S. LLEWELLYN & ASSOCIATES LIMITED
CONSULTING ENGINEERS

TECHNICAL MEMORANDUM

To:	Laura Schreiner Environmental Planner	**From:**	Steven DeGrow Steven Frankovich
		Date:	June 24, 2024
Project:	2030 Caroline Street Burlington, ON	**Pages:**	8 + Appendices A & B
		Job #:	23092
Re:	Floodplain Spill Hazard Analysis for 2030 Caroline Street		

1. Introduction

S. Llewellyn and Associates Limited has been engaged by Inaria Burlington Inc. to assess the existing floodplain spill elevations adjacent to and within the site limits. This evaluation supports the development of Phase 2, a 27-storey mixed-use condominium building that will be constructed adjacent to the existing Phase 1 building, which currently exists on the site. The 0.278 ha site is located east of Caroline Street, south of Elizabeth Street, West of Maria Street and north of John Street in the City of Burlington. The construction of the project builds on the existing planning framework for the entire block that was issued in 2010.

Rambo Creek inlets into an existing 3600mm x 1800mm box culvert situated approximately 25 meters north of the property line on the north side of Caroline Street. The constrained capacity of the 3600mm x 1800mm box culvert creates a flood spill scenario during both the 100-year and Regional Storm Events. The resulting overflow from Rambo Creek flows southward from the existing culvert inlet, inundating the adjacent municipal streets and the proposed development area. Refer to Figure 1 for the location plan.

For background information, a 100-year storm is used to describe a rainfall event that has a 1% statistical probability of occurring in any given year. Despite the term “100-year” it is possible for the event to occur more or less frequently than once every 100 years. A 100-year storm is often used in engineering and planning to design infrastructure, such as stormwater management facilities, channels and culvert crossings. The Regional Storm event in Burlington is defined by the measured rainfall data that was collected during Hurricane Hazel, which occurred in October 1954. A storm of this magnitude is a rare event for the region, however, it caused significant damage and loss of life in Ontario. The Regional Storm event is not often used to size infrastructure such as stormwater management facilities, channels and culvert crossings unless specifically required by the reviewing agencies due to area specific flood concerns. While both the 100-year and Regional Storm refer to weather events, a 100-year storm is a specific rainfall event with a defined return period, while the Regional Storm is based on weather phenomena that would impact a large region of Ontario with an unknown return period.

The purpose of this memorandum is to document the methodology and results from the spill flood hazard analysis and demonstrate how the grading of the proposed development can satisfy the criteria established by the Conservation Halton (CH). This criterion was provided to S. Llewellyn and Associates by CH staff via email on November 9, 2021.

2. Background

The following information was used in the preparation of this memo:

Ref. 1: Major Transit Station Area (MTSA) Phase 2 Flood Hazard Assessment Burlington GO and Downtown (WSP, March 06, 2023).

Ref. 2: River & Stream Systems: Flood Hazard Limit Technical Guide (Ontario Ministry of Natural Resources, 2002)

Ref. 3: Burlington-Downtown Hazard Mapping HEC-RAS modelling provided by Conservation Halton.

Ref. 4: Topographic survey prepared by A.T. McLaren Limited, dated December, 2023.

3. Methodology

The subject area is located within a spill hazard recently identified by Conservation Halton. Proposed redevelopment within this area must demonstrate that: there is no increased risk to “existing development”, the proposed development is not exposed to greater risk than the existing development, neighbouring properties are not negatively impacted by the proposed development, access and egress will be provided, and there are no feasible alternatives to developing outside of the hazard or within a lower risk area of the site.

The spill flood hazard analysis assessment included the following tasks:

- Review of the existing site topography within the 2D Downtown HEC-RAS model
- Update the hydraulic (HEC-RAS) model provided by the CH to incorporate the existing information captured by the topographic survey of the development area.
- Run the updated existing conditions model to confirm the spill hazard and flood elevations.
- Update the terrain to model the proposed site conditions.
- Run a proposed model with the updated terrain to determine changes to the floodplain and spill flood hazard areas.
- Review the proposed conditions results against the existing conditions results.



Figure 1 – Location Plan

4. Hydraulic Modeling Information

4.1. Flow Rates

Flows in the model are based on the Major Transit Station Area (MTSA) Phase 2 Flood Hazard Assessment (Ref. 1) and were included within the existing model provided by Conservation Halton. The *Regional Storm with FCF and Spills* unsteady flow file was used for both existing and proposed models.

4.2. Review of LiDAR Data

LiDAR is short for Light Detection And Ranging, and is a technique that uses lasers to create detailed 3D terrain models of the Earth's surface. LIDAR is normally completed using airplanes equipped with lasers that scan the earth's surface and record how long it takes for the light to bounce back, creating a 3D terrain of the ground below.

The LiDAR data within the HEC-RAS model was compared with five surveyed data points across varying surface types. It is noted that the LiDAR data has a vertical datum of CVGD2013 and the topographic survey has a vertical datum of CVGD1982. Based on this, it is expected that the LiDAR data points will be approximately 0.42m lower than the surveyed data points. **Table 4.1** shows the comparison of the points, along with the difference in vertical elevation and **Figure A1** in **Appendix A** shows the location from which the points were taken.

Table 4.1 – Data Point Comparison

Point Number	LiDAR Elevation (m)	Topographic Survey Elevation (m)	Difference in Elevation (m)
1	85.73	86.15	0.42
2	85.38	85.79	0.41
3	85.87	86.30	0.43
4	85.96	86.39	0.43
5	85.72	86.13	0.41

A clear understanding of the difference between topographic data and LiDAR data is crucial. Floodplain elevations must be accurately reflected in both engineering drawings and the 2D HEC-RAS model. Discrepancies between these data sources can lead to construction errors, potentially creating unsafe conditions for future residents or tenants. Through our review of the LiDAR and topographic data, the differences are within acceptable tolerances.

4.3. Geometry and Existing Conditions Analysis Results

The existing terrain file, MTSA_Structures_2013CGVD_0.5m, provided with the 2D Downtown HEC-RAS model, was updated to integrate the survey data provided by A.T. McLaren Limited. This survey covered the development area, municipal rights-of-way, sections of Rambo Creek, and the existing 17-storey condominium tower constructed as part of the first phase of this project. The updated terrain combines the MTSA_Structures_2013CGVD_0.5m file with the topographic data, resulting in an accurate representation of the existing conditions. The terrain is titled Original_Terrain_Birkley_Ph_1 in the revised HEC-RAS model. Furthermore, a new terrain file, Original_Terrain_Birkley_Topo_and_Proposed_Site_1, was created for the proposed condition which integrated the Phase 2 building and associated grading with the updated existing terrain file.

