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# Flood Hazard Maps in Manitoba; Present Status and Future Provincial Plans with respect to Climate Change

**Technical Report – UNCLASSIFIED**  
**OCRE-TR-2017-022**

Document Version: 1.0

Hossein Babaei

National Research Council Canada  
Ottawa, Ontario

30 March 2017





National Research Council  
Canada

Ocean, Coastal and River  
Engineering

Conseil national de recherches  
Canada

Génie océanique, côtier et  
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## Executive Summary

Flood risk maps currently in use by the province of Manitoba were created in the 70's and 80's under the Flood Damage Reduction Program (FDRP) of the federal government. Manitoba FDRP maps only contain information about the extent of flooding occasionally delineating the floodway and no information about flood velocities. These maps have not been updated and other than a few other recent maps that were created at the request of entities other than the province, no other new flood hazard map exists. It is believed that because of topographic, land use, flood frequency, and climatic changes, the FDRP maps generally need updates and new maps are needed for new locations. Particularly, how the future climatic changes impact Manitoba flooding has not been scientifically studied and considered for future flood hazard mappings. This is mainly because the province believes that present climate models do not provide sufficient accuracy, confidence and details required. The province has however been taking several measures to prevent and mitigate future flood damages including the increase of the regulatory flood to 1:200 year, the continuous update of Intensity-Duration-Frequency curves and the construction of several community dykes, to mention a few. The province is additionally planning to produce new flood hazard maps for three watersheds under the Federal Government National Disaster Mitigation Program. In addition to details of available flood maps in Manitoba, the present report lists several available data sources essential for future map generations.

To include flood-related recommendations in Canadian building codes, the existing knowledge about how flooding impacts public infrastructure needs to be collected and analyzed and if this knowledge does not exist, it needs to be created. How flood depth, dynamics, and debris including ice, rocks and boulders will threat public infrastructure needs to be considered and risks associated with each adverse effects of flooding need to be quantified. This quantification of risks which will be the basis of the upgrade of Canadian building codes has to be based on both present and future climatic trends.

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## Acknowledgements

Authors thank Ed Brethour, Economic Development Manager at the Town of Virden, for providing information about a recent flood risk mapping project and its final report. We are also thankful of Tony Capizzi, Inventory/Bridge Management System Technician with Manitoba Infrastructure for providing a comprehensive list of bridges and culverts in the province and Eugene Kozera and Brad Allum from Manitoba Infrastructure for providing information about the status of flood risk maps in Manitoba.

## 1 Introduction

Manitoba has experienced some of the most severe floods in the Canadian history. Recent floods of 2009 and 2011 in southern Manitoba were among the worst riverine floods in Canada since 2004 [1]. Red River of the North, in particular, has a well-known flood history including the flooding of 1950, and 1997 which were two of the largest Canadian natural disasters of the 20th century [2]. Flood damage mitigation and protection measures are of key relevance to the province when considering Manitoba's vulnerability to flooding, its considerable extent of farmlands (approximately 12% of total Canadian farmland extent [3]), and Manitoba's widespread rural and municipal population over the province's most flood-prone regions. This relevance is even more pronounced considering that climate models predict more extreme climactic events, including greater spring and winter precipitation for the Canadian Prairies [4] [5] while a large majority of runoffs in the Parries (of both USA and Canada) ends up in Manitoba [6].

The most extensive flood mapping initiative in the province was under the federally initiated Flood Damage Reduction Program (FDRP), which started in the 70's, where 17 communities were mapped [7]. All communities were mapped for a regulatory 100-year flooding, calculated by flow-frequency analysis, except for Winnipeg which was mapped for a 160-year flooding and two other communities which were mapped for the flooding of 1976. Under the FDRP, new developments are not usually allowed for floodways defined as portions of the flooded region where water depth is equal or more than a meter. The remaining portion of flooded regions is named flood fringes over which developments are usually allowed if structures are flood-proofed [8]. Several other communities in Manitoba are protected from large floods by ring dykes. A few of these communities are Emerson, Gretna, Letellier, Rosenfeld, and Dominion City [9]. In addition to smaller communities protected by ring dykes, the City of Winnipeg has recently completed the expansion of a large floodway protecting the city against 700-year floods [10].

