Homeowners' Risk Perceptions and Preferences for Property-Level Flood Protection

by

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in

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ABSTRACT

Evidence suggests that property-level risk reduction against natural hazards is worthwhile, however households often don't make these investments. The overall objective of this thesis was to understand the decision-making process concerning household investment in property-level flood protection (PLFP) measures, analyze whether specific PLFP devices were beneficial from a household perspective, and learn which factors were most salient to household choice.

Data were collected through a survey of Edmonton homeowners in four mature neighbourhoods. The principal method used was stated preference to elicit the homeowners' willingness-to-pay (WTP) for two PLFP devices: backwater valves and sump pump systems. In addition to preferences, the survey collected information on several factors that were deemed likely to influence choice regarding investment in flood protection, including households' risk perceptions and previous flood experience. We evaluated these data using econometric analysis. A household-level cost benefit analysis was also conducted to see whether these devices were economically efficient from the homeowner's perspective.

Key findings show that the average market cost to purchase and install these devices, as stated by local plumbers, was higher than the average WTP of households in our sample. Through the econometric analysis we found that WTP was influenced by household size, age, monetary incentives, and risk perceptions. Through the cost-benefit analysis we found that the average household would have a net benefit from having PLFP devices based on their risk perception for experiencing a flood event and their expected losses, however, they were still unlikely to invest.

The results of this thesis add to the empirical literature on property-level climate adaptation and resilience, the effectiveness of incentives for private goods with positive externalities, and the economic efficiency of property-level risk reduction.

PREFACE

This thesis is an original work by Marina Giannitsos. The research project, of which this thesis is a part, received research ethics approval from the University of Alberta Research Ethics Board, Project Name “Homeowners' Perceptions, Knowledge, and Uptake of Protection Against Stormwater Flood Risk”, Pro00111805, June 10, 2022.

This study was funded by Mitacs, a Canadian not-for-profit organization that brings academia, private industry, and government together to collaborate on research and innovation. The Mitacs Accelerate Fellowship provides funds to graduate students through sponsored internships with various organizations. The sponsor for this project was the Institute for Catastrophic Loss Reduction (ICLR), a Canadian not-for-profit research institute focused on multidisciplinary disaster prevention research and communication. ICLR's mission is to reduce the loss of life and property caused by severe weather and find ways to improve society’s capacity to adapt to, anticipate, mitigate, withstand, and recover from natural disasters. TD Insurance was also a sponsor through their partnership with ICLR on programs to reduce losses from flooding.

This research was also funded by the Social Sciences and Humanities Research Council of Canada (SSHRC), a federal research funding agency that promotes and supports research in the humanities and social science.

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I would like to extend my gratitude to Dan Sandink of ICLR and Huma Pabani of TD Insurance for being supportive partners and providing their expert insights and direction to the project. Thank you for trusting me to do this research and for being flexible when Covid-19 threw a wrench in the original plans for the study.

I would like to acknowledge my dedicated survey team, who took a month out of their summers to doorknock on 750 homes (sometimes twice!). Julia Poissant, Vaibhav Manawat, and Michael Sydora – thanks for being such troopers and supportive friends. I am glad to have met and shared my graduate school experience with you all.

I would like to thank everyone who participated in the study itself, including the experts and the 200 households who took the time to answer the questionnaire – your participation has made this research possible. Also, I would like to give a shout out to Brandon of KatRisk who provided us with flood data and for always having the time to explain the complexities of flood modelling.

I would be remiss if I didn't also mention how honoured I am for the funding I received throughout my three years at the University of Alberta. My ability to pursue greater education and research was made possible due to the generosity of my funders – Mitacs/ ICLR and SSHRC – as well as those within the REES who deemed me worthy of receiving departmental scholarships. I am truly grateful for all the support!

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1. INTRODUCTION

1.1 Overview

Floods are the costliest natural hazard in Canada, causing over $1 billion in direct damages annually to homes and businesses across the country (Swiss Re 2016). While some areas face risk of flooding from overflowing rivers or storm surges on the coast, almost all areas in Canada are at risk of potential flood damage from sudden and severe rainfall events. In recent decades, extreme rainfall events have been increasing in their severity and frequency (Actuaries Climate Index 2023; IBC 2019) and are thus posing a greater risk to Canadians than ever before. With this increased risk, the cost of residential property damages related to extreme rainfall events are expected to rise. The potential for damages to homes is particularly notable in urban areas due to aging sewer and stormwater infrastructure that may not be built to accommodate excess flows, the expansion of impermeable ground surfaces as a result of increasing densification, and the increase in number of homes that have finished basements (CCA 2022; IBC 2019; CIRC 2019). Therefore, the expected benefits of property-level defensive actions to protect against flooding are growing, particularly in older and high-risk homes.

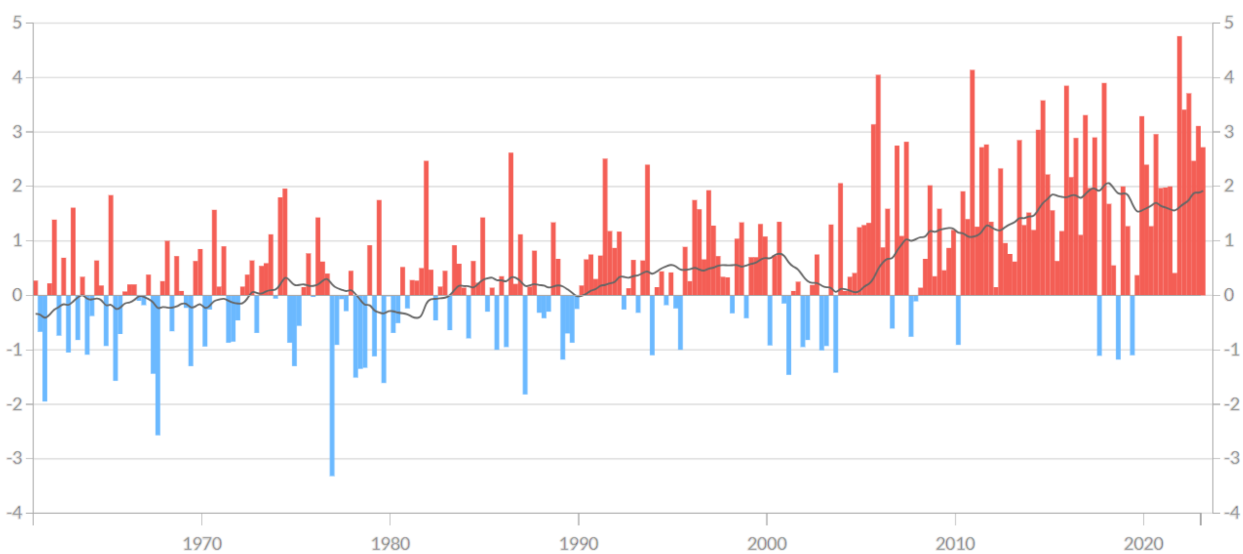


Figure 1.1. Extreme Precipitation Index for Canada

(defined as maximum rainfall over any five consecutive days in the month)

Image Source: Actuaries Climate Index, 2023

Since the costs of flooding are also borne by governments and insurers, there is public value in reducing household exposure to flooding. Therefore, many municipalities and some insurers across Canada offer programs with monetary incentives to assist homeowners in implementing property-level flood protection (PLFP). However, many homeowners do not participate in risk-reducing actions, despite the availability of incentives to do so (Sandink 2016). Low uptake in risk reduction poses a problem for governments, insurers, and others working in the disaster risk reduction space who are interested in increasing household resilience against flooding.

1.2 Objectives

The overall objective of this thesis was to understand the decision-making process concerning household investment in property-level flood protection (PLFP) measures, analyze whether specific PLFP devices were beneficial from a household cost perspective, and learn which factors were most salient to household choice.

To explore this topic, we conducted a household survey of four mature neighbourhoods in the City of Edmonton. A major component of the survey examines homeowners' willingness-to-pay (WTP) for two PLFP devices – backwater valves and sump pump systems – and the factors that affect their intentions such as cost, subsidies, and insurance premium reductions. While price and monetary incentives are expected to be key factors in why households may or may not adopt PLFP, other factors, such as level of awareness, risk perceptions, previous experience, and transaction costs (inconvenience, maintenance, etc.), are also expected to have an impact. Thus, this thesis uses economic theory and methods, specifically stated preference and cost-benefit analysis, to answer the following questions:

(1) How does household knowledge and awareness impact the adoption of PLFP?
(2) Are household risk perceptions correlated with their objective flood risk levels?
(3) Is the average WTP for PLFP comparable to the average market cost of these devices?
(4) What factors influence WTP for PLFP?
(5) Do financial incentives increase WTP for PLFP?
(6) Are PLFP devices economically efficient from the household's perspective?

1.3 Economic Theory

This thesis draws upon the theoretical assumptions of Expected Utility Theory, which is a common normative economic model of individual decision-making that incorporates uncertainty. While traditional Utility Theory looks at consumer decision-making based on outcomes that are certain, Expected Utility Theory suggests that individuals tend to make decisions that maximize their *expected* utility, or in other words, what they expect the outcome to be. Individuals do this by weighing the costs and benefits of each option and choosing the option that provides the greatest *expected* net benefit. In our study, households will purchase property-level flood protection (PLFP) at a price that will maximize their household expected utility, after taking into consideration the benefits and costs of having the device under their subjective assessment of risk, i.e., household perception on the probability they will face a flood and the device will be effective. However, it is worth noting that these subjective assessments can be different than objective assessments made using historic and geographic data (such as flood maps), which may mean households are at higher or lower probabilities of risk than what they believe. Additionally, a lack of information regarding the benefits and costs of PLFP to households could also lead to market failure – i.e., an inefficient allocation of resources that produces a less-than optimal outcome for consumers. Nonetheless, we use applied economic methods to determine household preferences regarding PLFP. Methods include stated preference, which is used to analyze household WTP for PLFP, and cost-benefit analysis, which is used to understand the economic efficiency of PLFP from the consumer's perspective. These methods are discussed in greater detail in later chapters.

1.4 Significance

This thesis adds to the empirical literature on property-level climate adaptation and resilience, the effectiveness of incentives for private goods with public externalities, and the economic efficiency of risk reduction. In addition, the answers to our questions may be of interest to policy makers and those working in disaster risk reduction on ways to effectively educate and encourage private flood protection investments. Through these findings we hope to improve the resilience of households in Canada and reduce the property and financial losses they face from flooding.

The findings of this research may also be of relevance to Edmonton's policy makers working in flood risk reduction. Most of Edmonton's flood risk is related to water ponding from extreme rainfall events. According to EPCOR, 6,000 properties (including 2,500 in the river valley neighbourhoods) in Edmonton have a high exposure to flooding because they are adjacent to areas where the water in the road could pool at depths above the 1-meter depth during an extreme storm or high river event. An additional 40,000 properties have mid to high exposure risk, where ponding in the road network could be between 0.35 and 1-meter during extreme rainfall events (EPCOR 2021). Furthermore, the number of homes at risk in Edmonton is likely to rise in the future due to an expected increase in precipitation. In the *Climate Resilient Edmonton: Adaptation Strategy and Action Plan* (2018), the City of Edmonton has projected the city's annual precipitation (currently 458 millimeters (mm)) to increase by 40 mm by 2050 and 54 mm by 2080. They also project the total annual precipitation from very heavy rainfall events to increase. With Edmonton's overall risk of flooding on the rise, this research may help inform new ways in which local policy makers can incentivize risk reduction at the property-level.

1.5 Paper Structure

This thesis is organized into nine chapters. Chapters one through three introduce the theme and objectives of the thesis, provide context to the study, and outline key concepts from the literature on natural hazard risk. The fourth chapter delves into the study design, which includes expert interviews, questionnaire design, and survey methods and outcomes. The fifth chapter provides an overview of the descriptive statistics of our household respondents. Chapters six through eight are organized as stand-alone papers, each with a literature review, description of data, methods, descriptive statistics, results, and discussion. Topics of each chapter are: (6) factors affecting risk-reducing behaviour; (7) homeowner preferences and WTP for property-level flood protection and (8) economic efficiency of property-level flood protection. The ninth chapter concludes the study by summarizing the overall findings, providing recommendations to policy makers, and providing suggestions for further research.

2. BACKGROUND

2.1 Introduction

This chapter outlines information that is important for the reader to understand as context for this study. It provides an overview on the types of flooding, types of property-level flood protection measures, and the current flood risk reduction initiatives in the City of Edmonton – where our study takes place. Additionally, this chapter outlines existing municipal incentives to reduce flood risk throughout the country and a short summary of flood insurance in Canada.

2.2 Distinction of the Types of Flooding

There are three common types of flooding: fluvial (river), pluvial (torrential rainfall), and coastal (storm surge) (Zurich Insurance Group 2023). Our study focuses on pluvial flooding, which, out of the three types, is the largest risk to the majority of residents in the City of Edmonton. A pluvial flood is caused by heavy rainfall that exceeds the capacity of a storm water system to evacuate water and/ or the capacity of the ground to absorb water (Houston et al. 2011). It is independent of an overflowing water body.

Within the pluvial flooding category there are three common ways that water can enter a home and cause damage: sewer backup, infiltration (seepage), and overland (Sandink and Binns 2021):

- *Sewer backup* occurs when a heavy rainfall overwhelms the municipal sewer system, causing rainwater and sewage to flow into a home through an input source, such as a floor drain, toilet, or shower.

- *Infiltration (seepage)* occurs when a heavy rainfall event (or multiple, consecutive rainfall events) saturates the soil around a home's foundation or raises the groundwater level to a point where it is higher than the home's foundation. The groundwater then enters the home through cracks in the foundation floors or walls, or through failed flood protection devices, such as a sump pump system or foundation drain.

- *Overland flooding* occurs when stormwater from a heavy rainfall event cannot enter the storm system due to over-capacity, poor yard grading, and/ or blockages in the system (such as blocked street grates). This can cause water to pond on yards and enter the home through low-lying above-grade openings such as doors, windows, garages, and vents.

A home's pluvial flood risk is not easily defined. Whereas floodplain mapping is becoming more common for areas at risk of fluvial and storm surge, pluvial flooding is often caused by a confluence of issues related to municipal sanitary and storm infrastructure capacity, house and property management, the existence (or not) of property-level flood protection measures, and the elevation of homes in relation to surrounding homes, land, and streets (Sandink and Binns 2021; Houston et al. 2011). Therefore, risk levels can vary greatly between homes, making it difficult to assess and communicate the risk to households (Sandink 2016).

2.3 Property-Level Flood Protection Measures

In the context of our study, we used the term property-level flood protection (PLFP) to define any modifications made to a home for the purpose of limiting or preventing damage caused by floods. These measures typically fall into two categories – physical or behavioural (Sandink 2016):

- A physical measure is a physical modification that is known to protect against floods. Physical measures can be in the form of (1) installed devices such as backwater valves, sump pump systems, foundation drains, etc.; (2) other home modifications known to reduce flood risk such as yard grading, removal of trees and roots close to the home, disconnecting downspouts from the urban storm or sewer system, etc.; or (3) maintenance and upkeep, such as keeping the gutters and storm drains clear of debris.

- A behavioural measure is an action to reduce harm or damage if a flood does occur. Examples of this include removing important items from the lower levels of a home, where flood damage is more likely, or protecting items in the lower levels of a home, such as storing belongings in waterproof bins.

These measures range in their monetary costs (price to implement) and transaction costs (difficulty to implement and level of maintenance required), which can be barriers to households' decision to invest or not invest in specific measures. Table 2.1 provides a comparison between common flood protection measures and these barriers. These tables were adapted from a list created by the Intact Centre on Climate Adaptation (2019). It is worth noting that the price and difficulty to implement may vary significantly based on a home's particular situation – for example the price and difficulty of landscaping will depend on the size of yard and existing grade.

Table 2.1. Implementation Costs of Various Property-Level Flood Protection Measures

		Monetary Cost	**Non-Monetary/ Transaction Costs**	
	Type of Measure	**Price**	**Difficulty to Implement**	**Level of Maintenance**
Remove Belongings from Basement	Behavioural	-	●	-
Protecting Belongings in Basement	Behavioural	$	●	-
Install Extended Downspouts	Physical	$	●	□
Install Rainwater Collection Device/ System	Physical	$	●	□□
Clear Gutters and Storm Drains	Physical	$	●	□□
Disconnect Downspouts from Sewer	Physical	$	●	-
Fix Cracks in Foundation	Physical	$	●●	-
Clear Blockages from Drains and Sewer	Physical	$	●●	-
Remove Trees / Roots Near House	Physical	$$	●●	-
Minor Landscaping for Flood Protection	Physical	$$	●●	-
Disconnect Foundation Drain from Sewer	Physical	$$	●●●	-
Install Backwater Valve	Physical	$$	●●●	□□□
Install Sump Pump System	Physical	$$	●●●	□□□
Install Sump Pump Battery Backup	Physical	$$	●●●	□
Major Landscaping for Flood Protection	Physical	$$$	●●●	-
Install Window Wells	Physical	$$$	●●●	□□
Fix/ Replace Sewer Lateral	Physical	$$$	●●●	-
Fix/ Install Foundation Drain	Physical	$$$	●●●	-

Adapted from Intact Centre on Climate Adaptation 2019

Legend for Table 2.1.

Price		**Difficulty to Implement**		**Level of Maintenance**	
$	Under $1,000	●	Easy, Do-It Yourself	□	Simple Check, Once a Year
$$	Between $1,000 and $5000	●●	May Require Technical Knowledge or Assistance	□□	Moderate Check, a Few Times a Year
$$$	Over $5,000	●●●	Typically Requires a Plumber /Contractor	□□□	Technical Maintenance, Once a Quarter

Our study focuses on two physical measures in the form of flood protection devices: backwater valves and sump pump systems.

As shown in Figure 2.1, a backwater valve is a device that is installed on the home's sanity service line. The device has a flap/ gate that is designed to close when a sewer backup occurs, which prevents sewer water from entering the home (see Figure 2.2).

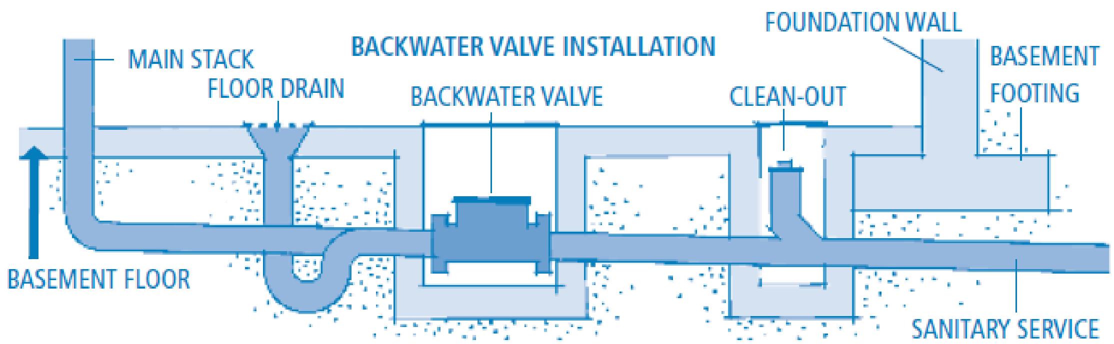


Figure 2.1. Backwater Valve Installation Diagram
Image Source: City of Edmonton 2020

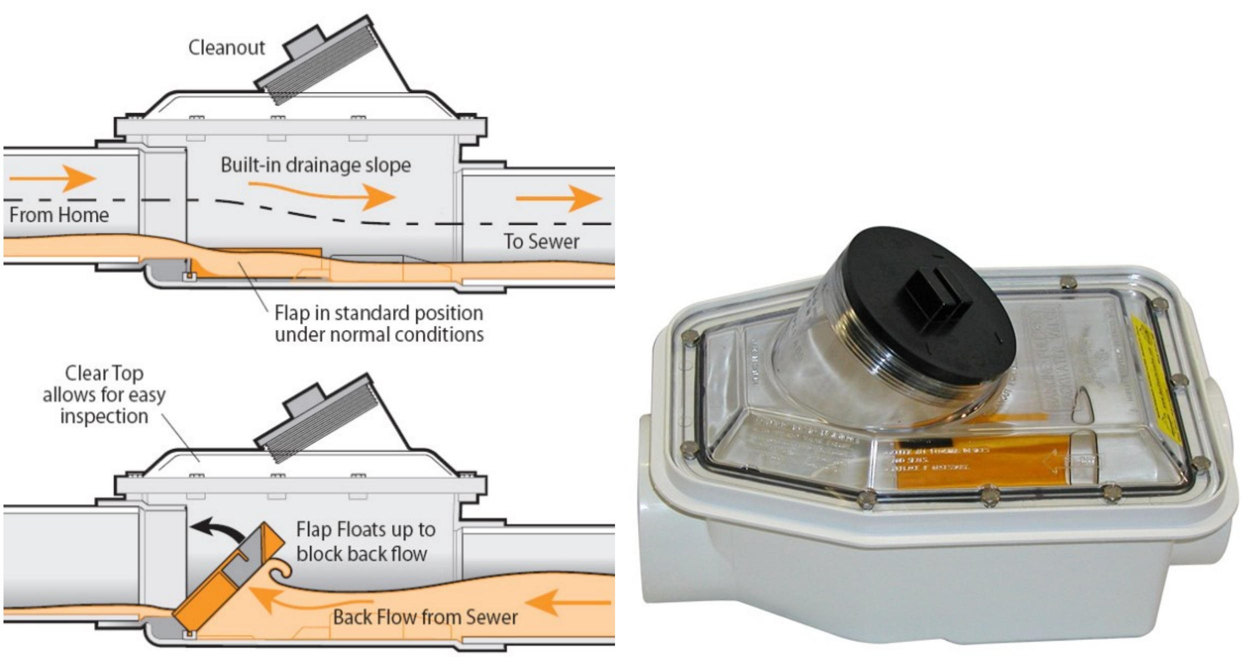


Figure 2.2. Backwater Valve Operation Diagram and Real Product Image
Image Source: backwatervalve.com n.d.

As shown in Figure 2.3, a sump pump is a device that is installed within a pit below a home's foundation and is often connected directly to the foundation drain (weeping tile). The pit is designed to collect rainwater from the foundation drain that runs along the home.

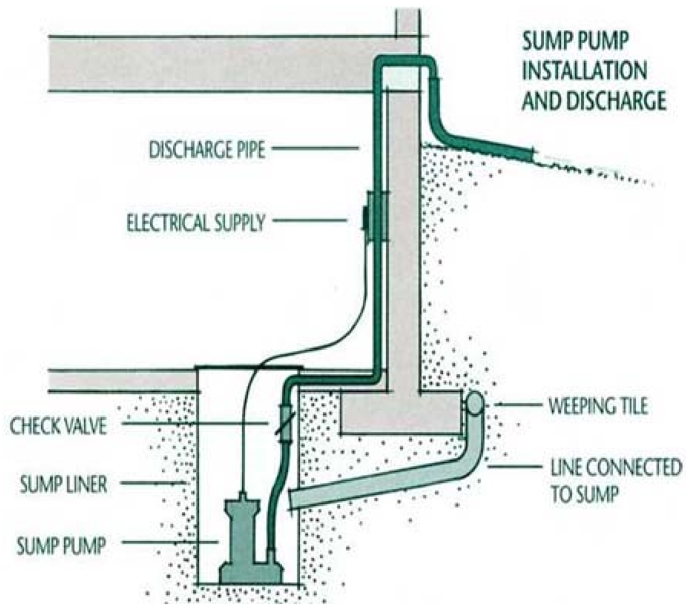


Figure 2.3. Sump Pump System Installation Diagram
Image Source: City of Edmonton 2020

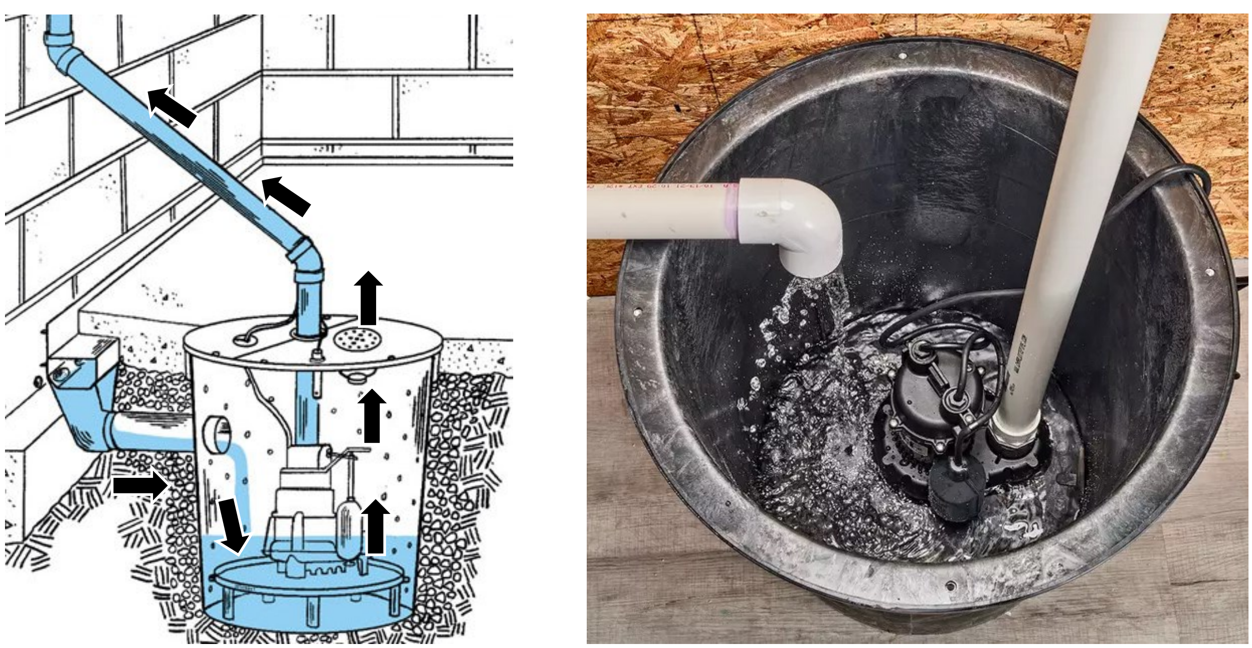


Figure 2.4. Sump Pump System Operation Diagram and Real Product Image
Image Source: waterguardplumbing.com n.d. and thespruce.com 2022

Once the water in the sump tank rises to a certain level, the sump pump will start running and push the water through the discharge pipe directly to the yard, away from the home's foundation, or directly to a storm sewer (some homes built after 2006). This prevents water from pooling near the home's foundation, reducing the chance of infiltration. In modern versions of sump pump systems, a battery backup pump may also be included. A battery backup allows the system to function if electricity is lost during a storm. While sump pump systems are easily installed in new homes, this is not the case when they are installed as a retrofit; it is difficult to connect a sump pump system to a foundation drain that does not have an existing line for a sump tank. In the case of retrofits, sump pumps are typically installed where water is already infiltrating the home, often at a low point in the foundation, or they are installed with the addition of an interior foundation drain. Therefore, retrofitted sump pump systems can be less effective in overall protection than those installed in new homes (local plumbers, personal communications, Dec 2021 - Jan 2022).

Backwater valves and sump pump systems were chosen to be the focus of our study for several reasons. The installation of these two devices in homes has been required in Edmonton since 1988, as part the Alberta Plumbing Code and Standards and City of Edmonton bylaws (City of Edmonton 2020), thus they provide a good representation of what the city deems effective property-level flood protection. Second, these devices are easily defined goods in terms of their price, implementation, and maintenance and don't vary greatly between properties, unlike other measures (lot grading, window well installation, etc.). The ability to clearly define the good is fundamental in the stated preference methods we use in this study. Third, we are interested in understanding the impact of subsidies and insurance discounts on homeowners' willingness-to-pay for flood protection. The installation of these two devices as retrofits is already commonly incentivized by cities and insurance companies, making them realistic choices for our study.

2.4 Stormwater Management in Edmonton

Although the responsibilities and costs of fluvial and coastal flood protection are often shared between all levels of government, the responsibilities and costs for pluvial protection often falls solely on the municipality as an element of water management. In the City of Edmonton, stormwater systems were managed by the City's Department of Drainage Services until 2017, at which time the department's responsibilities were transferred to Edmonton's public utility company, EPCOR Utilities. EPCOR's key flood mitigation strategy is the Stormwater Integrated Resource Plan (SIRP), which was developed in 2019. The strategy has five major investment dimensions: slow, move, secure, predict, and respond (see Table 2.2).

Table 2.2. Overview of EPCOR's SIRP Flood Mitigation Strategy Priorities

Theme	Description	Projects and Costs
Slow	Slow the entry of stormwater into the drainage network by absorbing it in green infrastructure and holding it in ponds, creating space in the collection system during storm events.	Ponds ($470M), Low Impact Development ($420 -570M)
Move	Move excess water safely away from areas at risk, quickly and efficiently.	Tunnels, Trunks, and Sewer Separation ($300M)
Secure	Help secure individual properties in higher risk areas against sewer backups, overland flooding, and river flooding.	Enhanced Flood Proofing ($60M), Outfalls and Control Gates ($30M), Inflow and Infiltration Reduction ($100M)
Predict	Predict and manage the movement of stormwater through smart sensors and technologies that integrate into the collection system.	Monitoring and Controls ($70M)
Respond	Respond through the fast rollout of flood barriers, traffic diversions and public communications to protect life, safety, and property.	Emergency Response Equipment ($45M)

Source: EPCOR 2019

The City of Edmonton is considered a national leader for its flood mitigation preparedness and is the only major city in Canada that provides information to residents to determine if their property is flood prone (Feltmate and Moudrak 2021). The city does this through two major resources: publicly available flood maps and EPCOR's Flood Prevention Program.

The City of Edmonton was the first major Canadian municipality to release flood map data to the public on November 9, 2016 (Stolte 2016). Created in 2014, the City of Edmonton flood maps model the impact of a 1-in-100-year (1 percent chance of happening in any given year) four-hour rainfall event across 164 mature neighbourhoods in Edmonton. The surface ponding map shows the expected depths of water pooling on the ground from severe rainfall, while the surcharge map shows how full the sewers pipes in the storm management system will get during a significant rainfall (City of Edmonton 2016). Examples of these maps are shown in Figure 2.5.

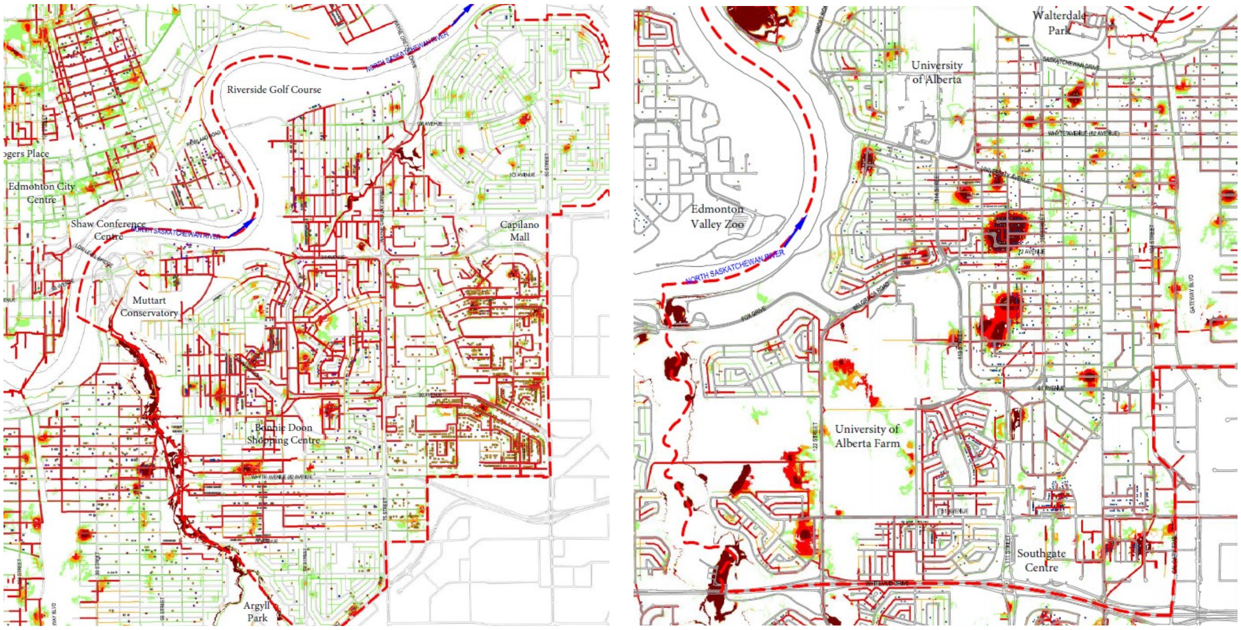
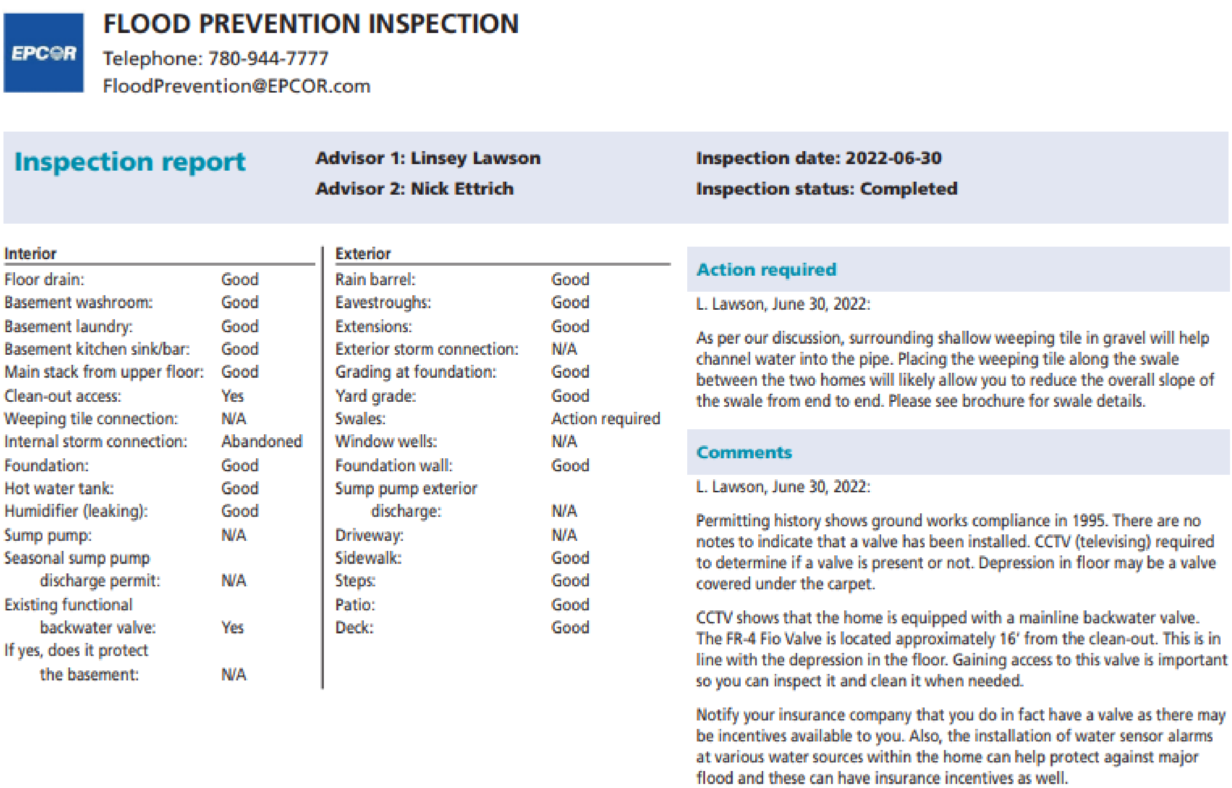


Figure 2.5. Example of City of Edmonton Flood Maps Showcasing Surcharge and Surface Ponding Risk from 1-100-Year Storm, 2014
Image Source: City of Edmonton 2016



EPCOR

FLOOD PREVENTION INSPECTION

Telephone: 780-944-7777
FloodPrevention@EPCOR.com

Inspection report

Advisor 1: Linsey Lawson
Advisor 2: Nick Ettrich

Inspection date: 2022-06-30
Inspection status: Completed

Interior	
Floor drain:	Good
Basement washroom:	Good
Basement laundry:	Good
Basement kitchen sink/bar:	Good
Main stack from upper floor:	Good
Clean-out access:	Yes
Weeping tile connection:	N/A
Internal storm connection:	Abandoned
Foundation:	Good
Hot water tank:	Good
Humidifier (leaking):	Good
Sump pump:	N/A
Seasonal sump pump discharge permit:	N/A
Existing functional backwater valve:	Yes
If yes, does it protect the basement:	N/A

Exterior	
Rain barrel:	Good
Eavestroughs:	Good
Extensions:	Good
Exterior storm connection:	N/A
Grading at foundation:	Good
Yard grade:	Good
Swales:	Action required
Window wells:	N/A
Foundation wall:	Good
Sump pump exterior discharge:	N/A
Driveway:	N/A
Sidewalk:	Good
Steps:	Good
Patio:	Good
Deck:	Good

Action required

L. Lawson, June 30, 2022:

As per our discussion, surrounding shallow weeping tile in gravel will help channel water into the pipe. Placing the weeping tile along the swale between the two homes will likely allow you to reduce the overall slope of the swale from end to end. Please see brochure for swale details.

Comments

L. Lawson, June 30, 2022:

Permitting history shows ground works compliance in 1995. There are no notes to indicate that a valve has been installed. CCTV (televising) required to determine if a valve is present or not. Depression in floor may be a valve covered under the carpet.

CCTV shows that the home is equipped with a mainline backwater valve. The FR-4 Fio Valve is located approximately 16' from the clean-out. This is in line with the depression in the floor. Gaining access to this valve is important so you can inspect it and clean it when needed.

Notify your insurance company that you do in fact have a valve as there may be incentives available to you. Also, the installation of water sensor alarms at various water sources within the home can help protect against major flood and these can have insurance incentives as well.

Figure 2.6. Example of EPCOR's Flood Prevention Program Free Home Inspection Report Showcasing Property-Level Information and Risks
Image Source: EPCOR 2022, Image Provided by ICLR

EPCOR's Flood Prevention Program is a free home inspection program, conducted by EPCOR, to identify property-level issues and risks related to flooding (see Figure 2.6). It also provides homeowners information on maintenance of property-level flood protection and is part of the eligibility criteria for the Backwater Valve Subsidy Program (also offered by EPCOR). Any resident of Edmonton can access this program. Between 2017 and May 2021, EPCOR conducted 1,948 home inspections as part of the program[1] (EPCOR 2021).

2.5 Municipal Incentive Programs

Property-level flood protection (PLFP) measures are private goods, however their adoption in older homes can have both private and public benefits. When a household takes certain measures – such as extending downspouts, properly grading their yard, and keeping gutters and storm sewers clear of debris – they not only protect themselves, but also their neighbours from experiencing excessive water around their homes during a severe rainfall event. Other measures – such as disconnecting gutters and foundation drains from the municipal sewer system and installing sump pumps instead – divert unnecessary stormwater from the municipal system to permeable surfaces, such as a home's lawn. By conducting these measures, households reduce the amount of water that would flow through the municipal system during a severe rainfall event, which lowers the chance of sewer backup to the community. Furthermore, diverting stormwater from the municipal system results in less water entering wastewater treatment, which should reduce utility costs for the community (Robinson, Sandink, Lapp 2019). These benefits have made PLFP measures desirable from a policy perspective. However, the cost of retrofitting flood protection devices and other extreme weather protections into older homes can be 10 times as expensive when compared to their installation in new homes (Feltmate 2022). Therefore, it is becoming more common for municipalities to offer subsidies to homeowners as a way of incentivizing adoption. According to the Intact Centre on Climate Adaptation, there are approximately 21 municipalities across Canada that offer subsidy/ grant programs to offset the

[1] Data could not be found on flood inspections conducted prior to when EPCOR took over responsibility for stormwater systems and flood mitigation for the City of Edmonton (prior to 2017).

cost of property-level flood protection (2020). Some communities offer more general subsidies to cover various flood protection measures, while others focus their subsidies to a select few measures. The most common subsidy programs are for backwater valves and sump pump systems. These programs are summarized in Table 2.3.

Table 2.3. Subsidy Programs Across Canada for Flood Protection Devices

Protective Device	Location	Subsidy Amounts
Backwater Valve Subsidy	Moncton, NB	$500
	Halton, ON	50% Up to $675
	Peel, ON	$700
	Vaughan, ON	50% Up to $750
	Edmonton, AB	**$800**
	Cornwall, ON	80% Up to $1,000
	Ottawa, ON	$1,000
	Windsor, ON	$1,000
	Brantford, ON	$1,200
	Kingston, ON	75% Up to $1,200
	London, ON	90% Up to $1,200
	Niagara Falls, ON	$1,200
	Toronto, ON	$1,250
	Hamilton, ON	$1,430
	Thunder Bay, ON	50% Up to $1,750
	Lethbridge, AB	$2,500
	St. Catharines, ON	$3,500**
	Welland, ON	$4,000**
	St. Thomas	$5,500**
Sump Pump System Subsidy	Brantford, ON	$1,200*
	Ottawa, ON	$1,250
	Kingston, ON	75% Up to $1,400
	Thunder Bay, ON	50% Up to $1,500
	Toronto, ON	80% Up to $1750
	Windsor, ON	$1,750*
	London, ON	90% Up to $2,475
	St. Catharines, ON	$3,500**
	Welland, ON	$4,000**
	Halton, ON	$5,000*
	St. Thomas	$5,500**

* Includes foundation drain disconnection
Source: Intact Centre on Climate Adaptation 2020
** Flexible programs, households can spend amount on any flood protective measures.

Since 1991, the City of Edmonton has offered a subsidy for backwater valve purchase and installation to homeowners of homes built prior to 1989. Originally, this subsidy program offered up to $975 for backwater valves, with an additional $1,400 if a sump pump and pit were required as a result of the backwater valve installation (Sandink 2007). The backwater subsidy has since been reduced and is currently valued at $800, with no additional value for sump pump and pit. There is currently no subsidy for sump pump systems in the City of Edmonton, and it is not a flood protection measure that is being considered for a future subsidy (EPCOR representative, personal communication, Jan 2022).

Between 2017 and May 2021, 1,439 homes in Edmonton received the backwater valve subsidy[2] (EPCOR 2021). In late 2020, EPCOR conducted a survey of 330 residents in their database who had conducted a home inspection and were eligible for the backwater valve subsidy, however never followed through with the installation. They received a total of 113 responses and found that 19 percent did install a backwater valve but did not apply for the subsidy. The top reasons include that they were unsure of how to apply (13 percent), too busy to apply (10 percent), and the model they installed was not approved by the program (10 percent). These descriptive results show that non-monetary costs, such as information seeking and time spent applying, can be a barrier to access incentive programs, which has also been found in the literature on energy efficiency upgrade incentives (Fowlie, Greenstone, Wolfram 2015). Of the remaining respondents, the top reason for not installing a backwater valve was the high cost of the installation, even with the subsidy (20 percent). Other reasons include feeling that their risk level was low, thus making the device not worth the cost (11 percent), too much disruption to the home (10 percent), and being told that there was no/ little benefit by the contractor of doing the work (9 percent) (EPCOR 2021).