The 2D Downtown HEC-RAS model was re-run with the updated existing terrain file in the plan titled Regional-Storm (Phase 1 Birkley). The results of this model reflect the current spill hazard based on current and most accurate topographic information. The RAS Mapper output illustrates that a spill from Rambo Creek occurs at the box culvert inlet, impacting Caroline Street and flowing eastward along Elizabeth and John Street. Subsequently, a portion of the spill reconnects with the Rambo Creek Floodplain, while the remaining portion continues, south ultimately reaching Lake Ontario without reconnecting with Rambo Creek. **Figure B1** in **Appendix B** provides a map displaying the floodplain water surface elevations for the existing conditions in the vicinity of the site.

Under existing conditions, John and Maria Street are categorized as low-risk hazards adjacent to the development area. However, the flood depths on these streets exceed private vehicular access guidelines based on the River & Stream Systems: Flooding Hazard Limit Manual, Ontario Ministry of Natural Resources, 2002. Furthermore, there are portions of Caroline and Elizabeth Street that are characterized as high hazard based on flood depths and the product of depth*velocity. It's important to note that these high-hazard portions would still be accessible by emergency vehicles with top exhausts, such as fire trucks. The high and low hazard risks in the right-of-ways surrounding the site would be present for approximately 4.5 hours, based on the results from the HEC-RAS model. **Figures B2-B4** in **Appendix B** illustrate the existing flood hazard risk for the area surrounding the site and the criteria used for determination.

4.4. Proposed Conditions Analysis Results

The proposed condition was modelled in the plan titled Regional-Storm w FCF and Spills (Birkley). Based on the results provided in RAS Mapper, the floodplain will remain at approximately the same elevation in the existing condition, with only a slight increase to the floodplain (0.01m +/-) directly north of the Phase 2 building. A proposed conditions map of the floodplain water surface elevations of the area surrounding the site is shown in **Figure B5** in **Appendix B.** In addition, **Figure B9** in **Appendix B** shows the change in water surface elevations in the vicinity of the development.

Figure B10 in **Appendix B** shows the change in water surface elevation over the whole downtown area. **Figure B10** shows the water surface elevation is relatively unchanged (less than 0.01m increase) or even decreased slightly over most of the spill hazards under proposed conditions. Additionally, the previously mentioned increase on Caroline Street of 0.01m, is located within the municipal right of way and does not impact any adjacent private lands.

Under proposed conditions, the hazard risks remain unchanged from the existing condition with respect to safe egress and ingress. In addition, the high and low hazard risks in the right-of-ways surrounding the site would be present for approximately 4.5 hours, which is consistent with the existing condition. Conservation Halton staff have also confirmed that an 0.01 m increase in the flood spill elevation is within an acceptable range. **Figures B7-B8** in **Appendix B** illustrate the proposed flood hazard risk for the area surrounding the site as well as the criteria used to determine this.

5. Discussion

The results indicate that the proposed building and associated grading will not adversely increase the floodplain over the downtown area. Additionally, the first-floor elevation of the proposed building will be set 0.30m above the highest floodplain elevation against the building (86.12m, CVGD2013) (86.54m, CVGD1982) to prevent inflow during a flood event.

However, setting all door sills located at the building's edge 0.30m above the floodplain is not feasible due to grading constraints. Instead, internal stairs and ramps will be designed to ensure the first-floor elevation is at the required elevation. Similarly, based on the existing grades within the John Street right of way it's also not feasible to set the top of the underground parking ramp 0.30m above the floodplain spill elevation. As a solution, a watertight overhead door is being considered for the underground parking ramp on John Street to prevent floodwaters from entering the building during the Regional or 100-year storm event. Furthermore, the parking ramp on Elizabeth Street is to the above-grade parking structure level, eliminating any potential for flooding within the Elizabeth Street right of way to enter the underground parking structure.

Additionally, a further analysis was completed to assess the impact of incorporating floodplain storage within the municipal parking lot on the north side of Caroline Street. Two iterations of the storage plan were considered. In the first iteration, a depression was added in the proposed terrain within the parking lot area with a total storage volume of around 10,000m^3, which was directly connected to Rambo Creek. This plan is titled Regional-Storm Birkley w Storage in the HEC-RAS model. In the second iteration, a similar depression in the terrain within the parking lot was considered, also with a total storage of approximately 10,000m^3. However, in this iteration, the depression was separated from Rambo Creek by the existing top of the creek bank. This plan is titled Sto-2 within the HEC-RAS model. Both storage areas had similar bottom elevations, representing the lowest elevation for a gravity-draining storage area.

The results from both models showed a negligible change to the peak flood depths within the spill area. **Figures B11-B12** in Appendix B show the relative change to the water surface elevation based on these two iterations of the model. Consequently, it was concluded that floodplain storage is not a viable solution to reduce these hazards. Therefore, no additional flood storage has been proposed for this development.

5.1. Conclusions and Recommendations

Based on the results of the HEC-RAS model, the following conclusions were drawn:

- The development will have a negligible impact on the floodplain and associated spill hazard, increasing it by a maximum of 1cm+/-, from 86.11m CVGD2013 to 86.12m CVGD2013, with the addition of the Phase 2 building.

- The proposed first-floor elevation will be set 0.30m above the highest modelled floodplain spill elevation around the building, determined to be 86.12m CVGD2013, resulting in a proposed first-floor elevation of approximately 86.85m to floodproof the building.

- John and Maria Street remain categorized as low-risk hazards, exceeding private pedestrian-vehicle access guidelines in the post-development condition adjacent to the development area.

- Caroline and Elizabeth Street remain characterized as high-risk hazards; however, they will still be accessible by emergency vehicles with top exhausts, such as fire trucks.

- A watertight overhead door will be installed at the top of the parking ramp to prevent floodwaters from spilling into the underground garage.

- Flood storage within the adjacent municipal parking lot is not deemed a feasible solution to elevate the flood spill in the area.

It should be noted that the City of Burlington and Conservation Halton have initiated work to determine and implement mitigation measures to reduce the impact of these spill hazards on existing residences and future development in the city. This work is complex and is expected to a number of years to be constructed. However, as demonstrated through the modeling provided, the solution to the flood spill issue is not practical or feasible to be implemented on a site-by-site basis. Flood mitigation measures are required to be implemented within the sub-watershed. This will have to be undertaken by the City of Burlington and Conservation Authority.

It is concluded that the proposed development will have minimal impact on the spill hazard in the downtown area and will not negatively affect the surrounding properties. Consequently, the proposed building at 2030 Caroline Street can be constructed to meet the requirements of the Conservation Halton, the City of Burlington and Halton Region.

We trust the information enclosed is satisfactory. Should you have any questions please do not hesitate to contact our office.

S. Llewellyn & Associates Limited.



Steven DeGrow, C.Tech.

Steven Frankovich, P. Eng.

