

# Using flood maps for community flood risk communication

**Causes of floods**  
Floods can occur at any time of year and have a variety of causes. The most common reasons for floods are:

- intense rainfall, which can occur at any time of year
- high temperatures in the summer and spring that cause snow and ice to melt quickly
- ice jams in the winter and spring, when large amounts of ice become lodged in the river channel, causing water to back up and spill over the banks.

**Flood forecasting**  
The CRCA monitors weather information, river flows, snow pack and ice conditions in order to predict when floods will occur and how high the water may rise. Flow rate gauges and barometric gauges in the Nish River watershed provide information on current conditions.

**Flood messages**  
When flooding is possible or about to occur, the CRCA issues flood messages to municipal emergency management officials and the media.

**There are three types of flood messages:**

- 1. Watched Conditions Statement - Flood Outlook**  
This message provides early notice of the potential for flooding based on weather forecasts calling for heavy rain, snow melt or conditions that could cause an ice jam.
- 2. Flood Watch**  
Flooding is possible in specific areas. Municipalities, municipal services and businesses in flood-prone areas should prepare.
- 3. Flood Warning**  
Flooding is occurring or is about to occur. Municipalities should take action to deal with flood conditions. This may include road closures and evacuations.

In addition to these flood messages, the CRCA may also issue a "Watched Conditions Statement - Water Safety" to warn about unsafe conditions around rivers, streams and ponds through flooding is not expected.

**Stay safe for important information on dealing with floods**

**Flood response**  
When the CRCA issues a flood warning, it is sent to the Waterloo Regional Police and the North Waterloo Fire/Rescue Department. This regional area flood response plan is a serious message; the warning may activate the Emergency Operations Centre to oversee the flood response.

- The warning flood coordinator will work with township staff to close roads, shut down utilities and take other action to protect lives and property.
- The police will warn households and businesses within the areas to be affected, based on the warning/water above on the map. This will be done through door-to-door visits by police officers.
- Firefighters, in the event of different times at different times, depending on the conditions across the flood front, firefighters will monitor only one warning.

**Flood warning levels**  
Flood warnings are issued when there is a nearby system that is known to be at risk of flow of water in the Nish River during floods. Water flows are measured in "cubic metres per second" (cms). This is the amount of water flowing past a fixed spot in one second.

**Residents should secure their property on the map to ensure it is affected at various warning levels.**

**Normal water level flow:** 1.0 m<sup>3</sup>/s, water level per second  
**Warning level 1:** up to 100 m<sup>3</sup>/s  
**Warning level 2:** 100-400 m<sup>3</sup>/s  
**Warning level 3:** 400-600 m<sup>3</sup>/s  
**Warning level 4:** 600-800 m<sup>3</sup>/s  
**Warning level 5:** 800-1000 m<sup>3</sup>/s

**Warning level 1:** Includes the first big warning level in a high water level. The level of water is high enough to cause the water to flow over the banks and onto the road. At this level, the water is high enough to cause the water to flow over the banks and onto the road. At this level, the water is high enough to cause the water to flow over the banks and onto the road.

**For more information on dealing with floods and on river flooding at any flow level or water flooding, visit the website for the CRCA. The CRCA website provides information on how to prepare for floods. The CRCA website provides information on how to prepare for floods.**

**Map properties warned in the event of Nish River flooding**  
If flooding is about to occur, the police will warn households and businesses within the area to be affected.

**March 7, 2004: Warning Level 3**  
Flow around 1 p.m., the approximate time of this picture, are about 175 m<sup>3</sup>/s.

**December 20, 2008: Warning Level 4**  
Flow around 1 p.m., the approximate time of this picture, are about 615 m<sup>3</sup>/s.



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Map credit: Grand River Conservation Authority, 2017

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## Executive Summary

Flood risk management “involves collaborative action across governments, the public sector, businesses, voluntary organizations and individuals” (Sayers et al., 2013). This requires that communities are informed and empowered to be effective participants in the decision-making process, and that residents view flooding as a serious threat to their homes and communities that should be addressed (Thistlethwaite et al., 2017). Flood maps are critical tools for informing communities about their flood risk and supporting flood management discussions that involve the public (CIRIA, 2015). Maps can be used for many purposes, such as regulating build-up in flood-prone areas, identifying which properties should adopt flood-proofing measures, and educating the public about local flood risks. Maps are effective for public risk communication at the community level if they:

