Toronto Islands Flood Characterization and Risk Assessment Project

Flood Risk Assessment Report

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Toronto Islands Flood Characterization and Risk Assessment Project

Flood Risk Assessment Report

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Executive Summary

Baird & Associates (Baird) was retained by Toronto and Region Conservation Authority (TRCA) to undertake a flood characterization and risk assessment for the Toronto Islands. The first report updated the return period water levels at Toronto. This report quantifies the financial costs and other impacts to Toronto Island residents, businesses, and the City of Toronto for the different return period flood events under existing conditions. The study is intended to assist TRCA and the City of Toronto in identifying and understanding risk to infrastructure on the islands.

Residential and business surveys were administered to island residents and businesses to understand the impact of the 2017 flood. Residents generally reported low depths of flooding and low financial damages (less than $3,000). The largest impact on residents was anxiety of not knowing how high the lake would get. Residents reported a high level of support from neighbours, City of Toronto, TRCA, and friends and family. A limited number of responses were received from the business survey. Businesses were most strongly impacted by the closure of Toronto Island Park between May 4 and July 30 (nearly the entire tourist season).

Tangible (financial) damages for Toronto Island residents and businesses were estimated using the Alberta Provincial Flood Damages Assessment Study (PFDAS) method. The method relies on depth-damage relationships that were developed following the Calgary 2013 flood. For a given building classification, structural and building contents damages can be estimated from the depth of floodwater and the floor area of the building. Residential indirect damages such as flood mitigation, cleanup, etc. were included as a 15% markup on the structural and contents damages. Non-residential indirect damages were estimated using a method of business disruption and productivity rates outlined in the Canadian Floodplain Mapping Guidelines Series by Natural Resources Canada. All damages were adjusted to Ontario 2017 dollars using indexing methods.

Estimated total tangible damages to residents and businesses range from $0.5M to $6.5M for the 2-year and 500-year flood event, respectively. The average annual tangible damages are estimated to be $387,000 per year. City of Toronto damages were not included in the damage estimates due to the nature of the buildings (no appropriate PFDAS category), and the fact that indirect damages such as flood mitigation, cleanup, lost ferry revenues, lost rents, etc. would not be captured in the damage estimates. Telephone and e-mail communications with City of Toronto staff confirmed that indirect damages will be difficult to quantify for different flood levels. The estimated City of Toronto damages from the 2017 flood are in the neighbourhood of $8M.

Intangible damages are non-financial damages such as impacts to health, society, and the environment. The more severe impacts include respiratory conditions that could develop due to mould, change in the social fabric of the island community, and loss of mature trees.

The tangible damage estimates in this study could be improved by better understanding the indirect damages incurred by the City of Toronto and the impacts on island businesses.

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1. Introduction and Study Objectives

Baird & Associates (Baird) was retained by Toronto and Region Conservation Authority (TRCA) to undertake a flood characterization and risk assessment for the Toronto Islands. The overall project objective is to develop conceptual designs, costs, and estimates of annualized reductions in flood damages for various flood mitigation alternatives. The project deliverables will include three reports and one set of emergency response maps. The assessment will consist of the following four main parts:

- **Flood Risk Characterization:** review the conditions that led to the 2017 flooding and re-evaluate return-period extreme lake levels in light of recent data and climate change science.
- **Flood Risk Assessment:** quantify tangible and intangible damages resulting from the return-period flood risk events.
- **Flood Response Plan:** develop emergency mapping based on input from the City of Toronto and TRCA.
- **Flood Mitigation Alternatives:** develop conceptual designs to mitigate the flood risk and quantify annualized expenditures or savings resulting from mitigation works.

This second report evaluates the damages that could be incurred by island residents, businesses, and the City of Toronto for different return-period flood levels. The study is intended to assist TRCA and the City of Toronto in identifying and understanding risk to the community and infrastructure on the islands.

1.1 Summary of Return Period Water Levels

Return period water levels for Ontario locations on the Great Lakes were developed by the Ontario Ministry of Natural Resources (OMNR, 1989). Baird updated the return period water levels at Toronto for the Flood Characterization Report (Baird, 2019). The update made use of the additional 31 years of measured data and included an adjustment to account for the change in Lake Ontario regulation plans.

Climate change research was also reviewed to understand how water levels may change in the future. Current research suggests that water levels in the Great Lakes will remain similar or decline slightly due to increased evapotranspiration (see e.g. Baird, 2019; McDermid et al., 2015). At this time, Baird does not recommend any increase or decrease in the return period water levels due to climate change. The estimated return period stillwater levels (static lake level plus storm surge) for Toronto are summarized in Table 1.1.

Table 1.1: Estimated Toronto Harbour Return Period Stillwater Levels Under 2014 Regulation Plan (Baird, 2019)

Return Period	2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year
Stillwater level (m IGLD85)	75.38	75.65	75.80	75.94	76.01	76.05	76.14	76.25

1.2 Note on Elevations and Datums

Unless otherwise noted, all water levels are reported in International Great Lakes Datum 1985 (IGLD85). IGLD85 is 8.4 cm below Canadian Geodetic Vertical Datum 1928-1978 Ontario Adjusted Version (CGVD 1928:1978), and 49.6 cm below Canadian Geodetic Vertical Datum 2013 (CGVD 2013) at the Canadian Hydrographic Service benchmark 0011959U9526 (also known as 00159U9526, 59U9526, and TORO 1-1959). The benchmark is located at the Toronto Harbour Gaugehouse at the south side of Queen's Quay. The elevation of the benchmark relative to the different datums is shown in Figure 1.1.

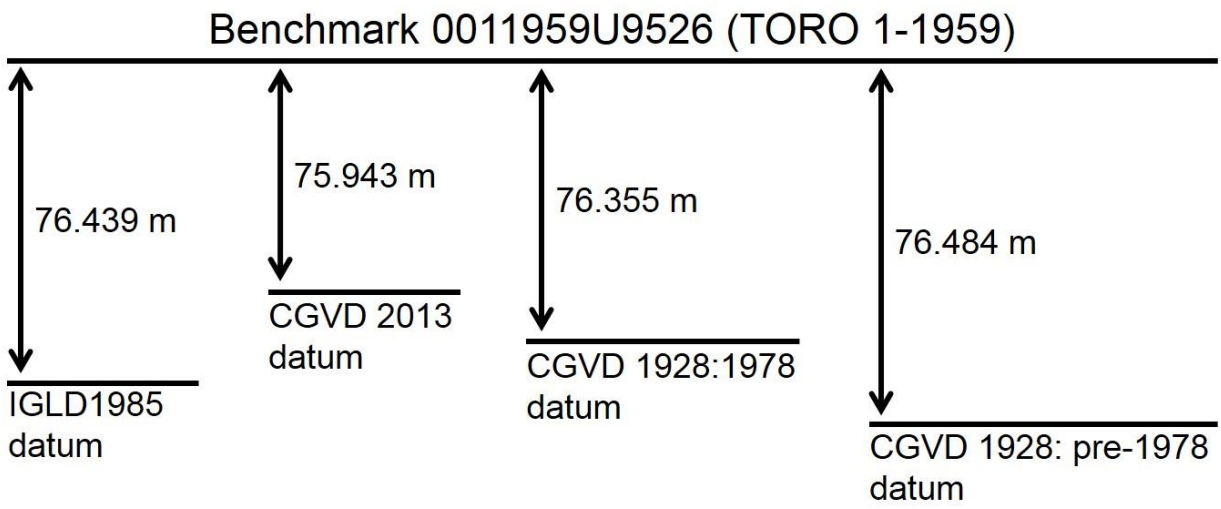

Figure 1.1: Elevation of the Toronto Harbour Gaugehouse Benchmark

2. Types of Flood Damages

The types of damages resulting from a flood can be categorized as either tangible or intangible. Tangible damages are financial damages that result from damages to property and other costs that were incurred because of the flood. Intangible damages are non-financial damages and include social, environmental and health impacts. The different types of flood damages, and terminology used in this report, are outlined in Figure 2.1.

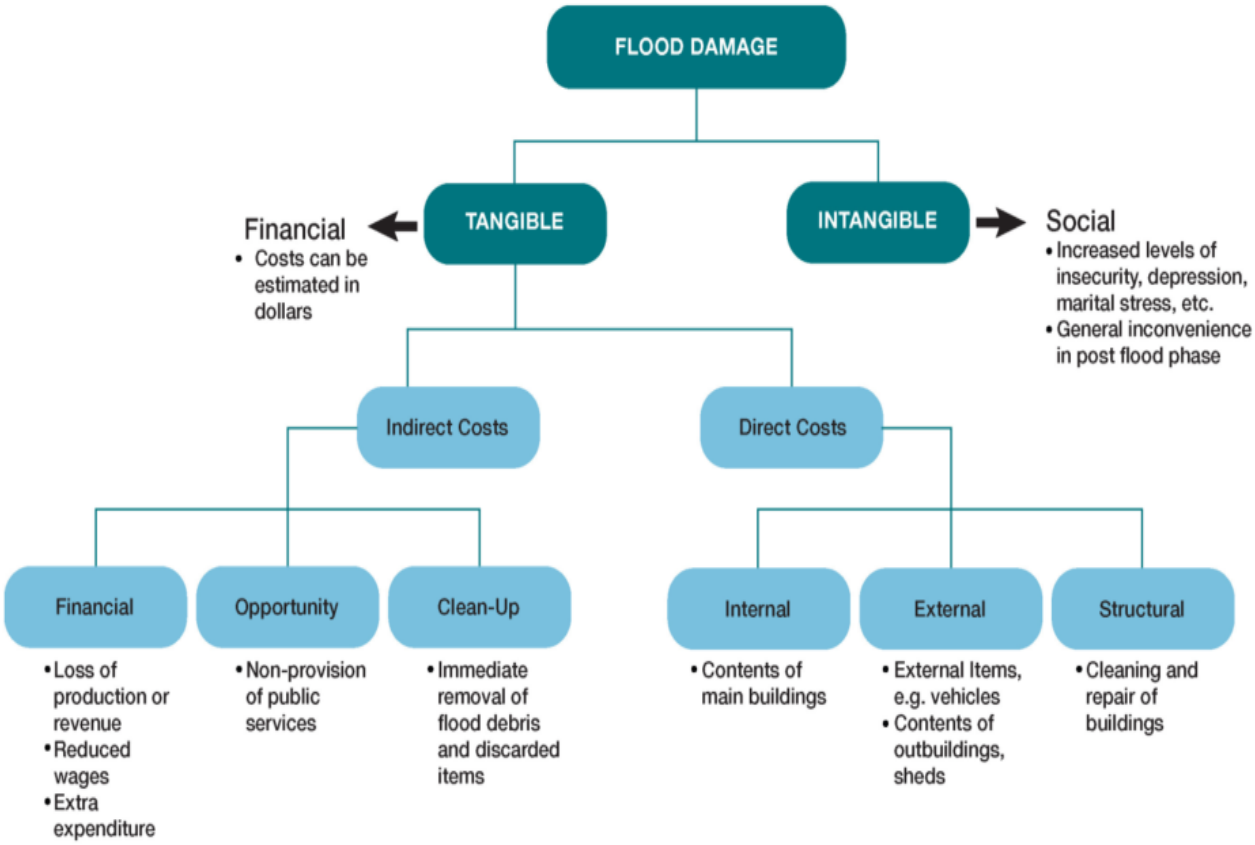

Figure 2.1: Classification of Flood Damages (from NRCAN, 2017)

2.1 Tangible Damages

2.1.1 Direct Damages

Direct damages are damages to property caused by floodwater. Direct damages include structural damages to a building and the internal and external building contents. Examples of direct damages include damaged: walls, flooring, appliances, insulation, household items, etc.

2.1.2 Indirect Damages

Indirect damages are financial costs that were incurred because of a flood. Indirect damages include flood mitigation actions, post-flood cleanup, evacuation, temporary housing, loss of opportunity, employment losses,

business disruption, etc. Some indirect damages are difficult to quantify, and total indirect damages are often estimated as a percentage of direct damages.

2.2 Intangible Damages

Intangible damages represent the social, health and environmental impacts associated with a flood. These types of damages can be significant and have long lasting impacts on the social fabric of a community, human health, and the environment. Examples of social impacts include separation from loved ones, disputes between neighbours, residents choosing to relocate after a flood, and general inconvenience. Stressful situations, such as a flood, can also bring communities together and strengthen the social fabric. Examples of health impacts include new or aggravated physical injuries, exposure to mould, stress, anxiety, and sleeping difficulties. Examples of environmental impacts include sewage overflows, loss of habitat, loss of mature trees, shoreline erosion, etc.

2.3 Factors Affecting Flood Damages

The depth and extent of flooding are the most important factors for estimating flood damages. However, other factors, such as warning time and flood duration, can affect the severity of flood damages. These factors may be accounted for by applying a mark up to the primary estimates. Factors or considerations relevant to the Toronto Islands include:

- **Warning Time:** adequate warning time can allow residents, businesses and municipalities to prepare for a flood event and potentially mitigate a portion of the expected damages
- **Flood Duration**: floods lasting extended periods of time can induce significantly higher damages.
- I**ce:** impacts from moving ice can damage buildings and contents. Indirect damages may be higher when ice is present.
- **Sediment:** sediment laden floodwater can result in higher damages (e.g. cleanup costs).
- **Groundwater Seepage**: porous soils can result in seepage of water into basements outside the floodplain extents.

3. 2017 Flood Damages

Toronto Island Park was closed between May 4 and July 30, 2017 as a result of the high water levels in Lake Ontario (City of Toronto, 2018a). Flooding on Toronto Islands was due to a high water table, which resulted in flooding of crawlspaces and basements in many homes. Wave overtopping at Algonquin Island and heavy rainfall contributed to localized flooding and ponding of water (see Figure 3.1).

Figure 3.1: Photograph of Wave Overtopping of Algonquin Island Seawall in 2017

The Toronto Islands ferry service was restricted to residents and authorized personnel during the park closure. Many public facilities and access roads were flooded, resulting in the temporary closure of the Island Public/Natural Science School (and relocation of students to the mainland) and cancellation of events. Life was considerably altered for residents on the islands and many businesses temporarily closed or operated at a reduced capacity.

Actions were taken by the City of Toronto, residents, and businesses owners to mitigate the flood impacts. The City provided a stockpile of sand and sandbags near the Ward's Island ferry dock and crews and volunteers filled and placed the bags around low-lying residential areas. It soon became apparent that the small sandbags would be insufficient and metre sandbags were installed at key locations across the islands. By the end of the mitigation effort, over 40,000 small sandbags, and over 1,000 metre sandbags were placed across the islands.

The City also deployed over 15 high-discharge trash pumps at key locations on the islands (mostly on Algonquin and Ward's Islands) to lower surface water levels from high precipitation and saturated ground conditions. Municipal assets such as sewage pumping stations and electrical transformers were also sandbagged for protection and were under constant surveillance by City personnel. A map showing the locations of sandbags across Toronto Islands and a photograph showing typical conditions are provided in Figure 3.2 and Figure 3.3.

Figure 3.2: Map of Sandbag Locations during 2017 Flood

Figure 3.3: Photograph of Sandbags and High-Discharge Pump on Algonquin Island

Residents and business owners also took actions to mitigate the flooding effects on their properties and businesses. Many installed sandbags around their properties or along the streets. Many people purchased small pumps to drain their yards and crawlspaces or basements. Some dug trenches or swales on their property to direct surface water to smaller pumps, or along streets to municipal pumps. Many homes and businesses had saturated or flooded yards and placed wood planks, soil, or wood chips to raise the local grade and to maintain access to their homes. These conditions and mitigation efforts are shown in Figure 3.4.

Figure 3.4: Photographs of Flooded Yards in 2017 (from Toronto Star, 2017; and French, 2017)

The impacts of the flood were widespread and significant. Residential properties on Algonquin and Ward's Island were saturated for up to 4 months, causing flooding of crawlspaces, basements, and yards. The damages reported by residents on the island included the appearance of mould in houses and crawlspaces, damage to contents, damage to landscaping and structural damage to houses. For businesses on the islands, damages were primarily due to disruption of business operations. Most of the island businesses rely heavily on summer tourism and were strongly affected by the closure of ferry services. The following sections summarize the impacts from information collected from public sources, and from survey questionnaires conducted by Baird.

3.1 Residential Survey

Two previous surveys of the impacts of the 2017 flood on island residents were conducted in 2017 and late 2018. The first survey was completed by a group of island residents known as the Toronto Islands Emergency Preparedness Committee. The results of the survey are available in the report prepared by the committee (French, 2017). The second survey was administered by Dr. Greg Oulahen, an assistant professor in the Department of Geography and Environmental Studies at Ryerson University. Dr. Oulahen provided a copy of the questionnaire but results were not available to TRCA at the time of the current study.

Baird used the previous survey questions and results as a starting point to understand the challenges, impacts, costs, and actions taken by the residents and the City in 2017. Thereafter, Baird and TRCA developed a targeted questionnaire of the physical, financial, and health impacts on island residents in 2017.

A summary of the impacts and damages from the Toronto Islands Emergency Preparedness Committee report is provided in Table 3.1. Although many homes experienced flooding of their yards and crawlspaces, the direct damages were relatively low due to the shallow depth of flooding and experience gained from previous floods (i.e. items not stored in crawlspaces). Conversely, the indirect damages were relatively high due to the long duration of flooding and efforts to install and maintain barrier and pump systems. Intangible impacts included health impacts (anxiety, physical injury), inconvenience, loss of use, and damage to trees and landscaping.

Table 3.1: Summary of Residential Damages from 2017 Flood (adapted from French, 2017)

Type of Damages		Summary
Tangible	Direct	• Many homes experienced flooding in crawlspaces • Contents in homes that were stored in crawlspaces were damaged • Many homes had furnaces, ducts, HRV systems, hot water tanks, and other essential building equipment damaged or destroyed • Slow rise and fall of water table provided prolonged high humidity conditions in crawlspaces; promoted mould growth • Vapour barrier and insulation in many crawlspaces destroyed • Some homes experienced damage to exterior finishes • Yard flooding restricted access and necessitated landscaping repairs
	Indirect	• Many residents purchased and installed pumps in their crawlspaces and yards • Some residents purchased electric heaters because their furnaces were damaged • Additional electricity costs due to pumps, heaters, fans, dehumidifiers, etc. • Additional costs due to health problems (medication, prescriptions, etc.) • Some residents dug swales or trenches to redirect surface water • Some residents purchased wood chips or soil to fill low areas and maintain access to their homes • Costs were incurred for temporary housing on the mainland • Time off work
Intangible		• Restricted ferry services • Poor communication from authorities caused higher stress for residents • Limited access to amenities such as parks, associations, etc. • Minor injuries due to poor ground visibility, hoses criss-crossing properties • Elevated sense of helplessness, anxiety, stress, isolation • Trees and island aesthetics suffered • Limited access and usage of yards for weeks to months • Constant noise pollution due to high-discharge City pumps operating

The residential survey developed in this study was used to compare the impacts of the 2017 flood with the estimated damages using the calculation procedures described in Chapter 4. The residents survey was divided into three sections: physical impacts, financial impacts, and health impacts of the flood. The physical impacts questions referred to the depth and duration of flooding the residents observed in their home and yard, and the actions that were taken to mitigate flooding and flood damage. The financial impacts section included questions concerning the monetary costs associated with mitigation measures, clean up, repairs, content replacement, additional flood related expenses, and days off work due to flooding. The health impacts section addressed the physical and mental health impacts experienced by residents during and after the flood.

The survey was distributed to each of the residents on December 6th, 2018. Ninety responses were received, corresponding to a response rate of approximately 35%. The survey results are presented in the following sections, and a copy of the survey is included in Appendix A.

3.1.1 Physical Damages

The survey included questions about depth of water, duration of flooding, mitigation actions, physical damages, and time to return to normal.

The number of respondents that reported first floor, basement/crawlspace, and yard flooding is shown in Figure 3.5. Thirty-three respondents experienced no flooding (empty circles), 7 respondents experienced only yard flooding, 18 respondents experienced only basement/crawlspace flooding, and 30 respondents experienced flooding in more than one area. Seven of the survey respondents experienced damage to their first floor such as floor warping.

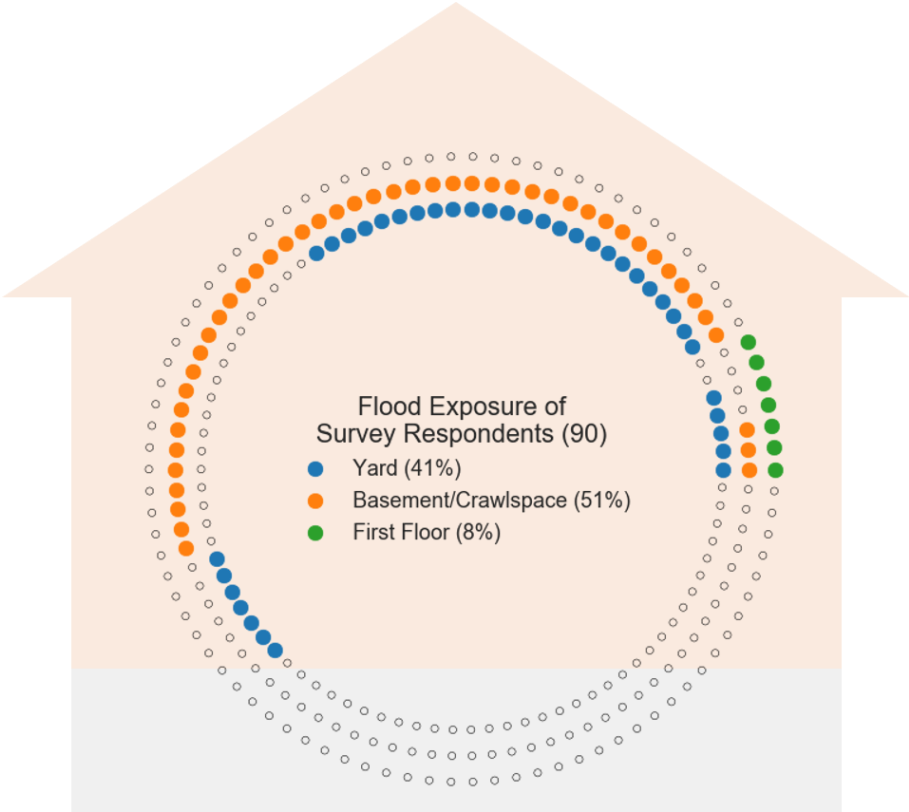

Figure 3.5: Summary of Flood Exposure of Residential Survey Respondents

The depth of flooding from the 37 respondents that reported yard flooding is shown in Figure 3.6. The figure indicates that yard flooding was generally shallow, with only 3 respondents reporting a water depth greater than 0.3 m. The survey responses for crawlspace and basement flooding cannot be readily summarized as the responses were mixed (some surveys reported water depth and others reported the clearance below the floor joists). In general, water depths were less than 0.3 m and clearance below the floor joists was greater than 0.15 m. None of the respondents that identified damage to the first floor (such as floor warping), reported a depth of standing water. This suggests that damage was caused by moisture or capillary rise through the flooring.

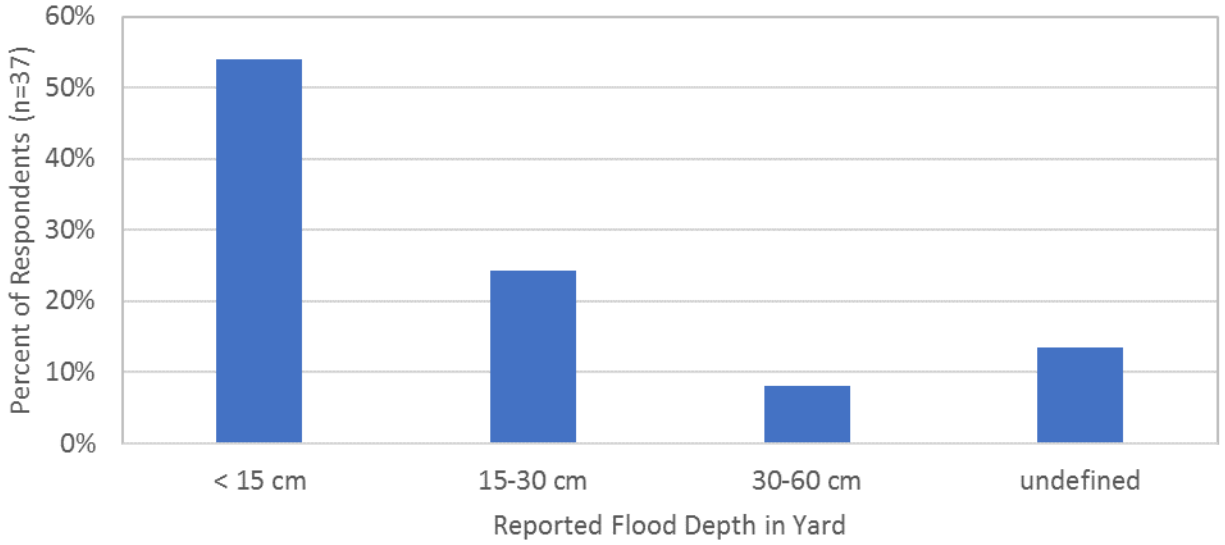

Figure 3.6: Summary of Flood Depths in Yard for Residential Survey Respondents

The reported duration of flooding for the affected households is shown in Figure 3.7. The duration of yard flooding was undefined or less than one month in 70% of responses. The duration of crawlspace or basement flooding was longer, with about 25% of respondents reporting 1 to 2 months. One of the respondents indicated a duration of 3 months for flood impacts to the first floor.