APPENDIX A

DATA POINT COMPARISON INFORMATION

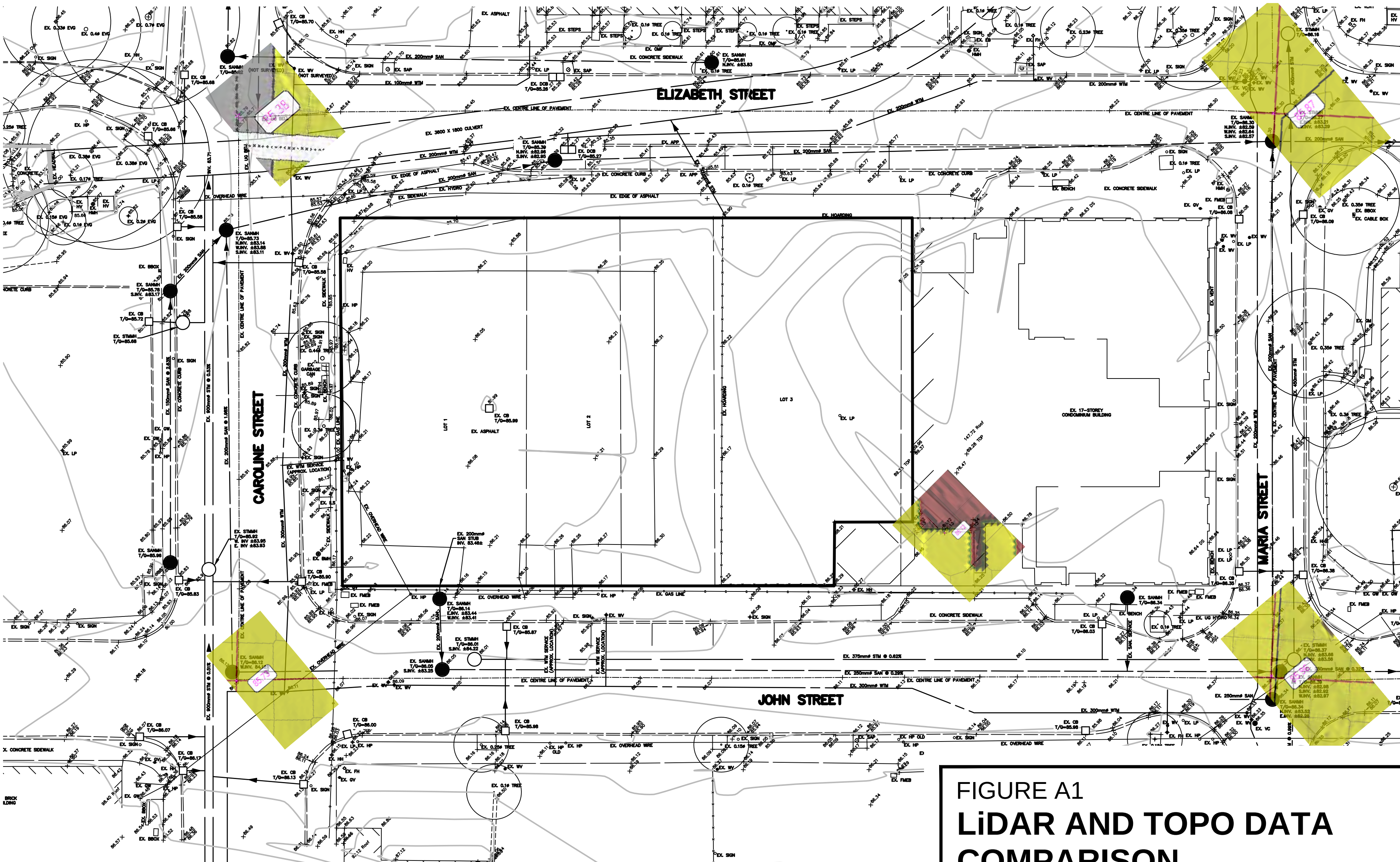


FIGURE A1

LiDAR AND TOPO DATA COMPARISON

SCALE: NTS

PROJECT: 2030 Caroline Street

PROJECT No.: 23092

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APPENDIX B

RAS MAPPER OUTPUTS



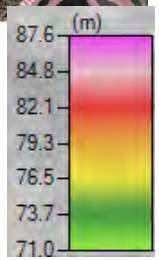


FIGURE B1

EXISTING WATER SURFACE ELEVATIONS

SCALE: NTS

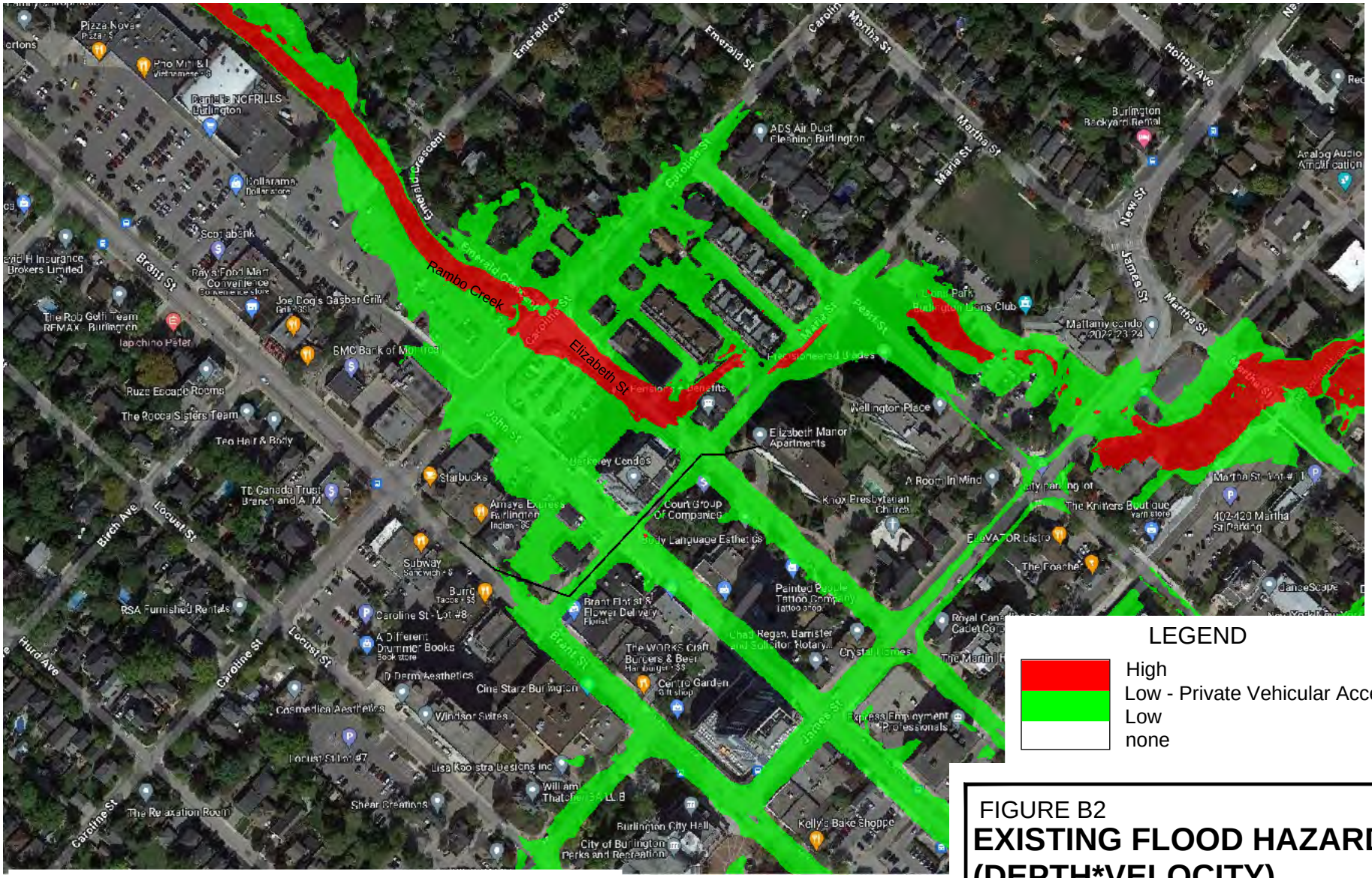
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Risk Level Criteria

