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Construction de resilient communities

Urban flooding in Canada

Lot-side risk reduction through voluntary retrofit programs, code interpretation and by-laws

By Dan Sandink

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ICLR's mission is to reduce the loss of life and property caused by severe weather and earthquakes through the identification and support of sustained actions that improve society's capacity to adapt to, anticipate, mitigate, withstand and recover from natural disasters. ICLR is achieving its mission through the development and implementation of its programs *Open for business,* to increase the disaster resilience of small businesses, *Designed for safer living*, which increases the disaster resilience of homes, and *RSVP cities*, to increase the disaster resilience of communities.

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Executive summary

While it has been previously reported that resolution of code enforcement issues may result in reduced vulnerability to extreme natural events, issues surrounding code interpretation have not previously been studied. Among other topics, this study investigated interpretation of code wordings that relate to installation of backwater valves to protect homes from sewer backup—a significant cause of basement flooding associated with extreme precipitation events and urban flooding.

Despite consistent application of code wordings related to backwater valves across the regions of Canada represented in this study, it was found that there are differing interpretations of code wordings, which resulted in differing reported frequencies of installation of backwater valves on both sanitary/combined and storm sewer service connections. Thus, the primary recommendation of this report is that sentences in the National Plumbing Code and provincial building and/or plumbing codes that relate to installation of backwater valves to protect against sewer backflow be reworded or clarified to ensure they are clearly and consistently interpreted and applied.

Urban flood damages are a recurrent and growing issue for municipalities, insurers and homeowners across Canada. Damages from urban flood events often total in the $10s and $100s of millions of dollars. In May, 2012, a storm system that affected Thunder Bay and moved through to Montréal resulted in $260 million in insured damages. In July, 2012, a storm moved through southern Ontario affecting several neighbourhoods in Hamilton and Ottawa, resulting in $90 million in insured damages. An extreme rainfall event that affected a large region of southern Ontario from Hamilton to Durham Region in August, 2005 resulted in over $500 million in insured damages, $247 million of which was associated with sewer backup. Also in 2005, heavy rainfall and associated flooding resulted in $300 million in insured damages in southern Alberta. A severe storm in Edmonton, Alberta in 2004 resulted in approximately $166 million in insured damages, $143 million of which were associated with sewer backup.

Urban flooding events also have serious implications for municipalities. Aside from damage caused to infrastructure and costs associated with response and recovery, several Canadian municipalities have faced litigation as a result of wide spread sewer backup events. Homeowners are particularly negatively affected by urban flooding events. Homeowners experience reduced home liveability, loss of irreplaceable items and are exposed to negative health impacts associated with flood waters containing untreated sanitary sewage as a result of sewer backup. Homeowners may also experience sewer backup insurance coverage limits, increasing premiums or cancellation of sewer backup coverage after the experience of multiple basement flood events. As a result of increasing frequency of extreme rainfall caused by climate change and as a consequence of increasing urban development and deteriorating urban infrastructure, urban flooding risk is likely to increase over the next few decades in Canada.

Backwater valves are recommended or required by many municipalities and local authorities across Canada as a lot-side (or household-level) measure to reduce the risk of sewer backup in new and existing homes. Many Canadian insurers, faced with increasing property claims resulting from sewer backup, have also begun to recommend or require the installation of backwater valves and other lot-side flood protection measures as conditions for sewer backup insurance coverage. Backwater valve installation may be encouraged by municipalities through education and subsidy programs, or may be required through by-laws or code interpretations that result in the installation of valves in new homes.

There are many advantages of installing backwater valves in new homes. Due to the unpredictable nature of extreme rainfall events and the unpredictability of infiltration and inflow (I/I) in relatively new, separated sewer systems, it is often impossible to identify which regions of an urban municipality are exposed to sewer backup risk until wide spread or regional sewer backup events have occurred. It is also more economical to install backwater valves in new homes when compared to retrofitting valves into existing homes. For example, several Canadian municipalities provide partial retrofit subsidies of several thousand dollars for the retrofit of backwater valves, while installation of valves in new homes costs approximately $250. Requiring installation of valves in new homes would also help offset relatively low uptake frequencies for municipal subsidy programs aimed at encouraging homeowners to adopt urban flood risk reduction measures.

In addition to municipal programs, the Canadian National Plumbing Code is another important tool that could require the installation of backwater valves. Sentence 2.4.6.4. (3) of the National Plumbing Code relates to the installation of backwater valves in homes, and states:

> ...where a building drain or a branch may be subject to backflow, a gate valve or a backwater valve shall be installed on every fixture drain connected to them when the fixture is located below the level of the adjoining street.

The wording of this sentence is adopted in provincial plumbing or building codes across Canada. However, the wording is open to interpretation by local authorities responsible for code implementation. In some cases, this section of the code is interpreted in a manner that requires or allows installation of backwater valves only in rare, specific circumstances (e.g., only in cases where new homes are being built in older subdivisions with histories of sewer backup or only when requested by individual developers or homeowners). In other cases, this sentence is interpreted in a manner that requires all or most new homes with below-ground living space to have backwater valves to protect against sewer backup.

Inconsistent code interpretations suggest that a better understanding of local and municipal efforts to promote the use of backwater valves is necessary to reduce the costs of basement flooding and sewer backup. In a survey of 160 municipalities and local authorities responsible for plumbing and building code interpretation and implementation from British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, New Brunswick and Nova Scotia, this study sought to answer the following questions:

- How do local authorities responsible for code implementation interpret code wordings as they relate to the installation of backwater valves in new homes?
- Under what circumstances are backwater valves being installed on sanitary and/or storm sewer connections in new homes?
- What proportion of new homes have backwater valves to protect against sanitary and storm sewer backup?
- Are alternatives to backwater valves being applied at the lot-side in Canadian communities to reduce the risk of sanitary and storm sewer backup?
- How are by-laws being applied in Canadian municipalities to reduce urban flood risk in new homes?

The study revealed that backwater valve code wording is interpreted differently across the country, though there is greater interpretation consistency in some regions than in others. Specifically, the survey revealed that 19% of British Columbia respondents, 81% of Alberta respondents, 86% of Saskatchewan respondents, 72% of Manitoba respondents, 26% of Ontario respondents and 58% of respondents from New Brunswick and Nova Scotia interpreted code wordings in a manner that required backwater valves to be installed in all or most new homes. The study further revealed that interpreting code wording in this manner was strongly correlated with a higher frequency of installation of backwater valves in new homes, indicating the importance of code interpretation for backwater valve installation.

The study also revealed differences in code interpretation related to the type of service connection that should be equipped with backwater valves. For example, while the majority (62%) of respondents indicated that backwater valve code wordings applied only to sanitary/combined sewer connections, 28% indicated that code wordings applied to both sanitary/combined and storm connections, and 6% of respondents indicated that backwater valve code wordings applied only to storm sewer connections in their jurisdictions.

Further findings from the study indicated that backwater valves were the most common lot-side method applied to reduce the risk of sanitary and storm sewer backup. Indeed, 88% and 81% of respondents reported that backwater valves were the only lot-side measure being applied in their jurisdictions to reduce the risk of sanitary and storm sewer backup, respectively. This study also revealed that many Canadian municipalities are using by-laws to reduce the risk of urban flooding in homes, including by-laws requiring backwater valves and restricting reverse slope driveways. Finally, the study revealed a level of uncertainty in some provinces about the ability of local authorities to apply by-laws that exceed provincial code requirements.

This study recommends that code wordings related to protection from backflow through the use of backwater valves be clarified, or that provincial and national code authorities provide guidance to local authorities about how code wordings related to protection of homes from sewer backflow should be interpreted. This guidance should outline that code wordings be interpreted in a way that requires the mandatory installation of backwater valves in all or most new Canadian homes. The substantial costs associated with sewer backup insurance claims, the legal liability of municipalities generated by regional sewer backup events, health and home liveability risks posed to households created by sewage flooding and the fact that urban flooding and sewer backup occurrences are likely to increase as a result of increasing frequency of extreme rainfall caused by climate change justify a mandatory requirement for installation. The need for lot-side protection from backflow is exacerbated by the changing nature of stormwater runoff caused by increasing urban development and the unpredictable nature of I/I leading to surcharging in separated sewer systems.

The lack of clarity in the wording of provincial codes as they relate to backwater valve installation was reflected in the comments of some survey respondents, further indicating a need for code wording clarification. For example, an Ontario municipal survey respondent stated that

> [the reference related to backwater valves] in the [Ontario Building Code]... is one of the worst worded articles of the Code. I can interpret this clause either to require backwater valves in all cases or very few cases. It needs to be re-worded to make the intent more easily understood.

Alternatively, municipalities may adopt interpretations of code wordings that would require developers and builders to install valves in new homes. This approach can be accomplished through the acknowledgement that any below-ground fixture may be subject to backflow given the appropriate conditions (e.g., extreme rainfall that exceeds design capacity of municipal sanitary and stormwater management infrastructure)—an approach that has been applied in Windsor and Toronto, Ontario.

Aside from wordings related to protection from backflow, this study identified further opportunities to reduce the risk of urban flooding at the lot-side through clarification of code wordings. Specifically, articles and sentences of the National Building Code that relate to site grading, backup systems for sump pumps and issues related to foundation drainage connections to sanitary sewer systems warrant further investigation to identify the impact of code wording on basement flood risk reduction for new home construction in Canada. Removal of reference to manual sewer backflow prevention devices in the NPC, including gate valves and removable floor drain screw caps, should also be considered.

1. Introduction

Cities across Canada are experiencing severe and repeated urban flood events. Recent urban flooding events associated with extreme rainfall and resulting in widespread basement flooding occurred in the cities of Montréal and Thunder Bay in May, 2012 (CBC, 2012a; CBC, 2012b), Calgary in July, 2012 (CBC, 2012c), Hamilton and Toronto in 2012 (Caton & Wong, 2012; Moloney, 2012 Van Dongen, 2012a,b), Winnipeg in 2010 (Skeritt, 2012), Mississauga, Ontario in 2009 (Inouye, 2012) among many other urban municipalities across Canada (Sandink, 2011). Indeed, the frequent occurrence of severe rainfall resulting urban flooding events across Canada in 2012, including events in Thunder Bay, Hamilton, Toronto, Montréal, and Steinbach, Manitoba, prompted Environment Canada to refer to 2012 as "The Year of the Urban Flood" (Environment Canada, 2012).

Damages from urban flood events often total in the $10s and $100s of millions of dollars. In May, 2012, a storm system that affected Thunder Bay and moved through to Montréal resulted in $260 million in insured damages. In July, 2012, a storm rolled through southern Ontario affecting several neighbourhoods in Hamilton and Ottawa, resulting in $90 million in insured damages (IBC, 2012a). In August, 2005, a severe rainfall event affected a large region of southern Ontario from Hamilton to Durham Region and resulted in over $500 million in insured damages, $247 million of which was associated with sewer backup. Also in 2005, heavy rainfall and associated flooding resulted in $300 million in insured damages in southern Alberta. A severe storm in Edmonton, Alberta in 2004 resulted in approximately $166 million in insured damages, $143 million of which were associated with sewer backup (Sandink, 2007).

It is also not uncommon for municipalities to experience repeated urban flood events within a relatively short time-period. For example, the City of Peterborough, Ontario was affected by a 1 in 100 year extreme rainfall event in 2002 and a significantly more severe rainfall event in 2004, both of which resulted in wide spread basement flooding (UMA, 2005). The City of Hamilton experienced over 10 wide spread basement flooding events associated with extreme rainfall between August 2009 and September 2010 (City of Hamilton, 2010).

Nationally, water damage claims associated with failure of household plumbing systems and sewer backup are a significant component of insurance claims paid to property owners. In 2012, the Insurance Bureau of Canada (IBC) estimated average yearly insurance payouts for water damage at $1.7 billion (IBC, 2012b). It has also been reported that water damage claims in some Canadian provinces have risen dramatically over the past few years. For example, IBC reported that water damage claims in New Brunswick rose from $7 million in 2005 to $23 million in 2009 (*Claims Canada*, 2012), and in Nova Scotia, water damage claims rose from $20 million in 2005 to $38 million in 2009 (Power, 2012). Further, water damage claims paid by Aviva Canada between 2000 and 2010 have increased by approximately 160% across Canada, including an increase of 200% in BC and over 180% in Alberta and Ontario over this time period (Carrick, 2012).

Urban flooding events also have serious implications for municipalities. Aside from damage caused to infrastructure and costs associated with response and recovery, several Canadian municipalities have faced litigation as a result of wide spread sewer backup events, including the municipalities of Thunder Bay, Kenora and Stratford, Ontario, Port Alberni, British Columbia and St. John's, Newfoundland (Campbell *et al*., 2007; City of Stratford, 2010).

Homeowners are particularly negatively affected by basement flooding events. In Canada, homeowner sewer backup insurance coverage is widely available, but the majority of Canadian homeowners are not insured for damages caused by groundwater (infiltration) flooding and coverage for overland flooding (e.g., stormwater flows that enter homes through windows and doors) is not available (Sandink *et al*., 2010). Further, repeated sewer backup claims may result in limiting or discontinuation of insurance coverage, increasing the liability of homeowners for expensive basement flood damages and rebuilding costs (Compu-Quote, 2011). Homeowners must also cope with the loss of irreplaceable items and reduced liveability of homes as a result of basement flood damages, especially in the case of sewer backup when raw sewage floods basements.

Health effects associated with poor indoor air quality caused by dampness and mould growth have been linked to the occurrence of flooding in homes in urban environments (Dales *et al*., 1991a,b; Ivers & Ryan, 2006; Kesik & Seymour, 2003; Ross *et al*., 2000; Taylor *et al*., 2011). Specifically, flooding associated with sewage can lead to faecal-oral transmission of disease (Ahern *et al*., 2005), and contamination of building materials with floodwaters that contain sewage can facilitate the growth of human pathogens deposited during flooding (Taylor *et al*., 2011).

In a Canadian survey of over 13,000 parents of children in kindergarten through grade two, Dales *et al*. (1991a) found higher rates of lower respiratory symptoms and disorders, including cough, wheeze, asthma, bronchitis and chest illness for children who live in homes with dampness. Twenty-four percent of parents in the study reported basement flooding in the past, and historical occurrence of basement flooding was found to be related to rates of wheezing and asthma in children (Dales, 1991a). In a study involving 14,799 Canadian adults, Dales *et al*. (1991b) also revealed a relationship between home dampness and mould growth related to flooding and occurrence of various symptoms and disorders, including upper and lower respiratory symptoms, chronic respiratory disease, asthma and eye irritation.

Various environmental and infrastructure-related factors may result in increasing basement flooding risk in Canada over the next few decades. For example, it expected that climate change will have implications for stormwater management in Canadian urban municipalities (Guo, 2006; Mailhot *et al*., 2010; Mladjic *et al*., 2011; Nguyen *et al*., 2007; Prodanovic & Simonovic, 2007). Specifically, Cheng *et al*. (2011) revealed that 1 in 100 year three-day accumulated rainfall amounts in the Thames, Grand, Humber and Rideau River basins of Ontario could increase by 34%, 73%, 50% and 30% respectively by the year 2050. Prodanovic and Simonovic (2007) further revealed that 24 hour precipitation amounts that wre historically associated with 1 in 100 year precipitation events could be associated with 1 in 30 year rainfall amounts in London, Ontario as a result of climate change.

Increasing stormwater-related flooding risk is not just a concern for Canadian municipalities. In a survey of 468 urban municipalities engaged in climate change adaptation work in Africa, Asia, Australia, New Zealand, Europe, Latin America, the United States and Canada, Carmin *et al*. (2012) revealed that over 65% of respondents expected an increase in stormwater runoff as a result of climate change—the most frequently reported expected climate change impact by survey respondents. The survey also revealed that 60% of the 26 Canadian municipal respondents reported that precipitation had already increased in their municipality as a result of climate change (Carmin *et al*., 2012).

Increasing urban development can also affect stormwater flows in urban areas (Booth & Jackson, 1997; Burby, 2006; Hood *et al*., 2007). Nirupama and Simonovic (2006) revealed a relationship between development and increasing flow rates in the Upper Thames River in London Ontario. In 1970, a 400 mm precipitation event resulted in a flow of 350 m^3/s in the Thames River at the Byron monitoring station. By 2000, a 200 mm precipitation event resulted in a flow of 800 m^3/s at the same monitoring station—an indication of the impact of increasing urbanization on the watershed (Nirupama & Simonovic, 2006). The impacts of climate change combined with increasing development and lack of funding and maintenance for municipal sewer infrastructure (Mirza, 2007) suggest that urban flood related damages and impacts will increase in Canada without the application of appropriate risk mitigation measures.

1.1. Codes and disaster risk reduction

The application and enforcement of building codes has been advanced by several researchers as a long-term, sustainable hazard mitigation strategy (Burby & May, 1999; Burby, 2006; Burton *et al*., 1993; Dean, 1995; Mileti, 1999; Simonovic, 2011; Tobin & Montz, 1997; Wisner *et al*., 2004). Codes are an important component in disaster resilience as they affect the construction and design of buildings, and specify "...not only structural design but also construction methods and materials" (Tobin & Montz, 1997: 212). Illustrating the role of codes in disaster risk reduction, Theckethil (2006) identified several functions of building codes, including reduction of death, property damage and reduction in the need for aid following disaster events (Table 1).

Table 1: Functions of building codes

• Reduce death, property damage, disruption to employment in institutions and businesses and need for aid following a disaster
• Contribute to the durability of buildings and help maintain quality of life and property values
• Ensure the protection of consumers especially homebuyers from purchasing substandard or dangerous housing
• Offer a predictable playing field for designers, builders and suppliers
• Allow economies of scale in the production of building materials and construction of buildings

Source: Theckethil, 2006: 97

The National Research Council oversees the production of Canada's national model codes, which include the National Building Code, the National Plumbing Code, the National Fire Code and the National Energy Code for Buildings (NRC, 2012a). National model codes are adapted and adopted by provincial governments, and most provinces adopt the National Building and Plumbing Codes with minor amendments (NRC, 2012b). Implementation and enforcement of provincial codes is undertaken at the local level, and it is the local authority (often municipal government) that is "responsible for creating the organizational structure for...code enforcement" (Simonovic, 2011: 35). The resources allocated to the enforcement of codes at the local level may be affected that the relative importance placed on construction and building inspections in comparison to other priorities of local government (Simonovic, 2011).

Much of the research on the role of codes in disaster risk reduction has been conducted in the US (Burby & May, 1999; Mileti, 1999; Theckethil, 2006; Tobin & Montz, 1997). This research has identified issues related to code enforcement on damage reduction from extreme natural events. For example, while the South Florida Building Code was identified as a successful approach at incorporating protection from hurricane winds in new construction, lack of adequate enforcement reduced its effectiveness in curbing damages from Hurricane Andrew in 1992 (Burby, 2006; Tobin & Montz, 1997). Indeed, Platt (1998) and Burby (2006) reported that approximately 25% of the damage that was experienced in Florida during Hurricane Andrew resulted from faulty construction and poor code enforcement—specifically, $4 billion in damages were attributed to code enforcement failures of Dade County, Florida.

A 1995 survey of local building administrators in southeastern US revealed that half of respondents felt that their departments were not adequately staffed to perform necessary inspections or handle necessary plan review responsibilities (Insurance Research Council and Insurance Institute for Property Loss Reduction, 1995 cited in Mileti, 1999). Burby (2006) further identified significantly higher levels of per-capita US National Flood Insurance Program payouts for states and regions that did not require building code enforcement in comparison to regions where code enforcement programs were in place. Mileti (1999) summarized the shortcoming of building codes as a tool for the reduction of natural disaster losses in the US, and stated that

> ...building codes are for life safety and do not provide for property protection or functionality after a disaster; many local jurisdictions do not have a building official or department many states allow local jurisdictions to petition wavers from the state-required building code, and; state-mandated codes are often reserved only for certain types of buildings and not for most commercial or residential structures (Mileti, 1999: 165-166).

Aside from enforcement, the content of codes can also affect their ability to limit disaster risk, and building code application in Canada and the US has been criticised for lack of adequate consideration of extreme natural events. For example, in both the US and in Canada, building codes establish the minimum acceptable standards for the preservation of public safety, health and welfare and for the protection of property and the built environment, rather than disaster risk reduction (Mileti, 1999; Simonovic, 2011; Tobin & Montz, 1997). The utility of building codes for reducing disaster risk is also affected by the fact that they apply only to new or proposed construction, and only affect existing buildings if major renovations are conducted (Simonovic, 2011). However, while building codes may apply only to new construction, the expected lifespan for housing ranges from 60 to 100 years with major alterations occurring every 10 to 20 years (Auld *et al*., 2007). Thus, incorporation of disaster risk reduction in new buildings can serve to reduce vulnerability over several decades.