Understanding the current status of flood hazard maps and available data sets within the province is necessary to aid in the development of a climate change informed building code for infrastructure within the flood plain with minimal duplication of effort. The work presented in this report summarizes the present status of flood maps within Manitoba, highlighting upcoming mapping initiatives which may be of use to the current project and information which may be used for the creation of future flood hazard maps for Manitoba.

## 2 Status of Flood Risk Maps in Manitoba

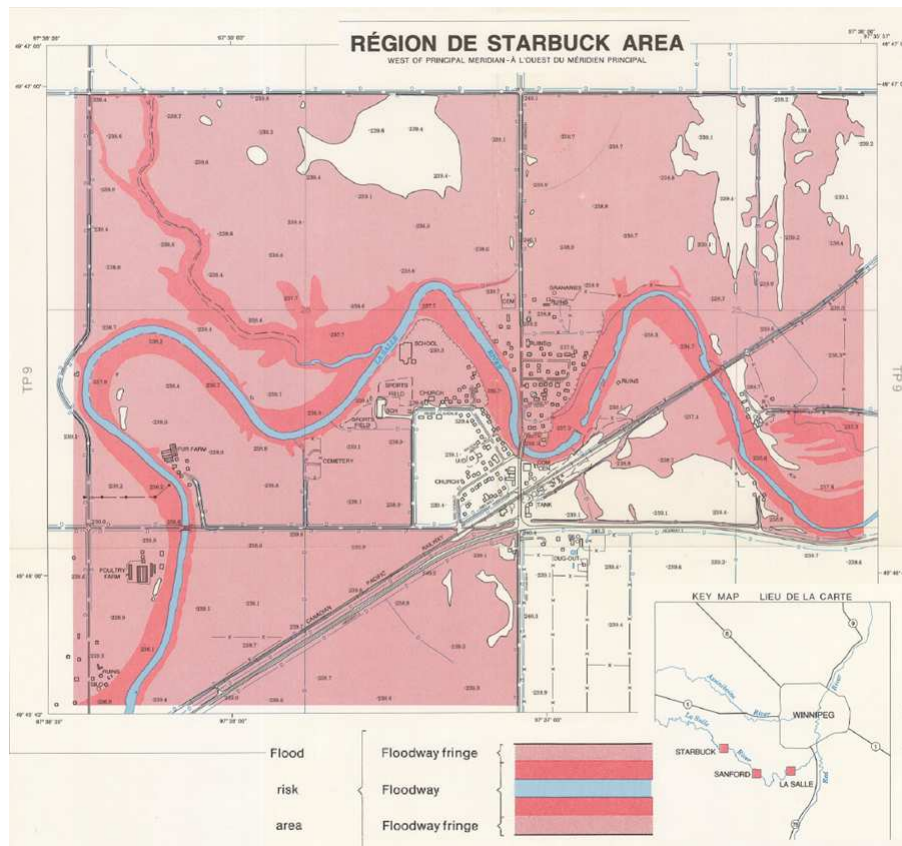
Manitoba's provincial government, namely Manitoba Infrastructure, is the only entity that has been so far responsible for the creation of flood hazard maps in the province. All maps generated under the FDRP and its guidelines are still in use by the province except the map for the community of Brandon for which there is currently no applicable map. This is because the 2011 Assiniboine River flood levels in Brandon exceeded those of the regulatory 100-year flooding. The community of Carman was also mapped, but the community is now protected from major flooding by a diversion channel (Personal communications with Eugene Kozera, Director of Water Management, Planning and Standards of Manitoba Infrastructure and with Brad Allum, Development Review Officer at the Hydrologic Forecasting of Manitoba Infrastructure). Figure 1 shows the FDRP flood hazard map for the community of Starbuck, Manitoba close to La Salle River, one of the tributaries of the Red River, west of Winnipeg. Manitoba Infrastructure provided this map to NRC. The available flood maps cover a length of approximately 360 km. To cover a large majority of flood-prone communities, an additional 185 km of mapping is required [1].