1. Are tailored for specific audiences and purposes
2. Are paired with local information to which the community can relate
3. Include information about historical floods
4. Consider cartographic aspects and avoid technical terminology for ease and speed of comprehension
5. Are provided online, through traditional media and public meetings, and are promoted regularly as a continuous reminder of flood hazards
6. Use real-time gauge levels to contextualize historic or extreme floods shown on the map
7. Use property-specific, searchable Web mapping services
8. Are complemented with information about the consequences of flooding and tangible protective actions

Maps can be useful tools to build a sense of personal responsibility in flood preparedness among citizens and also to empower communities towards informed decision-making as part of an overall flood risk management strategy. While there are no prescriptive “best practices” that apply to every context and culture, there are general lessons that emerge from existing expertise and knowledge, including:

1. Public flood maps differ from maps used by subject-matter experts and must be tailored to each community and audience, including supplementary information that is relevant to residents.
2. Publicly sharing flood maps online and through traditional media, and regularly reminding residents of their availability and usefulness, will aid in sustaining public interest and support in flood risk management.

3. Maps are one component of a national strategy for public risk awareness and engagement. All levels of government need defined responsibilities in flood risk management, and need to engage with their communities to improve risk awareness and motivate personal action.

Simply providing information to the public is not enough – pairing maps with relevant information on reducing risk, and repeating this information at regular intervals and through various communication channels, will encourage citizens to protect themselves and support community, provincial, and national-scale flood risk management initiatives. Local governments also need guidance on how to prepare and share these maps with their communities to get their attention, reduce anxiety and stigma, and drive support and flood protective action.

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## 1. Introduction

As a result of growing disaster costs confronted by governments and the introduction of residential flood insurance in the Canadian market, there is increasing interest from government bodies to raise public awareness about flood risks and encourage risk mitigative behaviour. Federal Minister for Public Safety and Emergency Preparedness, Ralph Goodale, stated at the National Roundtable for Flood Risk (November 16, 2017) that “Prevention can and should begin at the individual level”. He later went on to state that “to foster a change in attitudes and behaviour which can help Canadians take action before disaster strikes, especially in high-risk areas... we need to work together on ways to engage the public to protect themselves against flooding. Improved public awareness depends, in part, on the ability of Canadians to easily access up-to-date, accurate flood data.” The Minister’s remarks are echoed by experts in Canada and abroad who emphasize that flood risk management requires public participation (CIRIA, 2015; Alexander et al., 2016; Thistlethwaite et al., 2017).

Informing the public about flood risks is an initial step to encourage public participation in flood risk management. Maps are useful tools for informing communities about their flood risk as they can be used for prioritizing local mitigation efforts, such as regulating build-up in flood-prone areas, and identifying which properties should adopt flood-proofing measures (e.g., installing a backwater valve). In other developed nations, such as England and Germany, there are mass information campaigns designed to educate the public about local flood impacts, encourage uptake of private flood insurance, and provide guidance on how to mitigate flood risks at the property-level (Thistlethwaite et al., 2017; Thielen et al., 2016; Surminski et al., 2017). Flood maps are frequently recognized as being a clear communication tool for educating the public about flooding and its consequences (Nones, 2016). Nevertheless, flood maps meant for public use are recommended to have different characteristics than maps used by experts (e.g., planners and emergency managers). For example, public flood maps should avoid technical terminology without supporting explanations (e.g., 1:100-year or 1% annual exceedance probability flood), and should pair hazard information with information on the “possibilities, effectiveness and costs of private precautionary measures” (Merz et al., 2007; Hagemeyer-Klose and Wager, 2009).

Natural Resources Canada (NRCan) makes a distinction on the types of flood maps that are created by professionals for identifying flood-prone areas and enabling appropriate responses that minimize flood impacts. In NRCan’s recently published *Federal Floodplain Mapping Guidelines*, four types of maps are identified: inundation, hazard, risk, and awareness (see Appendix A for full descriptions) (NRCan and Public Safety Canada, 2017). This report focuses on flood awareness maps as tools towards communicating flood risk to the public. Awareness maps are typically community and context-specific, and can include relevant educational information for the public (e.g., photographs of past floods) and

information on how to prepare and cope with future floods (e.g., emergency management information). Nevertheless, publicly-available flood maps in Canada can vary significantly from one another as there is no national standard for creating flood maps.

The purpose of this report is to provide guidance, based on existing expertise and knowledge, on the general characteristics of effective maps for public risk communication. The report also assesses some existing Canadian examples and provides recommendations for creating flood maps meant to serve as flood risk communication tools.