2.6 Insurance Coverage for Flooding

Flood insurance in Canada is offered as optional, additional coverage to a home insurance policy. Most large insurance companies in Canada offer at least some coverage for flooding, either for sewer backup, surface, and/ or overland flood. Although these can be included as single endorsements, it is becoming increasingly common for insurers to bundle all types of flood insurance into a comprehensive package to avoid adverse selection[3] and keep costs affordable for all consumers (Thistlethwaite 2017; Oulahen 2015). It is estimated that approximately 55

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[2] Data could not be found on flood inspections conducted prior to when EPCOR took over responsibility for stormwater systems and flood mitigation for the City of Edmonton (prior to 2017).

[3] Only those living in known high risk areas have a demand for purchasing overland flood insurance, however insurance companies would prefer (and need) to sell to those at low risk to keep their costs and risk exposure low.

percent of personal insurance policies in Canada have flood insurance, but the take-up rate differs across the country (Li, 2022). The cost of flood coverage varies from home to home; most Canadians pay between $100-$300 annually, while those living in high-risk areas are likely to pay between $500-$1000 annually (Farooqui 2021). Homes in very high-risk areas for overland are often not eligible for insurance, which is one of the reasons the Government of Canada is exploring a national flood insurance program (Public Safety Canada 2022).

Although flood insurance is widespread in Canada now, this was not always the case. Prior to 2015, insurers did not offer flood coverage, except for sewer backup, due to several reasons, including insufficient economic conditions (adverse selection), inadequate government policy on flood risk management, and lack of reliable flood modelling data, which is needed to price risk based on the probability of occurrence (Thistlethwaite 2017; IBC 2019a). Insurers eventually changed their position due to pressures from consumers and governments following the 2013 floods in the City of Calgary and City of Toronto. The result of these events represented a major redistribution of responsibility for flood management, where insurers assessed their reputational and regulatory risk as more significant than the economic viability of offering flood insurance (Thistlethwaite 2017). The introduction of overland flood insurance has since contributed to the increase in insured losses due to water-related claims, which has been the number one cause of property insurance losses across Canada since 2005 (IBC 2019a).

3. LITERATURE REVIEW

3.1 Introduction

The literature on natural hazards and risk reduction is extensive, and spans many disciplines including economics, sociology, psychology, and communication theory. This review of literature focuses on broad concepts that were used to inform our study design including theories on motivating risk reduction behaviour, risk perceptions, self-efficacy, and the effect of previous experience with natural hazard events. Empirical literature related to the specific concepts of our study, such as flood risk perception, stated preference for flood risk reduction, and cost benefit analysis of flooding are explored throughout chapters six, seven, and eight.

3.2 Protection Motivation Theory

One of the leading theories in the literature on risk and motivation for protective behaviour is Protection Motivation Theory (PMT), introduced by Rogers (1975, revised 1983). The PMT framework was first applied within the health domain and later extended to natural hazards and flood risk reduction (Grothmann and Reusswig 2006). PMT aims to reflect the cognitive processes that lead an individual to the intention of protecting themselves against a threat (Bubeck, Botzen, Aerts 2012). It is formed of two steps, "threat appraisal" and "coping appraisal". Threat appraisal describes how threatened an individual feels by a specific risk. The first step is composed of an individual's perceived vulnerability (their perceived probability of facing the risk) and perceived severity of the consequences. According to PMT, an individual must reach a specific threshold in their threat appraisal of a risk before moving onto coping appraisal, where they begin to evaluate the benefits of possible actions to reduce risk and their capacity to do so (Bubeck, Botzen, Aerts 2012; Grothman and Reusswig 2006). The second step is composed of self-efficacy (the individual's belief in their ability to carry out the protective measure), response efficacy (the individual's belief that the protective measure will reduce their risk), and response cost (the cost of the protective measure). A visualization of the model, simplified and adapted from Grothmann and Reusswig (2006), is outlined in Figure 3.1.

Although a high threat and coping appraisal may motivate an individual to act, in reality there may be additional barriers to overcome before protective actions can be taken. These include a lack of knowledge, a lack of time, and a lack of finances, which suggests that more individuals have an intention to prepare for a risk than execute on it (Tang and Feng 2018; Poussin, Botzen, Aerts 2014; Reynaud, Aubert, Nguyen 2013; Grothmann and Reusswig 2006).

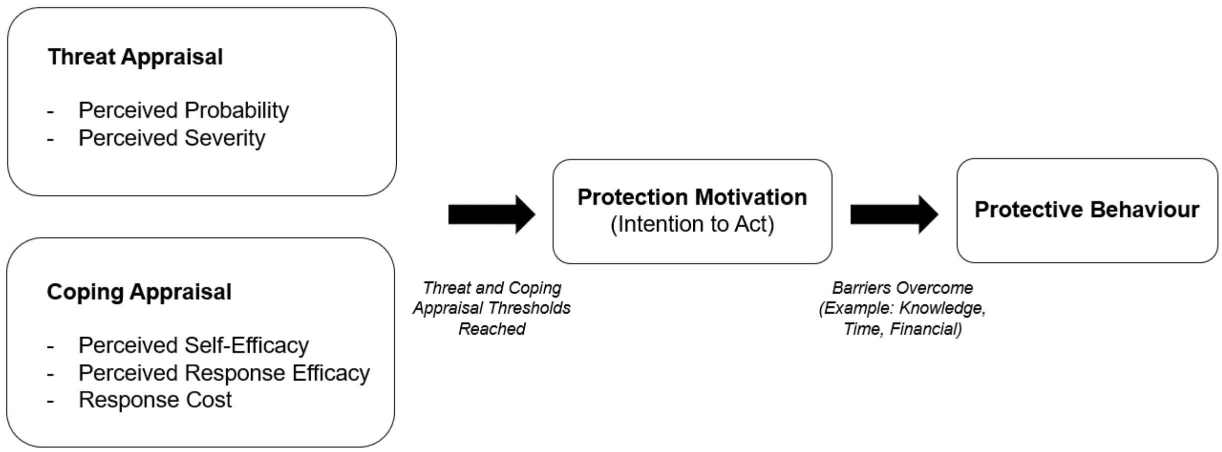

Figure 3.1. Protection Motivation Theory Summary Diagram
Adapted from Grothmann and Reusswig 2006

3.3 Risk Perceptions

Perhaps the most prevalent area of research related to risk reduction is the study of risk perceptions. Risk perception is the threat appraisal portion of PMT and is typically defined as the combination of the perceived (subjective) probability of experiencing the hazard and the perceived severity of potential damage based on location and value (Grothmann and Reusswig 2006). As opposed to objective risk levels, an individual's risk perceptions incorporate subjective factors such as their personal awareness, knowledge, beliefs, and experiences into their judgement on how at-risk they feel (Wallace, Poole, Horney 2016).

Most of the literature on the topic finds that risk perceptions have a positive effect on motivating protective behaviour, although the impact is typically weak or indirect (Richert, Erdlenbruch, Figuieres 2017; Poussin, Botzen, Aerts 2014; Wachinger et al. 2013; Bubeck et al. 2013; Bubeck et al. 2012; Bubeck, Botzen, Aerts 2012; Bourque et al. 2012; Terpstra and Lindell 2012;

Grothmann and Reusswig 2006). Grothmann and Reusswig (2006) suggest that high risk perceptions only lead an individual to adopt some coping response, which could be protective or non-protective. For example, Kreibich et al. (2005) found that households with previous flood experience had high estimates for being affected again (high risk perceptions), however had low intentions of protective behaviour, showing signs of fatalism. Additionally, individuals could have high risk perceptions, but if they accept the risk – i.e., they believe the costs outweigh benefits of risk reduction – or do not feel responsible for it, they will likely not undertake protective action (Wachinger et al. 2013). Another aspect that may influence the relationship between risk perceptions and protective action is a feedback loop effect caused by previous risk-reducing behaviour. In other words, an individual may have already taken actions to reduce their risk, which influences lower risk perceptions (Richert, Erdlenbruch, Figuieres 2017; Poussin, Botzen, Aerts 2014; Bubeck et al. 2013; Bubeck, Botzen, Aerts 2012). Studies that have controlled for this feedback effect were more likely to find risk perceptions statistically significant to protective behaviour, although the relationship was weak (Bubeck et al. 2012; Terpstra 2011, Botzen, Aerts, Van Den Bergh 2009a; Zaalberg et al. 2009). Thus, the varying degrees to which risk affects behaviour may stem from the design of the study as well as the methods used to define and elicit risk perceptions from the individual, making it difficult to compare results between studies (Dittrich et al. 2016).

3.4 Self-Efficacy

Studies that have used PMT to analyze risk reduction for natural hazards have investigated the different elements of the framework separately and have generally found that while both threat and coping appraisal are likely to impact a household's intention to adopt protective measures, a high coping appraisal is more likely to lead to action (Zaalberg et al. 2009, Grothmann and Reusswig 2006). Many of these studies find that self-efficacy, in particular, is significant to the implementation of protective behaviour (Weyrich et al. 2020; Botzen et al. 2019; Van Valkengoed and Steg 2019; Tang and Feng 2018; Dittrich et al. 2016; Oulahen 2015; Poussin, Botzen, Aerts 2014; Birkholz et al. 2014; Bubeck et al. 2013; Kellens et al. 2013; Koerth et al. 2013; Grothmann and Reusswig 2006). Self-efficacy is an individual's belief in their capacity to act and incorporates elements of experience, knowledge, and confidence. Therefore, it stands to reason that those with higher self-efficacy are more likely to be motivated in seeking out solutions to reduce their risk from natural hazards.

3.5 Previous Experience

Within the natural disaster literature, and the flood literature specifically, previous experience has been shown to be positively correlated with heightened risk perceptions (Roder, Hudson, Tarolli 2019; Osberghaus 2017; Botzen, Kunreuther, Michel-Kerjan 2015; Petrolia, Landry, Coble 2013; Kellens et al. 2011; Botzen, Aerts, Van Den Bergh 2009a; Zaalberg et al. 2009; Lindell and Hwang 2008; Keller, Siegrist, Gutscher 2006; Siegrist and Gutscher 2006; Weinstein 1989). The majority of the literature also finds that flood experience has a significant positive impact on risk mitigating behaviour, such as purchasing flood insurance and/or implementing flood protection measures (Grahn and Jaldell 2019; Thistlethwaite et al. 2018; Owusu, Wright, Arthur 2015; Osberghaus 2015; Bradford et al. 2012; Bubeck et al. 2012; Kreibich et al. 2011; Lindell and Hwang 2008; Thicken et al. 2007; Siegrist and Gutscher 2008; Siegrist and Gutscher 2006; Grothman and Reusswig 2006; Zhai et al. 2006; Kreibich et al. 2005). Weinstein (1998) suggests that the impact of personal experience with a hazard leads individuals to see themselves as potential future victims, increasing their motivation for protective behaviour. Siegrist and Gutscher (2008) found that individuals without flood experience envisaged the consequences of a flood differently and underestimated the negative non-monetary effects, when compared to those with experience. These findings suggest that previous experience may trigger motivating negative emotions such as fear, worry, and helplessness, leading to coping responses such as resilience (Kunreuther and Pauly 2018; Bradford et al. 2012; Zaalberg et al. 2009).

However, the results of some studies show that previous experience should be analyzed in the context of other factors, including level of damage or severity (Owusu, Wright, Arthur 2015; Kreibich et al. 2011; Siegrist and Gutscher 2008; Grothmann and Reusswig 2006; Takaeo et al. 2004), frequency (Owusu, Wright, Arthur 2015), and time passed since last experience (Netzel et al. 2020). It is possible that if an individual has experienced flooding, but the impact was not severe, not frequent enough, and/ or not recent, they may underestimate their future risk or need for protective action (Siegrist and Gutscher 2006).

3.6 Responsibility and Trust

As natural hazard events, such as flooding, are becoming more frequent, more severe, and more costly (Public Safety Canada, 2022), the element of responsibility for protection and action has become a focal point of many studies. The empirical literature shows that individuals typically believe flood risk reduction to be a shared responsibility between homeowners and government, however they feel that government, particularly at the municipality level, should take on the largest portion of that responsibility (Grahn and Jaldell 2019; Henstra et al. 2017; Owusu, Wright, Aurther 2015; Birkholz et al. 2014; Bichard and Kazmierczak 2012; Terpstra and Gutteling 2008). Many of these studies also show that individuals who see themselves as somewhat responsible for their own protection are more willing and/ or likely to take protective action (Grahn and Jaldell 2019; Henstra et al. 2017; Birkholz et al. 2014).

The literature also discusses the concept of both moral hazard and charity hazard – moral hazard being that individuals are less likely to invest in private risk mitigation if they believe they are covered by insurance (Osberghaus 2015), while charity hazard is when an individual is less likely to take action in anticipation that they will receive post disaster assistance from government (Osberghaus 2015; Petrolia, Landry, Coble 2013). However, results on whether these two concepts hold empirically are mixed, showing that insurance and access to government assistance can be seen as either substitutes or complements by different individuals (Osberghaus 2015; Petrolia, Landry, Coble 2013; Botzen, Aerts, Van Den Bergh 2009b; Grothmann and Reusswig 2006).

How individuals understand their responsibility toward natural hazard risk reduction may be somewhat related to the level of trust that they place in insurance and authorities. Babcicky and Seebauer (2017) found those that trusted government in flood risk reduction were less likely to feel at risk of flooding, therefore making them less likely to implement flood protection measures. In other words, when individuals believe government has flood risk under control they are instilled with a false sense of security (Bradford et al. 2012). These results were also mirrored in other studies (Roder, Hudson, Tarolli 2019; Reynaud, Aubert, Nguyen 2013; Wachinger et al. 2013; Terpstra 2011; Grothmann and Reusswig, 2006). However, trust can also help authorities communicate roles and responsibilities to citizens, increasing the likelihood that an individual will implement flood protection measures (Bamberg, et al. 2017; Richert, Erdlenbruch, Figuieres 2017; Poussin et al. 2014). When individuals lack knowledge about a hazard, their judgement on risk and behaviour towards that risk are often deferred to risk managers and other authority figures (Kellens, Terpstra, De Maeyer 2013; Wachinger et al. 2013; Terpstra 2011; Paton 2008).

3.7 Summary

Overall, risk perceptions, previous experience, self-efficacy, and feelings of responsibility and trust have all been studied extensively in the extant literature as factors that motivate risk reduction behaviour. This review has summarized the most relevant literature regarding these factors as they relate to this project, while also showing the complexity in how these factors influence individual responses to natural hazards. Key findings from the literature include:

(1) High risk perceptions generally have a positive effect on motivating protective behavior, however the impact is generally weak or indirect (correlated with other significant aspects such as flood experience);

(2) Empirical studies utilizing Protection Motivation Theory (PMT) find that an individual's self-efficacy (belief in their ability to act) is positively significant in the implementation of protective behavior;

(3) Previous experience with flooding positively correlates with heightened risk perceptions and tends to drive risk-mitigating behavior. However, the impact can be influenced by other factors such as severity, frequency, and time passed since the last experience;

(4) Natural hazard risk reduction is generally perceived as a shared responsibility between homeowners and the government, with individuals more likely to take protective action when they see themselves as somewhat responsible. The concepts of moral hazard (relying on insurance) and charity hazard (relying on government disaster assistance), show mixed results in the empirical literature.

4. STUDY DESIGN

4.1 Introduction

This chapter outlines the process used to design our study. It includes a summary of our expert interviews, which we conducted to gain further insight into the issues related to flood risk reduction, a brief outline of our questionnaire, and an explanation of our survey methodology and neighbourhood/ household selection process. This chapter also provides an overview of our survey outcomes, which may be of interest to those interested in methods to improve response rates, as well as descriptive statistics of our household respondents, namely information on demographics and existing property-level flood protection (PLFP).

4.2 Expert Interviews

We conducted 12 semi-structured interviews with professionals whose work and experience are associated with flood risk reduction. The objective of the interviews was to gain greater insight on the contextual situation and understand, from the subject matter experts' perspective, the most effective approaches to promote household awareness and inform household decision-making in flood risk reduction. In addition, the expert interviews were conducted to help inform the development of the questionnaire for our household survey. The questions asked in these interviews are described in APPENDIX C.

These experts were chosen using a snowball sampling method, which involves starting with some known experts and then asking them to refer others who are knowledgeable about and/ or work in flood risk reduction. Overall, we had 12 experts from a variety of fields including government, utilities/ infrastructure, non-profit, insurance, plumbing, and restoration and disaster management (two experts from each field).

Almost all experts agreed that homeowners don't invest enough in flood protection (11 out of 12), with the top reason being a lack of awareness about individual risk levels and how risk levels have changed overtime. However, each expert had other reasons for why there is low motivation amongst households. One expert described the use of technical language, such as the concept of the 1–100-year flood, as a pet-peeve, saying it is not the best way to inform the public of their risk. Instead, they suggested using a one percent chance in any given year or creating a low-, medium-, high- risk scale based on their home's topography. Inaction due to conflicting information from various trusted sources was also mentioned by our experts. One expert suggested that households will listen to who they trust about flood protection; however, there are often competing interests between trusted sources. For example, a plumber and the City of Edmonton may have different notions of what is best for flood protection, leaving the homeowner to decipher and make decisions on conflicting information. Low visibility of the issue, particularly amongst those without previous flood experience, was another suggested reason. One expert described researching and installing flood protection as a low priority on the hierarchy of day-to-day decision-making and households that feel their risk is not great enough will not be motivated to act. Similarly, another expert explained that households do not want to put their money into something that may or may not happen. They stated that is hard for households to justify spending money on flood protection devices since it is not something they would see and use on a day-to-day basis. When asked what they believe to be the best flood protection measure for homeowners to take, almost all experts stated that it would depend on the specific house and property. However, over half (7 out of 12) mentioned lot grading as being an effective method at reducing flood risk and just under half (5 out of 12) mentioned backwater valves as being important. One expert highlighted that building standards have changed significantly in Edmonton through the years and thus each property should have a property-specific assessment on the best way to mitigate flood risk. Another expert stated that the differences between homes (age, location, existing protection, etc.) is one of the greatest challenges of reducing flood risk – there is not a singular solution to the problem, and it must be dealt with on a case-by-case basis.

When the experts were asked what they believe to be the most effective way to motivate homeowners to invest in adequate flood protection, the most frequently mentioned course of action was providing education/ building awareness through targeted outreach (7 out of 12). Although the experts agreed that offering incentives was likely helpful, most did not believe it would drive a change in behaviour as much as other methods. Making the process of adopting flood protection simple was the second most mentioned strategy (4 out of 12). This concept was often connected to the idea of improving self-efficacy i.e., making an individual feel capable of protecting themselves against flooding. One expert suggested that showing households how they can protect themselves may help motivate them to adopt flood protection measures. Another expert echoed a similar thought, saying that if an individual can see themselves as a part of the solution or that they can do it themselves, then there is more buy-in.

When asked what governments and insurance companies could do to encourage homeowners to invest in flood protection, the majority of experts suggested more education and awareness, particularly through the development of tools such as nationwide flood maps. However, one expert mentioned the importance of building trust with homeowners being an essential first step, otherwise homeowners will not necessarily believe the information being given to them. They suggested that governments work with local community groups and plumbers to provide information and a consistent message to homeowners. Some suggestions that were more specific to insurance companies included more monetary incentives (premium discounts for having devices, etc.) and having flood insurance as a default option on home insurance plans.

Lastly, we asked our experts who they believe to be responsible for stormwater flood protection. Almost all (11 out of 12) experts agreed it was a shared cost, mostly between the homeowner and municipality, however some stated other entities, such as insurance providers, developers, and real estate agents. One expert noted that property-level protection is important, but can only go so far, and that exposure can also be greatly influenced by the municipality and its infrastructure - thus it is a shared responsibility and cost. Another expert stated that flooding is a whole of society problem that demands a whole of society solution, and that Canadians will foot the bill for floods, whether it in the form of mitigation or disaster recovery.

The findings from these interviews helped inform our questionnaire, particularly regarding the areas of trust (Q37) and responsibility (Q50), as well as innovative suggestions to motivate protection (Q38-39) (see APPENDIX N).

4.3 Questionnaire Design

The objective of the questionnaire was to collect information on factors that were deemed likely to influence the choice to invest in flood protection and to assess the demand for flood protection investments if they were not currently employed. The questionnaire was designed using the online survey software Qualtrics XM. There was a total of 67 questions informed by the literature and our expert interviews, however, due to conditional branch logic, few respondents were prompted to answer all questions. The questionnaire was comprised of nine sections which are summarized below (questions can be found in full in APPENDIX N).

House Information: These were questions related to the house and home ownership. Since the information gathered in these questions was required for the conditional branch logic, they were asked at the front of the questionnaire instead of the end with the other demographic questions. Questions included: current living situation (homeowner, renter, other), age of the home, and years of homeownership (if homeowner was selected).

Level of Knowledge: These questions aimed to understand the households' knowledge about their existing flood risk, their knowledge of local programs (to determine flood risk and incentives for flood risk reduction), their knowledge of their insurance coverage for flooding, and their knowledge of different property-level flood protection (PLFP) measures. The purpose of these questions was to provide context on how knowledgeable and aware households were regarding flood risk reduction in Edmonton.

Existing Protection: These questions collected information on the PLFP measures households already had in place, why they implemented these measures, and whether they maintain them regularly (if they were devices). The answers to these questions provided additional context and allowed us to eliminate households from the willingness-to-pay (WTP) questions if they already had backwater valves and/ or sump pump systems installed in their homes.

Risk Perceptions: These questions elicited household risk perceptions for stormwater flooding from sewer backup and infiltration. Questions were also asked about their perceptions on whether they expect severe stormwater flooding to increase or decrease in Edmonton over the next 10 years, and whether they felt they could protect themselves and afford repairs/ replacement of belongings in the event of a flood. These questions were asked to gauge average household risk levels and evaluate whether risk perceptions had an impact on WTP for PLFP.

Protection Motivations: These questions asked households who they trust when making decisions about flood protection and what approaches/ methods might incentivize them to invest in flood protection. The purpose of these questions was to better understand effective ways to motivate households to adopt flood protection measures.

Demand for Risk Reduction Investments/ Willingness-to-Pay: Using a discrete choice payment card approach, these questions elicit respondents' WTP for a backwater valve and sump pump system. Households were presented with scenarios describing the risk reduction, subsidy offered, and insurance premium reductions. They were then asked to indicate whether they would purchase the device, or not, for a series of price points from $0 to $2,500. This section of questions was directly related to our key study objectives; its purpose was to evaluate whether WTP was comparable to market costs for these devices and whether incentives had an impact on the amount households were willing to pay.

Common Goods/ Responsibility: This question asked households how they think the cost of stormwater flood prevention should be shared between homeowners, city government and utility providers, higher orders of government (provincial and federal), and any other entities. Respondents are asked to use sliding scales to assign a percentage of responsibility for each entity.

Flood Experience: This section asked households about their previous experiences with flooding including how many flooding incidents they have experienced, the year of their most recent experience, how water entered their home, the severity and cost of the damage, the length of repairs, and whether they submitted insurance claims. The purpose of this section was to help provide context to flood experience in these neighbourhoods and evaluate whether flood experience had an impact on estimates of WTP for PLFP.

Demographics: This part of the questionnaire collected household demographic information including gender, age, level of education, household size (number of adults and children), and household income. The answers to these questions helped us evaluate the representativeness of the sample and provided us with data to use in our statistical analysis on the factors that influence WTP for PLFP.

4.4 Survey Methods

<u>Neighbourhood Selection Rationale</u>

The study was conducted in Edmonton, Alberta, Canada. The neighbourhoods chosen for the survey were Duggan, Kenilworth, Ottewell, and Royal Gardens (see Figure 4.1 for their location within Edmonton). These neighbourhoods were chosen based on four criteria being met[4]: (1) the neighbourhoods are considered as having a higher-than-average flood risk; (2) over 65 percent of homes in the neighbourhood were built before 1981; (3) over 50 percent of the households in the neighborhood are homeowners, and (4) median household income levels of the neighbourhoods are approximately between $70,000 and $90,000. The neighbourhood census tract statistics that were used to evaluate the criteria are described in Table 4.1.

Additionally, the neighbourhood choices were discussed and decided with our partners – the Institute of Catastrophic Loss Reduction (ICLR) and TD Insurance (TDI). ICLR and TDI were collaborating on a project in Edmonton called the Showcase Homes Initiative to build consumer awareness of property-level flood protection measures through retrofitting at-risk homes. The survey was conducted alongside this project as part of a Mitacs Accelerate Fellowship.[5] Therefore, we wanted to make sure the communities chosen would be candidates for both the survey and retrofits. EPCOR was made aware of the chosen communities and confirmed that

[4] 2021 Federal Census data has not been released when discussions on neighbourhood first began. The differences in the indicators from the 2016 Census to the 2021 Census were negligible, but most prevalent in Duggan. Duggan had 162 new homes built in the neighbourhood between 2016 and 2021, lowering the overall percentage of homes built before 1980 below our original 65% threshold.

[5] The Mitacs Accelerate Fellowship provides funds to graduate students through sponsored internships with various organizations. The sponsor for this project was the Institute for Catastrophic Loss Reduction (ICLR), a Canadian not-for-profit research institute focused on multidisciplinary disaster prevention research and communication. ICLR's mission is to reduce the loss of life and property caused by severe weather and find ways to improve society's capacity to adapt to, anticipate, mitigate, withstand, and recover from natural disasters. TD Insurance was also a sponsor through their partnership with ICLR on programs to reduce losses from flooding.

they were good candidates based on our criteria and their experience working in the communities on flood mitigation improvements.

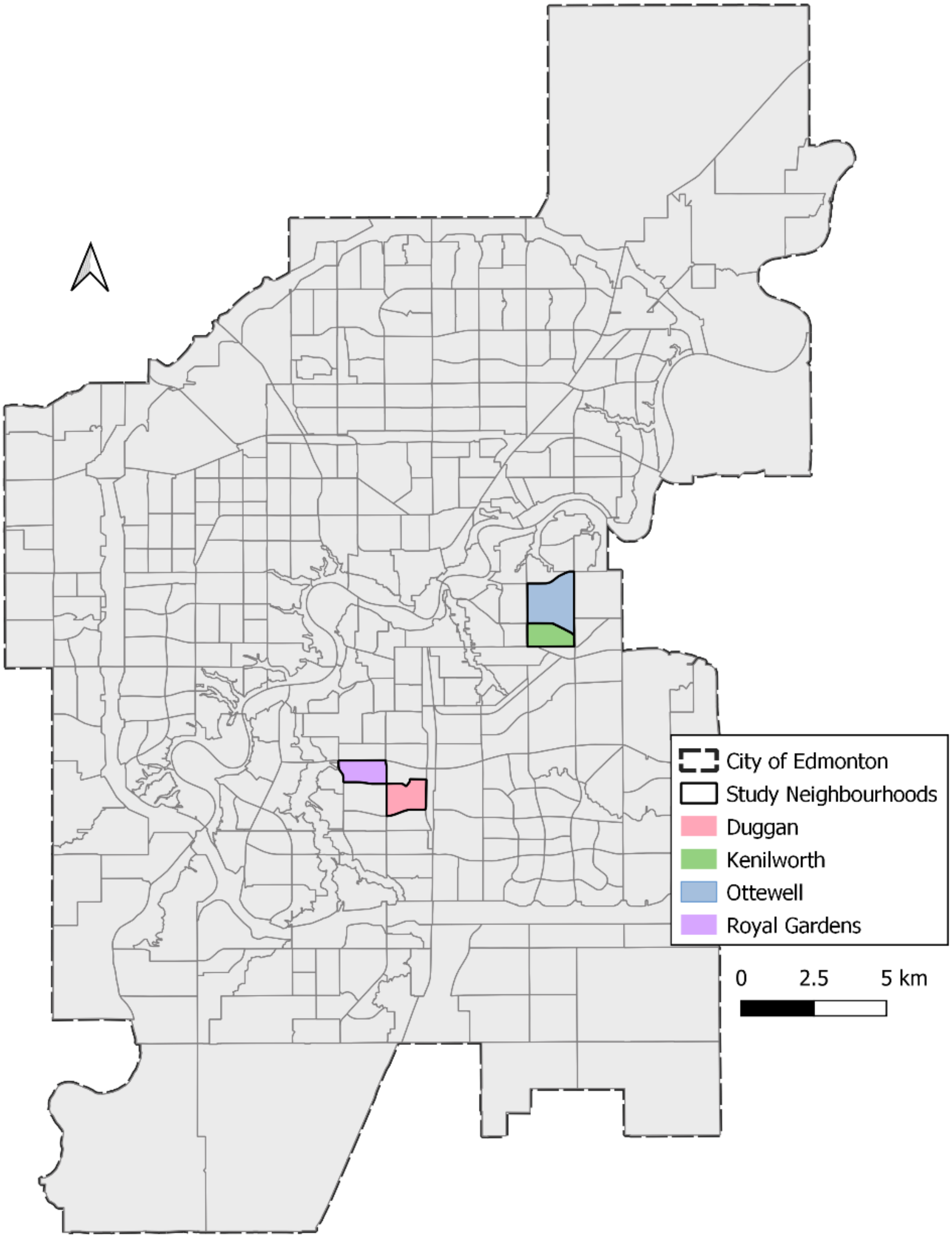

Figure 4.1. Map of Study Neighbourhoods in Edmonton

Table 4.1. Survey Selection Criteria Data by Neighbourhood (Census Tracts), 2016 - 2021

		Duggan (CT 8350001.03)	**Kenilworth** (CT 8350019.02)	**Ottewell** (CT 8350037.00 and 8350038.00)	**Royal Gardens** (CT 8350002.02)
2016 Census	Homes Built Before 1981 (%)	68%	89%	94%	84%
	Homeownership (%)	66%	64%	73%	52%
	Median Household Income ($)	$82,485	$69,875	$77,550	$72,305
2021 Census	Homes Built Before 1981 (%)	62%	88%	93%	83%
	Homeownership (%)	67%	64%	73%	52%
	Median Household Income ($)	$90,380	$74,075	$82,705	$78,700

Source: Statistics Canada, Federal Census 2016; Statistics Canada, Federal Census 2021

The age of these neighbourhoods is one of the predominant reasons they have a higher-than-average flood risk. All four chosen neighbourhoods are considered mature, which is defined as neighbourhoods that were well-established and effectively built out by 1970 (City of Edmonton 2010). Due to their age, the sewer infrastructure in these communities is more likely to have sag areas (i.e., geographical low spots). In addition, when these neighbourhoods were first developed the standards for sanitary and stormwater management were not as rigorous as they are today (City of Edmonton n.d.). For example, the neighbourhoods of Ottewell and Kenilworth have combined sewer systems, meaning both sanitary and stormwater are collected into the same pipes. Since combined sewer systems must carry more water, they are more prone to surcharge and flooding compared to systems where sanitary and storm are separated. Because of the higher risk, in addition to the higher cost of water treatment, the City of Edmonton began to separate their stormwater and sewer systems in the mid-1950s (City of Edmonton 2004). The infrastructure in these neighbourhoods also pre-dates several development bylaws related to current techniques used for managing stormwater surges, such as the requirement for storm management lakes in every new neighbourhood (City of Edmonton 2020). However, it is worth noting that all four neighbourhoods are currently undergoing flood mitigation improvements in the form of dry ponds and sewer separation as per EPCOR's Stormwater Integrated Resource Plan (EPCOR 2019).

Much like the age of the neighbourhood, the age of the homes also leads to a higher-than-average flood risk, which is why it was included in the selection criteria. At least two thirds of all homes in these four neighbourhoods were built before 1981. Most homes in these communities have aging clay tile as their service line material (lateral pipe from the home to the municipal sewer system), putting them at greater risk for lateral failure and sewer backup. In addition, many of the homes have their foundation drains (weeping tiles) and downspouts directly connected to the sewer system, which was common prior to 1960. These connections have the potential to cause sewer backup if the sewer system becomes inundated during a storm surge. These connections have not been allowed in the City of Edmonton since 1988 (City of Edmonton 2020). Lastly, the majority of homes in these neighbourhoods pre-date development bylaws related to mandatory property-level flood protection measures, which began in the early 1980s. Thus, there is a lack of consistent flood protection from home to home; some houses may have certain flood protection devices such as backwater valves, sump pumps, or foundation drains, while others do not.

The third and fourth selection criteria (over 50 percent homeownership and median household income between $70,000 and $90,000) were chosen because they represented the population we were most interested in surveying. Even though we were interested in the perspectives of both homeowners and renters, we wanted to ensure that the majority of respondents had the decision-making power to implement flood protection devices, such as the installation of backwater valves and sump pump systems. We also wanted to focus on neighbourhoods that had households within the range of Edmonton’s median income. According to the 2016 Federal Census, the City of Edmonton’s median total household income was $87,255. Although median income was a factor in the neighbourhood selection, we did not disqualify individual households from the survey based on their household income.

Pilot Study

A pilot study was conducted between May 31 and June 1, 2022. The pilot was conducted in all four neighbourhoods, as well as the neighbourhood of Kensington, which was being considered as a fifth study community at the time, but later dropped. Given the project time constraints, the pilot was conducted by going door-to-door to randomly selected households until a household answered the door, agreed to complete the questionnaire, and agreed to provide feedback within the week. Overall, 18 information, research ethics, and questionnaire access letters were distributed, and we received five completed questionnaires, for an overall response rate of 28 percent (see Table 4.2).

Table 4.2. Pilot Survey, Number of Questionnaires Issued and Completed

	Duggan	**Kenilworth**	**Ottewell**	**Royal Gardens**	**Kensington**	**Total**
Number of Questionnaires Handed Out	4	4	4	2	4	18
Number of Questionnaires Completed	1	0	1	2	1	5
Response Rate (%)	25%	0%	25%	100%	25%	28%

Out of the five households that completed the questionnaire, three answered an email to provide feedback on the survey questions and design (see APPENDIX F).

We were most interested in whether any questions were unclear, too complicated, irrelevant, or inappropriate. Based on the pilot feedback, two questions were removed, and clearer explanations were added to the willingness-to-pay questions (specifically on upfront cost and final cost). Since our hope was to increase our response rate by connecting with households in person, we also asked our pilot households whether the interaction at the door contributed to their decision to take part in the survey. Two households said they would have done the questionnaire regardless (even if the information was just left in the mailbox) and one said they probably would not have done the questionnaire without having communicated with the study team.

Another learning from the pilot study was how many houses could not be surveyed. The following reasons were identified as the need to skip houses: (1) houses were empty due to being for sale or sold; (2) houses were empty due to being under construction; (3) houses were boarded up or abandoned; (4) houses were not accessible due to large gates/fences or other forms of barrier to the door; and (5) houses were group homes or businesses. In addition, we skipped all homes that had a clear “no soliciting” sign. Even though “no soliciting” signs are generally used to avoid money-related requests, such as sales calls and requests for donations, the understanding of the word “soliciting” could constitute any request, including the request to complete a questionnaire. In other words, we assumed anyone with a no soliciting sign did not want to be bothered at the door.

Household Selection Process

Homes within each neighbourhood were selected using a systematic random sampling method of the City of Edmonton’s Property Assessment data. This method samples members from a larger population according to a random starting point, but with a fixed, periodic interval. The interval is calculated by dividing the population size by the desired sample size. For this survey we were interested in a 15 percent sample size, however it was scaled up to 16.7 percent to account for the number of homes we expected to skip based on the results from the pilot study. This sample size was chosen due to our estimation on how many responses would be needed to have statistical power, while also accounting for our limited resources going door-to-door. The assessment data were broken down into four datasets, one for each neighbourhood. A six-sided die was rolled to randomize the starting point and every sixth home from that starting point was then selected to be included in the original sample (N=834). Overall, we expected to survey 751 homes out of a total population 4,998 (see Table 4.3).

Table 4.3. Survey Sample Size Assessment, Number of Households

	Duggan	**Kenilworth**	**Ottewell**	**Royal Gardens**	**Total**
Total Number of Homes in Each Neighbourhood	1066	987	2174	771	4998
Original Sample (16.7% of Homes in Each Neighbourhood on Assessment)	178	164	363	129	834
Expected Sample (15.0% of Homes in Each Neighbourhood on Assessment)	160	148	327	116	751

Survey Administration

The choice to do a door-to-door survey, rather than an online panel survey, was made due to our interest in results from specific neighbourhoods. The surveying method was partially informed by the approach taken by Kennedy (2011). In total there were four survey team members. The team was split into two pairs; one pair tasked with surveying the southeast neighbourhoods of Ottewell and Kenilworth and the other pair tasked with surveying the southwest neighbourhoods of Duggan and Royal Gardens. The survey was comprised of two visits to each home – the initial contact visit and the follow-up visit.

The initial contact visits took place from June 13 to June 22, 2022. Team members visited each home chosen to be in the original sample (N=834). As each home was visited, the team members first evaluated the house under the skip criteria before knocking. These criteria were not always obvious and occasionally team members added houses to the skip list after interactions at the door (for example, told by nurse at the door that the house was a group home or told by construction worker that the home was not yet occupied). If a house was considered a skip, then it was not to be included in the sample or response rate. By the end of the initial contact visits, we had eliminated a total of 82 homes and reached a final sample that was close to what we had predicted (N=752). Although the final sample worked out to 15 percent of the total population, there were more skipped houses than expected in Royal Gardens, meaning the final sample for that neighbourhood was slightly below 15 percent (see Table 4.4).

Table 4.4. Number of Houses Skipped and Final Sample by Neighbourhood

	Duggan	**Kenilworth**	**Ottewell**	**Royal Gardens**	**Total**
House Skipped - Expected	18	16	36	13	83
Houses Skipped - Actual	13	16	32	21	82
Final Sample Size	178	164	363	129	834
Final Sample Size as Percentage of Neighbourhood	15.5%	15.0%	15.2%	14.0%	15.0%

Table 4.5 shows the number of houses that were skipped based on our previously mentioned criteria. There were two houses in Ottewell that were skipped for other reasons – one house had been demolished and replaced with an apartment building and the other house simply did not exist (could not be found, online maps showed address in middle of the street).

Table 4.5. Number of Survey Houses Skipped by Reason for Skip

Empty – Sale /Sold	Empty – Construction	Empty – Abandoned	Not Accessible	Group Home/ Business	No Soliciting	Do Not Exist
16	5	5	15	3	34	2

If the team members deemed a home to be valid (not a skip), the door was knocked. If the door was answered, the survey team explained the study to the resident and handed them a doorhanger (with access to the online questionnaire) and frequently asked questions and concerns sheet (see APPENDIX H). The resident was then informed that the survey team would be following up with households that had not completed the questionnaire in one to two weeks time to remind them about the study, which was also stated on the doorhanger. If the door was unanswered, the survey team left the doorhanger and frequently asked questions and concerns sheet on the door handle or mailbox hanger. Some households opted out at the door by telling the survey team they were not interested. These homes were still included in the sample, however, were not given the questionnaire access materials and were not given a follow-up visit.

The follow-up visits took place from June 27 to July 12, 2022. Survey team members visited each home from the final sample that had not opted out and had not already respond to the questionnaire by the time follow-up visits were conducted (N=616). Follow-up visits were conducted in a similar order to the initial contact visits. If the door was answered, the team members stated that they had previously visited the home and dropped off some information about the study and questionnaire. If the resident remembered the visit or remembered receiving information, then a follow-up letter with an access code was given (see APPENDIX K). If the resident did not remember the visit or receiving any information, then the original doorhanger and frequently asked questions and concerns sheet was given. The resident was informed that the survey team would not visit again and that the survey would end on July 18. If the door was unanswered, the team members left the follow-up letter in the mailbox.

Ethics

The survey received ethics clearance on June 10, 2022, under the ID Pro00111805. All households were prompted to read the research ethics at the beginning of the online questionnaire. Respondents had to consent to the ethics before proceeding with the questions. For those that did not consent, the questionnaire was terminated (see APPENDIX N).

4.5 Survey Outcomes

Response Rates

Of the 752 houses that were included in the survey, 196 completed the questionnaire. The overall response rate was 26.1 percent. As shown in Table 4.6, the response rate between neighbourhoods was consistent – between 25 and 27 percent.

Table 4.6. Questionnaires Completed, Opt Outs, and Response Rate Calculations

	Duggan	**Kenilworth**	**Ottewell**	**Royal Gardens**	**Total**
Final Sample (Number of Survey Households)	165	148	331	108	752
Questionnaires Completed	42	40	84	28	196*
Response Rate (% of Final Sample that Completed Questionnaire)	25.5%	27.0%	25.4%	25.9%	26.1%
Number of Households that Opted Out at Door	16	13	37	10	76
Number of Households that Opted Out in Questionnaire	3	2	4	1	10
Total Opt Out (% of Final Sample)	11.5%	10.1%	12.4%	10.2%	11.4%
Incomplete Questionnaires (Started Questionnaire, Not Finished)	2	1	7	5	15

* The final count includes 2 households that did not submit their addresses, so cannot be included in neighbourhood calculations.

Approximately 11 percent of households opted out of the survey, either by telling the survey team members they were not interested or by choosing the opt out option on the consent form in the questionnaire. These homes were still included in the sample calculation. There was concern that due to the length of the questionnaire and the technical nature of some of the questions that there may be a high dropout rate. However, this did not seem to be the case – only 15 questionnaires were started and left incomplete.

One of our key interests with the survey methodology was whether households would be more likely to complete the questionnaire if they interacted with the survey team. Overall, 67 percent of households in the final sample had at least one interaction with the survey team, either in the initial contact visit, follow-up visit, or both. Almost 80 percent of completed questionnaires came from these homes (see Table 4.8). Households that did not have an interaction during the initial contact visit but did receive an interaction in the follow-up often stated that they thought our survey materials were spam flyers and that they immediately recycled without reading. Others stated that they read the survey materials but thought they did not qualify because they had never had flooding before (even though the materials specifically state this did not disqualify households). These findings demonstrated the value in having interactions with households to state the importance of the study as well as answer questions, regardless of whether the questions were already answered in the survey materials.

Table 4.7. Number of Households That Interacted/ Did Not Interact with Survey Team

	Duggan	Kenilworth	Ottewell	Royal Gardens	Total
At Least One Interaction	100	100	229	75	504
At Least One Interaction (% of Sample)	60.6%	67.6%	69.2%	69.4%	67.0%
No Interactions	65	48	102	33	248
No Interactions (% of Sample)	39.4%	32.4%	30.8%	32.4%	33.0%

Table 4.8. Questionnaire Response Rates Based on Survey Team Interactions with Households

	Duggan	Kenilworth	Ottewell	Royal Gardens	Total
At Least One Interaction	34	35	66	18	153
At Least One Interaction (% of Sample)	81.0%	87.5%	78.6%	64.3%	78.9%
No Interactions	8	5	18	9	40
No Interactions (% of Sample)	19.0%	12.5%	21.4%	32.1%	20.6%

Another interest with the survey methodology was whether follow-up visits would increase the questionnaire response rate. Almost half of the responses (49 percent) were submitted after the follow-up visits were conducted (after households received two visits). Although we cannot make any conclusive statements about how many responses were due to the follow-up visit (since having more time could also be a factor), anecdotally, many residents at the door stated that they had forgotten about it and would complete it right away. In addition, we did see a spike in responses each day of follow-up visits after experiencing a bit of a lull between when the initial contact visits ended (June 22, 2022) and when the follow-up visits started (June 27, 2022). The follow-up visits also provided an opportunity to talk to other household members, some of whom were more interested in completing the questionnaire than the household member talked to in the initial contact visit.