FDRP flood maps have been created by the US Army Corp of Engineers' 1D HEC-RAS and its predecessor HEC-2 models. All maps show the extent of flooding and some of them additionally show the floodway, flooded region where the water depth is equal or more than 1 m. These maps could be made available upon request to Manitoba Infrastructure. However, it is unknown whether the data (if of any value at all because of data age) based on which the models have been developed are retrievable (personal communication with Brad Allum).

No FDRP map exists for communities in the vicinity of large lakes in Manitoba; all available maps are for regions prone to riverine flooding. In addition, none of the maps are for regions where ice-related flooding is greater than 100-year open-water flooding (personal communication with Eugene Kozera). It is believed that a considerable proportion of spring floods in Manitoba are impacted by the existence of ice and hence recorded flood levels are not purely open-water levels. This is a challenge for the calibration of open-water flood models, which require open-water flood conditions (personal communication with Jim Friesen, Manager of Water Resources at AECOM Canada Limited).

The province has not updated any of the maps after the FDRP initiated in 70's. The regulatory flood requirement has been since increased from 100-year flood to 200-year flood. However, the province has not yet created any new map with this new regulatory flood. Manitoba, however plans to flood hazard map three watersheds of Lower Assiniboine River, Souris River and, Whitemud River for 1:200 year flooding under the National Disaster Mitigation Program (NDMP) of the Federal Government. These flood risk maps will be produced using LIDAR elevation data and modern hydrotechnical tools and datasets. However, contribution rules under the NDMP program may impair progress as provinces cannot seek credit for datasets acquired in advance of an application to the NDMP (personal communication with Eugene Kozera).

Figure 2 shows the communities for which FDRP maps are currently in use by the provincial



**Figure 1:** The FDRP flood hazard map of Starbuck community. This is a sample map provided to NRC by Manitoba Infrastructure. Floodway is shown in red and blue, and flood fringes are shown in light red.

government.

Existing provincial flood risk maps are not available online. This is mainly because of misinterpretation concerns; the province believes that not all the maps are entirely valid and maps need to be used by special care to avoid misinterpretation. Maps are believed to require update by utilizing new technologies such as LIDAR elevation data, updated hydraulic models, and an expanded record of hydrometric and hydrologic data (personal communication with Eugene Kozera).

To find out whether any new flood hazard map has been or planned to be developed by governing bodies other than the province, all Manitoban conservation districts (18 conservation districts, CDs) and many towns, cities, rural communities and villages (approximately 74 communities) were contacted. A list of contacted entities and responders is given in table 1. Some of responses potentially useful for future stages of the present project follows: Jodi Goerzen (Seine-Rat River CD) believes that the CD needs maps. Chris McTaggart (Town of The Pas) responded that no maps exist except a recent topographic survey of floodplains. Brittany Lynn (Turtle River Watershed CD)



**Figure 2:** Manitoban communities for which flood risk maps created under the FDRP of the 70's are currently in use by the Government of Manitoba.

responded that the only available map for the districts is the map of the town of Lake Dauphin which was developed in the 80's and is likely out of date. She also added that pictures of the 1986 flooding of Turtle and Ochre Rivers are available for possible future model validation/calibration but no map for that area exist either. All responders were either unaware of any updates to the status of flood risk maps for the corresponding governing body/CD after the FDRP or certain about the lack of updates with one exception; town of Virden has recently [11] completed a flood risk mapping project for new economic developments in the town. Virden was not mapped under the FDRP and this recent project mapped risks of different flood magnitudes including the 100-year (the initial regulatory flood set by the FDRP) and 200-year (recent regulatory flood magnitude) flooding. Similar to the maps developed under the FDRP, 1D HEC-RAS model was employed for the generation of the maps. Data related to this recent flood risk mapping project is freely accessible to NRC (personal communication with Ed Brethour, Economic Development Manager at the town of Virden).