## 2. Characteristics of effective flood maps for risk communication

Based on studies that evaluate flood maps and Web mapping services from comparable nations (e.g., European countries, United States, Australia and Japan) and the expertise and experience of the Partners for Action team, the following key characteristics are recommended for flood maps designed to communicate risks to the public and raise awareness about flooding:

1. **Tailor maps for specific audience and purpose** – the public needs “easily understandable and accessible maps with a lower density of information” to enhance readability of the map and clarity of the information (Meyer et al., 2011).
2. **Pair flood maps with local information that the community can relate to**, such as overlaying flood-prone areas on orthophotos/community plans and showing street names and local features (Meyer et al., 2011).
3. **Include information about historical floods**, which can offer a local context and remind people of past experiences with flooding (“event maps”) (de Moel et al., 2009).
4. **Consider cartographic aspects for ease and speed of comprehension**, and avoid overly technical language without supporting explanations (e.g., 1% chance of flood in any given year, 1:100-year flood, high-to-low flood risk). A clear legend and meaningful colours to represent flooded areas (shades of blue representative of water) are particularly useful for public users (Kellens et al., 2009). Special considerations must be made for addressing color-blindness to ensure that maps are interpreted as intended by all audiences.
5. **Provide flood maps online and promote them regularly as a continuous reminder of flood hazards**, particularly for communities who have not been recently impacted by flooding and it is not a part of recent public memory (Kellens et al., 2009).
6. **Use real-time gauge levels**, if available, to help contextualize historic or extreme water levels shown on maps.
7. **Use property-specific, searchable Web mapping services** to allow citizens to look up their address or postal code and receive information on their property in relation to flooded areas. These efforts are primarily conducted at national and regional levels, and are common in comparable nations to Canada (Kellens et al., 2009).
8. **Complement flood maps with information about the consequences of flooding and tangible protective actions** to move from identifying a problem to motivating homeowners to act. This can include stories from survivors, information on private insurance, self-protection measures, evacuation routes, etc. (Kellens et al., 2009).



It is important to note that maps are recognized to be one piece of broader initiatives when it comes to flood risk awareness and engagement, and cannot be used alone when working at the community level to raise awareness, motivate action, and sustain public participation. There are numerous initiatives that supplement the public release of flood maps in other countries, such as local meetings to educate homeowners about insurance, and establishing a relationship between governments and insurers for the benefit of the public (e.g., mechanisms to re-evaluate premiums to incentivize homeowners to install flood protection measures on their property) (CAPFLO, 2017; OECD, 2016). It is also important to embed flood risk communication within existing community functions to ensure ongoing efforts, and to connect national projects with local information sources (e.g., add links for federal government online information campaigns to municipal pamphlets). In other nations, flood maps are also digitally released as open data to allow innovation among businesses in using flood information for their own intelligence platforms (e.g., Piinpoint using Federal Emergency Management Agency [FEMA] flood maps for retail site-selection) (Young, 2017)

It is also critical to recognize the ways in which the public interpret, understand, and use flood maps, and how these factors affect the dissemination of flood risk information. Most map users will likely have an extremely narrow focus, typically at the property level (Young, 2017), and unless information is provided and interpreted at this level of detail, most will lose interest and the effectiveness of the maps to drive behavioural change towards personal responsibility for protection will be lost (Priest et al., 2011). Maps are more likely to be effective when the public trust their government representatives, have ready access to information, believe in the accuracy of the maps, and clearly understand both their content and the intent of the message (Priest et al., 2011). Effective maps will also clearly demonstrate why those living in floodplains are at increased risk for flooding, and why development should be regulated or even prohibited in high-risk areas (Priest et al., 2011; Shrubsole et al.,2003). Maps should also communicate the limitations of structural solutions to reduce flood risk, meaning that some residual risk will always remain, which is why the public must take personal responsibility in preparing for flooding (Shrubsole et al.,2003).

Flood maps must be authoritative, created using reliable and current data, maintained on an ongoing basis by a reputable organization, and made freely accessible to the public (Shrubsole et al.,2003). They must communicate flood risk using high-quality hazard, probability, and exposure data that are trusted, accurate and accessible. Providing this information to residents achieves transparency and increases the legitimacy of flood risk policy decisions through building trust in the process and mapping products. To ensure that the maps are interpreted as intended, the map creators must limit the use of technical terminology used in the map, and instead include information that is relevant to the public in relation to flood preparedness, mitigation and response (Shrubsole et al.,2003). It is also important to

recognize the uncertainties, limitations and assumptions that flood maps are often built upon and using care when facing these issues before these maps are made public (e.g., data availability, uncertainties surrounding flood model analysis, impacts of climate change and changing flood lines) (Shrubsole et al., 2003; CSIRO, 2000).