Table 4.9. Questionnaire Response Rates After Follow-Up Visits from Survey Team

	Duggan	**Kenilworth**	**Ottewell**	**Royal Gardens**	**Total**
Number of Households that Received a Follow-Up Visit	135	120	272	89	616
Number of Responses After Follow-Up Visits	20	18	42	15	94
Responses After Follow-Up Visits (% of Total Responses)	47.6%	45.0%	50.0%	53.6%	48.7%

One of the issues with physically handing out survey materials for an online questionnaire was how to provide the access code. Our doorhanger had both a link, which could be typed into a browser address bar, as well as a QR code, which could be scanned by a mobile device (see APPENDIX H). An analysis of the results showed that approximately 60 percent of respondents used the link, while 40 percent used the QR code. Overall, we deemed it good practice to provide as many access methods as possible to increase the response rate.

5. DESCRIPTIVE STATISTICS

5.1 Introduction

This chapter showcases the descriptive findings from our survey (N=200). It includes the demographic information of respondents as well as household-level insights about existing property-level flood protection (PLFP), awareness of local programs and flood insurance, knowledge about PLFP, previous flood experience, responsibility and trust, and motivating factors for implementing PLFP.

5.2 Demographics of Respondents

The vast majority of respondents fit our household demographic criteria of being homeowners and having homes that were built prior to 1980. Of the 200 respondents (196 full survey households and 4 pilot households), 94 percent were homeowners, four percent were renters, and two percent were other (relatives of the homeowner). Additionally, 96 percent of homes surveyed were built before 1980. The average length of homeownership for respondents was 25 years, while the average length of homeownership in their current home was 19 years.

Table 5.1 and Table 5.2 present the demographics for our household respondents and the 2021 federal census data for each neighbourhood. Overall, when compared to the census, we captured a higher proportion of homes built before 1981, a higher proportion of homeowners than renters, and a higher median income. These differences may be attributable to the fact that we only surveyed single and semi-detached homes, which are more likely to be lived in by homeowners than renters. Homeowners may also have higher incomes; however, approximately 21 percent of respondents chose not to state their household income, which has the potential to sway the results if a higher proportion of lower income households chose not to respond to the question. In addition, since taking part in the survey was optional, there is likely some self-selection bias, which can also skew the results from the census.

Table 5.1. Key Demographic Characteristics of Household Respondents

	Duggan	Kenilworth	Ottewell	Royal Gardens
Homes Built Before 1981 (%)	86%	100%	99%	93%
Homeownership (%)	95%	93%	95%	90%
Median Household Income ($, Using Midpoint)	$125,000	$95,000	$125,000	$125,000
Gender Split (%, Male:Female)	56% : 42%	63% : 38%	55% : 40%	57% : 43%
Avg Age of Respondent (Using Midpoint)	53	53	55	56
Avg Persons Per Household	2.3	2.6	2.6	2.6

Table 5.2. 2021 Federal Census Data on Survey Neighbourhoods

	Duggan CT 8350001.03	Kenilworth CT 8350019.02	Ottewell CT 8350037.00 CT 8350038.00	Royal Gardens CT 8350002.02
Homes Built Before 1981 (%)	62%	88%	93%	83%
Homeownership (%)	67%	64%	73%	52%
Median Household Income ($, Using Midpoint)	$90,380	$74,075	$82,705	$78,700
Gender Split (%, Male:Female)	50% : 50%	51% : 49%	49% : 51%	49% : 51%
Avg Age of Household Maintainer	53	50	54	54
Avg Persons Per Household	2.6	2.3	2.4	2.7

Source: Statistics Canada, Federal Census 2021

Other demographic data collected from the survey includes gender, age, household size, and education levels of respondents. More males responded to our survey than females in every neighbourhood. The majority of respondents were either in their 40s or 60s, giving us an average age between 48 and 56 in each neighbourhood. The average household size of respondents was two adults and between one and two children. Approximately 82 percent of respondents had some form of post-secondary education, with just over half having completed a bachelor's degree or higher. Detailed demographic data from our entire sample (N=200) can be found in Table 5.3.

Table 5.3. Detailed Demographic Results of Responding Households

Demographic	Statistic	Count	Percent of Total
Gender	Male	113	56.5%
	Female	82	41.0%
	Prefer Not to Say	5	2.5%
Age	20-29	6	3.0%
	30-39	33	16.5%
	40-49	41	20.5%
	50-59	27	13.5%
	60-69	48	24.0%
	70-79	30	15.0%
	80+	11	5.5%
	Prefer Not to Say	4	2.0%
Education	Grade 1-11	6	3.0%
	High School Diploma	23	11.5%
	Trade Certificate/ Apprenticeship	16	8.0%
	College Diploma or Certificate	43	21.5%
	Bachelor's Degree	62	31.0%
	Master's Degree	32	16.0%
	Doctorate Degree	11	5.5%
	Prefer Not to Say	7	3.5%
Household Income	<$20,000 (Including Losses)	2	1.0%
	$20,000 – $39,999	8	4.0%
	$40,000 – $59,999	13	6.5%
	$60,000 – $79,999	25	12.5%
	$80,000 – $99,999	26	13.0%
	$100,000 – $149,999	36	18.0%
	$150,000 – $199,999	26	13.0%
	$200,000 – $249,999	13	6.5%
	>$250,000	9	4.5%
	Prefer Not to Say	42	21.0%
Ownership Status	Homeowner	187	94.0%
	Renter	8	4.0%
	Other	4	2.0%
Age of Home (Era Built)	Built in the 50s or Earlier	17	8.5%
	Built in the 60s	136	68.0%
	Built in the 70s	38	19.0%
	Built in the 80s	4	2.0%
	Built in the 90s	0	0.0%
	Built in the 00s or Later	1	0.5%
	Don't Know	4	2.0%
Years As Homeowner (Over Lifetime)	Less Than 1	5	2.5%
	Between 1-5	25	12.5%
	Between 6-10	14	7.0%
	Between 11-15	22	11.0%
	Between 16-20	22	11.0%
	Between 21-30	29	14.5%
	Between 31-40	32	16.0%
	Between 41-50	25	12.5%
	Over 50	14	7.0%
	Not Applicable	12	6.0%

5.3 Existing Flood Protection (Devices and Insurance)

When households were asked what PLFP they had, the most common responses were extended downspouts (89 percent of respondents) and landscaping (67 percent). More technical flood protection devices, such as backwater valves and sump pumps, had lower rates of uptake, possibly due to the more complex nature of retrofitting these devices into homes as well as the costs associated with their installation (see Table 5.4).

Almost one-fourth of respondents did not know whether they had a backwater valve in their home and almost half of respondents did not know if they had a foundation drain. Since backwater valves and foundation drains are buried systems, they may be difficult for households to detect when compared to more visible devices, such as rain barrels and extended downspouts.

Table 5.4. Percentage of Household Respondents With/ Without Property-Level Flood Protection

	Backwater Valve	**Extended Downspouts**	**Land-scaping**	**Rainwater Collection**	**Sump Pump**	**Foundation Drain**
Yes	37%	89%	67%	34%	16%	35%
No	39%	11%	23%	66%	78%	20%
Don't Know	24%	1%	10%	1%	7%	45%

Respondents who stated they had a backwater valve and/ or sump pump were asked follow-up questions on whether they maintain these devices at least once a year. Approximately 31 percent of respondents with backwater valves said they conducted annual maintenance on the device, while 52 percent of respondents with sump pumps said the same. It is concerning that maintenance on these devices, particularly on backwater valves, is low since their functionality and effectiveness during a flood event depends on regular inspection and maintenance (Sandink and Binns 2021).

In addition to PLFP, households were asked about their insurance coverage for flood damage. Almost 60 percent of respondents stated they had coverage for sewer backup. Less than half of respondents had coverage for overland or infiltration. Almost 30 percent of respondents did not know whether they were covered by insurance for flooding (see Table 5.5).

Table 5.5. Percentage of Household Respondents with Flood Insurance

Sewer Backup	Overland	Infiltration	No Flood Coverage	No Home Insurance	I Do Not Know
59%	38%	28%	7%	2%	29%

5.4 Level of Awareness and Knowledge

An area of interest was whether households knew if their homes were at risk of flooding, and, if so, from where they received or sourced that information. The top response was through personal experience (33 percent of respondents); in other words, they have had flooding issues in the past. The second most common source of information was through neighbors or community members (21 percent) and third was through municipal resources (12 percent). Approximately 38 percent of respondents stated that they had not sourced information about their flood risk potential, which could mean they did not feel at risk and thus find it unnecessary to source this information. Anecdotally, many households we talked to at the door made statements in passing about why they were not at risk, such as being on high ground and/ or they had lived in their homes for so long and had never had flood issues before.

We also asked households whether they were aware of any local programs or services that they can access to determine their home's flood risk. Through this question we wanted to gauge the awareness of EPCOR's Flood Prevention Program, which offers free property inspections to help homeowners maintain good drainage and minimize their risk of flooding. These types of inspection services are also provided by the private sector – primarily plumbers and home inspectors. Interestingly, 82 percent of respondents stated that they did not know of any programs or services to determine their flood risk. We asked a similar question regarding awareness of local incentives or subsidies that are available to households for the purpose of installing flood protection. Through this question we wanted to gauge the awareness of EPCOR's Backwater Valve Subsidy Program, which offers eligible homeowners $800 towards a backwater valve installation. Similar to the previous question, 83 percent of respondents stated that they did not know of any local incentives or subsidies available.

We asked households to rank their level of knowledge on common PLFP measures using a Likert-type scale with descriptions to clarify each level.[6] Results show that respondents were most confident in their knowledge of extended downspouts and landscaping for flood protection (see Table 5.6). Between 61 and 67 percent of respondents were confident in their knowledge about devices that required more technical knowledge – such as backwater valves, sump pumps, and rainwater collection systems. Less than half of respondents felt knowledgeable about sump pump battery backups, which is unsurprising since only two households in our sample stated that they had this device.

Table 5.6. Level of Knowledge of Different Flood Protection Measures – Percentage of Household Respondents who Stated Moderately or Very Knowledgeable

Backwater Valve	Extended Downspouts	Land-scaping	Rainwater Collection	Sump Pump	Battery Backup	Foundation Drain
67%	87%	84%	67%	61%	44%	58%

5.5 Previous Experience

Almost 60 percent of household respondents stated they have had at least one experience with water entering their home due to a flooding event (22 percent of total respondents had more than one experience). Out of the total number of respondents, 43 percent stated they had an experience in their current home. However, these numbers may be inflated by an opt-in bias; individuals who have had experience with flooding are more likely to complete a questionnaire on flooding. When households were asked about their most recent incident, the most frequent cause

[6] Levels of Knowledge:
- Not Knowledgeable: I don't know what it is, and I don't know how it works to prevent flooding.
- Slightly Knowledgeable: I know what it is, but I don't know how it works to prevent flooding.
- Moderately Knowledgeable: I know what it is, and I know how it works to prevent flooding.
- Very Knowledgeable: I know what it is, I know how it works, and I know how to maintain it.

of flooding was infiltration (see Table 5.7). When asked about the severity of damage in their most recent incident, 43 percent of respondents categorized it as only clean up required (see Table 5.8).

Table 5.7. Water Entry Type of Most Recent Flood Incident for Household Respondents with Previous Flood Experience

	Infiltration	Sewer Backup	Overland	Other
Percentage of Respondents with Flood Experience	47%	33%	16%	5%

Table 5.8. Severity of Damage* of Most Recent Flood Incident for Household Respondents with Previous Flood Experience

	No Damage, Clean Up Only	Minimal Damage	Moderate Damage	Severe Damage
Percentage of Respondents with Flood Experience	42%	26%	28%	4%

* Definition of Damages (Severity):
- No Damage, Clean Up Only
- Minimal: Minor home repairs needed and/or a minimal loss of belongings.
- Moderate: Moderate home repairs needed and/or a moderate loss of belongings; you could continue to live in your home while repairs were made.
- Severe: Major home repairs needed and/or a severe loss of belongings; there was possible health risks and a possible need to evacuate your home until repairs are made.

Approximately 73 percent of households with flood experience said clean up or repairs took three months or less for their most recent incident. We also asked households about the cost of home repairs (including both material and labour) and the cost of replacing destroyed belongings. Using a midpoint analysis, the average losses of those that had damage due to a flood event (i.e., not including clean up only households) was $18,769.[7] However, the number could be higher, since we did not clarify to respondents to provide their losses even if their insurance reimbursed them; some respondents may have thought the question only asked for out-of-pocket losses.

5.6 Responsibility and Trust

Households were asked to use sliding scales to assign percentages for how they believe stormwater flood prevention should be shared amongst homeowners, the municipality and utility providers, higher orders of government (provincial and federal), and any other party they feel is

[7] All losses were adjusted to 2023 dollars.

responsible. The average percentage of responsibility assigned to homeowners was 34 percent, municipality and utility was 41 percent, and provincial and/ or federal government was 22 percent (see Table 5.9). Respondents rarely assigned responsibility beyond these entities, even though they were given the option to do so. Overall, households felt that government entities should take on the majority of responsibility in flood prevention (63 percent). A number of respondents wrote comments about how responsibility does not matter because the payment of prevention would always fall on homeowners either through direct payment or taxes. We also asked households who they trust when making decisions about flood risk reduction. The top three choices were EPCOR (72 percent of respondents) the City of Edmonton (65 percent), and plumbers/ contractors (60 percent).

Table 5.9. Entities Households Trust When Making Flood Risk Reduction Decisions (N=200)

	Number of Households*	**Percentage of Sample**
EPCOR	144	72%
City of Edmonton	130	65%
Plumbers or Contractors	119	60%
Family or Friends	84	42%
Insurance	72	36%
Neighbours or Community	57	29%
News	30	15%
Other	4	2%
Myself/ No One	11	6%

* Respondents could choose multiple answers.

5.7 Motivation

To understand if specific monetary incentives and nudging-type activities would increase the households' likelihood of implementing PLFP measures, we asked the survey households: *"If you learned that your home was at risk of flooding, what approaches would increase the chance that you would install a flood protection measure?"* The approaches that we provided in the question were informed by our partners and expert interviews. Interestingly, clear information on how much risk would be reduced by a flood protection measure was the most chosen and top ranked approach. The results of this question showed that information provision was more important to most household respondents before any sort of monetary incentive or convenience (see Table

5.10). However, the results may have been different if we had stated a specific value for the subsidy.

Table 5.10. Approaches That Would Motivate Households to Increase Adoption of Property-Level Flood Protection (N=200)

	Number of Households*	**Percentage of Sample**	**Top Choice (Rank)**
Clear information on how much risk would be reduced by a flood protection measure.	139	70%	1
A subsidy from City/EPCOR given as a lump sump before installation of the device.	127	64%	2
The City pays the full cost of the device and installation up front and then you are responsible for paying off the full cost in installments (through property tax).	88	44%	3
A free service that would select a reputable plumber, book the time to install, and complete all necessary paperwork. You pay the cost for the device and installation.	109	55%	4
A subsidy from City/EPCOR given as a lump sum after installation of the device.	136	68%	5
A reduction in your annual home insurance premium.	127	64%	6
Knowledge of what others in the neighbourhood with similar flood risks have done for protection.	101	51%	7
Other	17	9%	8
None	11	6%	NA

* Respondents could choose multiple answers.

5.8 Discussion

Summary and Implications

Although the findings in this chapter are descriptive, they provide some insights into the contextual situation of households in our sample. Key findings include:

- ***There are major gaps in awareness and knowledge of flood risk reduction options.*** Household respondents had low levels of awareness regarding public programs that support flood risk reduction (EPCOR's inspection program and subsidy for backwater valves). In addition, almost a third of respondents were unsure of whether they were protected against flooding on their home insurance policy. The low levels of awareness and knowledge may suggest an information failure, where households may not have all the information required to efficiently allocate their funds for flood risk reductions. An information failure such as this could lead to an over or under-investment in PLFP.

- ***Previous experience is common and has the greatest impact on households' understanding of flood risk.*** Almost 60 percent of household respondents had experienced water entering their home due to a stormwater event at least once. Approximately 33 percent of respondents said personal experience was how they were informed about their flood risk potential. These statistics are concerning from the prevention perspective, since it is hoped that households would have the appropriate information prior to a flood event and thus have the opportunity mitigate it before it happens.

- ***Households place responsibility and trust regarding flood protection with the municipality and EPCOR.*** The majority of household respondents felt that the municipality and utility were predominantly responsible for stormwater flood prevention. Additionally, most respondents trusted EPCOR and the City of Edmonton when it came to making decisions about flood risk reduction. Plumbers and contractors were also well trusted in this area, which could mean that there needs to be more collaboration and cohesive messaging between the two entities on what constitutes as effective flood risk reduction.

- ***Motivation for flood risk reduction is connected to better understanding of risk and financial incentives.*** Most household respondents (70 percent) stated that clear information about how much their risk would be reduced by PLFP would motivate them to act. Additionally, the majority of respondents (64-68 percent) were interested in subsidies and financial incentives, however since most were not aware that subsidies already exist, information provision of local programs remains the first major hurdle for policymakers.

6. UNDERSTANDING RISK PERCEPTIONS

6.1 Introduction

Risk perceptions are commonly understood as an important element to motivating risk reduction behaviour, even though the effect is typically found to be weak or indirect (Richert, Erdlenbruch, Figuieres 2017; Poussin, Botzen, Aerts 2014; Wachinger et al. 2013; Bubeck et al. 2013; Bubeck et al. 2012; Bubeck, Botzen, Aerts 2012; Bourque et al. 2012; Terpstra and Lindell 2012; Grothmann and Reusswig 2006). Through pairwise correlation analysis, this chapter takes a deeper look at the complexity of risk perceptions as it relates to other factors shown to impact action on risk reduction, such as awareness, previous experience, and self-efficacy. In addition, an analysis between stated risk perceptions and objective risk levels (provided by flood modelling firm KatRisk) was conducted to see if households are cognizant of their true flood risk.

6.2 Relevant Literature

In chapter three we discussed the literature on risk perceptions as a general concept related to natural hazard mitigation. In the flood literature, the primary finding on risk perceptions is that most households do not feel their homes are vulnerable to flooding (low risk perceptions), which leads to low protective action (Thistlethwaite et al. 2020; Roder, Hudson, Tarolli 2019; Price et al. 2019; Wallace, Poole, Horney 2016; Sandink 2011; Botzen, Aerts, Van Den Bergh 2009a; Terpstra and Gutteling 2008). The literature suggests several reasons as to why risk perceptions can be low. One reason is lack of knowledge or awareness on how flooding happens (Botzen, Aerts, Van Den Bergh 2009a). Another reason is that individuals have difficulties understanding probabilistic processes (Weinstein 1989; Slovic 1987) and thus rely on heuristics to reduce the task of assessing and predicting probabilities of their risk (Tversky and Kahneman 1974). Heuristics are mental shortcuts that individuals use to simplify complex problems. In the context of flood risk perceptions, the availability and affect heuristics are commonly cited in the literature as relevant (Terpstra 2011; Siegrist and Gutscher 2008; Keller, Siegrist, Gutscher 2006). Individuals that use the availability heuristic as a cue estimate their probability of experiencing a hazard based on how easy it is to imagine or recall (Tversky and Kahneman 1974). Individuals that use the affect heuristic as a cue estimate their probability based on positive or negative emotions that they attach to the natural hazard (Slovic et al. 2004; Finucane et al. 2000). The availability and affect heuristics are often connected to an individual's previous flood experience and how they anchor on their experience to predict their future flood risk. Therefore, if one has never experienced any flooding in the past, they may have low availability and neutral affect, i.e., it hasn't happened yet, so it won't happen in the future (Lawrence, Quade, Becker 2014).

6.3 Data

The data used in this chapter were sourced from our questionnaire and from catastrophe modelling firm KatRisk. In this section we have detailed the construction of questions specific to risk perceptions, as they were most relevant to the analysis done in this chapter. Additionally, we have described the flood risk level data provided to us by KatRisk. We have also described the methodology regarding the comparison between the two datasets.

Risk Perception Questions Development

The questions we used to understand household risk perceptions were informed by the different elements of threat appraisal from Protection Motivation Theory (PMT). More specifically, we asked questions to elicit household's perceived probability of experiencing a flood event and perceived consequences if a flood were to occur. First, to inform households that may be unaware of what causes higher risk of flooding in homes, we provided a list of factors that can objectively increase a home's vulnerability to flood from sewer backup and infiltration. These factors were:

Sewer Backup

- Cracks in the sewer pipe caused by tree roots, shifting soil, poor installation, etc.;
- Collapse of the sewer pipe due to age or sewer pipe material;
- Clogs in the sewer pipe caused by pouring fats, oils, grease, or other debris in the sink;
- The home's downspouts, weeping tile, or drains are connected to sewer or storm system;
- The home does not have specific devices to protect against this sewer backup (such as a backwater valve).

Infiltration (Seepage)

- The home is located in a low-lying area with a high water table;
- The home has poor lot grading (yard slopes towards the home);
- There are cracks in the home's foundation walls or floor;
- The home's gutters/eaves are not regularly cleaned (clogged with leaves, debris, etc.);
- The home's sump pump discharge or downspouts evacuate too close to the foundation;
- The neighbouring lot(s) are graded towards your home;
- The neighbouring sump pump discharge or downspouts are directed towards your home;
- The home does not have specific devices to protect against infiltration (such as extended downspouts, foundation drain, or sump pump).

Second, we wanted to understand the perceived risk level of the households in our sample. We asked, "*What is the percent chance you will have water enter your home at least once over the next 10 years due to a sewer backup during a stormwater event?*" and prompted households to enter a percent chance probability (see Figure 6.1). We then asked the same question regarding infiltration.

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Assume you will still be living in your current home over the next 10 years.

In your opinion, what is the **percent chance** you will have water enter your home **at least once over the next 10 years** due to **sewer backup** during a stormwater flood event?

The following ranges provide guidance for percentage chance:

- No Chance (0%)
- Low (1-24%)
- Med-Low (25-49%)
- Med-High (50-74%)
- High (75-99%)
- Certain (100%)

Please write only one number in the box below - do not enter a range or the % sign. If you are unsure, please provide your best guess.

[ ] % Chance

Figure 6.1. Perceived Flood Risk Probability Question from Questionnaire

There is debate in the literature about probabilistic expectations and whether individuals have difficulty processing and representing their beliefs using numerical probabilities (Manski 2004). However, there are many advantages to eliciting expectations in probabilistic form. One advantage is that numerical scales are well-defined and may be interpersonally comparable (Manski 2004). In contrast, the use of verbal descriptors (such as very, fairly, likely, etc.), could be interpreted differently amongst respondents. Another advantage is that we can compare the elicited subjective probabilities with known objective probabilities based on previous events or engineered calculations of risk. Nonetheless, it is possible that not all individuals understand their risk in the form of probabilities and therefore we provided six ranges with descriptors on a scale of zero percent (no chance) to 100 percent (certain) as guidance for respondents. We purposefully avoided a middle category as there is evidence in the literature that individuals use the middle, or 50 percent, category as a proxy for uncertainty (Bruine de Bruin et al. 2002; Bruine de Bruin et al. 2000).

To understand the perceived level of consequence from a flood event, we asked the survey households about potential losses and their ability to financially cope with potential loss. The three questions we asked regarding consequences included:

- *"If you were to experience a flooding event in your basement today, and all belongings not raised at least two feet above the floor were damaged, what would you estimate the cost of replacing your belongings to be?"*
- *"Do you keep any irreplaceable belongings (example: old photo albums, keepsakes, heirlooms, sentimental items, etc.) in your basement in places vulnerable to flooding (not raised at least two feet above the floor or not in waterproof containers)?"*
- *"How much do you agree with the following statement?: "If I were to experience a basement flood, I would be able to afford the home repairs and replacement of my damaged belongings."*

KatRisk Flood Risk Levels and Map Data

KatRisk, a catastrophe modelling firm based in the United States of America, is one of the three firms that the Government of Canada is consulting to create nationwide flood maps for Canada (Public Safety Canada 2022). The firm provided us with data in the form of flood risk scores for our study neighbourhoods, which they modelled using peer reviewed methods from the fields of meteorology, hydrology, physics, statistics/machine learning, structural engineering, and computer science. More specifically, KatRisk used precipitation data and parameterized hydrologic and hydraulic models to compute return period-level flood maps. They then used these flood map data to create a flood risk score, from zero (low) to nine (high), using a weighted spatial average of 100- and 500-year flood loss. The flood risk score data were provided to us at the lot-level, which allowed us to merge KatRisk's dataset to our own.

6.4 Methods

As stated throughout the literature, there is a complex relationship between risk perceptions and protective behaviour (Poussin, Botzen, Aerts 2014; Wachinger et al. 2013; Bubeck, Botzen, Aert, 2012; Bourque et al. 2012; Terpstra and Lindell 2012; Grothmann and Reusswig 2006). Therefore, we were particularly interested in which variables within our dataset may be correlated with risk perceptions. We conducted Pearson and Spearman pairwise correlations between the risk perceptions of our household respondents and the results of other questions from the questionnaire using the Hmisc package (rcorr function) in R. Additionally, to understand whether a household's perceived risk was aligned with their objective risk, we conducted a pairwise correlation analysis between risk perceptions for infiltration flooding[8] from our questionnaire and the flood risk scores developed by KatRisk.

GIS software QGIS was used to showcase the results between objective and perceived risk visually through maps. The objective risk maps were provided to us by KatRisk using their spatial

[8] To properly model sewer backup knowledge of stormwater and sewer infrastructure is required. Therefore, it was not possible to have flood models and flood risk scores created for this type of flooding.

methodology, while the perceived risk maps were created by the researchers using inverse distance weighted (IDW) interpolation. The measurements used for the perceived risk from our question (scale: 1-100 percent) and the flood risk score (scale: 0-9 score) were not directly comparable, therefore, we had to adjust our scale to match the risk score format (see Table 6.1).

Table 6.1. Adjustments Made to Create a Comparative Scale Between Perceived Flood Risk Percentages and Flood Risk Score

Descriptor	Percentage	Adapted Descriptor	Lower Limit	Upper Limit	Flood Risk Score	Colour Code
No Chance	0%	No Chance	0%	0%	0	Gray
Low Risk	1% - 12%	Low: Low Bound	1%	12%	1	Purple
		Low: High Bound	13%	24%	2	Blue
Med-Low Risk	25% - 49%	Med-Low: Low Bound	25%	37%	3	Teal
		Med-Low: High Bound	38%	49%	4	Green
Med-High Risk	50% - 74%	Med-High: Low Bound	50%	62%	5	Yellow
		Med-High: High Bound	63%	74%	6	Light Orange
High Risk	75% - 99%	High: Low Bound	75%	87%	7	Dark Orange
		High: High Bound	88%	99%	8	Light Red
Certain	100%	Certain	100%	100%	9	Deep Red

6.5 Descriptive Results

After showing respondents the list of common factors that can make a home more vulnerable to flooding (outlined on pages 51-52), we asked whether their homes were at risk based on these factors. Over half of respondents said they were vulnerable to either sewer backup (16 percent), infiltration (14 percent), or both (21 percent). However, when we asked respondents for their perceived risk of flooding in the form of a percentage, most categorized their risk as low; between 1-24 percent chance of flooding over the next 10 years for both sewer backup and infiltration (see Figure 6.2 and Figure 6.3).[9] More specifically, the average percent chance of sewer backup over 10 years was 20.1 percent (2.0 percent chance a year), whereas the average percent chance of infiltration was 23.6 percent over 10 years (2.4 percent chance a year).

[9] Even though we emphasised that households answer with one number for the flood risk probability question, some respondents entered one of the ranges we provided for guidance instead (N=19). For these responses we chose the midpoint of the range for our analysis. We also had some respondents leave the boxes blank for each of the questions, which we dropped from our analysis (N=3).

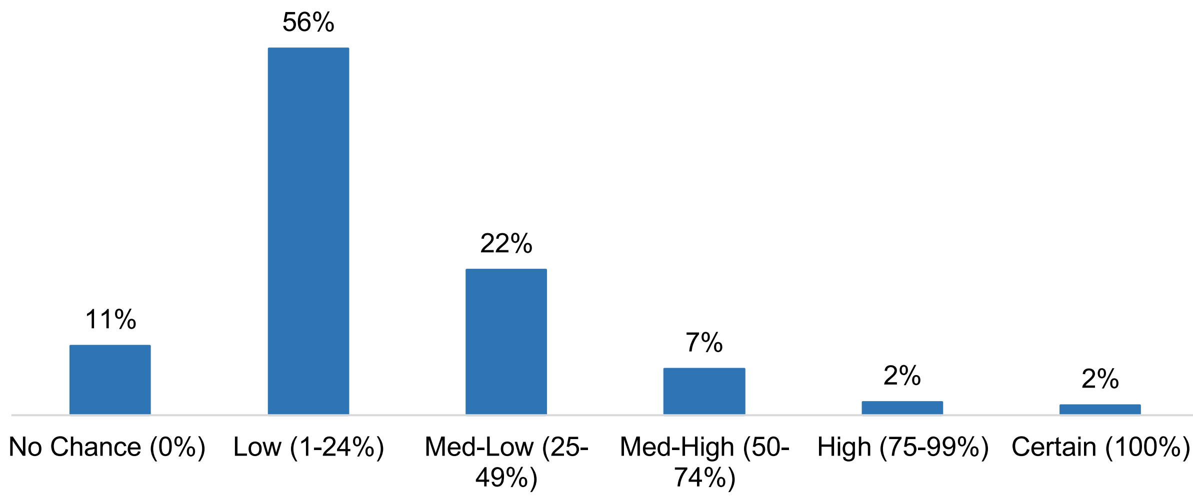

Figure 6.2.Distribution of Household Respondents by their Perceived Probability of Sewer Backup Over the Next 10 Years (N=197)

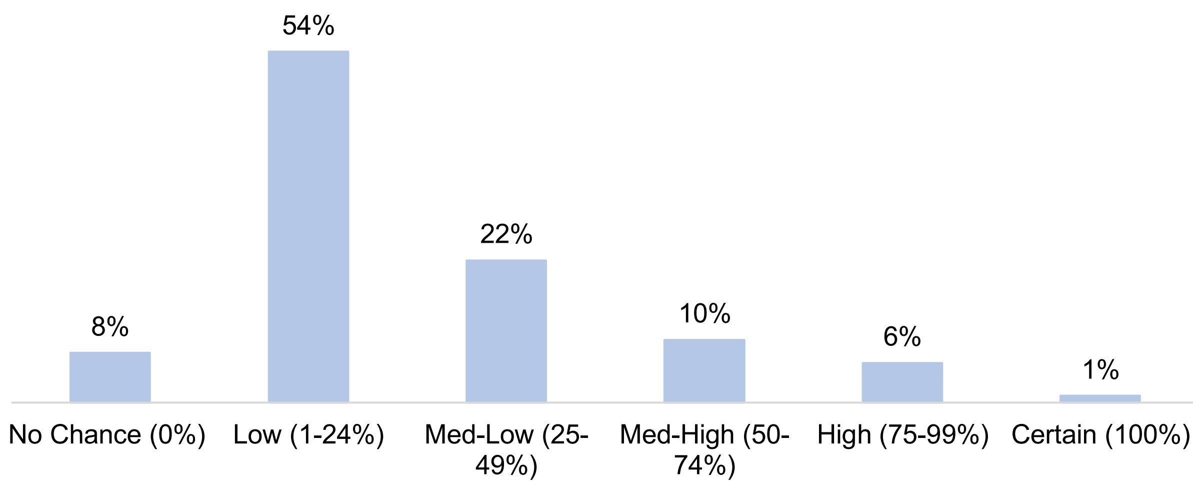

Figure 6.3. Distribution of Household Respondents by their Perceived Probability of Infiltration Over the Next 10 Years (N=197)

It is possible that although households recognize that their homes are vulnerable (based on the common risk factors), they may still believe the opportunity for those vulnerabilities to result in a flood event is low. However, it is worth noting that when we cross-tabulated the results from the common risk factors question with the perceived risk probability question, we found that the household respondents who said yes to having risk factors were more likely have higher risk perceptions than those that said no to having risk factors (see Figure 6.4 and Figure 6.5).

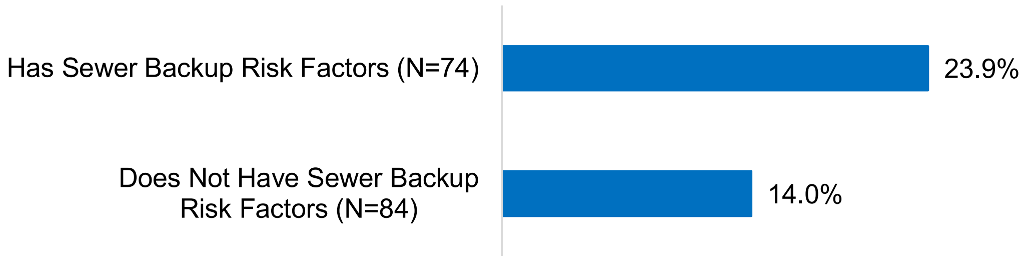

Figure 6.4. Household Respondents' Average Perceived Risk for Sewer Backup Cross-Tabulated with Common Risk Factors

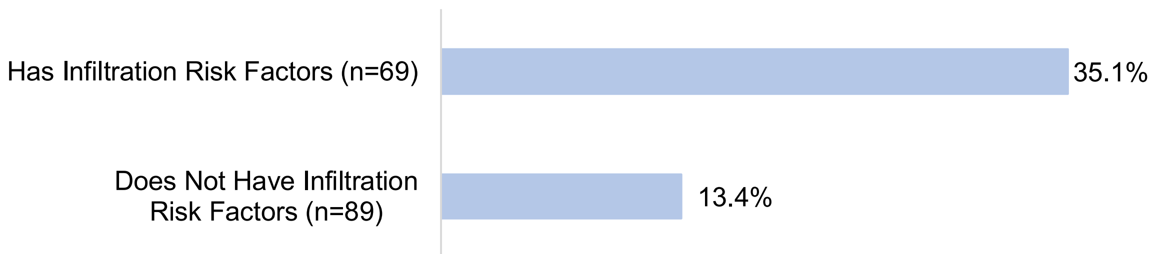

Figure 6.5. Household Respondents' Average Perceived Risk for Infiltration Cross-Tabulated with Common Risk Factors

Another interesting finding was that although most household respondents had low risk perceptions for their homes to experience flooding, almost two-thirds of respondents believed severe stormwater events will increase in the City of Edmonton over the next 10 years, either moderately (44 percent) or substantially (21 percent). This result shows that respondents may believe their homes to be invulnerable compared to others, which supports the findings of previous literature (Burningham, Fielding, Thrush 2008).

Regarding the potential consequences of a flood event, just over half of household respondents valued the potential loss of belongings in their basement to be $15,000 or less (see Figure 6.6). Using a midpoint analysis, this question produced an average loss value of $14,713. It is important to note that this does not include the potential cost of house repair as a result of a flood event, which could make the losses much more costly.

Two-thirds of the household respondents stated that they would be able to afford home repairs and the replacement cost of their damaged belongings if they were to experience a basement flood event. This was a surprisingly high percentage considering the average value of belongings stated in the previous question and the likelihood that repairs to the house are even more costly. However, households may have incorporated their insurance coverage into their understanding of this question when its purpose was to address their ability to pay without insurance. In retrospect, the question should have been more specific. A cross tabulation shows that 44 percent of respondents who said they could afford home repairs and the replacement of belongings also had at least one form of flood insurance (sewer backup, infiltration, and/ or overland).

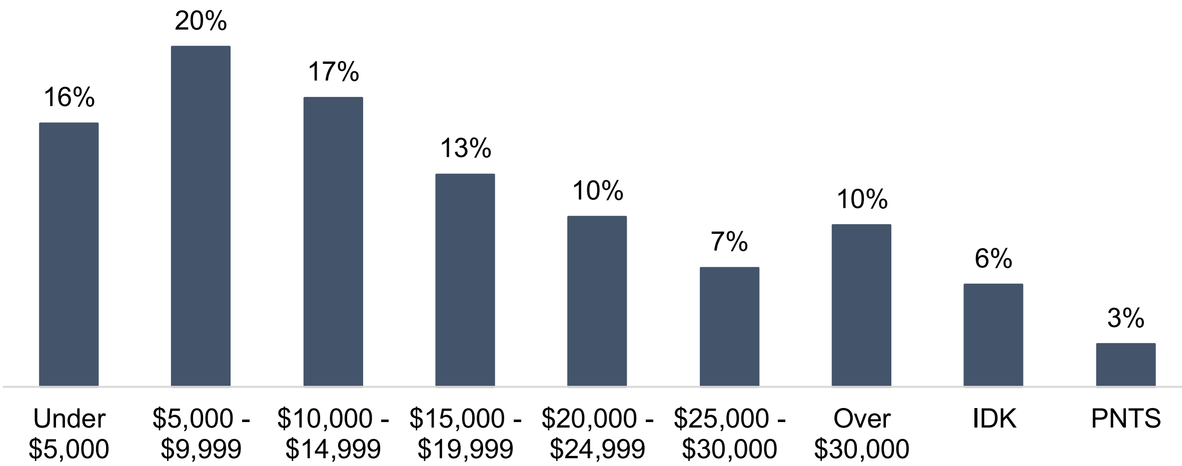

Figure 6.6. Distribution of Household Respondents by their Perceived Monetary Loss of Belongings from a Basement Flood Event (N=200)

While some belongings can be replaced, others cannot. It is difficult, if not impossible, to assign a monetary value for items such as keepsakes and heirlooms since their value is assigned by those with an emotional and sentimental connection to them. Approximately 30 percent of household respondents stated that they keep irreplaceable belongings in their basement without any protection, making them vulnerable to losing these items in the event of a basement flood.

6.6 Correlation Results

Pairwise Correlations with Risk Perception

Table 6.2 provides a summary of pairwise correlation coefficients between risk perceptions for flooding (sewer backup and infiltration) and various factors of interest from our questionnaire regarding knowledge, experience, and attitudes. The table shows that all correlations between risk perceptions and other factors are generally of low or moderate association; all coefficients are below +/-0.32. This could be related to the high level of heterogeneity in our sample, as well as our small sample size. However, the results still provide some insight into the complexity of risk perceptions and how they may inform risk-reducing behaviour indirectly.

Table 6.2. Pairwise Correlations of Flood Risk Perceptions and Various Factors Thought to Impact Household Understanding of Flood Risk

Variable	Risk Perception for Sewer Backup		Risk Perception for Infiltration	
	Pearson	**Spearman**	**Pearson**	**Spearman**
Flood Exp. (Y/N)	0.16*	0.19**	0.27***	0.26***
Flood Exp. in Current Home (Y/N)	0.09	0.14	0.21**	0.23***
Number of Previous Floods	0.19**	0.18**	0.27***	0.25***
Damage Severity in Last Flood Exp. (Scale 0-3)[a]	-0.09	-0.05	-0.12	-0.05
Years Since Last Flood Exp.	-0.19*	-0.18*	-0.32***	-0.33***
Number of Years in Current Home	-0.14*	-0.16*	-0.21**	-0.21**
Very Knowledgeable About Backwater Valves[b]	-0.16*	-0.24***	-0.21**	-0.22**
Very Knowledgeable About Sump Pumps[b]	-0.22**	-0.25***	-0.20**	-0.24***
Feel Capable in Protecting Home (Scale 1-5)[c]	-0.08	-0.12	-0.16*	-0.21**
Can Afford Repairs and Replacement (Scale 1-5)[c]	-0.19**	-0.08	-0.16*	-0.17*
Will Happen No Matter What I Do (Scale 1-5)[c]	0.16*	0.14*	0.14*	0.15*
Age	-0.16*	-0.21**	-0.24***	-0.25***

Significance Levels: 0 *** 0.001 ** 0.01 * 0.05

[a] Definition of Damages (Severity):

- 0 - No Damage, Clean Up Only
- 1 - Minimal: Minor home repairs needed and/or a minimal loss of belongings.
- 2 - Moderate: Moderate home repairs needed and/or a moderate loss of belongings; you could continue to live in your home while repairs were made.
- 3 - Severe: Major home repairs needed and/or a severe loss of belongings; there was possible health risks and a possible need to evacuate your home until repairs are made.

[b] Very Knowledgeable About Device: I know what it is, I know how it works, and I know how to maintain it.

[c] Questions presented in Likert scale format: 1 (Strongly Disagree), 2 (Somewhat Disagree), 3 (Neither Agree nor Disagree), 4 (Somewhat Agree), 5 (Strongly Agree).

Overall, the results showed that there was a positive correlation between previous flood experience and risk perception for both sewer backup and infiltration. In other words, a household's estimated probability of risk for sewer backup and infiltration was higher if they have had experience with water entering their home due to a previous stormwater event – a finding that aligns with the literature (Roder, Hudson, Tarolli 2019; Osberghaus 2017; Kellens et al. 2011; Botzen, Aerts, Van Den Bergh 2009; Zaalberg et al. 2009; Lindell and Hwang 2008; Keller, Siegrist, Gutscher 2006; Siegrist and Gutscher 2006; Weinstein 1989). The number of previous floods also had a positive relationship with risk perceptions, while the number of years since the last flood experience had a negative correlation with risk perceptions for both sewer backup and infiltration. The literature has also shown that frequency heightens risk perceptions (Owusu, Wright, Arthur 2015) and that the salience of previous experience fades over time (Netzel et al. 2020). However, unlike what was found in much of literature on the impacts of flood experience, the level of damage from previous events was not significantly correlated to risk perceptions in our dataset. (Owusu, Wright, Arthur 2015; Kreibich et al. 2011; Siegrist and Gutscher 2008; Grothmann and Reusswig 2006; Takaeo et al. 2004).

The number of years a respondent has lived in their current home had a negative association with risk perceptions for both sewer backup and infiltration, which could be due to the feedback effect expressed in the literature – i.e., those that have lived in their homes longer have had the time to understand the home's vulnerabilities and may have already invested in PLFP, leading them to feel more protected and therefore have lower risk perceptions (Richert, Erdlenbruch, Figuieres 2017; Poussin, Botzen, Aerts 2014; Bubeck et al. 2012). Alternatively, the length of time in a home could translate to feeling like a more capable homeowner (higher levels of self-efficacy) and therefore have lower risk perceptions. Lastly, it could be a result of the affect heuristic. When individuals use the affect heuristic as a cue, they are estimating their risk levels based on positive or negative emotions they have attached to the natural hazard (Finucane et al. 2000). The longer an individual has lived in their home, the more likely they have experienced a flood event. If the flood event was not severe, as was the case for most of our sample who had flood experience, then individuals may use that “positive” experience to inform their future risk perceptions. These latter two theories could also be why age had a negative correlation with risk perceptions.