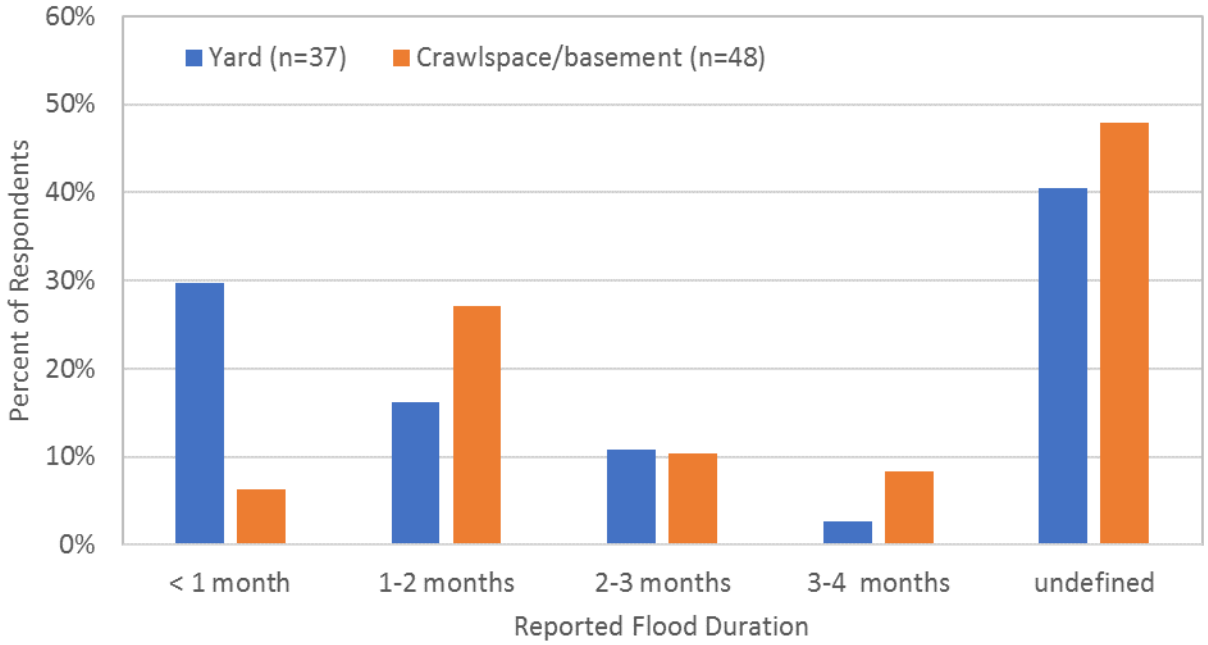

Figure 3.7: Summary of Flood Durations for Residential Survey Respondents

Residents were asked to identify damages to their home, contents, and yards. The responses are summarized in Figure 3.8. A low percentage of respondents reported structural damages to the walls and floors of their

homes. The most common damages were to landscaping/vegetation, contents in a crawlspace, and concerns with mould.

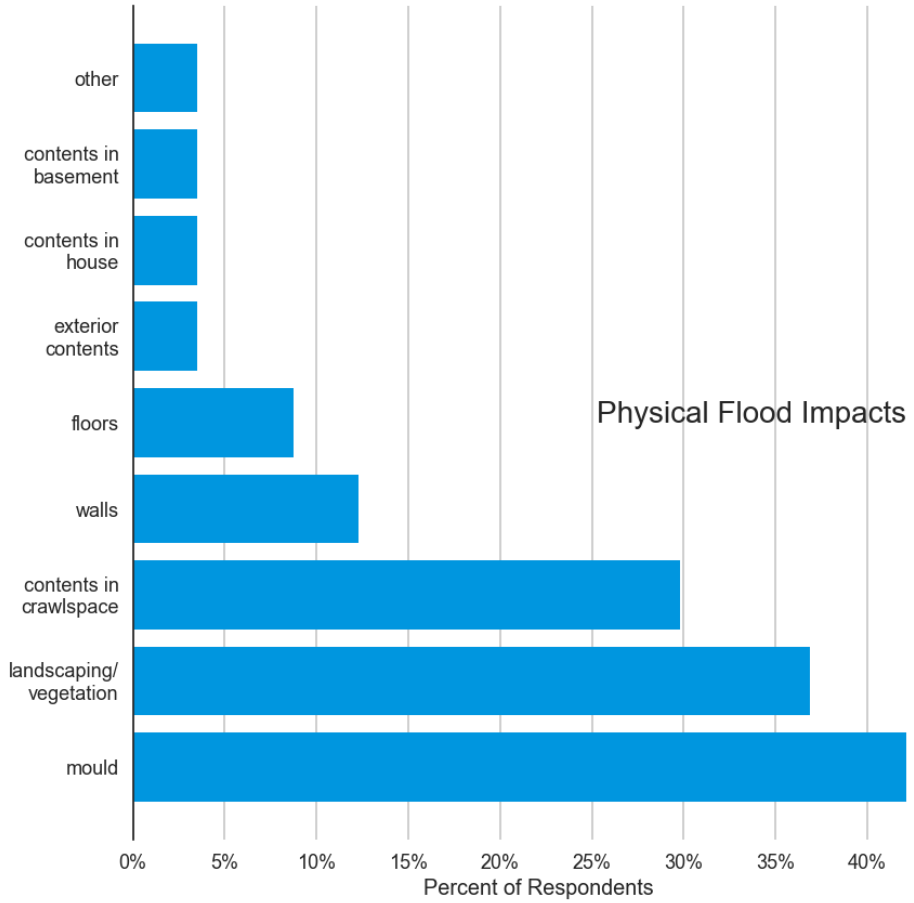

Figure 3.8: Summary of Flood Damages of Residential Survey Respondents

Residents were asked to identify what they did to reduce the impact of flooding on their house and property. The responses to this question are summarized in Figure 3.9. The most common mitigation actions included using fans to dry out their home after the flood, moving items, and using pumps and sandbags.

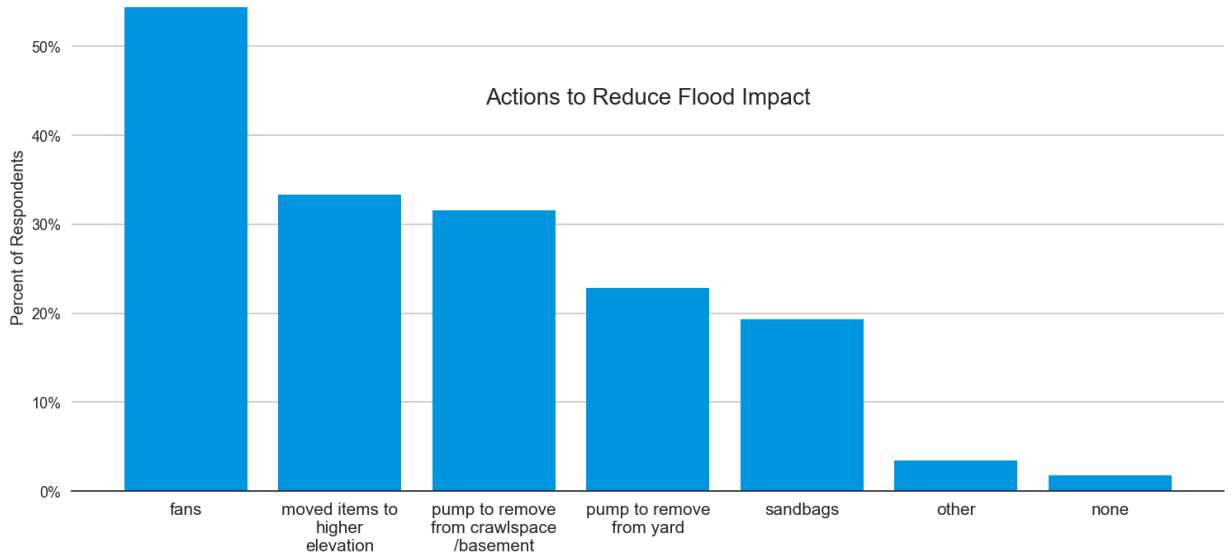

Figure 3.9: Summary of Mitigation Actions by Residential Survey Respondents

Lastly, residents were asked about recovery after the flood. Had their lives returned to normal, how long did it take, and any outstanding items. All but two respondents indicated that their lives had returned to normal, with time frames varying from weeks to one year. Several respondents indicated that they were concerned about mould, and two respondents were undertaking repairs to their homes.

3.1.2 Financial Impacts

The financial impacts section of the survey was directed towards understanding the total costs incurred due to the 2017 flood. Residents were asked to identify dollar and labour amounts spent on mitigation measures, cleanup, repairs, content replacement, additional flood related expenses, and days off work due to flooding.

Mitigation and cleanup costs were difficult for many residents to quantify and total costs were typically between $500 and $1,000. For homes that sustained structural damages, repair costs were between $1,000 and $10,000, which reflected the costs to replace flooring, drywall, furnaces, etc. Interior contents damages were zero for all but one response. Exterior contents damages were low, generally zero or a few hundred dollars. Three respondents had exterior contents damage around $1,000 to $3,000 dollars (estimated) which involved tree removal and landscaping. Few residents identified additional expenses such as hotels, meals, medication, etc. Generally, the additional expenses were low (less than $300), with one respondent reporting medication costs due to mould at $2,600 and another respondent renting an apartment in Toronto for 5 months.

The financial impacts were categorized into direct and indirect tangible damages and grouped by the floodwater depth (relative to basement/crawlspace) reported by the respondents. This information is shown as a box plot in Figure 3.10. Individual survey responses are shown as circles and the three horizontal lines in the coloured columns denote the 25th, 50th (median), and 75th percentiles. The ‘x’ markers denote the average damages for each category and the “whiskers” denote the range of expected data.

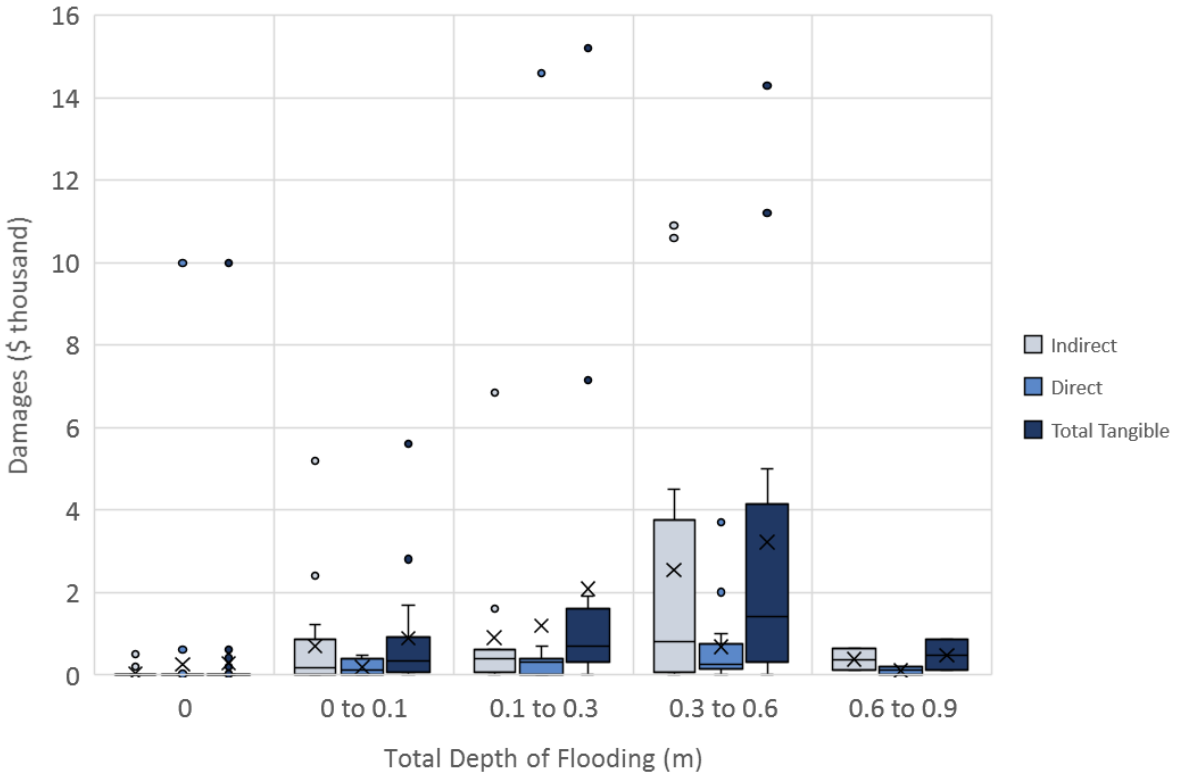

Figure 3.10: Summary of Financial Damages Incurred by Residential Survey Respondents

The figure indicates that the average total damages were $900 for homes experiencing up to 0.1 m of flooding (n=16); $2,100 for homes experiencing 0.1 m to 0.3 m of flooding (n=15); $3,200 for homes experiencing 0.3 m to 0.6 m of flooding (n=13); and $500 for homes which had greater than 0.6 m of flooding (n=2). Indirect damages were approximately 80% of the total damages for all flooding depths other than the 0.1 m to 0.3 m category. The financial damages incurred by homes in this category were approximately 60% direct, 40% indirect.

3.1.3 Health Impacts

Dealing with the mental and physical stresses during and after a flood can have lasting health impacts. Residents reported minor to severe injuries and health impacts due to the flood including body aches and strains, broken bones due to falls, and physical stress resulting from inability to use mobility aids due to road flooding. More severe health impacts reported by respondents include pneumonia and breathing problems or worsening allergies due to mould. Figure 3.11 summarizes the health impacts reported by respondents as a result of the flooding. Anxiety and stress beyond normal were the most commonly identified health impacts, followed by sore back or body, and sleeping difficulties. Residents were also asked if they have any ongoing health issues that were caused by the flood. Six respondents identified allergies (mould or other), pneumonia, and increased anxiety.

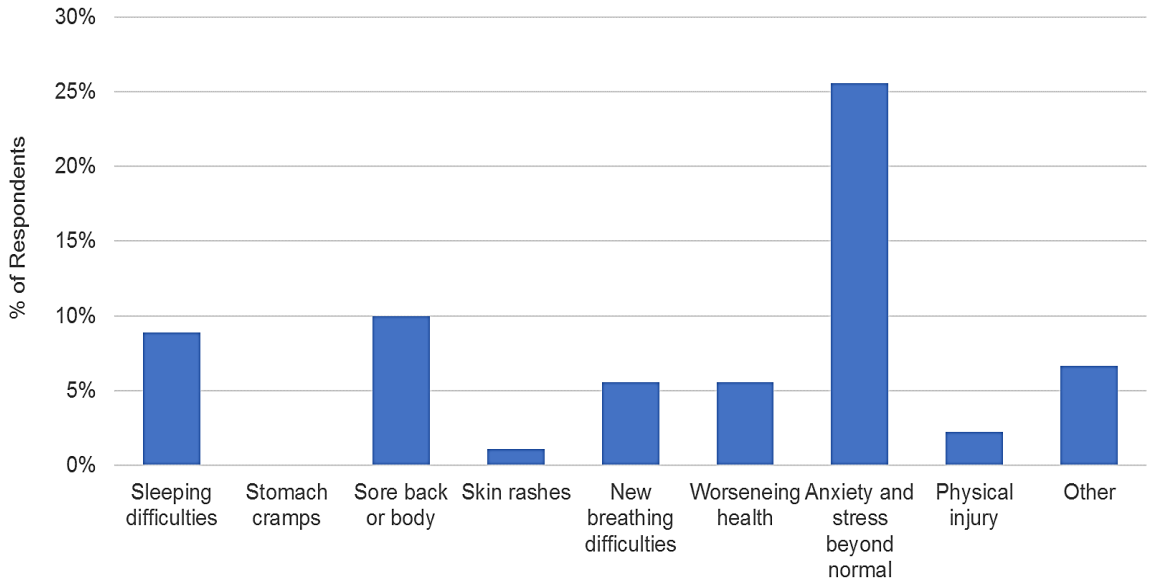

Figure 3.11: Summary of Health Impacts Reported by Residential Survey Respondents

The third question asked residents to identify the causes of their anxiety. The most common responses were not knowing how high the water was going to get, concern for others, and damage to their house and contents (see Figure 3.12).

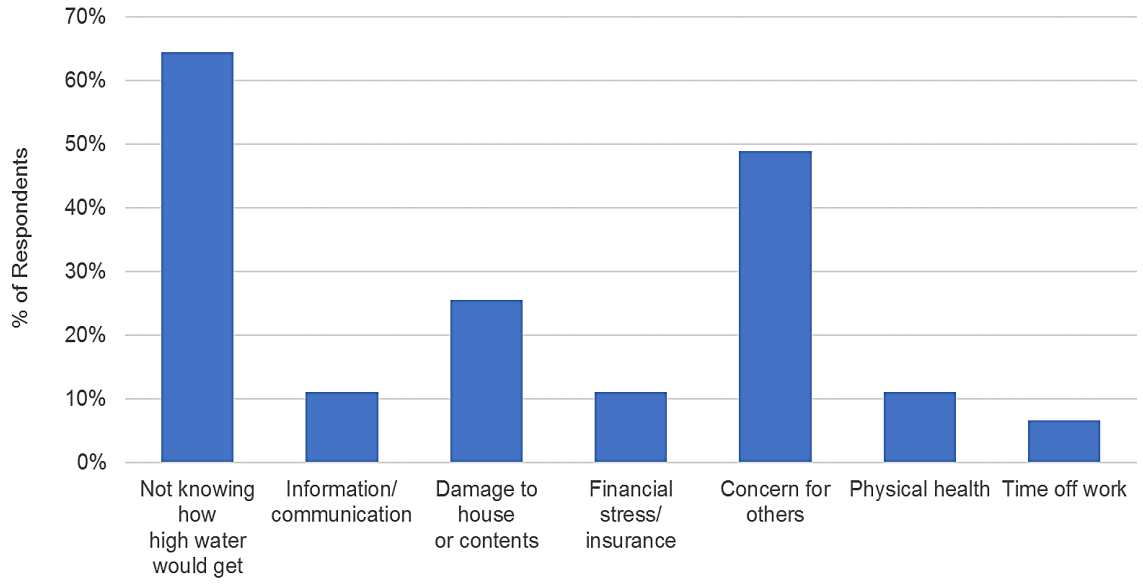

Figure 3.12: Summary of Causes of Anxiety Reported by Residential Survey Respondents

The final two questions asked residents to identify the sources of the physical and social support they received. The leading sources of physical support were City of Toronto PF&R, neighbours, TRCA, and friends/family. The same sources were identified as providing high levels of social support, but in a different order with neighbours and friends/family providing a higher level of social support than physical support (see Figure 3.13).

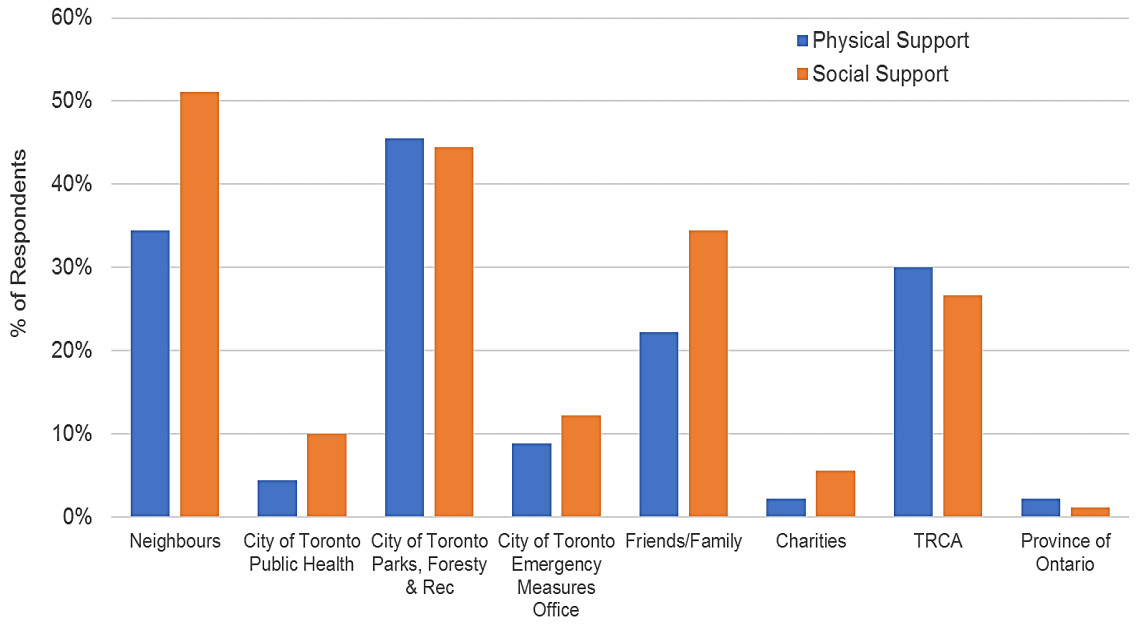

Figure 3.13: Summary of Sources of Support Reported by Residential Survey Respondents

3.2 Business Survey Results

A survey was distributed to the 22 businesses, clubs, and organizations operating on the islands on January 18th, 2019. The survey included questions about the business operating season, number of employees, building information, and building contents. Questions pertaining to the 2017 flood impacts included floodwater depths and physical impacts, business disruption, and expenditures. A copy of the survey is included in Appendix B.

Baird called each of the businesses to confirm that they received the survey, answer questions, and listen to concerns. About half of the businesses indicated that they will reply, one business was not interested, and voicemail messages were left with the remaining businesses. The response rate from businesses has been low, with only 3 businesses returning a survey (Island Café, Smiley's B&B, and Toronto Island SUP).

The responses that were received, phone calls with the businesses, and other information indicate that the primary impacts to the businesses were due to the closure of Toronto Island Park and restricted ferry services. The uncertainty surrounding the length of the closure affected many businesses, as they did not know whether they should keep or layoff staff. Some businesses expressed concerns that they may have lost some clients permanently, as clients found new services and venues on the mainland. There was also confusion and misinformation about visitor access to the islands, and clients of some businesses were turned away by ferry staff. A list of the businesses and organization operating on Toronto Islands is provided in Table 3.2.

Table 3.2: List of Businesses and Organizations Operating on Toronto Islands

Type	Business or Organization
Activities & Attractions	Centreville Amusement Park, Electric Island, GWN Dragon Boat, Toronto Island Bicycle Rental, Toronto Island SUP, Toronto Longboat Roadrunners
Community	Algonquin Island Association, Artscape Gibraltar Point, Sunshine Centre for Seniors, Toronto Island Canoe Club, Ward's Island Association
Lodging	Bay Window B&B, Nottawa B&B, Smiley's B&B
Restaurants/Venues	Island Café, Rectory Café, The Shaw House
Yacht Clubs	Island Yacht Club, Queen City Yacht Club, Royal Canadian Yacht Club, Toronto Island Marina, Toronto Island Sailing Club

3.3 City of Toronto Impacts

The 2017 flood caused considerable disruption to City activities and damages to City-owned assets and infrastructure. The impacts were felt across different City departments and recovery efforts are ongoing. Baird reviewed publicly available reports from the Department of Parks, Forestry and Recreation that estimated the financial impacts and recommended actions to address the 2017 flood damages. Assessments of the damages and repair costs are ongoing, and it is expected that the financial impacts will be refined in future reports. Baird reached out to a number of key municipal contacts to develop a better understanding of the impacts from the 2017 flood. These impacts are discussed below.

Toronto Parks, Forestry & Recreation

Baird discussed the impacts of the 2017 flood with Richard Ubbens (Director of Parks, Forestry & Recreation). Mr. Ubbens provided the initial reports and estimated impacts that are discussed above.

Ferry Services

The Toronto Island ferry service carries over one million passengers and generates approximately $8M to $10M in annual revenue for the City of Toronto. As previously mentioned, the ferry services to the island were suspended from May 4th to July 30th. These services only remained available to residents of the islands and authorized personnel. The City of Toronto (2017a) estimated that ridership dropped 90% over this 3-month period compared to 2016. This resulted in an estimated revenue loss of approximately $4.5M from ticket sales (City of Toronto, 2018a). The significant decrease in the number of visitors to the islands affected all of the businesses on the islands.

Island Water Treatment Plant

Baird discussed the impacts of the flooding with Niall Robertson (Manager of the Island Water Treatment Plant). When the flooding occurred, the access road was scheduled to be resurfaced and the works were delayed until water levels subsided. The water treatment plant buildings suffered no damage, however staff where not able to access the facility by road due to flooding. This required the treatment plant to hire a water taxi to transport staff (and other persons) between the facility and Ward's Island Ferry dock. The costs for the water taxi were approximately $10,000. A photo of the loading dock at the Island Water Treatment Plant taken on May 19, 2017 is shown in Figure 3.14.

Figure 3.14: Photograph of Toronto Island Water Treatment Plant (May 19, 2017 by Niall Robertson)

Toronto Fire Station #335 and EMS Station #48

Baird reached out to the Captain and Commander of the Island Fire Hall to obtain any information about their experiences during the 2017 flood. Baird did not received a response from the Island Fire Hall.

Toronto Hydro

Baird and TRCA discussed the impacts of the 2017 flood with Magda Sulzycki (Supervisor, Grid Emergency Management) and Paul Lopes (Engineer, Grid Emergency Management). The islands are served by two electrical system types. The Toronto Island Airport and Island Water Treatment Plant are serviced by a more modern, 13.8kV system that is comprised of underground equipment only. The remainder of the islands (including residential areas) are serviced by an older, 4.16kV system that is comprised of underground and overhead (pole-top) equipment. Both systems consist of submersible grade and non-submersible grade equipment.