Criterion	Low	Low: Exceeds Private Vehicular Access Guideline	High
Depth	< 0.30 m	> 0.30 and < 0.80m	> 0.80 m
Velocity	< 1.7 m/s	< 1.7 m/s	> 1.7 m/s
Depth x Velocity	< 0.37 m^2/s	< 0.37 m^2/s	> 0.37 m^2/s

FIGURE B2

EXISTING FLOOD HAZARD RISK (DEPTH*VELOCITY)

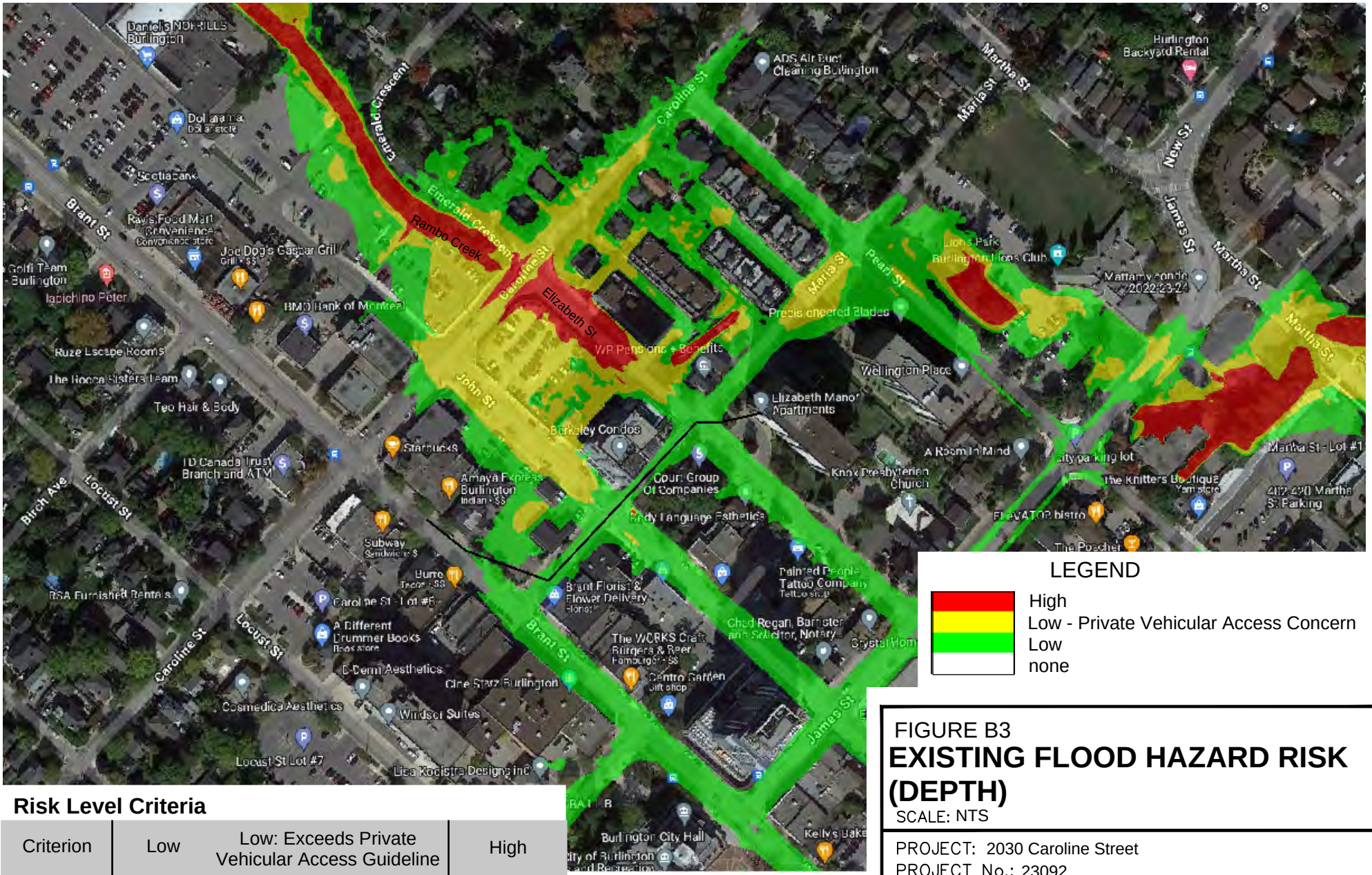
SCALE: NTS

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LEGEND

- High
- Low - Private Vehicular Access Concern
- Low
- none

Risk Level Criteria

Criterion	Low	Low: Exceeds Private Vehicular Access Guideline	High
Depth	< 0.30 m	> 0.30 and < 0.80m	> 0.80 m
Velocity	< 1.7 m/s	< 1.7 m/s	> 1.7 m/s
Depth x Velocity	< 0.37 m^2/s	< 0.37 m^2/s	> 0.37 m^2/s

FIGURE B3

EXISTING FLOOD HAZARD RISK (DEPTH)

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LEGEND

- High
- Low - Private Vehicular Access Concern
- Low
- none

Risk Level Criteria

Criterion	Low	Low: Exceeds Private Vehicular Access Guideline	High
Depth	< 0.30 m	> 0.30 and < 0.80m	> 0.80 m
Velocity	< 1.7 m/s	< 1.7 m/s	> 1.7 m/s
Depth x Velocity	< 0.37 m^2/s	< 0.37 m^2/s	> 0.37 m^2/s

FIGURE B4

EXISTING FLOOD HAZARD RISK (VELOCITY)

