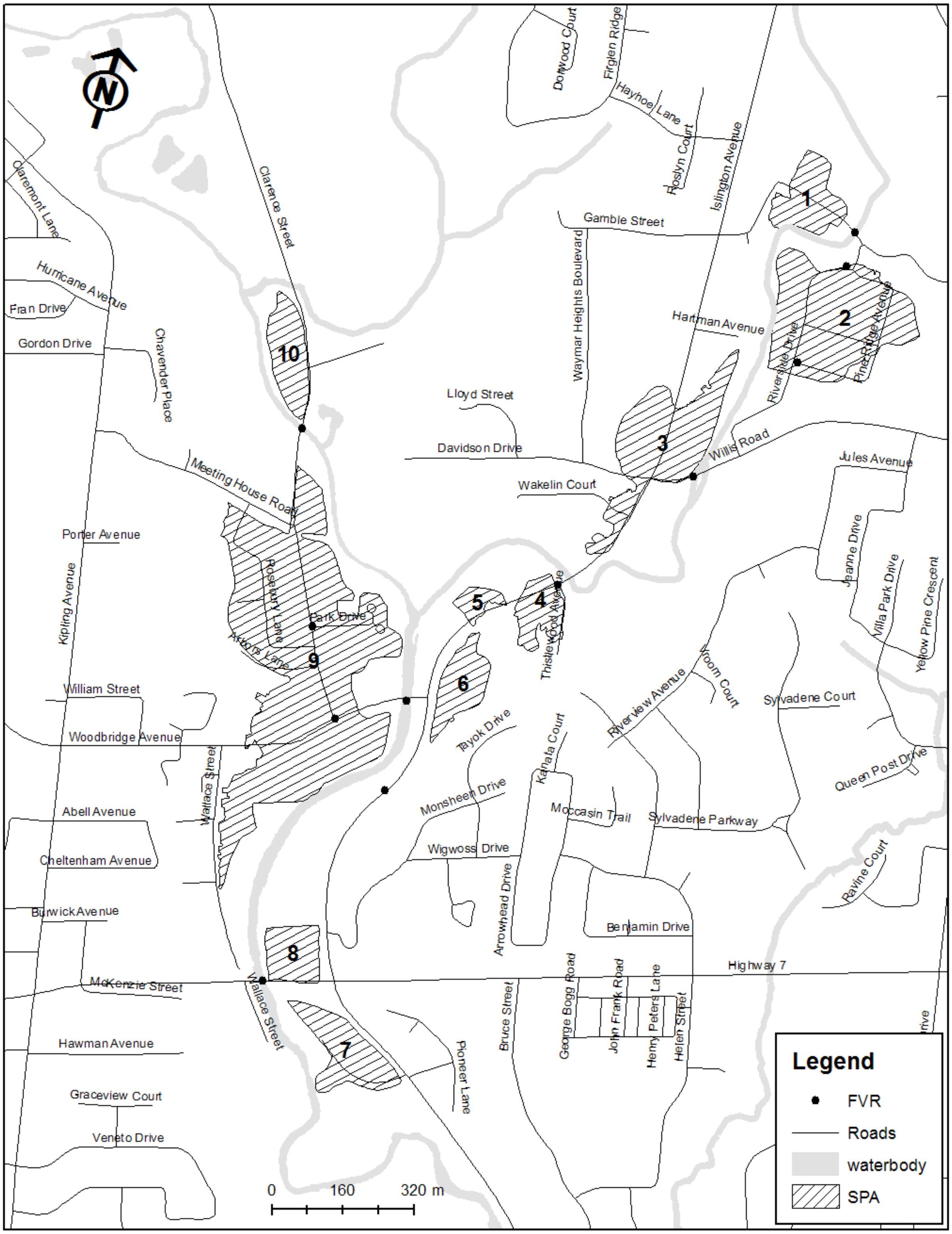

Figure G.6 Flood Vulnerable Roads (FVRs) in relation to the existing SPA. Source: City of Vaughan, 2009, City-wide Drainage and Stormwater Management Criteria Study. Prepared By: City of Vaughan.