The main risk to the electrical infrastructure is to the underground, non-submersible equipment (e.g. pad-mounted equipment). This equipment is designed to be in areas that are not prone to flooding and is mounted above ground on cement pads. If flooding were to occur, water could come into contact with electrical components housed within the unit. This would cause a short circuit resulting in either a breaker or fuse operating to protect the equipment and/or damage the equipment.

Toronto Hydro actively monitored the low-voltage system in 2017. If a similar flood situation were to arise in the future, Toronto Hydro could proactively de-energize the circuit to avoid equipment damage and potential public safety issues (e.g. fire or electrical tracking on the water). This measure would result in a loss of electricity to

everything downstream of the de-energized equipment. Further, restoring electricity could only occur after the flooding has subsided, the equipment has been inspected for damage, and Toronto Hydro personnel have determined it is safe to do so.

Toronto Water

Baird reached out to Maurice Balaski (Manager of Wastewater & Stormwater Pumping at the City of Toronto), to inquire about any issues they faced during the 2017 flood. Baird did not receive a response regarding issues encountered during the 2017 flood. However, geospatial data for the sanitary sewer network was provided and has been included in the flood depth maps.

Emergency Response and Short-term Repairs

An extensive emergency response was undertaken by the City including deploying crews to install and maintain mitigation measures (sandbags, high-discharge pumps, etc.), inspecting critical infrastructure, communicating with residents, and monitoring public health impacts. Other expenditures resulting from the flood included: staffing, supplies, contracted services, shoreline protection, and installation of ramps and fenders at the Jack Layton Ferry Terminal to maintain ferry service during the high water period. The emergency operations had an estimated cost of $2.45M, with an additional $1.3M extending into early 2018 to address urgent health and safety issues (City of Toronto, 2018a).

The City and TRCA assessed the damages caused by the flood. The review identified 74 instances of damage across the Toronto waterfront (e.g. structural damage, flooding, and erosion). Examples of the damages at Toronto Islands include damage to the Centre Island Washroom & Bathing Station and Grandstand (see Figure 3.15 and Figure 3.16). The City projected that $7.4M will be required to repair and protect damaged infrastructure across the Toronto waterfront (e.g. install permanent pumping facilities on the islands, install beach curbs at select locations to prevent shoreline degradation, etc.)

Figure 3.15: Photograph of Damage to Centre Island Washroom & Bathing Station (from City of Toronto, 2018a)

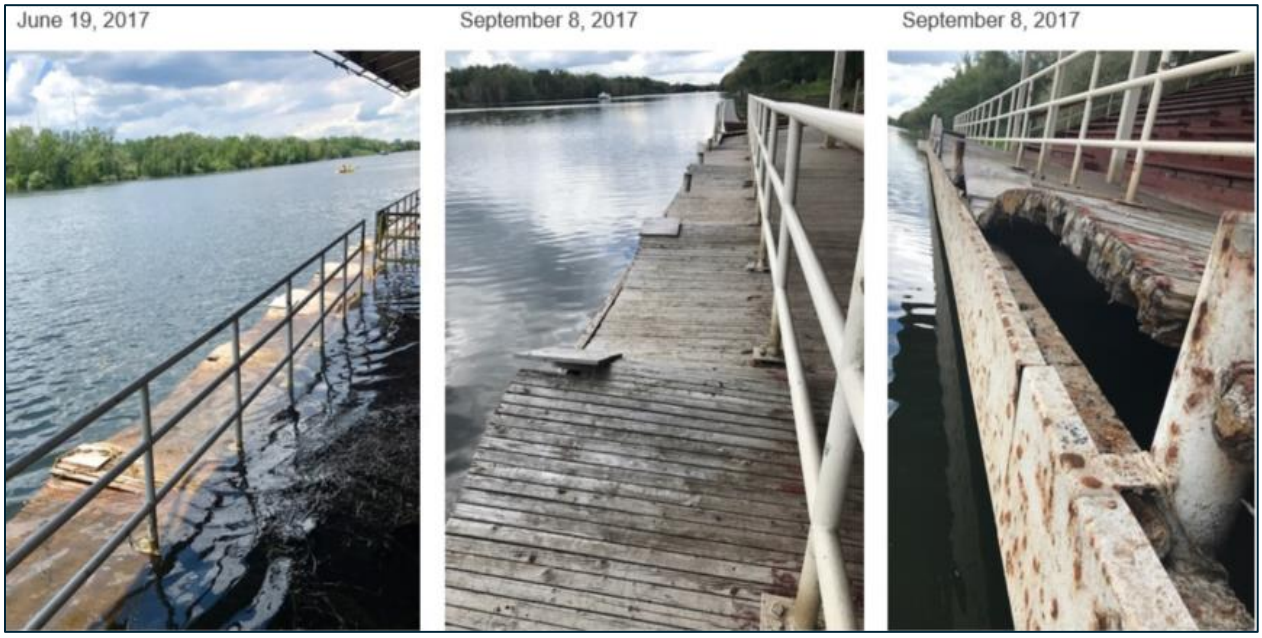

Figure 3.16: Photograph of Damage to Centre Island Grandstand (from City of Toronto, 2018a)

Long-term Repair & Resilience Measures

A significant amount of repairs and long-term resilience measures have yet to be implemented since the 2017 flood. Long term planning and coordination has occurred between the TRCA and the Chief Resilience Officer to determine long-term repair and resilience strategies that will ensure Toronto Islands, and the waterfront as a whole, are stewarded for future generations. These strategies have been prioritized to address health and safety issues, protect City assets, stabilize shorelines, and ensure safe access to beaches across the islands and entire waterfront. In order to address these issues, repair project estimates have been developed (City of Toronto, 2018b) for consideration in the 2019 Capital Budget. These projects have been broadly grouped into the following four categories:

- **Erosion control:** required where the wind and wave action has resulted in the loss of land along the shoreline. In some instances, this type of loss of land also undermined trails, embankments and has created beach scours.
- **Shoreline Infrastructure:** damaged infrastructure such as beach curbs and berms require restoration and repair to avoid future shoreline erosion.
- **Trails, Pathways and Boardwalks:** compromised by high water levels and storm related wave action. Considerable repairs are required and in some cases, complete lengths of pathways, trails or boardwalks need to be replaced. In other places, the repairs consist of asphalt or concrete segment work
- **Asset Infrastructure:** damage to waterfront buildings, bridges, and other structures occurred and have caused structural concerns which are in need of repair. This includes damage to footings, floors and concrete slabs and boat launches

Of the comprehensive breakdown of capital costs associated with this repair program (provided in City of Toronto, 2018b), the following expenditures were proposed that are directly attributable to Toronto Islands:

Immediate Projects (2019):

- Toronto Island Flood Study ($0.15M)
- Toronto Island Park and Centre Island Asset Infrastructure (portion of estimated $0.76M)
- Ward's Island Shoreline Infrastructure (portion of estimated $2.13M)
- Toronto Island Park Trails, Pathways and Boardwalks (portion of estimated $2.64M)

Short Term Projects (2020):

- Centreville Erosion Control (portion of estimated $3.95M)
- Toronto Island Park Asset Infrastructure (portion of estimated $2.55M)

Medium Term Projects (2021-2022):

- Toronto Island Park Asset Infrastructure ($1.5M)

Permits, Tenants and Licences

The City issues permits for a number of events and activities that take place on the islands each year. Nearly half of the permits were cancelled in the summer of 2017, with the remainder of the events relocated to the mainland or postponed (City of Toronto,2018b). Recreation programs that normally take place on the islands were also cancelled; this affected over 400 registrants in camps and speciality programs. The revenue loss related to the cancellation of these recreational programs, closure of the boathouse and tram is estimated to be $0.33M (City of Toronto, 2018a).

The estimated total value of lost permitting revenue during the closure of Toronto Island Park was $0.11M. The City also leases buildings and property to 11 businesses and organizations on the islands. Considering that business operations were considerably affected by the closure of Toronto Island Park, a significant portion of the rental fees will likely be abated to these leaseholders and licencees. At the time of reporting, the portion of the abatement was still under discussion. Budgeted revenue from rents and licence fees for 2017 are approximately $1.4M (see Table 3.3).

Table 3.3: Budgeted 2017 Revenue from Rents and Licence Fees (from City of Toronto 2018a)

Agreement	Annual Base Rent	Percentage Rent*	Total Fee
Wm. Beasley - Centreville	$690,000	$37,800	$727,800
Wm. Beasley - Centre Island Restaurant & Catering	$125,000	$6,700	$131,700
Wm. Beasley - Food & Beverage Concessions	$88,500	$4,800	$93,300
Toronto Island Bicycle Rental	$80,000	$80,000	
Island Yacht Club of Toronto	$64,172	$64,172	
Queen City Yacht Club	$19,978	$19,978	
Sunfish Cut Boat Club	$7,121	$7,121	
The Royal Canadian Yacht Club	$115,192	$115,192	
Toronto Island Marina	$15,000	$140,000	$ 155,000
Toronto Island Canoe Club	$300	$300	
Sunshine Centres for Seniors	$2,500	$2,500	
Total Budgeted Rent / Licence Fees	**$1,207,763**	**$189,300**	**$1,397,063**

* A portion of annual profit is paid by some tenants and licencees in accordance with their agreements. The City budgets for this revenue based on average of previous years.

4. Flood Damage Calculation Procedures

4.1 Overview of Alberta PFDAS Method

Several methods for estimating flood damages have been developed and applied to case studies in Canada, USA, and other countries. TRCA reviewed several of these methods and concluded that the Alberta Provincial Flood Damages Assessment Study (PFDAS) method was the most appropriate method for Toronto. This method was developed by IBI Group and Golder Associates Ltd. for the Alberta Provincial Government (IBI Group, 2015). This method was initially developed with the City of Calgary (post 2013 flood) as the location for the pilot study and method development and was then adjusted using indexing methods for other communities in Alberta. The PFDAS method was developed by integrating best practices and applicable methodology from previous case studies (Canada, USA, Europe, and Australia), updating, and further developing these methods to reflect current conditions and practices.

The PFDAS method calculates flood damages using a building classification and corresponding depth-damage curve. Depth-damage curves are a relationship between floodwater depth and financial damages. The PFDAS method includes a range of general classifications under which residential and non-residential type buildings can be categorized. For each of these classifications there is a corresponding depth-damage curve; using this simplified method, flooding depths can be easily translated into damages using the applicable depth-damage curve for each property. This method estimates damages to building contents and structural damages separately, with separate depth-damage curves provided for contents and structural damages.

The PFDAS depth-damage curves were developed form extensive post-flood surveys on a sample of representative residential and non-residential properties for each type of classification. A comprehensive inventory of building characteristics and contents were used to develop the contents damages curves. The structural damages curves were developed through field inspections by architectural personnel, and consultation with the local building industry. The depth-damage curves provide estimates for damages at various flood depths expressed in dollars per square metre of floor area ($/m^2), to average the scatter that was observed from the survey results.

Several assumptions, and inherent limitations, were necessary in the development of the PFDAS method to reflect current conditions and practices, and to streamline the damage estimation process. Most notably are the broad classifications under which buildings are categorized; these classifications lump together residential properties of similar type, and non-residential properties of similar function. This can introduce error in the estimation of damages for properties that do not necessarily fit the particular categories and pose challenges for properties whose types are not captured in the classification scheme. Other factors affecting flood damages such as: flood duration, velocity, warning time, season, and lessons learned from past experiences are not implicitly captured in the PFDAS method. Assumptions in the PFDAS methodology reflect current practices such as zero depreciation and zero salvageability for damaged items (full replacement of all items that have come into contact with floodwater).

Specific assumptions in the development of the methodology are outlined in the following sections.

4.2 Regional Price Adjustment for Toronto

The PFDAS method estimates flood damages in 2014 dollars for the City of Calgary. Indexing factors are used to adjust the contents and structural flood damages estimates for year and location.

The method for indexing contents and structural depth-damage curves to the Greater Toronto Area (GTA) provided by TRCA was updated by Baird in the current study. The method uses the Survey of Household Spending (SHS) by Statistics Canada to index contents damages. The SHS provides average household expenditures in categories similar to that covered by the Consumer Price Index (CPI) and is available on a provincial level. The SHS was used to convert residential contents damages from Alberta 2014 to Ontario 2017 (see Table 4.1). The development of the weighting factors is described in IBI Group (2015). Baird applied the method using 2017 data (Statistics Canada: Table 11-10-0222-01) to update the residential contents index factor. The index factor of 0.98 indicates that residential contents in Ontario are slightly lower than in Alberta three years earlier.

Table 4.1: Residential Contents Damages Indexing Factor – AB 2014 to ON 2017

Category	2014 AB SHS	2017 ON SHS	Weight	Weighted 2014 AB SHS	Weighted 2017 ON SHS	ON 2017 / AB 2014 Index
Furnishings and equipment	$2,359	$2,553	0.59	$1,392	$1,506	0.98
Clothing and accessories	$4,378	$3,721	0.21	$919	$781	
Recreation*	$1,444	$1,241	0.20	$289	$248	
Total	$8,181	$7,515	1.00	$2,600	$2,536	

*Does not include services and vehicles

The CPI is commonly used to convert historical dollars to current dollars for a wide variety of consumer products and services. Non-residential contents are less variable between major metropolitan areas and the CPI for all of Canada from January 2014 to January 2017 was used to calculate the non-residential contents index. The CPI values for the “goods aggregate excluding food purchased from stores and energy” for these periods (from Statistics Canada: Table 18-10-0004-13) resulted in an indexing factor of 1.06.

Structural indexing factors were determined using the 2014 Altus Construction Cost Guide and Statistics Canada Construction Price Indexes (Statistics Canada: Table 18-10-0135-01) to account for year and region, respectively. A ratio for average construction costs (per floor area) in the GTA and Calgary was calculated and scaled using the ratio of the 2014 and 2017 GTA Construction Prices Indexes. This procedure was completed for a range of building categories that reflect the classification scheme used in the PFDAS method; the resulting indexing factors are shown in Table 4.2. At the time of the current study, SHS data and average construction costs for 2018 and 2019 were not available.

Table 4.2: Structural Damages Indexing Factors – AB 2014 to ON 2017

Building Type	ON 2017 / AB 2014 Index
Office	1.010
Retail	0.914
Institutional	1.001
Hotels	1.004
Parking Structures	1.077
Apartments	0.965
Houses	1.144
Industrial	0.861

4.3 Building Classification Scheme

Accurate assessment of flood damages requires the formulation of a classification scheme that is versatile enough to capture and generalize the variations between structure types and functions without imposing significant errors. In the PFDAS method, residential and non-residential type structures are subject to two distinct classification schemes. Each classification has two corresponding depth-damage curves for both contents and structural damages.

Residential structures are classified according to their construction technique, size, quality, and number of storeys. The residential classification scheme was developed through analysis of previous case studies, and through comprehensive field surveys on a representative sample of structures. The residential classification types, and examples of each, are shown in Table 4.3, Figure 4.1 and Figure 4.2. For both contents and structural damages, residential properties utilize the same classification, i.e. a B-1 building will have corresponding B-1 contents and B-1 structural depth-damage curves. Observed in the current study were only A, B and C type buildings. The corresponding depth-damage curves (without indexing factors included) for these select classifications are provided in Appendix C.

Non-residential buildings contain a wider range of building type and function and do not demonstrate the same level of uniformity as seen in the residential classification scheme. Accordingly, non-residential classification scheme is much more complicated, and is grouped by similar functional area. While functional area ranges widely for non-residential structures, the construction technique does not. Consequently, non-residential structures are classified differently for contents and structural damages. The different types of non-residential classifications are shown in Table 4.4 and Table 4.5. The only classifications observed in the current study are restaurants (I-1), warehouses/industrial (L-1), and institutional/other (N-1). The corresponding contents and structural depth-damage curves are provided in Appendix C.

Table 4.3: PFDAS Residential Classification Scheme (from IBI Group, 2015)

Class	Floor Area	General Description
AA-1 AA-2	372+ m2 (4,000+ ft2) Typical 456 m2 (4,903 ft2)	Typically custom construction built during the 2000s, with superior architectural design and premium quality construction materials, finish materials and workmanship. These units typically include numerous large windows, extensive basement finishing, superior millwork, and built-in high-quality appliances. These very large dwelling units are few in number, and account for the highest reaches of the real estate price distribution, with an average value of $3,400,000.
A-1 A-2	223 – 371 m2 (2,400 – 3,999 ft2) Typical 266 m2 (2,858 ft2)	The A Class structures are relatively large, high-end homes typically featuring moderately high-quality construction materials and finishes. These units have good quality millwork and large window area ratios, and typically have most of the basement areas finished, and have attached garages. While much more numerous than the AA Class, the A units represent a relatively small share of the total population of single dwelling units, reflective of their upper-middle price positioning, with an average value of $1,400,000.
B-1 B-2	112 – 223 m2 (1,200 – 2,399 ft2) Typical 163 m2 (1,754 ft2)	B Class units are generally the most numerous type of single dwelling units in Alberta municipalities. These average quality units were generally built from stock plans as tract or speculative housing for mid-market consumers, from the 1950s onward. These houses are typified by conventional design, and medium quality materials, finishes and workmanship, with some basement finishing and detached garages. They have an average value of $680,000.
C-1 C-2	<112 m2 (<1,200 ft2) Typical 88 m2 (947 ft2)	The C Class units tend to be older housing stock in inner-city locations, or tract starter housing in newer suburban locations. These houses are of average to below average quality in terms of design and construction materials, finishes and workmanship. Generally, units of this class located in the municipal core area have a high land to building value ratio as these structures are approaching functional and physical obsolescence. While C Class units represent the lower range of real estate values, many of these units have been upgraded by owners and feature average or better quality finishes in the renovated areas. They have an average value of $450,000.
D	Typical 128 m2 (1,377 ft2)	D Class units are mobile homes, located on temporary foundations, and without basements. These units tend to reflect the lower range of real estate values.
MA	Typical 93 m2 (1,002 ft2)	MA units are apartment units located in high-rise (5+ storey) structures. The high-rise apartment towers are typically of concrete and light steel frame construction, and have one or more levels of underground parking.
MW	Typical 65 m2 (704 ft2)	MW units are apartments located in low-rise (less than 5 storey) apartment structures. These structures are typically of wood construction and often have single level concrete parking structures underground.

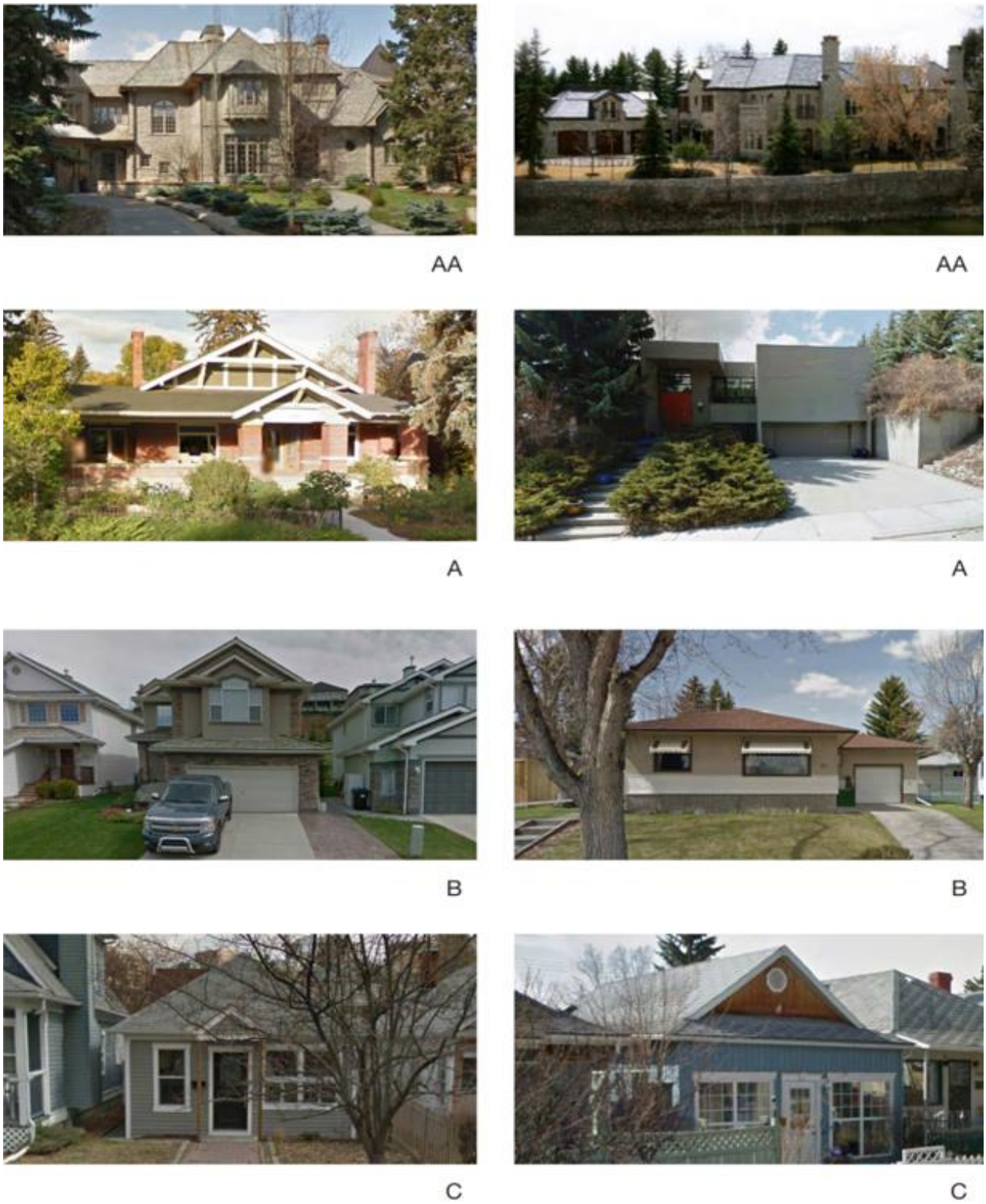

Figure 4.1: PFDAS Residential Building Classifications (AA-C) – Typical Examples (from IBI Group, 2015)

Figure 4.2: PFDAS Residential Building Classifications (D-MW) – Typical Examples (from IBI Group, 2015)

Table 4.4: PFDAS Non-Residential Contents Classification Scheme (from IBI Group, 2015)

Class	Name	General Description
A-1	General Office	This grouping includes municipal and provincial offices, real estate, consulting businesses and other professional offices such as surveyors and engineers. Salvage value was established at 10%.
B-1	Medical	The medical category pertains to doctors' and dentists' offices, as well as medical and veterinary clinics. A salvage value of 5% was established for the medical category.
C-1	Merchandise (Shoes)	These businesses are typically found in shopping malls and to a lesser extent street-front situations. The salvage value was estimated at 5%.
C-2	Merchandise (Clothing)	These businesses are typically found in shopping malls and to a lesser extent street-front situations. The salvage value was estimated at 5%.
C-3	Merchandise (Stereo/TV/Electronics)	Businesses included in this category are audio and video equipment sales, computer and peripherals, small appliances, cameras, musical instruments, and office equipment. A 5% salvage value was attached to this category.
C-4	Merchandise (Paper Products)	Stationery, office supplies and book stores are included under the category of paper products. A salvage value of 5% is employed for this category.
C-5	Merchandise (Hardware/Carpet)	Hardware stores, as well as paint and carpet stores are included under hardware/carpet, due to an overlapping of this product type. Salvage value has been established at 10% for this category.
C-6	Miscellaneous Retail	This category includes retail/commercial businesses not included under the specific designations above. Salvageability is pegged at 8% for this category.
C-7	Generalized Retail	This generalized retail curve aggregates the other retail categories including C-1, C-2, C-3, C-4, C-5, C-6, D-1 and E-1 to render an overall retail category average
D-1	Furniture/Appliances	This classification is relatively straightforward with consistency in both product types and methods of display and storage. Modern practices have reduced previous high salvageability levels to 5%.
E-1	Groceries	This classification contains grocery stores. Salvageability is slightly higher in the larger outlets, but overall still relatively low at 5%
F-1	Drugs	Businesses in this classification generally carry a wide range of sundry items in addition to the pharmaceutical products sold. A salvageability value of 5% is used in this category.
G-1	Auto	Included under this category are any businesses related to the sale and maintenance of automobiles, i.e., new and used car sales, parts

Class	Name	General Description
		suppliers, auto body and repair shops, muffler and transmission repair, and car washes. A salvage value of approximately 30% has been established for use in this particular category.
H-1	Hotels	This particular category includes both hotel and motel facilities. A salvage value of 5% is employed for this category.
I-1	Restaurants	All food serving establishments are classified under restaurants including both “sit down” and “fast food” type outlets. A salvage value of 5% is employed in this category.
J-1	Personal Service	Businesses in this category include travel services, dry cleaning, hairstylist/beauty salons and general services. Salvage value for personal services has been estimated at approximately 10%.
K-1	Financial	The financial category includes banks and trust companies and is similar to the general office category. Furnishings and other pertinent articles can usually be salvaged and a salvage value of 10% is employed for this category.
L-1	Warehouse/Industrial	The types of businesses in this category are extremely diverse ranging from storage and retailing of consumer goods to relatively heavy manufacturing plants. A salvage value of approximately 30% is employed for the warehouse/industrial category.
M-1	Theatres	This classification contains theatres/cinemas. An overall salvage value of 5% is employed in this category.
N-1	Institutional/Other	This category contains education, cultural and recreational facilities including libraries, YMCAs, post offices, schools, churches and recreation centres. A salvage value of 10% has been established for this category.