Self-efficacy is an individual’s belief in their capacity to act and it incorporates elements of experience, knowledge, and confidence. We found that numerous self-efficacy-related variables in our dataset were correlated with risk perceptions. The knowledge variables, which were characterized by a high-level understanding of a flood protection device and its maintenance, were found to be negatively correlated to risk perceptions. In other words, households that felt they were very knowledgeable about these devices were more likely to have lower risk perceptions. The capability variable, characterized by how much respondents agreed or disagreed with the statement: *"I am capable of implementing measures to protect my home and belongings from flooding",* had a negative association with risk perceptions for infiltration, but a non-significant finding for sewer backup. Therefore, households that felt in control or capable of protecting themselves, were more likely to have lower risk perceptions in some instances. The affordability variable, characterized by how much respondents agreed or disagreed with the statement: “*If I were to experience a basement flood, I would be able to afford the home repairs and replacement of my damaged belongings”,* had a negative association with risk perceptions for both sewer backup and infiltration; households that felt they could cope with the monetary consequences of a flood were more likely to have lower risk perceptions. The fatalism variable, characterized by how much respondents agreed or disagreed with the statement: “*If a stormwater flood event happens it will impact my home regardless of any protective measure I take,”* had a positive association with risk perceptions for both sewer backup and infiltration. Therefore, households that had a fatalism mentality toward flooding, and did not believe their devices would protect them, were more likely to have higher risk perceptions.

Correlations and Mapping of Objective and Perceived Risk

To see if there was a relationship between objective and perceived risk of our household respondents, we conducted a pairwise correlation analysis between KatRisk’s modelled flood risk score data and our risk perception data of infiltration flooding. In the end, we found no correlation between the two, suggesting that households may not know their objective risk levels, or, they know their risk levels, but inform their risk perceptions based on other factors, such as those described earlier. We have visualized the objective and perceived risk of our study neighbourhoods in Figure 6.7 and Figure 6.8.

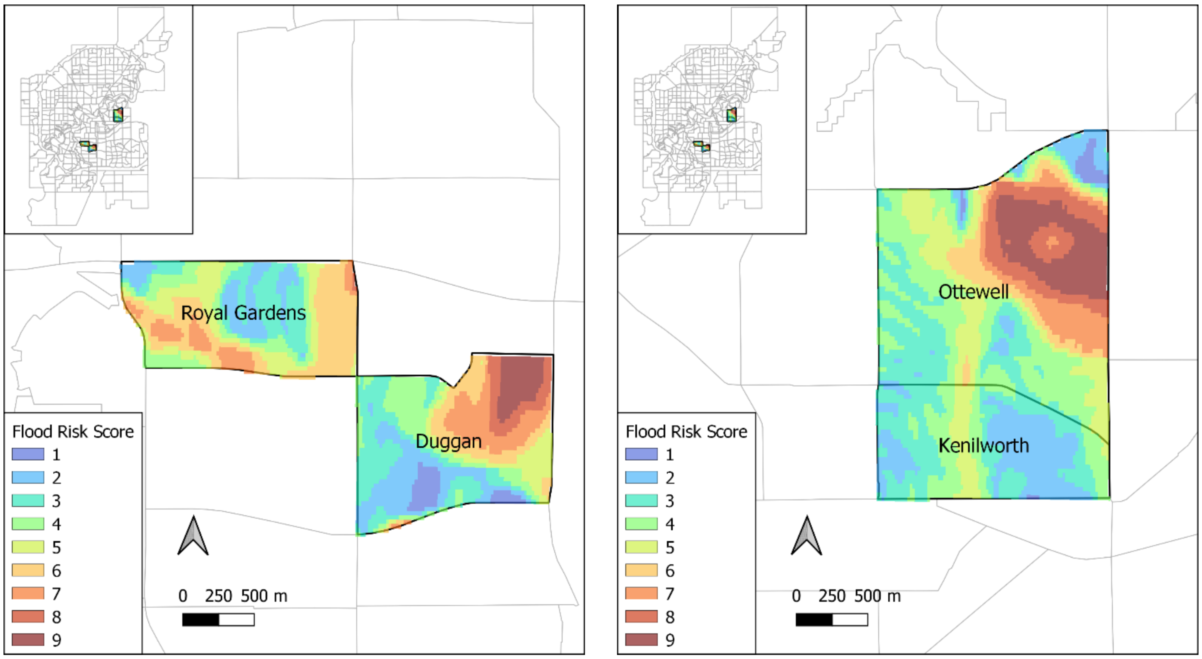

Figure 6.7. Flood Risk Maps of Study Neighbourhoods, Objective Risk by KatRisk

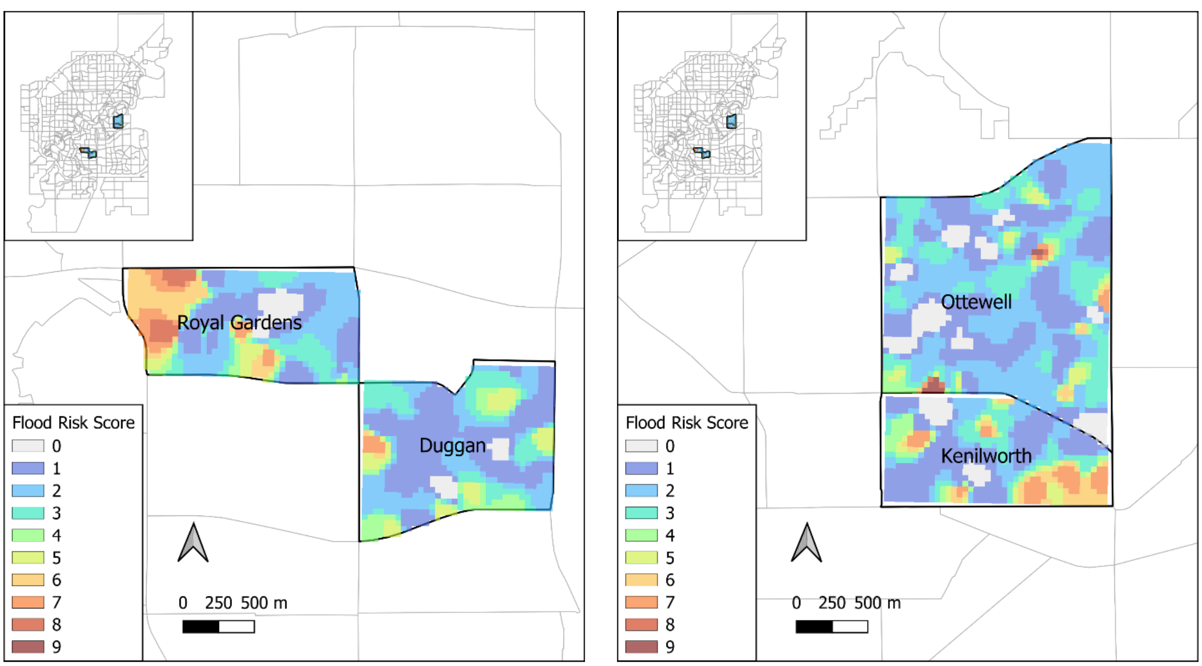

Figure 6.8. Flood Risk Maps of Study Neighbourhoods, Perceived Risk by Household Respondents

The finding that objective risk and perceived risk are not correlated is not surprising, as much of the literature has noted that flood risk perceptions often do not coincide with the flood risk levels determined by experts (Lechowska 2018; Siegrist and Gutscher 2006; Rowe and Wright 2001). It has also been shown in the literature that individuals have difficulty assessing low-probability, high consequence risk, such as flooding, which, according to Landry and Turner (2020), creates an ideal environment for behavioral biases to manifest.

6.7 Discussion

Limitations

This chapter focuses primarily on pairwise correlation analysis. Although correlations can provide interesting insights into the relationships between the different factors that may influence risk perceptions and risk-reducing behaviour, it is important to note that correlations are strictly descriptive and don't imply causality. As shown in the literature and throughout this chapter, risk perceptions, in particular, are multi-faceted and complex.

There are also limitations in the visualization of our perceived risk data through maps. The perceived risk data were based on responses to our questionnaire, and therefore, are not consistently spaced throughout the neighbourhoods. The lack of consistency in geographic spacing can complicate the analysis of IDW interpolation, since the method predicts attribute values at unsampled locations based on the spatial distance of known observations. Since household risk perceptions are not necessarily influenced by neighbouring perceptions, results shown in the map where there are large gaps between observations may be inaccurate.

Summary of Findings

Much like the last chapter, the findings in this chapter are descriptive. However, they do provide insight into how households understand their risk of flooding as well as the potential drivers of their perceptions. Some key findings include:

- ***Households generally have low risk perceptions.*** The majority of households categorized their sewer backup and infiltration flood risk potential as low; between 1-24 percent chance of happening over the next 10 years. The average percent chance of sewer backup over 10 years was 20.1 percent (2.0 percent chance a year), whereas the average percent chance of infiltration was 23.6 percent over 10 years (2.4 percent chance a year).
- ***Households are more likely to base their flood risk perceptions on subjective factors rather than their objective risk.*** Households have low awareness of their objective risk levels, and their risk perceptions are typically not associated with the objective risks they face. Instead, their flood risk perceptions are likely informed by other factors such as previous experience, years they have lived in their home, their ability to afford repairs, and even fatalism.
- ***Having previous flood experience(s) is correlated with heighten risk perceptions.*** Many of our findings aligned with the literature on flood experience, particularly the number of experiences (frequency) having a positive correlation with risk perceptions and the number of years since the last flood experience having a negative correlation with risk perception (Owusu, Wright, Arthur 2015; Netzel et al. 2020). However, interestingly, the damage level (severity) associated with previous experience was not correlated with the perceived risk perceptions, which is opposite of what the literature has shown (Owusu, Wright, Arthur 2015; Kreibich et al. 2011; Siegrist and Gutscher 2008; Grothmann and Reusswig 2006; Takaeo et al. 2004).
- ***Self-efficacy may lower risk perceptions, but how that translates into action is unclear.*** Self-efficacy, which could be understood in many ways including feeling knowledgeable about protection and/ or financially capable to recover from a flood event, was correlated with lower risk perceptions. However, lower risk perceptions connected to self-efficacy could also be due to the feedback effect; those that feel capable are more likely to have already taken action in some way, lowering their feelings of being at risk.

7. PREFERENCES FOR PROPERTY-LEVEL FLOOD PROTECTION

7.1 Introduction

This chapter uses stated preference methods to measure household preferences and willingness-to-pay (WTP) for two property-level flood protection (PLFP) devices: backwater valves and sump pump systems. Using descriptive statistics and econometric analysis, we analyze the data to: (1) develop measures of WTP, (2) compare average WTP to the average market cost of these devices; (3) examine factors that are correlated with, and potentially influence, the magnitudes of WTP; and (4) evaluate whether financial incentives, such as subsidies and insurance premium reductions, affect WTP.

Information on preferences and WTP provides insight into the demand for PLFPs and the factors that may influence demand. Evidence in the literature suggests that homeowners underinvest in flood risk reduction (Thistlethwaite et al. 2020; Roder, Hudson, Tarolli 2019; Price et al. 2019; Wallace, Poole, Horney 2016; Sandink 2011; Botzen, Aerts, Van Den Bergh 2009a; Terpstra and Gutteling 2008). Therefore, studying the WTP for flood protection devices is an important step in understanding why there may be low levels of PLFP adoption. If a household's WTP is less than the market price, then they are unlikely to purchase the device. The lack of interest in the device may arise because the costs to the household are greater than the benefits, or that the household is not aware of the benefits these devices could provide. A misperception of the private benefits may suggest that an information failure (market failure) may exist. The presence of public benefits of the devices (previously discussed in Section 2.5) suggests that a second type of market failure exists. Both market failures could be addressed by information provision and/ or providing subsidies or other incentives.

7.2 Relevant Literature

While numerous stated preference studies have been conducted to understand WTP for flood protection, the majority examine preferences for programs outside of our research focus. First, most of the WTP literature is centered on flooding from a body of water (ocean, river, creek, etc.), which can often be defined through the existence of floodplain mapping, i.e., the home is either inside or outside of the floodplain boundaries. In comparison, pluvial flooding (flooding caused by severe rainfall) can happen anywhere under the right circumstances, and the objective risk can vary between homes based on several factors that make a home more or less vulnerable. This variability can impact a household's ability to accurately perceive their risk level in the same manner as they would in a situation where they are at risk of fluvial (river) or coastal flooding. Some literature suggests that this difficulty of risk evaluation contributes to low-risk perceptions for pluvial flooding (Netzel et al. 2020; Rozer et al. 2016). Second, the WTP literature is predominantly focused on the WTP for flood insurance or public goods, such as green and gray infrastructure, rather than private risk-reducing measures. The lack of studies on private risk-reducing measures is likely related to the literature being predominantly focused on fluvial and coastal flooding, since insurance and large public infrastructure projects, such as seawalls and flood barriers, would have a greater impact on reducing fluvial or coastal flooding than PLFP measures. Nevertheless, the studies on flood insurance and public infrastructure for flood risk reduction provide valuable insights through their methods and findings. Table 7.1 presents the key information from the extant literature on WTP for flood protection.

Overall, the literature finds that WTP for flood protection – whether in the form of insurance, public infrastructure, or PLFP – is most commonly influenced by risk perceptions (Netusil et al. 2021; Withey, Sullivan, Lantz 2019; Oulahen 2015; Zhai et al. 2006), previous flood experience (Thistlewaite et al. 2018; Owusu, Wright, Arthur 2015; Botzen and Van Den Bergh 2012; Navrud, Huu Tuan, Duc Tnh 2012; Zhai et al. 2006), and income (Netusil et al. 2021; Owusu, Wright, Arthur 2015; Navrud, Huu Tuan, Duc Tnh 2012; Brouwer et al. 2008; Zhai et al. 2006; Clark et al. 2002). Additionally, for marketed goods (insurance and PLFP specifically), findings in the literature show that household WTP is generally lower than the good's actual value (Netusil et al. 2021, Thistlewaite et al. 2020; Owusu, Wright, Arthur 2015).

Table 7.1. Willingness-to-Pay for Flood Protection Literature Summary

Author	Year Pub.	Study Location	Risk Focus	Sample (Response)	Valuation Framing	Payment Vehicle	Product	Average WTP (Timeframe)	Significant Variables to WTP
Netusil et al.	2021	Portland, OR, USA	Creek/ Lake Flooding	(279)	Payment Card	Purchase	Flood Insurance	$405 USD (Annually)	Live in Flood Zone (+), Flood Risk Perceptions (+), Expectation of Flooding (+), Income (+)
Thistlethwaite et al.	2020	Canada	River/Lake Flooding	2,300	Unspecified	Purchase	Flood Insurance	$50-100 CAD (Annually)	Income (+)
Pagliacci et al.*	2020	Veneto Region, Italy	Rain Flooding	(265)	NA	NA	Various Property Level Protections	NA	Risk Perceptions (+), Previous Damages (+), Awareness of Benefits/ Response Efficacy (+), Education (+)
Landry et al.	2020	Glynn County, GA, USA	Multi-Peril	1194 (266)	Dichotomous Choice	Purchase	Multi-Peril Insurance	$3394-4397 USD (Annually)	Live in Flood Zone (+), Expected Damages (+), Politically Conservative (-)
Roder, Hudson, Tarolli	2019	Veneto Region, Italy	River Flooding	(849)	Open Ended Max WTP	Purchase	Flood Insurance	€26 - 40 (Annually)	NA
Withey, Sullivan, Lantz	2019	Halifax, NS, Canada	Coastal Flooding	(253)	Payment Card	Increase in Property Tax	Seawall	$144-156 CAD (Annually, 10 Years)	Concern (+), Risk Perceptions (+), Belief in Climate Change Increasing Harm to Community (+)
Robinson & Botzen	2019	Netherlands	River Flooding	(1041)	Payment Card	Purchase	Flood Insurance	€207-948 (Annually)	Probability of Flooding Below Threshold of Concern (-), Incentives (-), Worry (+)
Price, et al.	2018	Canada	Flooding (Non-Specific)	(1400)	Dichotomous Choice	Increase in Utility Tax/Bill	Gray and Green Infrastructure	$80-100 CAD (Annually, 10 Years)	Female (+), High Home Values (+), Rural (+)
Thistlethwaite et al.	2018	Canada	Flooding (Non-Specific)	2,300	Unspecified	Purchase	Various Property Level Protections	>$1000 CAD (One-Time)	Age (+), Education (+), Income (+), Type of House (+), Number of Years Lived in House (+), Flood Exp. (+)
Joseph, Proverbs, Lamond	2015	UK	Rain Flooding	2309 (280)	Open Ended Max WTP	Unspecified	Property Level Flood Risk Adaptation (Unspecified)	£653 (Annually, TF Unspecified)	Stress of Flood Impact (+), Worry of Having to Leave Home (+), Worry of Future Flooding (+), Worry of Increase in Insurance Premium (+), Inability to Obtain Insurance (+)
Owusu, Wright, Arthur	2015	Edinburgh & Hawick, Scotland, UK	River Flooding	1530 (256)	Unspecified	Purchase	Various Property Level Protections	£795 (One-Time)	Income (+), Age (+), Employment Status (+), Amount Spent on Previous Measures (+), Previous Damages (+)
Oulahen	2015	Vancouver, BC, Canada	Flooding (Non-Specific)	1540 (461)	Unspecified	Purchase	Overland Flood Insurance	>$100 CAD (Annually)	Perception of Sea Level Rise (+), Perception of Climate Change (+), Taken Protective Action (+).
Brouwer & Schaafsma	2013	Netherlands	River and Coastal Flooding	800 (410)	Choice Experiment	Purchase	Flood Insurance	€180 (Annually)	Risk Perceptions (+), Income (+)
Botzen & Van Den Bergh	2012	Netherlands	River Flooding	(982)	Dichotomous Choice	Purchase	Flood Insurance	€250-467 (Annually)	Belief in Climate Change Increasing Flood Risk (+), Flood Exp. (+), Expected Damages (+), Age (-), Education (-)
Navrud, Huu Tuan, Duc Tnh	2012	Quang Nam, Vietnam	Rain Flooding	(706)	Open Ended Max WTC	Contribution of Labour to Flood Prevention	Government Flood Prevention Plan	6.73 Days Per Household (Annually, TF Unspecified)	Income (+), Flood Exp. (+), Number of Labourers Per Household (+), Household in Flood Prone Village (+)
Botzen, Aerts, Van Den Berg	2009b	Netherlands	River Flooding	(509)	Unspecified	Purchase	Flood Insurance	€120 (Annually)	NA
Hung	2009	Keelung River Basin, Taiwan	River Flooding	(405)	Dichotomous Choice	Purchase	Flood Insurance	3275-4387 NT (Annually)	Income (+), Flood Experience (+), Homeownership (+), Gov Protection (-), Gov Distrust (+)
Brouwer et al.	2008	Homna, Bangladesh	River Flooding	(672)	Dichotomous Choice	Donation for Construction of Structures	Embankment Creation	$4.30 (Annually, TF Unspecified)	Income (+), Education (+), Risk Aversion/ Importance Placed on Flood Protection (+)
Zhai et al.	2006	Toki-Shonai River Region, Japan	River Flooding	962 (428)	Payment Card	Donation for Construction of Structures	Structures (dams and levees)	¥2,887-4,861 (Annually, TF Unspecified)	Income (+), Flood Exp. (+), Environmental Information (-), Individual Preparedness (+), Acceptability of Risk (-), Risk Perceptions (+), Perceptions of Other Risks (-)
Clark et al.	2002	Milwaukee, WI, USA	River Flooding	(999)	Open Ended Max WTP	Unspecified	Flood Retention Ponds and Wetlands	$76 USD (Annually, 20 Years)	Live in Flood Zone (+), Income (+), Willingness to Contribute to Citizen Organization (+), Belonging to Environmental Group (+)
Thunberg & Shabman &	1991	Roanoke, VA, USA	River Flooding	(73)	Payment Card	Increase in Utility Tax/Bill	Flood Control Project	$314 (One-Time)	NA

* Not a WTP study, instead looks at willingness to implement

In the literature reviewed, there were two studies that specifically asked individuals about their WTP for PLFP to protect against flood damage and two studies that analyzed the effects of financial incentives on motivating flood risk reduction. Thistlethwaite et al. (2018) found that most households in Canada were willing to pay under $1,000 CAD for PLFP to protect against flood damage. The authors found that the type of house, number of years a family has lived in the house, age, and income played a significant role in WTP and adoption of PLFP. Owusu, Wright, and Arthur (2015) found that households in the United Kingdom were willing to pay an average of £795 for various PLFP to prevent damage to their homes from river flooding. The authors found statistically significant positive relationships between WTP and household income, age, employment status, amount previously spent on PLFP, and previous financial and social flood impacts. However, interestingly, they found that those with previous flood experience had a lower mean WTP (£734) compared to those without previous flood experience (£834), indicating that people without previous experience were possibly overestimating the cost of protecting their property, although it is unclear whether they controlled for previous investments in flood protection. The study also found that the majority of those who were not willing to pay cited affordability as their main reason. Other reasons include unaccountability (they felt that the government should pay), they already had measures in place, low risk perceptions (they felt that they were not at risk), and they felt that the measures were not effective. Regarding the literature on financial incentives, Mol, Botzen, and Blasch (2020) conducted an experimental game to see if insurance premium reductions would influence homeowners' flood mitigation behaviour and found a positive effect, even under low probabilities of loss. Botzen, Aerts, and Van Den Bergh (2009) asked households whether they would be willing to purchase sandbags for £20 to receive a £5 annual discount on their flood insurance premium and whether they would be willing to move their laundry machines to a higher floor for the same discount. Their results found that incentives were effective in motivating the purchase sandbags, but not in moving household equipment to higher levels in the home. This suggests that incentives may work, but there is likely a threshold based on convenience and ease.

Our research adds to the literature by combining the analysis of preferences for PLFP and the effects of incentives (municipal subsidies and insurance premium reductions) on household purchasing choices of PLFP.

7.3 Data

Overview on Stated Preference Valuation

To measure households' WTP for flood protection we use stated preference methods. Stated preference valuation is a type of survey-based research methodology in which individuals are asked hypothetical questions about different choices. The aim is to understand the individual's preferences and willingness-to-pay (WTP) or willingness-to-accept (WTA) for products, services, or policies (Champ, Boyle, Brown 2017). Stated preference is commonly used to elicit WTP/ WTA for goods that are not traded in the market (non-market goods), such as environmental quality; however, this method can also be employed to measure WTP/ WTA for private goods and is commonly used in the marketing research space to understand factors that drive demand for products (Doyon et al. 2015). In addition, this method can be used to determine preferences for new attributes or characteristics of private goods that are non-existent or not widespread in the market, such as insurance premium reductions in our context. Insurance companies use various aspects of the home, such as flood protection, to determine an insurance price, however, cost reductions for the existence or installation of specific devices are typically not advertised nor explained to consumers.

Although the use of stated preference is popular as an empirical technique to analyze economic behaviour and preferences, there are several criticisms of the method (Arrow et al. 1993). The most common criticism is hypothetical bias, which can be defined as the difference between what a person indicates they would pay and what a person would actually pay in a non-hypothetical scenario (Johnston et al. 2017; Loomis 2013). In other words, since the questions are non-binding, individuals may not respond with actual budget constraints in mind (Arrow et al. 1993). The existence of hypothetical bias has led to evidence of overstatement of WTP (List and Gallet 2001). The hypothetical nature of the method can also lead to other anomalies in responses that may not reflect true preferences. These include protest responses (zero or low WTP due to question rejection), warm glow (high WTP due to feelings of public spiritedness), social desirability bias (WTP based on perceived social acceptability of response), and strategic behaviour (WTP based on perceived outcome/ use of the study) (Johnston et al. 2017; Arrow et al. 1993). As a result, there has been a substantial amount of literature that has studied ways to reduce these biases through questionnaire design (Johnston et al. 2017; Loomis 2013, Arrow et al. 1993). The recommendations from these studies have been incorporated into our survey design to the extent possible. This includes the use of techniques to reduce hypothetical bias, such as including a cheap talk script to remind the respondent of budget constraints and substitutes, and follow-up questions to identify hypothetical and/ or strategic behaviour (see APPENDIX N).

Willingness-To-Pay Question Development

There are several ways to present stated preference questions. In our survey, we used a payment card approach as outlined in Wang and Whittington (2005). Using this approach, we provide respondents with yes/ no questions for several price points. The payment card approach obtains a more nuanced WTP when compared to a dichotomous-choice style (i.e., take it or leave it at a single price) of stated preference (Wang and Whittington, 2005). A one-time subsidy from the City of Edmonton/ EPCOR and a discount on insurance premiums were incorporated and varied across respondents using a split sample design. These were included to see if financial incentives had an impact on the WTP. Each device had 16 different incentive combinations – a combination of one of four subsidies and one of four insurance discounts (see Table 7.2). The incentive combination shown to each respondent was chosen at random by Qualtrics (survey software).

Table 7.2. Financial Incentive Levels Incorporated into the Willingness-to-Pay Questions

Backwater Valve		**Sump Pump System**	
One-Time Subsidy Amounts	Annual Insurance Discounts	One-Time Subsidy Amounts	Annual Insurance Discounts
$600	$25	$1,200	$25
$800	$50	$1,400	$50
$1,000	$75	$1,600	$75
$1,200	$100	$1,800	$100

Each device had its own WTP question. These questions were only presented to household respondents who met three criteria: (1) the respondent stated that they were a homeowner in the ‘house information’ section of the questionnaire; (2) the respondent stated that they did not already have (or did not know if they had) these specific devices in the ‘existing protections’ section of the questionnaire; and (3) the respondent would have indicated a perceived percentage risk above zero for sewer backup and/ or infiltration in the ‘risk perceptions’ section of the questionnaire. The risk perception question was particularly important, since the risk percentage provided by the respondent was used to inform the amount the risk would be reduced in the WTP question. An example of the WTP question is shown in Figure 7.1.

The cost values (upfront and net) and subsidy amounts included in the payment card were developed using data collected from local plumbers. From December 2020 to January 2021, 35 plumbers in the Edmonton area were contacted to identify the cost of installation of these devices. Out of the 35 plumbers that were contacted, 20 responded to some or all the questions, four stated that they did not give out prices over the phone/ without viewing the property, and 11 did not respond or return messages left (57 percent response rate).

Plumbers were asked to provide a cost for backwater valves and sump pump systems, including the installation cost of these devices, in a mature home as a retrofit. They were specifically asked to provide either a low-high range or average cost of the device and installation. If a plumber provided a low-high range, the mid-point was taken to calculate the average. The costs varied substantially from plumber to plumber. For a backwater valve, the lowest average cost was $950, while the highest average cost was $3,000. For a sump pump system, the lowest average cost was $1,300, while the highest average cost was $4,600. Overall, the average reported cost of a backwater valve was $2,137, while the average cost for a sump pump system was $2,868 (see Table 7.3). It is worth noting that the average cost for the backwater valve as stated by the plumbers was lower than the average cost reported in EPCOR’s 2020 survey – $2,840 based on 54 Edmonton homeowners that had recently installed backwater valves (EPCOR 2021).

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Earlier in this survey, you stated that your chance of flooding from sewer backup was %

Assume installing a backwater valve in your home will **reduce your chance of sewer backup flooding to almost 0%** (with proper maintenance of the device).

Also assume that, with the installation of a backwater valve:

- The City of Edmonton/EPCOR will give you a **one-time $1,000 subsidy (rebate)** for the installation.
- Your insurance company will give you an **annual $50 discount** off your home insurance premium.

To get the subsidy you will need to have your home inspected, fill out paper work, and book a contractor for installation (approx. 2 hours). You will also need to be home for the installation of the device and a follow-up inspection (approx. 4-12 hours).

The subsidy will be given to you *after* the installation is complete, which means you will have to pay the full cost of the device and installation upfront. This is shown in the chart below as the **upfront cost**. The final cost to you, after you receive the subsidy, is shown in the chart below as the **final net cost**.

Upfront Cost	Final Net Cost	**How likely are you to install a backwater valve if the total cost to you is....?** *Please select one choice per row.*			
		Definitely Yes (100% Likely)	Probably Yes (51-99% Likely)	Probably No (1-49% Likely)	Definitely No (0% Likely)
$1,000	**$0**	○	○	○	○
$1,250	**$250**	○	○	○	○
$1,500	**$500**	○	○	○	○
$1,750	**$750**	○	○	○	○
$2,000	**$1,000**	○	○	○	○
$2,250	**$1,250**	○	○	○	○
$2,500	**$1,500**	○	○	○	○
$2,750	**$1,750**	○	○	○	○
$3,000	**$2,000**	○	○	○	○
$3,250	**$2,250**	○	○	○	○
$3,500	**$2,500**	○	○	○	○

Figure 7.1. Example of Willingness-to-Pay Question from Questionnaire

Table 7.3.Cost of Flood Protection Devices and Installation According to Local Plumbers

	Backwater Valve (N=19)	**Sump Pump System** (N=14)*	**Sump Pump Battery Backup** (N=18)
Average Cost	$2,137	$2,868	$1,683
Lowest Avg Cost	$950	$1,300	$650
Highest Avg Cost	$3,000	$4,600	$3,000

* One outlier was removed from the calculations.

Using the low and high ranges provided by the plumbers, we were able to construct subsidy amounts that, when combined with the net cost to households, would equal realistic total costs for these devices and their installation (see gray highlights in Figure 7.2 and Figure 7.3).

Backwater Valve / Net Cost to Respondents	Subsidy Amounts: **$ 600**	**$ 800**	**$ 1,000**	**$ 1,200**
$ -	$ 600	$ 800	$ 1,000	$ 1,200
$ 250	$ 850	$ 1,050	$ 1,250	$ 1,450
$ 500	$ 1,100	$ 1,300	$ 1,500	$ 1,700
$ 750	$ 1,350	$ 1,550	$ 1,750	$ 1,950
$ 1,000	$ 1,600	$ 1,800	$ 2,000	$ 2,200
$ 1,250	$ 1,850	$ 2,050	$ 2,250	$ 2,450
$ 1,500	$ 2,100	$ 2,300	$ 2,500	$ 2,700
$ 1,750	$ 2,350	$ 2,550	$ 2,750	$ 2,950
$ 2,000	$ 2,600	$ 2,800	$ 3,000	$ 3,200
$ 2,250	$ 2,850	$ 3,050	$ 3,250	$ 3,450
$ 2,500	$ 3,100	$ 3,300	$ 3,500	$ 3,700

Figure 7.2. Backwater Valve Subsidy and Cost Calculation for WTP Questions (Based on Local Plumber Estimates for Device and Installation)

Sump Pump System / Net Cost to Respondents	Subsidy Amounts: **$ 1,200**	**$ 1,400**	**$ 1,600**	**$ 1,800**
$ -	$ 1,200	$ 1,400	$ 1,600	$ 1,800
$ 250	$ 1,450	$ 1,650	$ 1,850	$ 2,050
$ 500	$ 1,700	$ 1,900	$ 2,100	$ 2,300
$ 750	$ 1,950	$ 2,150	$ 2,350	$ 2,550
$ 1,000	$ 2,200	$ 2,400	$ 2,600	$ 2,800
$ 1,250	$ 2,450	$ 2,650	$ 2,850	$ 3,050
$ 1,500	$ 2,700	$ 2,900	$ 3,100	$ 3,300
$ 1,750	$ 2,950	$ 3,150	$ 3,350	$ 3,550
$ 2,000	$ 3,200	$ 3,400	$ 3,600	$ 3,800
$ 2,250	$ 3,450	$ 3,650	$ 3,850	$ 4,050
$ 2,500	$ 3,700	$ 3,900	$ 4,100	$ 4,300

Figure 7.3. Sump Pump System Subsidy and Cost Calculation for WTP Questions (Based on Local Plumber Estimates for Device and Installation)

7.4 Methods

The dependant variable in our study was WTP for PLFP. We analyzed this dependant variable in two ways: (1) as a continuous variable (maximum WTP) and (2) as a discrete choice variable (yes/ no). Choosing the estimators and models used for each of these approaches has been outlined in this section.

Choosing Estimators for Continuous Model

When we analyzed our WTP data as a continuous variable, the WTP was each respondent's breakpoint – i.e., the highest final net cost where the respondent answers "definitely yes" or "probably yes" before changing their answer to "probably no" or "definitely no". Therefore, we can conduct our regression analysis using standard linear estimators. As a starting point, we used Ordinary Least Squares (OLS), which has several desirable properties (unbiased and consistent under certain assumptions), making it a reliable estimator and an ideal baseline for comparison with more complex models. However, OLS may not be the best estimator for our model due to two major concerns with our dataset: (1) the potential for endogeneity of factors such as risk perceptions, and (2) the presence of zeros within the dependent variable, reflecting a potential censoring or truncation issue. Therefore, we also conducted our regression analysis using an Instrumental Variable (IV) and Tobit estimators.

Using risk perceptions as an explanatory variable in regression analysis can lead to endogeneity concerns, particularly simultaneity and omitted variable bias, because individuals may be informing their decisions with other risk averting behaviour (Lloyd-Smith et al. 2016). For example, in the context of our study, respondents may consider their existing flood protection when making their choices. If they have other devices or measures in place, this may lower both their risk perception for flooding as well as their WTP for a backwater valve or sump pump system – this is often referred to as a feedback effect in the literature (Richert, Erdlenbruch, Figuieres 2017; Poussin, Botzen, Aerts 2014; Bubeck et al. 2012). Although the feedback effect is mentioned in many of the studies that were reviewed, few failed to address it in their empirical models. Not testing and controlling for this potential endogeneity can lead to a substantial underestimation in the value of risk reduction (Lloyd-Smith et al. 2016). For this reason, we also conducted an instrumental variable (IV) regression, which is used to control for the potential endogeneity. The instrumental variable used in the IV regression was the respondent's stated probability of experiencing a power outage (lasting more than a few hours) over a 10-year period. In order for this variable to serve as a valid instrument it must be correlated with the suspected endogenous variable – i.e., risk perception of sewer backup and risk perception of infiltration – and uncorrelated with the error term. Table 7.4 shows the Pearson correlation coefficients of the IV and suspected endogenous variables. Although the correlations were statistically significant, the correlation coefficients were lower than expected.

Table 7.4. Pairwise Correlation of Instrumental Variable and Risk Perception Variables

	Risk Perception of Sewer Backup	**Risk Perception of Infiltration**
	Pearson Correlation Coefficients	
Risk Perception of Power Outage	0.24	0.31

Our use of a payment card with the option to state $0 as WTP amount (see Figure 7.1) also complicated the estimation approach. Numerous zero observations within the dependent variable can lead to several econometric problems when using OLS. Therefore, we explored other estimation methods that are better suited to dealing with zeros, including Tobit, Hurdle, and Two-Part models (Humphreys 2010). Out of the three regressors we chose the Tobit as we deemed it best for our small dataset and number of zero responses. The Tobit regressor is similar to the OLS, however, unlike the OLS, it can account for potential censored data at the minimum value, maximum value, or both. The Tobit accounts for these censored data by introducing a latent variable which is used to model the probability of the observed values being censored. Since we used the payment card method, we had a minimum ($0) and maximum ($2500) value that respondents could choose from, meaning respondents were unable to choose a lower (less than $0) or higher (more than $2500) WTP than what we presented them. Therefore, we were able to account for both left and right censored values in the dependent variable when using the Tobit estimator.

Model Specification for Continuous Model

Since we had a small sample size for the WTP questions (backwater valves (N=90) and sump pump systems (N=126)) we started with a simple specification that only incorporated the incentives included in the survey design (M.1). The second specification extends the model to include a few key variables of interest, such as risk perceptions, flood experience, and demographic control variables (M.2).

$$WTP = a_0 + a_1\ Subsidy + a_2\ Insurance\ Premium\ Reduction \quad \text{(M. 1)}$$

$$WTP = a_0 + a_1\ Subsidy + a_2\ Insurance\ Premium\ Reduction + \beta_1\ Risk\ Perception + \beta_2\ Flood\ Experience + \beta_3\ Age + \beta_4\ University\ Education + \beta_5\ Household\ Size \quad \text{(M. 2)}$$

In these models, WTP is the cost break point i.e., the maximum amount the respondent would pay for the device. The subsidy and insurance premium reduction variables are the levels offered to each respondent when presented with the WTP question. The risk perception variable is the respondent's stated probability of experiencing either a sewer backup (for backwater valve) or infiltration (for sump pump system) event in their home over a 10-year period. The flood experience variable is a dummy that captures whether a respondent has had a flood experience or not (flood experience = 1). The remaining variables capture socio-economic factors that could impact the amount a respondent is willing to pay. Two separate equations were modelled for each specification, one for WTP for backwater valves and one for WTP for sump pump systems. In the IV model specification, risk perception of power outage is used as a predicted value for risk perception of sewer backup and infiltration.

Choosing Estimators for a Discrete Choice Model

When we analyzed our WTP data as a discrete choice variable, the WTP was a series of binary choices made by the respondent – i.e., yes/ no choice on final net cost for each of the 11 prices presented in the payment card (see Figure 7.1). For this analysis we used a multinomial logistic regression under McFadden's (1973) Random Utility Model (RUM) framework. The RUM is a framework for analyzing discrete choice behaviour using a linear-in-parameters functional form. It assumes individuals are making choices that would provide them with the highest utility (welfare), while incorporating observed and unobserved factors into their decision-making process. The inclusion of unobserved factors, such as behavioural elements, makes the RUM more flexible than traditional models. The RUM specification is:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \qquad \text{(Eq. 1)}$$

Where i represents the decision maker, j represents the alternatives, U_{ij} represents the utility of an individual under each alternative, V_{ij} represents the utility of observed (systematic) factors, and ε_{ij} represents the utility of unobserved (random) factors. In other words, everything that affects utility that isn't in V_{ij} is incorporated into ε_{ij}. Due to the incorporation of randomness into the model, we can not exactly predict an individual's choice, instead we can only analyze the probability of choosing one alternative over another as a function of systematic components. For example, the probability of alternative j being chosen can be expressed as the probability that the utility associated with j is greater than the utilities associated with other alternatives (note subscript i is suppressed in the following formulas for model simplicity):

$$PR(j) = [v_j(m - p_j, q_j) + \varepsilon_j > v_k(m - p_k, q_k) + \varepsilon_k], \forall\, j \neq k \qquad \text{(Eq. 2)}$$

Where p is the price, q is the set of quality characteristics of the good (in our study, the device, and its features, including the subsidy and insurance premium reduction, i.e., the program), and m is income.

We can use the parameters derived from the RUM estimation to conduct applied welfare analysis, such as estimating the WTP for a good. In the case of our study, households can choose to either buy or not buy the PLFP devices. These utilities are:

Without Device: $U_0 = \beta_{Bid}(m) + \varepsilon_0$

With Device: $U_1 = a_0 + \beta_{Bid}(m - bid) + \varepsilon_1$

(Eq. 3, 4)

Where a_0 is the marginal utility of the device/ program (proxy for q from Eq. 2), β_{Bid} is the coefficient for the bid (marginal utility of money) derived from the RUM estimation, m is the income, and bid is the price. When we equate the two formulas, we are setting the utility without the device equal to the utility with the device, making the bid a measure for WTP (Eq. 5). When solving for WTP, the income variables cancel out and the error terms are dropped due to the linearity of the model. We then arrive at the WTP formula for the device/ program, which is the marginal utility of the device divided by the coefficient for the bid (Eq. 6)[10]:

$$\beta_{Bid}(m) + \varepsilon_0 = a_0 + \beta_{Bid}(m - WTP) + \varepsilon_1 \qquad \text{(Eq. 5)}$$

$$WTP = a_0/\beta_{Bid} \qquad \text{(Eq. 6)}$$

To see how WTP is affected by individual-specific variables – such as risk perceptions, flood experience, and various demographic variables (such as age, university, etc.) – we can use the following formula:

$$WTP = \frac{a_0 + \sum(a_{n1} * Z_{n1}) + \sum(\beta_{n2} * Z_{n2})}{\beta_{Bid}} \qquad \text{(Eq. 7)}$$

Where a_{n1} is the coefficient for each of $n1$ device/ program-specific variables (subsidy, insurance premium reduction) included in the RUM estimation, β_{n2} is the coefficient of each of $n2$ individual-specific variables (risk perception, flood experience, age, demographics.) included in the RUM estimation, and Z_{n1} and Z_{n2} are the mean values of each variable. Comparing the results from Eq. 7 to Eq. 6, shows us the difference in WTP based on the addition of these other variables.

[10] Eq. 6 is an estimation on bid and not on income minus bid, which is why it's positive in this theoretical description, but negative in the modelling later on in this chapter.

Model Specification for Discrete Choice Model

For the RUM estimations, we started with simple specifications that only incorporated the costs and incentives included in the survey design (M.3 and M.4) before extending the model to similar specifications used in the simple linear models (M.5).

$$U_j = \alpha_0 + \beta_{Bid}\,Cost \quad \text{(M. 3)}$$

$$U_j = \alpha_0 + \beta_{Bid}\,Cost + \alpha_1\,Subsidy + \alpha_2\,Insurance\ Premium\ Reduction \quad \text{(M. 4)}$$

$$U_j = \alpha_0 + \beta_{Bid}\,Cost + \alpha_1\,Subsidy + \alpha_2\,Insurance\ Premium\ Reduction + \beta_1\,Risk\ Perception + \beta_2\,Flood\ Experience + \beta_3\,Age + \beta_4\,University\ Education + \beta_5\,Household\ Size \quad \text{(M. 5)}$$

7.5 Descriptive Results

We had a total of 94 responses to the backwater valve WTP question and 133 responses to the sump pump system WTP question. However, a total of 11 responses were removed due to either a clear misunderstanding of the question (N=2; 1 backwater valve, 1 sump pump system), an incomplete response (N=4; 2 backwater valve, 2 sump pump system), or a blank response (N=5; 1 backwater valve, 4 sump pump system).

Using the “break point” between a yes and no response to the purchase question, the average WTP for a backwater valve was $1,086. For the sump pump system, the average WTP was $798. These amounts are notably lower than the average cost to install a backwater valve ($2,137) or sump pump system ($2,868) as stated by local plumbers (see Table 7.5).

Table 7.5. Average Household Willingness-to-Pay for Property-Level Flood Protection Devices

	Backwater Valve (N=90)	**Sump Pump System (N=126)**
Mean	$1,086	$798
Standard Deviation	$735	$727

Figure 7.4 and Figure 7.5 show the percentage of respondents who were willing to pay for each of the devices at the various net costs presented in the payment card. The net cost amounts were the same across all questions, regardless of subsidy and insurance premium discount offered.