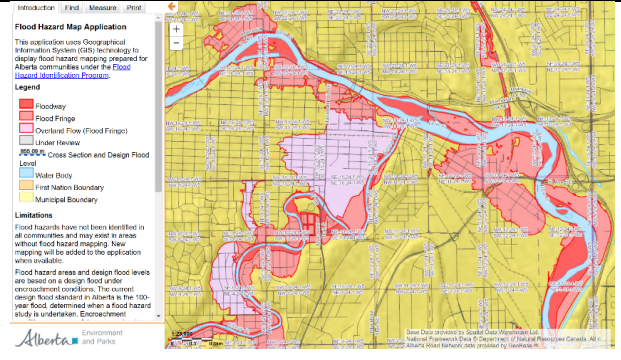
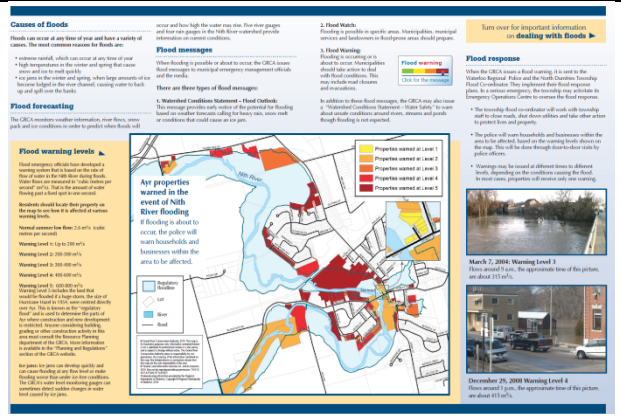
There are also challenges when using flood maps for public risk communication, including:

1. Capacity and resources – jurisdictions have varying levels of capacity and timeframes to acquire data and create, update and disseminate flood maps.
2. Lack of consistent nomenclature for flood risk mapping – jurisdictions will vary in their definition, use and purpose of maps.
3. Difficulty in using highly technical flood modelling and maps (e.g., flood return periods) to communicate to non-expert audiences.
4. Perception of decision-makers that public release of flood information will have negative consequences (e.g., impacts on real estate). International experience shows, however, that the actual impact from flooding reduces the value of a property substantially more than flood hazard disclosure—which could marginally affect property values or not influence at all (Yeo et al., 2015; Yeo, 2013).
5. Privacy concerns, particularly when displaying individual properties.
6. Inability to solely rely on maps as a stand-alone communication tool towards public flood risk awareness. There is a distinct difference between raising awareness and promoting and sustaining public engagement in flood risk management.
7. Lack of data or expertise for modelling different types of floods (e.g., fluvial, pluvial and coastal/storm surge).

### 3. Assessment of Canadian flood maps for risk communication

Given that flood mapping efforts have been pushed to local and regional governments in the past 20 years, there are various types of maps available that differ in terms of content, quality, currency, modelling practices used, etc. At varying capacities, jurisdictions also share flood maps online or through traditional media, putting valuable tools within the reach of the public to inform themselves about local flood impacts (Table 1). The purpose of this section of the report is to assess these maps relative to the characteristics outlined in Section 2 regarding effective flood maps for public risk communication. Subsequently, this section concludes with good practices in existing flood maps employed by Canadian government bodies, but also reflects on how these and other practices could be used to improve flood maps for public risk communication.

**Table 1.** Examples of publicly-accessible flood maps in Canada.

Publisher	Map	Description
<p>Alberta Environment and Parks, 2016</p>	 <p>The screenshot shows a web-based application for flood hazard mapping. It features a map of a river area with various flood hazard zones highlighted in different colors. A legend on the left side of the map identifies the zones: Floodway (red), Flood Fringe (orange), Overland Flow (Flood Fringe) (yellow), Under Heavy (green), and JMWMA Case Section and Design Flood Level (blue). The map also shows water bodies, great lakes boundaries, and municipal boundaries. A text box on the left provides an introduction to the application and its purpose, which is to provide flood hazard information for Alberta communities under the Flood Hazard Identification Process.</p>	<p>An online portal that provides flood maps for various communities in Alberta.</p>
<p>Grand River Conservation Authority (Ontario), 2017</p>	 <p>The screenshot shows a brochure with text and a map. The text is organized into sections: 'Cases of floods', 'Flood forecasting', 'Flood warning levels', 'Flood response', and 'Flood warning levels'. The 'Flood forecasting' section explains that floods can occur at any time of year and lists various causes. The 'Flood warning levels' section provides a color-coded legend for properties: Level 1 (yellow), Level 2 (orange), Level 3 (red), and Level 4 (dark red). The 'Flood response' section lists actions to take during a flood, such as staying on higher ground and avoiding flooded areas. The map shows a river area with properties marked according to the warning levels. There are also photographs of flooded areas and a warning sign.</p>	<p>A brochure that contains descriptive text and explanations about flooding, photographs, and points of contact during emergency situations.</p>

Reflecting on the characteristics outlined in Section 2, it is evident that these two Canadian examples have many components outlined in that list, and can be suitable for various public engagement initiatives. Evidently, each map was created with a particular purpose in mind and the map and its contents were designed to reflect that purpose.