It has also been revealed that it is difficult to encourage property owners to incorporate disaster risk reduction measures in existing buildings on a voluntary basis. A substantial body of research on public behaviour related to natural hazard risk reduction has shown that, before and after disaster events, there is often limited individual willingness to participate in disaster risk reduction (Burton *et al*., 1993; Mileti, 1999). Kunreuther (2006) described the "natural disaster syndrome," a central feature of which is the lack of voluntary adoption of disaster mitigation measures by individuals exposed to disaster risk. Kunreuther (2006) posits that it is difficult for homeowners to understand and adapt to high-consequence, low-probability events, and individuals tend to adopt the perception that natural disasters "will not happen to [them]," thus reducing their propensity to expend resources (time, money) on risk reduction measures (Kunreuther, 2006: 209).

A lack of voluntary mitigation action has been specifically identified for earthquake (Lindell & Perry, 2000; Palm, 1990), flooding (Laska, 1990; Shrubsole *et al*., 1995; Siegrist & Gutshcer, 2006; Yoshida & Deyle, 2005), and wildland fire (Brenkert-Smith *et al*., 2006; McCaffrey, 2004; McGee, 2007; Winter & Fried, 2000). Previous research has also revealed that few homeowners who have been exposed to urban flooding or who live in areas considered vulnerable to urban flooding adopt risk reduction measures including installation of backwater valves (Sandink, 2011; 2007), though a willingness to pay for increasing capacity of municipal infrastructure to reduce urban flood risk has been previously identified (Arthur, 2009). Thus, requirement of disaster mitigation measures in new homes may serve as a more effective alternative to voluntary adoption.

1.2. Purpose and outline

The purpose of this study was to survey local authorities responsible for building and plumbing code implementation in Canada. The survey was conducted to understand how building and plumbing code wordings are interpreted as they relate to incorporation of urban flood risk reduction in new homes. Specifically, this study explored how application of the same code wordings across the country has resulted in different frequencies of installation of backwater valves in new homes. This study also explored application of measures aside from backwater valves to reduce the risk of sanitary and storm sewer backup and application of by-laws by municipal governments to reduce urban flood risk in new homes.

While it has been previously reported that resolution of code enforcement issues may result in reduced vulnerability to extreme natural events (Burby, 2006; Mileti, 1999; Simonovic, 2011), issues surrounding code interpretation have not previously been studied. The study revealed that, despite consistent application of National Plumbing Code (NPC) wording related to backwater valves across the regions of Canada represented in this study, it was found that there are differing interpretations of code wordings resulting in differing reported frequencies of installation of backwater valves on both sanitary/combined and storm sewer service connections. Thus, the primary recommendation of this report is that wording in the NPC and provincial building and/or plumbing codes that relate to installation of backwater valves to protect against sewer backflow be reworded or clarified.

Section 2 of this paper provides a discussion of lot-side urban flood risk reduction options, with a focus on backwater valves and measures applied by local authorities to encourage their installation in new and existing homes. A description of code wordings related to backwater valves is also provided in Section 2. Section 3 discusses study methods and results of the survey are provided in Section 4. Discussion of the results and recommendations are provided in Section 5, and the paper concludes in Section 6.

2. Lot-side urban flood risk reduction

During intense rainfall events in urban areas, homes may be affected by overland flooding, infiltration flooding and/or sewer backup. Overland flooding occurs when extreme precipitation events exceed the capacity of urban stormwater management infrastructure, including underground storm or combined sewer systems and overland flow systems, resulting in uncontrolled flows of stormwater that can enter homes through windows, doors or other openings close to the surface of the ground. In Canada, underground stormwater management infrastructure is often designed for 1 in 5 year rainfall events and overland flow routes are often designed to handle 1 in 100 year rainfall events. When precipitation events exceed these standards, overland flooding can occur. However, in older subdivisions, infrastructure capacity may be designed to a lower standard (e.g., 1 in 2 year precipitation events) (UMA, 2005). Further, overland flow routes were not commonly incorporated into subdivision design until the 1970s in Canada (Hulley *et al*., 2008), resulting in higher overland flood risk in older urban subdivisions.

Infiltration flooding occurs as a result of rising groundwater levels or infiltration of water into the backfill zone surrounding the exterior of below-grade foundation walls. This water can enter basements through cracks in foundation walls and basement floors or where the basement floor joins the foundation wall. Foundation drainage systems, also referred to as weeping tiles, are incorporated into homes to reduce the risk of infiltration flooding, however infiltration flooding can occur when foundation drainage systems fail due to blockages or pipe collapse. Further, older Canadian homes (for example, those built before the 1950s) may not have foundation drainage systems, increasing their risk of experiencing infiltration flooding.

Sewer backup occurs as a result of surcharging or overloading of municipal underground sewer systems. When excess water enters sanitary sewers, surcharging can occur, which results in the reversal of flow of sewage, pushing sewage into homes through sanitary sewer connections. Sanitary surcharge is related to infiltration and inflow (I/I), where excess water enters municipal sanitary sewer systems through cracks and loose joints (infiltration), or through cross-connections between sanitary and stormwater infrastructure (inflow). For further information on household-level urban flooding, see Sandink (2009).

Table 2 summarizes measures that can be retrofitted into homes to reduce urban flood risk. Sealing cracks in foundation walls and floors reduces infiltration flood risk for individual homes. Homeowners can also decrease their risk of experiencing flooding from stormwater overland flows through lot-grading that directs water away form foundations and through installation of window wells. While providing limited protection for individual homes, disconnection of downspouts and foundation drainage from municipal sanitary sewer systems can significantly reduce I/I, thus reducing sewer backup risk at a regional level. Backwater valves, maintenance and repair of sewer laterals and sewage ejector systems serve to reduce the risk of sewer backup for individual homes.

Table 2: Lot-level urban flood risk reduction measures

Measure	Function
Seal cracks in foundation walls, basement floors	Reduces infiltration flood risk
Identify and seal overland flood entry points	Reduces overland/stormwater flow flood risk
Extension of downspouts and splash pads	Reduces infiltration flood risk, decreases amount of water that enters the municipal sewer system
Lot grading, backfilling and swales	Reduces infiltration flood risk, decreases amount of water that enters the municipal sewer system; reduces overland/stormwater flow flood risk
Backwater valve(s)	Reduces sewer backup risk
Sewage ejector system	Reduces sewer backup risk
Maintenance, repair of sewer laterals	Reduces sewer backup risk
Window wells and well covers	Reduces overland/stormwater flow flood risk
Downspout disconnection from municipal sanitary and combined sewer	Reduces sewer backup risk, decreases amount of water that enters the municipal sewer system
Foundation drain disconnection and sump installation	Reduces sewer backup risk, decreases amount of water that enters the municipal sewer system

Source: Sandink, 2011; 2009

2.1. Backwater valves

Backwater valves are recommended by municipalities across Canada as a sewer backup risk reduction measure. Cities across Canada have developed education programs, subsidy programs and by-laws to encourage the adoption of urban flood risk mitigation measures by individual households (Sandink, 2011). Backwater valves recommended for use by municipalities in Canada can be generally classified as open-port, mainline type backwater valves or inline backwater valves. The open-port, mainline valve is the only type of valve that can be placed directly in main building sanitary connections, as this valve design allows for the venting of sewer gasses. Inline valves are placed into branch lines and plumbing fixtures below street level. The NPC does not specify which type of valve would be required in specific circumstances, but prohibits the use of normally closed valves in building drains[1] and building sewers[2] (NRC, 2010a).

Backwater valves must be maintained to ensure that blockages do not affect the operation of the valve during a sewer backup, and should be monitored to ensure that they are in good working order. Reflecting maintenance issues, the City of Brantford's Basement Flooding Grant Programme Application Form, Agreement, and Release states that "in the event of the sale or lease of the Property, the Applicant will inform the purchaser or lessee of the existence of the completed Work installed and the applicable maintenance requirements" (City of Brantford, 2011b).

[1] National Plumbing Code definition: "Building drain means the lowest horizontal piping, including any vertical offset, that conducts sewage, clear-water waste or storm water by gravity to a building sewer" (NRC, 2010: 1-3).

[2] National Plumbing Code definition: "Building sewer means a pipe that is connected to a building drain 1m outside a wall of a building and that leads to a public sewer or private sewage disposal system" (NRC, 2010: 1-3).

Proper installation of a backwater valve in the main sanitary sewer connection requires the removal of all cross connections in existing homes. Cross connections that should be avoided include:

- Connection of foundation drainage to the sanitary lateral, either upstream or downstream of the valve, and;
- Connection of eavestrough downspouts to the sanitary lateral. This type of connection may come in the form of downspouts connection to the foundation drainage.

If foundation drainage is connected to the sanitary lateral upstream of the valve and the valve closes during a sanitary sewer surcharge event, foundation drainage water can enter the basements through basement floor drains. If foundation drainage is connected downstream of the valve, sewage could be forced into the foundation drainage and infiltrate into the basement through cracks in the foundation wall or through joints between the basement floor and the foundation wall during a sewer surcharge event (Sandink, 2009).

The NPC (sentence 6 of article 2.4.6.4.) states that "a subsoil drainage pipe that drains into a sanitary drainage system that is subject to surcharge shall be connected in such a manner that sewage cannot back up into the subsoil drainage pipe" (NRC, 2010a: 2-25). This wording specifically prohibits any type of connection of foundation drainage to the sanitary lateral that would result in the backing up of sewage into the foundation drainage during a surcharge event. In the case of a normally open valve placed on the main sanitary sewer connection, it is also important for homeowners to not use home plumbing during a sanitary sewer surcharge event; when the valve is closed sewage will not be able to exit the building and has the potential to flood the basement through floor drains.

2.2. Voluntary installations – retrofit programs

Several Canadian municipalities have adopted financial assistance programs to encourage retrofitting of basement flood risk reduction measures in homes. These programs are often targeted to homes that have had historical basement flooding issues or to homes that are located in areas that are considered vulnerable to basement flooding. However, some programs provide assistance for any homeowner in a municipality that is interested in retrofitting their home to reduce basement flood risk, regardless of flood history (Sandink, 2011).

Retrofit programs are targeted exclusively to the reduction of sewer backup risk, largely through installation of backwater valves (Figure 1) and elimination of storm/sanitary cross connections through the disconnection of eavestrough downspouts and foundation drainage from sanitary sewer connections, and do not provide assistance for retrofitting to reduce overland or infiltration flood risk (see Appendix A). Some programs provide financial assistance for downspout disconnection (see Appendix A), while others require that downspouts be disconnected in the appropriate manner before funding is made available (City of Kingston, 2012a).

While many of the programs have been implemented recently, some programs have been in place for a decade or more. For example, the City of St. Catharines' Flood Alleviation Program was implemented in 1998 and the City of Edmonton's program has been in place since 1991 (City of Edmonton, 2012a; City of St. Catharines, 2012). Many of these programs specify that only mainline, full-port backwater valves are eligible for subsides (Region of Durham, n.d.; City of Greater Sudbury, 2012; City of London, 2009; City of Welland, 2012; Region of Peel, 2011), while others allow for installation of in-line or mainline backwater valves (for example, City of Winnipeg, 2012).

Figure 1: Retrofitting a backwater valve in Hamilton, Ontario

Retrofitting a backwater valve requires the breaking of concrete flooring in basement, disconnection of foundation drainage from sanitary sewer connections and may require re-grading of sewer connections, adding to the expense of backwater valve retrofits.

Source: Institute for Catastrophic Loss Reduction.

It has been reported by several municipalities who have implemented grant or subsidy programs that it is often difficult to encourage homeowners to install valves, despite financial incentives. The experiences of these municipalities reflect literature on individual adoption of disaster mitigation adjustments, which has often revealed that property owners do not frequently adopt recommended risk reduction measures (see Section 1). For example, after an extreme rainfall flood in Mississauga, Ontario in August, 2009, a joint subsidy program provided by the Region of Peel and the City of Mississauga, Ontario was made available to 443 residents flooded during the event. Affected homeowners were provided free household drainage inspections to provide information on eligibility for backwater valves, foundation drainage disconnection and sump installation, and downspout disconnection (Inouye, 2012).

In Mississauga, drainage surveys revealed that 161 households were eligible for backwater valves, and that 37 households would require the removal of storm/sanitary cross connections, requiring the disconnection of foundation drainage, installation of sump pump systems and disconnection of eavestrough downspouts (Inouye, 2012). As presented in Appendix A, the Peel/Mississauga grant program would provide 50% of the cost up to $1,250 for backwater valve installations, 1/3 of the cost up to $6,000 for foundation drainage disconnection and $1,000 for the disconnection of downspouts. However, despite these comparatively generous subsidy amounts, the program experienced relatively low uptake, including only 10% uptake for the backwater valve grant (Table 3).

Table 3: Subsidy program eligibility and uptake in the City of Mississauga

Program component	Number of eligible households	Number uptake*	Percent uptake*
Drainage survey	443	210	47%
Backwater valve	161	16	10%
Sump systems	37	5	14%
Downspout disconnections	37	5	14%

*As of April, 2012
Source: Inouye, 2012

Other municipalities have experienced higher uptake rates for grant programs. For example, following a severe rainfall event in the Greater Toronto Area of Ontario in 2005, the City of Toronto mailed approximately 5,000 applications to homeowners in flood affected areas. Two thousand of these applications were filled out and returned to the City and 1,000 were approved for funding through the program (Sandink, 2007). When made available to the public in the years 2005, 2007 and 2010, the City of Saskatoon's subsidy program experienced uptake rates of over 50% (Table 4). Furthermore, the City of Saskatoon has found that the retrofit program has been highly successful at reducing the occurrence of sewer backup events. For example, following rainstorms that occurred after the retrofit program was implemented, the City found that sewer backup occurrence was reduced by 85% in households that received flood risk reduction retrofits, and 96% of households who participated in the program experienced reduced damages associated with sewer backup (Heinrichs, 2011).

Table 4: Uptake of City of Saskatoon retrofit grant programs in 2005, 2007 and 2010

Year	Number of households offered subsidy program	Number uptake	Percent uptake
2005	567	288	51%
2007	427	222	52%
2010	346	183	53%

Source: Heinrichs, 2011; City of Saskatoon, 2010

2.3. Code interpretation and mandatory backwater valve installation in new homes

As discussed above, model codes, including the NPC, are developed by the federal government, adopted in amended form by provincial governments and then applied and enforced at the local level. Provinces across Canada adopt the NPC in part or in whole, sometimes with minor modifications. The wording of article 2.4.6.4. of the NPC relates to protection of homes from backflow through the use of backwater valves, and is applied in provincial plumbing and building codes in most Canadian provinces, with minor variations.

NPC article 2.4.6.4. and the intent statements for each sentence of the article are provided in Table 5. The key sentence in NPC 2.4.6.4. that relates to the frequency of installation of backwater valves in new homes is sentence (3), which states "…where a *building drain*[3] or *branch*[4] may be subject to *backflow*[5], a gate valve or *backwater valve*[6] shall be installed on every *fixture drain*[7] connected to them…." Referring to

[3] Defined in the NPC as "...the lowest horizontal piping, including any vertical offset, that conducts sewage, clear-water waste or stormwater by gravity to a building sewer..." (NRC, 2010: Division A 1-3)

[4] Defined in the NPC as "...a soil-or-waste pipe connected at its upstream end to the junction of 2 or more soil-or-waste pipes or to a aoil-or-waste stack, and connected at its downstream end to another branch, a sump, a soil-or-waste stack or a building drain" (NRC, 2010: Division A 1-3)

[5] Defined in the NPC as "...a flowing back or reversal of the normal direction of flow" NRC, 2010: Division A 1-3)

[6] Defined in the NPC as "...a check valve designed for use in a gravity drainage system." (NRC, 2010: Division A 1-3)

[7] Defined in the NPC as "...the pipe that connects a trap serving a fixture to another part of a drainage system" (NRC, 2010: Division A 1-5)

“protection from backflow caused by surcharge,” Division B Appendix A of the NPC states that “these requirements are intended to apply when in the opinion of the authority having jurisdiction there is danger of backup from a public sewer” (NRC, 2010a: A-22, Division B). Thus, interpretation of this article as it relates to the requirement for the installation of backwater valves depends on the interpretation of the word “may” by local authorities in sentence (3) of the article.

One manner of interpretation of sentence 2.4.6.4. (3) of the NPC results in the installation of backwater valves only in specific circumstances. In these cases, only some homes “may” be subject to backflow, where, for example, local officials interpret this part of the code to mean that only homes in subdivisions constructed in areas that have had histories of sewer surcharging are required to have backwater valves. These areas might include infill development areas in older subdivisions, or newer subdivisions that are connected into older sewer systems that have had histories of surcharging causing sewer backup. This article of the code also allows for the installation of backwater valves should they be requested by individual homeowners or property developers.

A further manner of interpretation results in the installation of backwater valves in most or all new homes built in a municipality. In these cases, any home “may” be subject to backflow, as municipalities consider all homes that are connected to the sanitary sewer system as potentially at risk of sewer backup. For example, the Cities of Windsor, Toronto and Ottawa, among several others in Ontario, have adopted by-laws or code interpretations that require the installation of sanitary backwater valves in new home construction (City of Toronto, 2008; City of Windsor, 2011; Sandink, 2011). Other municipalities that require backwater valves on new home sanitary connections include Welland, Ontario, Saskatoon and Regina, Saskatchewan, Calgary, Alberta and Gatineau and Québec City, Québec (City of Ottawa, 2011).

Table 5: Summary of NPC 2.4.6.4. and statements of intent

Sentence	Intent Statement(s)[1]
1) Except as permitted in Sentence (2), a *backwater valve* or gate valve that would prevent the free circulation of air shall not be installed in a *building drain* or in a *building sewer*	**Sanitation:** To limit the probability of a restriction of waste flow in building drains or sewer systems, which could lead to the drainage system backing up, which could lead to surcharge, which could lead to unsanitary conditions, which could lead to harm to persons.
	Indoor Conditions: To limit the probability that a restriction of air flow between sewers and venting systems will lead to inadequate venting, which could lead to the entry of sewer gases into occupied space, which could lead to negative effects on indoor air quality, which could lead to harm to persons.
2) A *backwater valve* may be installed in a *building drain* provided that a) it is a "normally open" design... b) it does not serve more than one dwelling unit	**Indoor Conditions:** To limit the probability that a restriction of air flow between sewers and venting systems will lead to inadequate venting, which could lead to the entry of sewer gases into occupied space, which could lead to negative effects on indoor air quality, which could lead to harm to persons.
	Sanitation: To limit the probability of waste flow in building drains, which could lead to the drainage system backing up, which could lead to surcharge, which could lead to unsanitary conditions, which could lead to harm to persons.
3) Except as provided in Sentences (4), (5) and (6), where a *building drain* or a *branch* may be subject to *backflow*, a gate valve or a backwater valve shall be installed on every *fixture drain* connected to them when the fixture is located below the level of the adjoining street.	**Sanitation:** To limit the probability that a backup of public sewers will lead to backflow into building drainage systems, which could lead to unsanitary conditions, which could lead to harm to persons.
4) Where the *fixture* is a floor drain, a removable screw cap may be installed on the upstream side of the *trap*.	To modify the application of Sentence 2.4.6.4.(3) and allow gate valves or backwater valves, where removable screw caps are installed on the upstream side of traps to prevent backflow.
5) Where more than one *fixture* is located on a *storey* and all are connected to the same *branch*, the gate valve or *backwater valve* may be installed on the *branch*.	To modify the application of Sentence 2.4.6.4.(3) and allow the connection of the gate valve or backwater valve to the same branch.
6) A *subsoil drainage pipe* that drains into a *sanitary drainage system* that is subject to surcharge shall be connected in such a manner that *sewage* cannot back up into the *subsoil drainage pipe*.	**Sanitation:** To limit the probability that inappropriate backup protection will lead to sewage backflow into subsoil drainage pipes, which could lead to unsanitary conditions, which could lead to harm to persons.

Sources: NRC, 2012b; NRC, 2010

[1]Intent statements provide plain-language statements about what code sentences are intended to achieve (NRC, 2010a)

Recent extreme rainfall events have resulted in wide spread sewer backup flooding in areas of municipalities that were thought to be exposed to relatively low risk, including areas with relatively new infrastructure and separated sewer systems. For example, the 2005 urban flooding event in Southern Ontario affected a large portion of the City of Toronto that was serviced by separated sewer systems (Di Gironimo, 2007, 2008; Genivar & Clarifica, 2008; Stantec, 2008; XCG, 2008). The City of Mississauga was also affected by an extreme rainfall event that resulted in surcharged sanitary sewer systems causing sewer backup, despite the fact that the majority of the City is serviced by relatively new, separated sewer systems (City of Mississauga, 2012). The Binbrook neighbourhood of Hamilton, Ontario, a small isolated, relatively new development located in a rural area and serviced by a separated sewer system, also experienced a significant urban flood event that resulted in sewer backups in the summer of 2012 (Caton & Wong, 2012; Van Dongen, 2012a,b). These events illustrate that homes connected to relatively new, separated systems *may* be subject to backflow.

