Metadata Inventory of Existing Conservation Authority Flood Mapping

Prepared By:
Ganaraska Region Conservation Authority

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Contact: Conservation Ontario for further information about this Report

Ganaraska CONSERVATION

OTONABEE CONSERVATION

Conservation ONTARIO Natural Champions

Executive Summary

The Metadata Inventory of Existing Conservation Authority Flood Mapping project was initiated by the MNRF and Conservation Ontario (CO) in response to the federal NDMP program. The purpose of the project was to advance the understanding of floodplain mapping within the province to better position the MNRF and CA's in anticipation of federal funding for floodplain mapping. In addition, the floodplain inventory will serve COs case for re-investment in flood management programs, services and infrastructure (CO Flood Business Case) which includes:

- Accurately documenting floodplain mapping needs, and support associated cost estimates towards the development of a floodplain mapping strategy;
- Provide input into new floodplain mapping initiatives;
- Accurately communicating where we are with floodplain mapping in Ontario; and
- Informing the development of funding proposals for floodplain mapping from Public Safety Canada's National Disaster Mitigation Program

A concurrent project was also completed by the MNRF for those areas outside of CA jurisdiction, thus creating a comprehensive inventory of all floodplain mapping within the province. Funding for this project has been provided by the MNRF.

All 36 of Ontario's Conservation Authorities have provided information regarding the status of floodplain studies in their jurisdiction. This is the first time that this amount of floodplain information has been gathered into one inventory. The analysis of this data provides insights into the state of Ontario's floodplain mapping that was not possible in the past. The results of these interviews are reviewed in the following section. The inventory is based on each CA providing data related to a series of 94 questions regarding each floodplain project completed in their watershed area.

As the data was received from each CA it was reviewed for completeness, accurate interpretation of the questions and conflicting data. Conservation Authorities were contacted to clarify questions, assist in the interpretation and analysis of the information and address any concerns. All CAs voluntarily provided information and in some instances were unable to fully compile all data required for the inventory. Reasons for this included a number of cases where the requested data was not available due to the age of the existing information and projects. However, on average the submissions provided by CAs were 94.2% complete.

During the process of meeting with CAs, and after analysing and reviewing their floodplain reports and submitted data, it has become evident there are a few areas for improvements and efficiencies related to floodplain mapping initiatives. The following are recommendations to support CAs in ensuring accurate updates of regulatory floodplain products which are critical to the comprehensive flood management program in Ontario and the continued protection of people and property from flood risk.

1) The inventory created for this project should be updated on an annual or bi-annual basis. A significant number of new projects may be forthcoming as a result of NDMP funding. All data should be kept in a geospatial database, with appropriate metadata linked to delineated floodplain areas. The creation of a geodatabase is ongoing at the time of publishing this report.

2) The inventory provides sufficient information to undertake a more detailed cost analysis than is provided within this report. It is recommended that more refined and targeted estimates be undertaken as part of COs update to the Flood Business Case.

3) Climate change should be a consideration in all future floodplain mapping products. A recommendation put forth within the MMM study, stated that climate change considerations be addressed within new Hydrology Technical Guidelines. It is recommended that within the Province of Ontario any climate change scenarios or requirements be included in a revised MNRF Technical Guideline for flood hazard limits.

4) The need for a large scale elevation data acquisition cannot be understated; it is further recommended that this acquisition be accelerated so that the data may be utilized within the NDMP timelines. It is estimated that 33 percent of mapping is within a low risk area, and while these areas may not be given the same priority as a high risk area, the need within CAs to have accurate and reliable information still exists. The unit costs per kilometer of floodplain mapping in low risk areas incorporates a base mapping acquisition, and the costs could be greatly reduced if a large scale acquisition were to be completed. It is unlikely that the necessary accuracy of elevation data acquired from a large scale acquisition would be sufficient for high risk areas. The elevation data may however be useful in medium risk areas as well, further reducing costs.

5) It is recommended that a Provincial Flood Risk Assessment Methodology be defined to enable all practitioners engaged in evaluating floodplains in Ontario to have a common definition of flood risk. This study evaluates floodplain mapping based on a very preliminary approach that could be significantly improved with input from water resources experts. This recommendation is timely given the National Disaster Mitigation Plan requirement for Risk Assessment as part of that funding program.