The online mapping application published by Alberta Environment and Parks allows users to look up their individual address and see if they are within the “floodway” or the “flood fringe”. This map allows many Albertans to find out if their property is within a flood-prone area, which could then trigger interest in how to protect themselves or prepare for future floods. The information shown in this application could be improved to more specifically tailor messages that communicate personal responsibilities and the role of the public in flood protection. For example, key answers to common questions can be paired with these maps (e.g., What does ‘flood risk’ mean? What is my personal risk at work, at home, at school? Who do I contact if my home is flooded? What should I do if my home is flooded? What are some measures can I can take to reduce and manage my risks?), as well as information about past floods (e.g., the Calgary floods) to continuously serve as reminders of past experiences with floods. In addition to this, it is necessary to drive the message that floods do not solely affect those living beside waterbodies (e.g., rivers); as a result, homeowners living outside of riverine floodplains also require information about self-protection and must be made aware of rainfall-driven flood hazards.

The flood map created by the Grand River Conservation Authority closely follows NRCan’s description of an awareness map (Appendix A). This is a community-specific map that includes information on how homeowners can protect themselves before a flood, where information is available to monitor developing emergency situations (how to receive watching and warnings), and photographs to illustrate what is meant by various “flood warning levels”. This map can serve as a guidance document for other jurisdictions looking to create flood maps meant for public use. The content already developed for this map can also be used or enhanced for other purposes, such as informing the public about municipal subsidies for installing flood-protection devices, or limitations to disaster assistance programs. For example, government disaster assistance may not be available to those who have ready access to flood insurance (including those who chose to not purchase insurance) (Government of British Columbia, 2017), and secondary properties (e.g., cottages) may also not be eligible for disaster assistance (Ontario Ministry of Municipal Affairs, 2017). These messages are important to communicate to the public to avoid confusion in the aftermath of an event and to inform them of their role in flood preparedness. Finally, these maps can also be transformed into interactive mapping applications such as the one developed by Alberta Environment and Parks where homeowners can look up their address and find information that is specifically relevant to them.

The two Canadian examples highlighted in this section do follow some of the guidelines of effective flood maps for public risk communication. Though, ultimately, the purpose, message and target audience need to be the focus of the map and any additional content (i.e., what information is relevant to map viewers?) paired with the map. Additional considerations for language, literacy level, venue (online, print, or public meeting) must also be addressed in preparation and distribution of these maps. Table 2

outlines possible scenarios for maps, the types of information that could be illustrated and how the public can be involved.