Table 4.5: PFDAS Non-residential Structural Classification Scheme (from IBI Group, 2015)

Class	Name
S1	Office / Retail
S2	Industrial / Warehouse
S3	Hotel / Motel
S4	Highrise
S5	Institutional

4.4 Tangible Residential Damages

The PFDAS procedure for estimating tangible residential damages (both direct and indirect) is outlined in detail below along with key assumptions, limitations, and modifications made for application to Toronto Islands. An overview of the information required to produce the estimates and a flow chart of the generalized procedure is also provided.

4.4.1 Direct Damages

In order to better understand the process of estimating tangible direct damages (contents, structural, and external), the specific definitions used in the PFDAS method must be stated. In the PFDAS method, the term "contents damages" refers to damages to all items (internal or external) that would be taken when an individual is moving. Examples of contents are clothing, electronics, furniture and small appliances. Some larger appliances such as refrigerators and freezers are also considered to be contents. The term "structural damages" refers to damages to the structural systems of the building itself and building components that would not be taken when an individual is moving. Examples of structural damages are damages to structural members, insulation, cabinets, furnaces, hot water heaters, HVAC systems, wall-to-wall carpeting, and flooring. The term "external damages" refers to damages incurred to contents that are located outside of the residential building. These can be located in a yard, garage, storage shed, and includes damages to gardens and general landscaping.

Contents Damages

There were several key assumptions made in the development of the residential contents depth-damage curves. The contents damages were estimated using the notion of critical water levels and zero salvageability. During the field survey, IBI Group noted the critical water level for various residential contents which refers to the water level at which the item would be significantly damaged. Based on consultation with the insurance industry, cleaning and restoration contractors, and disaster recovery contractors, the assumption was made that when water levels reach the critical level, these contents would be considered as completely destroyed with no effort for repair or salvage. In addition, items that would be indirectly damaged through moisture exposure from prolonged high humidity conditions were not considered to be damaged or destroyed. The values assigned to residential contents reflect estimates of their current replacement cost without considering depreciation, and assumes replacement with similar quantities, sizes and quality. The replacement costs were estimated by a comprehensive merchant survey to determine the average price range for common household contents. Items with a replacement cost below $100 were omitted from the estimates as their impact was deemed to be negligible. In addition, reduction in damages that may occur due to lessons learned from past flooding experiences was not incorporated (e.g. moving contents to a higher floor). Once spatial and pricing information was available, contents damages at given depths of flooding above floor level were aggregated into regular depth intervals to produce the depth-damage curves. The contents depth-damage curves for the select residential building classifications encountered on Toronto Islands are provided in Appendix C.

Structural Damages

Residential structural depth-damage curves were developed through field inspection by architectural personnel and consultation with the local (Calgary) building industry. During the field survey, IBI Group collected information regarding the floor areas, interior and exterior finishes, and building and room dimensions. The depth-damage curves reflect the costs to clean, repair, and restore according to local material and labour costs. Cleanup, repair, and restoration includes: the removal of water and sediment, removal and disposal of damaged structural items, structural drying, sanitization, inspection, and testing for residual contamination. There is a high probability that mould growth will occur in common residential finish materials due to contact

with floodwater or from wicking of moisture through semi-permeable materials. Consequently, it is general practice to remove virtually all finish materials on a floor level that have been in contact with floodwater.

Major structural components of a residential building are generally well maintained and have a life expectancy that defies application of cost depreciation. The main damages occur to finishes, wall and floor coverings, etc., which are also generally well maintained. Thus, depreciation was not applied to cost estimates for restoration or replacement that were used to develop the residential structural depth-damage curves. The expected structural damages at given flood depths were then aggregated to generate the depth-damage curves. The structural depth-damages curves for the select residential building classifications encountered on Toronto Islands are provided in Appendix C.

External Damages

External damages encompass damages incurred to contents that are not located within the residential building. This can include contents located in a yard, garage, storage shed, etc. External damages also account for damages to gardens, trees, landscaping and general yard cleanup. Vehicles are not included as external damages in the PFDAS methodology. Exterior contents were inventoried as part of the comprehensive field survey in a similar fashion to interior contents and are accounted for implicitly in the contents depth-damages curves. Additionally, general landscaping and yard cleanup were accounted for by adding a nominal value of $7,500, $5,000, and $2,500 to class A, B and C structures respectively.

4.4.2 Indirect Damages

Residential indirect damages are difficult to quantify due to differing impacts on (and responses by) residents. Indirect damages include cost of evacuation, temporary accommodation, loss of wages, cleanup, and efforts to mitigate the flood impacts. Given the complexity and intensive nature of determining accurate indirect damages, they are often accounted for as a percentage of the direct damages. Based on a literature review of previous case studies and their respectively methodology, a constant percentage of 15% was used to estimate indirect damages for residential buildings in the PFDAS method and is applied in the current study.

4.4.3 Modifications for Toronto Islands

The PFDAS method does not include residential contents and structural depth-damage curves for buildings with crawlspaces. Considering that nearly all of the houses on Toronto Islands have crawlspaces, curves needed to be developed for residential buildings with crawlspaces. The residential survey responses for Toronto Islands indicated that crawlspaces were generally unfinished and contained low value contents and contents that would not be damaged by water. However, some houses contained essential components such as furnaces and hot water heaters.

To account for the damages that could be incurred, a nominal value of $1,000 was applied for contents damages and $2,500 for structural damages at any depth of flooding within the crawlspace. The nominal values were based on reported damages from the residential survey.

Flood damages above the crawlspace followed the PFDAS depth-damage curves for the first floor (in addition to the crawlspace nominal values). Residential buildings with basements used the PFDAS depth-damage curves.

4.4.4 Generalized Calculation Procedure Flowchart

A flow chart outlining the residential tangible damages calculation procedure is shown in Figure 4.3. The procedure begins by classifying each building and assigning the corresponding set of depth-damages curves. Thereafter, flood depths are calculated by subtracting the floor elevation from the flood elevation and a direct

damage cost per square metre of floor area is determined. The direct damage unit rate is multiplied by the total floor area to estimate the total direct damages to the building. Indirect damages and indexing (region and year) are then applied as markups to arrive at total tangible damages.

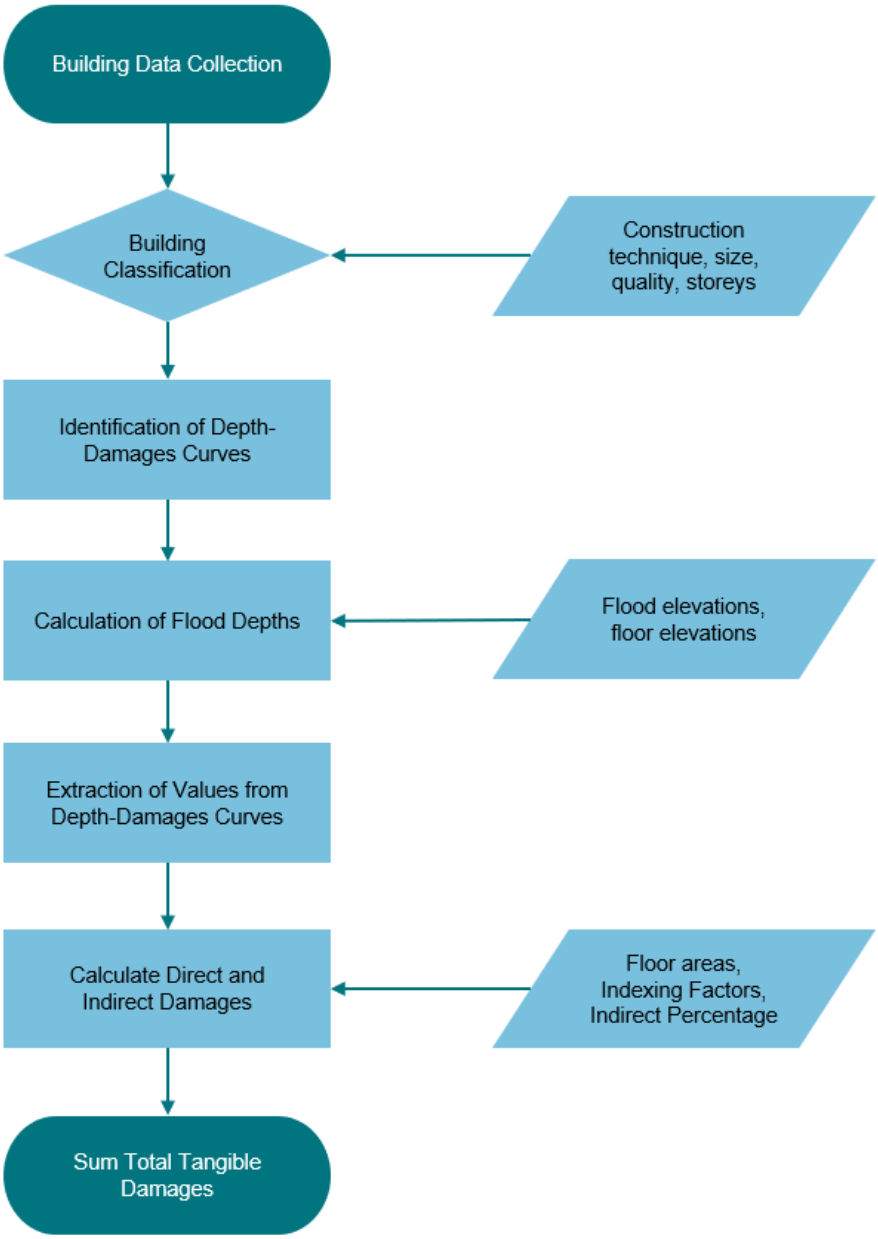

Figure 4.3: Generalized Procedure for Calculation of Residential Total Tangible Damages

4.5 Tangible Non-Residential Damages

The PFDAS procedure for estimating tangible non-residential damages is outlined below along with a discussion of the assumptions, limitations, and modifications made for Toronto Islands. An overview of the information required to estimate the damages and calculation procedure is also provided.

4.5.1 Direct Damages

Non-residential structures are subject to direct damages that include contents and structural damages. Following the same general procedure that is implemented for residential structures, both types of direct damages are calculated separately for non-residential structures. The contents of non-residential structures are highly variable and are classified by use and similar functional area. The structure type tends to be less variable among non-residential structures and only 5 classifications are needed for structure and construction type.

Contents damages are mainly associated with damages to inventory (a portion of which is considered to be salvageable). Structural damages are considerably lower than residential buildings due to the use of more durable materials, easier implementation of cleaning and structural drying, minimization of downtime, and the high degree of caution taken in residential homes due to potential liability regarding health and occupancy issues. Non-residential properties typically do not have the same amount of external contents and direct damages of this type were ignored in the development of the PFDAS method.

Contents Damages

Non-residential contents damages are comprised of damages to inventory, furnishings, fixtures, and equipment. IBI Group (2015) conducted comprehensive surveys of 90 businesses in Calgary to develop the non-residential damage curves. Floor areas, finishes, type, number, value, and vertical arrangement of equipment, fixtures and furnishings were noted in the surveys.

Typical salvageability rates were estimated by consulting facility managers. Compared to previous studies, the PFDAS method provides much lower salvageability rates, reflective of the same restoration difficulties, health and safety liability concerns, and cost issues described in the residential contents section. Damages associated with equipment, fixtures and furnishings reflect retail replacement costs, while the damages associated with inventory reflect wholesale replacement costs. While some larger, more established businesses may have specific contingency plans in place for the removal and safeguarding of inventory and equipment, past experience with reaction to flooding was ignored in the development of the PFDAS method. From the collected information, damages between flood level intervals were grouped together to produce the non-residential contents depth-damages curves. Of the comprehensive set of classifications, only classifications for restaurants (I-1), warehouses/industrial (L-1), and institutional/other (N-1) were encountered on Toronto Islands. This subset of depth-damage curves is provided in Appendix C.

Structural Damages

The structural depth-damages curves were developed from first principles for the structural classification scheme. As opposed to the survey technique implemented for residential buildings, non-residential building properties were determined through analysis of obtained building plans. This allowed for accurate assessment of areas, finishes, construction type, etc. Estimates of unit prices for replacing and/or repairing flood damaged materials were determined through consultation with local suppliers and contractors. Structural damages neglected effects due to differential hydrostatic pressure, as it was assumed that leakage would occur through window sashes, doors, and other openings. Similar to previously noted methodology, once damages at given levels were determined, they were lumped together at regular intervals to produce the non-residential structural depth-damages curves. Encountered on Toronto Islands were structural classifications for restaurants/retail

(S-1), warehouses/industrial (S-2), and institutional/other (S-5); the corresponding curves are provided in Appendix C.

4.5.2 Indirect Damages

Indirect damages to non-residential buildings can include such things as costs of evacuation, employment losses, administrative costs, net loss of profit and earnings, management and labour, and general inconvenience. Due to the complexity of accurately determining the above noted factors and values, it has been common practice in previous studies to allocate an additional percentage of direct damages to account for indirect damages. This nominal percentage mark up method is highly simplified and may not necessarily be accurate. For the PFDAS method, data regarding the impact of the 2013 Calgary flood on working hours was collected by a special Labour Force Survey conducted by Statistics Canada. This data provided estimates of the total hours of work lost and was combined with average productivity rates to estimate the total value of indirect damages. While this type of data is not available for Toronto Islands, a similar methodology outlined in the draft Canadian Floodplain Mapping Guidelines Series (NRCAN,2017) is employed to estimate the indirect damages associated with different flood levels. This methodology is detailed below.

4.5.3 Modifications for Toronto Islands

As the non-residential depth-damages curves for contents and structural damages only consider flooding above the first floor level, it was not necessary to develop curves specifically for properties with crawlspaces. In order to accurately determine total tangible damages for the Toronto Islands, the only modification from the PFDAS method was the calculation method of indirect damages. The steps outlined in NRCAN (2017) provides a methodology for assessing indirect damages incurred as a result of different flood levels. This methodology focuses on the business disruption and loss of productivity associated with a flood. Based on relationships derived from a previous method developed by FEMA (2009), the total duration of business disruption can be estimated for a given flood depth. The actual duration of complete productivity loss is not necessarily equal to the duration of business disruption. In this method, business disruption is likened to building restoration; thus, it is reasonable to assume that some productivity could still be generated during this time. Some businesses may be able to relocate, operate remotely, or operate at partial productivity during this time. The total duration of productivity loss is then a function of the total building restoration duration which was reduced using an empirical formula in NRCAN (2017). This included a reasonable but assumed maximum number of disruption days, and the percentage of original productivity that could be obtained at or after this time. The estimated duration of total productivity loss was then coupled with average productivity rates for Ontario (from Statistics Canada: Table 36-10-0480-01) to develop depth-damages curves for business interruption. The productivity rates provided in 2007 dollar values were indexed to 2017 values by applying the ratio of the 2007 and 2017 values for the Implicit Price Deflator (Statistics Canada: Table 36-10-0206-01), as per the methodology outlined in NRCAN (2017). These indexed productivity values were then used to obtain indirect damages for various flood levels per unit floor area. The estimated damages per unit floor area were based on the average floor areas per employee for each of the non-residential classifications. The floor areas were taken as the average of the prescribed values by Region of York (2017) and the suggested values from NRCAN (2017). The resulting depth-damages curves are provided in Appendix C. Given the nature of the businesses on Toronto Islands, and the limited information available, such factors as evacuation costs, and displacement costs were not included in the calculation of indirect damages.

4.5.4 Generalized Calculation Procedure Flowchart

A flow chart outlining the non-residential tangible damages calculation procedure is shown in Figure 4.4. The procedure begins by classifying each building by functional area and construction. Thereafter, direct damages are estimated based on contents and structural damage curves from the Alberta PFDAS methodology for the structure type and use (similar to the residential direct damage estimates). Indirect damages are estimated

using productivity depth-damage curves which must be developed using the methodology in NRCAN (2017). These can then be applied in a similar manner using flood elevations, floor elevations, floor areas and indexing factors.

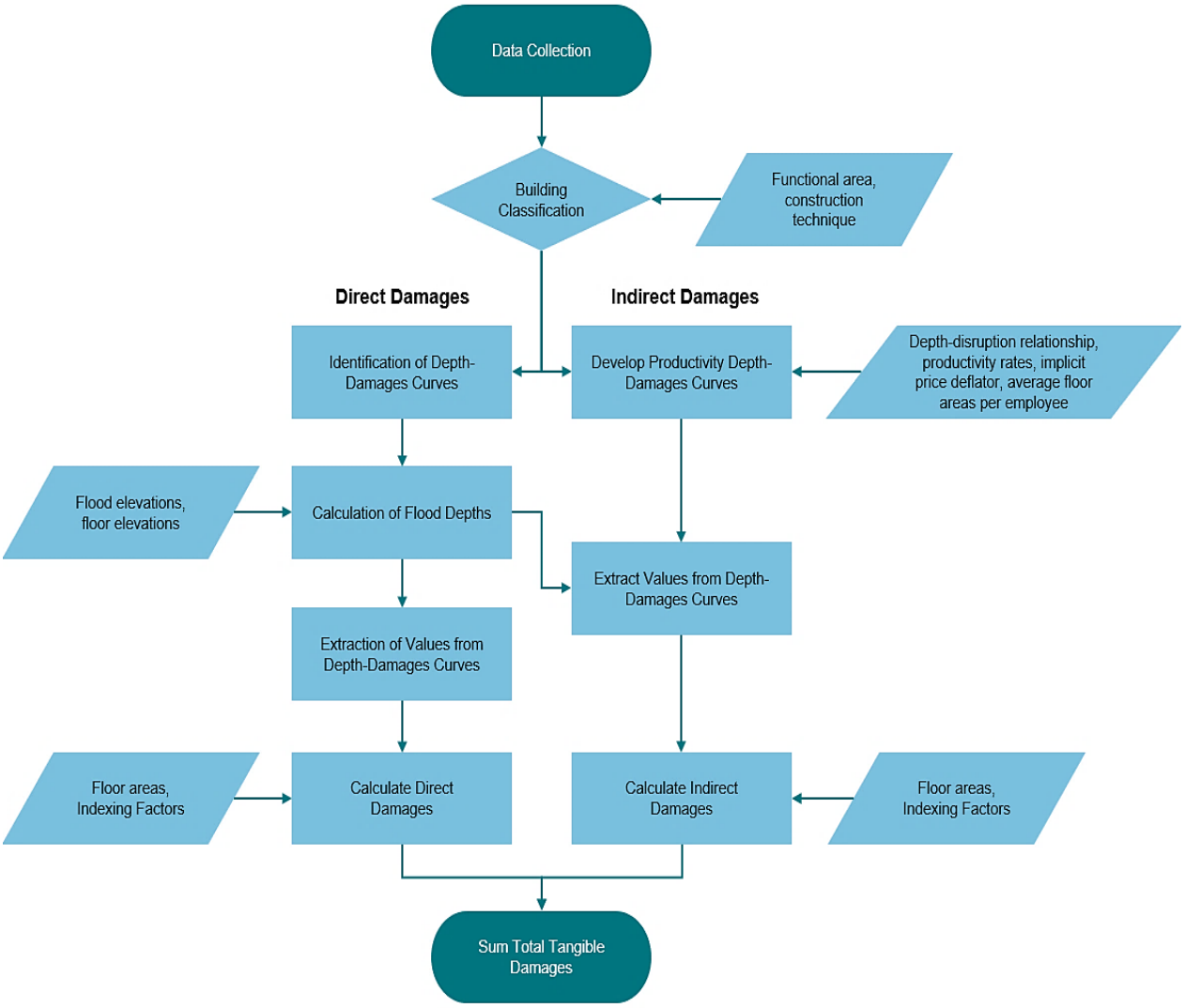

Figure 4.4: Generalized Procedure for Calculation of Non-residential Total Tangible Damages

5. Building Inventory

A building inventory was assembled from data collected from the following sources: Municipal Property Assessment Corporation (MPAC), City of Toronto Open Data, TRCA, Google Street View, and two field surveys conducted by Baird personnel. The MPAC database was merged with additional data from TRCA and provided to Baird. This database contained extensive information on each property on the islands, including but not limited to a list of all building addresses, number of storeys, building types, building footprint areas, elevation information along the building footprint, and an accompanying shapefile of all building footprints. A high-resolution digital elevation model (DEM) based on LiDAR flow in April 2014 and April 2015 was also provided by TRCA. Google Street View imagery was utilized as a preliminary assessment of each building and was used to plan the two field visits. Field surveys, undertaken by Baird personnel, were conducted on December 6th, 2018 and January 25th, 2019.

5.1 Field Survey

The two field surveys conducted by Baird were undertaken to assess current conditions on the islands, and to confirm various details required for the flood damages calculations outlined in Section 6.0 (specifically building classifications and floor elevations). Data collected during the two field visits included:

- Building qualities and approximate construction dates
- Construction and exterior cladding materials
- Number of storeys
- Building classifications
- Number of risers/steps (to estimate first floor elevation)
- Presence of a basements/crawlspaces and/or sheds
- Presence of exterior contents
- Photographs

The building inventory was compiled with the photographs and data collected during the field visits. This included all residential properties, and the majority of non-residential and City of Toronto buildings that were accessible to the public. The inventoried non-residential and City of Toronto buildings were limited to those located within the 500-year floodplain. The buildings were classified according to information gathered during the site visits. This resulted in a building inventory containing information for 258 residential homes, and over 110 non-residential and City of Toronto buildings. Examples of photographs and information collected during the two field surveys are shown in the following figures.

5.1.1 Residential Buildings

Examples of residential buildings and their classifications are shown in the following pages. The majority of the residential buildings (approximately 90%) were identified as Class C one story (C-1) or two story (C-2). Figure 5.1 and Figure 5.2 show Toronto Islands homes that are indicative of typical C-1 and C-2 classifications. The remaining 10% of residential homes consisted of B-2 classifications (Figure 5.3) with one A-2 classification (Figure 5.4).

Figure 5.1: Example of C-1 Residential Building on Algonquin Island

Figure 5.2: Example of C-2 Residential Building on Algonquin Island

Figure 5.3: Example of B-2 Residential Building on Algonquin Island

Figure 5.4: Example of A-2 Residential Building on Ward's Island

5.1.2 Non-Residential Buildings

The non-residential portion of the building inventory consisted of the buildings belonging to all businesses on the islands including yacht clubs, restaurants, venues, bed and breakfasts, island association clubhouses, Centreville facilities, etc. Due to restricted access during field visits, and missing data provided in the MPAC database, a small number of buildings were omitted from the non-residential building inventory. Most notably, the buildings at Toronto Island Marina and the small storage sheds at the various yacht clubs. The Toronto Island Airport buildings were not included in this study.

The following figures show examples of the buildings that were included in the non-residential portion of the building inventory.

Figure 5.5: Example of Centreville Buildings on Centre Island

Figure 5.6: Island Café on Ward's Island

Figure 5.7: The Shaw House Event Venue on Ward's Island

Figure 5.8: Bicycle Rental and Snack Bar on Centre Island

Figure 5.9: Algonquin Island Association Clubhouse and Montessori School on Algonquin Island

Figure 5.10: Queen City Yacht Club on Algonquin Island

5.1.3 City of Toronto Buildings

The City of Toronto buildings have a degree of complexity not present in the residential and non-residential buildings. As such, all of the buildings owned and operated by the City were identified in the building inventory and excluded from the non-residential damage calculations. Buildings owned by the City and leased to businesses were included in the non-residential damage estimates.

The City buildings that were excluded from the damage estimates include: washrooms, changerooms, the Island Water Treatment Plant, the Toronto Island Fire Hall, etc. While many of the buildings could be classified as institutional/other or warehouse (allowing direct damages to be calculated), indirect damages would be difficult to estimate without knowing how the disruption affected staffing, productivity, etc. Furthermore, several buildings such as the Island Public/Natural Science School were excluded as they were not in the 500-year floodplain. Disruption to City services on Toronto Islands appears to be more strongly related to access (ferry and roads) than flooding of the buildings.

Public infrastructure such as electrical transformers and sewage pumping stations were also photographed and logged in the building inventory. Examples of buildings belonging to the City of Toronto portion of the building inventory are shown in the following figures.

Figure 5.11: City of Toronto Fire Station #335 and EMS Station #48 on Ward's Island

Figure 5.12: Public Washrooms and Storage Building on Ward's island

Figure 5.13: Island Water Treatment Plant

Figure 5.14: Public Changerooms on Centre Island

5.2 Input for Estimate of Flood Damages

The building inventory database developed in this study contains all of the residential buildings on the islands, and all of the non-residential and City of Toronto buildings that are in the 500-year floodplain. The information that is required for the flood damage estimates are the building classification, the first floor elevation, and the floor area. The buildings were classified by Baird personnel during the site visits. The first floor elevations were estimated by adding the height of the risers (steps) to the ground elevation measured from the DEM. The building footprints (floor areas) were provided by TRCA.

The ground elevation and estimated first floor elevation of the buildings on Ward's and Algonquin Islands are shown in Figure 5.15. In the left image, buildings with an estimated first floor elevation below the 50-year and 500-year flood levels are shown in red and pink, respectively. In the right image, buildings with a ground elevation at the front entrance below the 50-year and 500-year flood levels are shown using the same colour scheme (indicating buildings that may experience crawlspace flooding). The majority of Algonquin Island is higher in elevation than Ward's Island and is less prone to flooding.

Figure 5.15 indicates that several buildings may be below the floodproofing standard elevation[1] for the Toronto Islands (note that first floor elevations were estimated from the number of risers to the front entrance). The floodproofing standard was defined in the Shoreline Management Plan (Baird & Reindeers, 1994) as 76.2 m Metro Geodetic Datum (approximately 76.1 m IGLD85) plus a 5 m horizontal setback for wave uprush along the Inner Harbour shore and a 15 m setback along the Lake Ontario shore.