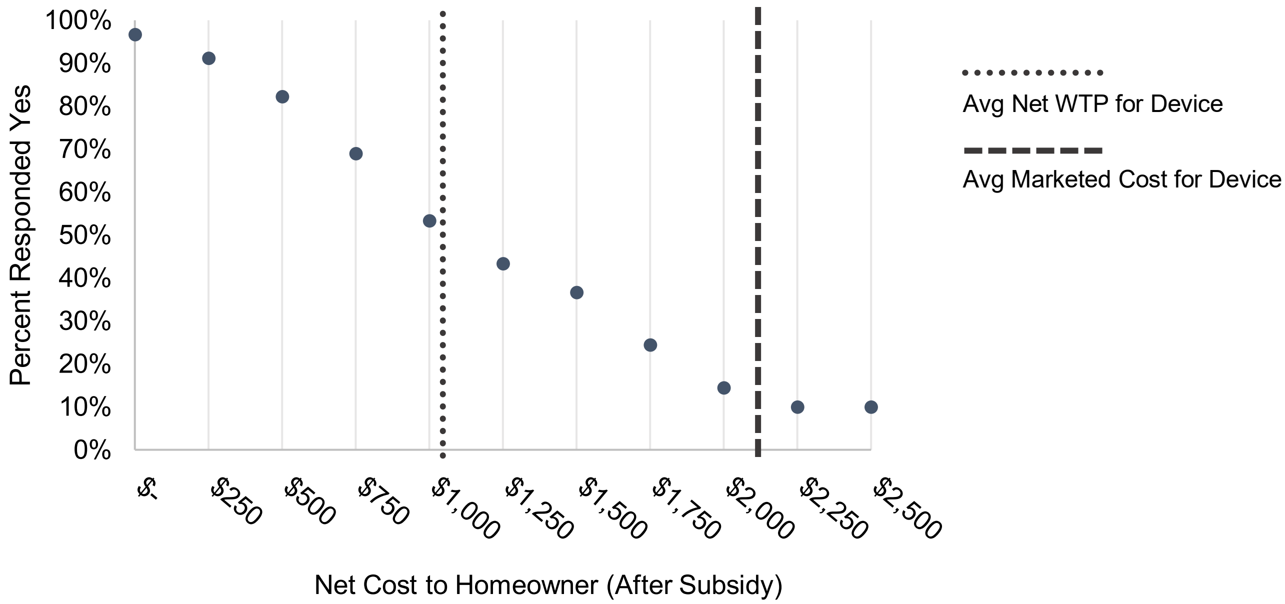

Figure 7.4. Probability of Backwater Valve Purchase Based on Net Cost (N=90)

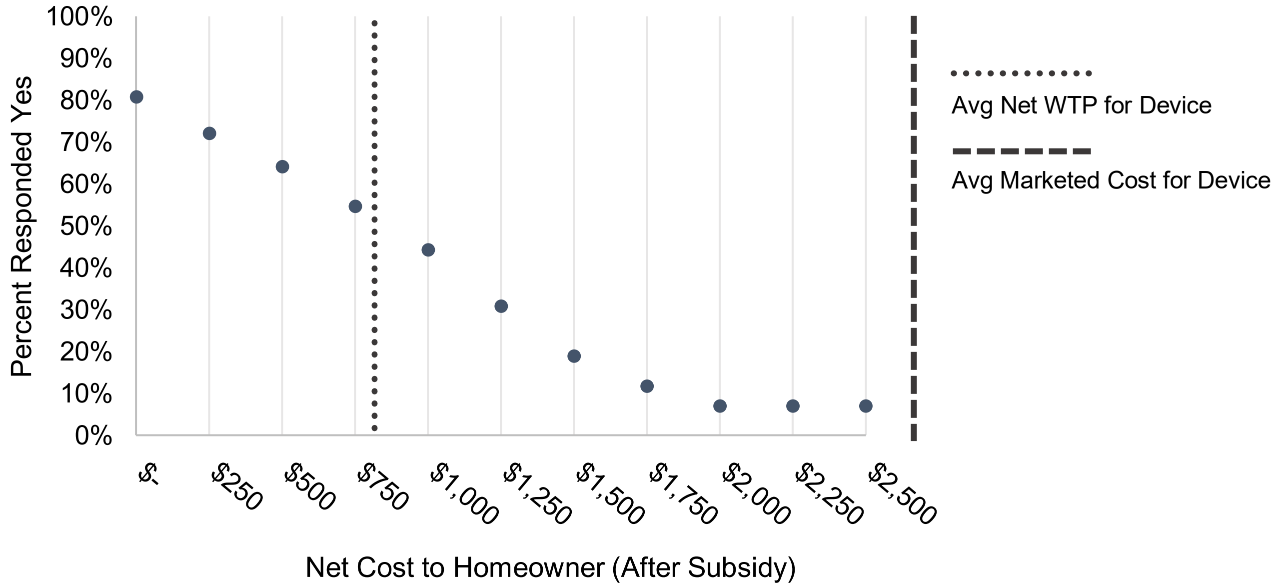

Figure 7.5. Probability of Sump Pump System Purchase Based on Net Cost (N=126)

Figure *7.6* and Figure 7.7 show the distribution of the breakpoints – the highest WTP of each respondent. An interesting finding was that some respondents were unwilling to install the device at any payment level, even if their net cost was $0 (represented by the $0 (NA)).

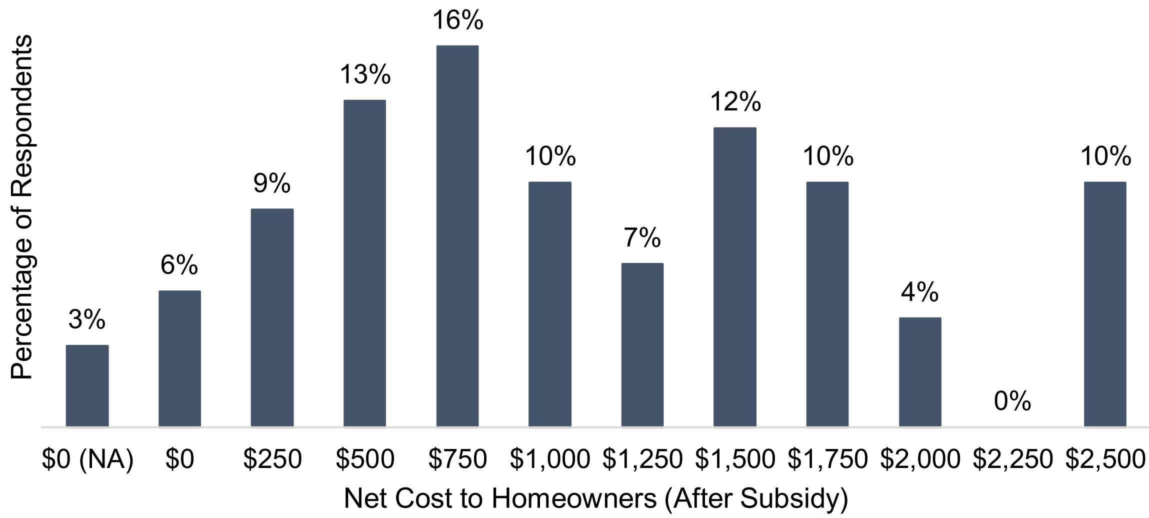

Figure 7.6. Distribution of Respondents' Maximum Willingness-to-Pay for Backwater Valves (N=90)

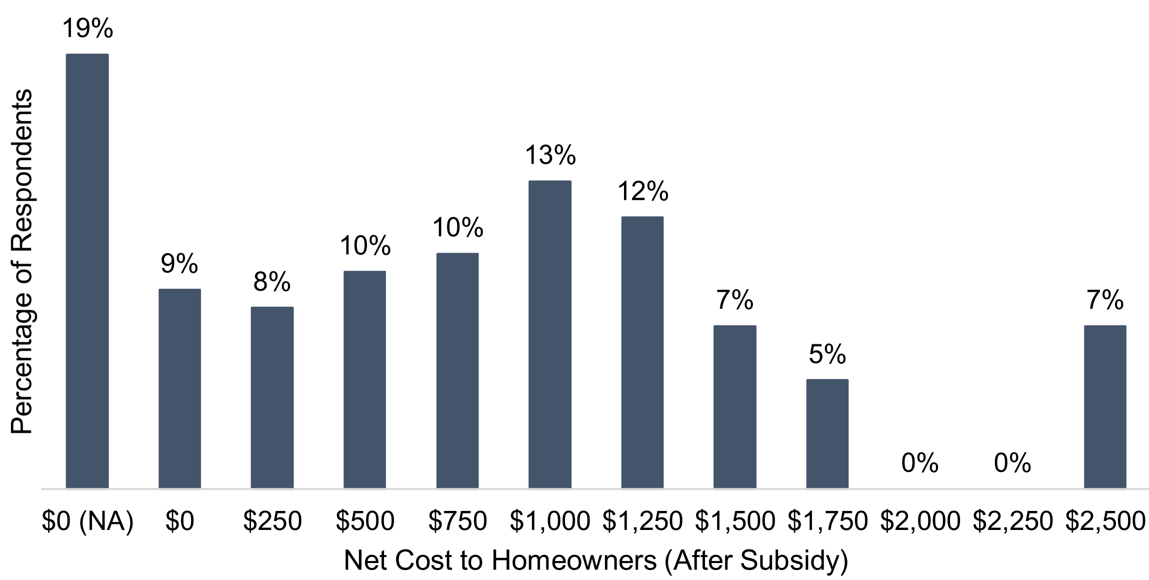

Figure 7.7. Distribution of Respondents' Maximum Willingness-to-Pay for Sump Pump Systems (N=126)

Overall, we found that 10 percent of respondents who answered the backwater valve WTP question were willing to pay the average market cost (or more) for the device, while up to 7 percent of respondents who answered the sump pump system WTP question were willing to pay the average market cost.[11] When the hypothetical subsidy was included in the calculation, the numbers rose to 40 percent and 20 percent, respectively (see Table 7.6).

Table 7.6. Household Respondent Willingness-to-Pay for Devices Compared to Market Cost

	Number of Households	**Percentage of Sample Asked WTP Question**
WTP for Backwater Valve Greater Than Average Market Cost	9	10%
WTP for Backwater Valve Greater Than Average Market Cost (Hypothetical Subsidy Incl.)	36	40%
WTP for Sump Pump System Greater Than Average Market Cost	0	Up to 7%[11]
WTP for Sump Pump System Greater Than Average Market Cost (Hypothetical Subsidy Incl.)	25	20%

We asked follow-up questions to understand respondents' intentions to purchase or not purchase the devices. The results of the follow-up questions follow a similar pattern for both devices; therefore, they have been aggregated in this discussion.[12]

Respondents who said no to all options ("NA"), no to all options except $0, or left the payment card blank were then asked: *"You said probably no or definitely no for all or the majority of the payment options in the last question. Why did you choose to keep your current situation over the installation of the device?"* An analysis of just the "NA" results shows that one third of respondents needed more information than what was provided. An analysis of all the no cost results – "NA" and $0 – shows that the most selected and top ranked reasons for not wanting the device was that the risk reduction was not worth the expense, cannot afford the upfront cost, and more information required (see Table 7.7). Inconvenience, maintenance, and reliance on insurance were ranked low on the list of reasons for why respondents did not want the device.

[11] Our maximum net cost was $2,500; therefore, we do not know how many respondents have a WTP equivalent to the average market cost of a sump pump system. We can assume it is between 0% and 7% of respondents to the question, since 7% had a WTP of the maximum amount presented ($2,500).

[12] Some households answered the WTP questions and the follow-up questions for both the backwater valve and a sump pump system, meaning they are represented twice in the follow-up question analysis. However, before being presented with the WTP questions, households were told to not compare between the flood protection devices presented to them and respond independently each time, therefore we are treating each response as independent in the analysis.

Table 7.7. Follow-Up for Household Respondents who Did Not Want the Device (N=51)

	Number of Households*	**Percentage of Households**	**Top Choice (Rank)**
Risk reduction not worth the expense	20	38%	1
Cannot afford the upfront cost	16	30%	2
More information required	14	26%	2
Unsure/ not interested in maintenance	12	23%	6
Not at risk of flooding	11	21%	3
Already adequately protected	10	20%	4
Inconvenience of installation	8	19%	6
Rely on insurance to cover damages	6	11%	7
Device is ineffective	4	8%	5
Other	2	4%	6

* Respondents could choose multiple answers.

For respondents who were willing to pay $500 or more (net) for the devices, we followed up with: *"You said probably yes or definitely yes to at least one of the payment options in the last question. Why did you choose to install the backwater valve over keeping your current situation?".* The majority (80 percent) of respondents who chose to pay for the device said that the city subsidy offered was part of their reason for doing so. The city subsidy was the most selected as well as the top ranked reason, which shows us that subsidizing costs likely has an impact on household's interest in installing the device (see Table 7.8). The second most selected and ranked reason was the desire to avoid the inconvenience and stress of damage and repairs, showing that non-monetary costs are also an important consideration for risk-reducing behaviour.

Table 7.8. Follow-Up for Household Respondents who Wanted the Devices (N=158)

	Number of Households*	**Percentage of Households**	**Top Choice (Rank)**
City subsidy made it worth the additional expense	127	80%	1
Avoid the inconvenience/ stress of flood damage repairs	117	74%	2
Risk reduction is worth the expense	112	71%	3
General worry; device will provide peace of mind	103	65%	4
Responsibility to protect home	91	58%	5
Avoid loss of valuable/ irreplaceable belongings	76	48%	6
Insurance reduction made it worth the additional expense	74	47%	8
Cannot rely on insurance/ don't have insurance	11	7%	NA
Other	4	3%	7

* Respondents could choose multiple answers.

7.6 Econometric Results

<u>*Linear Models*</u>

We conducted OLS, Tobit, and IV regressions to examine the impact of various factors on a household's WTP for backwater valves and sump pump systems. Table 7.9 showcases the results for simple model specifications based solely on the variables included in the randomized design (subsidy and insurance premium reduction), whereas Table 7.10 showcases the results of the extended model specification.

Within our simple and extended models, we find that insurance premium reductions are statistically significant at a 95 percent confidence interval, having a positive effect on WTP for sump pump systems. The coefficient shows that for every additional dollar received in insurance premium reduction, households are willing to pay an additional $5.70 - $10.71 towards flood protection devices. Risk perception was not significant to the WTP for a backwater valve, which supports the literature on it having a weak or indirect effect on protective behaviour (Poussin, Botzen, Aerts 2014; Wachinger et al. 2013; Bubeck, Botzen, Aerts, 2012; Bourque et al. 2012; Terpstra and Lindell 2012; Grothmann and Reusswig 2006). However, risk perception was statistically significant at a 95 percent confidence interval for WTP for a sump pump system, specifically in the OLS and Tobit regressions. The coefficient shows that for every additional percentage point of perceived risk, households are willing to pay an additional $10.25 - $13.32 towards flood protection devices. Nonetheless, the validity of this result is uncertain since risk perception could be endogenous to the model and the IV regression eliminates the significance of the variable. Flood experience was not significant in any of our regressions, which conflicts with much of the literature (Grahn and Jaldell 2019; Thistlethwaite et al. 2018; Owusu, Wright, Arthur 2015; Osberghaus 2015; Bubeck et al. 2012; Kreibich et al. 2011; Lindell and Hwang 2008; Thicken et al. 2007; Siegrist and Kreibich et al. 2005). Additionally, we found some significance within our control variables. For the backwater valve WTP models, we found that household size was statistically significant at a 95 percent confidence interval, having a negative effect in all three regressions. As the household size increases, there may be less disposable income for goods that may not be top of mind, such as flood protection devices. For the sump pump system WTP models, we found that age was statistically significant at a 95 percent confidence interval, having a negative effect in all three regressions.

Table 7.9. Linear Regression Results, Simple Model Specification (M.1*)

Variable	Backwater Valve		Sump Pump System	
	OLS	Tobit	OLS	Tobit
Intercept	1509.48 (347.46)***	1676.63 (419.56)***	-208.10 (466.47)	-996.39 (713.03)
Subsidy	-0.36 (0.36)	-0.47 (0.42)	0.40 (0.28)	0.66 (0.42)
Insurance P. Reduc.	-2.01 (2.79)	-3.34 (3.36)	6.74 (2.42)**	10.71 (3.65)**
- - - - - - - - - - -				
N	90	90	126	126
Adjusted R^2	-0.00	-	0.05	-
AIC	1449	1245	2016	1462
BIC	1459	1255	2028	1473
Censored Left	-	8	-	35
Censored Right	-	9	-	9

Significance Levels: *** 0.001 ** 0.01 * 0.05; Standard Errors in Parentheses
* M1: Randomized Design Model (includes Cost, Subsidy, and Insurance Premium Reduction)

Table 7.10. Linear Regression Results, Extended Model Specification (M.2*)

Variable	WTP for Backwater Valve			WTP for Sump Pump System		
	OLS	Tobit	IV	OLS	Tobit	IV
Intercept	2403.89*** (607.93)	2766.86*** (712.13)	2481.14*** (723.32)	308.15 (621.60)	-95.14 (855.26)	846.44 (928.85)
Subsidy	-0.38 (0.39)	-0.47 (0.45)	-0.31 (0.52)	0.36 (0.28)	0.57 (0.39)	0.27 (0.32)
Insurance P. Reduc.	-1.20 (2.86)	-2.30 (3.33)	-1.35 (2.98)	5.70* (2.40)	8.33* (3.35)	4.52 (2.96)
Risk Perception	1.68 (4.75)	0.60 (5.60)	-3.23 (24.96)	10.25*** (2.84)	13.32** (3.90)	-2.37 (15.26)
Flood Experience	-241.46 (168.59)	-309.21 (196.52)	-224.91 (188.78)	14.08 (133.51)	22.42 (184.76)	182.68 (246.80)
Age	-7.56 (5.67)	-9.23 (6.61)	-7.56 (5.71)	-9.26* (4.36)	-14.29* (6.06)	-11.03* (5.18)
University Education	215.91 (189.43)	278.76 (220.67)	187.53 (237.54)	127.76 (128.84)	219.06 (179.40)	96.94 (144.73)
Household Size	-203.35* (83.80)	-244.82* (97.56)	-207.47* (86.85)	-83.41 (64.69)	-101.73 (88.26)	-84.01 (70.33)
- - - - - - - - - - -						
N	84	84	84	117	117	117
Adjusted R^2	0.02	-	0.00	0.16	-	0.01
AIC	1356	1164	1357	1862	1402	1882
BIC	1378	1186	1379	1887	1427	1906
Censored Left	-	7	-	-	28	-
Censored Right	-	9	-	-	9	-

Significance Levels: *** 0.001 ** 0.01 * 0.05; Standard Errors in Parentheses
* M2: Extended Model (Randomized Design RUM Model with Socioeconomic Variables)

Random Utility Models

In the case of our study, the choice to each individual was whether or not to purchase a property-level flood protection device at the 11 different price points offered in the payment card (from $0 to $2500 in $250 intervals). Individuals were given four choices for each price option (definitely yes, probably yes, probably no, definitely no), which was transformed into a binary yes/ no. Thus, the different price points represent the alternatives in our model and the respondent's yes or no decision at each price point represents their choice set.

Using the RUM framework, we conducted a conditional logit regression with clustered standard errors across each individual's choice set. We used the Apollo package in R, which is specifically designed to estimate choice models. The results of the estimation and the robust standard errors can be found in Table 7.11 and Table 7.12. Much like the linear models, we showcase the results of both the simple model specifications, based solely on the variables included in the randomized design (Table 7.11), and the extended model specification (Table 7.12). All coefficients are interpreted as marginal utilities. The cost, subsidy, and insurance premium reduction variables have been scaled by 100 to make the coefficients easier to interpret.

Table 7.11. Conditional Logit Regression Results, Simple Model Specifications (M.3 and M.4*)

Variable	**Backwater Valve (M. 3)**	**Backwater Valve (M. 4)**	**Sump Pump System (M. 3)**	**Sump Pump System (M. 4)**
Intercept	2.525 (0.26)***	3.554 (0.84)***	1.488 (0.21)***	-1.140 (1.28)
Cost	-0.212 (0.02)***	-0.214 (0.02)***	-0.185 (0.02)***	-0.193 (0.02)***
Subsidy	--	-0.810 (0.82)	--	1.096 (0.75)
Insurance P. Reduc.	--	-0.553 (0.68)	--	1.74 (0.61)**
- - - - - - - - - - -				
N	90	90	126	126
Adjusted R^2	0.31	0.31	0.25	0.28
AIC	945	940	1358	1312
BIC	954	959	1368	1333

Significance Levels: *** 0.001 ** 0.01 * 0.05; Robust Standard Errors in Parentheses
Cost, Subsidy, and Insurance Premium Reduction Scaled by 100
* M3: Cost Only RUM Model
* M4: Randomized Design RUM Model (includes Cost, Subsidy, and Insurance Premium Reduction)

Table 7.12. Conditional Logit Regression Results, Extended Model Specification (M.5*)

Variable	Backwater Valve	Sump Pump System
Intercept	5.914 (1.44)***	0.432 (2.46)
Cost	-0.223 (0.02)***	-0.224 (0.02)***
Subsidy	-0.898 (0.86)	0.105 (0.10)
Insurance P. Reduc.	-0.370 (0.69)	1.599 (0.66)*
Risk Perception	0.005 (0.01)	0.028 (0.01)***
Flood Experience	-0.596 (0.40)	0.05 (0.27)
Age	-0.019 (0.01)	-0.027(0.01)
University Education	0.549 (0.48)	0.415 (0.35)
Household Size	-0.510 (0.19)**	-0.218 (0.22)
- - - - - - - - - - -		
N	84	117
Adjusted R^2	0.33	0.35
AIC	855	1115
BIC	899	1161

Significance Levels: *** 0.001 ** 0.01 * 0.05; Robust Standard Errors in Parentheses
Cost, Subsidy, and Insurance Premium Reduction Scaled by 100
* M5: Extended RUM Model (Randomized Design RUM Model with Socioeconomic Variables)

Cost was statistically significant in all models, which is to be expected – as the cost rises, the probability of purchase decreases. The statistical significance of the exogenous variables in the conditional logit estimations were similar to the OLS and Tobit estimations. For the backwater valve, only household size was statistically significant in the systematic factors. The results show that an increase in household size decreases the probability that a household would purchase a backwater valve. For the sump pump system, risk perceptions and insurance premium reduction were the only statistically significant systematic factors. An increase in risk perceptions and/ or insurance premium reduction led to a higher probability of purchasing the sump pump system.

In addition to the discrete choice modelling, we estimated the WTP using Eq. 6 and Eq. 7. For the simplest models (M.3 and M.4), WTP was $1,191 for a backwater valve and $805 for a sump pump system (see Table 7.13). For the extended model (M.5) we analyzed WTP under different alternatives for our two binary variables – university education and flood experience. The WTP for the average individual in our sample, which has both a university education and previous flood experience, was $1,191 for a backwater valve and $960 for a sump pump system. For the sump pump system, having both a university education and flood experience led to the highest WTP for the device, however, for backwater valves, having a university education and no flood experience led to the highest WTP for the device.

Table 7.13. Average Willingness-to-Pay for the Device Based on Attributes of Respondents (M.3, M.4, and M.5*)

	Backwater Valve			**Sump Pump System**		
	(M. 3)	**(M. 4)**	**(M. 5)**	**(M. 3)**	**(M. 4)**	**(M. 5)**
WTP	$1,191.22 (38.23)	$1,191.24 (38.02)	--	$804.65 (37.75)	$806.00 (36.89)	--
WTP, Avg Respondent: - Flood Experience (=1) - University Education (=1)	--	--	$1,190.77 (56.27)	--	--	$960.27 (49.75)
WTP, Alternative 2: - Flood Experience (=1) - University Education (=0)	--	--	$944.98 (82.82)	--	--	$775.30 (61.18)
WTP, Alternative 3: - Flood Experience (=0) - University Education (=1)	--	--	$1,457.51 (73.39)	--	--	$936.75 (58.62)
WTP, Alternative 4: - Flood Experience (=0) - University Education (=0)	--	--	$1,211.73 (79.32)	--	--	$751.79 (67.45)
- - - - - - - - -						
N	90	90	84	126	126	117

Standard Errors in Parentheses
* M3: Cost Only RUM Model
* M4: Randomized Design RUM Model (includes Cost, Subsidy, and Insurance Premium Reduction)
* M5: Extended RUM Model (Randomized Design RUM Model with Socioeconomic Variables)

7.7 Discussion

Limitations

There were several limitations with this study that could have an impact on the results of this chapter. The first limitation was that we received a low number of questionnaire responses considering the heterogeneity of the sample. Having a low number of observations sets a limit on the complexity that is possible in modelling, and it also impacts the robustness of the resulting inferences. Another limitation was the number of households that preferred not to answer the demographic questions, particularly the question on household income (21 percent did not provide their household income). Observations that were incomplete (missing responses to specific questions included in the model) would be dropped from the dataset, leading to a loss in statistical power. Thus, we decided not to include income in our model, even though this is a common variable included throughout the literature. Lastly, there were likely issues of endogeneity and the potential for our models to have omitted variable and simultaneity bias. Although we attempted to control for some of these issues with an instrumental variable (IV), our IV was most likely not strong enough to be valid.

Summary of Findings

- ***WTP for installing flood protection devices was lower than market value.*** The average market cost to purchase and install these devices, as stated by local plumbers, was $2,137 for a backwater valve and $2,868 for a sump pump system. However, the average WTP of our household respondents was $1,086 for a backwater valve and $798 for a sump pump system. When analyzing the net cost to respondents, only 10 percent were willing to pay the average market cost (or more) for a backwater valve and up to 7 percent were willing to pay the average market cost for a sump pump system.
- ***Insurance premium reductions increased WTP, while subsidies motivated intent to purchase.*** Insurance premium reductions were found to be statistically significant at a 95 percent confidence interval, having a positive effect on WTP. The majority (80 percent) of respondents said that the hypothetical city subsidy included the WTP question made the devices worth the additional expense to them. However, in the econometric analysis the subsidy value was found to be insignificant to WTP – in other words, the amount of the subsidy didn’t matter as much as the fact that the subsidy existed, which may reflect a notion that people want to see the government contribute to a solution.
- ***Upfront costs and information were key barriers to installation.*** The majority of household respondents who did not want to install the devices, even if the net cost to them was $0, stated that they could not afford the upfront cost (30 percent) and/ or they required more information

before making a decision (26 percent). Inconvenience, maintenance, and reliance on insurance were ranked low on the list of reasons for why respondents did not want a device.

- ***Previous flood experience did not have an impact on WTP***. Most of the WTP literature on flood protection has found a positive effect of previous experience on risk-reducing behaviour. However, previous flood experience was not statistically significant in our models.

- ***Risk perception may have had an impact on WTP***. Risk perception was found to be statistically significant at a 99 percent confidence interval, having a positive effect on the WTP for sump pump systems, however it was insignificant in the WTP for backwater valves. This result may be impacted by endogeneity and is therefore not conclusive.

- ***WTP for flood protection devices was sensitive to costs***. Household size was found to statistically significant at a 95 percent confidence interval, having a negative effect on the WTP for backwater valves. Household size could be seen as a proxy for disposable income, since a larger household likely means less money for discretionary spending. We also found a negative cost effect in our random utility model analysis – i.e., the more these devices cost, the lower the probability a household will buy them.

8. ECONOMIC EFFICIENCY OF PROPERTY-LEVEL FLOOD PROTECTION

8.1 Introduction

This chapter uses a household Cost-Benefit Analysis (CBA) method to measure the economic efficiency of two property-level flood protection (PLFP) devices: a backwater valve and a sump pump system. In the context of our study, the device is economically efficient to the household if the investment cost of protection is less than the cost of damages from a probabilistic flood event over a 10-year period. In other words, the device provides a net benefit to households if the total cost over a 10-year period is less than the total valued losses from a flood, taking into consideration the probability of experiencing a flood.

Two analyses are conducted in this chapter. The first analysis assesses the efficiency of the devices using reported average costs for a retrofit, the benefit of the retrofit (i.e., avoided losses from expected damages), and flood risk probability. The second analysis examines whether each household within our dataset has expressed a WTP that reflects their own situation, using their independently reported willingness-to-pay (cost of protection), expected damages (benefit if protected), and perceived flood risk probability.[13] If a household's WTP is less than their expected damages then it is likely there are other factors we are not able to measure influencing their decision, such as transaction costs, or that the household doesn't believe that these devices are as effective as we have assumed them to be in this analysis. The information gained from this chapter helps us understand whether these devices are worth the investment from the consumer's (household) perspective.

8.2 Relevant Literature

Although there are many CBA studies for flood risk management policies and investments in flood control infrastructure, there are only a handful that discuss the value of PLFP to households. Most

[13] The households included in the second analysis are those that have answered the following questions from our questionnaire:
- Q29 (risk perception for sewer backup), Q33 (replacement cost of belongings), Q40 (WTP for backwater valve).
- Q30 (risk perception for infiltration), Q33 (replacement cost of belongings), Q43 (WTP for sump pump system).

of the literature in this area has found that flood damages are almost always reduced by flood protection measures. However, the economic efficiency of these measures relies heavily on the flood probability faced by each household. Kreibich, Christenberg, and Schwarze (2011) conducted a CBA of PLFP in Germany based on previous flood damages reported by households. They focused on three measures and concluded that structural, large investments, such as basement water proofing, were only economically efficient if the building was located in a high-risk area, while smaller investments were found to be economically efficient even if the building is only flooded once every 50 years. They suggest that both legislation and financial incentives could motivate households to undertake precautionary measures. Poussin et al. (2015) conducted a similar study in France on 11 different flood protection measures. The authors found that major structural measures such as water proofing and strengthening the foundation of a home were not cost-effective, while simple measures, such as raising electrical appliances, were always cost-effective. They found that most other measures they tested (including backwater valves) were economically efficient in areas with a 1 in 10-year flood probability or larger. Lastly, in their cost-benefit analysis, Aerts et al. (2014) show that elevating a property to reduce flood risk is economically efficient for new structures, but not existing ones.

Several papers have tried to quantify and measure the non-monetary psychological impacts of flooding. Hudson et al. (2019) analyzed the subjective well-being (SWB) of survey respondents with and without previous flood experience in France and then estimated the psychological impact (intangible) of flooding by subtracting the cost of damages (tangible) from the monetised value of SWB. The authors found that the psychological impacts were about twice as large as the monetary flood losses – the average cost of damages suffered by the respondent in their previous flood was €50,000, while the psychological impact was estimated to be an average of €100,000. Joseph, Proverbs, and Lamond (2015) found that households in the United Kingdom were willing to pay an average of £653 annually, for unspecified PLFP, to avoid or reduce the psychological impacts of flooding such as stress, worry, dealing with insurance, builders, loss of sentimental items, etc. The study found a positive correlation between the respondents WTP values, and the intangible impacts associated with flooding, such as stress and worry.

8.3 Data

The data used in this chapter comes from the various sources listed below:

- The probability of flooding data was sourced from our questionnaire, specifically the risk perception questions (see questions 29 and 30 in APPENDIX N).
- The estimated cost of damages data, which includes the replacement cost of belongings and the repair cost of the home, was sourced from our questionnaire (see question 33 in APPENDIX N) and the City of Edmonton Property Assessment for 2022, respectively.
- The cost of devices was the average cost for installation (for retrofits) as stated to us in our discussions with local plumbers (see Table 7.3).
- The WTP preference data was sourced from our questionnaire, specifically the stated preference questions (see questions 40 and 43 in APPENDIX N).
- The insurance premium and deductible data were based on the averages as stated by the Insurance Bureau of Canada. The average premium for flood protection was $300, and the average insurance deductible was $1,500 (Farooqui 2021).

8.4 Methods

Cost-Benefit Analysis (CBA) is an economic tool that is used to evaluate the benefits and costs of a decision to determine if there is a net benefit. CBAs are generally used by policymakers as a formal framework for making decisions on public projects and programs; however, a similar framework can also be applied at the household-level to understand consumer behaviour and the economic efficiency of purchasing decisions, without accounting for the public goods aspects of such investment. For example, CBA methods have been used to understand household preferences for uptake of home energy efficiency measures (Fowlie, Greenstone, Wolfram 2018).

The results of a CBA are typically presented as Net Present Value (NPV), which represents the difference between the total discounted benefits and the total discounted costs (see Eq. 8).

$$NPV = \sum_{t=0}^{n} \frac{B_t}{(1+r)^t} - \sum_{t=0}^{n} \frac{C_t}{(1+r)^t} \quad \text{(Eq. 8)}$$

Where the first part of the equation represents the sum of monetized benefits (B) discounted by interest rate, r, over time, t; the second part of the equation represents the sum of monetarized costs (C) discounted by r over the same time horizon, t. In CBA, the costs and benefits are typically divided into four categories: direct/ tangible, indirect/ tangible, direct/ intangible, and indirect/ intangible. Tangible impacts are typically economic/ financial, making them easy to quantify in monetary terms, while intangible impacts are typically psychological and difficult, sometimes impossible, to quantify. Table 8.1 provides an example of the four CBA categories within the context of our research; damages (costs) faced by those impacted by a flood event.

Table 8.1. Types of Damages (Costs) Experienced After a Flood Event

	Direct	**Indirect**
Tangible (Financial)	• Damage to house, • Damage to belongings.	• Time spent away from work to conduct repairs, • Disruption to economic and social activities.
Intangible (Psychological)	• Loss of irreplaceable belongings, • Psychological distress of event.	• Trauma, • Loss of trust in authorities and insurance (if claim is unsuccessful).

Adapted from Merz et al. 2010

Our analysis strictly looks at the direct, tangible costs and benefits of the flood protection devices as retrofits in older homes. Although our key interest is in the economic efficiency of flood protection devices, protective action against flooding can take many forms, such as having a flood rider on a home insurance policy. Therefore, we have created four NPV formulas – NPV_1 represents the status quo of no protection /action (i.e., the expected cost of flooding under a specific probability of occurrence), while NPV_2, NPV_3, and NPV_4 represent common protective scenarios which contribute to reduced probability or avoidance of having to pay damages (i.e., the benefit in this cost-benefit analysis) at the cost of implementing the protective measure, whether device, insurance, or both (i.e., the cost in this cost-benefit analysis):

Scenario 1: Household does not purchase protection (no flood insurance, no device). In other words, this formula represents the cost of flooding and no action.

$$NPV_1 = 0 - \sum_{t=1}^{10} \frac{FP * RR}{(1+r)^t}$$

Scenario 2: Household purchases the device (retrofit) but does not purchase flood insurance.

$$NPV_2 = \sum_{t=1}^{10} \frac{(FP * E_t) * RR}{(1+r)^t} - DC_0$$

Scenario 3: Household purchases flood insurance but does not purchase the device (retrofit).

$$NPV_3 = \sum_{t=1}^{10} \frac{FP * RR}{(1+r)^t} - \sum_{t=1}^{10} \frac{IP + (FP * ID)}{(1+r)^t}$$

Scenario 4: Household purchases both the device (retrofit) and flood insurance.

$$NPV_4 = \sum_{t=1}^{10} \frac{(FP * E_t) * RR}{(1+r)^t} - DC_0 + \sum_{t=1}^{10} \frac{IP + (FP * ID)}{(1+r)^t}$$

Where:

DC = device cost as retrofit (first analysis) / net WTP (second analysis)
FP = flood probability, annualized over the 10-year period
RR = repair and belonging replacement cost incurred by the homeowner if flood occurs
E = efficiency of device
ID = insurance deductible
IP = insurance premium specific to flooding coverage
t = year
r = discount rate

To conduct these analyses, several assumptions were made. First, the devices' effectiveness declines with time due to wear. To build this into our analysis, we have assumed the device starts at 100 percent effectiveness in the first year and decreases by five percent annually. Second, since we did not have data related to repair costs after flooding, we have assumed repairs as five percent of each home's assessed value, making the average repair cost for homes in our neighborhoods approximately $20,000. Third, we assumed that if the household has insurance that they will be fully compensated for all repair and replacement costs. Fourth, we have assumed two discount rates for the first analysis as proposed by the Treasury Board of Canada: the discount rate (7 percent) and social discount rate (3 percent) (TBS 2007). For the second analysis we have assumed a discount rate between the two recommendations (5 percent). The discount rate was used to calculate the present value of future benefits and costs (Bonner 2022). In other words, it was used to compare the current cost of loss to future benefits, taking into account the time value of money. The higher the discount rate, the lower the present value of the future benefits and the lower the cost-benefit ratio. This was done to account for the fact that humans typically value immediate resources at higher levels than those in the future (NOAA 1999).

8.5 CBA Results

First Analysis, Economic Efficiency Based on Reported Averages

Figure 8.1 to Figure 8.4 illustrate the NPVs for the four flood protection scenarios with the two different devices at three and seven percent discount rates. All four figures show the NPVs calculated at average prices for the devices (backwater valves = $2,137, sump pump = $2,868), flood probability (sewer backup = 2.0 percent chance annually, infiltration = 2.4 percent annually), insurance premium for flood protection ($300 annually), and insurance deductible ($1,500). The black line in all figures represents the no protection scenario, i.e., the NPV of expected damages. The blue, yellow, and green lines represent the three protective scenarios, i.e., the NPV of protection while accounting for the NPV of expected damages. The point where the black and blue line intersect is where investment in the device offsets the expected damages; it is the minimum amount of damage required to make investing in the device worthwhile.

The results of the first analysis show that backwater valves were worth investing in as a retrofit if the minimum cost of total damage from a sewer backup event is expected to be $7,000 (3 percent discount) or $8,450 (7 percent discount). Sump pump systems were worth investing in as a retrofit if the minimum cost of total damage from an infiltration event is expected to be $7,900 (3 percent discount) or $9,450 (7 percent discount). These values represent the point where the expected cost of damages equals the NPVs for the devices (see Table 8.2). Out of the four flood protection scenarios, insurance is generally the best option from a cost perspective. Additionally, the value of insurance increases at a greater rate than the value of the device as the expected cost of damage grows (see Figure 8.1 to Figure 8.4). There are several reasons insurance may be a better option for most households than a device retrofit. Due to the upfront investment that is required to install the device, the economic efficiency of the device is more sensitive to the discount rate than the insurance scenario. Additionally, we have accounted for some expected failure of the device overtime, which may make it a riskier option if the cost of expected damages is large. However, this analysis does not account for several risks associated with insurance, which are important to highlight. First, we have assumed that insurance will always pay for the damages, which is not always the case depending on the situation. Second, we have not accounted for the increase in insurance premium, or the potential to be uninsurable for future events, after a claim has been made. Third, while insurance may replace belongings, it does not reduce risk – our analysis cannot quantify the psychological aspects of being flooded, which, if considered, would increase the benefits associated with a device that reduces the risk of flooding and increase the likelihood of having both insurance and the device being an optimal choice.

Table 8.2. Minimum Damages Required to Make Investment in Flood Protection Worthwhile for the Average Household

Variable	**Backwater Valve (3% DR)**	**Backwater Valve (7% DR)**	**Sump Pump (3% DR)**	**Sump Pump (DR 7%)**
Investment in Device Worthwhile (Damages = NPV_2)	~$7,000	~$8,450	~$7,900	~$9,450
Investment in Insurance Worthwhile (Damages = NPV_3)	~$8,300	~$8,300	~$7,000	~$7,000
Investment in Device and Insurance Worthwhile (Damages = NPV_4)*	~$13,950	~$15,250	~$13,500	~$14,900

* Even though the NPV_4 scenario presents the minimum damages required to make investment in both the device and insurance worthwhile, the amounts shown do not equal the sum of NPV_2 and NPV_3 scenarios. This is because the likelihood of paying the insurance deductible is reduced if the device is efficient under the specified flood probability.