The potential for the occurrence of sewer backup in subdivisions regardless of histories of sewer backup has compelled the municipalities of Toronto and Windsor, Ontario do declare that the entire municipality may be at risk of sanitary sewer surcharge in the event of extreme rainfall, resulting in an interpretation of the Ontario Building Code article 7.4.6.4.[8] that requires installation of backwater valves in all new homes with below-grade living areas (City of Toronto, 2008; City of Windsor, 2011). For example, Toronto City Council adopted the recommendation in September, 2008 that:

> The whole City be declared at risk of basement flooding in the event of unusually severe or extreme precipitation, and the Chief Building Official, in collaboration with the General Manager, Toronto Water, the Chief Planner, the Executive Director of Municipal Licensing & Standards, and the City Solicitor, in accordance with the Ontario Building Code, require any applicant of a Plumbing Permit related to the sewer drain where there is a below grade living area anywhere in the City of Toronto to install a backwater valve on their sanitary sewer lateral (City of Toronto, 2008: 5).

Further, following a severe rainfall event in June, 2010, the City of Windsor adopted a code interpretation that requires backwater valves in all new homes. Specifically, it was stated that (City of Windsor, 2011: 3):

> The severe weather event of June 2010 was uncharacteristic for the historical climate conditions of the City. Various homes within the City experienced flooding. This occurrence has demonstrated that despite all reasonable precautions the City's sewer system could be overwhelmed, and building drains may be subject to backflow. In the opinion of the City Engineer, there is no single building drain, below the level of the adjoining street that is completely immune from this possibility. Accordingly, pursuant to Section 7.4.6.4(3) of the OBC, the Chief Building Official is obligated to mandate the installation of BWV on building drains of all new construction of single family dwellings, semi-detached dwellings and townhouses where the fixtures are located below the level of the adjoining street.

Some municipalities have required backwater valves in new homes for several decades. For example, the City of Edmonton has had this requirement since 1989 and the City of Winnipeg since 1979 (City of Edmonton, 2008; City of Winnipeg, 2012).

Municipalities may also adopt by-laws that require the installation of backwater valves in new homes. For example, Neepawa, Manitoba's by-law number 3059 requires that "all new plumbing fixtures below ground level shall be protected by a backwater valve" and that the "owner shall maintain the backwater valve to ensure that it is in good mechanical condition." Similar wording requiring backwater valves is also used in Portage La Prairie, Manitoba's by-law number 6748. The City of

[8] The wording of article 7.4.6.4. in the OBC is the same as the wording of article 2.4.6.4. of the NPC, aside from the removal of sentence 4 and removal of references to gate valves (see Section 5.2.)

Welland, Municipal Standards, 9.6 requires that "…all new houses (single detached, semi-detached and townhouses) to be fitted with a normally open backwater valve, in accordance with the Ontario Building Code 7.4.6.4., located in the building drain inside the house." Quispamsis, New Brunswick requires that "backwater valves are to be installed on building drains, inside foundation walls on all new building construction regardless of foundation elevation with roadway…." This approach differs from the advice of other municipalities that require backwater valves only for below-ground living space (Sandink, 2011). Section 3.1 of City of Moncton by-law P-209 also requires that "no person shall make any connections to the municipal sewage works with installing a backwater valve that is of a normally open design to the building drain."

Several municipalities that require backwater valves have integrated language related to backwater valve maintenance into by-laws. For example, maintenance requirement language in Welland and Kenora, Ontario and Neepawa, Manitoba, requires that backwater valves be maintained by the home occupant or owner. Similarly, Pointe Claire, Québec's by-law number 2495C stated that "… any connection to public sanitary, storm or combined sewer shall be equipped with a backwater valve…" and that "any backwater valve shall be maintained in good working condition by the owner" (see Sandink, 2011).

3. Methods

3.1. Questionnaire administration

A survey targeting local officials responsible for code interpretation and implementation was administered over a four month period starting in June and ending in October, 2012 using the online survey tool (SurveyMonkey—http://www.surveymonkey.com/). The questionnaire included sections that related to interpretation of article 2.4.6.4. of the NPC, measures applied to reduce sewer backup risk and municipal by-laws related to basement flood risk reduction (see Appendix B).

Several strategies were applied to collect responses through the online survey. Building and plumbing officials' associations were contacted and asked to distribute the survey to their members through emails and newsletters. In several instances, municipalities or authorities responsible for code interpretation, such as Saskatchewan's Regional Health Authorities, were contacted directly to request survey responses. Building and plumbing inspection departments and individual building and plumbing inspectors were also contacted directly and asked to fill out the survey.

Requests to complete the questionnaire were sent via email directly to members of building and plumbing officials' associations in British Columbia (through the Plumbing Officials Association of British Columbia) and Manitoba (through the Manitoba Building Officials Association). In Alberta, email requests were sent to Alberta Safety Codes Officers through the Alberta Safety Codes Commission. The Ontario Building Officials Association (OBOA) posted notices of the survey and requests for participation in newsletters that were sent to OBOA members and on their website. Email requests were also sent to municipal building officials listed in the Association of Municipal Managers, Clerks and Treasurers of Ontario database of municipal staff contacts. Email requests were sent to local authorities responsible for the plumbing code in Saskatchewan, including the Regional Health Authorities and municipalities responsible for code application.

Finally, email requests were sent to municipal building departments in Nova Scotia and New Brunswick. In several cases, initial contacts forwarded the email requests on to other members of their municipality, as well as colleagues in other municipalities. Requests for responses were also sent to relevant authorities in Newfoundland and Prince Edward Island, but no responses were received from these provinces. The survey was conducted in English and was not distributed in Québec.

3.1.1. Confidentiality

To ensure that survey responses were valid, all respondents were asked to report the name of their municipality or Regional Health Authority. Given the potentially sensitive nature of some of the responses, it was feared that respondents would not be willing to provide the name of their municipality or local authority. Thus, respondents were asked permission to communicate the name or their municipalities or local authorities in reports and publications generated from the survey.

Despite this assurance of confidentiality, several respondents did not report the name of their municipality, citing reasons such as lack of authority to speak on behalf of their municipality. When the name of the municipality and/or the personal contact information of respondents were not provided, responses were omitted from the overall analysis. Respondents were also asked to provide their name, title and contact information. This information was collected only to allow contact with respondents to clarify responses and to transmit findings of the study to survey participants. Respondents were guaranteed confidentiality of personal information provided as part of their participation with the survey.

4. Results

4.1. Summary of responses

A total of 243 respondents participated in the survey. Where there were multiple responses from individual municipalities, if available, only the responses from the most senior respondent from the municipality (including, for example, responses from the Chief Plumbing Official) were included in the analysis. In some instances, several respondents replied to the survey from the same municipality, but did not leave contact or title information. In these cases, responses with no title information were left out of the analysis, and only respondents who clearly indicated that they were associated with the municipality were incorporated into the analysis.

The respondent filtering process described above resulted in the identification of 160 valid responses from individuals representing local authorities responsible for code interpretation and implementation in the Yukon, British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, New Brunswick and Nova Scotia. Respondents from all regions except Saskatchewan worked for municipal governments or local municipal authorities. The majority of Saskatchewan respondents (6 of 7) responded from the perspective of Regional Health Authorities, which are responsible for plumbing code interpretation and implementation for all but three Saskatchewan municipalities. A summary of total and valid responses for each province represented in the survey is provided in Table 6. The combined populations of local authorities and municipalities represented in the survey are also provided in Table 6.

Table 6: Response summaries

	Responses		Combined population of valid response municipalities and local authorities[1]	Percent of province or region population[1]
Province or region	Total	Valid		
British Columbia	69	41	1,882,665	44%
Alberta	42	21	2,150,714	65%
Saskatchewan	8*	7*	>430,466†	>44%†
Manitoba	37	25	766,016	67%
Ontario	82	58	6,261,979	51%
New Brunswick and Nova Scotia	8	7	675,191	41%

* 6 Regional Health Authorities, representing 9 cities and 107 towns, and hundreds of additional municipalities and includes one municipal respondent

† Includes population only for 116 cities and towns under the jurisdiction of Regional Health Authority respondents and the individual municipality that replied to the survey

[1] 2006 figures. Sources: BC Stats, 2011; Saskatchewan Ministry of Municipal Affairs, 2012; Statistics Canada, 2011

4.1.1. British Columbia

A total of 41 communities and municipalities were represented by BC respondents in the survey (Table 7). Seven of the respondents indicated that they worked in rural municipalities, six of which included homes that were serviced by underground sewer systems. One respondent from the village of Belcarra indicated that their municipality was rural and that there were no homes serviced by an underground sewer system. One small municipality reported that they did not have a storm sewer system. The majority of respondents (80%) identified themselves as plumbing, gas and/or building inspectors, 12% did not provide a professional title, and the remaining respondents identified themselves as operations managers, permits and licenses managers and development inspectors.

Table 7: Municipalities represented from British Columbia

Respondents that did not request confidentiality	• Abbotsford • District of Saanich • District of West Vancouver • Fernie • Kitimat • Ladysmith • Nelson • North Saanich	• Osoyoos • Princeton • Keremeos • Okanagan Falls • Terrace • Victoria • Belcarra • Kelowna
Respondents that requested municipal confidentiality	• 25 municipalitiess	

Article 7.4.6.4 of the 2006 British Columbia Building Code relates to backflow protection, and applies the same wording as the 2010 NPC, article 2.4.6.4. (Office of Housing and Construction Standards, 2006). Article 2.4.6.4. of the 2012 BC Building Code applies the same wording as article 7.4.6.4 of the 2006 BC Building Code (British Columbia Office of Housing and Construction Standards, 2012a). The 2012 Plumbing Code came into effect on December 20, 2012 (British Columbia Office of Housing and Construction Standards, 2012b), thus, when BC respondents filled out the questionnaire the 2006 BC Building Code was still in effect.

4.1.2. Alberta

A total of 42 responses, representing 21 municipalities, were attained for the Province of Alberta (Table 8). The majority of Alberta respondents represented urban or suburban municipalities. Two respondents represented rural municipalities and both of these respondents reported that there were homes in their municipalities that were serviced by underground storm or sanitary/combined sewer systems. A number of provincial officials from Alberta also responded to the survey. Responses from provincial officials were not included in descriptive analysis of survey responses, but are included for context in the results section of this paper were appropriate. The majority of Alberta respondents (48%) indicated that they were Safety Codes Officers. In some cases, individual respondents were responsible for plumbing inspections and/or code interpretation for a number of smaller municipalities. For example, one respondent represented at least seven small towns and counties.

The Alberta Plumbing Code Regulation, under the *Alberta Safety Codes Act*, indicates that the province adopts the 2010 National Plumbing Code of Canada, with minor variations, none of which relate to article 2.4.6.4. of the NPC (Alberta Safety Codes Act, Alberta Plumbing Code Regulation, 2012).

Table 8: Municipalities represented from Alberta

Respondents that did not request confidentiality	• Airdrie • Calgary	• Edmonton • Cold Lake	• Foohills #31 • St. Albert
Respondents that requested municipal confidentiality	• 15 municipalitiess		

4.1.3. Saskatchewan

In Saskatchewan, Regional Health Authorities are designated as the local authorities responsible for provincial Plumbing and Drainage Regulations for all but three Saskatchewan municipalities. Larger municipalities, including Saskatoon, Regina and Lloydminster are the local authorities responsible for plumbing regulations within their own jurisdictions (Government of Saskatchewan, 2012). Reflecting the nature of the Saskatchewan sample, a separate questionnaire was administered to Regional Health Authority respondents (See Appendix C).

A total of seven Regional Health Authority respondents, representing six of the 13 Regional Health Authorities of the province, replied to the survey (Table 9). The respondents largely represented health regions in the southern areas of Saskatchewan. Most Regional Health Authority respondents (57%) identified themselves as Public Health Inspectors. Respondents from four of the six health regions represented in survey responses requested anonymity for their Regional Health Authority.

Together, the seven Saskatchewan Regional Health Authorities represented approximately 65% of all communities within the jurisdiction of Regional Health Authorities in the Province. Regional Health Authority respondents further represented nine of the 15 cities of Saskatchewan, and 107 of the 145 towns of the province (Saskatchewan Ministry of Municipal Affairs, 2012). Together, these 116 towns and cities had a 2006 population of 430,466 or 44% of the 2006 population of the province of Saskatchewan (Saskatchewan Ministry of Municipal Affairs, 2012; Statistics Canada, 2011). One municipality that is responsible for plumbing regulations within its own jurisdiction also responded to the survey. The Province of Saskatchewan has adopted the 2005 National Plumbing Code as the provincial plumbing code, with minor amendments (Public Health Act: Plumbing Regulations, 2011).

Table 9: Regional health authorities, municipalities represented from Saskatchewan

Respondents that did not request confidentiality	• Prairie North Health Region • Sunrise Health Region
Respondents that requested municipal and Regional Health Authority confidentiality	• 4 Regional Health Authorities • 1 municipality

4.1.4. Manitoba

A total of 37 responses were attained in the Province of Manitoba, representing 25 individual communities and municipalities (Table 10). Nine of these municipalities and communities were reported as being either urban or suburban, and responses indicated that 16 communities and municipalities represented in the survey were rural. Fifteen of the rural respondents indicated that a portion of homes in their communities were serviced by an underground municipal sewer system. Manitoba respondents identified themselves as plumbing and/or building inspectors, development officers and district property managers. The majority of respondents (65%) were plumbing and/or building inspectors. The Province of Manitoba adopts the 2010 National Plumbing Code, with minor amendments (Buildings and Mobile Homes Act: Manitoba Plumbing Code Regulation, 2011).

Table 10: Municipalities and local authorities represented from Manitoba

Respondents that did not request confidentialit	• Brandon • Headingley • Minnedosa • R.M. of Morris • Selkirk and District Planning Area Board	• Town of Altona • R.M. of Rhineland • Town of Souris • Winnipeg
Respondents that requested municipal confidentiality	• 16 municipalitiess	

4.1.5. Ontario

A total of 83 Ontario respondents representing 58 municipalities responded to the survey (Table 11). Seventy-six percent of Ontario respondents reported that they worked for urban or suburban municipalities, and 21% indicated that they worked in rural municipalities. Of the 12 respondents that indicated they worked in rural municipalities, four indicated that no homes in their municipality were serviced by underground sewer systems. The majority of Ontario respondents identified themselves as building inspectors (67%). Additional respondents included backflow prevention officers, building and planning managers, building engineers, facilities managers, among other disciplines.

Article 7.4.6.4 of the Ontario Building Code relates to backflow protection through the use of backwater valves. The wording of this article of the OBC is the same that is used in the 2010 NPC, aside from the removal of NPC 2.4.6.4. (4), which allows for use of removable screw caps in floor drains to reduce sewer backup risk, and removal of references to "gate valves" in sentences (1) and (3) (Ontario Building Code Act: Ontario Regulation 350/06 Building Code, 2012). In 2012, an updated version of the OBC, to come into effect on January 1, 2014, was released by the Ministry of Municipal Affairs and Housing (Ontario Building Code Act: Ontario Regulation 332/12 Building Code, 2012). The revised OBC wording includes changes to sentence (3) of article 7.4.6.4. However, the word "may" was retained in the first part of the sentence (see Appendix D).

Table 11: Municipalities represented from Ontario

Respondents that did not request confidentiality	• Town of Hearst • City of Brantford • Laurentian Valley Township • Town of Laurentian Hills • City of Cambridge • Huron County • Town of Ajax • Pembroke • Town of Bracebridge	• Wainfleet • City of Windsor • City of Kawartha Lakes • Town of Fort Frances • Dryden • Northumberland County • City of St. Catharines • City of Belleville • City of Kingston	• City of Waterloo • City of London • City of Ottawa • Wilmot Township • Bradford West Gwillimbury • City of Brampton
Respondents that requested municipal confidentiality	• 33 municipalitiess		

4.1.6. Nova Scotia and New Brunswick

Seven respondents from New Brunswick and Nova Scotia replied to the survey, including respondents from the Cities of Moncton and St. John, New Brunswick and Halifax Regional Municipality, Nova Scotia (Table 12). All respondents indicated that they worked in municipalities that were either urban/suburban, or rural with homes connected to underground municipal sewer systems. Six of the respondents indicated that they were plumbing and/or building inspectors, inspections service managers or supervisors of inspections, and one respondent did not provide title information.

Table 12: Municipalities represented from New Brunswick and Nova Scotia

Respondents that did not request confidentiality	• St. John, New Brunswick • Moncton, New Brunswick • Halifax Regional Municipality, Nova Scotia • County of Colchester, Nova Scotia
Respondents that requested municipal confidentiality	• 3 Municipalities

The provinces of Nova Scotia and New Brunswick adopt the National Plumbing Code with some amendments (NRC, 2012b). In New Brunswick, the 2005 National Plumbing Code is adopted and in Nova Scotia, the 2010 National Plumbing Code has been adopted (Building Code Act: Nova Scotia Building Code Regulations, 2011; Province of New Brunswick, 2012; Province of Nova Scotia, 2012).

4.1.7. Yukon

In addition to responses from the provinces and regions presented in Table 6, one response was received from a Yukon municipality. The respondent from this municipality requested anonymity for their municipality. A summary of responses for this municipality is provided in Table 13. As presented in Table 13, the respondent indicated that article 2.4.6.4. of the NPC would be interpreted to mean that backwater valves would only be required in rare, specific circumstances, and that the article related only to sanitary/combined sewer connections and not storm connections. The respondent reported that 1-5% and 0% of homes built since 2005 had sanitary and storm backwater valves respectively. By-laws applied in this municipality included requirements for foundation drainage in all new homes and lot grading that directs water away from foundations (Table 13).

Table 13: Yukon municipal responses

Interpretation of NPC 2.4.6.4.	Backwater valves are only required in rare, specific circumstances
	Code article applies only to sanitary and combined sewer backflow protection
Percent of homes built since 2005 with sanitary backwater valves	1 to 5%
Percent of homes built since 2005 with storm backwater valves	0%
By-laws applied	• Require foundation drainage in all new homes • Require lot grading that directs water away from foundations in all new development

4.2. Interpretation of article on backflow protection

Respondents were asked how the wording of article 2.4.6.4. of the NPC would be interpreted in their municipality. A considerable portion of respondents from all provinces indicated that the code would be interpreted in a way that would require backwater valves for sanitary sewer connections in all or most new homes. Specifically, the majority of respondents from Alberta, Saskatchewan, Manitoba, New Brunswick and Nova Scotia indicated that the code is interpreted in a way that would require sanitary backflow protection for all or most new homes (Tables 14 and 15). One Alberta municipal respondent clarified that backwater valves are only "required on plumbing below street level."

A portion of respondents from all regions except Alberta indicated that this article of the code only required backwater valves in "rare, specific circumstances." The majority of Respondents from British Columbia (66%) and Ontario (60%), however, reported that this article of the code would be interpreted in a way that would only require sanitary backwater valves in rare, specific circumstances (Tables 14 and 15).

Table 14: Interpretation of article 2.4.6.4. of the NPC

	Province or Region					
Response	**BC[1]**	**AB[2]**	**SK[3]**	**MB[4]**	**ON[5]**	**NB/NS[6]**
All new homes	7%	52%	43%	52%	14%	29%
Most new homes	12%	29%	43%	20%	12%	29%
Rare, specific circumstances	66%	19%	–	28%	60%	14%
Code does not require BWVs in any circumstance	7%	–	–	–	3%	–
Not sure how this part of the code would be interpreted in my municipality	2%	–	–	–	3%	–
No response	6%	–	14%	–	8%	28%

[1] n=41, [2] n=21, [3] n=7, [4] n=25, [5] n=58, [6] n=7

Respondents who did not ask for local authority confidentiality indicated that the following local authorities and municipalities interpreted article 2.4.6.4. of the NPC to require that backwater valves be installed in all or most new homes:

- Fernie and Terrace, British Columbia;
- Airdrie, Calgary and Foothills #31, Alberta;
- Prairie North Health Region and Sunrise Health Region, Saskatchewan;
- Headingley, Minnedosa, R.M. or Morris, Selkirk and District Planning Area Board, Altona, R.M. of Rhineland, Souris, Winnipeg and Brandon, Manitoba;
- Town of Laurentian Hills, Town of Bracebridge, City of Windsor, Town of Fort Frances, City of Sault Ste. Marie, Township of Wilmot, and City of Ottawa, Ontario;
- Moncton, New Brunswick, and;
- County of Colchester and Halifax Regional Municipality, Nova Scotia.

Not included in this list are municipalities and local authorities for which respondents requested confidentiality.

Table 15: Summarized interpretation of article 2.4.6.4. of NPC

	Province or Region					
Response	**BC[1]**	**AB[2]**	**SK[3]**	**MB[4]**	**ON[5]**	**NB/NS[6]**
All or most new homes	19%	81%	86%	72%	26%	58%
Article requires BWVs in rare circumstances or no circumstances	73%	19%	–	28%	63%	14%

[1] n=41, [2] n=21, [3] n=7, [4] n=25, [5] n=58, [6] n=7

One Saskatchewan Regional Health Authority respondent who did not respond to the above question reported that they

> encourage normally closed on the branch but accept normally open as per the code [and that] all new homes [with below grade living space] are required to have one or the other. We never see both. Homes on private septic systems are encouraged to have protection but not required if the tank is lower than the basement.