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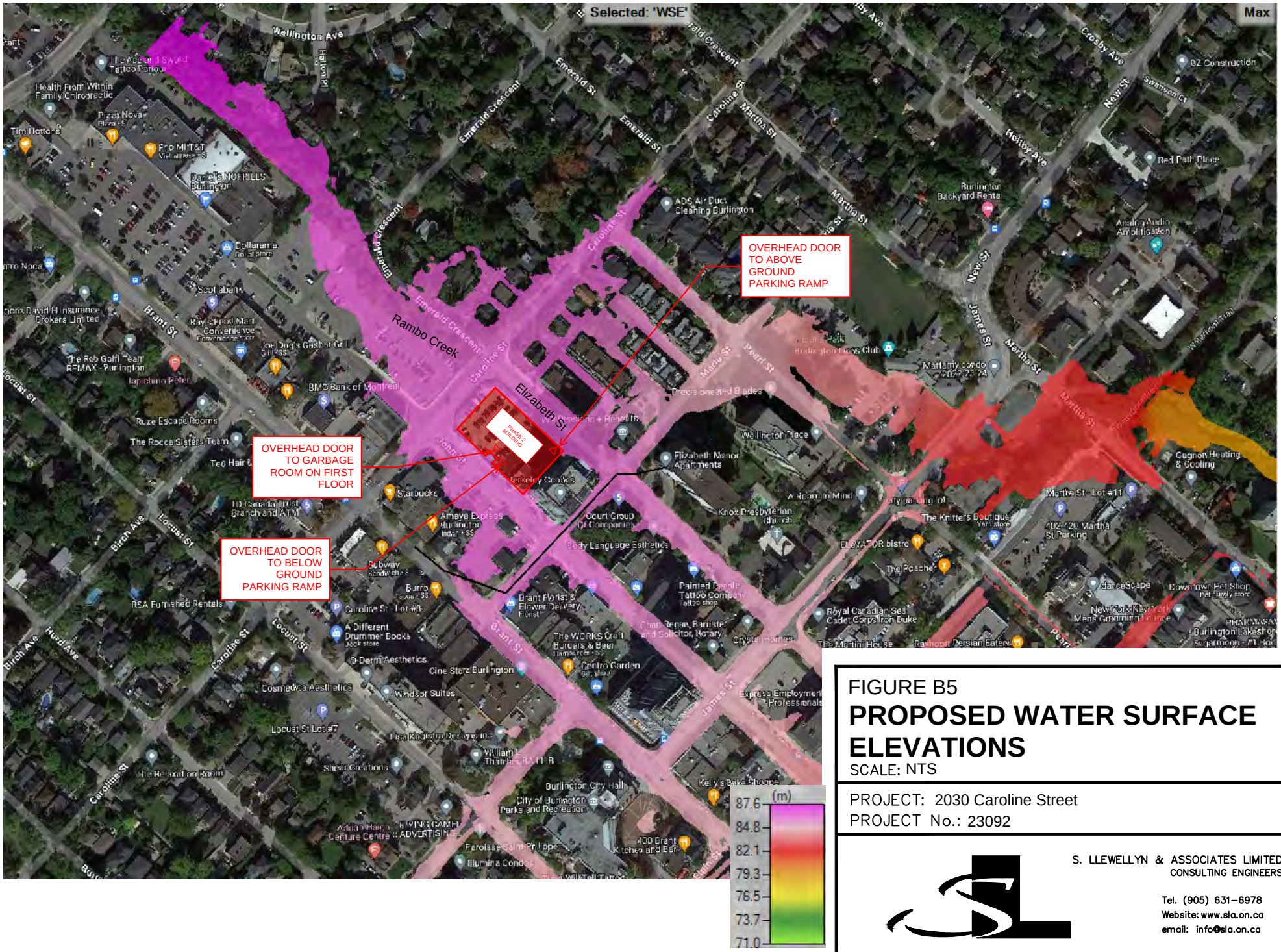


FIGURE B5

PROPOSED WATER SURFACE ELEVATIONS

SCALE: NTS

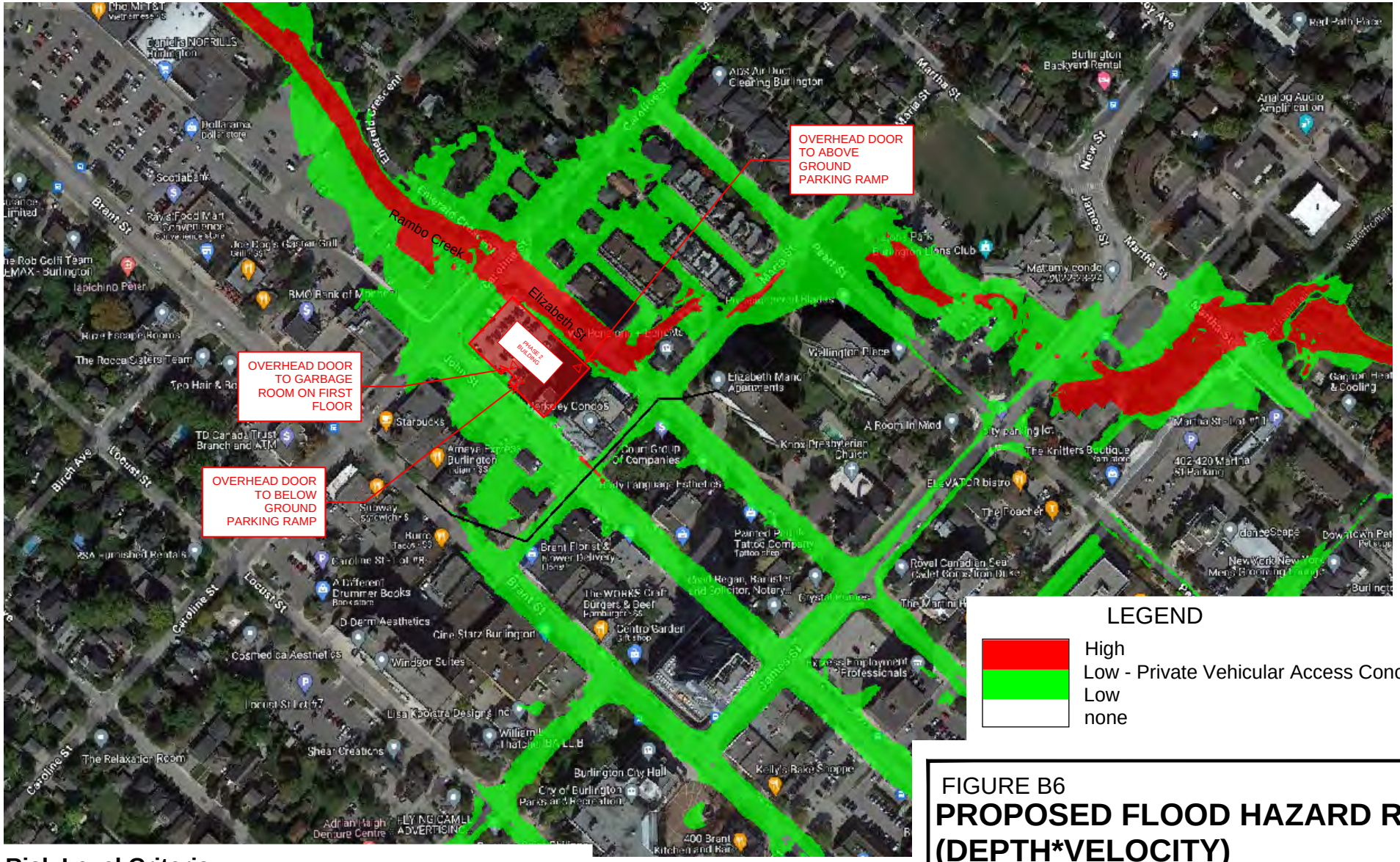
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Velocity	< 1.7 m/s	< 1.7 m/s	> 1.7 m/s
Depth x Velocity	< 0.37 m^2/s	< 0.37 m^2/s	> 0.37 m^2/s