**Table 2.** Map content, use and characteristics on risk communication needs

<b>How will the map be used/what is the need?</b>	<b>Characteristics of map</b>	<b>How could the public be involved?</b>
<ul style="list-style-type: none"> <li>▪ Initial public consultation about a new flood management project</li> <li>▪ Emergency management meeting or consultation</li> </ul>	<ul style="list-style-type: none"> <li>▪ Show various types of floods (e.g., a more frequent vs. a less frequently occurring flood); consider a darker blue for the most frequent flood, and a lighter blue for the less frequent.</li> <li>▪ For emergency management purposes, the map can also show evacuation centres and routes.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Learn about the need for creating new flood maps (e.g., new data available, improved modelling, outdated current information)</li> <li>▪ Learn and provide feedback about emergency management plans and evacuation procedures</li> <li>▪ Contribute to the mapping process (citizen science) if data for modelling is limited or unavailable (e.g., stream flow data)</li> </ul>
<ul style="list-style-type: none"> <li>▪ Planning regulation purposes</li> </ul>	<ul style="list-style-type: none"> <li>▪ Show the current floodplain and the proposed changes in the floodplain boundary</li> <li>▪ Overlay the map on an orthophoto or community plan</li> <li>▪ Overlay a recent flood to remind citizens of the need for planning regulations</li> </ul>	<ul style="list-style-type: none"> <li>▪ Learn about the need for changes in planning regulations (e.g., climate change is creating more frequent flooding)</li> <li>▪ Learn about the consequence of flooding, and how they could be impacted</li> <li>▪ Provide feedback about their experience with flooding and local and traditional knowledge (e.g., photographs) that could help validate flood modelling results</li> </ul>
<ul style="list-style-type: none"> <li>▪ Risk reduction and risk management meetings</li> </ul>	<ul style="list-style-type: none"> <li>▪ Damage or loss information</li> <li>▪ Public and private assets</li> <li>▪ Economic benefits of flood reduction investments (e.g., before and after modelled losses)</li> <li>▪ Showcase areas that are benefited by existing flood defences and limitations to structural flood defences (i.e., flood risks cannot be fully eliminated)</li> <li>▪ Identify and clearly explain what low, medium, high risk classification</li> </ul>	<ul style="list-style-type: none"> <li>▪ See where floods can cause potential life loss and/or high economic damage</li> <li>▪ Discuss how to prioritize response</li> <li>▪ Understand the benefits of flood reduction and self-protective behaviour</li> <li>▪ Learn what is meant by high flood risk, and residual risk</li> </ul>
<ul style="list-style-type: none"> <li>▪ Mass distribution through traditional and online media</li> <li>▪ Part of a national or provincial flood strategy</li> <li>▪ Community meetings on flood, emergency management, and community preparedness/resiliency</li> </ul>	<ul style="list-style-type: none"> <li>▪ Create an online portal where people can search for their individual address and/or neighborhood and receive information that is tailored to their level of risk</li> <li>▪ Consider including additional information to increase comprehension of the problem (e.g., photographs of historical floods, past flooded areas, current areas benefited by flood defences)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Access flood hazard (multiple flood return periods) and/or risk information online with supplemental information, such as how to address personal flood risks</li> <li>▪ Learn about possible inaccessible neighborhoods during emergency situations.</li> <li>▪ Learn about the benefits of risk reduction and why it is important</li> <li>▪ Provide feedback in a focus group on map/resources comprehension and how to improve materials before they are made public</li> <li>▪ Commit to preparedness action</li> </ul>

## 4. Recommendations

Maps can be useful tools to build a sense of personal responsibility in flood preparedness among citizens and also to empower communities towards informed decision-making as part of an overall flood risk management strategy. While standardized guidelines are not recommended, the recommendations provided here are meant to foster a national set of ‘good’ practices for raising flood risk awareness using flood maps.

**Public flood maps differ from maps used by subject-matter experts and must be tailored to each community and audience, including supplementary information that is relevant to residents.**

No one type of map will work in every situation, maps and risk information have to be conscious of the audience and purpose of the message. International experience shows that to effectively raise risk awareness, maps must be localized (to property-level where possible), simple to understand (red-yellow-green or low-medium-high risk levels, shades of blue for flood extents, and avoiding return period terminology, rather frequent-medium-extreme events), clearly displayed, and paired with information that is relevant to the user. Maps can showcase the problem, but supplementary materials provide information that citizens can use to personalize the risk, protect themselves before, during, and after an event (Where do I go? Who do I contact?), enhance their flood preparedness, and manage the costs of flooding if they are affected. In addition, flood maps must be reflective of the audience and the purpose of the message to ensure that the map is interpreted as intended. Including information on only riverine floods would, for example, not suffice in Canadian urban centres like Toronto and Ottawa, where rainfall-based flooding also needs to be mitigated. The same would apply for coastal areas that are subject to riverine, heavy-rainfall, and coastal flooding/storm surge. This continues to pose a challenge to practitioners, as data or expertise for modelling multiple types of flooding is not always available for every community across the country.

**Publicly sharing flood maps online and through traditional media, and regularly reminding residents of their availability and usefulness, will aid in sustaining the need for flood risk management.** Floods are easily forgotten, particularly given the low probability of events that have catastrophic consequences. Preparedness levels “disintegrate in periods of calm” (Ontario Ministry of Municipal Affairs, 2017), so governments must “combine different kinds of communication and information tools to find new, regular, and repeated ways of activating recipients and to address different target groups” (Hagemeyer-Klose and Wagner, 2009). In European states, like Czech Republic, Germany, the UK, Luxembourg, Austria and Sweden, flood maps are publicly accessible through online portals - often at the national scale. In the United States, FEMA provides this information publicly and freely as well. In Canada, flood maps are often not easily accessible to the public, and there is a lack of awareness

even from those at-risk of flooding (i.e., 94% of at-risk homeowners do not consider themselves at risk (Thistlethwaite et al., 2017)). Online portals can help to sustain interest in flooding from local governments and the public, and increase participation of residents towards increased public support of flood risk management decisions and policy changes.