It would be prudent to update the floodproofing standard elevation for Toronto Islands using the 100-year monthly mean lake level accounting for the change in Lake Ontario regulation plans (Baird, 2019), the 100-year wind setup (Baird, 2019), and the default freeboard allowance for sheltered sites on the Great Lakes (see Section 7 in OMNR, 2001). This results in a floodproofing standard elevation of 76.44 m IGLD85 (75.86 m IGLD85 + 0.28 m + 0.3 m).

[1] The minimum floodproofing standard elevation as required by provincial policy for development and site alternation within the flooding hazard limit is the 100 year monthly mean lake level plus the 100 year wind setup plus a flood allowance for wave uprush and other water related hazards.

Figure 5.15: Estimated First Floor Elevation (left) and Ground Elevation at Front Entrance (right) on Algonquin and Ward's Island

6. Estimation of Tangible Damages

Estimates of tangible damages for residential, non-residential, and City buildings on Toronto Islands for the eight return period flood levels are outlined in this section. The estimates follow the calculation procedures outlined in the report. Estimated damages using the maximum daily water level at Toronto in 2017 (75.93 m IGLD85) are compared to reported damages to assess the applicability of the current method.

The distinction between the three categories of buildings is important to note in this section. Residential damages refer to damages to residential buildings. Non-residential damages encompass damages to all businesses, associations, and any other buildings that are not owned and operated by the City. Businesses operating in leased buildings are included in the non-residential damage estimates. City of Toronto damages correspond to damages to all municipal buildings and facilities (i.e. public washrooms, water treatment plant, fire hall, school and other infrastructure). The City damages include financial losses due to rental abatements from the 2017 flood.

6.1 Residential Buildings

6.1.1 Calculation Results

The number of residential buildings that would experience any level of flooding during the different flood return periods are shown in Table 6.1. The total number of residential buildings on the islands is 258, with 152 on Ward's Island and 106 on Algonquin Island. It should be noted that the values listed for the 2017 flood were determined using the calculation procedure; this will be compared to observed values further in this section.

Table 6.1: Estimated Number of Residential Buildings Flooded at Different Flood Levels

Flood Return Period (Years)	2	5	10	25	50	100	200	500	2017 flood
Water Level (m IGLD85)	**75.38**	**75.65**	**75.80**	**75.94**	**76.01**	**76.05**	**76.14**	**76.25**	**75.93**
Ward's	6	6	30	81	106 (1)	121 (2)	133 (10)	139 (34)	79
Algonquin	0	0	4	12	23	36	50	62	11
Total	6	6	34	93	129 (1)	157 (2)	183 (10)	201 (34)	90
% of All Homes	2%	2%	13%	36%	50%	61%	71%	78%	35%

*Estimated number of residential buildings with first floor flooding shown in parentheses

The general topography of Ward's Island is lower than Algonquin Island, resulting in a higher number of impacted houses on Ward's Island.

Figure 6.1 shows the calculated total direct, total indirect, and total tangible damages for all residential buildings for all flood return periods, as well as the 2017 flood level. Total residential damages range from $0.5M at the 2-year flood to $3.1M at the 500-year flood.

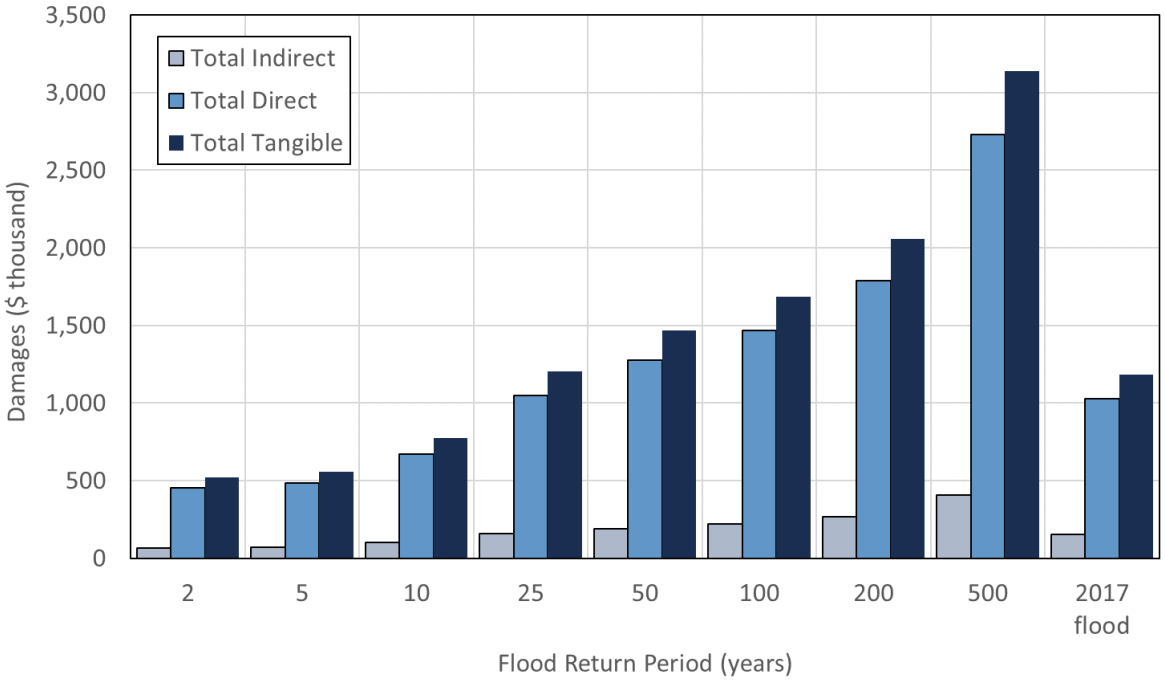

Figure 6.1: Calculated Direct, Indirect and Total Tangible Damages for Different Flood Return Periods

6.1.2 Comparison of 2017 Flood Calculations to Survey Data

The estimated flood damages were compared with the results from the resident survey. It is very important to note that of the 258 homes that received a resident survey, only 90 homes returned the survey with relevant information. In a fair portion of cases, ambiguity in the survey response did not allow for extraction of information that could be meaningfully compared to the calculations. In addition, the survey did not ask for street addresses in order to protect the privacy of the respondents. The resident surveys that were returned were treated as a representative sample of the population of residential homes on the islands, and thus percentages were calculated accordingly from the total.

Figure 6.2 shows the percentage of homes experiencing any level of flooding in their homes (including crawlspaces and basements) from the 2017 flood. A higher percentage of flooded homes was observed in the survey responses than was estimated from the DEM. A higher percentage of the survey responses may have been received by people who experienced flooding.

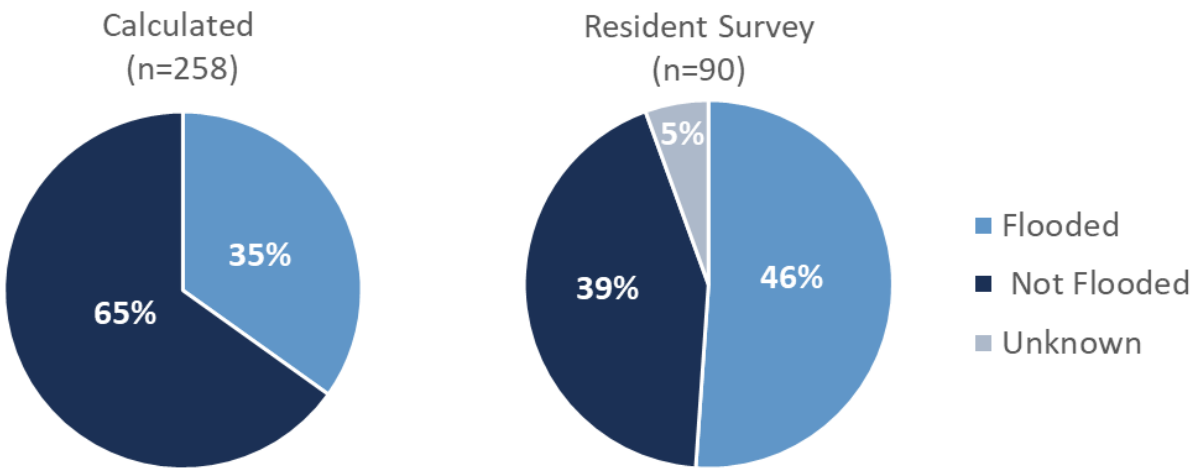

Figure 6.2: Percentage of Homes with Crawlspace, Basement, or First Floor Flooding in 2017

The estimated depth of flooding was also compared to the survey responses (see Figure 6.3). The figure indicates that a high number of responses were received by residents with moderate flooding (0.1 to 0.6 m depth) and fewer responses were received from those with no flooding.

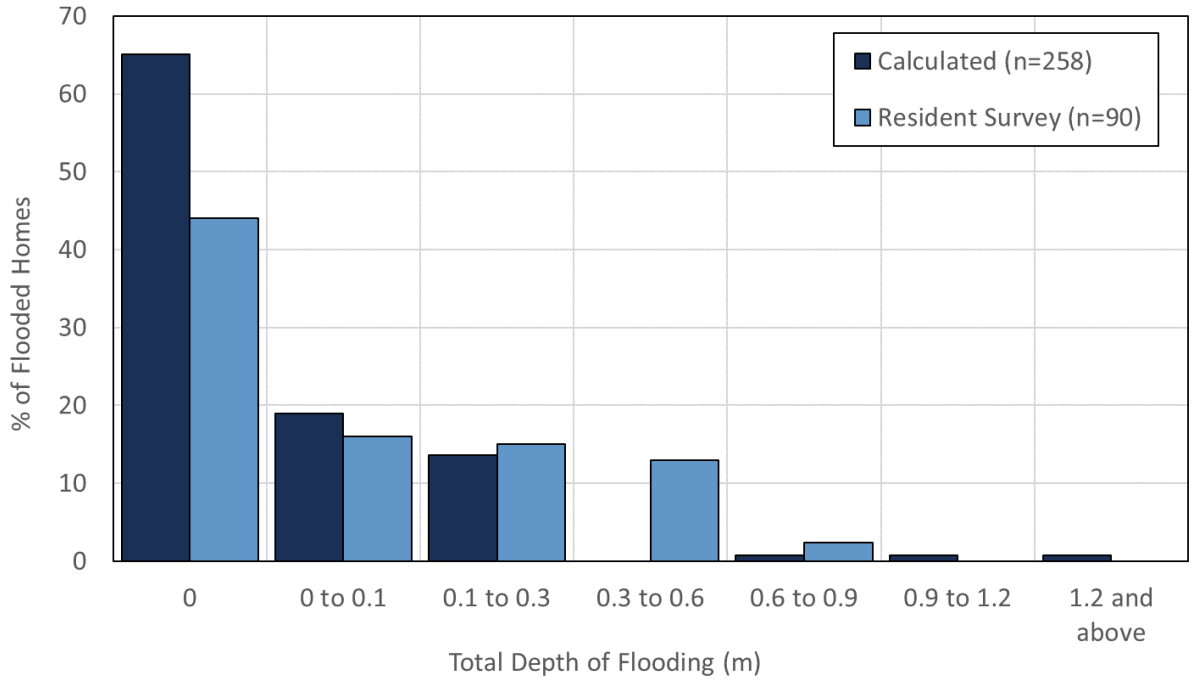

Figure 6.3: Percentage of Flooded Homes by Total Depth of Flooding

The residential survey also asked about the financial impacts of the 2017 flood. As discussed previously, only 35% of residents responded to the survey. Given the complexity of tallying indirect damages, it is likely that indirect costs were underestimated by the survey respondents.

A comparison between the resident survey results and the calculated financial impacts for the 2017 flood is shown in Figure 6.4. The estimated financial damages agree with the maximums reported by residents (rather

than the average damages from the survey). The method resulted in a small proportion of homes experiencing flood depths greater the maximum reported by respondents, leading to much larger damages for these specific homes (e.g. flooded basements).

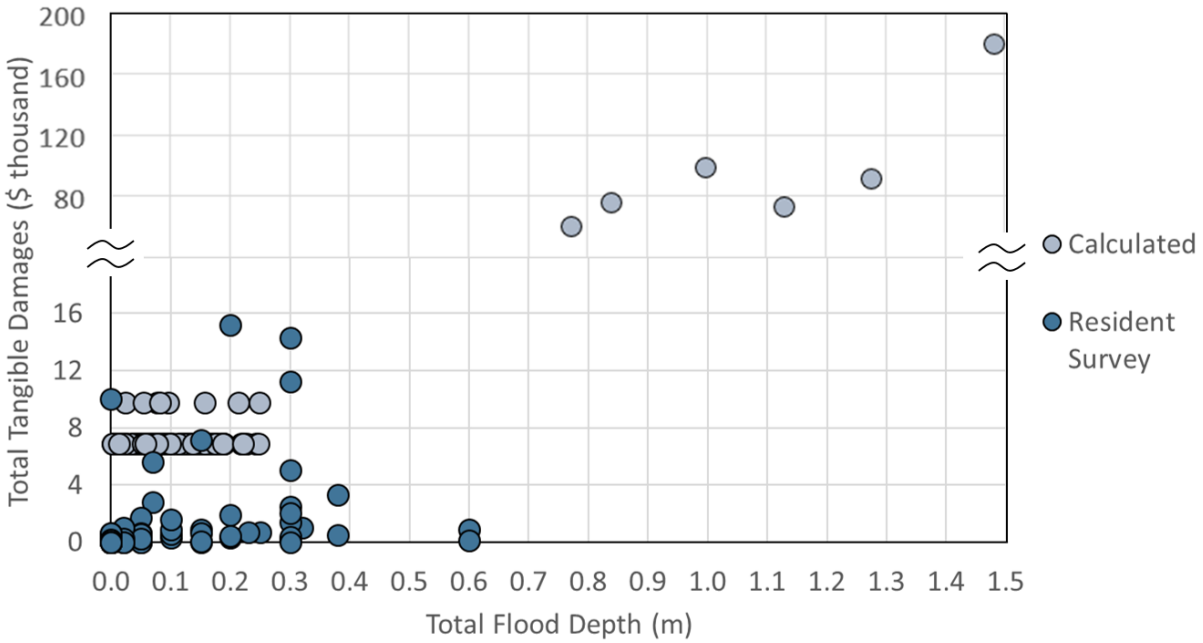

Figure 6.4: Comparison of Total Tangible Damages from Calculations vs. Resident Survey

Another key factor leading to the higher estimates are the nominal values applied for exterior contents ($2,500 to $10,000) and contents and structural damages in homes with crawlspaces ($3,500). Some respondents reported having contents and structural components damaged in their crawlspaces, while others did not. The nominal values assumed that all residents would have some contents and structural components in their crawlspaces. In general, the calculations resulted in higher total tangible damages than were reported in the residential survey. The lower reported damages are likely due to the mitigation efforts, past experience, and adequate warning time.

6.1.3 Assumptions and Limitations

The three parameters consider in the flood damage calculations are the building classification, floor elevation, and floor area. The first floor elevation was estimated by adding the approximate height of the risers to the estimated ground elevation. For crawlspaces, it was assumed that the riser height was equal to the crawlspace height (i.e. built on grade). Basements were assumed to have a height of 2.4 m (as per the PFDAS method).

The onset of flooding was assumed to occur when the flood elevation reached the level of the basement/crawlspace. This was deemed reasonable due to the long flood durations and high permeability of the soil. Flood mitigation efforts such as sandbags and pumps, which may reduce flood damages, were not accounted for (leading to conservative damage estimates). Flood damages at lower flood levels (e.g. 2-year flood) may be partially or completely mitigated by mitigation actions.

It was assumed that at the onset of flooding, the nominal external damages would be applied (namely $2,500 for Class C buildings, $5,000 for Class B buildings, and $7,500 for Class A buildings). As mentioned previously, the PFDAS depth-damage curves were modified for homes with crawlspaces; instead of following

the prescriptive values, constant values of $1,000 for contents and $2,500 for structural damages were applied for any depth of flooding in the crawlspace.

6.2 Non-Residential Buildings

6.2.1 Calculation Results

Flood damages were estimated for non-residential buildings located below the 500-year flood elevation. The estimated indirect, direct, and total tangible damages for the flooded non-residential buildings from each of the 8 return period water levels, and the 2017 flood level is shown in Figure 6.5. The financial impact of the closure of Toronto Island Park on non-flooded businesses is discussed in Section 6.2.4.

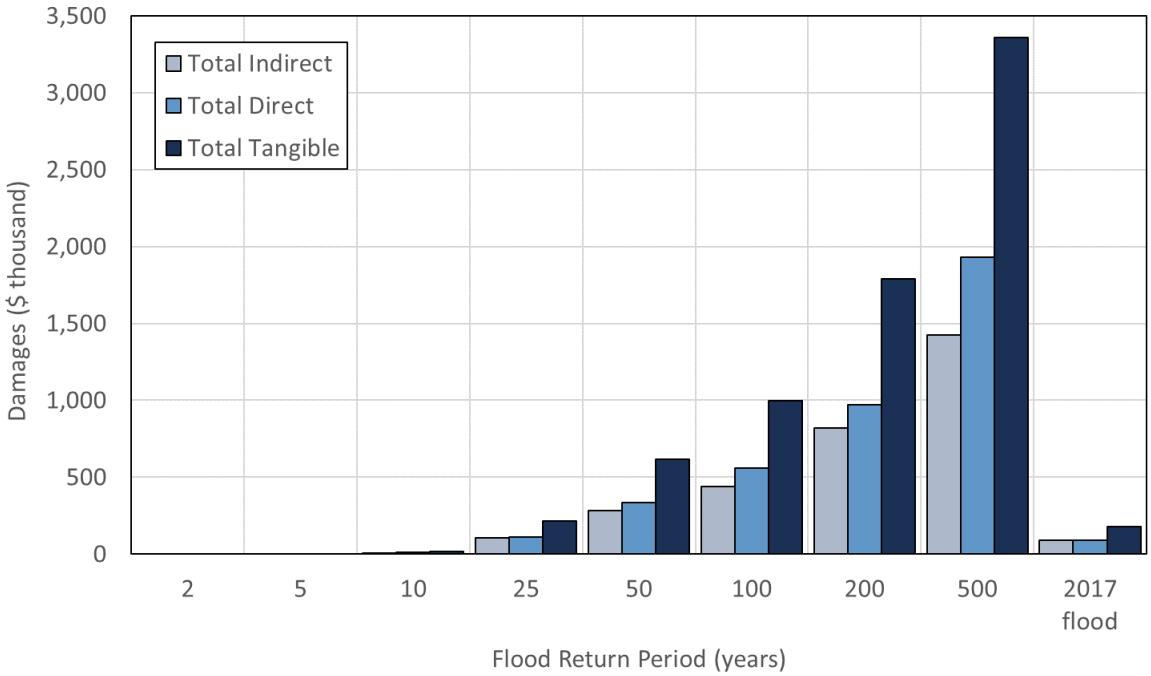

Figure 6.5: Calculated Non-residential Direct, Indirect and Total Tangible Damages

Many of the businesses are located on relatively higher ground than the residential buildings. As a result, the results show no damages occurring to businesses until the 10-year return period flood level is reached. However, non-residential damages increase at a significantly higher rate than residential damages for floods greater than the 10-year event.

6.2.2 Comparison of 2017 Flood Calculations to Survey Data

The low response rate for the business survey prevented a meaningful comparison between the calculation results and what was experienced during the 2017 flood. In lieu of a detailed comparison, the following discussion is provided to give a sense of the general trends of the survey responses, and why similarities or differences between calculations and observed damages may occur.

A portion of the businesses contacted noted that damage had occurred in their crawlspaces/basements. The PFDAS method does not account for damages occurring below the first floor in non-residential structures. Many non-residential buildings operate as a bed and breakfasts, cafés, restaurants or island association

clubhouses. Several of these buildings appeared to be renovated residential properties now operating as businesses. These properties (as with all businesses) were classified as non-residential buildings.

The methodology employed for the calculation of indirect damages followed the NRCAN (2017) recommendations. The method does not allow for indirect damages if a building was not physically damaged. This is not the case for Toronto Islands as businesses were financially impacted by the closure of Toronto Island Park.

The majority of the business survey respondents noted varying depths of flooding in their buildings but did not provide any information regarding the vertical arrangement and value of inventory, furnishings, fixtures, or equipment. It was not possible to directly compare the PFDAS depth-damage curves with the information provided in the responses. The total damages incurred by the businesses were difficult to measure and objective information was not provided that could be directly translated into dollar amounts for comparison.

Assuming further survey responses are received, these results will be incorporated into the final report and applicable comparisons will be made where possible.

6.2.3 Assumptions and Limitations

Several assumptions were made in the non-residential damage calculations to apply the method to the Toronto Islands. As with the residential calculations, ground elevations and first floor elevations were determined from the DEM and the height of the risers. Before the calculation process began, the list of non-residential buildings was limited to only those below the 500-year flood level. As mentioned previously, A small number of non-residential buildings were omitted from the calculations (mostly storage sheds and similar sized facilities) due lack of data and/or restricted access during field visits. The PFDAS non-residential depth-damages curves do not apply to elevations below the main floor.

Many of the non-residential buildings on the islands did not fit the classification scheme provided in the PFDAS method. The MPAC database included non-residential classifications for these buildings, but many seemed unreasonable and were reclassified on a case-by-case basis. For example, yacht club clubhouses were classified as restaurants (I-1) while the remainder of the storage and maintenance facilities were classified under warehouse/industrial (L-1). Bed and breakfast operations, as well as island association clubhouses, were also classified as restaurants (I-1). Buildings with recreational or community purposes, such as Artscape Gibraltar Point and Sunshine Center for Seniors, were classified as institutional/other (N-1). The Centreville amusement park was very difficult to classify due to the many properties, rides and attractions. The majority of the Centreville buildings are food services or retail and were classified accordingly. Damages to rides and equipment could not be included without further detailed inspection and information that was not available for the current study. Further complications arise from businesses of this type that were not considered, such as closure of the entire business if a given percentage of buildings are flooded.

The calculation of indirect damages was the most rigorous aspect of the non-residential calculations. The indirect damages were attributed solely to those incurred due to disruption of business operation and lost productivity. As mentioned previously, the indirect damages calculation procedure (NRCAN, 2017) only calculates indirect damages for building that also experienced direct damages. This is not true for Toronto Islands as business would be affected by ferry services and closures of Toronto Island Park.

The productivity depth-damages curves were generated specifically for application to the Greater Toronto Area, and relied on various inputs and subjective assumptions. Average weekly operating hours for the various non-residential classifications were based on recommendations made in NRCAN (2017). Gross floor areas per employee for the various non-residential classifications were averaged between the recommendations provided in NRCAN (2017) and from a comprehensive survey conducted by Region of York (2017). The ratio between total business disruption and total days of productivity loss depends on an assumed maximum

disruption duration, and a maximum rate of productivity obtained after this duration. Based on the operating characteristics of the majority of the businesses on the islands, feedback from the business survey, and recommendations from NRCAN (2017), values of 240 days of interruption and 20% productivity recovery were chosen. In the NRCAN (2017) report, a productivity depth-damage curve was not provided for the institutional/other (N-1) classification. As this classification was applied to a small number of recreational and community type buildings, this curve was generated using productivity rates obtained from Statistics Canada that best applied to the function of the buildings.

6.2.4 Non-Residential Indirect Damages as a Function of Toronto Island Park Closure

In 2017, most of the businesses on Toronto Islands were not flooded but were significantly affected by the closure of Toronto Island Park. For comparison purposes, the non-residential indirect damages (business disruption) were estimated for closures of Toronto Island Park ranging from one week to four months. The non-residential indirect damages were calculated using the methodology outlined in Section 4.5.3 for the existing building inventory (all buildings within the 500-year floodplain). The estimated indirect damages shown in Figure 6.6 range between approximately $0.7M to $0.8M per week. The estimates are intended for comparison purposes only as the duration of flooding (and closure of Toronto Island Park) at different flood levels depends on many factors. It is noted that the estimates may be affected by public awareness concerning the reopening of the park, retention of staff, loss of clientele, and other factors.

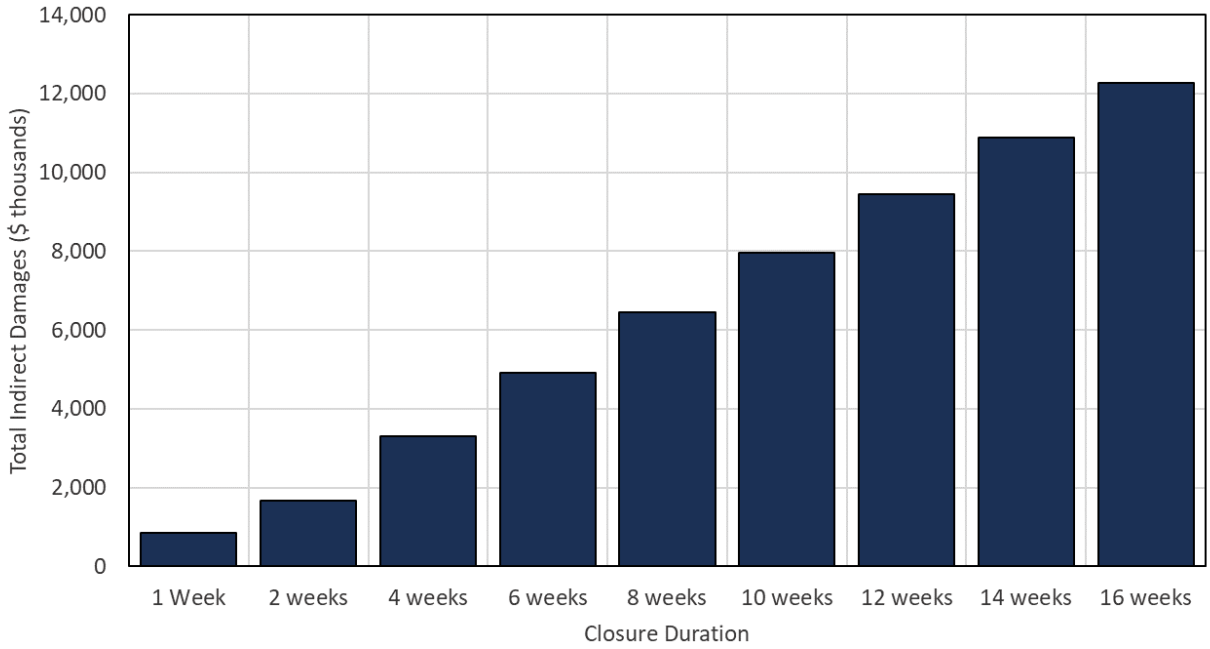

Figure 6.6: Estimated Non-Residential Indirect Damages Resulting from Closure of Toronto Island Park

6.3 City of Toronto

City of Toronto damages correspond to damages to all municipal buildings and facilities (i.e. public washrooms, water treatment plants, fire halls, schools and other public infrastructure). The City of Toronto damages also encompass damages that occur due to such things as: loss of operational revenue, emergency operations, emergency repairs, permits, leases and rental payments from businesses occupying City land. As mentioned previously, the airport was not considered in the assessment of City damages.