In addition to the new maps developed for the Town of Virden, several other maps have been recently created for the Lower Pembina River floodplains and the southern part of the Canadian

**Table 1:** Entities contacted to collect information about status of flood risk maps in Manitoba

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**Contacted entities to collect information about the status of flood maps.**  
**= Those who responded**

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**Conservation Districts:** Alonsa\*, Assiniboine Hills, Cooks Creek, East Interlake, Intermountain, Kelsey, LaSalle Redboine, Lake of the Prairies, Little Saskatchewan, Pembina Valley\*, Seine-Rat River\*, Swan Lake Watershed, Turtle Mountain, Turtle River Watershed\*, Upper Assiniboine River\*, West Interlake Watershed, West Souris River, Whitemud Watershed\*

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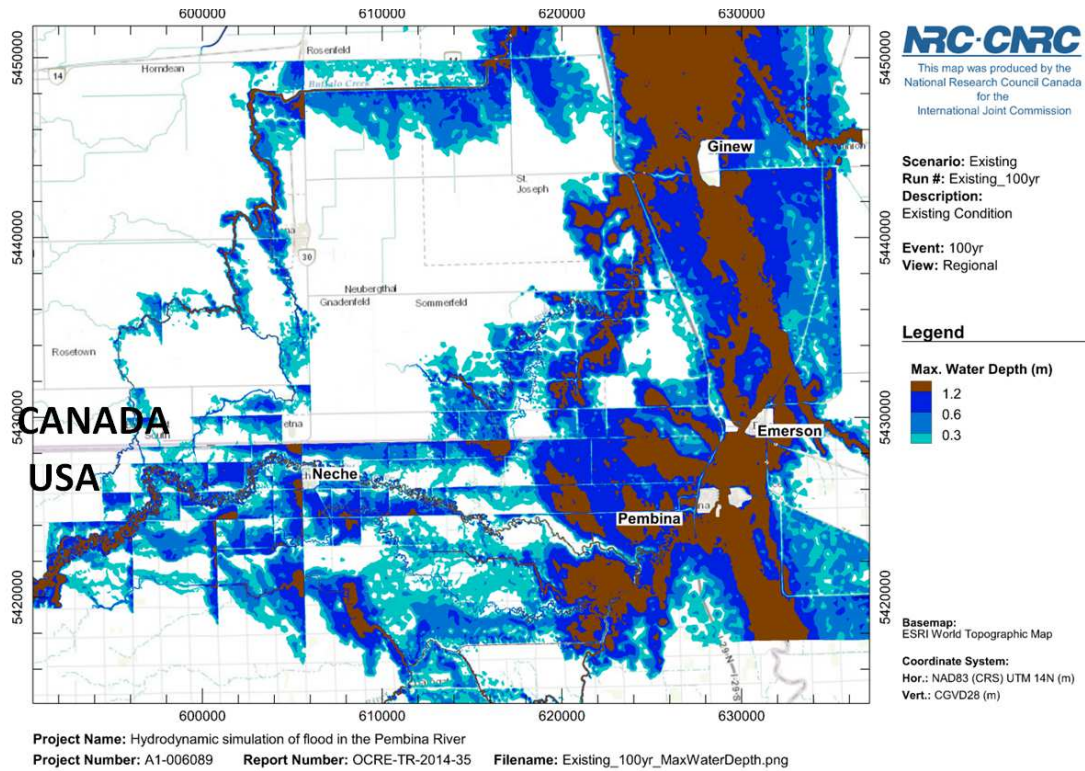
**Departments and Branches of the Provincial Government:** Climate Change and Air Quality\*, Water Management, Planning & Standards\*, Hydrologic Forecasting\*