**Maps are one component of a national strategy for public risk awareness and engagement. All levels of government need defined responsibilities in flood risk management, and need to engage with their communities to improve risk awareness and motivate personal action.** It is important to include publicly released risk information as part of broader initiatives on flood risk management. Governments must recognize that flood maps are not static and need frequent review and updating (i.e., every 5-6 years as needed, according to the European Union and FEMA) (European Commission, 2017; FEMA, 2017). Communities need clear, localized maps from an authoritative source to help in prioritizing flood risk and efforts; the level of risk tolerance is individual to each community, and must be understood for effective flood risk management. To support flood risk management, the public should see tangible benefits from their engagement, such as in Germany, where a “flood pass” allows homeowners to improve their accessibility to flood insurance with an expert-approved property risk assessment (GDV, 2013). Finally, local governments need to embed flood risk in existing local initiatives and ensure long-term awareness-building, as online resources cannot be assumed to receive any attention (EXCIMAP, 2007).

Simply providing information to the public is not enough – pairing mapping with relevant information on reducing risk, and repeating this information at regular intervals, will empower residents to protect themselves and support community, provincial, and national-scale flood risk management initiatives. Local governments also need guidance on how to prepare and share these maps with their communities to get their attention, reduce anxiety and stigma, and drive support and flood protective action.

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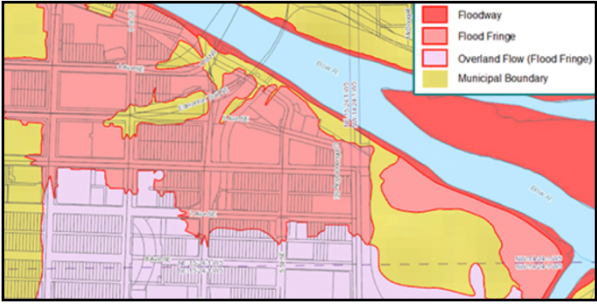

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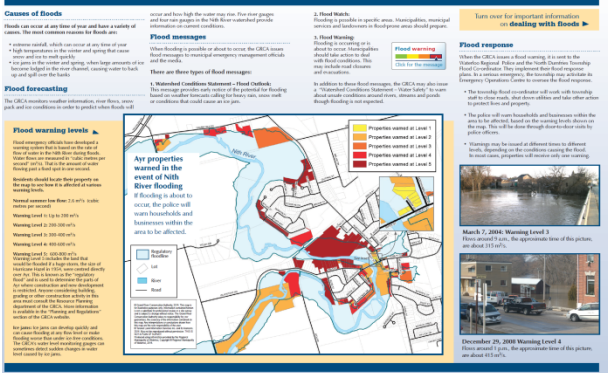
# Appendix A - Map types, definitions and assessment of Canadian examples

Natural Resources Canada (NRCan) makes a distinction on the types of flood maps that are created by professionals for identifying flood-prone areas and enabling appropriate responses that minimize flood impacts. In NRCan's recently published Federal Floodplain Mapping Guidelines, four types of maps are identified: inundation, hazard, risk and awareness (Table 1-A). Despite all being "flood maps", each shows a different combination of characteristics of flooding and flood impacts (e.g., hydraulic, economic, social). Under NRCan's definitions, inundation maps illustrate the extent that flood waters could travel under floods of different magnitudes, and are used for emergency management and preparedness purposes, whereas flood hazard maps are built for planning regulation purposes and showcase the regulatory flood line. Flood risk maps illustrate the consequences of flood events, such as potential property damage within flooded areas, and can be used by planners and insurers to better understand where floods can cause the biggest impact. Finally, public awareness maps are typically community and context-specific, and can include relevant educational information for the public (e.g., photographs of past floods) and information on how to prepare and cope with future floods (e.g., emergency management information).

The **inundation map** can be useful for emergency planning, as it clearly illustrates the flood hazard (in blue) and affected areas at the local level. Its weakness, however, is that this map is not paired with additional information about flooding that can aid the public (e.g., photographs of historical flooding, water depths), and may not be effective at communicating risk on its own if it is publicly released online or through traditional means (e.g., brochures, pamphlets). This map may be suitable for local meetings between municipalities and citizens, where staff can provide additional context when presenting this information, such as evacuation routes. For emergency preparedness and emergency management, this map should also be paired with critical infrastructure locations (e.g., hospitals, fire stations), and road segments that may become unpassable by emergency vehicles during a flood event.