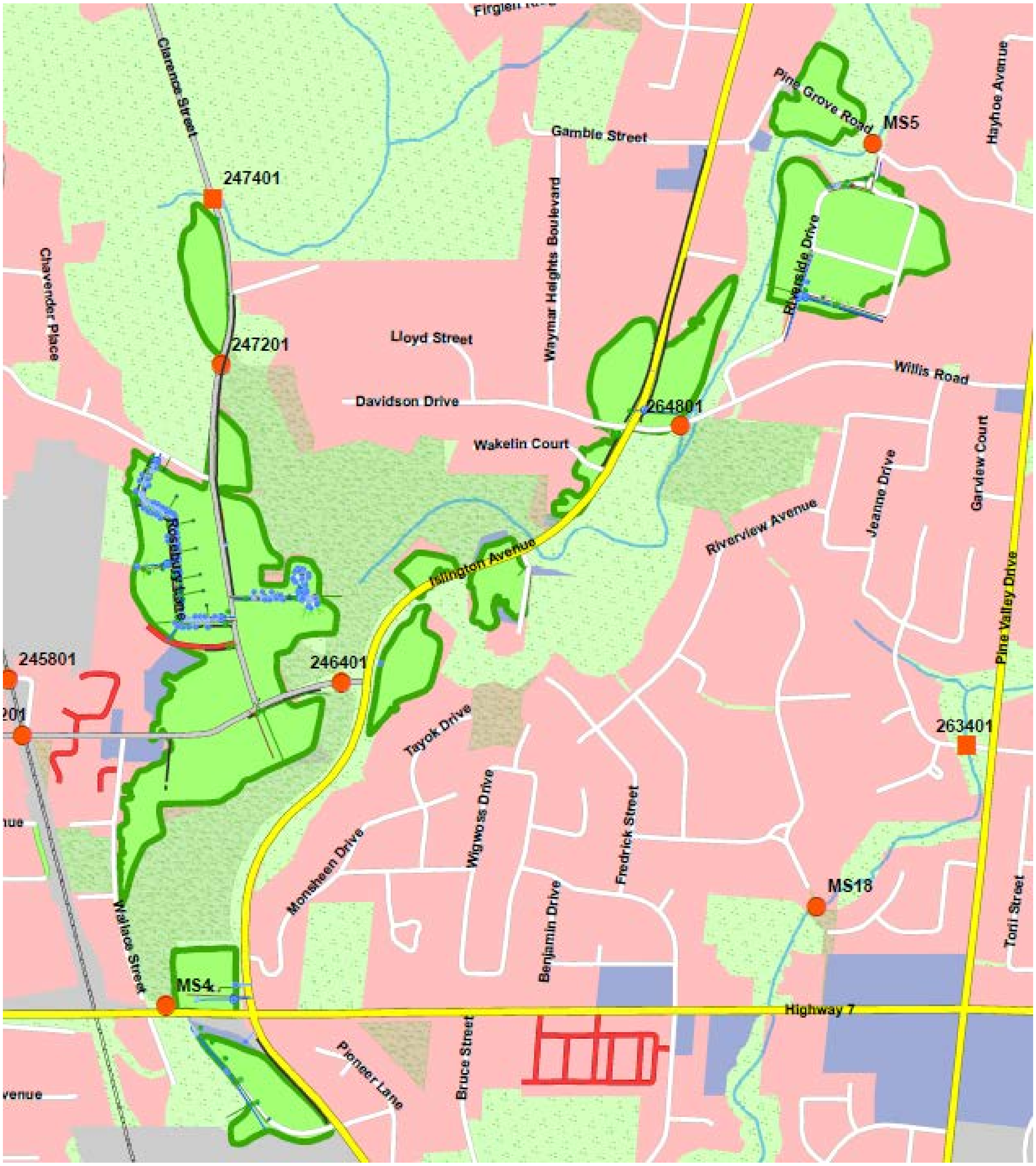

Figure G.7 Inventory of Infrastructure in the existing SPA. Source: City of Vaughan, Engineering Services.