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**Municipalities:** Altona\*, Arborg\*, Brokenhead, Beausejour, Carberry, Churchill, Dauphin\*, Dunnottar, Gillam, Lac du Bonnet, Lynn Lake, Melita, Minnedosa, Minto-Odanah, Oakview, Morden, Morris, Neepawa, The Pas\*, Portage la Prairie, Powerview - Pine Falls\*, Selkirk\*, Ste. Anne, Steinbach\*, Swan River\*, Teulon\*, Rhineland\*, Whithead, Armstrong, Bifrost, Boissevain, Brenda-Waskada, Cartier, Erickson\*, Coldwell, Cornwallis\*, Deloraine, De Salaberry, East St. Paul, Ellice – Archie, Elton, Emerson-Franklin, Gilbert Plains, Gimli\*, Grandview, Grey, Hamiota, Hanover\*, Headingley, Shell River, Kelsey, Lakeshore, Macdonald, Montcalm\*, Mossey River\*, Norfolk Treherne\*, Prairie View\*, Reynolds, Ritchot, Riverdale\*, Souris-Glenwood, St. Andrews, St. Clements, St. François Xavier\*, St. Laurent, Ste Rose du Lac, Stuartburn\*, Two Borders\*, Victoria Beach, Wallace-Woodworth\*, West Interlake, WestLake Gladstone\*, West St. Paul\*, Whitemouth\*

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Red River. These maps have been developed by the National Research Council Canada for the International Joint Commission through a series of 2D hydrodynamic studies using Telemac2D [12] [13] [14]. Several flood severities including 10, 20, 50, and 100-year floods have been modelled for the existing and natural conditions and for several hypothetical scenarios to evaluate performance and feasibility of several flood damage mitigation measures. Direct model outputs of Telemac2D are water depth and velocities throughout the modelled domain extending from Morris, Manitoba, located 40 km north of the Canada-USA border, to a region in the USA 20 km south of the border. The east-west extent of the modelled domain is 55 km encompassing Dominion City, Manitoba on the East. Figure 3 shows one of the maps created through these series of studies and shows the water depth for the 100-year event. Model inputs and outputs and the developed 2D Telemac model are freely available to NRC for future flood hazards maps developments.



**Figure 3:** The 100-year flood depth map of Lower Pembina River floodplains created through a 2D hydrodynamic modelling for the International Joint Commission. The figure is reproduced from a map given in [13].

### 3 The Issue of Climate Change

The climate Change and Air Quality branch of the Department of Sustainable Development of the Province of Manitoba was contacted about whether forecast future intensifications in climatic events are being considered in future flood estimations; the branch with other branches of Manitoba Infrastructure prepared a response and what follows is what follows is quoted from part of the response communicated by Eugene Kozera:

Due to its location, many areas of Manitoba are vulnerable to flooding, extreme precipitation or periods of drought, and cold weather events. Current climate and precipitation prediction models do not adequately provide sufficient accuracy, confidence and details required to plan and prepare for long term climate change. Through its engineering, planning and hydrology specialists, Manitoba will continue to address vulnerabilities and build resiliency into the transportation and water control infrastructure network, thereby providing flexibility to respond to changing weather patterns, which in turn mitigates future damages and reduces emergency response costs. Evidence shows that our climate has warmed in recent decades and it is expected that future climate will be even more disruptive, bringing frequent extreme precipitation events, floods, droughts, and changing precipitation patterns and water regimes. Manitoba's plans for enhancing the resilience on its bridges and crossings, water management and flood protection infrastructure include:

1. Recent expansion of the number of meteorological stations in Manitoba.
2. Continuing to develop and update IDF curves across Manitoba and refining methods to characterize design precipitation events. IDF curves are critical for design of infrastructure including bridges and crossings in smaller watersheds.
3. Exploring new methods for developing design discharge hydrographs in catchments up to 260 square km in area. The new methods focus on rainfall driven flooding which can generate higher instantaneous peaks than snow-melt runoff.
4. Adoption of the 1:200 year flood as the design standard for flood protection levels, while not specific to climate change, a higher flood protection standard will increase resilience to flood events in the face of an uncertain future climate.
5. For bridges and large culverts, Manitoba is also reviewing and updating hydraulic design standards and reviewing our current design standards for thermal extremes.