Thus, though this respondent did not provide a response to the above question, they indicated that all new homes are required to have backflow protection in the form of either normally open or normally closed backwater valves. Further, the municipal respondent from Saskatchewan indicated most new homes were required to have backwater valves. Thus, all Saskatchewan local authorities represented in the survey required backwater valves for sanitary connections in all or most new homes.

Several Ontario municipal respondents provided additional comments for the question relating to interpretation of the code, summarized in Table 16. Three percent (n=2) of Ontario respondents indicated they did not know how this article of the code would be interpreted in their municipality. Several "other" responses provided for the question related to the interpretation of the word "may" in article 7.4.6.4. OBC. One of these respondents indicated that "…the key word here is 'MAY' be installed. A by-law should be passed by a municipality to mandate these [types of] backwater valves." A further respondent who did not know how this part of the code would be interpreted indicated that "the code states that a backwater valve shall be installed on drains that "may" be flooded. Any drain "may" flood, but there is little political will to force residents to spend money."

Table 16: Ontario, other code interpretation responses

• Backwater [valve] is required if the building drain is subject to backflow or a local by-law applies (Huron County respondent).
• We don't have any history of sewer backups.
• The key word above is 'May', it's saying that if one is installed it must comply with sentence 2, it does not say that one has to be installed nor does it say that one is not required. It's a grey area of the code.
• The code states that a backwater valve shall be installed on drains that "may" be flooded. Any drain "may" flood, but there is little political will to force residents to spend money.
• O.B.C. as the same interpretation 7.4.6.4. The key word here is "MAY" be installed. A by-Law should be passed by a Municipality to mandate these [types of] backwater valves.

The respondent from Saint John, New Brunswick did not respond to the above question, however reported that "any fixtures below street level require a backwater valve on the branch that has those fixtures." A further respondent from a Nova Scotia municipality who did not respond to the above question indicated that sanitary backwater valves "are only required on a branch line only-fixture connected to drain." The respondent from the County of Colchester clarified that all new homes must have backwater valves, but only when these homes have fixtures below street level.

4.2.1. Type of service connection

Respondents were asked what type of service connection article 2.4.6.4. of the NPC was interpreted to refer to in their jurisdictions. As reported in Table 5, article 2.4.6.4. sentences (1), (2) and (3) refer to application of backwater valves in "building drains," which are defined in the NPC as "...the lowest horizontal piping, including any vertical offset that conducts sewage, clear-water waste or storm water by gravity to a building sewer" (NPC, 2010: 1-3). However, the majority of respondents from all regions indicated that this article of the code referred only to sanitary and/or combined sewer service connections (Figure 2, Table 17). The next most common response from all regions was that the code article referred to both sanitary and/or combined sewer connections and storm connections. Few respondents indicated that this article of the code referred only to storm connections (Figure 2, Table 17).

Figure 2: Service connection type referred to in article 2.4.6.4.

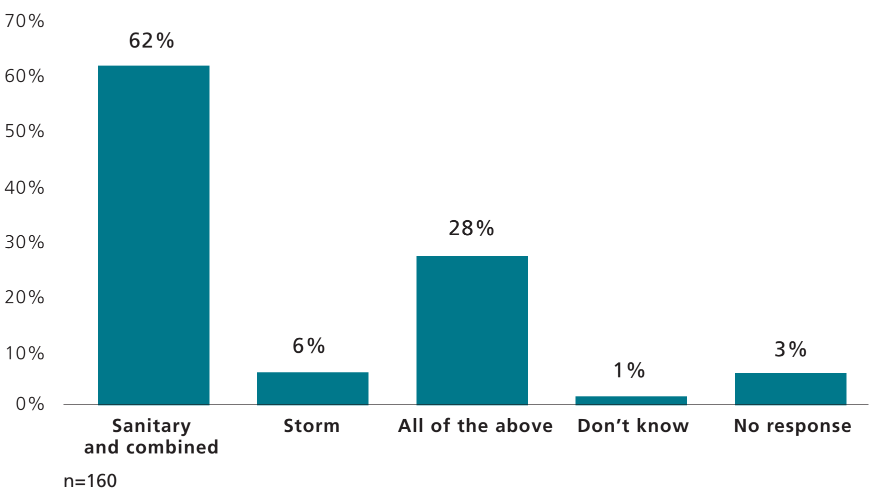

Table 17: Service connection type referred to in article 2.4.6.4.

	Province or Region					
Response	**BC[1]**	**AB[2]**	**SK[3]**	**MB[4]**	**ON[5]**	**NB/NS[6]**
Sanitary and combined	56%	71%	86%	76%	50%	86%
Storm	7%	–	–	8%	5%	–
All of the above	27%	24%	14%[7]	12%	36%	14%
Don't know	–	–	–	–	2%	–
No response	10%	5%	–	4%	7%	–

[1] n=41, [2] n=21, [3] n=7, [4] n=25, [5] n=58, [6] n=7, [7] Saskatchewan municipal respondent

4.3. Estimated sanitary backwater valve installation frequencies

Respondents were asked to estimate the proportion of homes built since 2005 in their jurisdictions that had backwater valves to protect sanitary connections from sewer backup. Few respondents from any region indicated that 0% of homes built since 2005 had sanitary backwater valves. Indeed, only 20% of British Columbia respondents, 4% of Manitoba respondents and 19% of Ontario respondents reported that no homes built since 2005 had sanitary backwater valves. The most common response in both British Columbia and Ontario was that between 1% and 5% of homes built since 2005 had sanitary backwater valves (Table 18). A considerable portion of respondents from all regions represented in the survey indicated that 50% or more homes built since 2005 had sanitary backwater valves, including 20% of British Columbia respondents, 81% of Alberta respondents, 86% of Saskatchewan respondents, 32% of Manitoba respondents, 10% of Ontario respondents and 71% of New Brunswick/Nova Scotia respondents (Tables 18 and 20).

Table 18: Estimated proportion of homes built since 2005 with sanitary backwater valves

		Province or Region					
Response		**BC[1]**	**AB[2]**	**SK[3]**	**MB[4]**	**ON[5]**	**NB/NS[6]**
0%		20%	–	–	4%	19%	–
1 to 50%	1 to 5%	32%	5%	–	4%	41%	14%
	6 to 20%	15%	–	–	4%	14%	–
	21 to 50%	2%	–	–	24%	7%	14%
51 to 99%	51 to 75%	5%	5%	–	–	–	28%
	76 to 99%	5%	–	–	4%	3%	14%
	96 to 99%	–	14%	43%	8%	2%	–
100%		10%	62%	43%	20%	5%	28%
Don't know		7%	14%	14%	28%	9%	–
N/A		2%	–	–	–	–	–

[1] n=41, [2] n=21, [3] n=7, [4] n=25, [5] n=58, [6] n=7.

Two respondents from the Government of Alberta indicated that the code required that most new homes have backwater valves on sanitary connections. An official from Alberta Municipal Affairs who responded to the survey indicated that the majority of Safety Codes Officers interpret this article of the provincial plumbing code in a manner that requires backwater valves for new homes with below ground living spaces. Indeed, the majority of Alberta municipal respondents (62%) reported that sanitary backwater valves had been installed in 100% of homes built in their municipalities since 2005 (Table 20). The respondent from Foothills #31, a rural municipality that includes homes that are connected to underground sewer systems, indicated that, while backwater valves were required by provincial building/plumbing codes, these types of valves are not required for private sewage systems, which are common in rural areas.

Table 19: Summary A: Estimated proportion of homes built since 2005 with sanitary backwater valves (0-50% vs. 51-100%)

	Province or Region					
Response	**BC[1]**	**AB[2]**	**SK[3]**	**MB[4]**	**ON[5]**	**NB/NS[6]**
0 to 50%	69%	5%	–	36%	81%	28%
51 to 100%	20%	81%	86%	32%	10%	71%

[1] n=41, [2] n=21, [3] n=7, [4] n=25, [5] n=58, [6] n=7

Table 20: Summary B: Estimated proportion of homes built since 2005 with sanitary backwater valves (0-50% vs. 51-100%)

	Province or Region					
Response	**BC[1]**	**AB[2]**	**SK[3]**	**MB[4]**	**ON[5]**	**NB/NS[6]**
0%	20%	–	–	4%	19%	–
0 to 50%	49%	5%	–	32%	62%	28%
51 to 100%	10%	19%	43%	12%	5%	42%
100%	10%	62%	43%	20%	5%	28%

[1] n=41, [2] n=21, [3] n=7, [4] n=25, [5] n=58, [6] n=7

A total of 121 respondents provided both a response to the code interpretation question presented in Table 14 and provided an approximate proportion of homes built since 2005 with sanitary backwater valves (Table 18). Chi-square analysis revealed a very high statistical correlation (p=<0.001) between interpreting that the code requires backwater valves for all or most new homes and reports that over 51% of homes built since 2005 had sanitary backwater valves (Table 21). This finding reveals that code interpretation had a significant relationship with incorporation of backwater valves in new homes.

Table 21: Impact of code interpretation on estimated proportion of homes with sanitary backwater valves

	Approximate proportion of homes built since 2005 with sanitary BWVs	
Code requires BWVs in:	**0% to 50%**	**51% to 100%**
All or most new homes	14	39
Rare or no circumstances	64	3

Chi-square: 62.121, p=0.000

Respondents who reported that between 1 and 50% of homes built since 2005 had backwater valves were further asked why a portion of homes in their municipalities had backwater valves. It was hypothesized that sewer backup risk in infill subdivisions or in subdivisions that were to be connected into sewers systems that had histories of sewer backup would be motivators for installation of backwater in these cases.

As displayed in Table 22, 15% (n=6) of BC respondents, 5% (n=1) of Alberta respondents, 4% (n=1) of Manitoba respondents, 17% (n=10) of Ontario respondents and 14% (n=1) of respondents from New Brunswick/Nova Scotia reported that between 1% and 50% of homes built since 2005 in their municipality had backwater valves because they were built in infill areas with histories of sewer backup.

Twelve percent (n=5) of BC respondents and 17% (n=10) of Ontario respondents indicated that backwater valves had been installed in homes built since 2005 because they were located in developments that were being connected into older sanitary sewer systems with histories of sewer backup.

Table 22: Motivators for sanitary valve installation in a minority of new homes

	Province or Region					
Response	**BC[1]**	**AB[2]**	**SK[3]**	**MB[4]**	**ON[5]**	**NB/NS[6]**
Infill areas with SB history	15%	5%	–	4%	17%	14%
Developments connected in to older systems with SB history	12%	–	–	–	17%	–
Other	32%	–	–	8%	29%	14%

[1] n=41, [2] n=21, [3] n=7, [4] n=25, [5] n=58, [6] n=7

A total of 32% (n=13) of BC respondents indicated that backwater valves had been placed in a portion of homes built since 2005 in their municipalities for reasons aside from sewer backup risk in infill development and development connected to older systems with histories of sewer backup. "Other" responses provided by BC respondents are provided in Table 23.

Table 23: BC, other motivatiors for sanitary valve installation in a minority of new homes

- "They could be affected by a failure on an adjacent property" (Nelson respondent)
- "Basement was lower than the nearest street cleanout" (respondent representing Priceton, Keremeos and Okanagan Falls)
- Victoria "For Sanitary, basement fixtures are below the flood level of the adjoining road. For storm, the basement floor is below the road, so the perimeter piping requires a BWV" (Victoria respondent)
- "Service room floor drain outfalls to an open storm drainage system with minimal building drain slope. Backwater valve installed in the event the storm water exceeded the outfall elevation of the building drain" (Belcarra respondent)
- "Engineering policy"
- "Case by case"
- "By owner/developer request"
- "Owner's choice for additional protection"
- "Requirement design of registered professional (P.Eng)"
- "Pressure assisted storm/sanitary discharges"
- "Building drain above basement floor level as is the case with a sump at the basement floor elevation"

Two respondents (8%) from Manitoba also indicated that backwater valves for sanitary connections had been incorporated into a minority of homes built since 2005. "Other" responses from Manitoba respondents are provided in Table 24

Table 24: Manitoba, other motivators for sanitary valve installation in a minority of new homes

- "Required by code (as interpreted)"
- "The development had town sewer hook up for grey water and their own septic tank-something new required extra protection"

Several Ontario respondents indicated that their municipalities implemented by-laws or policies to require backwater valves in new homes later than 2005 (including Windsor, Ottawa and the Township of Wilmot). In these cases, though the municipalities require backwater valves, only a minority of homes built since 2005 may have had backwater valves installed. For example, though the City of Windsor respondent indicated that their municipality interprets the code to require that "all new homes are required to have backwater valves" on sanitary connections, the respondent further indicated that only 1-5% of homes built since 2005 have backwater valves as the backwater valve requirement only came into effect in January, 2012 (City of Windsor, 2011). Additional "other" responses from Ontario municipal respondents are provided in Table 25.

Table 25: Ontario, other motivators for sanitary valve installation in a minority of new homes

• "Insurance company requests in high surcharge areas of the city" (Brantford respondent)
• "Because of the sewer elevations, it is possible to backflow into a basement before it overflows onto a street!" (Laurentian Valley Township respondent)
• "We recommend them" (Pembroke respondent)
• "If there is plumbing lower than the street man hole a back water valve is required" (Bracebridge respondent)
• "Mandatory requirement for all homes, as the City Engineer has opined that there is a potential of backup throughout the City of Windsor" (Windsor respondent)
• "Home by home assessment previous history etc." (Northumberland County respondent)
• "Significant rainfall events have caused backups. Sewer by-law amended requiring mandatory installation of a full port backwater value on sanitary for all new low rise residential buildings with a basement" (City of Ottawa respondent)
• "Since 2009 we have required [backwater valves] in all new homes" (Wilmot Township respondent)
• "Added to older existing systems that have problems" (City of Brampton respondent)
• "Interests of builders"
• "Required by by-law and precautionary"
• "Builders' preference"
• "Sewage pumping station had a power failure"
• "Owners wanted them"
• "Owner specified"
• "We had a flood in September 2011, [insurers] are asking home owner to install normally open backwater valves on building drain & building sewer repairs"

One rural municipal respondent from Nova Scotia indicated that backwater valves were installed on homes serviced by municipal sanitary sewer systems, but were not required for homes serviced by septic systems or homes with site sewage disposal (Table 26).

Table 26: Nova Scotia, other motivators for sanitary valve installation in a minority of new homes

• "They were connected to a Municipal sewer system serving multiple buildings and not on site sewage disposal system or septic."

Respondents who estimated that the majority of homes (51-100%) built since 2005 in their municipality had sanitary backwater valves were asked if these homes had backwater valves because they were required as part of provincial building/plumbing codes, if they are required by a municipal by-law or if there were other reasons why the majority of homes had backwater valves installed (Table 27).

Table 27: Motivators for sanitary valve installation in a majority of new homes

	Province or Region					
Response	**BC[1]**	**AB[2]**	**SK[3]**	**MB[4]**	**ON[5]**	**NB/NS[6]**
BWVs required by provincial plumbing/building codes	5%	48%	71%	32%	9%	57%
Municipal by-law requirement for new homes	7%	–	–	8%	5%	–
Other	7%	14%	14%	–	2%	14%

[1] n=41, [2] n=21, [3] n=7, [4] n=25, [5] n=58, [6] n=7

Five percent (n=2) and 7% (n=3) of BC respondents reported that the majority of the homes built in their municipality since 2005 had sanitary backwater valves because they were required by the provincial building code or by municipal by-laws, respectively (Table 27). Three (7%) BC respondents indicated that the majority of homes built since 2005 in their municipality had sanitary backwater valves for other reasons (Table 28).

Table 28: BC, other motivators for sanitary valve installation in a majority of new homes

- "We have made it a policy to require backwater valves in the form of sewer flaps for all new inspection chambers installed as part of the sanitary sewer service connection. These flaps are never 100% closed and therefore it has been our experience that they do allow for some air circulation between the sanitary sewer and the house venting system"
- "Most homes have basements and are built below street level"
- "Areas known to have backflow problems require them"

The majority of Alberta respondents who reported that most or all homes in their municipality had been equipped with backwater valves for sanitary or combined connections indicated that backwater valves were required by provincial plumbing or building codes. The respondent from Foothills #31, a rural municipality that includes homes that are connected to underground sewer systems, indicated that while backwater valves were required by provincial building/plumbing codes, these types of valves are not required for private sewage systems common in rural areas.

The Saskatchewan municipal respondent indicated that 100% of new homes built since 2005 had backwater valves on sanitary connections due to provincial code requirements. The Regional Health Authority respondent who replied "other" to the above question responded that 100% of the homes built since 2005 in their jurisdiction had backwater valves on sanitary connections "either by code or municipal by-law."

Most Ontario municipal respondents who estimated that the majority of homes (51-100%) built in their municipality since 2005 had backwater valves indicated that valves were required by the provincial building code (n=5) and/or that valves were required by a municipal by-law (n=3). One respondent reported that valves were installed in 51-100% of homes built since 2005 for an "other" reason. In this case, despite sentence A-7.4.6.4.(5) of OBC Appendix A, which states that requirements related to protection from backflow are "...intended to apply when in the opinion of the local authority having jurisdiction there is a danger of backup from a public sewer" (MMAH, 2010: A-80), the municipality required backwater valves in homes with below-ground living space (Table 29).

Table 29: Ontario, other motivators for sanitary valve installation in a majority of new homes

- "Article 7.4.6.4. of Volume 2, Appendix A of the OBC provides for the authority having jurisdiction to not require that a backwater valve be installed. However it is the standard practice in this municipality that they are required in all newly constructed buildings unless the home is constructed on a slab on ground above the level of the adjoining street." (Town of Fort Frances respondent)

One respondent from Nova Scotia reported that the majority of homes built since 2005 have backwater valves because "most have fixtures in the basement," indicating an interpretation of the code that requires backwater valves on below-grade fixtures.

4.4. Estimated storm backwater valve installation frequencies

Respondents were asked to estimate the proportion of homes built in their municipalities since 2005 that had backwater valves installed on storm connections. Backwater valves on storm connections may be applied as a tool to prevent backflow into subsoil drainage systems (foundation drainage), where drainage is gravity fed into storm sewer connections. For example, the City of Ottawa's Sewer Design Guidelines require installation of backwater valves on storm and combined sewer connections to prevent storm sewer backup into foundation drainage (City of Ottawa, 2011).

Aside from respondents from Alberta municipalities and Saskatchewan, few respondents estimated that the majority of homes built in their jurisdictions since 2005 had backwater valves installed on storm connections (Tables 30-32). While most Alberta respondents estimated that the majority of homes built in their municipality were equipped with backwater valves to protect against sanitary and/or combined sewer backflow, application of backwater valves for storm connections was more inconsistent. Again, several municipalities indicated that the majority of new homes had storm backwater valves, but a greater proportion indicated that no or few homes were equipped with backwater valves on storm connections (Tables 30-32).

Table 30: Estimated proportion of homes built since 2005 with storm backwater valves

		Province or Region					
Response		BC[1]	AB[2]	SK[3]	MB[4]	ON[5]	NB/NS[6]
0%		54%	19%	29%	24%	59%	14%
1 to 50%	1 to 5%	20%	–	–	–	14%	43%
	6 o 20%	5%	5%	–	24%	5%	14%
	21 to 50%	5%	–	–	–	–	–
51 to 99%	51 to 75%	2%	–	–	–	–	–
	76 to 99%	–	–	29%	4%	2%	–
	96 to 99%	–	5%	14%	–	–	–
100%		–	48%	–	4%	10%	–
Don't know		7%	19%	14%	32%	5%	–
N/A		2%	5%	14%*	8%	5%	14%

[1] n=41, [2] n=21, [3] n=7, [4] n=25, [5] n=58, [6] n=7, *Saskatchewan municipal respondent

Table 31: Summary A: Estimated proportion of homes built since 2005 with storm backwater valves (0-50% vs. 51-100%)

	Province or Region					
Response	**BC[1]**	**AB[2]**	**SK[3]**	**MB[4]**	**ON[5]**	**NB/NS[6]**
0 to 50%	84%	24%	29%	48%	78%	71%
51 to 100%	2%	53%	43%	8%	12%	–

[1] n=41, [2] n=21, [3] n=7, [4] n=25, [5] n=58, [6] n=7

Table 32: Summary B: Estimated proportion of homes built since 2005 with storm backwater valves (0-50% vs. 51-100%)

	Province or Region					
Response	**BC[1]**	**AB[2]**	**SK[3]**	**MB[4]**	**ON[5]**	**NB/NS[6]**
0%	54%	19%	29%	24%	59%	14%
1% to 50%	30%	5%	0%	24%	19%	57%
51% to 99%	2%	5%	43%	4%	2%	–
100%	–	48%	–	4%	10%	–

[1] n=41, [2] n=21, [3] n=7, [4] n=25, [5] n=58, [6] n=7

Chi-square analysis revealed that interpretation that related to the type of sewer connection referred to in article 2.4.6.4. of the NPC (i.e., combined and sanitary vs. combined, sanitary and storm) was not significantly correlated with the reported frequency of installation of storm backwater valves in homes built since 2005 in local jurisdictions represented in the survey (Table 33). Similar to sanitary backwater valve installation frequencies, interpretation of the code in a manner that required backwater valves on all or most new homes had a significant correlation with reported frequency of installation of backwater valves on storm connections of new homes (Table 34). Logistic regression analysis further revealed that interpreting article 2.4.6.4. of the NPC to relate to storm connections as well as sanitary/combined connections was statistically associated with reported frequency of installation of storm backwater valves in homes built since 2005 (Table 35)

Table 33: Impact of code interpretation on approximate proportion of homes with storm backwater valves (A)

	Approximate proportion of homes built since 2005 with storm BWVs	
Code requires BWVs in:	**0% to 50%**	**51% to 100%**
Combined, sanitary and storm	35	9
Combined and sanitary	55	10

Chi-square: 0.469, p=0.494

Table 34: Impact of code interpretation on approximate proportion of homes with storm backwater valves (B)

	Approximate proportion of homes built since 2005 with storm BWVs	
Code requires BWVs in:	**0% to 50%**	**51% to 100%**
All or most new homes	31	16
Rare or no circumstances	61	2

Chi-square: 18.741, p=0.000

Table 35: Impact of code interpretation on approximate proportion of homes with storm backwater valves (C)

Interpretation	B	P	Exp (B)
All or most new homes vs. rare or no circumstances*	3.221	0.000	25.057
Applies to sanitary/combined vs. sanitary, combined, storm**	1.349	0.043	3.854

* NPC 2.4.6.4. requires that all or most new homes have backwater valves vs. valves are required in rare, specific or no circumstances

** NPC 2.4.6.4. applies to sanitary, combined and/or storm backflow protection vs. sanitary and combined backflow protection

Respondents who reported that 1-50% of homes in their municipality built since 2005 had backwater valves to protect against storm sewer backflow were asked whether valves were required in these homes because they were located in infill areas with histories of storm sewer backup, because these homes were in developments that were connected into older systems with histories of storm sewer backup, or for other reasons (Table 36). Few respondents indicated that backwater valves were installed on storm connections in homes built since 2005 because of concerns related to storm sewer backup in infill development (Table 36).