FIGURE B6

PROPOSED FLOOD HAZARD RISK (DEPTH*VELOCITY)

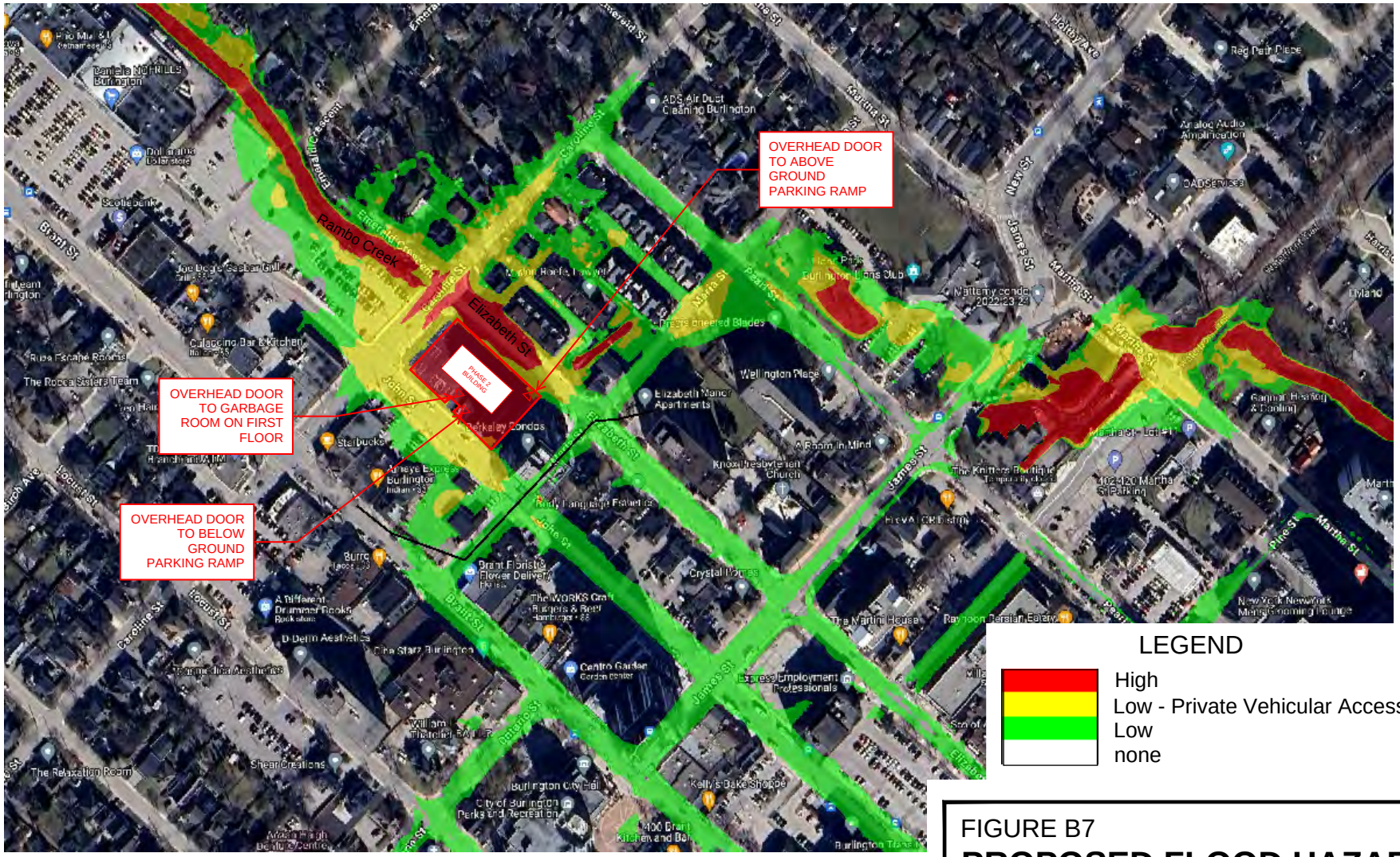
SCALE: NTS

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Depth	< 0.30 m	> 0.30 and < 0.80m	> 0.80 m
Velocity	< 1.7 m/s	< 1.7 m/s	> 1.7 m/s
Depth x Velocity	< 0.37 m^2/s	< 0.37 m^2/s	> 0.37 m^2/s

FIGURE B7

PROPOSED FLOOD HAZARD RISK (DEPTH)