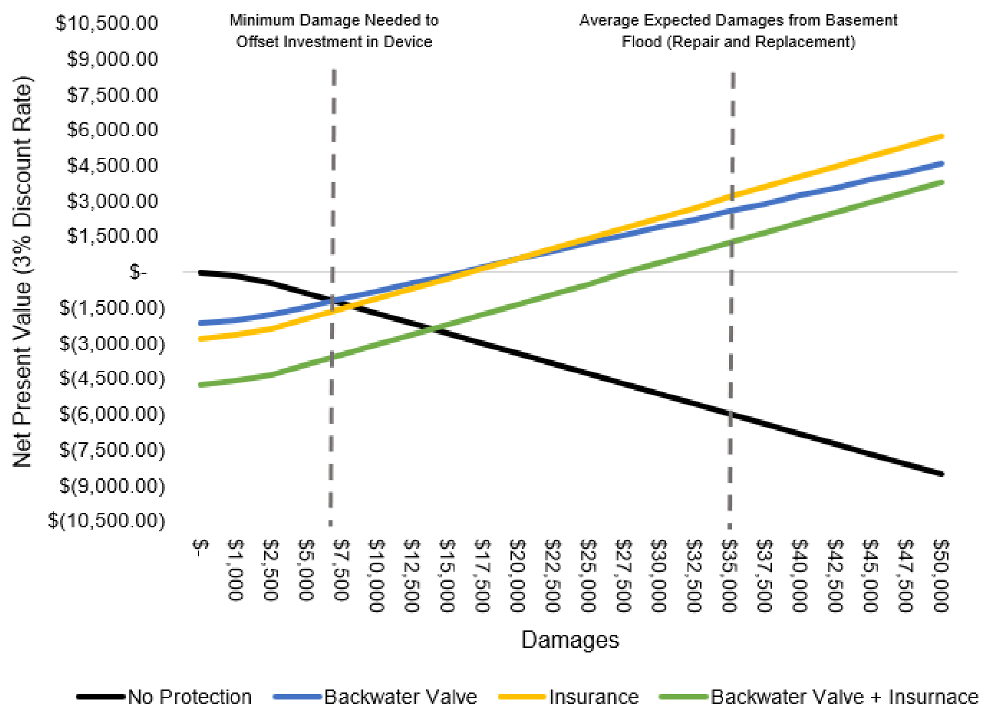

Figure 8.1. NPVs of Flood Protection Scenarios at Various Levels of Damage (Backwater Valve Device; 3% Discount)

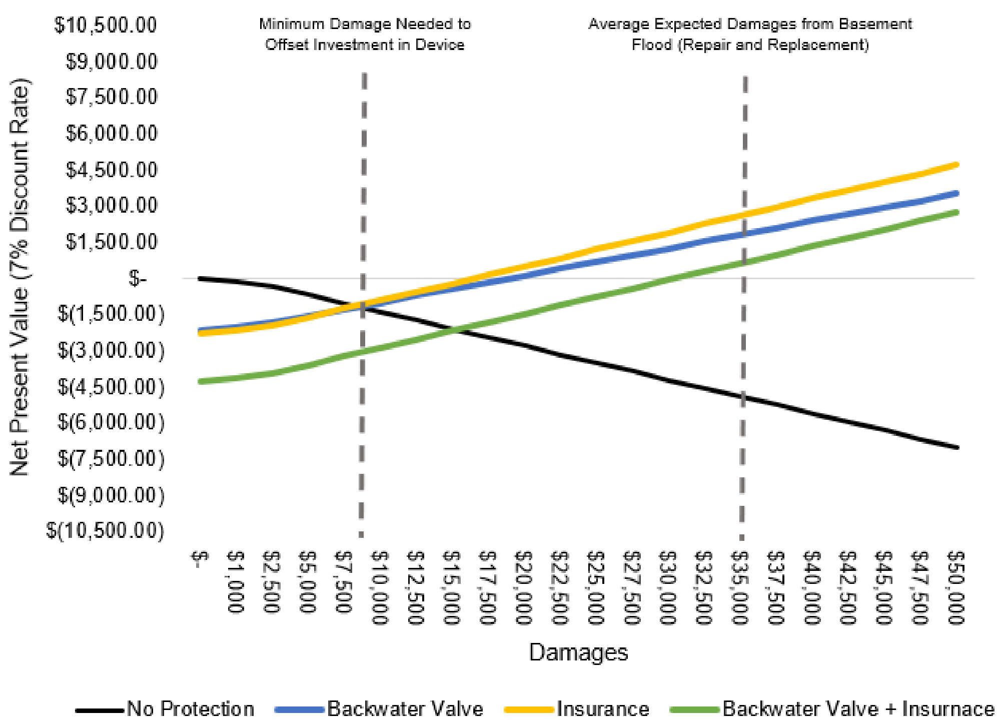

Figure 8.2. NPVs of Flood Protection Scenarios at Various Levels of Damage (Backwater Valve Device; 7% Discount)

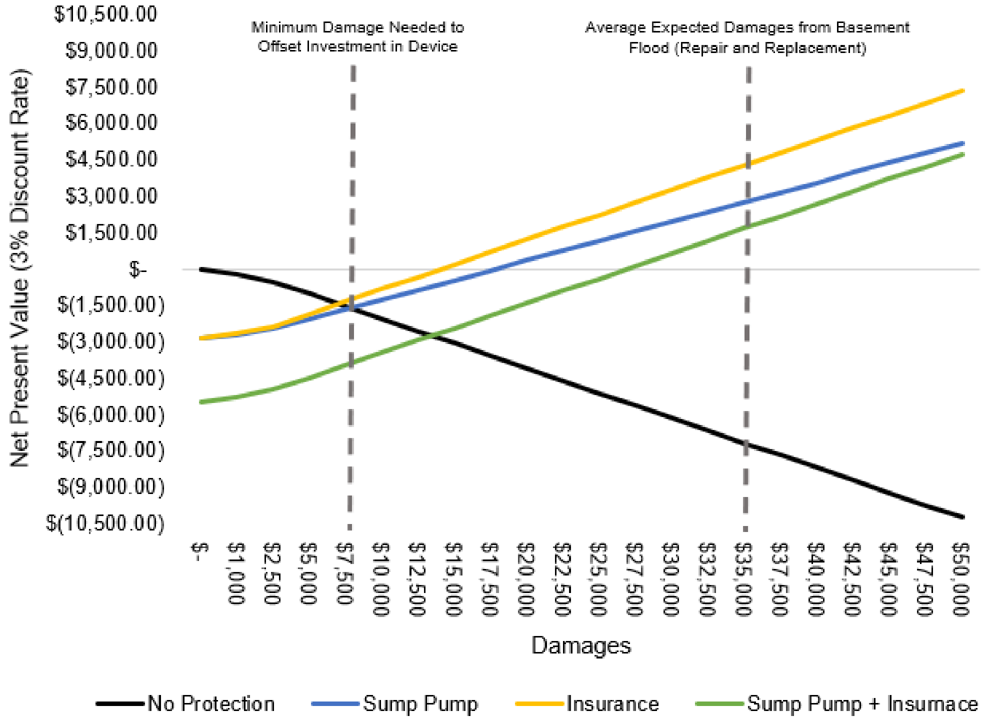

Figure 8.3. NPVs of Flood Protection Scenarios at Various Levels of Damage (Sump Pump Device; 3% Discount)

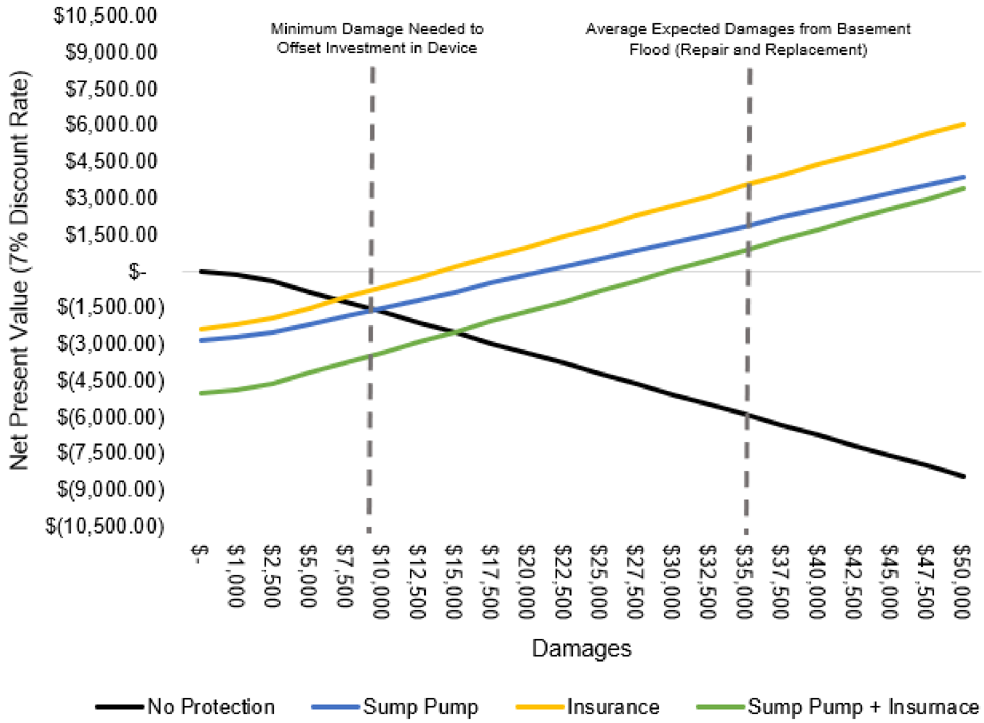

Figure 8.4. NPVs of Flood Protection Scenarios at Various Levels of Damage (Sump Pump Device; 7% Discount)

If the household deems the cost of stress, irreplaceable loss, hassle, and transactions costs to exceed the NPV of the device, then investment in both the device and insurance is worthwhile – since having the device eliminates the potential to be flooded. The average total cost of expected damages in our dataset is approximately $35,000, which shows that all protection scenarios have positive net present values for the average household. As the expected total cost of damages rise, so does the value provided by flood protection. It is also worth noting that the average total cost of expected damages in our study is conservative compared to Government of Canada figures, which put the average value at approximately $43,000 (Government of Canada 2022).

Second Analysis, Examining Household Risk, Expected Damages, and WTP

In the second analysis we created individual NPVs for each household using a mix of average and reported data. Similar to the first analysis, we used averages for the device cost as retrofits (backwater valves = $2,137, sump pump = $2,868), insurance premium for flood protection ($300 annually), and insurance deductible ($1,500). Flood probabilities were calculated based on households' reported risk perceptions and damages were calculated using households' reported replacement cost of belongings, plus five percent of the assessed property value of their home to account for repair costs. Additionally, we used a discount rate of five percent. When analyzing the results, findings show that backwater valves would be worth purchasing for 75 percent of our household respondents and sump pump systems would be worth purchasing for 55 percent of the households (see Table 8.3). The average net benefit to households was $2,479 for backwater valves and $2,406 for sump pump systems. These values only capture the direct/ tangible benefit, so the value could be higher if also considering the indirect and intangible benefits.

However, for households where it made sense to purchase a backwater valve, only 32 percent had a WTP that was greater than or equal to the average market cost for the device (financial subsidy from the government included). If we discount the subsidy and only accounted for households' net WTP, the number of households that were willing to pay for the device drops to eight percent. For households where it made sense to purchase a sump pump system, only 16 percent had a WTP that was greater than or equal to the average market cost for the device (financial subsidy from the government included). We cannot analyze the net values for sump pump systems since households were not given the option to have a net WTP equal to the average market cost of the device (the maximum payment card option was $2,500 whereas the average market cost of a sump pump system was $2,868).

Table 8.3. Analysis on Household-Level Net Present Values and Willingness-To-Pay to Assess Worthwhile Investment

Variable	**Backwater Valve (Houses)**	**Backwater Valve (%)**	**Sump Pump (Houses)**	**Sump Pump (%)**
Worth Investing Based on Household NPV Using Reported Expected Loss and Risk Level	65	75%	68	55%
Total WTP is Greater Than Average Cost of Device (for households worth investing)	28	32%	20	16%
Net WTP is Greater Than Average Cost of Device (for households worth investing)	5	6%	NA	NA
- - - - - - - - -				
N	87	100%	124	100%

The low values for investment could signal that there is an information failure, where households are not properly informed of the long-term benefits of these devices when considering their perceived risk levels and consequences (losses). However, it is worth re-iterating that CBA is only a tool to evaluate alternatives or identify trade-offs using monetary measures (Champ, Boyle, Brown 2014; Freeman et al. 2014). In reality, decision-makers may have other objectives besides economic efficiency and may not be incorporating those objectives into their personal CBA (Freeman et al. 2014). Therefore, although households may not be acting according to neoclassical economic thought, they still have identified their preferences for the devices.

8.6 Discussion

Limitations

There are several limitations in the analyses conducted in this chapter. First, there are a number of assumptions made in order to calculate NPV. One such assumption is linearity, which can be a problem for aspects of the equation that may be nonlinear. For example, we are assuming the effectiveness of device declines in a linear fashion, however, this is likely not the case. Another assumption is that the average values we are using are representative, even though the situation is heterogenous and would vary from household to household. We try to remedy this limitation by conducting the second analysis using reported figures from the individual households. We have outlined other assumptions made regarding repair costs, insurance payout, and discount rates in Section 8.4. If these assumptions do not hold then the calculations may not be representative of the true situation.

Second, there are limitations in our ability to capture all the costs and benefits from investing in flood protection. In our first analysis on averages, we were only able to capture the direct, tangible (financial) costs and benefits, which means we did not account for the indirect and intangible (psychological) costs and benefits. We were also not accounting for the transaction costs related to the installation of the devices (information gathering, getting quotes, setting up time to install, being available for install, etc.) or the transaction costs related to getting insurance and/ or making claims with insurance. In the second analysis we have assumed that we were able to capture the indirect and intangible costs and benefits of the devices through the inclusion of WTP preferences, however if information to households about flood risk reduction is imperfect, then WTP may not fully capture these additional costs and benefits.

Summary of Findings

This chapter explores whether flood protection devices, specifically backwater valves and sump pump systems, are worthwhile investments as retrofits from the household's perspective. The key findings include:

- ***Most households would benefit from some form of flood protection.*** After calculating NPVs using average flood probabilities (2.0 - 2.4 percent annually) and losses ($35,000) over a 10-year period, we found that the average household in our sample would have a net benefit from having some form of flood protection, whether it be in the form of devices, insurance, or both.

- ***Devices might not be the most economically efficient option for everyone.*** We found that having flood insurance was more cost effective than flood protection devices in most situations. This is largely due to the upfront cost of the devices, which is impacted by the discount rate more so than insurance. Additionally, we have accounted for some expected failure of the devices, which would lower the value of the devices overtime and make them a riskier investment for those who have high expected losses. However, insurance does not reduce risk of flooding, and therefore the devices or both devices and insurance may be more economically efficient if we account for the indirect and intangible benefits of risk reduction.

- ***WTP for flood protection devices is low when considering the risk perceptions and expected losses of individual households.*** An assessment of household-level risk perceptions and expected losses showed that the majority of households in our sample would benefit from having flood protection devices (75 percent for backwater valve; 55 percent for sump pump system). However, there is a significant gap between households' understanding of their current situation and their WTP for flood protection devices. This could signal an information failure where households are not properly informed of the long-term benefits of these devices, or it could mean that households are making their decisions based on factors other than economic efficiency.

9. CONCLUSION

9.1 Study Findings

The overall objective of this thesis was to explore what contributes to household investment in property-level flood protection (PLFP). To summarize the study findings, we have answered the questions presented at the beginning of the thesis:

(1) How does household knowledge and awareness impact the adoption of PLFP?

Our study found that many households in our sample had low levels of knowledge and awareness regarding flood risk reduction. Although descriptive, these findings add context to some of the potential issues and reasons for inaction regarding PLFP. For example, households in our study had low awareness of public programs that support flood risk reduction, such as EPCOR's inspection service and subsidy for backwater valves, meaning they are not aware that there is information and financial support available. In addition, almost a third of households were unsure of whether they were protected against flooding on their home insurance policy and almost a quarter of households didn't know whether they had a backwater valve, showing the topic is not a top-of-mind issue. Most households (70 percent) stated that having clear information on how much their risk would be reduced by protective measures would motivate them to act, meaning that they are interested in understanding their objective risk before making decisions such as purchasing PLFP.

(2) Are household risk perceptions correlated with their objective flood risk levels?

This study found no correlation between the risk perceptions of households in our sample and KatRisk's flood risk scores, which were modelled using precipitation data and parameterized hydrologic and hydraulic models. Thus, the households in our study may not be informed by the actual risk they face; instead, their perceptions are more likely informed by other factors such as previous experience, years they have lived in their home, their ability to afford repairs, and even feelings of fatalism.

(3) Is the average WTP for PLFP comparable to the average market cost of these devices?

Our study specifically analyzed the WTP for two PLFP devices: backwater valves and sump pump systems. Our findings show that the average market cost to purchase and install these devices, as stated by local plumbers, was higher than the average WTP of households in our sample. Only 10 percent of households that were asked the backwater valve WTP question (N=90) were willing to pay the average market cost or more for the device. Of the sample that was asked the sump pump system WTP question (N=126), up to 7 percent were willing to pay the average market cost for the device.

(4) What external factors influence WTP for PLFP?

Through our regression analysis we found different external factors influenced WTP for the two devices. Having a larger household size, which could be acting as a proxy for disposable income, had a negative effect on WTP for backwater valves, while age had a negative effect on WTP for sump pump systems. We also found that higher risk perceptions had a positive effect on WTP for sump pump systems. Surprisingly, flood experience was not significant to WTP in any of our models, contrary to previous literature that shows flood experience motivates a higher WTP.

(5) Do financial incentives, such as subsidies and insurance premium reductions, increase WTP for PLFP?

There is evidence that financial incentives increase WTP and, perhaps more importantly, make PLFP more affordable to the average household. In our regression analysis, insurance premium reductions were found to be statistically significant at a 95 percent confidence interval, having a positive effect on WTP for sump pump systems. Additionally, in follow-up questions to the WTP, the majority (80 percent) of respondents stated that the city subsidy made the devices worth the additional expense to them. If the existing subsidy of $800 from EPCOR’s Backwater Valve Subsidy Program was added to household respondents’ net WTP for backwater valves, the percentage of households that would be willing to pay the market cost or more for the device increases from 10 percent to 36 percent (of the sample that was specifically asked about their WTP for backwater valves).

(6) Are PLFP devices economically efficient from the household's perspective?

Our findings show that the average household would have a net benefit from having PLFP devices. This is under the assumption that the average flood probability is between 2.0 to 2.4 percent annually and expected losses are at least $7,000 to $9,450 over a 10-year period. However, we found that having flood insurance was more economically efficient than flood protection devices in most situations. This is likely due to the upfront cost of the device, which is impacted by the discount rate more so than insurance. Additionally, we have accounted for some expected failure of the devices, which would lower the value of the device over time and make it a riskier investment for those who have high expected losses. One aspect we didn't account for in our analysis is the need for device maintenance, which could lower effectiveness at an even greater rate than we have estimated if they are not maintained properly. Therefore, households that are not inclined to maintain PLFP devices are also likely better off purchasing flood insurance. When using household reported flood risk perceptions and expected damages, backwater valves would be a worthwhile investment for 75 percent of our household respondents and sump pump systems would be a worthwhile investment for 55 percent of the households. However, this analysis only captures the direct/ tangible benefit, so the value could be higher if also considering the indirect and intangible benefits.

9.2 Recommendations to Policymakers

Throughout this study we have shown that the factors that influence households in their investment decisions for risk reduction are numerous and complex. At the core of the decision there is the need for an appropriate level of information to understand the likelihood of a flood event as well as understand the PLFP measures, i.e., how they work, their limitations, their maintenance, etc. Only when the appropriate level of information is available can a household be expected to accurately evaluate whether the cost of protection is worth the risk reduction in their situation. Thus, there are four recommendations that could be made to policymakers working in this space to help improve resilience of households in Canada and reduce the property and financial losses homeowners face from flooding.

(1) Provide objective, consistent, and easy to understand flood risk information – an important first step to building awareness and encouraging risk reduction amongst households.

As mentioned earlier in our findings, households' risk perceptions for flooding are not correlated with objective risk levels. However, these objective risk levels are typically unknown to households since the information is not widely available to the public throughout Canada. Flood mapping, which is the most common method of showcasing flood risk, is not a standardized process and households currently rely on municipalities or provinces to make it a priority to develop and update, which has led to inconsistent availability and measurement of flood information. In addition, existing maps are often expressed in technical terms that may not be easily understood by a general population. The lack of objective flood data for households has already been recognized as an issue by the Government of Canada, which is currently exploring the development of nation-wide flood maps (Public Safety Canada 2022). However, our recommendation emphasizes that the maps made available to the public are easily understood as well as updated frequently. Furthermore, with the increasing trend of severe, sudden, and highly localized rainfall events, these maps should also incorporate pluvial flood vulnerability and not only the risk defined by river or coastal floodplains. Pluvial flood risk is challenging to define since it is based on various factors that influence vulnerability such as municipal sanitary and storm infrastructure capacity, house and property management, the existence (or not) of property-level flood protection measures, and the elevation of homes in relation to surrounding homes, land, and streets (Sandink and Binns 2021; Houston et al. 2011). Therefore, to accurately assess and communicate this type of risk to households, current data on infrastructure and PLFP adoption need to be incorporated into flood map design (Bryant et al. 2022).

(2) *Work collaboratively with trusted partners to have consistent messaging about risk reduction to reduce confusion about an already complicated topic.*

Our findings showed that most households place responsibility and trust regarding flood protection with the municipality and EPCOR. However, plumbers and contractors were also well trusted in this area. Throughout our study, specifically during our interviews and discussions with homeowners when surveying, there was evidence of inconsistent messaging between trusted sources for flood risk reduction, particularly regarding the efficacy of backwater valves and sump pump systems over other PLFP measures (grading, downspouts, fixing sewer lateral, etc.). This inconsistent messaging could be confusing for households and lead to inaction on flood protection. Therefore, we recommend that trusted partners (particularly municipal government officials and plumbers) work together to develop policies and programs that are beneficial to the households.

(3) *Make flood protection information and training widely available at the household-level (if self-protection is deemed important for a climate resilient future).*

Our findings show the lack of information households have on PLFP measures, how they work, how they are maintained, and their benefits may be preventing action. For example, there was a significant gap between the average expected losses from a flood event and average WTP for flood protection devices. This disparity could signal an information failure where households are not properly informed of the long-term benefits of these devices and thus not valuing them according to their economic efficiency. Additionally, of all the households in our study that did not want the device installed (even at $0 net cost to them), 26 percent stated that they need more information on the devices to make a decision. Therefore, information provision and training on flood protection measures needs to be improved and made more accessible to the average household. Similarly, there needs to be greater awareness of existing public incentives and programs for PLFP. The majority of households in our sample that were interested in installing the devices (64-68 percent) stated the subsidies offered in the valuation question were their top reason for choosing to install the device. However, in a separate question, 84 percent of the households didn't know about EPCOR's already existing Backwater Valve Subsidy Program. This lack of awareness could be leading to inaction from households that are interested in PLFP but may not be able to (or may not want to) cover the total cost. Following recommendation #2, the creation and dissemination of information and training on PLFP should be a collaborative effort between trusted sources such as governments and plumbers, but also insurance brokers and providers since they are often a first point of contact for homeowners looking to reduce their risks.

(4) Consider expanding and increasing financial incentives as well as creating alternative ways to access these incentives (if PLFP is believed to be generally beneficial to households).

Many of the findings throughout this study show that cost is a significant barrier for household investment in backwater valves and sump pump systems. Perhaps the most noteworthy finding is that there is a significant gap between household WTP and the marketed price for these devices. If municipal policy makers are interested in the public and private benefit these devices provide, they should consider increasing the dollar value for existing subsidy programs or working with insurance companies and/ or other orders of government to provide benefits that bridge the price gap. Particularly for Edmonton, the value of the Backwater Valve Subsidy Program has not increased since its inception in 1989 (in fact, the dollar value has decreased since then), even though the cost of the device and its installation as a retrofit has likely increased in that time.

Another consideration should be expanding incentive programs to include multiple PLFP measures. Making a general flood protection improvements subsidy, which already exists some municipalities (e.g., Brantford ON, St. Catherines ON, St. Thomas ON, and Welland ON), would offer households greater flexibility to manage their home's unique problems and thus may increase uptake of flood risk reduction. In our expert interviews there was an overwhelming agreement that the best flood protection measures depended specifically on the context of the home and its existing issues.

Lastly, the payment structure of incentives should be re-evaluated. Our study shows that subsidies provided after installation of a device may be prohibitive to some households due to the device's upfront cost. Out of all the households that did not want the device installed (even at $0 net cost to them) 30 percent stated that they could not afford the upfront cost. Furthermore, when the time value of money is taken into consideration, it makes the upfront cost of these devices an even larger barrier than the absolute dollar value. Therefore, policymakers could consider alternative ways of subsidizing these devices, either through paying subsidies upfront or directly to the plumbers, re-payment schemes through property taxes, or other financing options.

9.3 Areas for Further Research

This thesis adds to the empirical literature on property-level climate adaptation and resilience, the effectiveness of incentives for private goods with public externalities, and the economic efficiency of PLFP, specifically backwater valves and sump pump systems. However, as mentioned throughout this thesis, the topic of household-level risk perception and risk reduction is complex. There are often multiple factors motivating behaviour, with cost being only one aspect. Therefore, areas for further research should focus on: (1) how investment in property-level adaptation against natural hazards is motivated by trust in those providing risk communication, (2) the impacts of greater information provision on risk reduction (ex-ante/ex-post analysis), (3) how household self-efficacy could impact natural hazard protection and resilience, and (4) the benefits of PLFP when incorporating the social and public goods aspects.

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APPENDICES

APPENDIX A – SECONDARY DATA USE

Various secondary data informed different elements of this study. Below is a list of all secondary data sources as well as what data was used, how it was incorporated, and any limitations:

Statistics Canada Census of Population (2021, 2016): Dwelling and income data at the census tract level were used in the neighbourhood selection rationale for the household survey. Since Statistics Canada does not publicly publish results at the census tract level, the data was sourced using the SimplyAnalytics software made available through the University of Alberta library.

It should be noted that the data used for neighbourhood selection were sourced from the 2016 census because the relevant 2021 census data were not released until spring and summer 2022.

Although the Census of Population provides some of the most accurate demographic, economic, and social data in Canada, there is a limitation is the accuracy of data at a neighbourhood level. Data at the census tract level is the closest approximate to neighbourhoods, however, the boundaries do not perfectly align in most cases.

City of Edmonton's Property Assessment (2022): The residential addresses from in this dataset were used to create a systematic random sample of homes for the household survey. It was sourced from the City of Edmonton's Open Data Portal on May 25, 2022. The dataset is updated on a weekly basis, providing the most current and complete list of addresses for each neighbourhood in Edmonton.

KatRisk Flood Risk Score (2022): KatRisk used precipitation data and parameterized hydrologic and hydraulic models to compute return period-level flood maps. They then used these flood map data to create a flood risk score, from zero (low) to nine (high), using a weighted spatial average of 100- and 500-year flood loss. The flood risk score data were provided to us at the lot-level, which allowed us to merge KatRisk's dataset to our own.

APPENDIX B – CONSENT FORM FOR EXPERT INTERVIEWS

Resource Economics and Envinronmental Sociology

UNIVERSITY OF ALBERTA

Faculty of Agricultural, Life and Environmental Sciences
College of Natural and Applied Science

Homeowners' Perceptions, Knowledge, and Uptake of Protection Against Stormwater Flood Risk

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You are invited to participate in a study on flooding perceptions and prevention.

What is the Purpose of this Interview? This interview is being done as part of a graduate student's thesis research. The goal of this study is to understand homeowners' perceptions of flood risk, homeowners' awareness of flood protection measures, and homeowners' reasons for wanting, or not wanting, to install flood protection measures on their homes. The interview should take no more than 30 minutes to complete.

Why Were You Chosen to Participate? The interviews are being conducted with individuals working in municipal government, utilities, insurance, and construction (plumbing) who have insights into the study's purpose from an expert perspective.

What are the Benefits/ Risks to You? There are no direct benefits to you from this project. However, interview participants will help the researchers understand perceptions of flooding risk and views on flood prevention programs and practices. There are no known or anticipated risks associated with your participation in this study.

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Who is Funding this Study? This study is being funded by MITACS, a Canadian not-for-profit organization that funds research and training programs at universities. MITACS funding is matched with sponsor funding to support internships. The sponsor for this project is the Institute for Catastrophic Loss Reduction (ICLR), a Canadian not-for-profit research institute focused on multidisciplinary disaster prevention research and communication. ICLR's mission is to reduce the loss of life and property caused by severe weather and find ways to improve society's capacity to adapt to, anticipate, mitigate, withstand and recover from natural disasters. TD Insurance is also a sponsor through their partnership with ICLR on programs to reduce losses from flooding.

Confidentiality and Data Storage: The information that you share with researchers will remain strictly confidential and will only be used for the purposes of this research. Your name will not be associated with any of your responses. The interviews will be recorded for transcription purposes and these recordings will be stored securely on a shared drive that can only be accessed by the investigators listed on the previous page. These recordings will be stored for five years following the completion of the research project, after which time they will be destroyed.

Participation and Withdrawal: Participation in this study is **voluntary**. If you wish, you may decline to answer any questions asked. You may decide to withdraw from this study at any time. There is no penalty to you for declining to answer or withdrawing from the interview. If you withdraw from the interview before completion, your information will not be included in the analysis. However, once the interview has been completed you cannot withdraw the information you provided.

Publication of Results: Results of this study may be published in academic journals and presented at conferences as well as in the graduate student's thesis. After the completion of the survey process and analysis, feedback about this study will be available from the investigators using the contact info provided on the previous page.

Ethics Clearance: This study has been reviewed and received ethics clearance through the Research Ethics Board at the University of Alberta (ID Pro00111805). If you have questions about your rights or how research should be conducted, you can contact the University of Alberta's Research Ethics Office at XXX-XXX-XXXX or XX@ualberta.ca. This office is independent of the researchers.

Contact: If you have any questions about this study or require further information, please contact Vic Adamowicz using the contact information provided on the previous page.

Thank you for your assistance in this research project!

Resource Economics and Envinronmental Sociology

UNIVERSITY OF ALBERTA

Faculty of Agricultural, Life and Environmental Sciences
College of Natural and Applied Science

Interview Consent Form

Do you understand that you have been asked to participate in an interview about perceptions, knowledge, and uptake of flood protection measures by homeowners?

Yes No

Do you understand that the information collected is part of a study being developed by the researchers listed above?

Yes No

Do you understand the benefits and risks involved in taking part in this interview?

Yes No

Do you understand that you can choose to not participate in this interview, or you can choose to withdraw at any point during the interview, however once the interview is complete your answers can no longer be withdrawn?

Yes No

Do you understand that the information that you provide will be kept in strict confidence and that any link between your answers and your name will be destroyed?

Yes No

Do you give us permission to use the data that you provide in the interview for the purposes specified in the information above (masters thesis, published papers, conference presentations)?

Yes No

I understand that the completion of this interview means that I consent to participate in this study.

Yes No

To represent your signature, please print your full name and date in the fields below:

Name:

Date:

University of Alberta
515 General Services Building
Edmonton, Alberta T6G 2H1

APPENDIX C – EXPERT INTERVIEW QUESTIONS

1. Do you feel the that the average homeowner invests enough (too little, too much) in flood protection measures?

2. In your experience, what are the reasons why a homeowner may not invest enough in flood protection measures?

3. What do you think is the top reason homeowners may not invest enough and why?

4. In your experience, what are the reasons why a homeowner may choose to invest in flood protection measures?

5. What do you think is the top reason and why?

6. In your opinion, what would be the best flood protection investment for homeowners to make?

7. What do you think are the most effective ways of getting homeowners to invest in adequate flood protection measures?

8. What are your thoughts on these methods and their effectiveness in getting homeowners to invest in flood protection measures?

    a. Providing Information /Education
    b. Providing Financial Incentives
    c. Providing Examples of Neighbours' Investments

9. Outside of homeowner actions, what specific actions, policies, regulations, or other measures do you think are or could be effective in dealing with stormwater flood mitigation?

10. What do you think can be done by governments/ insurance companies to encourage customers to invest in flood protection measures?

Do you have any comments, experiences, or anything else that you would like to add? [*allow interviewee about 10 seconds to think and add any other thoughts or comments they may have*].

Do you have any other questions or concerns for me about the study? [*answer questions if there are any*].

APPENDIX D – LETTER OF INTRODUCTION FOR PILOT HOUSEHOLDS

UNIVERSITY OF ALBERTA

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Faculty of Agricultural, Life and Environmental Sciences
College of Natural and Applied Science

Homeowners' Perceptions, Knowledge, and Uptake of Protection Against Stormwater Flood Risk

Dear Resident of XX:

You are invited to participate in a study on flooding perceptions and prevention.

My name is Marina Giannitsos and I am a graduate student at the University of Alberta doing my masters thesis research on the issue of stormwater flooding in Edmonton.

As part of my research, I am conducting a survey of homes in six different neighbourhoods to understand household views on stormwater flooding and what efforts homeowners have taken, or are thinking of taking, to reduce any potential flood risks.

Your household has been chosen for the pilot phase of our survey. This means you'll be one of the first households to do the survey and then we would like to follow-up with you afterwards to share your thoughts on our survey design.

We are not trying to sell you a product or a service, we are only interested in learning from homeowners. What we learn from this survey will help us create best practices to help homeowners in Edmonton prevent future flooding in their homes.

You can take the online survey through computer or mobile device. The survey can be found by typing this link into your internet browser's address bar: tinyurl.com/n38j8esk

Alternatively, you can scan the QR code (bottom right of page) with your mobile device to access the survey. You can do this by pointing your phone camera at the square barcode and opening the link.

The survey should take 20-25 minutes to complete. We are asking that you complete the survey at a time of your convenience sometime before June 5th, since we would like to follow up with you between June 2nd and June 5th to discuss your thoughts on the survey.

We have included a list of common questions and concerns, so you have more information about the study. If you have a question or concern that is not listed, please contact me or my supervisor.

I really appreciate your participation and being a part of my thesis research!

Marina Giannitsos
Graduate Student, University of Alberta
Department of Resource Economics & Environmental Sociology
Email: XX@ualberta.ca

Dr. Vic Adamowicz
Supervisor/ Professor, University of Alberta
Department of Resource Economics & Environmental Sociology
Phone: XXX-XXX-XXXX
Email: XX@ualberta.ca

University of Alberta
515 General Services Building
Edmonton, Alberta T6G 2H1

Pilot Phase Introduction

Your household was selected to be included in the pilot phase of this survey. This means we would like your input on our survey after you complete it.

Your input will help us make sure the survey we designed is easy to understand and free of technical issues before administering it to other homeowners. Once we have gathered feedback from all the pilot households, we will adjust our survey as needed and then administer it to other homeowners in your neighbourhood.

Therefore, we would like to invite you to a quick follow-up with the investigators about your thoughts sometime between **June 2nd and June 5th**. It should take no more than 15 minutes of your time. In the survey you will have options to pick a follow-up method (in-person, phone, or by email).

The questions we will be asking are:

- What are your thoughts on the survey's length?
- Were the definitions provided throughout the survey easy to understand?
- Was there anything that didn’t make sense or was unclear?
- Was there anything that was too complicated and needed greater explanation?
- Were there any technical issues or difficulties using the survey software?
- Was there anything you felt was inappropriate to ask?
- Were there any questions you felt like you had to “guess” the answer

Note that the contact information you provide for the follow-up discussion will be separated from your survey results and will be deleted after the follow-up.

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515 General Services Building
Edmonton, Alberta T6G 2H1

Resource Economics and Envinronmental Sociology

UNIVERSITY OF ALBERTA

Faculty of Agricultural, Life and Environmental Sciences
College of Natural and Applied Science

COMMON QUESTIONS & CONCERNS

I Have Never Had a Flood Before

That is okay - we are looking for residents with and without previous flooding experience.

I Don't Know Much About Flooding

That is okay - we are not expecting homeowners to know about flooding.

I am a Renter, not a Homeowner

That is okay - while the key focus of our study is on homeowners, understanding the perspectives of renters is also important to us.

How Long is the Survey?

The survey should take no more than 20-25 min to complete. We recognize this is a long survey and we really appreciate you taking the time to do it and help us in our research.

To thank you for your time, if you complete the survey you will be entered into a draw where you will have a chance of winning one of two gift cards valued at $100 each for Canadian Tire. The actual odds of winning will depend on the number of people who participate in the survey, but approximate odds are 1/400. If you wish to enter the draw, you will have to answer a skill-testing question and provide an email address so we can inform you of the draw result if you win. Your email address will not be used for any other reason. Once submitted, your email address will be removed from the dataset and saved in a separate document until the draw is complete, at which point it will be deleted.

How Often Will You Be Contacting Me?

This letter represents our first contact with you.

We plan to conduct another, shorter survey sometime between Fall 2022 and Spring 2023, which we will also contact you about. Your continued participation would be incredibly helpful to our results, so we hope you choose to continue with us.

There will be no further contact after the two surveys are complete.

Why Was I Chosen to Participate?

Your neighbourhood was one of six chosen by researchers to be included in the study and a random sample was used to select homes within each neighbourhood to be part of the survey.

Within that random sample we chose a number of homes, including yours, to be part of our pilot study. The purpose of the pilot study is to make sure we address any issues with the survey before we administer to the rest of the households.

We require the respondents of the survey to be 18 years and older.

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515 General Services Building
Edmonton, Alberta T6G 2H1

What are the Benefits of Participating?

There are no direct benefits to you from this project. However, by participating you will help us understand perceptions on flooding and find the best ways to help homeowners prevent flooding in their homes. You would also be helping me to complete my thesis, which I appreciate!

Who is Funding this Study?

This study is being funded by MITACS, a Canadian not-for-profit organization that funds research and training programs at universities. MITACS funding is matched with sponsor funding to support internships. The sponsor for this project is the Institute for Catastrophic Loss Reduction (ICLR), a Canadian not-for-profit research institute focused on multidisciplinary disaster prevention research and communication. ICLR's mission is to reduce the loss of life and property caused by severe weather and find ways to improve society's capacity to adapt to, anticipate, mitigate, withstand and recover from natural disasters. TD Insurance is also a sponsor through their partnership with ICLR on programs to reduce losses from flooding.

Confidentiality / Who Will Have Access to My Data?

The information that you share will remain strictly confidential. All information you provide will be grouped with responses from other participants and results will never be reported by your address or any other identifying information. The data will be stored on a shared drive that can only be accessed by the investigators (me and my supervisors). This data will be stored on this drive indefinitely. Our partners and funders will not have access to the raw data. Anonymized data may be made available to other researchers for replication purposes.

Participation and Withdrawal:

You participation in this study is voluntary. If you wish, you can decline to answer any questions or participate in any component of the study. You may withdraw from this study at any time. There is no penalty to you for declining to answer or withdrawing from the survey. If you withdraw from the survey before completion, your information will not be included in the analysis. However, once the survey has been completed you cannot withdraw the information you provided.

Who Will Get to See the Results of the Study?

Grouped results of this study will be included in my thesis research paper, which will be available at https://era.library.ualberta.ca/ when complete. The results may also be published in academic journals and presented at conferences in the future.

Ethics Clearance: This study has been reviewed and received ethics clearance through the Research Ethics Board at the University of Alberta (ID Pro00111805). If you have questions about your rights or how research should be conducted, you can contact the University of Alberta's Research Ethics Office at XXX-XXX-XXXX or XX@ualberta.ca. This office is independent of the researchers.

APPENDIX E – CONSENT FORM FOR PILOT HOUSEHOLDS

UNIVERSITY OF ALBERTA

Resource Economics and Envinronmental Sociology

Faculty of Agricultural, Life and Environmental Sciences
College of Natural and Applied Science

Homeowners' Perceptions, Knowledge, and Uptake of Protection Against Stormwater Flood Risk

Investigators:

Marina Giannitsos
Graduate Student, University of Alberta
Department of Resource Economics & Environmental Sociology
Email: XX@ualberta.ca

Dr. Vic Adamowicz
Supervisor/ Professor at University of Alberta
Department of Resource Economics & Environmental Sociology
Phone: XXX-XXX-XXXX
Email: XX@ualberta.ca

Dr. Peter Boxall
Professor at University of Alberta
Department of Resource Economics & Environmental Sociology
Phone: XXX-XXX-XXXX
Email: XX@ualberta.ca

Dr. John Parkins
Professor at University of Alberta
Department of Resource Economics & Environmental Sociology
Phone: XXX-XXX-XXXX
Email: XX@ualberta.ca

You are invited to participate in a study on flooding perceptions and prevention.

What is the Purpose? This survey is being done as part of a graduate student's thesis research. The goal of this study is to understand homeowners' perceptions of flood risk, homeowners' awareness of flood protection measures, and homeowners' reasons for wanting, or not wanting, to install flood protection measures on their homes.

Why Were You Chosen to Participate? Your neighbourhood was one of six chosen by researchers to be included in this survey. Your household was randomly selected from all households within your neighbourhood to be included in the pilot phase of this survey. We require that the individual responding to this survey from your household is **18 years of age or older**.

The survey should take no more than 20-25 minutes to complete. To thank you for your time, if you complete the survey, you will be entered into a draw where you will have a chance of winning one of two gift cards valued at $100 each for Canadian Tire. The actual odds of winning will depend on the number of people who participate in the survey, but approximate odds are 1/400. If you wish to enter the draw, you will have to answer a skill-testing question and provide an email address so we can inform you of the draw result if you win. Your email address will not be used for any other reason. Once submitted, your email address will be removed from the dataset and saved in a separate document until the draw is complete, at which point it will be deleted.

What are the Benefits/ Risks to You? There are no direct benefits to you from this survey. However, by participating you will help us understand household perceptions on flooding and find the best ways to help individuals prevent flooding in their homes. There are no known or anticipated risks associated with your participation in this survey.

Who is Funding This? This study is being funded by MITACS, a Canadian not-for-profit organization that funds research and training programs at universities. MITACS funding is matched with sponsor funding to support internships. The sponsor for this project is the Institute for Catastrophic Loss Reduction (ICLR), a Canadian not-for-profit research institute focused on multidisciplinary disaster prevention research and communication. ICLR's mission is to reduce the loss of life and property caused by severe weather and find ways to improve society's capacity to adapt to, anticipate, mitigate, withstand and recover from natural disasters. TD Insurance is also a sponsor through their partnership with ICLR on programs to reduce losses from flooding.

Confidentiality and Data Storage: The information that you share will remain strictly confidential. All information you provide will be grouped with responses from other participants and results will never be reported by your address or any other identifying information. The data will be stored on a shared drive that can only be accessed by the investigators listed on the previous page. This data will be stored on this drive indefinitely. Our partners and funders **will not** have access to the raw data. Anonymized data may be made available to other researchers for replication purposes.

Participation and Withdrawal: Participation in this survey is **voluntary**. If you wish, you may decline to answer any of the questions asked. You may withdraw from this survey at any time. There is no penalty to you for declining to answer or withdrawing from the survey. If you withdraw from the survey before completion, your information will not be included in the analysis. However, once the survey has been completed you cannot withdraw the information you provided.

Publication of Results: Grouped results of this survey may be published in academic journals and presented at conferences as well as in the graduate student's thesis. After the completion of the survey process and analysis, feedback about this study will be available from the investigators using the contact info provided on the previous page.

Ethics Clearance: This study has been reviewed and received ethics clearance through the Research Ethics Board at the University of Alberta (ID Pro00111805). If you have questions about your rights or how research should be conducted, you can contact the University of Alberta's Research Ethics Office at XXX-XXX-XXXX or XX@ualberta.ca. This office is independent of the researchers.

Contact: If you have any questions about this study or require further information, please contact Vic Adamowicz using the contact info provided on the previous page.

Resource Economics and Envinronmental Sociology

UNIVERSITY OF ALBERTA

Faculty of Agricultural, Life and Environmental Sciences
College of Natural and Applied Science

Pilot Phase Introduction

Your household was randomly selected from all households within your neighbourhood to be included in the pilot phase of this survey. This means we would like your input on our survey after you complete it.

Your input will help us make sure the survey we designed is easy to understand and free of technical issues before administering it to other homeowners. Once we have gathered feedback from all the pilot households, we will adjust our survey as needed and then administer it to other homeowners in your neighbourhood.

Therefore, we would like to invite you to a quick follow-up with the investigators about your thoughts. The follow-up discussion will take place between June 2 and 5. It should take no more than 15 minutes of your time.

The questions we will be asking are:

- Your thoughts on the survey length
- Were the definitions provided throughout the survey easy to understand?
- Was there anything that didn't make sense or was unclear?
- Was there anything that was too complicated and needed greater explanation?
- Were there any technical issues or difficulties?
- Was there anything you felt was inappropriate to ask?
- Were there any questions you felt like you had to "guess" the answer?

If you are willing to have a discussion with investigators about your thoughts, please check the box of what method of follow up you would like and provide the appropriate info. Note that the contact information you provide will be separated from your survey results and will be deleted after the follow-up.

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515 General Services Building
Edmonton, Alberta T6G 2H1

Survey/Pilot Interview Consent Form

- I understand that the completion and submission of this survey means that I consent to participate in this study as well as a discussion about the survey design. I would like the follow-up discussion to take place in-person.
- I understand that the completion and submission of this survey means that I consent to participate in this study as well as a discussion about the survey design. I would like the discussion to take place over the phone (please provide your phone number in the box below).
- I understand that the completion and submission of this survey means that I consent to participate in this study as well as a discussion about the survey design. I would like the discussion to take place over email (please provide your email in the box below).
- I do not consent to participate in this study and I would like to opt out of the survey with no further contact from the research team. Please fill your address in the box below so we do not revisit your home (Example: 1234 56 ST).

APPENDIX F – PILOT INTERVIEW QUESTIONS

I. Introduction

- We appreciate you taking the time to help us with our study on homeowner perceptions on stormwater flood risk and protection measures.

- The input here is going to help us to make sure the survey we designed is easy to understand and free of technical issues.

- Once we have gathered feedback from all the pilot households, we will adjust our survey as needed and administer it to other homeowners in your neighbourhood.

- Please be honest and frank with your comments on the survey. You can't "hurt our feelings" - we're looking for feedback on what's unclear, uncertain, confusing, etc. as well as what's interesting.

III. General Survey Questions

- What were your thoughts on the survey length?
- Were the definitions provided throughout the survey easy to understand?
- Was there anything that didn't make sense or was unclear?
- Was there anything that was too complicated and needed greater explanation?
- Were there any technical issues or difficulties?
- Was there anything you felt was inappropriate to ask?
- Were there any questions you felt like you had to "guess" the answer?