Table 36: Motivators for storm valve installation in a minority of new homes

	Province or Region					
Response	**BC[1]**	**AB[2]**	**SK[3]**	**MB[4]**	**ON[5]**	**NB/NS[6]**
Infill areas with SB history	7%	–	–	–	3%	14%
Developments connected in to older systems with SB history	15%	–	–	24%	3%	14%
Other	15%	5%	–	–	10%	29%

[1] n=41, [2] n=21, [3] n=7, [4] n=25, [5] n=58, [6] n=7

Six respondents from BC indicated that there were other reasons why backwater valves had been installed in 1-50% of homes built since 2005 in their municipalities. Other reasons included installation due to possibilities of storm sewer backup into foundation drainage and requests made by specific building owners or other professionals (Table 37). The respondent from Alberta who responded "other" to the above question indicated that this requirement had "always been in the code."

Table 37: BC, other motivators for storm valve installation in a minority of new homes

• "For storm sewer the basement floor is below the flood level of the adjoining road, so the perimeter piping requires a BWV" (Victoria respondent)
• "Homes built below storm sewer mains or homes located at bottom of hills where back ups are more possible"
• "Owner's request"
• "The level of the Inspection Chamber or the sump lid is higher than the level of the basement or lowest floor."
• "Owner's choice"
• "Required by registered professional design (P. Eng)"

Six (10%) Ontario respondents indicated that there were other reasons why storm backwater valves had been installed in under 50% of homes built since 2005 in their municipalities (Table 38). Other reasons in Ontario municipalities included location of new homes relative to riverine floodplains, owner and builder requests and municipal "recommendations."

Table 38: Ontario, other motivators for storm valve installation in a minority of new homes

• "Built in or near floodplains, and it is possible for a ditch, stream or river to rise above the basement floor" (Laurentian Valley Township respondent)
• "Backwater valve installed on storm building drain to prevent sanitary from backing up into the storm drain" (Huron County respondent)
• "Owner preference" (Town of Ajax respondent)
• "We recommend them" (Pembroke respondent)
• "Individual assessment" (Northumberland County respondent)
• "Interests of builders"

One respondent from New Brunswick and one respondent from Nova Scotia indicated that there were other reasons why backwater valves had been installed on storm connections in under 50% of homes built since 2005 for other reasons. Other reasons included policy orientation toward older homes rather than new homes, and connection of homes to sewer systems that provide service for both sanitary and storm sewage (Table 39).

Table 39: NB/NS, other motivators for storm valve installation in a minority of new homes

• "We only started a program for all homes to protect the storm in older homes" (City of Moncton, NB respondent)
• "They were connected to a Municipal sewer system which may also service storm drains." (Nova Scotia respondent)

Respondents who reported that the majority of homes (51-100%) built since 2005 in their jurisdictions had backwater valves on storm connections were asked if they were a requirement of provincial plumbing or building codes, if there were municipal by-laws that required storm backwater valve installation in their jurisdictions, or if storm backwater valves were installed on the majority of new homes in their jurisdiction for other reasons (Table 40).

Table 40: Motivators for storm valve installation in a majority of new homes

	Province or Region					
Response	**BC[1]**	**AB[2]**	**SK[3]**	**MB[4]**	**ON[5]**	**NB/NS[6]**
Storm BWVs required by provincial plumbing/building codes	–	48%	29%	8%	5%	–
Municipal by-law requirement for new homes	2%	5%	–	4%	7%	–
Other	–	–	14%	–	2%	–

[1] n=41, [2] n=21, [3] n=7, [4] n=25, [5] n=58, [6] n=7

Only one BC respondent indicated that the majority of homes (in this case, 51-75%) built since 2005 in their municipality had backwater valves on storm connections. This respondent further indicated that this type of valve was required by a municipal by-law (Table 40). All Alberta respondents who reported that the majority of homes in their municipalities built since 2005 had storm backwater valves indicated that this was a requirement of provincial codes. One (5%) Alberta respondent who reported that 100% of homes built since 2005 had storm backwater valves indicated that their municipality also had a by-law that required this type of installation (Table 40).

Two of the three Saskatchewan Regional Health Authority respondents who reported a very high frequency (76-99%) of installation of backwater valves on storm connections for homes built since 2005, including the Sunrise Health Region, indicated that storm backwater valves were a requirement of the provincial plumbing code. The other Regional Health Authority respondent who indicated that 76-95% of homes built since 2005 had storm backwater valves reported that they were installed because the "sump is not connected to the sewer." In Ontario, the majority of respondents who reported high frequencies of storm backwater valve installations on homes built since 2005 indicated that this was a requirement of the Ontario Building Code or that municipal by-laws required this type of valve (Table 40). One Ontario respondent indicated that storm backwater valves were installed on the majority of homes built since 2005 because the municipality "recommended them."

4.5. Alternative lot-side sanitary and storm risk reduction methods

4.5.1. Alternative lot-sde sanitary sewer backup risk reduction methods

Survey respondents were asked whether lot-side alternatives to backwater valves were being applied in their municipality to reduce sanitary and storm sewer backup risk at the lot-level, and what these alternatives were. Some municipalities provide assistance for measures aside from backwater valves to reduce sewer backup risk. For example, the City of London subsidy program has included a subsidy for sewer ejector systems, which could be applied when backwater valves are considered inappropriate for particular properties (City of London, 2009). Further, the NPC allows for use of gate valves and removable screw caps in floor drains as alternatives to backwater valves. However, as displayed in Figure 3 and Table 41, the majority of respondents from all regions indicated that alternatives to backwater valves were not being applied to reduce sanitary sewer backup risk.

Figure 3: Other non-BWV technologies, methods applied to reduce sanitary sewer backup

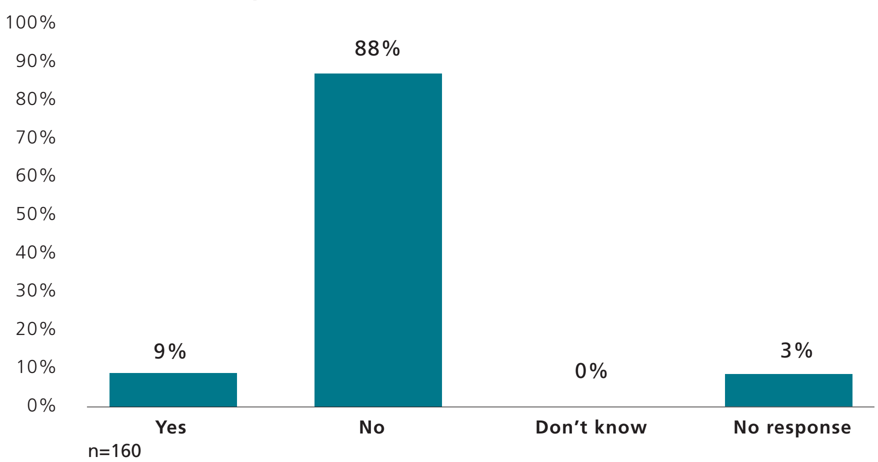

Table 41: Other non-BWV technologies, methods applied to reduce sanitary sewer backup

	Province or Region					
Response	**BC[1]**	**AB[2]**	**SK[3]**	**MB[4]**	**ON[5]**	**NB/NS[6]**
Yes	10%	–	14%	–	12%	14%
No	80%	100%	71%	96%	85%	86%
Don't know	–	–	14%	–	–	–

[1] n=41, [2] n=21, [3] n=7, [4] n=25, [5] n=58, [6] n=7

Four BC respondents reported the application of alternative methods to reduce the risk of sanitary sewer backup (Table 42). These alternatives included spring check valves, and sanitary lift pumps. One respondent reported that "floodplain elevation requirements" were applied to help reduce the risk of sanitary sewage backup in homes.

Table 42: BC, other sanitary backflow protection methods

• "Spring check valves are installed at [municipal] hook-ups on Low Pressure Forced Main systems." (North Saanich respondent)
• "Floodplain elevation requirements"
• "Sanitary lift pump"

No Alberta or Manitoba municipal respondents indicated that approaches alternative to backwater valves were being applied in their municipality to reduce lot-side risk of sanitary or combined sewer backup (Table 41). The municipal respondent from Saskatchewan indicated "weeping tile is diverted to a sump and pumped outside" as an alternative to backwater valves for sanitary sewer backup risk reduction. Though the Sunrise Health Region respondent indicated that alternative methods were being applied in their jurisdiction, they did not indicate what these measures were.

Seven Ontario respondents indicated that methods aside from backwater valves were being applied in their municipality to reduce lot-side risk of sanitary sewage backup (Table 43). The respondent from Windsor indicated that materials were being distributed through homebuilders to educate homeowners about backwater valve and sump pump maintenance requirements, among other measures to reduce sewer backup risk. Discontinuance of storm sewer servicing to residences, flushing of municipal sewer systems, by-laws and property standards, no longer installing combined sewers and draining foundation drainage to the lot via sump pumps were further alternative methods identified by Ontario respondents, however few of these measures are applied at the lot-side. One respondent indicated that check valves were required on sanitary sewage sump discharge pipes, as per OBC 7.4.6.3. (6).[9] Finally, the respondent from Halifax Regional Municipality, Nova Scotia indicated that "flood check devices installed in floor drains that are not protected by a backwater valve" are used as alternative sanitary backflow protection devices in their municipality.

[9] Sentence 7.4.6.3 (6) of the OBC states that "the discharge pipe from every pumped sanitary sewage sump shall be equipped with a union, a check valve and a shut-off valve installed in that sequence in the direction of discharge."

Table 43: Ontario, other sanitary backflow protection methods

• "Provide homebuilders with general information to be shared with new homeowners related to maintenance of BWVs, sump pumps (where applicable) and other measures that can reduce the risk of basement backups." (Windsor respondent)
• "We no longer run storm water lines to residential."
• "Regular flushing of lines with historical backflow issues."
• "Property Standards By-law may require installation"
• "Check valve on discharge pipe from pumped sanitary sewage sump. 7.4.6.3.(6) OBC"
• "Combined sewer is not permitted to be installed"
• "Storm sump pumps spill over ground"

4.5.2. Alternative lot-side storm sewer backup risk reduction methods

Respondents were asked if lot-side alternatives to backwater valves to protect homes from storm sewer backup were being applied in their jurisdictions. Similar to responses regarding alternatives to backwater valves for lot-side sanitary sewer backup risk reduction (see Section 4.5.1.), the majority of respondents indicated that alternatives to storm backwater valves were not being applied in their jurisdictions (Figure 4, Table 44). However, a number of alternatives were identified by municipal respondents.

Figure 4: Other non-BWV technologies, methods applied to reduce storm sewer backup

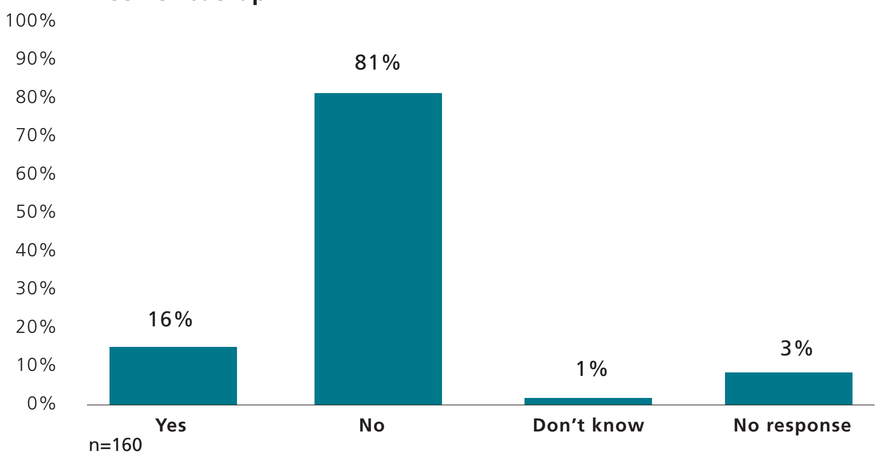

Table 44: Other non-BWV technologies, methods applied to reduce storm sewer backup

	Province or Region					
Response	**BC**[1]	**AB**[2]	**SK**[3]	**MB**[4]	**ON**[5]	**NB/NS**[6]
Yes	15%	14%	29%	8%	20%	14%
No	78%	86%	43%	88%	76%	86%
Don't know	–	–	29%	–	–	–

[1] n=41, [2] n=21, [3] n=7, [4] n=25, [5] n=58, [6] n=7

Alternatives to storm backwater valves were reported in six (15%) of the BC municipalities represented in the survey. Alternatives included the use of sump pumps, lack of the use of underground storm sewer systems, the use of on-site foundation drainage disposal, and restriction of the connection of downspouts to foundation drainage systems (Table 45).

Table 45: BC, other storm backflow protection methods

• "Sump pump" (Kitimat respondent)
• "Stormwater discharges are primarily daylighted into either open culverts, or run-outs to ocean." (North Sannich respondent)
• "Not connecting to a storm sewer but using on site disposal based on an engineered rock pit/trench" (Belcarra respondent)
• "We encourage the use of on-site drainage control by installing drywells. Our municipality has very few storm sewers."
• "In ground disposal"
• "Roof water leaders are not permitted to connect into the same building sump that the perimeter drains discharge to."

Responses indicated that alternatives to backwater valves were being applied in three (14%) Alberta municipalities represented in the survey. Alternatives included stormwater management features—including stormwater management ponds and an arrangement of storm connections to homes where the storm connection "rises beside the building and does not enter the structure." One Manitoba respondent indicated that alternative approaches that were applied to reduce storm sewer backup risk included side drainage to drywells, ditches and private swales. Another Manitoba respondent reported that home connections to storm systems are not permitted in their municipality, which prevents the occurrence of storm sewer backup.

Two Saskatchewan Regional Health Authority respondents reported that methods aside form storm backwater valves were applied in their jurisdictions to reduce storm sewer backup risk. One respondent did not indicate what the alternatives were, while the other respondent indicated "sump pit[s] directed to drain outside of the building[s]" were applied as alternatives. As an alternative to backwater valves installed on storm sewer lines, the respondent from Moncton, NB indicated that "all storm is now tied outside" and "all that comes in the building is a clean-out."

Eleven (19%) Ontario respondents reported that alternative measures were applied in their municipalities to reduce the risk of storm sewer backup. Alternatives included restricting connections to the municipal storm sewer system, engagement of homeowners in flood reduction options, and use of sumps for foundation drainage (Table 46).

Table 46: Ontario, other storm backflow protection methods

• "Municipality does not permit drainage connected to storm water" (Town of Bracebridge respondent)
• "Provide homebuilders with general information to be shared with new homeowners related to maintenance of BWVs, sump pumps (where applicable) and other measures that can reduce the risk of basement backups." (City of Windsor respondent)
• "Use of sump pump for building drain water complete with check valve" (City of Sault Ste. Marie respondent)
• "We have stopped bringing storm sewers to the buildings, and now not even to the lot lines." (City of St. Catharines respondent)
• "Sump pump discharging into a vertical pipe that is part of storm sewer via indirect connection and the connection is outside of building and above a street level. Vertical article of storm sewer has a check valve." (City of London respondent)
• "Discharge to the storm is above grade and outside of the foundation" (Wilmot Township respondent)
• "The building storm/weeping tile is directed above the roadway flood level, usually through the ring joist before connecting to the storm sewer." (City of Cambridge respondent)
• "No storm connections, all to grade level"
• "Stormwater lines no longer run from residential basements"
• "Separate storm and sanitary sewer"
• "Storm sump pumps spill over ground"

4.6. Application of municipal by-laws

Respondents were asked whether they were legally able to pass by-laws in their municipalities that exceeded the requirement of provincial building codes. The majority of respondents from Manitoba, New Brunswick/Nova Scotia indicated that their municipalities could apply by-laws that exceeded the requirements of provincial building codes (Table 47). Saskatchewan Regional Health Authority respondents were not asked about application of municipal by-laws, however the municipal respondent from Saskatchewan indicated that they were able to apply by-laws that exceeded provincial building code requirements.

Table 47: Municipality is legally able to apply by-laws that exceed provincial code requirements

	Province or Region*				
Response	**BC[1]**	**AB[2]**	**MB[3]**	**ON[4]**	**NB/NS[5]**
Yes	24%	43%	84%	28%	86%
No	54%	10%	–	66%	14%
Don't know	20%	48%	8%	2%	–

[1] n=41, [2] n=21, [3] n=25, [4] n=58, [5] n=7. *Saskatchewan Regional Health Authority respondents were not asked about application of additional by-laws at the municipal level in their jurisdictions

It has been reported that provincial building code legislation in some provinces prohibits municipalities from applying building by-laws that exceed provincial building code requirements (CHBA, 2008). Sentences 35 (1) and 35 (2) of the Ontario *Building Code Act* refer to application of municipal by-laws and state that "this Act and the building code supersede all municipal by-laws respecting the construction or demolition of buildings" and that "in the event that this Act or the building code and a municipal by-law treat the same subject-matter in different ways in respect to standards for the use of a building described in section 10 or standards for the maintenance or operation of a sewage system, this Act or the building code prevails and the by-law is inoperative to the extent that it differs from this Act or the building code" (Ontario Building Code Act, 2012). Thus, municipalities in Ontario do not have the authority to implement by-laws that exceed provincial building code requirements.

Ontario *Building Code Act* regulations were reflected in the Ontario responses, where 66% reported that their municipalities did not have the authority to implement by-laws that exceeded the requirements of the provincial building code (Table 47). However, a considerable portion of Ontario respondents (28% or 16 municipalities) indicated that that their municipalities were legally able to apply by-laws that exceed the requirements of the provincial building code.

Sentence 66 (1) of the Alberta *Safety Codes* Act states that "a bylaw of a municipality that purports to regulate a matter that is regulated by this Act is inoperative," limiting the authority of municipalities to establish by-laws that exceed the standards of provincial codes (CHBA, 2008). However, a considerable portion of Alberta respondents (43%) reported that they could legally apply by-laws that exceed provincial building code requirements, though a considerable proportion of respondents (48%) indicated that they could not respond to the question (Table 47).

The majority of BC respondents (54%) also indicated that their municipalities were not legally able to apply by-laws that exceeded the requirements of the provincial building code. In general, BC responses indicated a level of uncertainty within provinces about municipal authority to apply by-laws that exceed provincial code requirements (Table 47). However, it has been reported that restriction on application of building by-laws that exceed provincial code requirements are not as strict in BC as in other provinces, including Ontario and Alberta (CHBA, 2008). Further, municipalities in Nova Scotia may enact municipal by-laws that exceed provincial building code requirements pending provincial approval (CHBA, 2008), and the majority of New Brunswick and Nova Scotia respondents reported that they could apply by-laws that exceed provincial code requirements (Table 47).