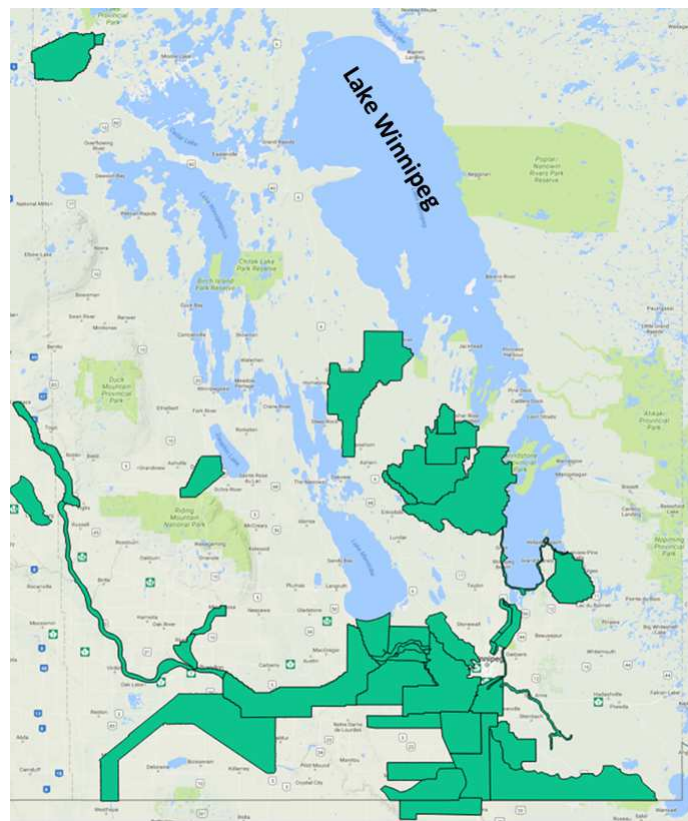
In addition to the new regulatory flood value of 1:200 year quoted above, an additional freeboard is required when designing new flood hindering structures and buildings. This requirement is an additional measure to prevent and mitigate probable future severe floods (personal communication with Eugene Kozera). This additional freeboard requirement is usually 0.6 m in the design of dykes and similar flood hindering structures, and 1 m for buildings.

## 4 Sources of Data for Future Flood Hazard Map Modelling

This section identifies and directs to data sources required for the generation of future flood hazard maps:

### 4.1 Topographic information

Natural Resources Canada provides a Canada-wide Digital Elevation Model (CDEM) with spatial resolutions of 0.75-arc seconds which depending on location is equivalent to spatial resolutions of tens of meters. CDEM is freely available through <http://geogratis.gc.ca>. In addition to the CDEM, the province and its partners have generated several other DEM datasets, for different regions and at different times. These datasets are freely available through the Manitoba Land Initiative website <http://mli2.gov.mb.ca/dems/index.html>. The horizontal resolution of the provincial DEMs are generally 5 m or finer. Figure 4 shows the coverage of the provincial datasets updated in Feb. 2016.



**Figure 4:** Spatial coverage of provincially generated DEMs in Manitoba. Datasets spatial resolutions are generally 5 m or finer. The above map was updated in Feb. 2016.

In addition to these two sources of DEMs (NRCan and Provincial datasets), we are aware of two

other DEM datasets prepared by Agriculture and Agri-food Canada (AAFC) for Manitoba; one for southern Manitoba in the Pembina River region and one for La Salle region, both with the horizontal resolution of 1 m. The latter is freely available online through [open.canada.ca/data/en/dataset/aba9fd46-2921-43f6-9bdb-c9f021aee4ee](http://open.canada.ca/data/en/dataset/aba9fd46-2921-43f6-9bdb-c9f021aee4ee) and the former has been previously provided to NRC for a previous project [12] which can be freely used for future work.