IV. Specific Questions

- Probability Questions: How confident were you in your response to these questions?

- Flood Experience Questions: Were you easily able to recall the details from your experience?

- Investment to Reduce Flood Risk Questions:

    - Was the information provided necessary? Did you find it too long?
    - Was there any information missing that you thought was necessary?
    - Were the choices clear?
    - What were you thinking about when you were deciding between the choices?

V. Conclusion

- Do you have any further comments or questions?

APPENDIX G – SCRIPT FOR TALKING TO HOUSEHOLDS, INITIAL VISIT

Our names are XX and XX and we are graduate students at the University of Alberta.

We are doing a study on stormwater flooding in Edmonton and are conducting a survey of homes in your neighbourhood to understand household views on the topic.

All the information about the project can be found here ***HAND DOORHANGER***

It includes a URL and a QR code to access the survey online, which you can do through computer, tablet, or phone.

The second page has a list of common questions and concerns. If you have any questions or concerns that are not addressed on there, please contact us using the contact information listed.

We are asking households to do the survey whenever they get a chance in the next week, and we will be doing follow ups as a reminder after a week for households that haven't completed it.

Thank you for your time!

APPENDIX H – LETTER OF INTRODUCTION FOR SURVEY HOUSEHOLDS (DOOR HANGER AND INFORMATION SHEET)

What are your views on stormwater flood risk?

Your home has been selected for a University of Alberta survey on stormwater flooding in Edmonton.

We want to understand household views on the topic and what efforts homeowners have taken, or are thinking of taking, to reduce any potential flood risks.

The results of the survey will guide us in creating best practices to help homeowners prevent future flooding in their homes.

UNIVERSITY OF ALBERTA

Hi!

My name is Marina and I am the graduate student leading this survey. By taking this survey you will help me complete the thesis component of my master's degree. I want to thank you for your time and participation in this study.

The online survey can be accessed by typing this link into your internet browser's address bar:

https://tinyurl.com/4bvjwzsa

Or you can scan the QR code below with your mobile device (open your camera app, point your camera at the square barcode, and open the link presented):

The survey should take 20-25 minutes to complete. Please take the survey at a time that works for you in the next week. We will follow up with you in one to two weeks.

We have also attached a list of common questions and concerns so you have more information about the study. Contact us for additional information.

Faculty of Agricultural, Life & Environmental Sciences
DEPARTMENT OF RESOURCE ECONOMICS AND ENVIRONMENTAL SOCIOLOGY

Marina Giannitsos
Graduate Student
e: [redacted]

Dr. Vic Adamowicz
Study Supervisor
e: [redacted]

This study has been reviewed and has received ethics clearance through the Research Ethics Board at the University of Alberta (ID Pro00111805).

Resource Economics and Envinronmental Sociology

UNIVERSITY OF ALBERTA

Faculty of Agricultural, Life and Environmental Sciences
College of Natural and Applied Science

COMMON QUESTIONS & CONCERNS

I have never had a flood before

That is okay - we are looking for residents with and without previous flooding experience.

I don't know much about flooding or flood prevention

That is okay - we are not expecting homeowners to know about flooding.

I am a renter, not a homeowner

That is okay - while the key focus of our study is on homeowners, understanding the perspectives of renters is also important to us.

Why was I chosen to participate?

Your neighbourhood was one of four chosen by researchers to be included in the study and a random sample was used to select homes within each neighbourhood to be part of the survey.

We require the respondents of the survey to be 18 years and older.

How often will you be contacting me?

This letter represents our first contact with you. We will follow-up, in-person, in one to two weeks as a reminder to complete the survey.

We plan to conduct another, shorter survey sometime between Fall 2022 and Spring 2023, which we will also contact you about. Your continued participation would be incredibly helpful to our results, so we hope you choose to continue with us.

There will be no further contact after the two surveys are complete.

How long is the survey?

The survey should take 20-25 min to complete. We recognize this is a long survey and we really appreciate you taking the time to do it and help us in our research.

To thank you for your time, if you complete the survey, you will be entered into a draw where you will have a chance of winning one of two gift cards valued at $100 each for Canadian Tire. The actual odds of winning will depend on the number of people who participate in the survey, but approximate odds are 1/300.

If you wish to enter the draw, you will have to answer a skill-testing question and provide an email address so we can inform you of the draw result if you win. Your email address will not be used for any other reason. Once submitted, your email address will be removed from the dataset and saved in a separate document until the draw is complete, at which point it will be deleted.

University of Alberta
515 General Services Building
Edmonton, Alberta T6G 2H1

What are the benefits of participating?

There are no direct benefits to you from this project. However, by participating you will help us understand perceptions on flooding and find the best ways to help homeowners prevent flooding in their homes. You would also be helping me to complete my thesis.

Do I have to take the survey?

You participation in this study is voluntary. If you wish, you can decline to answer any questions (skip questions) or participate in any component of the study. You may withdraw from this study at any time. There is no penalty to you for declining to answer or withdrawing from the survey. Your information will not be included in the analysis if you start the survey but do not complete it. However, once the survey has been completed you cannot withdraw the information you provided.

I do not want to do the survey online, can I do it in-person instead?

Yes! Please email or call us and we can book a time to go through the survey together.

Who is funding this study?

This study is being funded by MITACS, a Canadian not-for-profit organization that funds research and training programs at universities. MITACS funding is matched with sponsor funding to support internships. The sponsor for this project is the Institute for Catastrophic Loss Reduction (ICLR), a Canadian not-for-profit research institute focused on multidisciplinary disaster prevention research and communication. ICLR's mission is to reduce the loss of life and property caused by severe weather and find ways to improve society's capacity to adapt to, anticipate, mitigate, withstand, and recover from natural disasters. TD Insurance is also a sponsor through their partnership with ICLR on programs to reduce losses from flooding.

Who will have access to my data?

The information that you share will remain strictly confidential. All information you provide will be grouped with responses from other participants and results will never be reported by your address or any other identifying information. The data will be stored on a shared drive that can only be accessed by the investigators (me and my supervisors). This data will be stored on this drive indefinitely. Our partners and funders will not have access to the raw data. Anonymized data may be made available to other researchers for replication purposes.

Who will get to see the results of the study?

Grouped results of this study will be included in a master's thesis research paper, which will be available at https://era.library.ualberta.ca/ when complete. The results may also be published in academic journals and presented at conferences in the future.

Ethics Clearance: This study has been reviewed and received ethics clearance through the Research Ethics Board at the University of Alberta (ID Pro00111805). If you have questions about your rights or how research should be conducted, you can contact the University of Alberta's Research Ethics Office at XXX-XXX-XXXX or XX@ualberta.ca. This office is independent of the researchers.

University of Alberta
515 General Services Building
Edmonton, Alberta T6G 2H1

APPENDIX I – CONSENT FORM FOR SURVEY HOUSEHOLDS

Resource Economics and Envinronmental Sociology

UNIVERSITY OF ALBERTA

Faculty of Agricultural, Life and Environmental Sciences
College of Natural and Applied Science

Homeowners' Perceptions, Knowledge, and Uptake of Protection Against Stormwater Flood Risk

Investigators:

Marina Giannitsos
Graduate Student, University of Alberta
Department of Resource Economics & Environmental Sociology
Email: XX@ualberta.ca

Dr. Vic Adamowicz
Supervisor/ Professor at University of Alberta
Department of Resource Economics & Environmental Sociology
Phone: XXX-XXX-XXXX
Email: XX@ualberta.ca

Dr. Peter Boxall
Professor at University of Alberta
Department of Resource Economics & Environmental Sociology
Phone: XXX-XXX-XXXX
Email: XX@ualberta.ca

Dr. John Parkins
Professor at University of Alberta
Department of Resource Economics & Environmental Sociology
Phone: XXX-XXX-XXXX
Email: XX@ualberta.ca

You are invited to participate in a study on flooding perceptions and prevention.

What is the Purpose? This survey is being done as part of a graduate student's thesis research. The goal of this study is to understand homeowners' perceptions of flood risk, homeowners' awareness of flood protection measures, and homeowners' reasons for wanting, or not wanting, to install flood protection measures on their homes.

Why Were You Chosen to Participate? Your neighbourhood was one of four chosen by researchers to be included in this survey. Your household was randomly selected from all households within your neighbourhood. We require that the individual responding to this survey from your household is **18 years of age or older**.

The survey should take no more than 20-25 minutes to complete. To thank you for your time, if you complete the survey, you will be entered into a draw where you will have a chance of winning one of two gift cards valued at $100 each for Canadian Tire. The actual odds of winning will depend on the number of people who participate in the survey, but approximate odds are 1/400. If you wish to enter the draw, you will have to answer a skill-testing question and provide an email address so we can inform you of the draw result if you win. Your email address will not be used for any other reason. Once submitted, your email address will be removed from the dataset and saved in a separate document until the draw is complete, at which point it will be deleted.

What are the Benefits/ Risks to You? There are no direct benefits to you from this survey. However, by participating you will help us understand household perceptions on flooding and find the best ways to help individuals prevent flooding in their homes. There are no known or anticipated risks associated with your participation in this survey.

Who is Funding This? This study is being funded by MITACS, a Canadian not-for-profit organization that funds research and training programs at universities. MITACS funding is matched with sponsor funding to support internships. The sponsor for this project is the Institute for Catastrophic Loss Reduction (ICLR), a Canadian not-for-profit research institute focused on multidisciplinary disaster prevention research and communication. ICLR's mission is to reduce the loss of life and property caused by severe weather and find ways to improve society's capacity to adapt to, anticipate, mitigate, withstand and recover from natural disasters. TD Insurance is also a sponsor through their partnership with ICLR on programs to reduce losses from flooding.

Confidentiality and Data Storage: The information that you share will remain strictly confidential. All information you provide will be grouped with responses from other participants and results will never be reported by your address or any other identifying information. The data will be stored on a shared drive that can only be accessed by the investigators listed on the previous page. This data will be stored on this drive indefinitely. Our partners and funders **will not** have access to the raw data. Anonymized data may be made available to other researchers for replication purposes.

Participation and Withdrawal: Participation in this survey is **voluntary**. If you wish, you may decline to answer any of the questions asked. You may withdraw from this survey at any time. There is no penalty to you for declining to answer or withdrawing from the survey. If you withdraw from the survey before completion, your information will not be included in the analysis. However, once the survey has been completed you cannot withdraw the information you provided.

Publication of Results: Grouped results of this survey may be published in academic journals and presented at conferences as well as in the graduate student's thesis. After the completion of the survey process and analysis, feedback about this study will be available from the investigators using the contact info provided on the previous page.

Ethics Clearance: This study has been reviewed and received ethics clearance through the Research Ethics Board at the University of Alberta (ID Pro00111805). If you have questions about your rights or how research should be conducted, you can contact the University of Alberta's Research Ethics Office at XXX-XXX-XXXX or XX@ualberta.ca. This office is independent of the researchers.

Contact: If you have any questions about this study or require further information, please contact Vic Adamowicz using the contact info provided on the previous page.

Survey Consent Form

- I understand that the completion and submission of this survey means that I consent to participate in this study.
- I do not consent to participate in this study (note: choosing this option will lead to termination of the survey).

APPENDIX J – SCRIPT FOR TALKING TO HOUSEHOLDS, FOLLOW-UP VISIT

Our names are XX and XX and we are graduate students at the University of Alberta.

IF TALKED TO IN FIRST ROUND: We dropped by last week and gave you some information about our survey on stormwater flooding. We are now doing follow ups with households as a reminder about the survey and the importance of your participation to our ability to conduct our study.

HAND FOLLOW UP LETTER

We are asking households to do the survey whenever they get a chance before July 18, at which time we will be doing our draw for one of two $100 Canadian Tire gift cards. However, we will keep the survey open until the end of the month.

Thank you for your time!

IF HANGER WAS LEFT IN FIRST ROUND: Last week we dropped off a door hanger on our survey about stormwater flooding, did you have a chance to look over it?

HAND FOLLOW UP LETTER

We are asking households to do the survey whenever they get a chance before July 18, at which time we will doing our draw for one of two $100 Canadian Tire gift cards. However, we will keep the survey open until the end of the month.

Thank you for your time!

APPENDIX K – FOLLOW-UP LETTER FOR SURVEY HOUSEHOLDS

UNIVERSITY OF ALBERTA

Resource Economics and Envinronmental Sociology

Faculty of Agricultural, Life and Environmental Sciences
College of Natural and Applied Science

Homeowners' Perceptions, Knowledge, and Uptake of Protection Against Stormwater Flood Risk

Hello!

Last week we came by to invite you to participate in a University of Alberta study on stormwater flood perceptions and prevention. We either spoke to you at the door or left a doorhanger.

This letter is a follow-up to remind you of the survey and to re-iterate the importance of your response for our study. What we learn from this survey will guide us in creating best practices to help homeowners in your community, and across Edmonton, prevent future flooding in their homes.

You can do the online survey using your computer or mobile device. The survey can be found by typing this link into your internet browser address bar: **https://tinyurl.com/4bvjwzsa**

You can also access the survey by scanning the QR code (bottom right). You can do this by pointing your phone or tablet camera app at the square barcode and opening the link that is presented to you.

The survey should take 20-25 minutes to complete. We appreciate you taking the time to help us in our research.

We are asking that you complete the survey at a time of your convenience **before July 18** - this is the date we will be closing the survey and entry into the draw for one of two $100 Canadian Tire gift cards.

If you wish to enter the draw, you will have to answer a skill-testing question and provide an email address at the end of the survey. The email address is to inform you of the draw result if you win and will not be used for any other reason. Once submitted, your email address will be removed from the dataset and saved in a separate document until the draw is complete, at which point it will be deleted.

If you have any questions, concerns or technical difficulties accessing the survey, please reach out to us using the contact info below. Thank you for your support and participation in my thesis research!

Marina Giannitsos
Graduate Student, University of Alberta
Department of Resource Economics & Environmental Sociology
Email: XX@ualberta.ca

Dr. Vic Adamowicz
Supervisor/ Professor at University of Alberta
Department of Resource Economics & Environmental Sociology
Phone: XXX-XXX-XXXX
Email: XX@ualberta.ca

This study has been reviewed and received ethics clearance through the Research Ethics Board at the University of Alberta (ID Pro00111805). If you have questions about your rights or how research should be conducted, you can *contact the University of Alberta's Research Ethics Office at* XXX-XXX-XXXX or XX@ualberta.ca. This office is independent of the researchers.

University of Alberta
515 General Services Building
Edmonton, Alberta T6G 2H1

APPENDIX L – PRIZE DRAW WINNER EMAIL

Hello!

Thank you for participating in the survey "**Homeowners' Perceptions, Knowledge, and Uptake of Protection Against Stormwater Flood Risk**" conducted by the University of Alberta, Department of Resource Economics and Environmental Sociology.

As mentioned in the survey, participants could opt into a prize draw as a token of gratitude for completing the questionnaire.

Congratulations! You have been selected to win a Canadian Tire gift card valued at $100.

If you would like to accept this prize, please reply to this email so we can arrange a time to deliver the gift card. We require you to be home during the time of delivery to sign an acknowledgement receipt of the gift card.

Feel free to email me back with any questions or concerns. Thank you again for being a part of my thesis research!

Sincerely,
Marina

APPENDIX M – PRIZE DRAW WINNER ACKNOWLEDGEMENT

UNIVERSITY OF ALBERTA

Resource Economics and Envinronmental Sociology

Faculty of Agricultural, Life and Environmental Sciences
College of Natural and Applied Science

Acknowledgement

Thank you for participating in the survey "**Homeowners' Perceptions, Knowledge, and Uptake of Protection Against Stormwater Flood Risk**" conducted by the University of Alberta, Department of Resource Economics and Environmental Sociology.

Congratulations! You have been selected to win a Canadian Tire gift card valued at $100.

For financial auditing purposes, we would appreciate receiving your acknowledgement of receipt of the gift card.

I ___________________________, hereby acknowledge that I was offered a Canadian Tire gift card valued at $100 in total as an honorarium for participating in the survey. By signing below, I acknowledged that I have received the Canadian Tire gift card.

____
Signature

____
Date

University of Alberta
515 General Services Building
Edmonton, Alberta T6G 2H1

APPENDIX N – SURVEY QUESTIONNAIRE

Start of Block: Introduction

Intro-Consent1

You are invited to participate in a study on flooding perceptions and prevention.

Principal Investigators:

Marina Giannitsos
Graduate Student at University of Alberta, Dept. of Resource Economics & Environmental Sociology
Email: XX@ualberta.ca

Vic Adamowicz
Professor at University of Alberta, Dept. of Resource Economics & Environmental Sociology
Phone: XXX-XXX-XXXX
Email: XX@ualberta.ca

Peter Boxall
Professor at University of Alberta, Dept. of Resource Economics & Environmental Sociology
Phone: XXX-XXX-XXXX
Email: XX@ualberta.ca

John Parkins
Professor at University of Alberta, Dept. of Resource Economics & Environmental Sociology
Phone: XXX-XXX-XXXX
Email: XX@ualberta.ca

What is the Purpose? This survey is being done as part of a graduate student's thesis research. The goal of this study is to understand homeowners' perceptions of flood risk, homeowners' awareness of flood protection measures, and homeowners' reasons for wanting, or not wanting, to install flood protection measures on their homes.

Why Were You Chosen to Participate? Your neighbourhood was one of four chosen by researchers to be included in this survey. Your household was randomly selected from all households within your neighbourhood. *We require that the individual responding to this survey from your household is **18 years of age or older**.*

The survey should take no more than 20-25 minutes to complete. To thank you for your time, if you complete the survey, you will be entered into a draw where you will have a chance of winning one of two gift cards valued at $100 each for Canadian Tire. The actual odds of winning will depend on the number of people who participate in the survey, but approximate odds are 1/400.

What are the Benefits/ Risks to You? There are no direct benefits to you from this survey. However, by participating you will help us understand household perceptions on flooding and find the best ways to help individuals prevent flooding in their homes. There are no known or anticipated risks associated with your participation in this survey.

Who is Funding This? This study is being funded by MITACS, a Canadian not-for-profit organization that funds research and training programs at universities. MITACS funding is matched with sponsor funding to support internships. The sponsor for this project is the Institute for Catastrophic Loss Reduction (ICLR), a Canadian not-for-profit research institute focused on multidisciplinary disaster prevention research and communication. ICLR's mission is to reduce the loss of life and property caused by severe weather and find ways to improve society's capacity to adapt to, anticipate, mitigate, withstand, and recover from natural disasters. TD Insurance is also a sponsor through their partnership with ICLR on programs to reduce losses from flooding.

Intro-Consent2

Confidentiality: The information that you share will remain strictly confidential. All information you provide will be grouped with responses from other participants and identifying information, such as names or addresses, will not be associated with any survey responses. *Access to the original data will be restricted to the investigators listed on the previous page*. Our partners and funders **will not** have access to the original data. Anonymized data may be made available to other researchers for replication purposes.

Participation and Withdrawal: Participation in this survey is ***voluntary***. If you wish, you may decline to answer any of the questions asked. You may decide to withdraw from this survey at any time. There is no penalty to you for declining to answer or withdrawing from the survey. If you withdraw from the survey before completion, your information will not be included in the analysis. However, once the survey has been completed you cannot withdraw the information you provided.

Publication of Results: Grouped results of this survey may be published in academic journals and presented at conferences as well as in the graduate student's thesis. After the completion of the survey process and analysis, feedback about this study will be available from the investigators using the contact info provided on the previous page.

Ethics Clearance: This study has been reviewed and received ethics clearance through the Research Ethics Board at the University of Alberta (ID Pro00111805). If you have questions about your rights or how research should be conducted, you can contact the University of Alberta's Research Ethics Office at XXX-XXX-XXXX or XX@ualberta.ca. This office is independent of the researchers.

Contact: If you have any questions about this study or require further information, please contact Vic Adamowicz using the contact info provided on the previous page.

Thank you for participating in my thesis research!!

○ I understand the completion and submission of this survey means I consent to participate in this study.

○ I do not consent to participate in this study, and I would like to opt out of the survey with no further contact from the research team. Please fill your address in the box below so we do not revisit your home (Example: 1234 56 ST).

____

Intro-Address

Before we get started, please enter your address in the box below. Please only enter your **house number** and **street/avenue.** Example: 1234 56 ST.

We require your address for two reasons:

- It will tell us that you completed the survey, so we do not follow up with you in person.
- It will allow us to connect the results from this survey to a second, shorter follow-up survey we are hoping to do sometime between Fall 2022 and Spring 2023.

Your address ***will not*** be associated with your answers to the survey.

____

Exiting Reminder

Your answers and position will be automatically saved as you go through the survey.

This means if you accidently exit the survey you can return to where you left off, as long as you are using the same device.

End of Block: Introduction

Start of Block: House Information (H)

H-1 What best describes your current living situation?

- ○ Homeowner
- ○ Renter
- ○ Other (please explain in the box below)

____

H-2 Approximately how many years have you been a homeowner over your lifetime? If less than 1 year, please write 0.

Number of years as a homeowner: ____

H-3 Approximately how many years have you lived in the home you live in now? If less than 1 year, please write 0.

Number of years lived in current home: ____

H-4 When was your current home (the home you live in now) built?

- ○ Before 1950
- ○ Between 1950 and 1959
- ○ Between 1960 and 1969
- ○ Between 1970 and 1979
- ○ Between 1980 and 1989
- ○ Between 1990 and 1999
- ○ Between 2000 and 2009
- ○ Between 2010 and 2019
- ○ Between 2020 and 2021
- ○ I don't know

End of Block: House Information (H)

Start of Block: Definitions

Def-1

Before we continue with questions, we would like to familiarize you with definitions that are important to know throughout the survey.

Def-2

A stormwater flood happens when a severe rainfall event overwhelms urban storm and sewer systems, causing excess water to pool in low lying areas within yards and streets.

Image Source: americanrivers.org, n.d. & cbc.ca, 2021.

This type of flooding is **<u>not</u>** related to an overflowing body of water (river, lake, etc.) and can happen anywhere under the right conditions.

The aftermath of a stormwater flood event can range from only clean-up required to severe water damage to homes, businesses, and city infrastructure.

Def-3

Stormwater flood events are most likely to cause damage to the basement or lower levels of a home.

Damage is usually caused by water entering the home, either through sewer backup, infiltration, overland flooding, or a combination.

Image Source: utilitieskingston.com, n.d.

Sewer backup happens when heavy rainfall overwhelms the municipal sewer system. This causes sewage to flow into a home through an input source, such as a floor drain, toilet, or shower.

Image Source: permaseal.net, 2011

Infiltration (seepage) happens when heavy rainfall saturates the soil around a home or raises the groundwater level to a point where it is higher than the home's foundation. The groundwater then enters the home through cracks in the basement floors or walls, or through failed flood protection devices, such as a sump pump system or foundation drain (weeping tile).

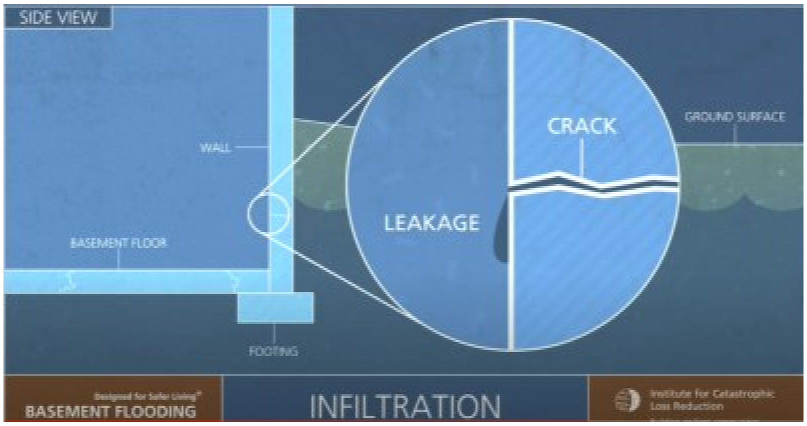

Image Source: iclr.org, 2012

Overland happens when heavy rainfall cannot enter the storm system due to over-capacity, poor yard grading, impermeable surfaces (such as concrete), or blockages in the system (including blocked street grates). This causes water to overflow onto yards and streets, and can enter homes through doors, windows, garages, vents, and other above-ground openings.

Def-4

A flood protection measure is any modifications made to a home for the purpose of limiting or preventing damage caused by floods.

These can be installed devices such as backwater valves, sump pump systems, foundation drains (weeping tiles), etc. OR they can be other home modifications known to help protect against floods, such as proper yard grading, removal of trees close to the home, disconnecting downspouts from the urban storm or sewer systems, to name a few.

Image Source: canadianrooter.com, n.d.

Def-5

The term **flood risk** is used throughout this survey to indicate the likelihood of any amount of water (minimal or severe) entering your home due to a severe rainfall event.

End of Block: Definitions

Start of Block: Level of Knowledge (LOK)

LOK-5 Do you know if your home is at risk of flooding? If so, where did you source your information? Choose **all** that apply.

- ▢ From previous personal experience (you have had water enter your current home before)
- ▢ From talking to family or friends
- ▢ From talking to neighbours or community members
- ▢ From news media
- ▢ From information sessions on flooding
- ▢ From municipal resources (city website, reports, flood maps, etc.)
- ▢ From the Epcor Flood Prevention Home Check-Up Program or other home assessment services
- ▢ From your plumber
- ▢ From your insurance company, broker, or agent
- ▢ Other (please specify in the box below)

____

- ▢ ⊗Have never looked for or received information on home's flood risk potential

---

LOK-6a Do you have coverage against flood damage on your home insurance policy? If so, what kind of flooding does your coverage entail? Choose **all** that apply.

- ▢ Sewer backup coverage
- ▢ Infiltration (seepage) coverage
- ▢ Overland flood coverage
- ▢ ⊗I have home insurance, but do not have coverage for flood damage
- ▢ ⊗I don't have home insurance or coverage for flood damage
- ▢ ⊗I don't know

LOK-6b Do you have coverage against flood damage on your renters insurance policy? If so, what kind of flooding does your coverage entail? Choose **all** that apply.

- ☐ Sewer backup coverage
- ☐ Infiltration (seepage) coverage
- ☐ Overland flood coverage
- ☐ ⊗I have home insurance, but do not have coverage for flood damage
- ☐ ⊗I don't have home insurance or coverage for flood damage
- ☐ ⊗I don't know

LOK-7 What is the annual cost of your insurance premium, deductible, and flood damage rider (if applicable)?

- ☐ Insurance Premium ($) ____
- ☐ Deductible ($) ____
- ☐ Flood Damage Rider ($) _______________________________________
- ☐ ⊗I don't know/ I don't remember

LOK-8 Do you know of any local programs or services that you can access to determine your home's flood risk?

- ○ Yes
- ○ No

LOK-9 Do you know of any financial incentives or subsidies that are available to you for installing flood protection measures on your home to reduce your flood risk?

- ○ Yes
- ○ No

LOK-10 What is your level of knowledge for the following flood protection measures? Please select a response for each measure.

If you are taking this survey on a mobile device you may need to rotate your device horizontally/ sideways to see this question as intended.

	Not knowledgeable *I don't know what it is and don't know how it works to prevent flooding*	Slightly knowledgeable *I know what it is, but don't know how it works to prevent flooding*	Moderately knowledgeable *I know what it is and know how it works to prevent flooding*	Very knowledgeable *I know what it is, know how it works, and know how to maintain it*
Backwater valve	○	○	○	○
Extended downspouts	○	○	○	○
Landscaping for flood protection (yard grading, swales, berms, etc.)	○	○	○	○
Rainwater collection devices/ systems	○	○	○	○
Sump pump system	○	○	○	○
Sump pump battery backup	○	○	○	○
Foundation drain (weeping tile)	○	○	○	○

End of Block: Level of Knowledge (LOK)

Start of Block: Existing Protection (EP)

EP-11 Do you have a **backwater valve** installed in your current home?

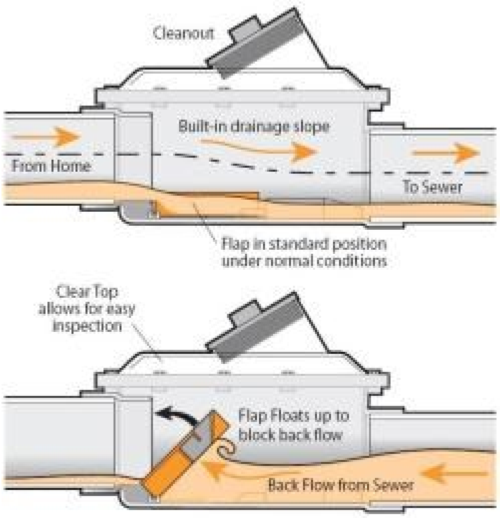

Image Source: backwatervalve.com, n.d.

Definition: A backwater valve is a device installed on the sewer line that is designed to automatically close when a sewer backup occurs so that sewer water cannot enter the home.

- ☐ Yes, my home had a backwater valve installed **before** I moved in
- ☐ Yes, I had a backwater valve installed **after** I moved in
- ☐ ⊗No
- ☐ ⊗I don't know

EP-12 Please fill in the approximate dollar amount spent on installing the backwater valve (including labour, if applicable) and the year it was installed.

- ☐ Money Spent on Measure ($) ____
- ☐ Year Measure was Installed ____
- ☐ ⊗I don't know/ I don’t remember

EP-13 Do you maintain your backwater valve at least once a year?

- ○ Yes
- ○ No

EP-14 Do you have **extended downspouts** installed on your current home?

Image Source: edmonton.ca, n.d.

Definition: Downspouts are pipes that carry rain water or snowmelt from the roof gutter system to the yard or storm service. As a flood protection measure, they can be extended further away from the home.

- ☐ Yes, my home had extended downspouts installed **before** I moved in
- ☐ Yes, I installed extended downspouts **after** I moved in
- ☐ ⊗No
- ☐ ⊗I don't know

EP-15 Do you have any **landscaping for flood protection** around your current home?

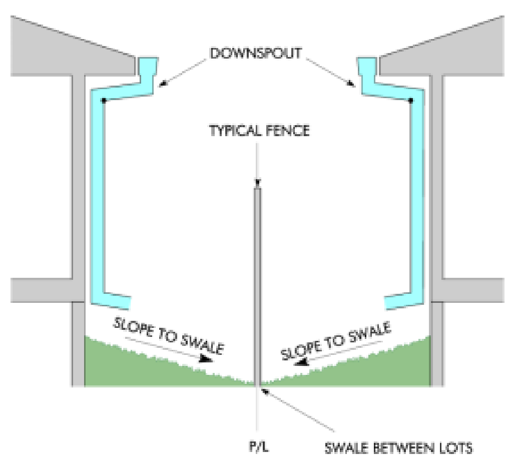

Image Source: edmonton.ca, n.d.

Definition: Landscaping to protect against floods can include a slight slope to the surface of a yard to re-direct water away from the home (grading); a shallow, sloped ditch in the yard to direct surface runoff towards a city lane or street (swale); and or a raised bank/ retaining wall to keep water from entering the yard (berm).

- ☐ Yes, my home had landscaping for flood protection installed **before** I moved in
- ☐ Yes, I had landscaping for flood protection done **after** I moved in
- ☐ ⊗No
- ☐ ⊗I don't know

EP-16 Do you have a **rainwater collection device/ system** installed on your current home?

Image Source: edmontonfoodcouncil.org, 2020

Definition: A rainwater collection device or system is connected to a home's downspouts and allows for the collection of rain water or snowmelt from the roof. When the device/ system is full, it will drain the collected rain water away from the home. A rain barrel is an example of a rain water collection device.

- ☐ Yes, my home had a rainwater collection system **before** I moved in
- ☐ Yes, I installed a rainwater collection system **after** I moved in
- ☐ ⊗No
- ☐ ⊗I don't know

EP-17 Do you have a **sump pump system** installed in your current home?

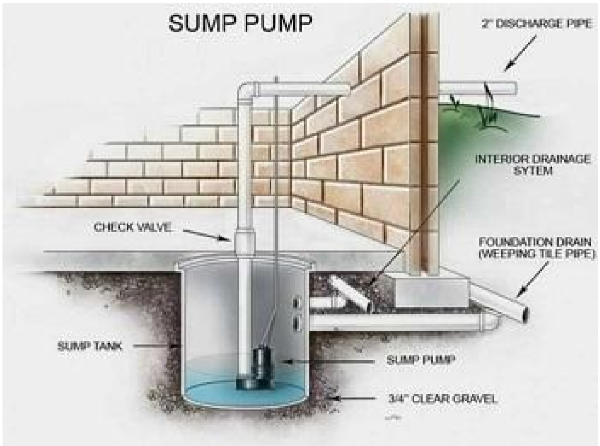

Image Source: homeinspectiongeeks.com, n.d. & basements911.com, 2019

Definition: A system that includes a sump tank, a sump pump, a check valve, and a discharge pipe. During a rainstorm, groundwater around the foundation of a home will collect in the sump tank, which is located at the lowest point in the basement. When the water in the sump tank rises to a certain level, the sump pump, which is located inside the sump tank, pumps the water through the discharge pipe directly to the yard.

- ☐ Yes, my home had a sump pump system **before** I moved in
- ☐ Yes, I had a sump pump system installed **after** I moved in
- ☐ ⊗No
- ☐ ⊗I don't know

EP-18 Please fill in the approximate dollar amount spent on installing the sump pump system (including labour, if applicable) and the year it was installed.

- ☐ Money Spent on Measure ($) ____
- ☐ Year Measure was Installed ____
- ☐ ⊗I don't know/ I don’t remember

EP-19 Do you maintain your sump pump system at least once a year?

- ○ Yes
- ○ No

EP-20 Does your sump pump system also have a **battery backup**?

Image Source: peachyrooms.com, 2021

Definition: A battery backup is a secondary (backup) pump, connected to a battery, that is installed next to the primary pump in the sump tank. The backup pump is designed to pump water out of the sump tank if the power goes out.

- ☐ Yes, my home had a sump pump battery backup **before** I moved in
- ☐ Yes, I had a sump pump battery backup installed **after** I moved in
- ☐ ⊗No
- ☐ ⊗I don't know

EP-21 Please fill in the approximate dollar amount spent on installing the sump pump battery backup (including labour, if applicable) and the year it was installed.

- ☐ Money Spent on Measure ($) ____
- ☐ Year Measure was Installed ____
- ☐ ⊗I don't know/ I don’t remember

EP-22 Do you maintain your sump pump battery backup at least once a year?

- ○ Yes
- ○ No

EP-23 Do you have a **foundation drain (weeping tile)** installed around your current home?

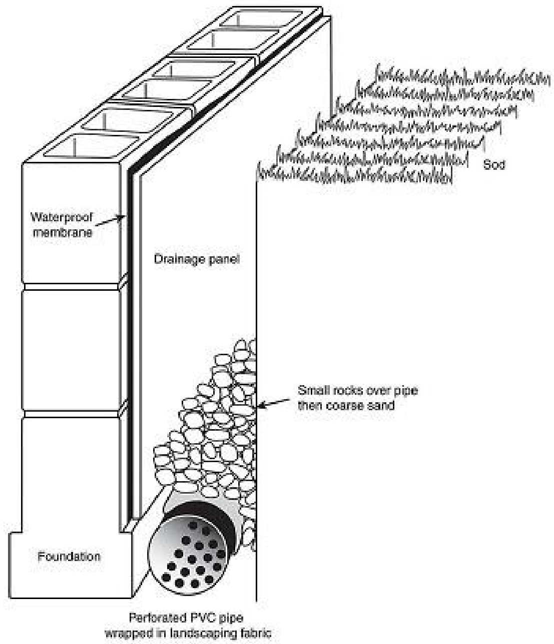

Image Source: waterproof-experts.ca, n.d.

Definition: A foundation drain, also called a weeping tile, is buried around the exterior (sometimes interior) footing of a home and is designed to collect groundwater that seeps down around the foundation walls and move it away from the home or towards a sump tank.

- ☐ Yes, my home had a foundation drain installed **before** I moved in
- ☐ Yes, I had a foundation drain installed **after** I moved in
- ☐ ⊗No
- ☐ ⊗I don't know

EP-24 Is your foundation drain/ weeping tile connected directly to the municipal storm and or sewer system?

- ○ Yes
- ○ No
- ○ I don't know

EP-25 Below is a list of additional stormwater flood protection measures. Please choose **all** measures that you or someone else has taken during the time you have lived in your home.

- ☐ Disconnected downspouts from the sewer system
- ☐ Fixed/ replaced the sewer line from house to main line
- ☐ Removed trees/ roots from yard
- ☐ Fixed cracks in home foundation
- ☐ Protected important belongings in basement/ lower level of home (example – put belongings in waterproof containers)
- ☐ Removed important belongings from basement/ lower level of home
- ☐ Other (please specify in the box below)

____

- ☐ ⊗I haven't taken any of the above measures

EP-26a Which of the following reasons best describe why you chose to implement flood protection measures on your home? Please choose **all** relevant reasons.

- ☐ General worry about being flooded; flood protection puts my mind at ease
- ☐ I experienced a flood and did not want to experience it again
- ☐ My family, friends, and or neighbours experienced a flood and I did not want to experience one
- ☐ I learned about the importance of flood protection from information sessions or news media
- ☐ I noticed aspects about my house that made it vulnerable to flooding (cracks, tree roots, etc.)
- ☐ I had an assessment done on my home that showed potential for flood issues
- ☐ I was conducting renovations /repairs on my home already and decided to include flood protection measures
- ☐ I received a financial incentive from the city/ government
- ☐ I received a financial incentive from my insurance company
- ☐ I did/do not have flood insurance/ cannot rely on insurance
- ☐ Other (write the reason in the box below)

____

EP-27a Below you will find all the reasons you chose in the last question.

Please choose the reason that was **most important** to your decision in implementing flood protection measures.

- ○ General worry about being flooded; flood protection puts my mind at ease
- ○ I experienced a flood and did not want to experience it again
- ○ My family, friends, and or neighbours experienced a flood and I did not want to experience one
- ○ I learned about the importance of flood protection from information sessions or news media
- ○ I noticed aspects about my house that made it vulnerable to flooding (cracks, tree roots, etc.)
- ○ I had an assessment done on my home that showed potential for flood issues
- ○ I was conducting renovations /repairs on my home already and decided to include flood protection measures
- ○ I received a financial incentive from the city/ government
- ○ I received a financial incentive from my insurance company
- ○ I did/do not have flood insurance/ cannot rely on insurance
- ○ Other (write the reason in the box below)

EP-26b Which of the following reasons best describe why you did not implement flood protection measures (FPM) on your home? Please choose **all relevant** reasons.

- ☐ My home is not at risk of flooding
- ☐ My home was already protected with adequate flood protection measures when I purchased it
- ☐ I have flood coverage on my home insurance
- ☐ I never thought about it
- ☐ I do not have enough information to make a decision on what flood protection measures to take
- ☐ I have received conflicting information about flood protection measures from various sources and decided against implementing
- ☐ Flood protection measures are too expensive
- ☐ Inconvenience of flood protection installation (time commitment involved, construction noise/ debris/ waste/ odour, finding and scheduling contractors, etc.)
- ☐ Maintenance (I am unsure of how to conduct maintenance on flood protection measures / I am not interested in conducting maintenance)
- ☐ It is the government's responsibility to protect residents against flooding
- ☐ Flood protection measures are ineffective at protecting against flooding
- ☐ Other (write the reason in the box below)

____

EP-27b Below you will find all the reasons you chose in the last question.
Please choose the reason that was **most important** for your decision in not implementing flood protection measures.

- ○ My home is not at risk of flooding
- ○ My home was already protected with adequate flood protection measures when I purchased it
- ○ I have flood coverage on my home insurance
- ○ I never thought about it
- ○ I do not have enough information to make a decision on what flood protection measures to take
- ○ I have received conflicting information about flood protection measures from various sources and decided against implementing
- ○ Flood protection measures are too expensive
- ○ Inconvenience of flood protection installation (time commitment involved, construction noise/ debris/ waste/ odour, finding and scheduling contractors, etc.)
- ○ Maintenance (I am unsure of how to conduct maintenance on flood protection measures / I am not interested in conducting maintenance)
- ○ It is the government's responsibility to protect residents against flooding
- ○ Flood protection measures are ineffective at protecting against flooding
- ○ Other (write the reason in the box below)

End of Block: Existing Protection (EP)

Start of Block: Risk Perceptions (RP)

Context-1

As we mentioned earlier in this survey, a **stormwater flood** happens when a severe rainfall event overwhelms urban storm and sewer systems, causing excess water to pool in low lying areas within yards and streets.

There are a number of signs your home may be vulnerable to water damage caused by a stormwater flood event.

Context-2

Common factors that can increase a home's risk of experiencing **sewer backup** during a stormwater flood event include:

- Cracks in the sewer pipe caused by tree roots, shifting soil, poor installation, etc.;
- Collapse of the sewer pipe due to age or sewer pipe material;
- Clogs in the sewer pipe caused by pouring fats, oils, grease, or other debris down the sink;
- The home's downspouts, weeping tiles, or area drains are connected to the urban sewer or storm system;
- The home doesn’t have specific devices to protect against this type of flooding, such as a backwater valve;
- The city sewer system does not have the capacity for the water usage of the neighbourhood.

Context-3

Common factors that can increase a home's risk of experiencing **infiltration** during a stormwater flood event include:

- The home is located in a low lying area with a high water table;
- The home has poor lot grading (yard slopes towards the home);
- There are cracks in the home's foundation walls or floor;
- The home’s roof gutters/eavestroughs are not regularly cleaned (clogged with leaves, debris, etc.);
- The home’s sump pump discharge pipe and or downspouts evacuate too close to the foundation;
- The neighbouring lot(s) are graded towards your home;
- The neighbouring sump pump discharge pipe and or downspouts are directed towards your home.

RP-28 Is your home vulnerable to either sewer backup or infiltration (seepage) based on the factors you just read about?

○ Yes, sewer backup
○ Yes, infiltration
○ Yes, both sewer backup and infiltration
○ No
○ I don't know

RP-29 BACKUP

Assume you will still be living in your current home over the next 10 years.

In your opinion, what is the **percent chance** you will have water enter your home **at least once over the next 10 years** due **to sewer backup** during a stormwater flood event?

The following provides guidance for percentage chance:
No Chance (0%)
Low (1-24%)
Med-Low (25-49%)
Med-High (50-74%)
High (75-99%)
Certain (100%)

Please write only one number in the box below - do not enter a range or the % sign. If you are unsure, please provide your best guess.

____

RP-30 INFILTRATION

Assume you will still be living in your current home over the next 10 years.

In your opinion, what is the **percent chance** you will have water enter your home **at least once over the next 10 years** due to **infiltration (seepage)** during a stormwater flood event?

The following provides guidance for percentage chance:
No Chance (0%)
Low (1-24%)
Med-Low (25-49%)
Med-High (50-74%)
High (75-99%)
Certain (100%)

Please write only one number in the box below - do not enter a range or the % sign. If you are unsure, please provide your best guess.

____

RP-31 POWER IV

Assume you will still be living in your current home over the next 10 years.