Respondents were asked about whether a range of basement flood risk-reduction related by-laws were being applied in their municipalities. As discussed in Section 2.3., several municipalities had applied by-laws that required backwater valves for sanitary connections in new homes. The frequency of by-law requirements for sanitary backwater valves reflected the reported frequency of installation of backwater valves in homes built since 2005, with higher frequencies of application of this type of by-law in Alberta, Manitoba and New Brunswick/Nova Scotia in comparison to BC and Ontario (Table 48). Further, reflecting the lower frequency of installation of storm backwater valves in homes built since 2005, fewer respondents reported the application of by-laws for the requirement of backwater valves in storm connections (Table 48).

Table 48: Reported application of basement flood reduction by-laws

	Province or Region*				
Response	**BC[1]**	**AB[2]**	**MB[3]**	**ON[4]**	**NB/NS[5]**
Require BWVs for sanitary connections in new homes	10%	38%	64%	19%	43%
Require BWVs for storm connections in new homes	2%	19%	4%	12%	–
Prohibit reverse slope driveways in new homes	5%	5%	12%	26%	–
Require foundation drainage in all new homes	44%	52%	72%	60%	43%
Require lot grading that directs water away from foundations	56%	48%	92%	78%	57%
Restrict connection of eavestrough downspouts to storm laterals	27%	33%	40%	64%	71%
Other	12%	10%	12%	10%	–

[1] n=41, [2] n=21, [3] n=25, [4] n=58, [5] n=7. *Regional Health Authority respondents were not asked about municipal by-laws in their jurisdiction

Reverse slope driveways include driveways that slope downward from public streets to fully or partially below-ground garages beneath low density residences, including single and semi-detached homes and town homes (Town of Markham, 2009). In 2008, City of Toronto staff recommended application of a zoning regulation for restriction of the installation of reverse slope driveways in new homes to reduce the risk of basement flooding (Di Gironimo, 2008; Wright, 2008). A similar approach was recommended for the Town of Markham in 2009, where the engineering department has discouraged incorporation of reverse slope driveways in new development due to stormwater flood risk concerns (Town of Markham, 2009). Currently, when reverse slope driveways are incorporated into new homes in Markham, the Town requires "…property owners to enter into an agreement with the Town in order to indemnify the municipality in the event of damage occurring to the property through flooding as a result of the use of…reverse slope driveways" (Town of Markham, 2011). The contribution of reverse slope driveways to basement flood risk has been identified in other Canadian municipalities (e.g., City of Kingston, 2012b; Region of Peel, 2012).

Several respondents from BC, Alberta, Manitoba, and Ontario reported that by-laws were being applied in their municipalities to prohibit the use of reverse slope driveways in new homes (Table 48). Specifically, respondents indicated that the municipalities of Brandon, Manitoba and the municipalities of London, Ottawa, Cambridge, Ajax, and Bracebridge Ontario, among others, had applied methods to prohibit reverse slope driveways in new homes.

Sentence 9.14.2.1 (1) of the National Building Code (NBC) (2010) states that

> unless it can be shown to be unnecessary, the bottom of every exterior foundation wall shall be drained by drainage tile or pipe laid around the exterior of the foundation…or by a layer of gravel or crushed rock….

Similar wording is applied in provincial building codes, including the Ontario Building Code and the 2006 BC Building Code (also articles 9.14.2.1). Despite existing code requirements, foundation drainage by-laws were reported by a number of respondents in each province (Table 48).

Sentence 9.12.3.2. (1) of the NBC states that "…backfill shall be graded to prevent drainage towards the foundation after settling." The same wording is applied in the Ontario Building Code and the 2006 BC Building Code. As presented in Table 48, the requirement of lot grading that directs water away from foundations was the most frequently cited by-law in BC, Manitoba and Ontario, and was the second most frequently cited by-law by municipalities represented in Alberta and New Brunswick/Nova Scotia.

Several "other" responses were provided by BC respondents (Table 48). The respondent from Kitimat, BC indicated that the by-laws listed in the questionnaire were adopted "as per [the] BC building code." Similarly, the respondent from Terrace, BC reported that the "above are enforced through the Building By-law that prescribes code compliance." The respondent form Kelowna, BC reported that normally open backwater valves are required "only when the basement floor level is lower than the crown of the road at the service connection." Two further BC respondents who requested municipal anonymity reported that backwater valves are installed in all new "sanitary sewer inspection chambers when the lowest plumbing fixture is less than [one foot] above the elevation of the sanitary sewer manhole located adjacent to the property," and "all storm water must be directed to an on-site storm system," thus negating the need for a by-law that would prohibit connection of downspouts to storm sewer systems.

"Other" responses from Manitoba respondents included restriction of connection of foundation drainage systems and sump pump systems into the sanitary sewer through municipal building by-laws (n=2). In Ontario, the Town of Ajax respondent reported that the policies listed in the questionnaire were "applied through engineering design criteria, not through by-laws." Jurisdictional issues were also identified in "other" responses, as one respondent from an upper-tier municipality reported that they were unsure about application of local by-laws as the "…city controls and enforces the [building] code on the lost side" and that the "…Region has no jurisdiction on the lot-side."

4.7. Additional comments

At the end of the questionnaire, respondents were asked to provide any additional comments they had about basement flooding issues in their jurisdictions (Table 49). Topics discussed by survey respondents included deficiencies in current regulations related to building, plumbing and building codes (e.g., "current building and plumbing by-laws are antiquated..."), and recommendations for risk reduction through application of codes (e.g., "building codes should specifically prohibit finishing space in a house below the level of floodplain water..."). Comments were also made regarding difficulties in interpreting code wordings related to backwater valves. For example, the respondent from the City of Belleville, Ontario stated that

> [the reference related to backwater valves] in the OBC...is one of the worst worded articles of the Code. I can interpret this clause either to require backwater valves in all cases or very few cases. It needs to be re-worded to make the intent more easily understood.

The respondent from Halifax Regional Municipality, Nova Scotia also cited interpretation issues related to the wording of the NPC as it relates to backwater valves (Table 49).

Comments related to the inadequacy of infrastructure were also provided by survey respondents. For example, a BC municipal respondent reported that "development is starting to exceed the capability of infrastructure. [Urban flooding] will become a more common problem in the future," and a respondent from the City of Brampton stated that "Storm water management does not work, think about it. Start fixing the old infrastructure" (Table 49).

Further responses included recommendations related to the use of backwater valves in all new homes, including responses such as "it is my opinion that back flow preventers should be mandatory in all new...construction." However, one respondent favoured more accurate risk assessment for sites slated for development over use of backwater valve to reduce sewer backup risk, and stated

> …more in-depth Geotech needs to be done prior to development of new lands and limits/design criteria developed from that. If you are going to build in areas that have high water tables then maybe backwater and or sump pumps are mandatory in all homes, maybe basements are not permitted. Maybe if there is existing surface drainage then incorporation of [backwater valves] into the design is made mandatory. It seems that every time we try to fight Mother Nature on issues we don't win, and it costs us money.

Further responses related to further considerations related to appropriate use of backwater valves and risk issues associated with basement flooding, land-use planning issues related to flood risk, flood risk associated with overflowing sump systems, and issues related to lack of homeowner maintenance of plumbing features designed to reduce basement flood risk (Table 49).

Table 49: Additional comments

British Columbia	Lot grading and infiltration (rock pits) are used where storm sewers are unavailable. Slopes and soil conditions are huge factors. The depth and proximity are also issues as to location for future service and maintenance. House prior to the 92 code have had problems with the old one pipe system with the amount of rain we receive.
	If someone wants to construct a basement to be used as living space, the foundation damp-proofing or waterproofing and the storm system should be required to be engineered, especially in wet areas like ours. We strongly recommend crawlspaces or slab on grade in our District.
	BC plumbing code requires that if a fixtures flood level is below the flood level of the road then a BWV is required to protect the fixture subjected to the Backflow. This is the same for Storm Drain and the basement slabs, if below the road then the perimeter is required to have a BWV to protect the perimeter piping only.
	Current Building and Plumbing By-laws are antiquated and extremely overdue for review and revision.
	Building Codes should specifically prohibit finishing space in a house below the level of floodplain water, as storm drains will not remove water in the event of a flood. New cases with people dealing with sand bagging and pumping water and distraught because of the flooding are what is to be expected if you build below high water levels.
	My community is on a hillside so we have very little problem with sewers backing up.
	Development is starting to exceed the capability of infrastructure. This will be a more common problem in the future.
	It is my opinion that back flow preventers should be mandatory in all new SFD construction.
	Planning departments must be very cognizant about relaxing flood control regulations. They should consult their respective Building departments as part of any decision making process for applications of this nature.
Alberta	Point of interest: As all furnaces installed now are high efficient and produce condensate our municipality will no longer accept a floor drain with a screw top cap as means of protection from backflow because you continually require the floor drain open as a means of disposing of any condensate produced by the furnace thus we require a backwater valve installed.
	Rarely do we experience basement flooding due to sewer backup, but from weeping tile sumps overflowing. People are not educated on sumps and most do not know they are even there and are sometimes covered over. Most times pump quits and/or power goes out causing flooding of basements in heavy rain.
	I have found that even though the devices are installed and have access covers the home owners are never made aware that the device is installed and is a serviceable device that must be checked a [minimum] of yearly and as such they become gummed up with the sewage and do not function maybe a gov't public awareness campaign would alleviate the problem somewhat. Thanks

Table 49: Additional comments (continued)

Saskatchewan	The biggest problem is sump pumps discharging into plumbing systems. Since they are almost always indirect connections we do not regulate or control them under the plumbing code but they can easily cause systems to fail from to much water. Municipalities occasionally pass by-laws after this becomes a problem but by then it's too late as the infrastructure is already in place. Consideration should be given to better deal with this issue. We do not allow it for private septic systems as we are the regulatory authority that permits them however this does nothing for communal systems. (Regional Health Authority respondent)
Manitoba	[Backwater valves] should be required for all new builds as I do believe it also affects insurance premiums and claims.
Ontario	Storm water management does not work, think about it. Start fixing the old infa-structure. (Brantford respondent)
	The best way for a municipality to ensure backwater valves are installed in all new homes is to declare their entire municipality entire "subject to backflow", as the city of Toronto has. (Town of Ajax respondent)
	A backflow may need to be installed for renovations to a basement if there is under floor plumbing being added. (Town of Bracebridge respondent)
	We have had a FLAP program in the city for close to twenty years. This was put in place to help homeowners who were being flooded by the combined sewers. The city paid for the home owner to install a backwater valve and to disconnect the weepers from the sanitary and install a sump pump with some sort of backup system so it could work during blackouts. At first we were having normally closed valves installed, then we went to protecting all branches instead to follow the OBC regulations and this turned out to be the worst solution because too much regular maintenance was required by the homeowner. Eventually we went to the 'mainline' backwater valve and things have improved. We found the biggest part of the program was getting the foundation drains out of the sanitary sewers, if the weepers were not disconnected then when the surcharge was in progress the backwater valve would work but the water in the foundation drains would pressurize the basement floor and water would come up every little crack. (City of St. Catharines respondent)
	This reference in the OBC to backwater valves is one of the worst worded articles of the Code. I can interpret this clause either to require backwater valves in all cases or very few cases. It needs to be re-worded to make the intent more easily understood. (City of Belleville respondent)
	Backwater valves are not an issue as we have 0% municipal sewers.
	If the idea is to have the code to enact on new development I do not agree. The older articles seem to be more of an issue. More in-depth Geotech needs to be done prior to development of new lands and limits/design criteria developed from that. If you are going to build in areas that have high water tables then maybe backwater and or sump pumps are mandatory in all homes, maybe basements are not permitted. Maybe if there is existing surface drainage then incorporation of them into the design is made mandatory. It seem that every time we try to fight Mother Nature on issues we don't win, and it costs us money.
New Brunswick	All new construction must have a normally open backwater valve on the sanitary and if the line is larger a closed one is used with a 3" vent on the street side through the building roof so we have a good vent on that line. (Moncton Respondent)
Nova Scotia	The code indicates Backflow prevention is required when a fixture is located below the level of the adjoining street. This has caused interpretation issues, for example; on a sloping street, if a building sewer is connected to the main sewer at a point between two manholes, there is a possibility of backflow even though in some circumstances fixtures may not be below the level of the street (Halifax Regional Municipality Respondent)

5. Discussion and recommendations

Simonovic (2011: 35) stated that "any code is only as good as the enforcement that goes along with it." The results of this study indicate that, in addition to enforcement, interpretation is also important when considering the effectiveness of codes for reducing disaster losses. This study revealed that code interpretation differs between many local authorities responsible for code implementation within the case study provinces of BC, Alberta, Saskatchewan, Manitoba, Ontario, New Brunswick and Nova Scotia. Differences in interpretation exist despite consistent wording across the country.

It has been reported elsewhere that the wording of the National Plumbing Code requires backwater valves on sanitary connections in new homes (City of Windsor, 2011). However, despite application of the same wording across Canada, it is clear that articles relating to backwater valves are interpreted differently across the country. Difficulties associated with interpreting code article wordings in provincial codes were reflected in comments made by survey respondents. For example, the City of Belleville, Ontario respondent reported that

> this reference in the [Ontario Building Code] to backwater valves is one of the worst worded articles of the Code. I can interpret this clause either to require backwater valves in all cases or very few cases. It needs to be re-worded to make the intent more easily understood.

Two additional Ontario respondents also provided comments related to difficulty in interpreting article 7.4.6.4. of the OBC, and stated that "the key word here is 'MAY' be installed. A by-law should be passed by a municipality to mandate these [types of] backwater valves." A further Ontario respondent who did not know how this part of the code would be interpreted indicated that "the code states that a backwater valve shall be installed on drains that 'may' be flooded. Any drain 'may' flood, but there is little political will to force residents to spend money." Further, the respondent from Halifax Regional Municipality further stated that

> the code indicates backflow prevention is required when a fixture is located below the level of the adjoining street. This has caused interpretation issues, for example on a sloping street, if a building sewer is connected to the main sewer at a point between two manholes, there is a possibility of backflow even though in some circumstances fixtures may not be below the level of the street,

indicating a further interpretation issue. The fact that fixtures do not have to be below the level of the adjoining street to be exposed backflow risk is addressed in the 2012 rewording of sentence 7.4.6.4.(3) of the OBC (see Appendix D).

As discussed in Section 4.2. of this paper, code interpretation in Alberta was somewhat more consistent than in other provinces, notably Ontario. While the Government of Alberta does not require local authorities to interpret this article of the code in a specific way, guidance on interpretation issues is provided through the Alberta Safety Codes Council. The Council offers several mechanisms, including the training of Safety Codes Officers and interpretation support, including an inspector phone-line that is staffed by a plumbing officer that can provide advice on code interpretation issues. Twice-yearly meetings of a professional association which include Safety Codes Officer discussion on code interpretation issues also aids in consistent interpretation of code wordings in the province (Pers. Comm., S. Manning, Chief Plumbing and Gas Administrator, Alberta Municipal Affairs, Aug. 2, 2012).

As part of Safety Codes Officer training in Alberta, the province issues information bulletins to assist in code and building inspection issues. The bulletin related to protection of building drainage systems provides advice on interpretation of NPC (adopted by Alberta as the provincial plumbing code) sentence 2.4.6.4. (3), and provides the following advice on interpretation: "A backwater valve or gate valve shall be installed on drains to every fixture that is installed below the adjoining street and, therefore, subject to backflow" (Safety Codes Council, 2007). In comparison, NPC sentence 2.4.6.4. (3) states that "…where a building drain or branch may be subject to backflow, a gate valve or backwater valve shall be installed…." The interpretation provided by the Safety Codes Council removes uncertainty associated with the term "may" in sentence 2.4.6.4. (3) of the NPC. The results of this study indicate a clear need for more consistent interpretation of the code articles relating to protection from backflow in many provinces in Canada, specifically Ontario and British Columbia.

Alternatively, municipalities may adopt interpretations of code wordings that would require developers and builders to install valves in new homes. This approach can be accomplished through the acknowledgement that any below-ground fixture may be subject to backflow given the appropriate conditions (e.g., extreme rainfall that exceeds design capacity of municipal sanitary and stormwater management infrastructure)—an approach that has been applied in Windsor and Toronto, Ontario.

As discussed above, the NPC defines building drains as "...the lowest horizontal piping, including any vertical offset, that conducts sewage, clear-water waste or storm water by gravity to a building sewer" (NRC, 2010: 1-3), indicating a reference to both sanitary and storm sewer systems. However, inconsistency regarding the type of service connection that NPC article 2.4.6.4. refers to (i.e., sanitary/combined and/or storm) also identified in the survey. In general, the majority of respondents from each region represented in survey responses interpreted the code article to refer only to sanitary and combined sewer service connections, but a portion of respondents from each region, ranging from 12% in Manitoba to 36% in Ontario, indicated that the code article referred to storm as well as sanitary/combined connections. Further, 7%, 8% and 5% of BC, Manitoba and Ontario respondents respectively indicated that this article of the code referred only to storm sewer service connections (See Table 17).

There is a need for backwater valves on both sanitary laterals and storm laterals when foundation drainage is gravity fed into storm sewer service connections. Storm backwater valves have been required or recommended in municipalities to reduce the risk of storm sewer backup entering foundation drainage or entering basements through sump pits when foundation drains are gravity fed to storm sewer connections (City of Ottawa, 2011; City of Moncton, n.d.). The range of responses regarding the type of service connection referred to in NPC article 2.4.6.4. signifies further need to clarify code wordings related to backwater valves.

This study further revealed a positive correlation between interpreting NPC article 2.4.6.4. in a way that requires backwater valves on most or all new homes with estimated frequency of sanitary and storm backwater valve installation in homes built since 2005. Specifically, interpretation of the code to mean that "all or most" new homes are required to have backwater valves was positively correlated with increased frequency of backwater valve installation for both sanitary and storm backwater valves at a very high statistical confidence level ($p<0.001$). Further, there was a statistically significant correlation with interpreting the code to relate to storm sewer connections and/or all types of connections with installation of storm backwater valves ($p=0.043$). These findings suggest that code wording interpretation is an important component of increasing the frequency of backwater valve installation in new homes in Canada.

In all regions aside from Saskatchewan, a portion of respondents reported that a minority (1-50%) of homes built since 2005 in their jurisdictions had sanitary backwater valves, including 49%, 5%, 32%, 62% and 28% of BC, Alberta, Manitoba, Ontario and New Brunswick/Nova Scotia municipalities respectively. In was hypothesized that, due to the interpretation of which homes "may" be subject to backflow, backwater valves would be required for homes located in infill subdivisions located in older areas with histories of sewer backup, or for new subdivisions that were to be connected into municipal sanitary systems with sewer backup histories. While respondents reported that these factors were motivators for the installation of backwater valves in a minority of homes built since 2005, a number of other motivating factors were identified by respondents. For example, several respondents reported that backwater valves had been incorporated into new homes due to specific owner and builder preferences as well as requests made by insurers. This finding warrants further investigation into motivators for installing backwater valves in specific circumstances in new homes. Future research should explore why specific individuals or developers have requested installation of backwater valves in new homes when valves are not required through municipal by-laws or code interpretations.

The majority (80% or above) of respondents in all regions represented in the study reported that backwater valves were the only lot-side measure being applied to reduce the risk of sanitary and storm sewer backup (see Section 4.5.). While the majority of respondents reported that backwater valves on storm connections were the only lot-side measure being applied in their jurisdiction to reduce storm sewer backup risk, lot-side alternatives to storm backup risk reduction were more common when compared to lot-side alternatives for sanitary sewer backup risk reduction. Storm backup risk reduction alternatives included the use of sump pumps to pump foundation drainage to grade, use of on-site foundation drainage disposal, restriction of the connection of downspouts to foundation drainage systems, not permitting storm connections in new homes, among other measures (see Section 4.5.).

While backwater valves are a common measure to reduce the risk of sewer backup into foundation drainage systems that are gravity fed into storm sewer connections, there have been reports of failure of backwater valves used to protect foundation drainage from storm sewer backup. For example, following approximately 1,500 sewer backup flood events caused by extreme rainfall in the City of Ottawa on July 24, 2009, it was identified that approximately 119 sewer backup events resulted from failure of storm backwater valves (City of Ottawa, 2011b). An investigation of 29 of the 119 homes that experienced flooding due to valve failure revealed that main cause of failure of backwater valves was failure through the valve cap. In these instances, it was reported that the valve cap may not have been screwed down tightly to the valve body or had been installed improperly (City of Ottawa, 2011b). Considering the variety of alterative measures applied to control storm sewer backup risk reported by survey respondents, further investigation into the effectiveness of storm backwater valves in comparison to other measures (e.g., not permitting storm connections and pumping foundation drainage to grade) is necessary.

5.1. Benefits and drawbacks of requiring backwater valves in new homes

Table 50 provides a number of benefits and drawbacks associated with retrofitting backwater valves and installing valves in new homes. It has been argued that a drawback of building code changes to reduce disaster risk is potential increases in construction costs (Dean, 1995). However, installation of backwater valves in new homes is significantly less expensive than retrofitting valves after homes have experienced sewer backup damages. As reported in Appendix A, municipal subsidies provided for backwater valve retrofits into existing homes vary between municipal grant programs, ranging from $500 to $2,000. However, estimates for the cost of installing mainline, open-port backwater valves in new homes are approximately $250 per installation (City of Ottawa, 2011; City of Windsor, 2011).