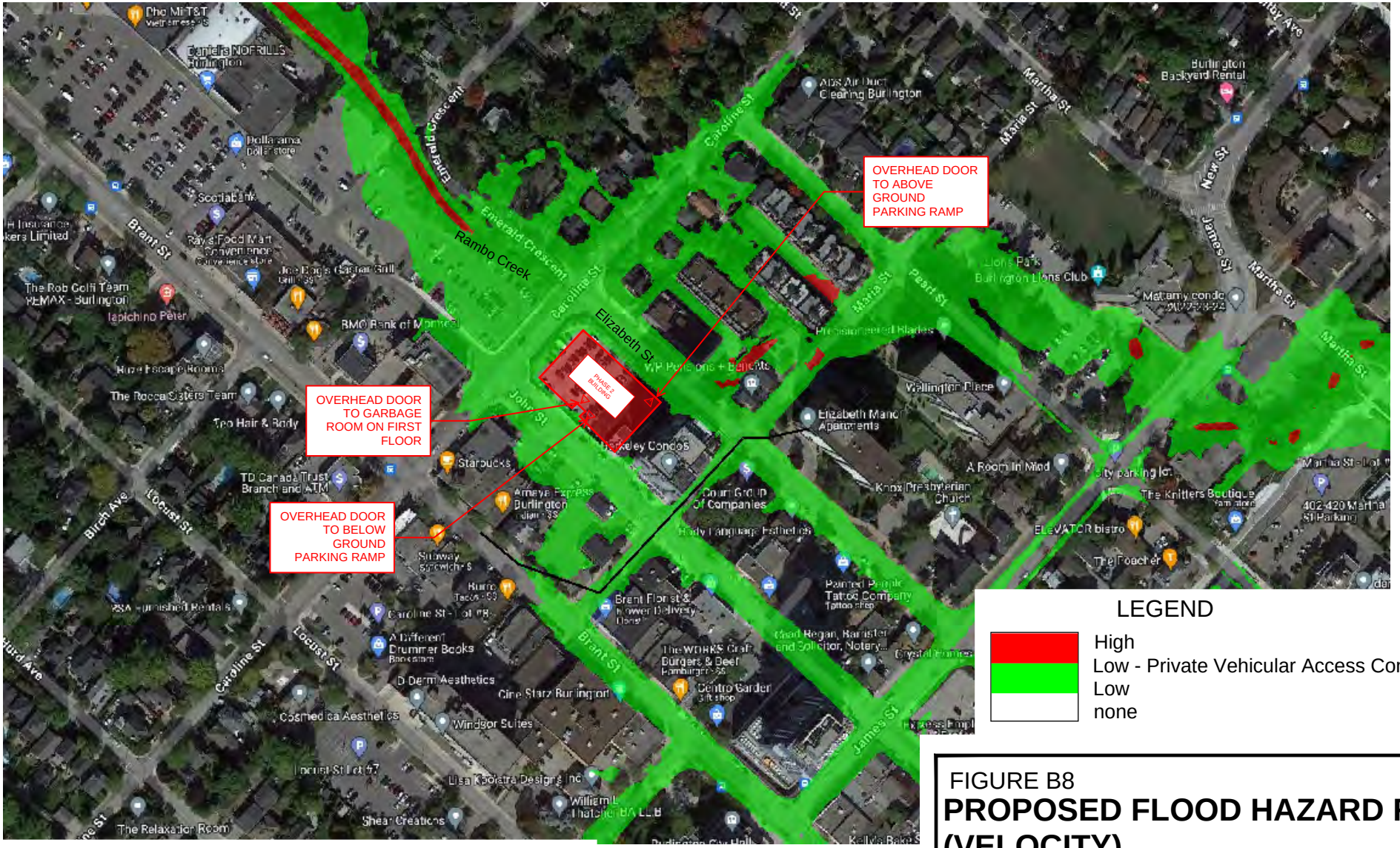
SCALE: NTS

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Depth x Velocity	< 0.37 m^2/s	< 0.37 m^2/s	> 0.37 m^2/s

FIGURE B8

PROPOSED FLOOD HAZARD RISK (VELOCITY)

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FIGURE B9

CHANGE IN WATER SURFACE ELEVATION

SCALE: NTS

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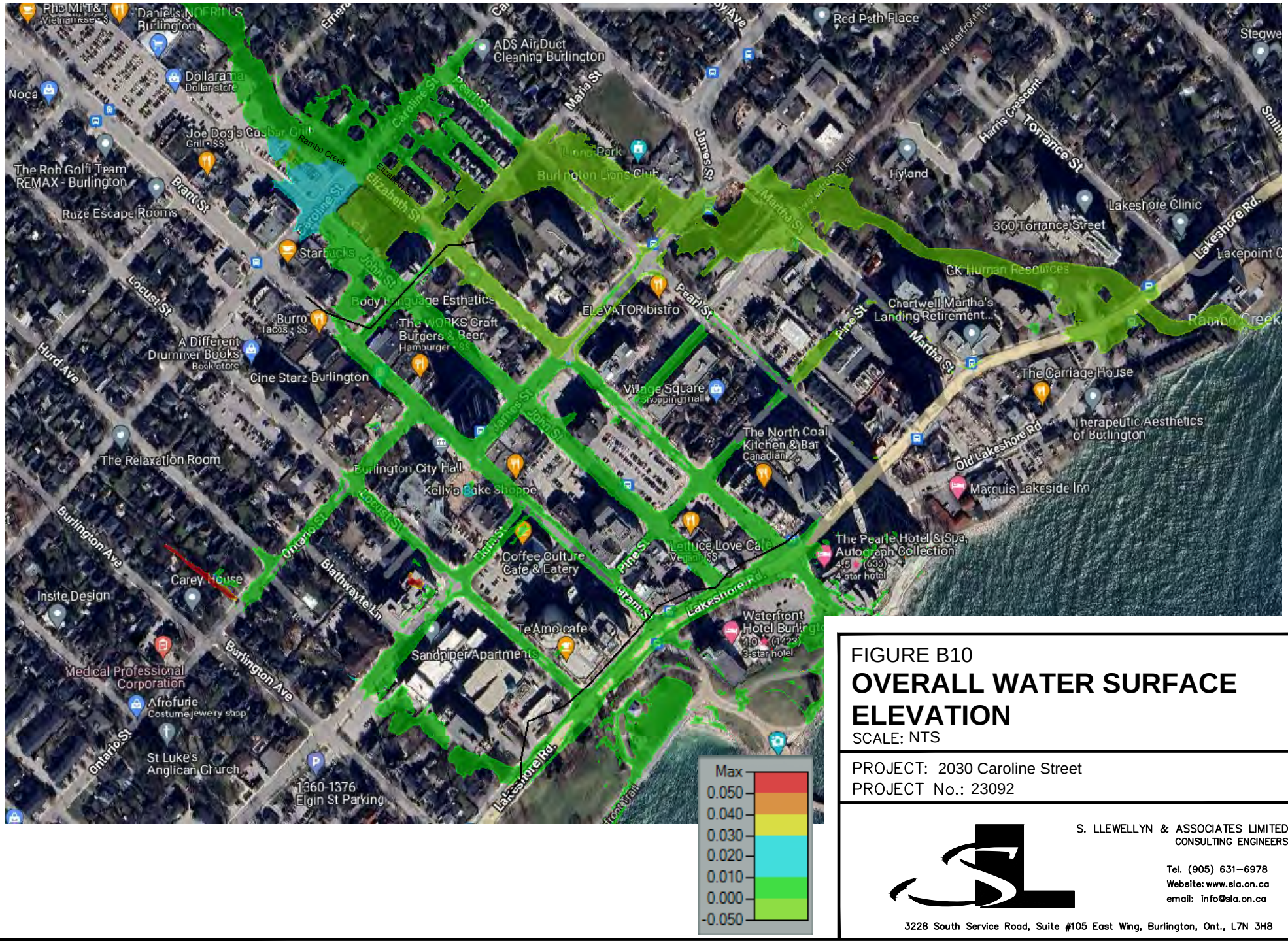