In your opinion, what is the **percent chance** you will have an **unexpected power outage** lasting continuously for a few hours **at least once over the next 10 years**?

The following provides guidance for percentage chance:
No Chance (0%)
Low (1-24%)
Med-Low (25-49%)
Med-High (50-74%)
High (75-99%)
Certain (100%)

Please write only one number in the box below - do not enter a range or the % sign. If you are unsure, please provide your best guess.

____

RP-32 In your opinion, the number of severe stormwater flood events in Edmonton will _________ over the next 10 years?

- ○ Increase substantially
- ○ Increase moderately
- ○ Stay the same
- ○ Decrease moderately
- ○ Decrease substantially

RP-33 If you were to experience a flooding event in your basement today, and all belongings not raised at least 2 feet above the floor were damaged, what would you estimate the cost of replacing your belongings to be?

- Nothing, I do not keep any of my belongings in my basement
- Under $5,000
- $5,000-$9,999
- $10,000-$14,999
- $15,000-$19,999
- $20,000-$24,999
- $25,000-$30,000
- Over $30,000
- I don't know
- I prefer not to say

RP-34 Do you keep any irreplaceable belongings (example: old photo albums, keepsakes, heirlooms, sentimental items, etc.) in your basement in places vulnerable to flooding (not raised at least 2 feet above the floor or not in water proof containers)?

- Yes
- No

RP-35 How much do you agree or disagree with this statement?:

"I am capable of implementing measures to protect my home and belongings from flooding."

- Strongly Agree
- Somewhat Agree
- Neither Agree or Disagree
- Somewhat Disagree
- Strongly Disagree

RP-36 How much do you agree or disagree with the following statement?:

"If I were to experience a basement flood, I would be able to afford the home repairs and replacement of my damaged belongings."

- Strongly Agree
- Somewhat Agree
- Neither Agree or Disagree
- Somewhat Disagree
- Strongly Disagree

End of Block: Risk Perceptions (RP)

Start of Block: Prevention Motivation (PM)

PM-37 Who do you trust when it comes to making decisions about flood risk reduction and protection? Choose **all** that apply.

- ☐ Family or friends
- ☐ Neighbours or community members
- ☐ News media
- ☐ EPCOR
- ☐ City of Edmonton
- ☐ Plumber
- ☐ Insurance company, broker, or agent
- ☐ Other (please specify in the box below)

____

- ☐ ⊗No one

PM-38 If you learned that your home was at risk of flooding, what approaches would increase the chance that you would install a flood protection measure? Choose **all** that apply.

- ☐ Clear information on how much of your risk would be reduced by a flood protection measure
- ☐ Knowledge of what others in the neighbourhood with similar flood risks have done regarding installation of flood protection
- ☐ A free service that would select a reputable plumber for you, book the time to install the flood protection measure, and complete all necessary paperwork. All you have to do is pay the cost for the device and installation.
- ☐ A subsidy from the City/EPCOR to cover some of the cost of the flood protection measure, received as a lump sum after install complete (you have to pay the full cost of the device and installation up front).
- ☐ A subsidy from the City/EPCOR to cover some of the cost of the flood protection measure, received as a lump sum before install complete (you have to pay for any remaining costs afterwards).
- ☐ Having the City pay the full cost of the device and installation up front and then you are responsible for paying off this cost in installments (through your property taxes) over a number of years.
- ☐ A reduction in your annual home insurance premium.
- ☐ Other 1 (please specify in the box below)

  ____
- ☐ Other 2 (please specify in the box below)

  ____
- ☐ ⊗No approach - not interested/ already adequately protected.

PM-39 Below you will find the approaches you chose in the last question.

Please rank the approaches, by putting numbers in the boxes, with 1 being the **most likely** to increase the chance that you would install a flood protection measure.

______ Clear information on how much of your risk would be reduced by a flood protection measure.
______ Knowledge of what others in the neighbourhood with similar flood risks have done regarding installation of flood protection.
______ A free service that would select a reputable plumber for you, book the time to install the flood protection measure, and complete all necessary paperwork. All you have to do is pay the cost for the device and installation.
______ A subsidy from the City/EPCOR to cover some of the cost of the flood protection measure, received as a lump sum after install complete (you have to pay the full cost of the device and installation up front).
______ A subsidy from the City/EPCOR to cover some of the cost of the flood protection measure, received as a lump sum before install complete (you have to pay for any remaining costs afterwards).
______ Having the City pay the full cost of the device and installation up front and then you are responsible for paying off this cost in installments (through your property taxes) over a number of years.
______ A reduction in your annual home insurance premium.
______ Other 1 (please specify in the box below)
______ Other 2 (please specify in the box below)

End of Block: Prevention Motivation (PM)

Start of Block: Stated Preference Intro

SP-Intro1

We are now going to ask whether or not you would be willing to install specific flood protection devices.

You will be presented with one or two flood protection devices. If you are presented with two, please choose independently each time. In other words, do not compare between the flood protection devices.

SP-Intro2

We know that survey takers make choices that are not always consistent with the choices they would make in real life.

Survey takers often ignore the sacrifices they would need to make if their choice meant they would have less money to spend on other goods (food, clothing, vehicles, etc.), other home renovations, or holidays.

Therefore, we are asking you to please make your choices as if they were real. In other words, as if you were speaking with a contractor who was ready to install the flood protection measure on your home today, and you would then be responsible for paying the price presented to you.

There are no right or wrong answers and we are not looking for you to answer a specific way.

End of Block: Stated Preference Intro

Start of Block: Willingness to Pay for Backwater Valve (WTP-BWV)

BWV-Info1 Please read the following information on backwater valves before moving onto the question.

How does a backwater valve work? Sometimes, during sudden and heavy rainfall, sewer lines can become overwhelmed, causing sewage to "backup" from the city sewer system and into your house.

Backwater valves are designed to automatically close when a sewer backup occurs, reducing your chances of experiencing sewer backup flooding.

Figure 1: Mechanics of a Backwater Valve

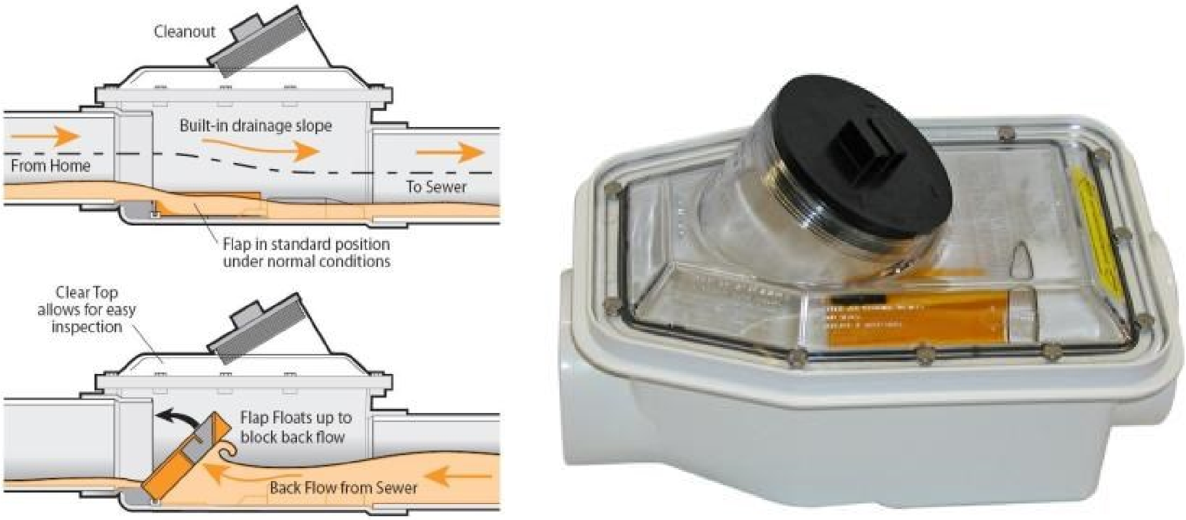

Image Source: backwatervalve.com, n.d.

BWV-Info2 <u>Please read the following information on backwater valves before moving onto the question.</u>

How is a backwater valve installed? A backwater valve is typically installed by a licensed plumber, who will dig into your basement floor where the sewer pipe is located and replace a short piece of the pipe with the backwater valve. An inspection will need to be done and then the basement floor is re-sealed with a panel access for the valve.

Installing a backwater valve takes between 4 to 12 hours, on average, depending on the home.

Figure 2: Backwater Valve Connection to Home

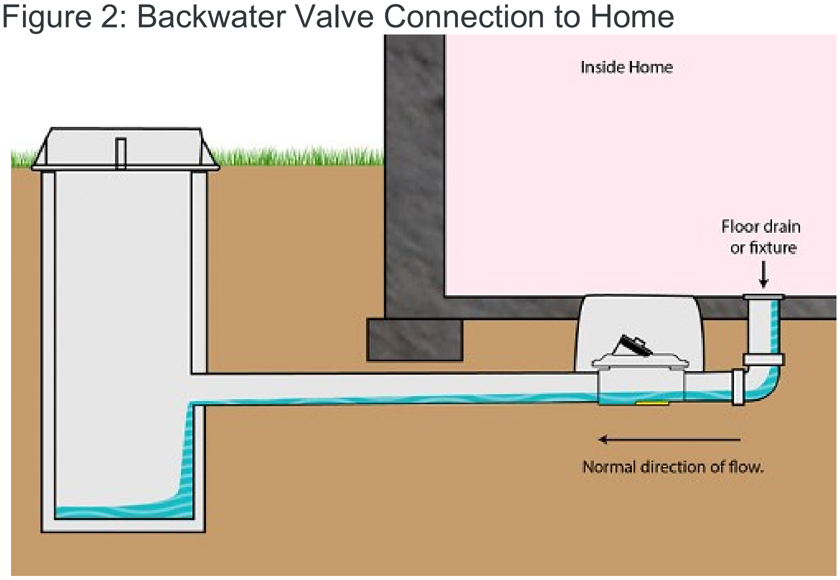

Image Source: torontoplumbers.com, n.d.

Figure 3: Backwater Valve Installation Example

Image Source: torontoplumbers.com, n.d.

BWV-Info3 Please read the following information on backwater valves before moving onto the question.

How is a backwater valve maintained? Like many things in a home, backwater valves require periodic maintenance to ensure proper performance over time. It should be inspected at least once a year, but preferably every three months. Homeowners may require the assistance of a qualified plumber to carry out maintenance or repairs of a backwater valve.

An improperly maintained valve may fail during a flood event.

BWV-Info4 We are now going to ask whether or not you would choose to install a backwater valve.

Keep in mind that some people might not install a backwater valve because:

- They believe their home is already adequately protected against flooding
- They believe the device will be ineffective at protecting against flooding
- They believe the risk reduction is not worth the expense
- They do not want the inconvenience of the installation or maintenance of the device
- They have insurance coverage that will cover the replacement of belongings if a flood event occurs

Other people might install a backwater valve because:

- They believe their home is not adequately protected against flooding
- They believe the device will be effective at protecting against flooding
- They believe the risk reduction is worth the expense
- They do not want the inconvenience of clean-up and or repair after a flood event
- They do not want to lose valuable or irreplaceable belongings due to a flood event

If you are taking this survey on a mobile device you may need to rotate your device horizontally/ sideways to see the following question as intended.

BWV-40-600.25 Earlier in this survey, you stated that your chance of flooding from sewer backup was **${RP-24 BACKUP/ChoiceTextEntryValue}%**

Assume installing a backwater valve in your home will **reduce your chance of sewer backup flooding to almost 0%** (with proper maintenance of the device).

Also assume that, with the installation of a backwater valve:

- The City of Edmonton/EPCOR will give you a **one-time $600 subsidy (rebate)** for the installation.
- Your insurance company will give you an **annual $25 discount** off your home insurance premium.

To get the subsidy you will need to have your home inspected, fill out paper work, and book a contractor for installation (approx. 2 hours). You will also need to be home for the installation of the device and a follow-up inspection (approx. 4-12 hours).

The subsidy will be given to you *after* the installation is complete, which means you will have to pay the full cost of the device and installation upfront. This is shown in the chart below as the **upfront cost.** The final cost to you, after you receive the subsidy, is shown in the chart below as the **final net cost**.

How likely are you to install a backwater valve if the total cost to you is?

Please select one choice per row

Upfront Cost | Final Net Cost	Definitely Yes (100% Likely)	Probably Yes (51-99% Likely)	Probably No (1-49% Likely)	Definitely No (0% Likely)
$600 | $0	○	○	○	○
$850 | $250	○	○	○	○
$1,100 | $500	○	○	○	○
$1,350 | $750	○	○	○	○
$1,600 | $1,000	○	○	○	○
$1,850 | $1,250	○	○	○	○
$2,100 | $1,500	○	○	○	○
$2,350 | $1,750	○	○	○	○
$2,600 | $2,000	○	○	○	○
$2,850 | $2,250	○	○	○	○
$3,100 | $2,500	○	○	○	○

NOTE FOR THESIS READER: There were a total of 16 different combinations of the WTP question on backwater valves, made up of four different subsidy levels and four different insurance premium discounts.

Subsidy Levels: $600; $800; $1000; $1200
Insurance Premium Discount Levels: $25; $50; $75; $100

Every respondent that was triggered to answer the willingness to pay question on backwater valves was presented with one combination at random. The only difference between combinations was the upfront cost; the final net cost remained the same no matter what combination a respondent was presented with.

BWV-41a You said probably yes or definitely yes to at least one of the payment options in the last question. Why did you choose to install the backwater valve over keeping your current situation?

Choose **all** relevant reasons.

If you have other reasons that are not listed, please write your top reason in the "other" option box.

- ☐ The risk reduction is worth the expense
- ☐ The City subsidy made it worth the additional expense
- ☐ The insurance premium reduction made it worth the additional expense
- ☐ General worry about being flooded; installing this measure will provide some peace of mind
- ☐ I do not have home insurance/ I do not have flood coverage/ I cannot rely on my insurance
- ☐ I do not want the inconvenience and stress of repairing home/ replacing belongings after a flood event
- ☐ I do not want to lose valuable and or irreplaceable belongings due to a flood event
- ☐ It is my responsibility to protect my house and belongings from flooding
- ☐ Other (write the reason in the box below)

____

BWV-42a Below you will find all the reasons you chose in the last question.

Please choose the reason that was **most important** for your decision to install the backwater valve over keeping your current situation.

- ○ The risk reduction is worth the expense
- ○ The City subsidy made it worth the additional expense
- ○ The insurance premium reduction made it worth the additional expense
- ○ General worry about being flooded; installing this measure will provide some peace of mind
- ○ I do not have home insurance/ I do not have flood coverage/ I cannot rely on my insurance
- ○ I do not want the inconvenience and stress of repairing home/ replacing belongings after a flood event
- ○ I do not want to lose valuable and or irreplaceable belongings due to a flood event
- ○ It is my responsibility to protect my house and belongings from flooding
- ○ Other (write the reason in the box below)

BWV-41b You said probably no or definitely no for the majority of the payment options in the last question. Why did you choose to keep your current situation over the installation of the backwater valve?

Choose **all** relevant reasons.

If you have other reasons that are not listed, please write your top reason in the "other" option box.

- ☐ The risk reduction is not worth the expense
- ☐ Cannot afford the upfront cost (before receiving the subsidy)
- ☐ This measure will be ineffective at protecting my home against flooding
- ☐ My home is not at risk of flooding
- ☐ My home is already protected with adequate flood protection measures
- ☐ I have flood coverage on home insurance / I can rely on my insurance
- ☐ I do not want the inconvenience (time, invasiveness, etc.) of the installation
- ☐ I am unsure of how to conduct maintenance/ not interested in maintenance on the device
- ☐ I do not have enough information to make a decision
- ☐ Other (write the reason in the box below)

____

BWV-42b Below you will find all the reasons you chose in the last question.

Please choose the reason that was **most important** for your decision to keep your current situation over installing the backwater valve.

- ○ The risk reduction is not worth the expense
- ○ Cannot afford the upfront cost (before receiving the subsidy)
- ○ This measure will be ineffective at protecting my home against flooding
- ○ My home is not at risk of flooding
- ○ My home is already protected with adequate flood protection measures
- ○ I have flood coverage on home insurance / I can rely on my insurance
- ○ I do not want the inconvenience (time, invasiveness, etc.) of the installation
- ○ I am unsure of how to conduct maintenance/ not interested in maintenance on the device
- ○ I do not have enough information to make a decision
- ○ Other (write the reason in the box below)

End of Block: Willingness to Pay for Backwater Valve (WTP-BWV)

Start of Block: Willingness to Pay for Sump Pump System (WTP-SPS)

SPS-Info1 Please read this information on sump pump systems before moving onto the question.

How does a sump pump system work? Sometimes, during sudden and heavy rainfall, the ground around a home's foundation can become saturated with water, putting the home at risk of water seeping in through the foundation floor or walls. Sump pump systems are designed to collect the groundwater around the home's foundation into the sump tank and pump it out to the yard, far from the foundation. This reduced your chances of experiencing infiltration flooding.

A battery backup pump is also often included in new installations. This allows the system to function if electricity is lost, which is sometimes the case in a large storm.

Figure 1: Mechanics of a Sump Pump

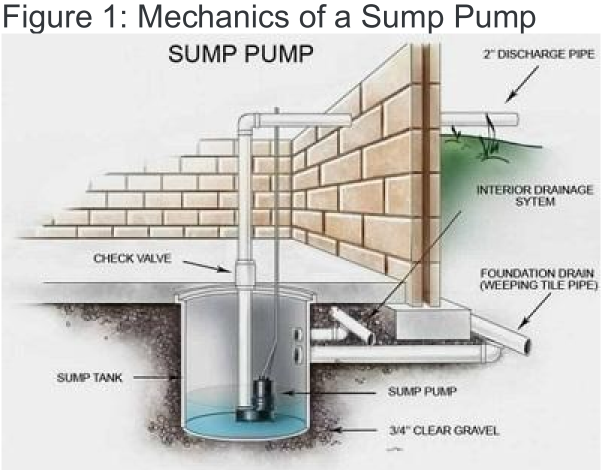

Image Source: homeinspectiongeeks.com, n.d. & basements911.com, 2019

SPS-Info2 Please read this information on sump pump systems before moving onto the question.

How is a sump pump system installed? A sump pump system is typically installed by a licensed plumber. The plumber will dig a hole in the basement floor to accommodate the sump tank, which is usually placed at the lowest point or in a specific area that's experiencing infiltration issues. A hole is also created in the exterior foundation wall for the discharge pipe. The pump is then placed inside the tank and connected to the discharge pipe and battery. The basement floor is re-sealed with a panel access for the pump.

Installing a sump pump takes between 8 to 16 hours, on average, depending on the home.

Figure 2: Sump Pump System Installation Example

Image Source: HouseImprovements, 2016 (YouTube).

SPS-Info3 Please read this information on sump pump systems before moving onto the question.

How is a sump pump system maintained? Like many things in a home, sump pump systems require periodic maintenance to ensure proper performance over time. It should be inspected every three months.

An improperly maintained system may fail during a flood event.

Homeowners may require the assistance of a qualified plumber to carry out maintenance or repairs of a sump pump system.

SPS-Info4 Please read this information on sump pump systems before moving onto the question.

Installing a sump pump system may benefit your community more than it may benefit your home.

Some older homes have their foundation drains/ weeping tiles directly connected to the municipal sewer and storm system.

If many homes in a community are connected directly, a heavy rainfall event is more likely to overwhelm the system, potentially causing flooding throughout the community and unnecessary groundwater in wastewater treatment.

Therefore, homeowners who have their foundation drains directly connected are encouraged to disconnect and run their foundation drains to a sump pump system instead. This way, the groundwater can be released onto the lawn instead of the municipal system.

However, an improperly maintained sump pump system is more likely to put you at risk of infiltration flooding than if you did not have one at all. ***Therefore, the homeowner takes on more responsibility for the overall benefit of the community.***

SPS-Info5 We are now going to ask whether or not you would choose to install a sump pump system.

We are now going to ask whether or not you would choose to install a sump pump system.

Keep in mind that some people might not install a sump pump system because:

- They believe their home is already adequately protected against flooding
- They believe the device will be ineffective at protecting against flooding
- They believe the risk reduction is not worth the expense
- They do not want the inconvenience of the installation or maintenance of the device
- They have insurance coverage that will cover the replacement of belongings if a flood event occurs

Other people might install a sump pump system because:

- They believe their home is not adequately protected against flooding
- They believe the device will be effective at protecting against flooding
- They believe the risk reduction is worth the expense
- They do not want the inconvenience of clean-up and or repair after a flood event
- They do not want to lose valuable or irreplaceable belongings due to a flood event

If you are taking this survey on a mobile device you may need to rotate your device horizontally/ sideways to see the following question as intended.

SPS-43a-1200.25 Earlier in this survey, you stated that your chance of flooding from infiltration was **${RP-25 INFILTRATION/ChoiceTextEntryValue}%**

Assume installing a sump pump system in your home will **reduce your chance of infiltration flooding to almost 0%** (with proper maintenance of the device).

Also assume that, with the installation of a sump pump system:

- The City of Edmonton/EPCOR will provide you a **one-time $1,200 subsidy (rebate)** for the installation.
- Your insurance company will give you an **annual $25 discount** off your home insurance premium.

To get the subsidy you will need to have your home inspected, fill out paper work, and book a contractor for installation (approx. 2 hours). You will also need to be home for the installation of the device and a follow-up inspection (approx. 8-16 hours).

The subsidy will be given to you *after* the installation is complete, which means you will have to pay the full cost of the device and installation upfront. This is shown in the chart below as the **upfront cost**. The final cost to you, after you receive the subsidy, is shown in the chart below as the **final net cost**.

How likely are you to install a sump pump system if the total cost to you is?

Please select one choice per row

Upfront Cost | Final Net Cost	Definitely Yes (100% Likely)	Probably Yes (51-99% Likely)	Probably No (1-49% Likely)	Definitely No (0% Likely)
$1,200 | $0	○	○	○	○
$1,450 | $250	○	○	○	○
$1,700 | $500	○	○	○	○
$1,950 | $750	○	○	○	○
$2,200 | $1,000	○	○	○	○
$2,450 | $1,250	○	○	○	○
$2,700 | $1,500	○	○	○	○
$2,950 | $1,750	○	○	○	○
$3,200 | $2,000	○	○	○	○
$3,450 | $2,250	○	○	○	○
$3,700 | $2,500	○	○	○	○

NOTE FOR THESIS READER: There were a total of 16 different combinations of the WTP question on sump pump systems, made up of four different subsidy levels and four different insurance premium discounts.

Subsidy Levels: $1200; $1400; $1600; $1800
Insurance Premium Discount Levels: $25; $50; $75; $100

Every respondent that was triggered to answer the willingness to pay question on sump pump systems was presented with one combination at random. The only difference between combinations was the upfront cost; the final net cost remained the same no matter what combination a respondent was presented with.

SPS-44aa You said definitely yes for at least one of the payment options in the last question. Why did you choose to install the sump pump system over keeping your current situation?

Choose **all** relevant reasons.

If you have other reasons that are not listed, please write your top reason in the "other" option box.

- ☐ The risk reduction is worth the expense
- ☐ The City subsidy made it worth the additional expense
- ☐ The insurance premium reduction made it worth the additional expense
- ☐ General worry about being flooded; installing this measure will provide some peace of mind
- ☐ I do not have home insurance/ I do not have flood coverage/ I cannot rely on my insurance
- ☐ I do not want the inconvenience and stress of repairing home/ replacing belongings after a flood event
- ☐ I do not want to lose valuable and or irreplaceable belongings due to a flood event
- ☐ It is my responsibility to protect my house and belongings from flooding
- ☐ Other (write the reason in the box below)

____

SPS-45aa Below you will find all the reasons you chose in the last question.

Please choose the reason that was **most important** for your decision to install the sump pump system over keeping your current situation.

- ○ The risk reduction is worth the expense
- ○ The City subsidy made it worth the additional expense
- ○ The insurance premium reduction made it worth the additional expense
- ○ General worry about being flooded; installing this measure will provide some peace of mind
- ○ I do not have home insurance/ I do not have flood coverage/ I cannot rely on my insurance
- ○ I do not want the inconvenience and stress of repairing home/ replacing belongings after a flood event
- ○ I do not want to lose valuable and or irreplaceable belongings due to a flood event
- ○ It is my responsibility to protect my house and belongings from flooding
- ○ Other (write the reason in the box below)

SPS-44ab You said definitely no for the majority of the payment options in the last question. Why did you choose to keep your current situation over the installation of the sump pump system?

Choose **all** relevant reasons.

If you have other reasons that are not listed, please write your top reason in the "other" option box.

- ☐ The risk reduction is not worth the expense
- ☐ Cannot afford the upfront cost (before receiving the subsidy)
- ☐ This measure will be ineffective at protecting my home against flooding
- ☐ My home is not at risk of flooding
- ☐ My home is already protected with adequate flood protection measures
- ☐ I have flood coverage on home insurance / I can rely on my insurance
- ☐ I do not want the inconvenience (time, invasiveness, etc.) of the installation
- ☐ I am unsure of how to conduct maintenance/ not interested in maintenance on the device
- ☐ I do not have enough information to make a decision
- ☐ Other (write the reason in the box below)

____

SPS-45ab Below you will find all the reasons you chose in the last question.

Please choose the reason that was **most important** for your decision to keep your current situation over installing the sump pump system.

- ○ The risk reduction is not worth the expense
- ○ Cannot afford the upfront cost (before receiving the subsidy)
- ○ This measure will be ineffective at protecting my home against flooding
- ○ My home is not at risk of flooding
- ○ My home is already protected with adequate flood protection measures
- ○ I have flood coverage on home insurance / I can rely on my insurance
- ○ I do not want the inconvenience (time, invasiveness, etc.) of the installation
- ○ I am unsure of how to conduct maintenance/ not interested in maintenance on the device
- ○ I do not have enough information to make a decision
- ○ Other (write the reason in the box below)

End of Block: Willingness to Pay for Sump Pump System (WTP-SPS)

Start of Block: Willingness to Pay for Sump Pump Battery Backup (WTP-SPB)

SPB-Info1

Please read the following information pages on a sump pump battery backup system before moving onto the question.

What is a sump pump battery backup system? A battery backup system allows the sump pump to continue to function if electricity is lost, which is sometimes the case in a large storm event. These systems run on automotive or marine batteries and will run the sump for several hours depending on the amount of water and height or distance pumped. A battery backup system is a secondary (backup) pump that is installed next to the primary pump in the sump tank. The backup pump is connected to a battery that will continue to be pump water out of the tank if the power goes out.

Image Source: peachyrooms.com, 2021

SPB-Info2

Please read the following information pages on a sump pump battery backup system before moving onto the question

How is a sump pump battery backup system installed? A battery backup system is typically installed by a licensed plumber who will place the secondary (backup) pump in the sump pit, install additional discharge piping, install the battery, and plug in and test the system.

Installing a sump battery backup system takes between 2 to 8 hours, on average, depending on the existing sump pump system.

SPB-Info3

Please read the following information pages on a sump pump battery backup system before moving onto the question.

How is a sump pump battery backup system maintained? Like many things in a home, a battery backup system requires periodic maintenance to ensure proper performance over time. It should be inspected every three months.

An improperly maintained battery backup system may fail during a flood event.

Some manufacturers recommend that the battery be replaced every two to five years.

SPB-Info4

We are now going to ask whether or not you would choose to install a sump pump battery backup.

Keep in mind that some people might not install a sump pump battery backup because:

- They believe their home is already adequately protected against flooding
- They believe the device will not be effective at protecting against flooding
- They believe the risk reduction is not worth the expense
- They do not want the inconvenience of the installation or maintenance of the device
- They have insurance coverage that will cover the replacement of belongings if a flood event occurs

Other people might install a sump pump battery backup because:

- They believe their home is not adequately protected against flooding
- They believe the device will be effective at protecting against flooding
- They believe the risk reduction is worth the expense
- They do not want the inconvenience of clean-up and or repair after a flood event
- They do not want to lose valuable or irreplaceable belongings due to a flood event

If you are taking this survey on a mobile device you may need to rotate your device horizontally/ sideways to see the following question as intended.

SPB-43b-200.25 Earlier in this survey, you stated that your chance of flooding from infiltration was **${RP-25 INFILTRATION/ChoiceTextEntryValue}%**

Assume installing a sump pump battery backup in your home will **reduce your chance of infiltration flooding to almost 0%** (with proper maintenance of the device).

Also assume that, with the installation of a sump pump battery backup:

- The City of Edmonton/EPCOR will provide you a **one-time $200 subsidy (rebate)** for the installation.
- Your insurance company will give you an **annual $25 discount** off your home insurance premium.

To get the subsidy you will need to have your home inspected, fill out paper work, and book a contractor for installation (approx. 2 hours). You will also need to be home for the installation of the device and a follow-up inspection (approx. 2-8 hours).

The subsidy will be given to you after the installation is complete, which means you will have to pay the full cost of the device and installation upfront. This is shown in the chart below as the upfront cost. The final cost to you, after you receive the subsidy, is shown in the chart below as the final net cost.

How likely are you to install a sump pump battery backup if the total cost to you is?

Please select one choice per row

Upfront Cost | Final Net Cost	Definitely Yes (100% Likely)	Probably Yes (51-99% Likely)	Probably No (1-49% Likely)	Definitely No (0% Likely)
$250 | $0	○	○	○	○
$450 | $250	○	○	○	○
$700 | $500	○	○	○	○
$950 | $750	○	○	○	○
$1,200 | $1,000	○	○	○	○
$1,450 | $1,250	○	○	○	○
$1,700 | $1,500	○	○	○	○
$1,950 | $1,750	○	○	○	○
$2,200 | $2,000	○	○	○	○
$2,450 | $2,250	○	○	○	○
$2,700 | $2,500	○	○	○	○

NOTE FOR THESIS READER: There were a total of 16 different combinations of the WTP question on sump pump battery backups, made up of four different subsidy levels and four different insurance premium discounts.

Subsidy Levels: $200; $400; $600; $800
Insurance Premium Discount Levels: $25; $50; $75; $100

Every respondent that was triggered to answer the willingness to pay question on sump pump battery backups was presented with one combination at random. The only difference between combinations was the upfront cost; the final net cost remained the same no matter what combination a respondent was presented with.

SPB-44ba You said definitely yes for at least one of the payment options in the last question. Why did you choose to install the sump pump battery backup over keeping your current situation?

Choose **all** relevant reasons.

If you have other reasons that are not listed, please write your top reason in the "other" option box.

- ☐ The risk reduction is worth the expense
- ☐ The City subsidy made it worth the additional expense
- ☐ The insurance premium reduction made it worth the additional expense
- ☐ General worry about being flooded; installing this measure will provide some peace of mind
- ☐ I do not have home insurance/ I do not have flood coverage/ I cannot rely on my insurance
- ☐ I do not want the inconvenience and stress of repairing home/ replacing belongings after a flood event
- ☐ I do not want to lose valuable and or irreplaceable belongings due to a flood event
- ☐ It is my responsibility to protect my house and belongings from flooding
- ☐ Other (write the reason in the box below)

____

SPB-45ba Below you will find all the reasons you chose in the last question.

Please choose the reason that was **most important** for your decision to install the sump pump battery backup over keeping your current situation.

- ○ The risk reduction is worth the expense
- ○ The City subsidy made it worth the additional expense
- ○ The insurance premium reduction made it worth the additional expense
- ○ General worry about being flooded; installing this measure will provide some peace of mind
- ○ I do not have home insurance/ I do not have flood coverage/ I cannot rely on my insurance
- ○ I do not want the inconvenience and stress of repairing home/ replacing belongings after a flood event
- ○ I do not want to lose valuable and or irreplaceable belongings due to a flood event
- ○ It is my responsibility to protect my house and belongings from flooding
- ○ Other (write the reason in the box below)

SPB-44bb You said definitely no for the majority of the payment options in the last question. Why did you choose to keep your current situation over the installation of the sump pump battery backup? Choose **all** relevant reasons.

If you have other reasons that are not listed, please write your top reason in the "other" option box.

- ☐ The risk reduction is not worth the expense
- ☐ Cannot afford the upfront cost (before receiving the subsidy)
- ☐ This measure will be ineffective at protecting my home against flooding
- ☐ My home is not at risk of flooding
- ☐ My home is already protected with adequate flood protection measures
- ☐ I have flood coverage on home insurance / I can rely on my insurance
- ☐ I do not want the inconvenience (time, invasiveness, etc.) of the installation
- ☐ I am unsure of how to conduct maintenance/ not interested in maintenance on the device
- ☐ I do not have enough information to make a decision
- ☐ Other (write the reason in the box below)

____

SPB-45bb Below you will find all the reasons you chose in the last question.

Please choose the reason that was **most important** for your decision to keep your current situation over installing the sump pump battery backup.

- ○ The risk reduction is not worth the expense
- ○ Cannot afford the upfront cost (before receiving the subsidy)
- ○ This measure will be ineffective at protecting my home against flooding
- ○ My home is not at risk of flooding
- ○ My home is already protected with adequate flood protection measures
- ○ I have flood coverage on home insurance / I can rely on my insurance
- ○ I do not want the inconvenience (time, invasiveness, etc.) of the installation
- ○ I am unsure of how to conduct maintenance/ not interested in maintenance on the device
- ○ I do not have enough information to make a decision
- ○ Other (write the reason in the box below)

End of Block: Willingness to Pay for Sump Pump Battery Backup (WTP-SPB)

Start of Block: Willingness to Pay Yay/Nay Check (WTP-YN)

YN-46 How much do you agree or disagree with the following statement?:

"I am the kind of person who avoids taking risks whenever possible."

- ○ Strongly Agree
- ○ Somewhat Agree
- ○ Neither Agree or Disagree
- ○ Somewhat Disagree
- ○ Strongly Disagree

YAY-47 How much do you agree or disagree with the following statement?:

"With the proper measures in place, flood damage can always be prevented."

- ○ Strongly Agree
- ○ Somewhat Agree
- ○ Neither Agree or Disagree
- ○ Somewhat Disagree
- ○ Strongly Disagree

NAY-48 How much do you agree or disagree with the following statement?:

"If a stormwater flood event happens it will impact my home regardless of any protective measure I take."

- ○ Strongly Agree
- ○ Somewhat Agree
- ○ Neither Agree or Disagree
- ○ Somewhat Disagree
- ○ Strongly Disagree

YAY-49 How much do you agree or disagree with the following statement?:

"I would spend whatever it takes to eliminate any risk of future flooding in my home."

- ○ Strongly Agree
- ○ Somewhat Agree
- ○ Neither Agree or Disagree
- ○ Somewhat Disagree
- ○ Strongly Disagree

End of Block: Stated Preference Yay/Nay Check (WTP-YN)

Start of Block: Common Goods/ Responsibility (CG)

CG-50 In your opinion, how should the cost of **stormwater flood prevention** be shared?

Below you will find sliders from 0 to 100 % for each party. These sliders represent the percentage of responsibility each party has in cost sharing. If you believe there are other parties that should share this cost please list up to two in the 'other' boxes, otherwise leave these boxes empty. If there is a party you do not feel is responsible in the cost sharing, leave the slider at 0 %.

Note that **the sum of all choices must total 100**.

If you are taking this survey on a mobile device you may need to rotate your device horizontally/ sideways to see the following question as intended.

_______ Home Owners
_______ City Government and Utility Providers
_______ Provincial and or Federal Government
_______ Other 1
_______ Other 2

End of Block: Common Goods/ Responsibility (CG)

Start of Block: Flood Experience (FE)

Motivator

Just a few more questions... you're getting close to the end of the survey!

FE-51 Have you ever experienced water entering your home (either current or previous residence) due to a flooding event?

- ○ Yes, once
- ○ Yes, more than once (please enter how many times in the box below) ____
- ○ No

FE-52 Have you experienced water entering your **current home** (the home you live now) due to a flooding event?

- ○ Yes, once
- ○ Yes, more than once (please enter how many times in the box below) ____
- ○ No

FE-Info1

If you have experienced more than one incident of water entering your home, please answer the following questions using information from your **most recent** incident.

FE-53 What year did you experience your incident?

____

FE-54 What best describes your living situation at the time of the incident?

- ○ Owner
- ○ Renter
- ○ Other (please explain the box below)

____

FE-55 How did the water enter your home? Choose **all** that apply.

- ☐ Sewer backup
- ☐ Infiltration (seepage)
- ☐ Overland
- ☐ Other (please explain in the box below)

____

- ☐ ⊗I don't know

FE-56 What was the severity of the damage of this incident?

- ○ No damage, only clean up required.
- ○ Minimal (minor home repairs needed and or a minimal loss of belongings)
- ○ Moderate (moderate home repairs needed and or a moderate loss of belongings; you could continue to live in your home while repairs were made)
- ○ Severe (major home repairs needed and or a severe loss of belongings; there was possible health risks and a possible need to evacuate your home until repairs are made)

FE-57 Approximately how long did the clean up and or repairs on your home take, from start to completion?

If this incident was recent and repairs are ongoing, please estimate how long they will take.

- ○ Less than a month
- ○ Between 1 - 3 months
- ○ Between 4 - 6 months
- ○ Between 7 - 9 months
- ○ Between 10 months to a year
- ○ Over a year
- ○ I don't remember

FE-58 What was the estimated total cost of home repairs (including both material and labour costs if professionals were hired to do the work)?

If your incident was recent and repairs are ongoing, please estimate how much they will cost.

- $0
- Less than $1,000
- Between $1,000 - $4,999
- Between $5,000 - $9,999
- Between $10,000 - $14,999
- Between $15,000 - $19,999
- Between $20,000 - $24,999
- Between $25,000 - $29,999
- Between $30,000 - $34,999
- Between $35,000 - $39,999
- Between $40,000 - $44,999
- Between $45,000 - $49,999
- Over $50,000
- I don't know/ I don't remember

FE-59 What was the estimated total cost of destroyed belongings?

- $0
- Less than $1,000
- Between $1,000 - $4,999
- Between $5,000 - $9,999
- Between $10,000 - $14,999
- Between $15,000 - $19,999
- Between $20,000 - $24,999
- Between $25,000 - $29,999
- Between $30,000 - $34,999
- Between $35,000 - $39,999
- Between $40,000 - $44,999
- Between $45,000 - $49,999
- Over $50,000
- I don't know/ I don't remember

FE-60 Were irreplaceable belongings (photo albums, keepsakes, heirlooms, sentimental items, etc.) lost in the incident?

- ○ Yes
- ○ No

FE-61 Did you submit a claim with your insurance for reimbursement of the **home repair** costs caused by the incident?

- ○ Yes I submitted a claim and received reimbursement
- ○ Yes I submitted a claim, but did not receive reimbursement (please briefly explain why in the box below) ____
- ○ No I did not submit a claim - it was covered, however I did not want to pay the deductible
- ○ No I did not submit a claim - it was not covered (did not have flood coverage on my insurance)
- ○ No I did not submit a claim - the cost of the damage was small and it was not worth it
- ○ No I did not submit a claim - I don't know if it was covered/ I didn't contact my insurance to find out
- ○ No I did not submit a claim - other (please fill reason in box below) ____
- ○ N/A, I did not have home insurance at the time

FE-62 Did you submit a claim with your insurance for reimbursement of **destroyed belongings** caused by the incident?

- ○ Yes I submitted a claim
- ○ Yes I submitted a claim, but did not receive reimbursement (please briefly explain why in the box below) ____
- ○ No I did not submit a claim - it was covered, however I did not want to pay the deductible
- ○ No I did not submit a claim - it was not covered (did not have flood coverage on my insurance)
- ○ No I did not submit a claim - the cost of the damage was small and it was not worth it
- ○ No I did not submit a claim - I don't know if it was covered/ I didn't contact my insurance to find out
- ○ No I did not submit a claim - other (please fill reason in box below) ____
- ○ N/A, I did not have home insurance at the time

End of Block: Flood Experience (FE)

Start of Block: Demographic Questions (D)

D-63 What gender do you identify as?

- Female
- Male
- Non-binary
- Prefer not to say

D-64 What age group do you belong to?

- Under 14
- 15 - 19
- 20 - 24
- 25 - 29
- 30 - 34
- 35 - 39
- 40 - 44
- 45 - 49
- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- 70 - 74
- 75 - 79
- 80 - 84
- 85 and over
- Prefer not to say

D-65 What is your highest level of education?

- ○ Grade 1-11 (never completed high school)
- ○ High school diploma
- ○ Trade certificate/ apprenticeship
- ○ Diploma or college certificate
- ○ Bachelor degree
- ○ Masters degree
- ○ Doctorate degree
- ○ Prefer not to say

D-66 How many adults and children live in your household?

- ☐ Adults (fill number of adults in box below)

____

- ☐ Children (fill number of adults in box below)

____

- ☐ ⊗Prefer not to say

D-67 What is your annual total household income (before taxes)?

- ○ Less than $10,000 (including losses)
- ○ $10,000 - $19,999
- ○ $20,000 - $29,999
- ○ $30,000 - $39,999
- ○ $40,000 - $49,999
- ○ $50,000 - $59,999
- ○ $60,000 - $69,999
- ○ $70,000 - $79,999
- ○ $80,000 - $89,999
- ○ $90,000 - $99,999
- ○ $100,000 - $149,999
- ○ $150,000 - $199,999
- ○ $200,000 - $249,999
- ○ More than $250,000
- ○ Prefer not to say

End of Block: Demographic Questions (D)

Start of Block: End of Survey

Final Comments

If you have any additional comments or feedback related to stormwater flooding, please use the box below. Your feedback is highly appreciated.

____

____

ICLR Retrofit

The Institute for Catastrophic Loss Reduction (ICLR) is a not-for-profit disaster risk reduction research institute affiliated with Western University, based in Toronto and London, Ontario (www.iclr.org).

ICLR is seeking to work with a small number homeowners in Edmonton this year to conduct a free home retrofit for basement flooding (including installation of backwater valves and sump pump systems), to better understand and demonstrate basement flood protection options.

As such, ICLR would like to connect with you, or homeowners in your neighbourhood that are interested in having their home and property retrofitted, **at no cost to the homeowner**, with basement flood protection measures.

Please contact Dan Sandink, ICLR's Director of Research, at dsandink@iclr.org if you or someone you know would like more information or would like to become a candidate for a retrofit.

Links

For more information on stormwater flooding and how you can protect your home please visit the following websites:

Institute of Catastrophic Loss Reduction, Info on Protecting Your Home from Basement Flooding: https://www.iclr.org/flooding/

EPCOR, Flood Prevention Maintenance and Programs: https://www.epcor.com/products-services/drainage/flooding-flood-prevention/Pages/default.aspx

Draw

As a thank you for participating in this survey, we would like to offer you a chance to enter a prize draw to win one of two gift cards valued at $100 each for Canadian Tire.

If you wish to enter the draw, you will have to successfully answer a skill-testing question (a legal requirement under federal law). We will also need to collect your email address to inform you of the draw result. Your email address will not be used for any other reason than this draw. Please fill the answer to the question and your email in the boxes below.

If you do not wish to enter the draw, leave the boxes blank.

- ○ (5+5) / 2 = ____
- ○ Email Address: ____

End of Block: End of Survey