**Table 1-A.** Map types and characteristics of Canadian examples (adapted from Federal Floodplain Mapping Framework Guidelines)

Type of map	Map characteristics	Example
Inundation	<ul style="list-style-type: none"> <li>▪ Show extent of floodwater coverage during floods of various magnitudes (including climate change scenario projections, if available)</li> <li>▪ Used for emergency preparedness</li> <li>▪ Can be used for initial public consultation and engagement on the topic</li> </ul>	
Type of map	Map characteristics	Example
Hazard	<ul style="list-style-type: none"> <li>▪ Engineering maps that show the extent of a regulatory or design flood (1% annual exceedance probability[AEP] flood)</li> <li>▪ Maps can show depth and velocity of flood waters</li> <li>▪ Used for regulatory planning purposes</li> </ul>	
Risk	<ul style="list-style-type: none"> <li>▪ Maps that show the consequences of flooding (e.g., economic, social)</li> <li>▪ Maps can be used to demonstrate vulnerability and hazard to inform policy and decision-making</li> </ul>	

Type of map	Map characteristics	Example
Awareness	<ul style="list-style-type: none"> <li>Maps show historical flood information, emergency and preparedness advice, photographs and text</li> <li>Used to inform the public about flooding in their community</li> </ul>	 <p>The screenshot shows a webpage with several sections: 'Causes of floods', 'Flood forecasting', 'Flood warning levels', 'Flood messages', 'Flood Warning', and 'Flood response'. A central map shows the city of Calgary with color-coded areas indicating different flood warning levels (Level 1 to Level 4). The map includes a legend and a scale bar. Text boxes provide detailed information about flood risks and emergency procedures.</p>

The **hazard map** can be useful for planning and land-use decisions as this map shows the extent of the floodplain for a particular flood event (a design or regulatory flood, such as 1% AEP, or a historical flood, such as Hurricane Hazel in parts of Ontario, or the flood of record on the Fraser River in British Columbia). This Calgary example uses Alberta’s two-zone planning system, depicting where, during a specific event, flood waters would be fastest and deepest (“floodway”), and where flood waters would be shallow (“flood fringe”). In this example, it is beneficial that these maps are available online for the public to access; however, the terminology used (e.g., flood fringe) may be too technical and not intuitive for community members. For public use, this map could be customized to show flood waters in blue paired with historical flood extents of the most recent (2013) Calgary floods and images of flood-damaged locations. This map is available online, so there is flexibility in terms of content that can be paired with the hazard map, such as searching for an address and receiving information on precautionary measures to reduce personal flood risks (including areas vulnerable to fluvial and pluvial flooding).

The **risk map** can be useful for depicting where a flood could have the biggest impact on private and public property and vulnerable populations. The effectiveness of this map for policy and decision-making (e.g., where to focus mitigation efforts to reduce impacts) could be improved through additions used in other countries, such as mapping locations that would result in the costliest damages from a rare flood event (e.g., 0.2% AEP flood). Or flood risk could be represented as “average annual loss” by calculating the potential damage to structures from floods that have various probabilities of occurring in any given year. These types of maps can be classified as “low”, “medium” and “high” risk, with additional context, to demonstrate clear benefits of personal flood protection (e.g., where there is a clear return on investment for homeowners after installing flood-proofing devices). Risk maps, however, are perhaps best suited for governments looking to better detect areas where there can be large economic consequences from flooding, and where risk reduction and risk management efforts are justified (e.g., land use regulations, increased permeability, promoting private insurance uptake, etc.). Citizens can then

be better engaged in helping to prioritize government investments that are clearly linked to reducing damage. Governments can then also account for residual risks and improvements in spatial planning in areas behind structural defences.

The **awareness map** shown above (found within a community-specific brochure developed by Grand River Conservation Authority) has many of the beneficial characteristics of public flood maps. This map has been tailored for reaching out to specific neighborhoods within a flood risk area, with descriptive text, historical photos to illustrate water levels, and information about emergency planning. Users actively decide to look, to absorb, and to act on the information presented in a map, so the initial message is critical for driving behaviour change towards personal preparedness. This map is specific, eye-catching and easy to read, leading to potentially better uptake and further information-seeking by users. A brochure-style map, such as this one, could be used by other jurisdictions to include information about risk mitigation (such as self-protection and warnings), links to government and other informative websites (e.g., Flood Ready), and information on flood insurance and municipal subsidy programs for home improvements to reduce risk (e.g., sump pumps, backwater valves, and disconnecting downspouts from municipal systems). These efforts can be transformed into interactive online maps that homeowners can access for individual information on property risk, with multiple jurisdictions potentially partnering to avoid duplication of efforts. Nevertheless, traditional information resources are beneficial to involve all population groups in these discussions.