As discussed in Section 3.3, detailed cost breakdowns of the damages incurred for the 2017 flood were not available. However, approximate damages were estimated from the City reports.

A significant portion of the City damages in 2017 were indirect costs associated with mitigation, cleanup and lost revenue. The methodology used in this study calculates indirect damages as a percentage (e.g. 15%) of the direct damages to buildings that were flooded. Furthermore, the methodology does not account for damages to infrastructure such as roads, utilities, etc. NRCAN (2017) provides general recommendations to account for infrastructure damages; however, significant consultation with the City would be required to understand critical water levels, critical flood durations, etc. and repair and replacement costs of municipal infrastructure.

This section describes the damages that could be incurred by the City at different flood levels based on information from 2017 and flood mapping.

6.3.1 Temporary Flood Mitigation

The City of Toronto led efforts to protect the residential areas on Ward's and Algonquin Island, Island Water Treatment Plant, sewer pump stations, electrical transformers, and some roads. Other municipal infrastructure such as hydro poles, street lights, benches, picnic tables, pathways, washrooms, etc. are less vulnerable to flood damage and were left unprotected.

It is anticipated that future temporary flood mitigation actions taken by the City would be similar to the 2017 response, but perhaps using newer technology such as rubber/synthetic flood barriers rather than sandbags. The areas requiring protection will depend on the lake level, and efforts will likely be concentrated on Ward's and Algonquin Islands.

The flood depth mapping shows that the onset of flooding in the residential areas occurs at a flood level of approximately 75.8 m. Significant flooding occurs at around 75.9 m (similar to the 2017 flood levels), especially near the Ward's Island Ferry Dock and Queen City Yacht Club (see Figure 6.7). At 76.1 m much of Ward's Island is flooded and depths become significant. Based on the flood mapping, 75.8 m is approximately the level that would trigger significant emergency action by the City.

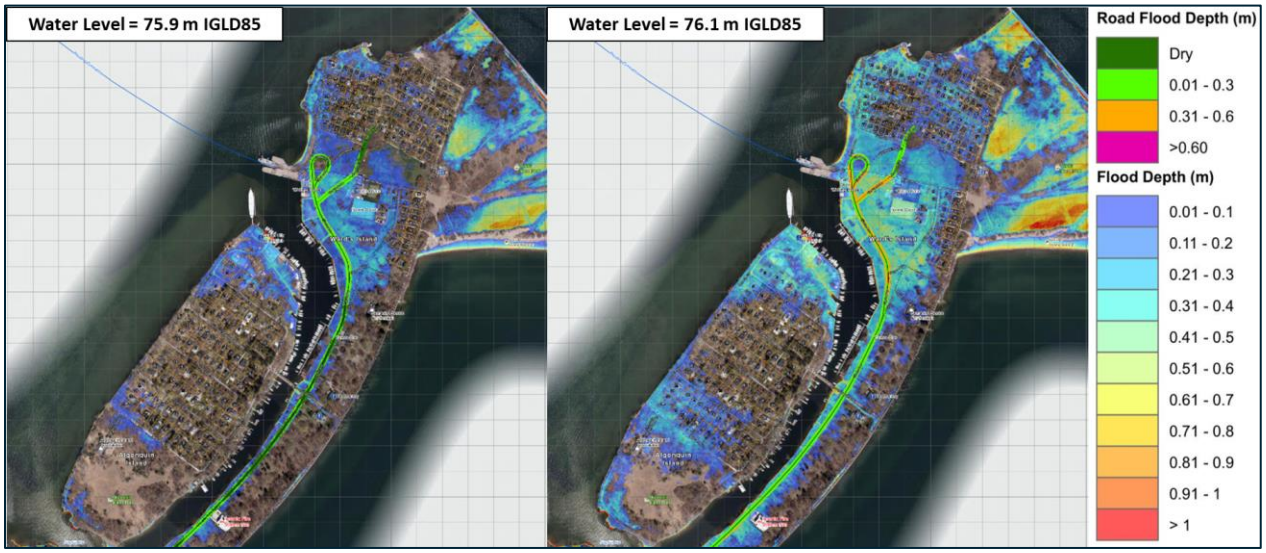

Figure 6.7: Floodwater Depths in Residential Areas at 75.9 m (left) and 76.1 m (right)

Seepage rates through and under barrier systems (such as sandbags) depend on the difference in water levels inside and outside the barrier. The City should be prepared to expend additional efforts at higher lake levels.

6.3.2 Ferry Services

Ferry services run between the mainland and Ward's Island, Centre Island, Hanlan's Point, and Toronto Island Airport. The Centre Island and Hanlan's Point terminals were closed during the 2017 flood.

The largest indirect damages to the ferry service were lost revenues due to the closure of Toronto Island Park. In 2017, the park was closed when Lake Ontario exceeded 75.6 m and reopened after the lake dropped below 75.6 m. Figure 6.8 shows that the land adjacent to the Centre Island and Hanlan's Point docks is higher than the Ward's Island ferry dock. Ferry revenues would be less impacted by high water levels if the park and Centre Island dock remained open to visitors at water levels up to about 75.8 m. It is anticipated that the Ward's Island and Toronto Island Airport ferry docks will remain open up until the islands are evacuated.

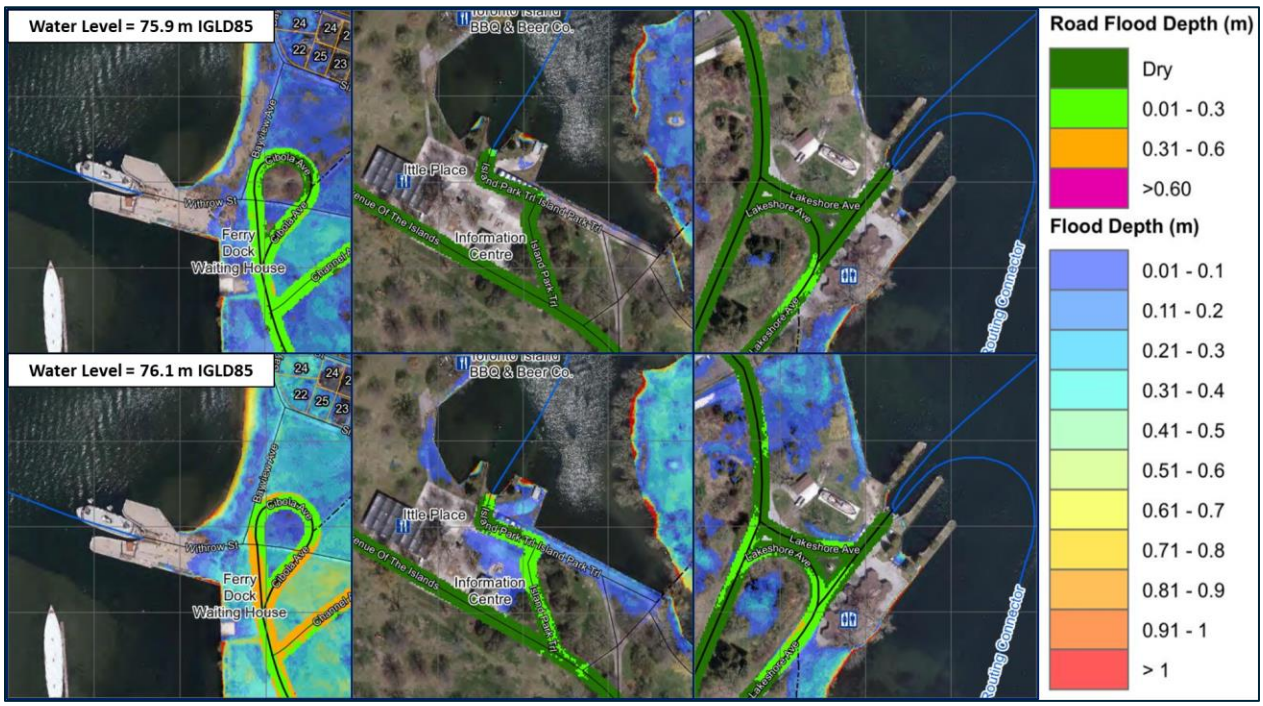

Figure 6.8: Floodwater Depths at Ward's Island Ferry Dock (left), Centre Island Ferry Dock (middle) and Hanlan's Point Ferry Dock (right) at 75.9 m (top) and 76.1 m (bottom)

6.3.3 Roads and Pathways

Lakeshore and Cibola Avenue are the main road arteries on Toronto Islands and connect the airport with the Island Water Treatment Plant, Island Public/Natural Science School, Fire Station, Ward's Island ferry dock, and residential areas on Ward's and Algonquin Islands. Low spots at Gibraltar Point and south of the Fire Station are vulnerable to flooding (see Figure 6.9). Smaller roads (or pathways) in the residential streets are also vulnerable to flooding.

Figure 6.9: Photograph of Cibola Ave. During 2017 Flood (from National Post, 2017)

Direct damages to the roads and pathways on Toronto Islands in 2017 were not quantified. It is assumed that damages were minimal. Direct damages at higher water levels are uncertain.

Indirect damages to the roads and pathways include mitigation actions, such as the metre sandbags placed at Gibraltar Point in 2017 to mitigation road flooding. Figure 6.10 shows that water depths along Lakeshore Ave. at Gibraltar Point are around 0.3 to 0.4 m at the 2017 flood levels (75.9 m). At a water level of 76.1 m portions of the road are greater than 0.6 m deep.

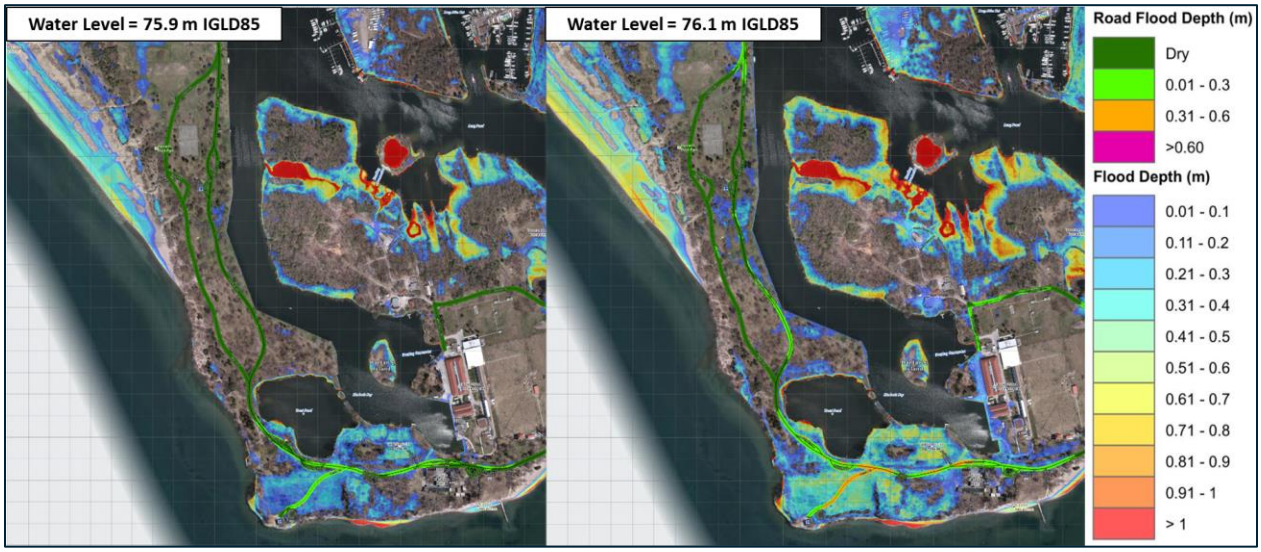

Figure 6.10: Floodwater Depths at Gibraltar Point at 75.9 m (left) and 76.1 m (right)

Indirect damages due to the road closures, such as the use of water taxis at the Island Water Treatment Plant and temporary closure of the Island Public/Natural Science School, were attributed to those buildings. The ferry and road closures were the leading causes of indirect damages to island businesses and many City services.

6.3.4 Public Amenities

Public amenities such as parks, green spaces, picnic areas, playgrounds, and tennis courts are generally not heavily damaged by flooding. Direct damages include cost of repairs, landscaping, tree removal, etc. Indirect damages include flood mitigation and cleanup costs.

Park space and public amenities begin to be impacted at water levels around 75.8 m and widespread, shallow flooding occurs around 75.9 m (see Figure 6.11). Many areas such as Olympic Island, Snake Island, Chippewa Islands, and green spaces along Centre Island are significantly inundated at 76.1 m.

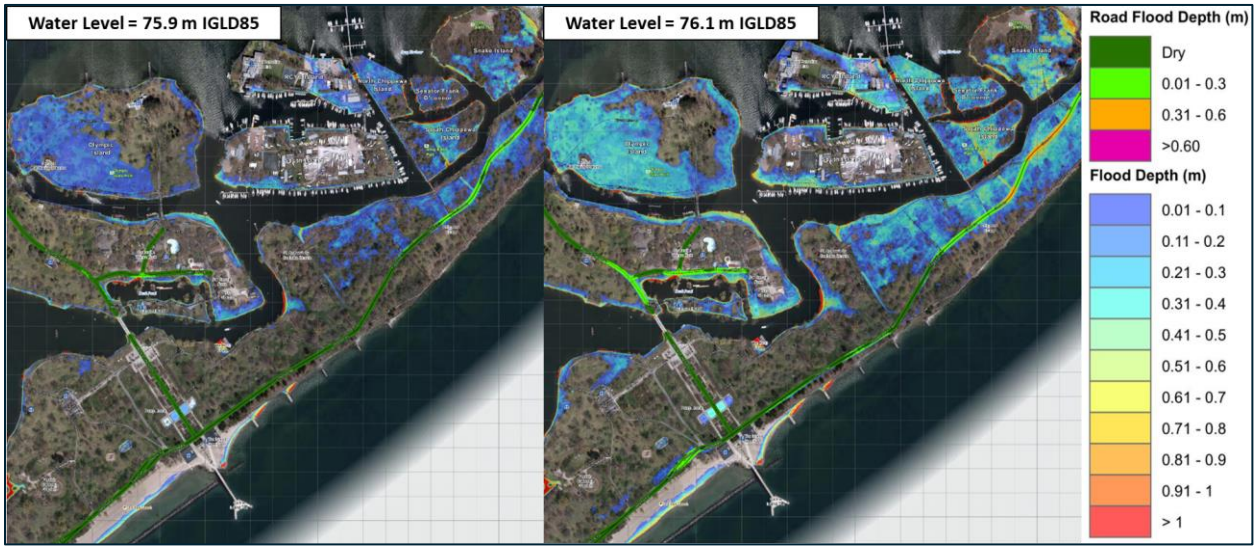

Figure 6.11: Flooding in Central Area of Toronto Islands at 75.9 m (left) and 76.1 m (right)

6.3.5 Permits, Licences and Tenants

As described in Section 3.4, the City issues permits and licences for special events and activities on the islands. The City also leases lands and collects rents from 11 businesses on the islands.

Actions taken by the City, such as closing Toronto Island Park, can impact the businesses causing indirect damages to both the businesses and the City. It is estimated that the indirect damages to the City due to the cancellation or refunding of permits, licences, and rents will be up to $1.4M for 2017. The indirect damages resulting from permits, licences and rents depend on the closure of Toronto Island Park.

6.3.6 Institutional Buildings

Over 30 institutional buildings were identified below the 500-year flood level. The buildings include: Island Water Treatment Planet, Toronto Fire Station 335, public washrooms and changerooms, and the Centre Island Police Building. A number of smaller storage and maintenance buildings were also identified. The buildings falling under the institutional classification did not include any businesses that reside on leased City lands. The Island Public/Natural Science School is above the 500-year flood level. The institutional buildings that could experience the greatest damages due to flooding are discussed below.

Island Water Treatment Plant

The Island Water Treatment Plant produces approximately 20% of Toronto's drinking water and is part of the deep lake water cooling system. The manager of the plant indicated that buildings on the property were not

damaged during the 2017 flood. However, access roads to the plant were flooded, which required that water taxis be used to shuttle people to and from Ward's Island ferry dock. The shipping and receiving of chemicals was not disrupted and operations were not altered due to the high water levels. Approximately 300-400 sandbags were placed at the loading dock along Service Rd. to protect against storm surge.

Direct damages could occur at water levels greater than 75.9 m; however, the extents of the damages are not known. It is likely that mitigation measures such as barriers and pumps would be installed before plant operations are affected. Thus, direct damages to the plant are likely to be low and indirect damages are expected to increase with the level of the mitigation actions.

Island Public/Natural Science School

The Island Public/Natural Science School serves over 270 students with approximately 30 of these students being residents of Toronto Islands. The building is located above the 500-year flood level and direct damages are not expected. However, indirect damages could result from the closure of the ferry or roads that service the school. The school was temporarily closed in 2017 due to flooding on the island and students were relocated to Nelson Mandela Park Public School on the mainland for the remainder of the school year. Indirect damages include temporary accommodation and bussing arrangements to transport students from the Jack Layton Ferry Terminal to Nelson Mandela Park Public School.

Toronto Fire Station 335 and EMS Station #48

The Toronto Fire Station and EMS Station provides critical emergency response services to residents and visitors on Toronto Islands. The station is located on Cibola Ave, south of the Algonquin Island bridge. The station (and Cibola Ave in this region) will become flooded at around 75.9 m. Baird reached out to the Captain and Commander of the fire hall regarding the conditions experienced during the 2017 flood but did not received a response. Direct and indirect damages (such as damage to equipment) are not known.

Public Washrooms

There are several public washrooms and changerooms on Toronto Islands below the 500-year flood level. The buildings tend to be constructed out of concrete blocks and direct damages to the structure should be minimal for shallow flooding. The exceptions are the change room at the Centre Island Pier and washroom at Gibraltar (Hanlan's) Point which are exposed to waves and shoreline erosion. Indirect damages would likely be limited to post-flood cleanup at many of the facilities.

6.3.7 Utility Infrastructure

Toronto Island is serviced by utilities that connect to the mainland under the Western Channel. These utilities include hydro, gas, sanitary sewers, telephone and internet. Additionally, watermains are present on the island and come from the Island Water Treatment Plant. The various utility companies have assets located across the island such as: hydro poles and overhead lines, electrical transformers and sewage pumping stations (see Figure 6.12).

Figure 6.12: Examples of a Sewage Pump Station and an Electrical Transformer on Ward's Island

Floodwater poses risk to these assets; however, further engagement with the utility companies is required to better understand the critical levels that would affect the operation and the damages that could be incurred. It is likely that temporary flood mitigation barriers and pumps would be installed around critical utilities before high water levels are reached. Thus, direct damages to the critical infrastructure should be minimal and indirect damages will likely be proportional to the level of flooding.

6.4 Total Tangible Damages

The estimated total tangible damages for the various return period floods is shown in Figure 6.13. The City of Toronto total tangible damages have been excluded due to the limitations discussed previously.

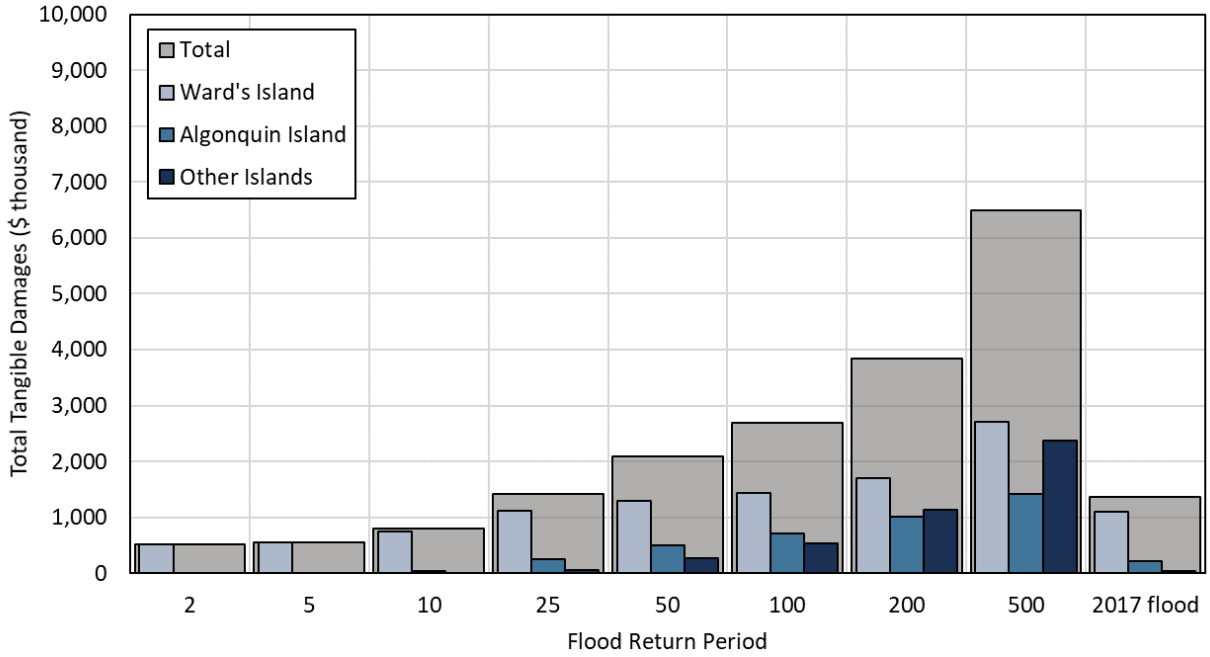

Figure 6.13: Total Tangible Damages for Different Flood Return Periods

The total tangible damages occurring at the 2, 5, and 10-year return period flood levels are almost completely concentrated in residential damages. This is due to the assumptions in the calculation methodology such as damages at the onset of flooding (see Section 6.1.3). The low return period damages are dependent on the duration of the flood and would likely be reduced or eliminated through typical mitigation measures. The total tangible damages for return periods of 25-years and higher affect both residential and non-residential buildings. For the higher return periods, the non-residential portion increases at a higher rate than residential. Damage estimates range from $0.5M at the 2-year flood to $6.5M for the 500-year flood (not including City damages).

The estimated 2017 flood damages are relatively low for non-residential buildings. This is due to assumptions in the calculation methodology, most notably that indirect damages are only calculated for businesses that experience building flooding. Many businesses in 2017 were not flooded and did not sustain direct damages.

6.5 Average Annual Tangible Damages

Average annual damages are the sum of all the flood damages that would occur over an extended period of time, averaged over that time. For example, the average annual damages for Toronto Islands for the past 50 years would be the total of all the damages experienced in flood years (e.g. 1973, 1993, 2017) divided by 50 years.

In this study, total tangible damages were estimated for 8 return period floods. The average annual damage is obtained by summing the area under the damage-probability curve (shown in Figure 6.14). The average annual damages for the residential and non-residential buildings on Toronto Islands is estimated to be $387,000 per year.

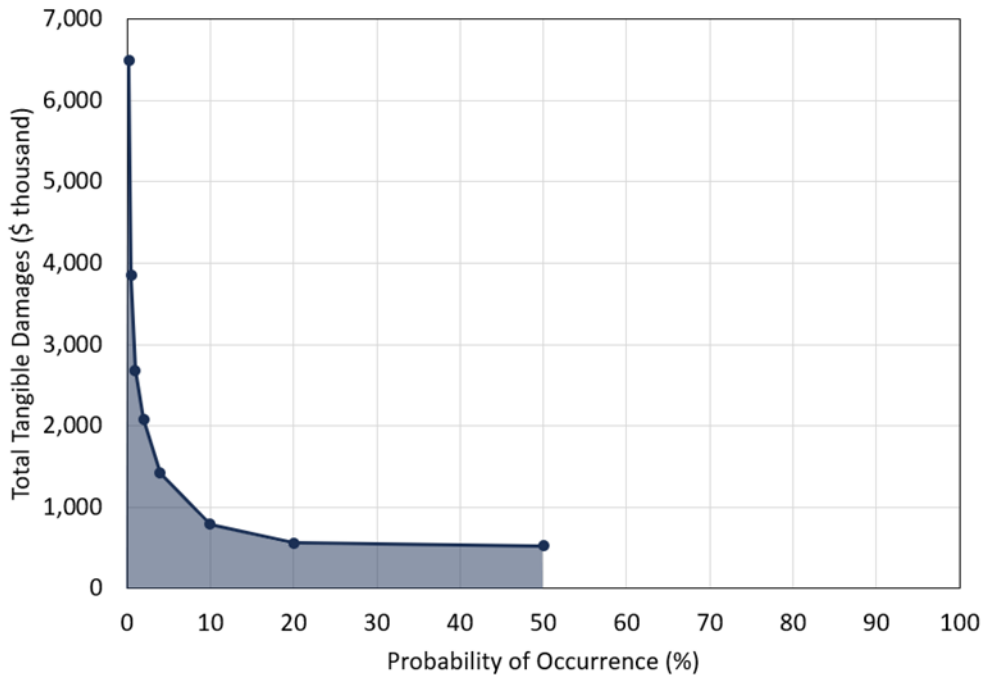

Figure 6.14: Total Tangible Damages vs. Probability Curve for Different Return Periods

7. Estimation of Intangible Damages

Intangible flood damages are damages without an associated dollar value. Intangible damages can be difficult to measure and vary widely (even for the same flood event). To those impacted by a flood, intangible damages can have a greater negative effect than the financial damages. Table 7.1 provides a comparative ranking of tangible and intangible impacts due to a flood.