Table 50: Benefits and drawbacks of backwater valve retrofits vs. installation in new homes

Application type	Benefits	Drawbacks
Retrofit	• Known risk areas, identified through historical sewer backup occurrence, can be targeted with retrofit programs	• It is difficult to encourage homeowners to retrofit valves • Expense • Reactive, post-event • Long-term maintenance requirements • Possibility for displacement of other methods of reducing sewer backup risk (e.g., improved infrastructure)
Installation in new homes	• Significantly lower installation costs • Provides protection to all homes regardless of sewer backup history • Accounts for uncertainties created by climate change • Shifts liability of installation costs (e.g., retrofit program cost) away from municipality	• Long-term maintenance requirements • Possibility for displacement of other methods of reducing sewer backup risk (e.g., improved infrastructure, pre-development risk assessments)

Retrofit costs are higher than installing valves in new homes, as valve retrofits require the breaking up of concrete basement floors and installing the valve in existing plumbing systems and in many cases, re-grading of main sewer connections ensure appropriate valve slope. Indeed, a council report from the City of Ottawa (2011) states that

> requiring the installation of a BWV on sanitary sewer service laterals, as part of the initial new construction, would have minimal impacts on costs to the homebuilder. When installed with new home construction, the cost of a storm or sanitary BWV is approximately $250, as compared with retrofit costs of approximately $1,400 under the City's Residential Protective Plumbing Program. There is a clear benefit to having this protective device installed at the time of original construction.

Thus, installation of valves in new homes is considerably more economical than retrofitting valves into existing homes.

The economy of installing valves in new homes is augmented by the potential savings in insurance claims associated with sewer backup events. For example, the average payout for sewer backup damages during a heavy rainfall event in the Greater Toronto Area in 2005 was approximately $19,000, and insurance claims totalling over $10,000 are common in other parts of Canada, in some cases reaching as high as $80,000 (Foster, 2012; Sandink, 2007). Insurance premiums for sewer backup coverage may also increase by several hundred dollars per year for individuals who have made insurance claims for sewer backup events. Homeowners may face coverage limits and even cancellation after they have made claims for sewer backup damages, which could increase their liability for damages by several thousand dollars for future sewer backup damage events (Compu-Quote, 2011).

Maintenance of backwater valves has been identified where they are required in new construction (City of Ottawa, 2011). For the normally open mainline backwater valve, the manufacturer states that "backwater valves are mechanical devices sitting in a sewage environment, and regular maintenance is required." The manufacturer provides the following maintenance instructions:

- Remove cleanout plug on top of the valve and inspect visually;
- Inspect inside the valve with a flashlight;
- Inspect for debris build-up on the valve body, gate or beneath the gage;
- Flush clean if debris is found;
- Inspect and replace O-ring if necessary;
- Ensure valve gate moves freely, and;
- Properly reinstall cleanout plug when maintenance and inspection are complete (Source: Mainline Backwater Valves, 2012).

The City of Edmonton has also provided backwater valve maintenance recommendations that should be completed yearly (preferably in the early spring before snow-melt), including ensuring the valve is accessible, removal of debris from the valve, lubrication of valve hinges and ensuring the cleanout cap is properly installed (City of Edmonton, n.d.).

To ensure valve maintenance, there are potential opportunities for insurance industry collaboration. For example, several Canadian insurers incentivize backwater valve installation through adjustments to water damage endorsement premiums, deductibles and caps and may only offer sewer backup coverage in areas considered at high risk if backwater valves (or other plumbing measures) have been installed. Insurers that incentivize backwater valve installation could consider requiring evidence that the valve has been maintained for insured homeowners to retain these incentives.

The provision of protection to all homes regardless of sewer backup history is a specific benefit of incorporation of backwater valves in new homes. As discussed in Section 1, climate change and changing development patterns present many uncertainties related to the occurrence of urban flooding (Sandink, 2011), and it is not possible to identify all areas of urban municipalities that will exposed to urban flooding during extreme rainfall events. Indeed, many municipalities have experienced regional sewer backup events in neighbourhoods that were thought to be of relatively low risk due to the existence of relatively new, separated sewer systems (see Section 2.3.). Infiltration and inflow (I/I) is also a recurrent problem for municipal separated sanitary sewer systems, which can increase sewer backup risk in modern, separated sewer systems (Capital Regional District, 2010; Genivar & Clarifica, 2008; Stantec, 2008; Region of Halton, 2012; XCG, 2008; York Region, n.d.). Thus, incorporation of backwater valves into all new homes, regardless of sewer backup history in specific neighbourhoods, would help account for the unpredictability of sewer backup risk.

The potential for urban flood and sewer backup risk in any area of a municipality is reflected in the code interpretations adopted by municipalities that require backwater valves in all new homes, including the City of Toronto (City of Toronto, 2008) and the City of Windsor (City of Windsor, 2011) and the code interpretation guidance provided the Safety Codes Officers in the province of Alberta (Safety Codes Council, 2007).

A substantial body of literature has revealed that it is difficult to encourage private property owners to implement disaster mitigation measures before or after the occurrence of disaster events (see Brenkert-Smith *et al*., 2006; Laska, 1990; Lindell & Perry, 2000; McCaffrey, 2004; McGee, 2007; Mileti, 1999; Palm, 1990; Shrubsole *et al*., 1995; Siegrist & Gutshcer, 2006; Winter & Fried, 2000; Yoshida & Deyle, 2005). Recent studies on homeowner urban flood mitigation behaviour have also revealed limited adoption of urban flood risk reduction measures in Canadian municipalities. For example, a 2007 study revealed that only 18% and 35% of homeowners in Toronto and Edmonton respectively who had histories of sewer backup had installed backwater valves (Sandink, 2007). A study of 674 homeowners in London, Ontario in 2010 in a neighbourhood that experienced a severe urban flooding event revealed that only 13% had installed a backwater valve, despite the existence of a municipal basement flood reduction subsidy program and 32% of respondents in the same study could not indicate whether or not they had a backwater valve (Sandink, 2011).

As discussed in Section 2.2., municipalities that implement a subsidy program after regional basement flooding events may experience relatively low uptake of subsidies—indeed, the program made available to over 160 Mississauga residents had only a 10% uptake rate. Thus, mandatory installation of backwater valves in new homes through code interpretation or clearer code wordings would help to alleviate basement flood damages in new homes, and would limit reliance on post-flood education and incentive programs, which have been shown to have somewhat limited effectiveness.

The potential displacement of other measures to limit urban flood risk may pose as a drawback to the requirement of backwater valves in all new development. For example, several respondents argued that old or failing infrastructure was the cause of sewer backup problems (see Section 4.7.); an issue that cannot be fully solved through the installation of backwater valves or other lot-side measures in new subdivisions. Restricting the building of basements in new homes was also identified as an alternative to reduce flood risk, and one BC respondent reported that they "strongly recommend crawlspaces or slab on grade in [their] District."

There are many alternatives to the reduction of urban flood risk both at the municipal- and lot-sides of new and existing development, and decision makers should not consider only one approach for risk reduction. It is also important that requirements for backwater valves do not displace other potentially more effective measures where they are appropriate. Indeed, there are multiple opportunities to incorporate urban flood risk reduction measures in new development, notably source control measures and Low

Impact Development, which can limit peak stormwater flows during rainfall events (Damodaram *et al*., 2010; Hood *et al*., 2007; Miguez *et al*., 2011). However, clearer wording and interpretation of code articles that relate to backwater valves should be viewed as a "low hanging fruit" for urban flood risk reduction and is a measure that has been applied with a great deal of precedent across the country.

The shifting of responsibility or liability for the cost of installation of backwater valves away from municipalities serves as an additional benefit for installation of backwater valves in new homes. As discussed above, several Canadian municipalities provide subsidies up to and sometimes over $2,000 for the installation of backwater valves in existing homes (see Appendix A). Through incorporation of valves into new homes, the responsibility for the cost of valve installation—a cost that is much lower for new installations in comparison to retrofits—is shifted to developers and homeowners and away from municipalities.

5.2. Additional code opportunities

A review of the 2010 National Building and Plumbing Codes identified further opportunities for better incorporation of basement flood risk reduction measures in new homes. These opportunities include clarifying requirements for lot grading around homes, requiring backup systems for sump pumps, clarification of requirements related to connection of foundation drainage to sanitary sewer systems and restricting use of manual devices that are designed to reduce the risk of sewer backup, including gate valves and removable floor drain screw caps.

Sentence 9.12.3.2.(1) of the NBC refers to the grading of backfill (i.e., earth that is used to fill in the excavation area around the foundation after the foundation has been constructed), and states that "backfill shall be graded to prevention drainage towards the foundation after settling" (NRC, 2010b: 9-79). Further, article 9.14.6.1. sentence 1 states that "the building shall be located or the building site graded so that water will not accumulate at or near the building" (NRC, 2010b: 9-85).

Recommendations for site grading presented in the National Research Council Construction Technology Update number 69 include specific recommendations to reduce the risk of surface water entering basements. Recommendations in the document include (Swinton & Kesik, 2008):

- Incorporation of well-defined swales between houses;
- Minimum swale depths of 150 mm;
- Top of foundation walls should be minimum 200 mm above grade;
- The slope of the backfill and yard, up to and including 1.5 m away from the house, should be a minimum of 7-10%;
- Slope for the remainder of the lot (outside of the 1.5 m perimeter) should be at least 1.5%;

– Minimum elevation of the lot, at the house, should be 450 mm above street level;
– Decks, fences, landscaping and other site alterations should not compromise the integrity of lot grading;
– Backfill should be capped with an impermeable surface, and;
– The initial grade next to the foundation should be exaggerated to compensate or long-term backfill settling.

Similar to the backwater valve article, articles of the NBC that relate to site and backfill grading may be considered somewhat vague and may be open to interpretation. Considering the importance of lot-grading for reducing basement flood risk (City of Edmonton, 2012a; CMHC, 2012; Swinton & Kesik, Sandink, 2008; Region of Durham, n.d.), further research on how lot grading articles of the code are interpreted and applied is warranted.

Sentence 9.14.5.2. (3) of the NBC refers to the disposal of foundation drainage through use of sump pumps, and states that "where gravity drainage is not practical, an automatic sump pump shall be provided to discharge the water from the sump pit…into a sewer, drainage ditch or dry well" (NRC, 2010b: 9-85). It is notable that this sentence of the code makes no mention of backup power systems or backup pump systems, though these measures are commonly recommended by municipalities and insurers as part of retrofit education and subsidy programs (see Appendix A).

Backup power systems, including backup battery systems and backup pumps powered by potable water pressure, help reduce the risk of foundation drainage entering the basement in the event of a power failure (Sandink, 2009). Failure of sump pumps during power outages was specifically identified as a source of flooding by an Alberta municipal respondent, who stated that "...most times pump quits and/or power goes out causing flooding of basements in heavy rain" (see Table 49). Further, backup sump pumps reduce the risk of basement flooding caused by foundation drainage in the event of primary sump pump failure. Thus, incorporation of backup power and pump systems into code requirements provides a further opportunity to reduce basement flood risk in new homes. The benefits and drawbacks of backup system requirements should be further studied.

The connection of foundation drainage to sanitary sewer systems presents a further potential opportunity to clarify code wording to reduce basement flood risk. Sentence 9.14.5.1 (1) of the 2010 NBC states that "foundation drains shall drain to a sewer, drainage ditch or dry well," but does not specifically define "sewer" as storm sewer. Further adding to the uncertainty, NPC sentence 2.4.6.4.(6) states that "a subsoil drainage pipe that drains into a sanitary drainage system that is subject to surcharge shall be connected in such a manner that sewage cannot back up into the subsoil drainage pipe," where "subsoil drainage pipe" is defined as "…a pipe that is installed underground to intercept and covey subsurface water" (NRC, 2010a: 1-7), and "sanitary drainage system" is defined as a drainage system that conveys sewage," where "sewage" is defined as "…any liquid waste other than clear-water waste or storm water" (NRC, 2010a: 1-6), indicating that connection of foundation drainage to sanitary systems would be permitted through application of NBC and NPC wordings.

It is notable that the wording of NBC articles related to connection of foundation drainage to sewers was altered in the Ontario Building Code (OBC, 2012), where article 7.4.5.3. ("Connection of Subsoil Drainage Pipe to a Sanitary Drainage System") provides the following requirements:

(1) Except as permitted in Sentence (2), no foundation drain or subsoil drainage pipe shall connect to a sanitary drainage system.

(2) Where a storm drainage system is not available or soil conditions prevent drainage to a culvert or dry well, a foundation drain or subsoil drainage pipe may connect to a sanitary drainage system.

(3) Where a subsoil drainage pipe may be connected to a sanitary drainage system, the connection shall be made on the upstream side of a trap with a cleanout or a trapped sump.

Alberta Safety Codes Council interpretation advice also provides clarification on connection of foundation drainage to sanitary sewer connections in new homes (Safety Codes Council, 2007). Again, sentence 2.4.6.4.(6) of the NPC states that when a subsoil drainage pipe drains "…into a sanitary drainage system that is subject to surcharge…[it]…shall be connected in such a manner that sewage cannot backup into the subsoil drainage pipe," indicating that an acceptable manner of disposal of foundation drainage is through connection of foundation drains into sanitary sewer connections. However, in reference to this sentence of the NPC, the Safety Codes Council's information bulletin states that "sub-soil drain connections to sanitary lines are not acceptable in most localities in Alberta as it increases the liquid load on…waste water treatment systems."

As reported by the City of St. Catharines respondent, disconnection of foundation drainage is an important component of proper backwater valve installation. Referring to the City's basement flood protection subsidy program (see Appendix A), the respondent reported that the

> biggest part of the program was getting the foundation drains out of the sanitary sewers, if the [foundation drains] were not disconnected then when the surcharge was in progress the backwater valve would work but the water in the foundation drains would pressurize the basement floor and water would come up every little crack.

As part of installation of backwater valves, disconnection of foundation drainage from the sanitary sewer is recommended or required by almost every municipality that has implemented a basement flood subsidy program to ensure proper operation of backwater valves (see Appendix A) and to reduce I/I in sanitary systems, which can lead to basement flooding (Sandink, 2009).

It is further noted that a number of municipal survey respondents reported that by-laws were in place to restrict the connection of foundation drainage to sanitary sewer systems. The restriction of this type of connection has been in place in several municipalities in Canada for a number of years, including the Region of Durham since 1983, the City of Peterborough since 1991 and the City of London since 1985 (Sandink, 2011; UMA, 2005), among many other Canadian municipalities. Considering connection of foundation drainage to sanitary systems is frequently cited as a major contributor to I/I leading to sewer backup and basement flooding, and considering the importance of restriction of foundation drain connections to sanitary systems for proper function of backwater valves, implications of the wording adopted by the NBC and NPC related to connection of foundation drainage to sanitary systems should be further studied.

A further opportunity to reduce basement flood risk through alteration of code wordings includes removal of reference to gate valves and removable floor drain screw caps in NPC article 2.4.6.4. Gate valves and removable screw caps require homeowners to be present during a sewer surcharge event to physically close gate valves or install the basement floor drain screw caps to prevent sewer backup. A homeowner survey in a neighbourhood exposed to sewer backup risk in London, Ontario in 2010 revealed that over 30% of homeowners could not indicate weather or not backwater valves were present in their home, indicating a relatively limited homeowner awareness of lot-side flood risk reduction measures (Sandink, 2011). Further, as discussed above, various risk factors associated with sewer surcharging, including I/I and extreme precipitation, are difficult to predict. Thus, reference to manual backflow protection measures that require homeowner action to protect homes during surcharge events, including gate valves and floor drain screw caps, should be removed form article 2.4.6.4. of the NPC.

A comparison of the wording of sentences (1) and (3) of articles 7.4.6.4. of the OBC and 2.4.6.4. of the NPC is provided in Table 51. As presented in Table 51, reference to gate valves has been removed from article 7.4.6.4. of the OBC. Further, the OBC does not allow for use of removable screw caps to protect homes from sewer backup (see NPC 2.4.6.4.(4) in Table 5). Thus, there is precedent in Canada for removing reference to these devices in provincial building codes.

Table 51: Comparison of OBC 7.4.6.4.(1) and (3) with NPC 2.4.6.4.(1) and (3)

Sentence	OBC 7.4.6.4.	NPC 2.4.6.4.
1	Except as permitted in Sentence (2), a backwater valve that would prevent free circulation of air shall not be installed in a building drain or in a building sewer.	Except as permitted in Sentence (2), a backwater valve **or a gate valve** that would prevent the free circulation of air shall not be installed in a building drain or in a building sewer.
3	Except as provided in Sentences (4) and (5), where a building drain or a branch may be subject to backflow, a backwater valve shall be installed on every fixture drain connected to them when the fixture is located below the level of the adjoining street.	Except as provided in Sentences (4), (5) and (6), where a building drain or a branch may be subject to backflow, **a gate valve** or a backwater valve shall be installed on every fixture drain connected to them when the fixture is located below the level of the adjoining street.

In summary, articles and sentences of the NBC that relate to site grading, backup systems for sump pumps and issues related to foundation drainage connections to sanitary sewer systems warrant further investigation the impact of code wording on basement flood risk reduction for new homes in Canada. Further, considering the unpredictability of sewer backup caused by surcharging sewer systems and relatively low homeowner awareness of lot-side backflow protection measures, removal of references in NPC 2.4.6.4. to gate valves and removable screw caps should be considered.

6. Conclusion

Basement flooding resulting from sewer backup continues to be a serious problem for homeowners, municipalities and insurers across Canada. There are several measures that can be applied at the lot-side to reduce sewer backup risk. Some measures, including disconnection of foundation drainage and eavestrough downspouts, help reduce the risk of regional sewer backup events by limiting inflow of excess water into municipal sanitary sewer systems. Other measures, including backwater valves, serve to reduce the risk of sewer backup through isolation of homes from underground municipal sewers systems during sewer system surcharge.

While it has been previously reported that resolution of code enforcement issues may result in reduced vulnerability to extreme natural events, issues surrounding code interpretation have not previously been studied. This study investigated interpretation of the wording of the NPC that relates to installation of backwater valves to protect homes from sewer backup. Despite consistent application of NPC wording related to backwater valves across the regions of Canada represented in this study, it was found that there are differing interpretations of code wordings, which result in differing reported frequencies of installation of backwater valves on both sanitary/combined and storm sewer service connections.

The primary recommendation of this report is that sentences in the National Plumbing Code and provincial building and/or plumbing codes that relate to installation of backwater valves to protect against sewer backflow be reworded or clarified. Considering recurring and escalating costs borne by the insurance industry for sewer backup damages, uncertainties created by climate change, aging infrastructure and infiltration/inflow, and considering the significant hardship that is caused to homeowners who experience basement flood events and the health risks created by sewer backup, it is recommended that codes be worded in a way that requires installation of backwater valves on sanitary connections on all homes with fixtures below the adjoining street and/or below the nearest upstream manhole cover. Further, it is also considerably less expensive to incorporate backwater valves into new homes when compared to retrofitting after basement flood events have occurred.

The provision of advice on interpretation of the code in a manner that would require backwater valves on most or all new homes, as applied in Alberta, could also be considered as an approach to achieve the same goal. Alternatively, municipalities may adopt code interpretations that require backwater valves in all new homes through acknowledging that any drain below upstream manhole covers or below grade may be subject to backflow under severe rainfall or I/I conditions. Finally, considering the unpredictability of sewer backup caused by surcharging sewer systems and relatively low homeowner awareness of lot-side backflow protection measures, removal of references in NPC 2.4.6.4. to gate valves and removable screw caps should be considered.