FIGURE B10

OVERALL WATER SURFACE ELEVATION

SCALE: NTS

PROJECT: 2030 Caroline Street

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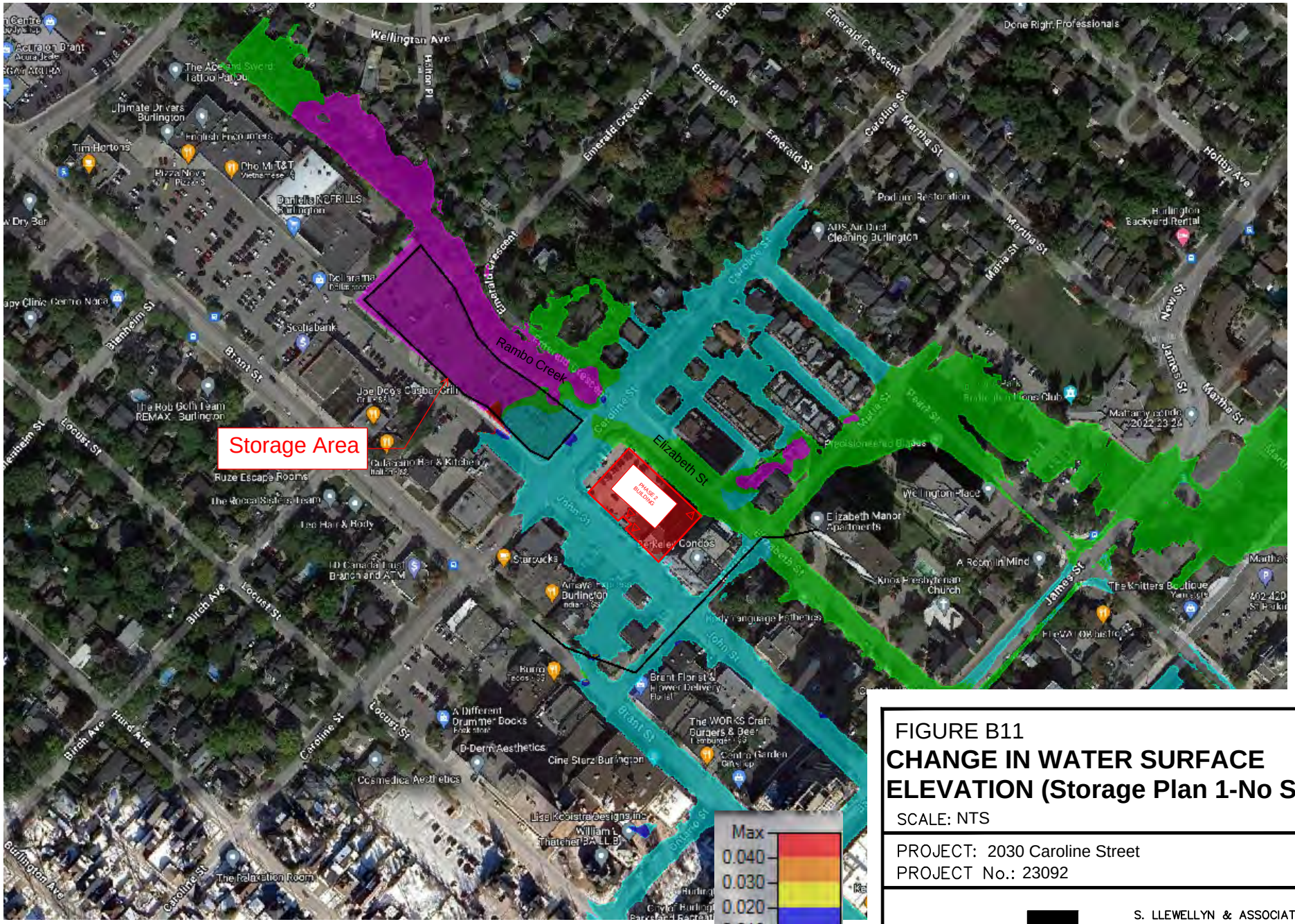


FIGURE B11

CHANGE IN WATER SURFACE ELEVATION (Storage Plan 1-No Storage)

SCALE: NTS

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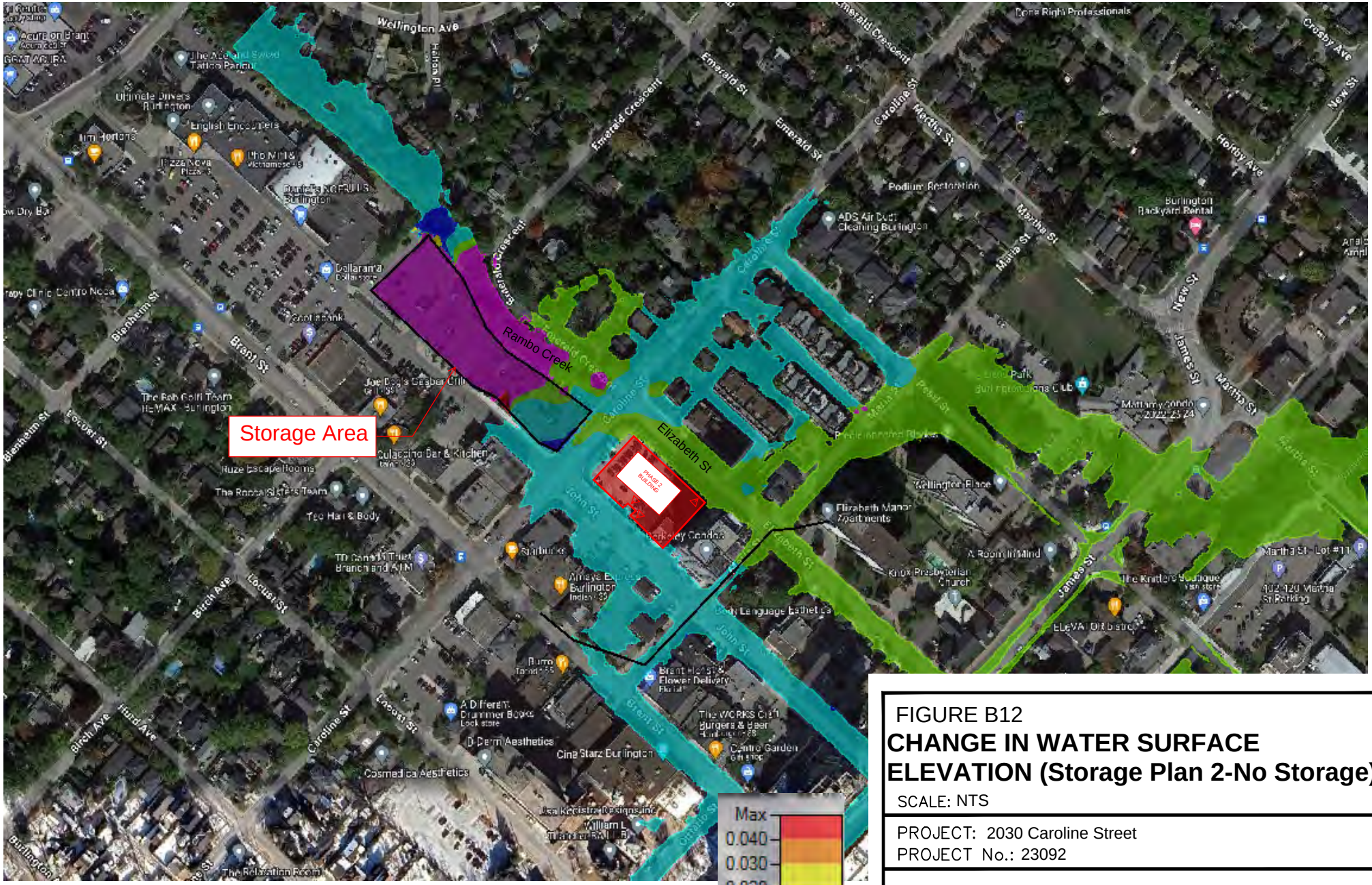


FIGURE B12

CHANGE IN WATER SURFACE ELEVATION (Storage Plan 2-No Storage)

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