Table 7.1: Subjective Rating of Severity of Flood Impact on Households (from NRCAN, 2017)

Effect	Mean Rating*
Getting house back to normal	7.8
Stress of flood	7.1
Having to leave home	7.0
Worry about flooding	6.6
Damage to replaceables	6.5
Damage to house itself	6.4
Irreplaceable item loss	5.6
Builder problems	4.9
Insurance problems	4.7
Loss of or distress to pets	4.6
Loss of house value	4.6
Effects on health	4.5
Overall effect	7.3

*1 = no effect, 10 = extremely serious effect

Intangible damages include: health impacts, social impacts, and environmental impacts. This section discusses some of the intangible damages that may be experienced as a result of a flood on Toronto Islands. A number of media photographs from 2017 are shown to illustrate the impact of the flood on the islands.

7.1 Health Impacts

Health impacts can include both physical and psychological effects that may be experienced as a result of flooding. In terms of physical health effects, the risk of physical injury would be greatly increased during a flood event. As noted in French (2017), some residents experienced injuries during the 2017 flood, which could be worsened during more extreme flood levels. These injuries can be due to limited visibility of ground conditions, and having crawlspace hatches open for long periods of time to pump standing water or to dry residual water. Additionally, physical work such as installing sandbags, digging trenches and swales, etc. could lead to physical injuries such as pulled muscles, back pains, sprained ankles, etc. Existing physical conditions and injuries could also be reaggravated. Floodwater, or elevated humidity levels, present in homes for long periods of time promote the growth of mould. This could lead to respiratory problems, rashes, etc.

Figure 7.1: Photograph of City Crew Filling Sandbags During 2017 Flood (from CTV, 2017)

Flood can also cause increased levels of stress and anxiety for residents and business owners. This could be due to uncertainly of knowing how high the water level will rise, and the sense of helplessness due to the limited control of the outcome. Communication from municipal entities, or lack thereof, can also increase this level of uncertainty, and contribute to mental health impacts. The elevated sense of stress and anxiety may be due to financial concerns, time off work, and having to relocate to temporary accommodations. Toronto Islands consists of a tight-knit community, and residents would likely worry about the safety of fellow community members.

Business owners would experience similar mental health impacts, as their livelihood (and their employees) would be threatened by the flood. Due to external factors affecting island accessibility, uncertainty about business operations, whether to keep or layoff staff, bookings, damage to business reputation, as well as factors noted above, would negatively affect the mental well being of business owners.

The combination of physical and mental health impacts would negatively influence the quality of life of island residents and business owners. The health impacts would likely be low for flood levels below about 75.80 m. At higher flood levels, the percentage of flooded homes and businesses markedly increases. At 76.0 m, nearly half of the residential homes would experience some level of flooding (mostly crawlspace flooding).

7.2 Social Impacts

The number of residents impacted at different flood levels was estimated from the number of homes experiencing some level of flooding and the average number of residents per household obtained from the residential survey. Table 7.2 indicates that approximately one-third of the residents (200 people) were directly impacted by flooding in 2017. At the 500-year return level approximately 80% of the population would experience some level of flooding, with 73 people on Ward's Island affected by first floor flooding.

Table 7.2: Estimated Number of Residents Impacted at Different Flood Levels

Flood Return Period (Years)	2	5	10	25	50	100	200	500	2017 flood
Water Level (m IGLD85)	**75.38**	**75.65**	**75.80**	**75.94**	**76.01**	**76.05**	**76.14**	**76.25**	**75.93**
Ward's Island	13	13	65	175	229 (2)	261 (4)	287 (22)	300 (73)	171
Algonquin Island	0	0	9	26	50	78	108	134	24
Total	13	13	73	201	279 (2)	339 (4)	395 (22)	434 (73)	194
% of All Residents	2%	2%	13%	36%	50%	61%	71%	78%	35%

*Estimated number of residents with first floor flooding shown in parentheses

French (2017) describes the social impacts of the 2017 flood on the Toronto Island community including physical damages, cleanup, concern about West Nile virus and mould, and loss of use of island amenities. Additional social impacts include temporary impacts such as restricted or difficult access to homes and businesses (see Figure 7.2). At higher flood levels, access to neighbours and services may become severely restricted.

Figure 7.2: Photograph of a Resident's Front Yard in 2017 (from CityNews, 2017)

There is also the possibility that relationships could deteriorate under the stress and uncertainty of a flood. However, many of the residents noted that the community came together and supported the more vulnerable residents during the 2017 flood (French, 2017). Potential long-term impacts such as changes to the way of life and social fabric could occur if a portion of the population were to leave the islands and relocate to the mainland.

The ability of emergency vehicles to respond may become impacted at a flood level of about 75.9 m. At this level, large portions of Cibola Ave. and Lakeshore Ave. begin to flood. Public amenities also begin to be impacted around a lake level of 75.9 m, resulting in fewer visits to the islands from Toronto residents and use of park facilities (see Figure 7.3).

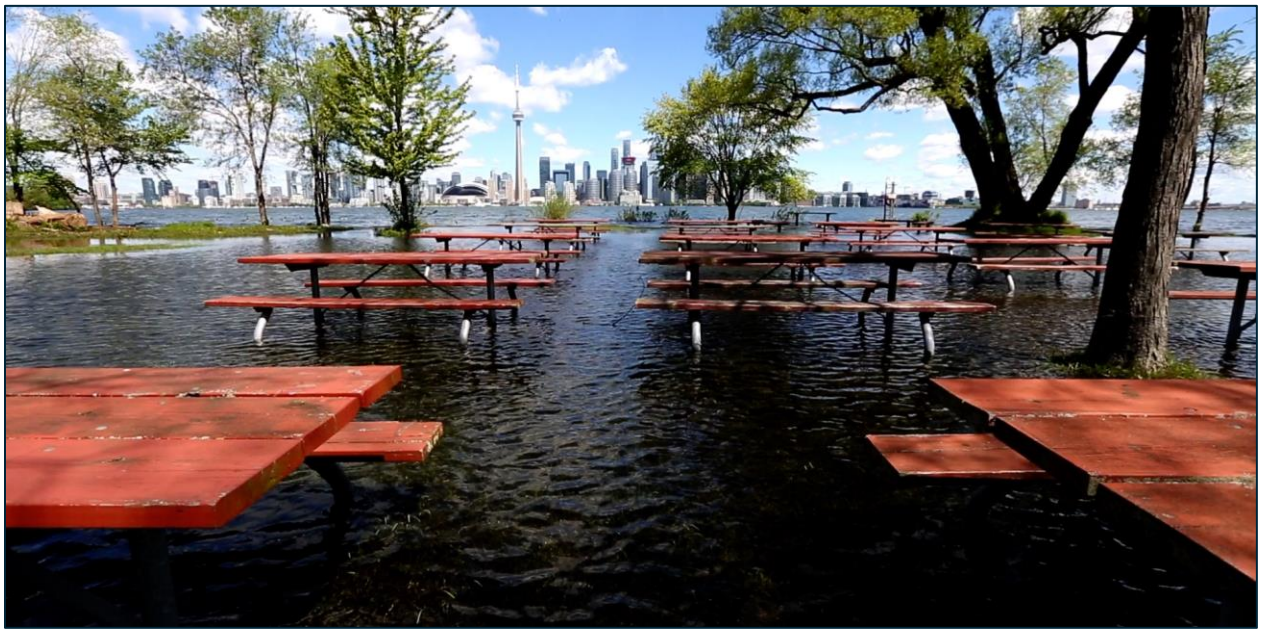

Figure 7.3: Photograph of Loss of Use of Public Amenities in 2017 (from Globe and Mail, 2017)

7.3 Environmental Impacts

The most severe impact of the high water levels on the Toronto Islands environment is the potential loss of mature trees. Trees may be blown over more easily when the ground is saturated and may die from the extended period of flooding. Flooding reduces the available oxygen in the soil and causes a tree's fine roots to die. After the floodwaters have receded, the remaining root system may be unable to sustain the tree, making the tree vulnerable to pests and pathogens. It may take several years for a flood damaged tree to recover or die. The tree species on the islands likely include flood tolerant species such as willow, ash, elm, silver maple, etc.

Tree mortality depends on the tree species, size of the tree (and health), and duration of flooding. Younger trees are more vulnerable to flooding than larger trees. Yin et al. (1994) provide an equation to estimate the probability of tree mortality due to flooding for inundations varying between about 40 and 200 days. The mortality rate of 10 cm diameter silver maple trees and 10 cm diameter black willow trees is estimated to be approximately 10% and 16%, respectively, after 4 months of flooding. A photograph of the widespread flooding in 2017 is shown in Figure 7.4

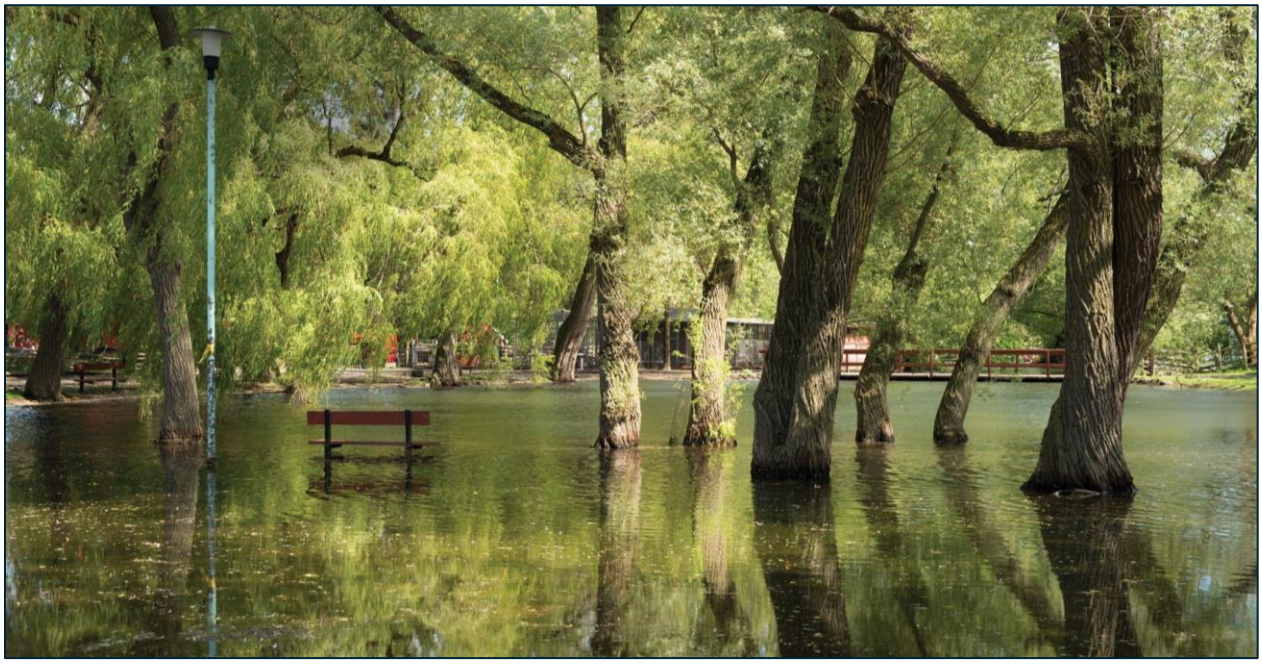

Figure 7.4: Photograph of Flooded Parkland and Trees in 2017 (from Toronto Life, 2017)

The areas most at risk of loss of mature trees include parts of Ward's Island, North and South Chippewa Islands, Snake Island, Centre Island from St. Andrew's Church to the Fire Hall, Gibraltar Point, and Olympic Island. Flood depths in these areas for the 25-year flood event are shown in Figure 7.5. These areas would be inundated longer than land located at higher elevations and are thus the most vulnerable to tree blow over and root die off.

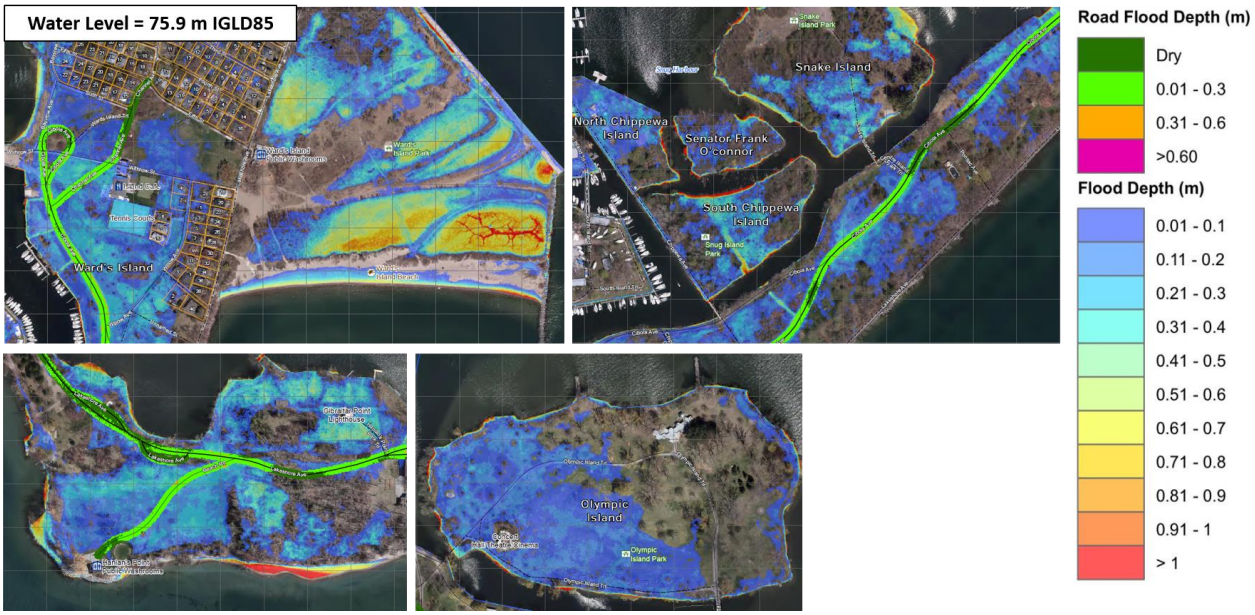

Figure 7.5: Forested Areas that are Vulnerable to Flood Damage include (clockwise from top left): Ward's Island, Snake Island, North & South Chippewa Islands, Centre Island between the Fire Hall and St. Andrew's Church, Olympic Island, and Gibraltar Point

8. Conclusions and Recommendations

Baird & Associates (Baird) was retained by Toronto and Region Conservation Authority (TRCA) to undertake a flood characterization and risk assessment for the Toronto Islands. The first report updated the return period water levels at Toronto. This report quantifies the financial costs and other impacts to Toronto Island residents, businesses, and the City of Toronto for the different return period flood events. The study is intended to assist TRCA and the City of Toronto in identifying and understanding risk to infrastructure on the islands.

Residential and business surveys were administered to island residents and businesses to understand the impact of the 2017 flood. Residents generally reported low depths of flooding and low financial damages (less than $3,000). The largest impact on residents was anxiety of not knowing how high the lake would get. Residents reported a high level of support from neighbours, City of Toronto, TRCA, and friends and family. A limited number of responses were received from the business survey. Businesses were most strongly impacted by the closure of Toronto Island Park between May 4 and July 30 (nearly the entire tourist season).

Tangible (financial) damages for Toronto Island residents and businesses were estimated using the Alberta Provincial Flood Damages Assessment Study (PFDAS) method. The method relies on depth-damage relationships that were developed following the Calgary 2013 flood. For a given building classification, structural and building contents damages can be estimated from the depth of floodwater and the floor area of the building. Residential indirect damages such as flood mitigation, cleanup, etc. were included as a 15% markup on the structural and contents damages. Non-residential indirect damages were estimated using a method of business disruption and productivity rates outlined in the Canadian Floodplain Mapping Guidelines Series by Natural Resources Canada. All damages were adjusted to Ontario 2017 dollars using indexing methods.

Estimated total tangible damages to residents and business range from $0.5M to $6.5M for the 2-year and 500-year flood event, respectively. The average annual tangible damages are estimated to be $387,000 per year. City of Toronto damages were not included in the damage estimates due to the nature of the buildings (no appropriate PFDAS category), and the fact that indirect damages such as flood mitigation, cleanup, lost ferry revenues, lost rents, etc. would not be captured in the damage estimates. Telephone and e-mail communications with City of Toronto staff confirmed that indirect damages will be difficult to quantify for different flood levels. The estimated City of Toronto damages from the 2017 flood are in the neighbourhood of $8M.

Intangible damages are non-financial damages such as impacts to health, society, and the environment. The more severe impacts include respiratory conditions that could develop due to mould, change in the social fabric of the island community, and loss of mature trees.

The tangible damage estimates in this study could be improved by better understanding the indirect damages incurred by the City of Toronto and the impacts on island businesses.

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Appendix A

2017 Flood Impact Resident Survey

Toronto Islands 2017 Flood Impact Resident Survey

Toronto and Region Conservation Authority (TRCA), in collaboration with the City of Toronto, is working with W.F. Baird & Associates Coastal Engineers Ltd. (the Consultant) to complete a Flood Characterization and Risk Assessment Study for Toronto Islands.

This project will serve to characterize the lake-based flood hazard on the Toronto Islands, and will help facilitate an understanding of the community and infrastructure vulnerabilities, such as potential impacts, risks to residents, and municipal assets. It will also provide flood maps and response plans to supplement the City's emergency management plan, and will be used to inform future structural and non-structural flood mitigation investments.

As part of this study, a survey of the financial costs and health impacts is being conducted. The present survey is intended to supplement the survey information from the Toronto Islands Emergency Preparedness Committee report (Mike French) and Ryerson University study (Greg Oulahen). Data obtained from this survey will be aggregated to protect the privacy of the respondents. ***Please return the survey using the provided stamped envelope.***

If you have any questions regarding this project please contact:

Danny Moro, Senior Project Manager
Toronto and Region Conservation Authority
T: 416.661.6600 ext. 5372
E:dmoro@trca.on.ca

In collaboration with:

TORONTO

Toronto and Region Conservation Authority

Thank you for your participation

Street name: _____ # of people at address: _____

PHYSICAL IMPACTS

1. Was your yard flooded? If so, how deep was the water? How long was it flooded?

_____

2. Was your crawlspace flooded? If so, how high was the water relative to the floor joists? How long was it flooded?

_____

3. Was your basement flooded? If so, how deep was the water in the basement? How long was it flooded?

_____

4. Were there any impacts to the first floor of your house (e.g. floor warping)? If so, what was the depth of water on the floor? How long was it flooded?

_____

5. Please circle the things you did to reduce the impact of the flood on your house and property.

-Moved items to higher elevation	-Used fans to dry out house & crawlspace	-Installed barriers (sandbags) around house	-Installed pump to remove water from yard	-Installed pump to remove water from crawlspace or basement

6. Please circle the flood impacts on your house and property.

-Damage to floors	-Damage to walls	-Damage to contents in crawlspace	-Damage to contents in house
-Damage to landscaping & vegetation	-Damage to exterior contents	-Damage to contents in basement	-Mold

7. Has your life returned to normal? If so, how long did it take to return to normal after the flood? If not, what hasn't returned to normal?

_____

FINANCIAL IMPACTS

1. How much did you spend on mitigation measures during the flood? (e.g. pumps, barriers, electricity, etc.)

_____

2. How much did you spend cleaning up after the flood? (e.g. wet vacuum, pumps, fans, electricity, disposal of damaged items, mold removal, etc.)

_____

3. How much did you spend repairing damage to your house caused by the flood? (e.g. flooring, drywall, insulation, vapour barrier, hot water heater, furnace, ductwork, electrical, doors, windows, etc.)

_____

4. How much did you spend replacing contents that were damaged by the flood? (e.g. appliances, clothing, furniture, electronics, food, etc.)

_____

5. How much did you spend replacing exterior contents and landscaping that were damaged by the flood? (e.g. outdoor furniture, BBQ, lawnmower, snowblower, trees/shrubs/perennials, etc.)

_____

6. How much did you spend on additional expenses due to the flood? (e.g. hotels, transportation, meals, medication, chiropractor, counselling, etc.)

_____

7. How many days did you spend mitigating, cleaning up, and repairing damage caused by the flood? How many of these days required you, a family member, or friend to take time off work?

_____

HEALTH IMPACTS

1. Please circle any health impacts experienced in 2017 due to the flood. Please write in any impacts not identified.

-Sleeping difficulties	-Stomach cramps	-Sore back or body	-Skin rashes
-New breathing difficulties	-Worsening of existing health issues	-Anxiety & stress beyond normal	-Physical injury

2. Do you have any ongoing health issues that were caused by the flood? If so, please describe.

_____

3. Please circle any causes of anxiety during or after the flood that were beyond normal. Please write in any causes not identified.

-Not knowing how high the water would get	-Information/ communication	-Damage to house & contents	-Financial stress/ insurance
-Concern for others	-Physical health	-Time off of work	

4. Please circle the social support you received. Please write in support you received that is not identified.

-Neighbours	-City of Toronto Public Health	-City of Toronto Parks, Forestry & Recreation	-City of Toronto Emergency Measures Office
-Friends/family	-Charities	-TRCA	-Province of Ontario

5. Please circle the physical support you received. Please write in support you received that is not identified.

-Neighbours	-City of Toronto Public Health	-City of Toronto Parks, Forestry & Recreation	-City of Toronto Emergency Measures Office
-Friends/family	-Charities	-TRCA	-Province of Ontario

Appendix B

2017 Flood Impact Business Survey

Toronto Islands 2017 Flood Impact Business Survey

Toronto and Region Conservation Authority (TRCA), in collaboration with the City of Toronto, is working with W.F. Baird & Associates Coastal Engineers Ltd. (the Consultant) to complete a Flood Characterization and Risk Assessment Study for Toronto Islands. This project will serve to characterize the lake-based flood hazard on the Toronto Islands, and will help facilitate an understanding of the community and infrastructure vulnerabilities, potential impacts and risk to residents and municipal assets, provide flood maps and response plan to supplement the City's Emergency Management Plan, as well as inform future structural and non-structural flood mitigation investments.

As part of this study, a survey of the financial costs incurred by island businesses is being conducted. The survey will be used to quantify the impacts of different return period flood levels on island businesses. Please return the survey via e mail to Josh Wiebe at jwiebe@baird.com.

If you have any questions regarding this project please contact:

Danny Moro, Senior Project Manager
Toronto and Region Conservation Authority
T: 416.661.6600 ext. 5372
E:dmoro@trca.on.ca

In collaboration with:

TORONTO

Toronto and Region Conservation Authority

Thank you for your participation

BUSINESS INFORMATION:

Business Name: _____ Business Type: _____

Address: _____ Contact: _____ Phone Number: _____

OPERATING HOURS *(Modify dates to suit)*

SEASON	MONDAY TO FRIDAY	SATURDAY AND SUNDAY
May 1 to August 31		
September 1 to April 30		

EMPLOYMENT INFORMATION

SEASON	MONDAY TO FRIDAY	NUMBER	AVERAGE WAGES
May 1 to August 31	Full time		$ /week
May 1 to August 31	Part time		$ /week
September 1 to April 30	Full time		$ /week
September 1 to April 30	Part time		$ /week

BUILDING INFORMATION

BUILDING	USE	CONSTRUCTION TYPE /MATERIALS	NUMBER	AVERAGE EXTERIOR DIMENSIONS (length x width)	# OF FLOORS	IMPACTED BY 2017 FLOOD (Y or N)
1.						
2.						
3.						
4.						
5.						

ESTIMATED WATER DEPTHS IN MAY/JUNE 2017

BUILDING	DEPTH OF WATER IN YARD	DEPTH OF WATER IN CRAWLSPACE	DEPTH OF WATER ON FIRST FLOOR BUILDING
1.			
2.			
3.			
4.			
5.			

2017 FLOOD IMPACTS

1. Please circle the things you did to reduce the impact of the flood on your business and property.

Moved items to higher elevation	Installed barriers (sandbags) around building(s)	Installed pumps to remove water from yard	Installed pumps to remove water from building(s)	Used fans to dry out building(s)

Other: _____

2. Please circle the flood impacts to your building(s) and property.

Damage to floors	Damage to walls	Damage to contents in crawlspace or basement	Damage to contents on first floor of building	Damage to exterior contents	Damage to landscaping and vegetation	Mold

Other: _____

BUSINESS DISRUPTION

1. Did your business close in 2017 due to the flooding? If so, when did it close and when did it reopen?

_____

2. If your business closed in 2017, what was the estimated net financial impact?

_____

3. Has your business returned to normal? If so, how long did it take to return to normal after the flood?
If not, what hasn't returned to normal?