Appendix A: Municipal subsidy programs

Municipality	Summary of eligible measures	Maximum grant, BWW	Maximum grant
City of Brantford	• Sump pump, battery backup, foundation drain disconnection, backwater valve, downspout disconnection	Not specified	$3,000
Region of Durham	• Backwater valve, sump system	Not specified	$3,000 interest free loan, repaid over three years
City of Greater Sudbury	• Backwater valve, sump system	50% of the cost of installation up to $1,000	50% of total cost up to $2,250
Region of Halton	• Sump system, foundation drain disconnection, downspout disconnection, backwater valve	50% of cost of installation up to $675	50% of total cost up to $2,725
City of Hamilton	• Backwater valve, sump system, downspout disconnection, plumbing assessment and CCTV inspection	$2,000	$2,500 (plus $40 per downspout disconnection)
City of Thunder Bay (proposed in 2012)	• Backwater valve • Sump system • Weeping tile disconnection	50% of cost up to $1,250	$3,500
City of Kingston	• Installation of backflow prevention device • Inspection costs, permits, etc. associated with installation • Sump system with battery backup • Foundation drain disconnection from sanitary • Disconnection of sump pump discharge to sanitary	75% of cost up to $1,200	$3,000 (75% of cost of backflow prevention device, sump system, foundation drain disconnection, 50% of cost of disconnection of sump system from sanitary sewer)
City of London	• Foundation drain disconnection • Backwater valve • Sewage ejector system (in lieu of a backwater valve) • Storm private drain connection	75% up to $575	Max for foundation drain disconnection: 75% up to $2,650 Max for backflow prevention with sewage ejector system: 75% up to $1,525 Max for Storm PDC installation: 75% up to $3,775
City of Niagara Falls	• Foundation drain disconnection • Sump system • Backwater valve • Weeping tile investigation	$500	$3,000
City of Ottawa	• Measures required to reduce sewer backup risk, including backwater valve, sump systems and other relevant measures	Not specified	$4,000 for homes with a history of sewer backup, 50% up to $2,500 for homes with no sewer backup history but located in a risk area

Municipality	Summary of eligible measures	Maximum grant, BWW	Maximum grant
City of Peterborough	• Backwater valve • Sump system	$800	$1,800
Region of Peel/ City of Mississauga	• Household drainage survey, plumbing investigation • Downspout disconnection • Backwater valve • Foundation drain disconnection • Sump system	50% up to $1,250	$6,250
City of St. Catharines	• Backwater valve • Sump system with batter backup • Foundation drain disconnection	Not specified	$3,000
City of Toronto	• Backwater valve • Sump system • Foundation drain disconnection	80% of cost up to $1,250	80% of cost up to $3,200
City of Vaughan	• Backwater valve	50% up to $750	50% up to $750
City of Welland	• Backwater valve • Sump system with batter backup • Foundation drain disconnection • Downspout disconnection • Plumbing assessment	Not specified	$3,000
City of Windsor	• Backwater valve • Sump system • Foundation drain disconnection • Camera, dye inspections	80% up to $1,000	80% of cost up to $2,800
City of Edmonton	• Backwater valve	$1,200	$1,200
City of Saskatoon	• Plumbing assessment • Backwater valve • Sump system • Permits • Necessary measures for installation	Not specified	$3,000
City of Winnipeg	• Backwater valve(s) • Sump system	60% of the cost up to $1,000	60% of the cost up to $3,000
City of Brandon	• Backwater valve(s) • Sump system	60% of the cost up to $1,000	60% of the cost up to $3,000
City of Moncton	• Backwater valve	$500	$500

Sources: City of Brandon, 2012; City of Brantford, 2011a; City of Edmonton, 2010, 2012b; City of Greater Sudbury, 2012; City of Kingston, 2012a; City of Hamilton, 2012; City of London, 2009; City of Niagara Falls, 2012; City of Peterborough, 2012; City of Saskatoon, 2010; City of St. Catharines, 2012; City of Thunder Bay, 2012; City of Toronto, 2012; City of Vaughan, n.d.; City of Welland, 2012; City of Windsor, 2012; Region of Durham, n.d.; Region of Halton, n.d.; Region of Peel, 2011

Appendix B: Municipal questionnaire

ICLR NPC/By-Law Survey

Introduction

The Institute for Catastrophic Loss Reduction (ICLR) is a non-profit disaster mitigation and prevention research organization affiliated with the Canadian property and casualty insurance industry and the University of Western Ontario.

We are asking for your help to better understand how section 2.4.6.4 of the National Plumbing Code may be interpreted in different parts of Canada. This section of the code relates to lot-side (or home-level) protection from sewer backflow through the use of backwater valves.

Results from this survey will be distributed to key organizations, including building officials' associations and municipalities across Canada, to help ensure consistent interpretation of this section of the code, and will assist our organization in ongoing research related to the reduction of basement and urban flood risk in Canada.

The National Research Council indicates that most provinces adopt this section of the National Plumbing Code with minor alterations. If you feel that this section of the code is substantially different than that applied in your province, please let me know.

We are also interested in how by-laws are used to reduce urban flooding risk at the lot-side in municipalities across Canada.

At the end of the survey, we will ask if you are interested in receiving a report of the results after we have collected responses throughout your province and from across Canada.

We greatly appreciate your help with our survey. If you have any questions or comments, please feel free to contact me.

Kind regards,

In which province or territory is your municipality located?

Please read National Plumbing Code Section 2.4.6.4 provided here, and answer the two questions below.

2.4.6.4. Protection from Backflow

1) Except as permitted in Sentence (2), a *backwater valve* or a gate valve that would prevent the free circulation of air shall not be installed in a *building drain* or in a *building sewer*. (See Appendix A.)

2) A *backwater valve* may be installed in a *building drain* provided that

a) it is a "normally open" design conforming to

i) CSA B70, "Cast Iron Soil Pipe, Fittings, and Means of Joining,"

ii) CAN/CSA-B181.1, "Acrylonitrile-Butadiene-Styrene (ABS) Drain, Waste, and Vent Pipe and Pipe Fittings,"

iii) CAN/CSA-B181.2, "Polyvinylchloride (PVC) and Chlorinated Polyvinylchloride (CPVC) Drain, Waste, and Vent Pipe and Pipe Fittings," or

iv) CAN/CSA-B182.1, "Plastic Drain and Sewer Pipe and Pipe Fittings," and

b) it does not serve more than one *dwelling unit*.

3) Except as provided in Sentences (4), (5) and (6), where a *building drain* or a *branch* may be subject to *backflow*, a gate valve or a *backwater valve* shall be installed on every *fixture drain* connected to them when the *fixture* is located below the level of the adjoining street.

4) Where the *fixture* is a floor drain, a removable screw cap may be installed on the upstream side of the *trap*.

5) Where more than one *fixture* is located on a *storey* and all are connected to the same *branch*, the gate valve or *backwater valve* may be installed on the *branch*.

6) A *subsoil drainage pipe* that drains into a *sanitary drainage system* that is subject to surcharge shall be connected in such a manner that *sewage* cannot back up into the *subsoil drainage pipe*. (See Appendix A.)

In your municipality, this part of the Code would be interpreted to mean:

- ◯ ALL new homes are required to have backwater valves
- ◯ MOST new homes are required to have backwater valves
- ◯ Backwater valves are only required in RARE, SPECIFIC circumstances
- ◯ This section of the code DOES NOT REQUIRE backwater valves IN ANY CIRCUMSTANCES
- ◯ I am not sure how this part of the code would be interpreted in my municipality

If you are not sure how this part of the Code would be interpreted in your municipality, please explain why:

In your municipality, this section of the Code would apply primarily to:

- ◯ Sanitary and combined sewer backflow protection
- ◯ Storm sewer backflow protection
- ◯ All of the above
- ◯ Don't know

Approximately what percentage of homes with basements built since 2005 in your municipality have backwater valves to protect them from SANITARY or COMBINED sewer backflow?

- ◯ 0%
- ◯ 1-5%
- ◯ 6-20%
- ◯ 21-50%
- ◯ 51-75%
- ◯ 76-95%
- ◯ 96-99%
- ◯ 100%
- ◯ Don't know
- ◯ Not applicable

[If between 1 and 50%]: In the previous question, you indicated that a portion of homes built since 2005 in your municipality have backwater valves to protect against sanitary or combined sewer backflow. Backwater valves were incorporated into these homes because:

- ☐ They were built as infill development in areas that had histories of sanitary sewer surcharge causing sewer backup
- ☐ The developments were connected into older sewer systems that had histories of sewer surcharge causing sewer backup
- ☐ Other, please specify:

[If between 51 and 100%]: In the previous question, you indicated that most or all homes built since 2005 in your municipality have backwater valves to protect against sanitary or combined sewer backflow. In your municipality, most or all homes built since 2005 have backwater valves because:

- ☐ Backwater valves are required by provincial plumbing and/or building codes
- ☐ Our municipality has a by-law that requires backwater valves in new homes
- ☐ Other, please specify:

Approximately what percentage of homes with basements built since 2005 in your municipality have backwater valves to protect them from STORM sewer backflow?

- ◯ 0%
- ◯ 1-5%
- ◯ 6-20%
- ◯ 21-50%
- ◯ 51-75%
- ◯ 76-95%
- ◯ 96-99%
- ◯ 100%
- ◯ Don't know
- ◯ Not applicable

[If between 1 and 50%]: In the previous question, you indicated that a portion of homes built since 2005 in your municipality have backwater valves to protect them from storm sewer backflow.

Backwater valves were incorporated into these homes because:

- ☐ They were built as infill development in areas that had histories of storm sewer backup
- ☐ The developments were connected into older sewer systems that had histories of storm sewer backup
- ☐ Other, please specify:

[If between 51 and 100%]: In the previous question, you indicated that most or all homes built since 2005 in your municipality have backwater valves to protect them from storm sewer backflow.

In your municipality, most or all homes built since 2005 have backwater valves because:

- ☐ Backwater valves for storm connections are required by provincial building and/or plumbing codes
- ☐ Our municipality has a by-law that requires backwater valves on storm connections in new homes
- ☐ Other, please specify:

Aside from backwater valves, are there other technologies or methods that are used in your municipality to protect against SANITARY or COMBINED sewer backup at the lot-side?

- ◯ Yes
- ◯ No
- ◯ If YES, please describe

Aside from backwater valves, are there other technologies or methods that are used in your municipality to protect against STORM sewer backup at the lot-side?

- ◯ Yes
- ◯ No
- ◯ If YES, please describe

Is your municipality legally able to apply building bylaws that exceed the requirements of provincial building or plumbing codes?

- ◯ Yes
- ◯ No
- ◯ Don't know

Does your municipality apply bylaws that:

- ☐ Prohibit reverse sloped driveways in new homes
- ☐ Require backwater valves for SANITARY connections in all new homes
- ☐ Require backwater valves for STORM connections in all new homes
- ☐ Require foundation drainage in all new homes
- ☐ Require lot grading that directs water away from foundations in all new development
- ☐ Restrict connection of eavestrough downspouts directly to storm sewer laterals
- ☐ Other (please specify)

Is your municipality primarily urban/suburban or rural?

- ○ Urban/suburban
- ○ Rural
- ○ Not applicable

[If rural]: Are any homes in your municipality serviced by underground municipal sewer systems?

- ○ Yes
- ○ No
- ○ Don't know
- ○ Not applicable

To ensure that the final results of this survey are accurate, please provide the name of your municipality.

Municipality

We understand that there may be instances where survey respondents may want to retain anonymity of their municipality. If you do not want us to mention the name of your municipality in reports or publications based on this survey, please indicate here:

- ○ Please DO NOT mention the name of my municipality in reports and publications based on this survey
- ○ It is OK to mention the name of my municipality in reports and publications based on this survey

Would you like a report on the results of this survey?

- ○ Yes
- ○ No thank you

We ask that you provide your name and contact information only so that we may contact you to ask for additional clarification on your responses, if necessary.

Providing contact information will also allow us to send survey results to you directly.

To ensure your personal confidentiality, we will not associate survey results with your name in any reports or publications.

Name
Title
Phone number
E-mail address

If you have any further comments about building and plumbing codes or bylaws as they relate to basement flooding, please provide them here.

Thank you for your help!

Appendix C: Saskatchewan Regional Health Authority questionnaire

ICLR NPC/By-Law Survey-Sask Regional health Authorities

Introduction

The Institute for Catastrophic Loss Reduction (ICLR) is a non-profit disaster mitigation and prevention research organization affiliated with the Canadian property and casualty insurance industry and the University of Western Ontario.

We are asking for your help to better understand how section 2.4.6.4 of the National Plumbing Code may be interpreted in different parts of Canada. This section of the code relates to lot-side (or home-level) protection from sewer backflow through the use of backwater valves.

Results from this survey will be distributed to key organizations, including building officials' associations and municipalities across Canada, to help ensure consistent interpretation of this section of the code, and will assist our organization in ongoing research related to the reduction of basement and urban flood risk in Canada.

The National Research Council indicates that most provinces adopt this section of the National Plumbing Code with minor alterations. If you feel that this section of the code is substantially different than that applied in your province, please let me know.

At the end of the survey, we will ask if you are interested in receiving a report of the results after we have collected responses throughout your province and from across Canada.

We greatly appreciate your help with our survey. If you have any questions or comments, please feel free to contact me.

Kind regards,

Please read National Plumbing Code Section 2.4.6.4 provided here, and answer the two questions below.

2.4.6.4. Protection from Backflow

1) Except as permitted in Sentence (2), a *backwater valve* or a gate valve that would prevent the free circulation of air shall not be installed in a *building drain* or in a *building sewer*. (See Appendix A.)

2) A *backwater valve* may be installed in a *building drain* provided that
a) it is a "normally open" design conforming to
i) CSA B70, "Cast Iron Soil Pipe, Fittings, and Means of Joining,"
ii) CAN/CSA-B181.1, "Acrylonitrile-Butadiene-Styrene (ABS) Drain, Waste, and Vent Pipe and Pipe Fittings,"
iii) CAN/CSA-B181.2, "Polyvinylchloride (PVC) and Chlorinated Polyvinylchloride (CPVC) Drain, Waste, and Vent Pipe and Pipe Fittings," or
iv) CAN/CSA-B182.1, "Plastic Drain and Sewer Pipe and Pipe Fittings," and
b) it does not serve more than one *dwelling unit*.

3) Except as provided in Sentences (4), (5) and (6), where a *building drain* or a *branch* may be subject to *backflow*, a gate valve or a *backwater valve* shall be installed on every *fixture drain* connected to them when the *fixture* is located below the level of the adjoining street.

4) Where the *fixture* is a floor drain, a removable screw cap may be installed on the upstream side of the *trap*.

5) Where more than one *fixture* is located on a *storey* and all are connected to the same *branch*, the gate valve or *backwater valve* may be installed on the *branch*.

6) A *subsoil drainage pipe* that drains into a *sanitary drainage system* that is subject to surcharge shall be connected in such a manner that *sewage* cannot back up into the *subsoil drainage pipe*. (See Appendix A.)

In your region, this part of the Code would be interpreted to mean

- ○ ALL new homes are required to have backwater valves
- ○ MOST new homes are required to have backwater valves
- ○ Backwater valves are only required in RARE, SPECIFIC circumstances
- ○ This section of the code DOES NOT REQUIRE backwater valves IN ANY CIRCUMSTANCES
- ○ I am not sure how this part of the code would be interpreted in my region
- ○ If you are not sure how this part of the Code would be interpreted in your region, please explain why:

In your region, this section of the Code would apply primarily to:

- ◯ Sanitary and combined sewer backflow protection
- ◯ Storm sewer backflow protection
- ◯ All of the above
- ◯ Don't know

Approximately what percentage of homes with basements built since 2005 in your region have backwater valves to protect them from SANITARY or COMBINED sewer backflow?

- ◯ 0%
- ◯ 1-5%
- ◯ 6-20%
- ◯ 21-50%
- ◯ 51-75%
- ◯ 76-95%
- ◯ 96-99%
- ◯ 100%
- ◯ Don't know
- ◯ Not applicable

[If between 1 and 50%]: In the previous question, you indicated that a portion of homes built since 2005 in your region have backwater valves to protect against sanitary or combined sewer backflow. Backwater valves were incorporated into these homes because

- ☐ They were built as infill development in areas that had histories of sanitary sewer surcharge causing sewer backup
- ☐ The developments were connected into older sewer systems that had histories of sewer surcharge causing sewer backup
- ☐ Other, please specify: ____________________

[If between 51 and 100%]: In the previous question, you indicated that most or all homes built since 2005 in your region have backwater valves to protect against sanitary or combined sewer backflow. In your region, most or all homes built since 2005 have backwater valves because

- ☐ Backwater valves are required by provincial plumbing and/or building codes
- ☐ Other, please specify: ____________________

Approximately what percentage of homes with basements built since 2005 in your region have backwater valves to protect them from STORM sewer backflow?

- ◯ 0%
- ◯ 1-5%
- ◯ 6-20%
- ◯ 21-50%
- ◯ 51-75%
- ◯ 76-95%
- ◯ 96-99%
- ◯ 100%
- ◯ Don't know
- ◯ Not applicable

If between 1 and 50%]: In the previous question, you indicated that a portion of homes built since 2005 in your region have backwater valves to protect them from storm sewer backflow. Backwater valves were incorporated into these homes because:

- ☐ They were built as infill development in areas that had histories of storm sewer backup
- ☐ The developments were connected into older sewer systems that had histories of storm sewer backup
- ☐ Other, please specify:

[If between 51 and 100%]: In the previous question, you indicated that most or all homes built since 2005 in your region have backwater valves to protect them from storm sewer backflow. In your region, most or all homes built since 2005 have backwater valves because:

- ☐ Backwater valves for storm connections are required by provincial building and/or plumbing codes
- ☐ Other, please specify:

Aside from backwater valves, are there other technologies or methods that are used in your region to protect against SANITARY or COMBINED sewer backup at the lot-side?

- ◯ Yes
- ◯ No
- ◯ Don't know
- ◯ If YES, please describe

Aside from backwater valves, are there other technologies or methods that are used in your region to protect against STORM sewer backup at the lot-side?

- ◯ Yes
- ◯ No
- ◯ Don't know
- ◯ If YES, please describe

To ensure that the final results of this survey are accurate, please provide the name of your Regional Health Authority.

Regional health Authority name

If you do not want us to mention the name of your Regional Health Authority in reports or publications based on this survey, please indicate here:

- ◯ Please DO NOT mention the name of my Health Authority in reports and publications based on this survey
- ◯ It is OK to mention the name of my Health Authority in reports and publications based on this survey

Would you like a report on the results of this survey?

- ◯ Yes
- ◯ No thank you

We ask that you provide your name and contact information only so that we may contact you to ask for additional clarification on your responses, if necessary.

Providing contact information will also allow us to send survey results to you directly.

To ensure your personal confidentiality, we will not associate survey results with your name in any reports or publications.

Name

Title

Phone number

E-mail address

If you have any further comments about building and plumbing codes as they relate to basement flooding, please provide them here.

Thank you for your help!

Appendix D: Ontario Building Code Article 7.4.6.4. – comparison of 2012 and 2006 wordings

Sentence	2012 wording	2006 wording	Comparison
1	Except as permitted in Sentence (2), a backwater valve that would prevent free circulation of air shall not be installed in a building drain or in a building sewer.	Except as permitted in Sentence (2), a backwater valve that would prevent free circulation of air shall not be installed in a building drain or in a building sewer.	Same wording
2	A backwater valve may be installed in a building drain provided that,	A backwater valve may be installed in a building drain provided that,	Same wording
2 (a)	it is a "normally open" design conforming to,	it is a "normally open" design conforming to,	Same wording
2 (a)(i)	CSA B70, "Cast Iron Soil Pipe, Fittings, and Means of Joining",	CSA B70, "Cast Iron Soil Pipe, Fittings, and Means of Joining",	Same wording
2 (a)(ii)	CAN/CSA-B181.1,"Acrylonitrile-Butadiene-Styrene (ABS) Drain, Waste, and Vent Pipe and Pipe Fittings",	CAN/CSA-B181.1,"Acrylonitrile-Butadiene-Styrene (ABS) Drain, Waste, and Vent Pipe and Pipe Fittings",	Same wording
2 (a)(iii)	CAN/CSA-B181.2, "Polyvinylchloride (PVC) and Chlorinated Polyvinylchloride (CPVC) Drain, Waste, and Vent Pipe and Pipe Fittings", or	CAN/CSA-B181.2, "Polyvinylchloride (PVC) and Chlorinated Polyvinylchloride (CPVC) Drain, Waste, and Vent Pipe and Pipe Fittings", or	Same wording
2 (a)(iv)	CAN/CSA-B182.1, "Plastic Drain and Sewer Pipe and Pipe Fittings", and	CAN/CSA-B182.1, "Plastic Drain and Sewer Pipe and Pipe Fittings", and	Same wording
2 (b)	it does not serve more than one dwelling unit.	it does not serve more than one dwelling unit.	Same wording
3	Except as provided in Sentences (4) and (5), where a building drain or a branch may be subject to backflow	Except as provided in Sentences (4) and (5), where a building drain or a branch may be subject to backflow, a backwater valve shall be installed on every fixture drain connected to them when the fixture is located below the level of the adjoining street	Sentence 3 of 2006 code was split into two sub-sentences for 2012 code
3 (a)	a backwater valve shall be installed on every fixture drain connected to it when the fixture is located below the level of the adjoining street, or	–	Sentence 3 of 2006 code was split into two sub-sentences for 2012 code
3 (b)	a backwater valve shall be installed to protect fixtures which are below the upstream sanitary manhole cover when a residential building is served by a public sanitary sewer.	–	New to 2012 code wording
4	Where more than one fixture is located on a storey and all are connected to the same branch, the backwater valve may be installed on the branch.	Where more than one fixture is located on a storey and all are connected to the same branch, the backwater valve may be installed on the branch.	Same wording
5	A subsoil drainage pipe that drains into a sanitary drainage system that is subject to surcharge shall be connected in such a manner that sewage cannot back up into the subsoil drainage pipe.	A subsoil drainage pipe that drains into a sanitary drainage system that is subject to surcharge shall be connected in such a manner that sewage cannot back up into the subsoil drainage pipe.	Same wording

Sources: Ontario Building Code Act: Ontario Regulation Building Code 332/12, 2012; Ontario Building Code Act: Ontario Regulation 350/06 Building Code, 2012

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