#### *4.2 Bathymetric Information*

No river bathymetric information was found through internet and the Water Management and Structures Division of Manitoba Infrastructure was unaware of any related data. We are however aware of a few datasets: A 2009 bathymetric survey by AAFC for an approximately 30 km of the Red River from Letellier to approximately 10 km upstream of the Pembina River junction. This dataset has been previously provided to NRC for a previous project [12]. Another bathymetric dataset by AAFC for a short portion of the Red River, a few kilometers, has been also previously provided to NRC [12]. Additionally, the bathymetric surveys of watercourses in and around town of Virden for the recent flood hazard mapping project, as mentioned previously, will be available to NRC. Course depth contours of several Manitoban lakes are also freely available through [http://www.gov.mb.ca/waterstewardship/fisheries/fish\\_stocking\\_gMap\\_MVC\\_V2/index.html](http://www.gov.mb.ca/waterstewardship/fisheries/fish_stocking_gMap_MVC_V2/index.html).

More investigations are required to identify other bathymetric surveys, particularly for watercourses, and whether and how they could be provided to NRC.

#### *4.3 Past Flooding Extents*

Several remotely sensed past flood extents in Manitoba are available through NRCan Flood Maps, freely accessible online through [130.179.67.140/dataset/nrcan-flood-maps](http://130.179.67.140/dataset/nrcan-flood-maps). These maps are useful for the validation and calibration of future hydrodynamic models.

#### *4.4 Aerial Photos*

Approximately one million air photos of Manitoba taken since 1928 are available. It is believed that some of the photos show past flooding events in the province. Manitoba air photos are available for purchase through [MapSales@gov.mb.ca](mailto:MapSales@gov.mb.ca). More information about these photos is available online through [gov.mb.ca/sd/geomanitoba/distribution/index.html#library](http://gov.mb.ca/sd/geomanitoba/distribution/index.html#library).

#### *4.5 Water Levels and Discharges*

Water Survey of Canada is the primary source of these data which is freely accessible through [wateroffice.ec.gc.ca](http://wateroffice.ec.gc.ca). United States Geological Survey also has some gauges in Manitoba that are accessible through <https://nd.water.usgs.gov/floodinfo/red.html>.

#### *4.6 Land Use and Land Cover*

Extensive Canada-wide land cover information is available through Natural Resources Canada website <http://geogratis.gc.ca>. This dataset is named circa 2000-Vector (LCC2000-V) and originated from remotely-sensed data with similar spatial resolutions to those of NRCan's CDEM data mentioned earlier. In addition to this NRCan data source, several provincially generated datasets for different regions of the province are freely available through [mli2.gov.mb.ca/landuse/index.html](http://mli2.gov.mb.ca/landuse/index.html).

#### *4.7 Culverts and Bridges*

A comprehensive list of culverts and bridges in Manitoba with their locations and other specifications was provided to NRC at our request.

## 5 Conclusions

Manitoba is regularly impacted by flooding with complex adverse environmental and socio-economic consequences. Although the Government of Manitoba has been taking major steps to reduce the impacts of flooding in Manitoba communities including the construction and upgrade of several floodways and dikes, continuous update of IDF (intensity-duration-frequency) curves and expansion of weather stations across the province, as a few examples, there is still a need for the upgrade of existing flood risk maps, mainly dating back to the 70's and 80's, and the increase of spatial coverage of the maps. Additionally, more research is required to quantify how future climatic changes will impact Manitoba and whether present measures will be enough to prevent damages of future flooding. The present section of the report also introduced several freely available data sources required for the development of future flood hazard maps.

With respect to the upgrade of Canadian building codes to include recommendations for flooding, the knowledge of how flooding impacts public infrastructure needs to be collected and analyzed and if this knowledge does not exist, it needs to be created. How flood depth, dynamics, and debris including ice, rocks and boulders will impact public infrastructure needs to be considered and risks associated with each adverse effects of flooding need to be quantified. This quantification of risk will be the basis of recommendations in Canadian building codes.

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