_____

EXPENDITURES

1. How much did you spend on mitigation measures during the flood? (e.g. pumps, barriers, electricity, etc.)

_____

2. How much did you spend cleaning up after the flood? (e.g. wet vacuum, pumps, fans, electricity, disposal of damaged items, mold removal, etc.)

_____

3. How much did you spend repairing damage to your building(s) caused by the flood?
(e.g. flooring, drywall, insulation, vapour barrier, hot water heater, furnace, ductwork, electrical, doors, windows, etc.)

_____

4. How much did you spend replacing inventory that was damaged by the flood?

_____

5. How much did you spend replacing equipment, furnishings, and fixtures that were damaged by the flood?

_____

6. How much did you spend replacing exterior contents and landscaping that were damaged by the flood?

_____

7. How much did you spend on additional expenses due to the flood (please specify)?

_____

Please describe the value and salvageability of inventory, equipment, and furnishings/fixtures relative to the height above the first floor. This information will be used to estimate damages for different return period flood events.

CONTENTS OF FIRST FLOOR OF BUILDING #1

HEIGHT ABOVE FLOOR	VALUE OF INVENTORY	% SALVAGEABLE	VALUE OF EQUIPMENT	% SALVAGEABLE	VALUE OF FIXTURES/ FURNISHINGS	% SALVAGEABLE
0.0 to 0.1 m						
0.1 to 0.3 m						
0.3 to 0.6 m						
0.6 to 0.9 m						
0.9 to 1.2 m						
1.0 to 1.5 m						

CONTENTS OF FIRST FLOOR OF BUILDING #2 *(if applicable)*

HEIGHT ABOVE FLOOR	VALUE OF INVENTORY	% SALVAGEABLE	VALUE OF EQUIPMENT	% SALVAGEABLE	VALUE OF FIXTURES/ FURNISHINGS	% SALVAGEABLE
0.0 to 0.1 m						
0.1 to 0.3 m						
0.3 to 0.6 m						
0.6 to 0.9 m						
0.9 to 1.2 m						
1.0 to 1.5 m						

CONTENTS OF FIRST FLOOR OF BUILDING #3 *(if applicable)*

HEIGHT ABOVE FLOOR	VALUE OF INVENTORY	% SALVAGEABLE	VALUE OF EQUIPMENT	% SALVAGEABLE	VALUE OF FIXTURES/ FURNISHINGS	% SALVAGEABLE
0.0 to 0.1 m						
0.1 to 0.3 m						
0.3 to 0.6 m						
0.6 to 0.9 m						
0.9 to 1.2 m						
1.0 to 1.5 m						

CONTENTS OF FIRST FLOOR OF BUILDING #4 *(if applicable)*

HEIGHT ABOVE FLOOR	VALUE OF INVENTORY	% SALVAGEABLE	VALUE OF EQUIPMENT	% SALVAGEABLE	VALUE OF FIXTURES/ FURNISHINGS	% SALVAGEABLE
0.0 to 0.1 m						
0.1 to 0.3 m						
0.3 to 0.6 m						
0.6 to 0.9 m						
0.9 to 1.2 m						
1.0 to 1.5 m						

CONTENTS OF FIRST FLOOR OF BUILDING #5 *(if applicable)*

HEIGHT ABOVE FLOOR	VALUE OF INVENTORY	% SALVAGEABLE	VALUE OF EQUIPMENT	% SALVAGEABLE	VALUE OF FIXTURES/ FURNISHINGS	% SALVAGEABLE
0.0 to 0.1 m						
0.1 to 0.3 m						
0.3 to 0.6 m						
0.6 to 0.9 m						
0.9 to 1.2 m						
1.0 to 1.5 m						

If more than five buildings, please fill out a second form.

Appendix C

Selected Alberta PFDAS Depth-Damage Curves

C.1 Residential Depth-Damage Curves

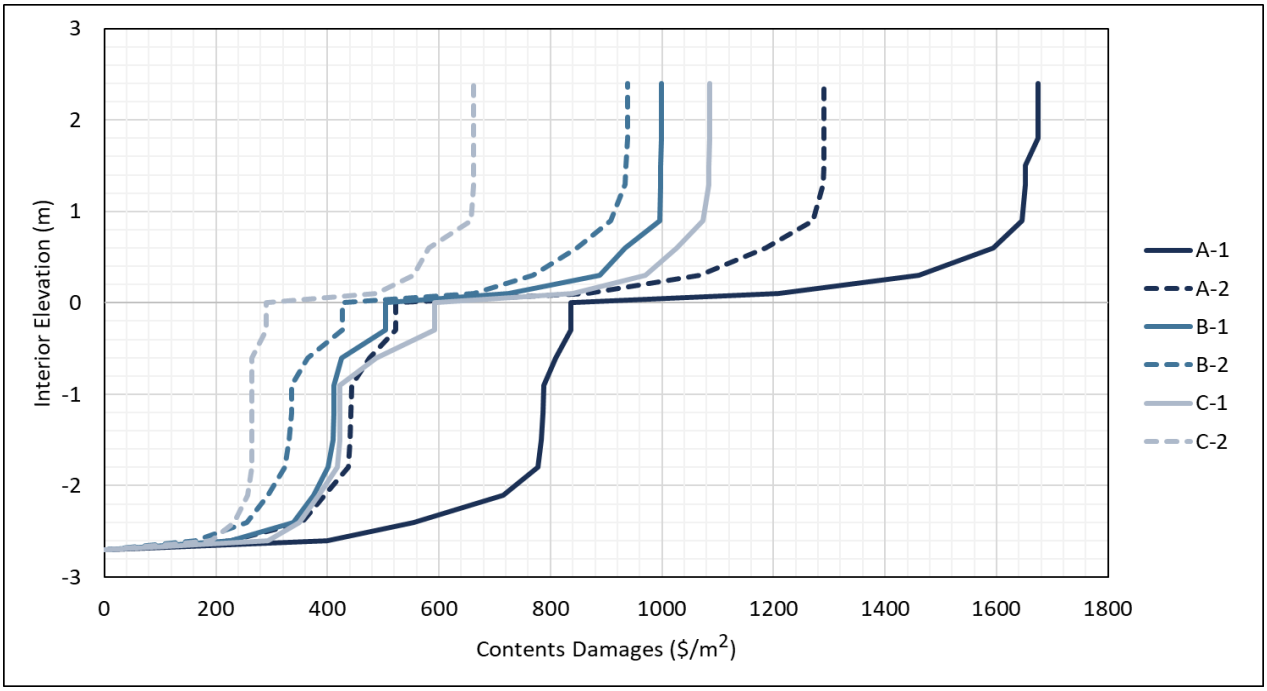

Figure C.1: Residential Contents Depth-Damages Curves (adapted from IBI Group, 2015)

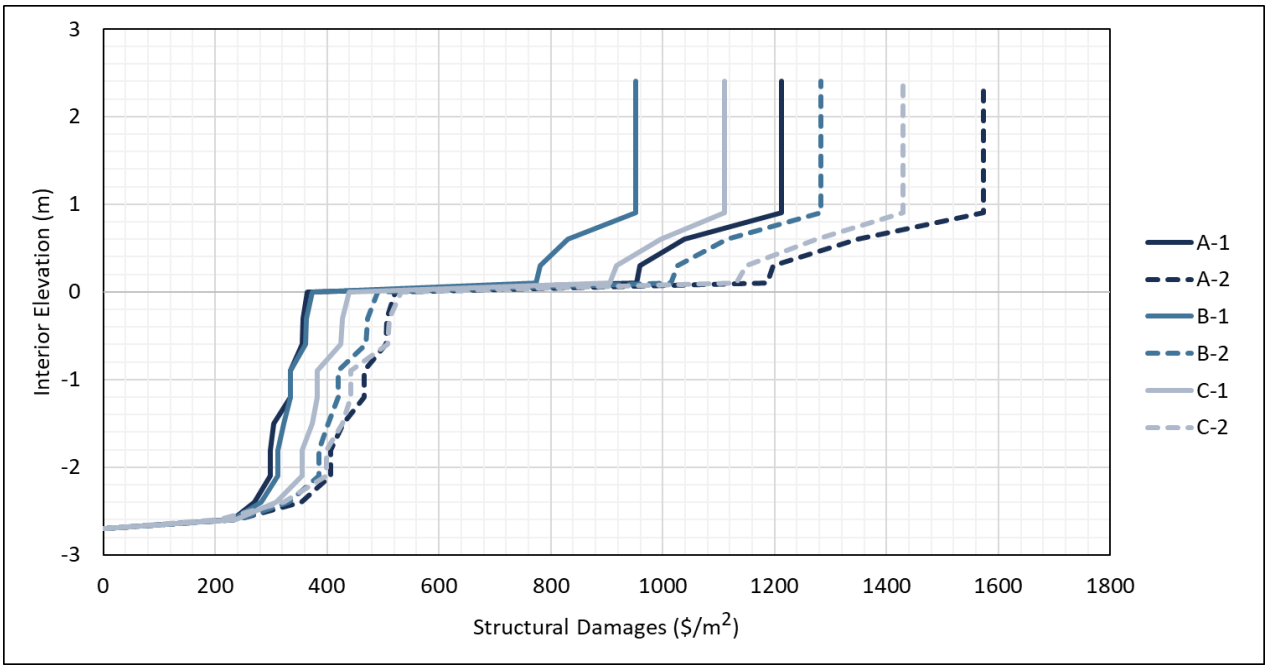

Figure C.2: Residential Structural Depth-Damages Curves (adapted from IBI Group, 2015)

Table C.1: Residential Contents Damages Values in $/m^2 (adapted from IBI Group, 2015)

Interior Elevation		A-1	A-2	B-1	B-2	C-1	C-2
Level 0 Floor	-2.7	0	0	0	0	0	0
	-2.6	400	226	226	163	294	191
	-2.4	554	354	339	255	350	232
	-2.1	715	395	375	294	385	257
	-1.8	778	437	401	324	418	264
	-1.5	784	440	410	332	422	264
	-1.2	786	442	411	336	422	264
	-0.9	788	444	412	336	423	264
	-0.6	810	475	426	364	487	264
Level 0 Ceiling	-0.3	836	523	504	427	592	290
Level 1 Floor	0	836	523	504	427	592	290
	0.1	1209	866	725	662	839	487
	0.3	1460	1068	888	769	970	554
	0.6	1594	1186	934	848	1026	582
	0.9	1645	1271	996	908	1074	657
	1.3	1652	1289	998	934	1084	662
	1.5	1652	1290	998	935	1084	662
	1.8	1675	1290	999	938	1085	662
	2.1	1675	1290	999	938	1085	662
Level 1 Ceiling	2.4	1675	1290	999	939	1085	662

Table C.2: Residential Structural Damages Values in $/m^2 (adapted from IBI Group, 2015)

Interior Elevation		A-1	A-2	B-1	B-2	C-1	C-2
Level 0 Floor	-2.7	0	0	0	0	0	0
	-2.6	231	241	232	242	237	207
	-2.4	271	354	282	331	309	322
	-2.1	299	406	312	385	356	399
	-1.8	299	406	312	385	356	399
	-1.5	305	429	322	402	374	428
	-1.2	335	466	334	420	383	442
	-0.9	335	466	334	420	383	442
	-0.6	356	506	362	470	424	508
Level 0 Ceiling	-0.3	357	507	363	473	427	512
Level 1 Floor	0	365	522	374	490	439	532
	0.1	953	1187	774	1014	906	1131
	0.3	959	1198	781	1026	918	1150
	0.6	1039	1348	831	1115	996	1275
	0.9	1213	1573	952	1282	1111	1429
	1.3	1213	1573	952	1282	1111	1429
	1.5	1213	1573	952	1282	1111	1429
	1.8	1213	1573	952	1282	1111	1429
	2.1	1213	1573	952	1282	1111	1429
Level 1 Ceiling	2.4	1213	1573	952	1282	1111	1429

C.2 Non-residential Depth-Damages Curves

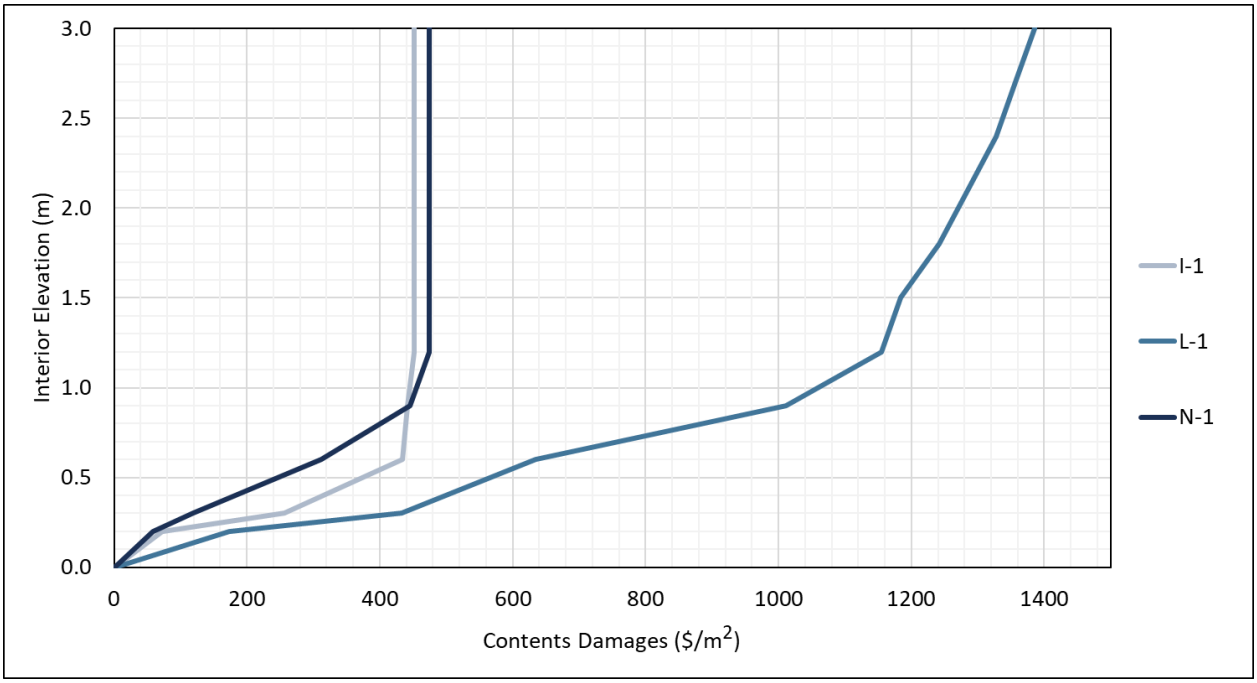

Figure C.3: Non-residential Contents Depth-Damages Curve (adapted from IBI Group, 2015)

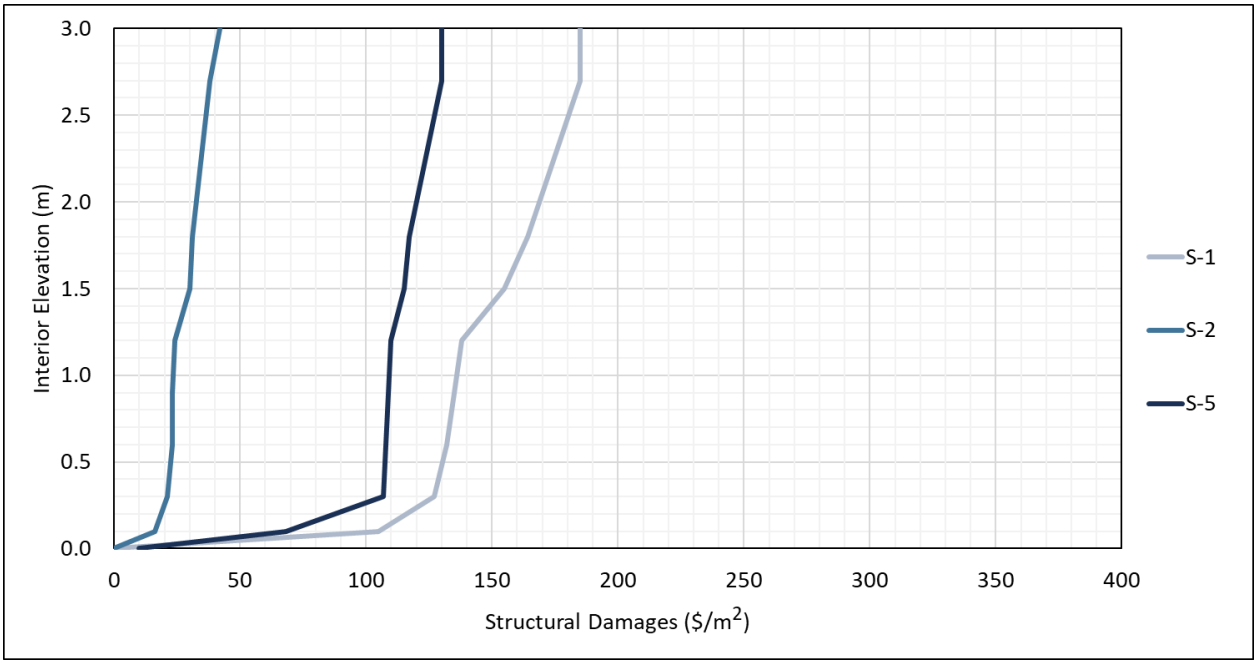

Figure C.4: Non-residential Structural Depth-Damages Curves (adapted from IBI Group, 2015)

Table C.3: Non-residential Contents Damages Values in $/m^2 (adapted from IBI Group, 2015)

Interior Elevation		I-1	L-1	N-1
Level 1 Floor	0.0	0	0	0
	0.2	72	173	59
	0.3	257	433	119
	0.6	434	635	312
	0.9	442	1011	446
	1.2	452	1155	475
	1.5	452	1184	475
	1.8	452	1242	475
	2.1	452	1285	475
	2.4	452	1328	475
	2.7	452	1357	475
Level 1 Ceiling	3.0	452	1386	475

Table C.4: Non-residential Structural Damages Values in $/m^2 (adapted from IBI Group, 2015)

Interior Elevation		S-1	S-2	S-5
Level 1 Floor	0.0	0	0	10
	0.1	105	16	68
	0.3	127	21	107
	0.6	132	23	108
	0.9	135	23	109
	1.2	138	24	110
	1.5	155	30	115
	1.8	164	31	117
	2.7	185	38	130
Level 1 Ceiling	3.0	185	42	130

C.3 Non-residential Business Disruption Curves

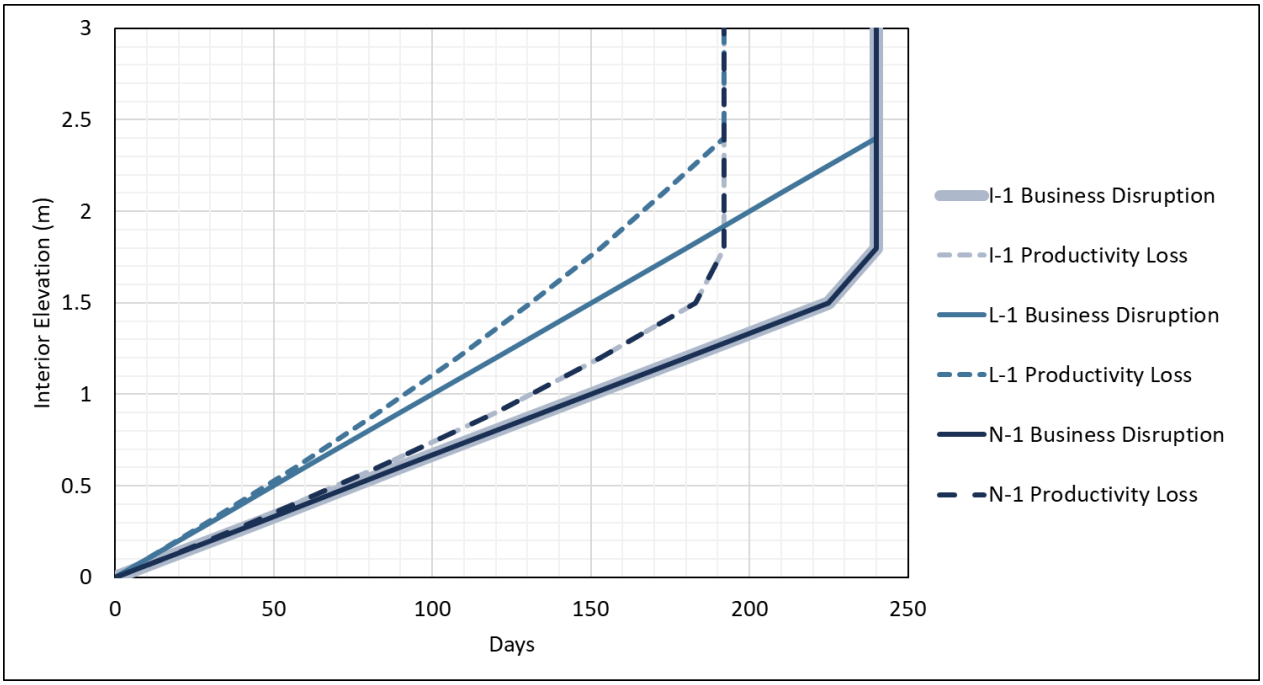

Figure C.5: Non-Residential Days of Business Disruption and Productivity Loss

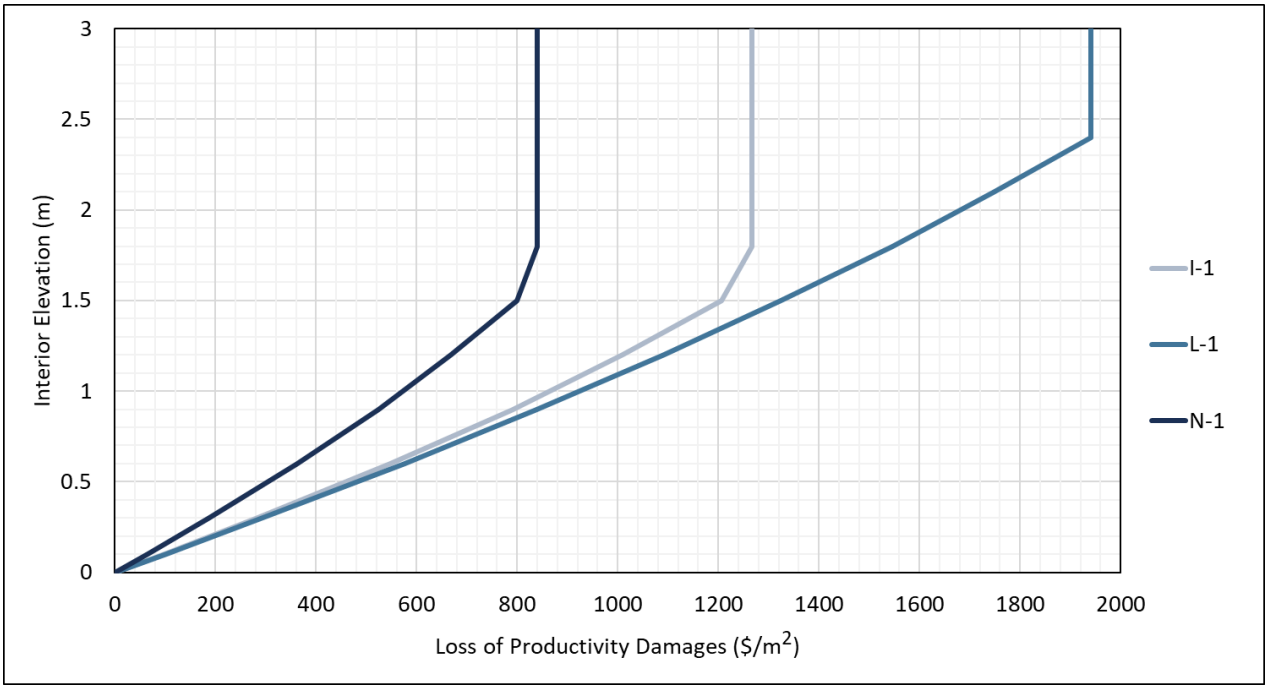

Figure C.6: Non-Residential Productivity Loss Depth-Damages Curves

Table C.5: Non-Residential Days of Business Disruption

Interior Elevation		I-1	L-1	N-1
Level 1 Floor	0.0	0	0	0
	0.1	15	10	15
	0.3	45	30	45
	0.6	90	60	90
	0.9	135	90	135
	1.2	180	120	180
	1.5	225	150	225
	1.8	240	180	240
	2.1	240	210	240
	2.4	240	240	240
	2.7	240	240	240
Level 1 Ceiling	3.0	240	240	240

Table C.6: Non-Residential Days of Productivity Loss

Interior Elevation		I-1	L-1	N-1
Level 1 Floor	0.0	0	0	0
	0.1	15	10	15
	0.3	43	29	43
	0.6	83	57	83
	0.9	120	83	120
	1.2	153	108	153
	1.5	183	131	183
	1.8	192	153	192
	2.1	192	173	192
	2.4	192	192	192
	2.7	192	192	192
Level 1 Ceiling	3.0	192	192	192

Table C.7: Non-Residential Loss of Productivity in $/m²

Interior Elevation		I-1	L-1	N-1
Level 1 Floor	0.0	0	0	0
	0.1	99	101	66
	0.3	284	293	188
	0.6	547	576	363
	0.9	791	839	524
	1.2	1009	1092	669
	1.5	1207	1324	800
	1.8	1266	1547	839
	2.1	1266	1749	839
	2.4	1266	1941	839
	2.7	1266	1941	839
Level 1 Ceiling	3.0	1266	1941	839