6) The most important recommendation from this inventory is that floodplain mapping in Ontario needs a major investment, as much of it needs to be updated. The MMM Group in their 2014 report, "National Floodplain Mapping Assessment – Final Report" suggests that urban floodplain mapping should be reviewed every 5 years rural floodplain mapping should be reviewed every 15-20 years. This inventory provides a first step in that review. If a comprehensive update of Ontario floodplain mapping is to be realized, the results of this inventory could be expanded to create a meaningful path forward for that update.

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Acknowledgements

The Project Team of Ganaraska Region Conservation Authority, Otonabee Region Conservation Authority and Conservation Ontario staff would like to acknowledge the incredible support provided by the 36 Conservation Authorities of Ontario. Conservation Authority staff spent many hours reviewing old floodplain studies to provide valuable data for this inventory. Without this significant effort, this project would not have been possible.

We would also like to acknowledge the support and technical input of many Ministry of Natural Resources and Forestry (MNRF) staff; these include Bryce Matthews, Frank Kenny and Steve Lenny. Their input has been valuable in ensuring the larger vision for this database is continually promoted.. The MNRF also provided the funding to make this project possible.

Finally, it is important to recognize the work of the Conservation Ontario Flood Business Case Technical Committee. This committee suggested what types of data could be provided by Conservation Authorities and helped the project team form the inventory questions.

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1.0 Introduction

In Ontario, the Emergency Management and Civil Protection Act was enacted to create disaster resilient communities, through a risk-based Emergency Management (EM) program. The EM program is based on five pillars: Prevention, Mitigation, Preparedness, Response and Recovery. The EM program includes the development and maintenance of a Hazard Identification and Risk Assessment (HIRA) for each of 37 identified provincial hazards, which includes flooding. Floodplain maps identify areas subject to flooding as defined by provincial standards, based upon water flow and level forecasts. Floodplain maps can therefore be used as a planning tool to minimize future risks, and provide for better emergency preparedness and response.

> **"Ontario's long-term prosperity, environmental health and social well-being depend on reducing the potential for public cost or risk to Ontario's residents from natural or human-made hazards."**
>
> **PPS (2014)**

In 1978, Ontario joined the federal Flood Damage Reduction Program (FDRP), a cost sharing program between the federal government, the province, and municipalities, which ran until 1996 and was designed to curtail escalating disaster assistance payments in known flood risk areas and reliance on costly infrastructural measures. The work included identification of flood risk areas and hazard land designations to discourage new development in these areas.

Over the past decade, flooding in Canada has cost billions in disaster relief payments. The federal government recently proposed the National Disaster Mitigation Program (NDMP), a cost-sharing program to reduce financial exposure to disasters and shift to investment in mitigation, build on existing programs and satisfy prerequisites of the insurance industry in order to provide overland flood insurance across Canada. The federal NDMP priority for the first five years is flooding disasters. The insurance industry also requires up to date floodplain mapping in order to provide overland flood insurance to residents. A national floodplain mapping assessment was completed by MMM Group Limited for Public Safety Canada in June 2014 to help guide the initiatives of the NDMP program.

Through the Conservation Authority Act, the Ministry of Natural Resources and Forestry (MNRF), in collaboration with conservation authorities (CAs), plays a primary role in the overall management of floodplains through MNRF's CA natural hazard program (flood and erosion control operations), and through Minister approved regulations. CAs may develop mapping under these regulations that delineate the regulatory limits of hazards, including flooding.

Through the Planning Act & the Provincial Policy Statement (PPS) (2014), Ministry of Municipal Affairs and Housing (MMAH) and municipalities are responsible for land use planning; MNRF and CAs act as advisors on matters related to flooding. CAs have been delegated by MNRF to comment on municipal planning documents and applications for consistency with the PPS natural hazard policies. CAs may update hazard mapping for their municipalities to inform municipal statutory obligations under the Planning Act to encourage suitable land use and zoning and to help inform municipal emergency management plans. As a result of these responsibilities, CAs have gained substantive expertise in floodplain mapping within the Province of Ontario.

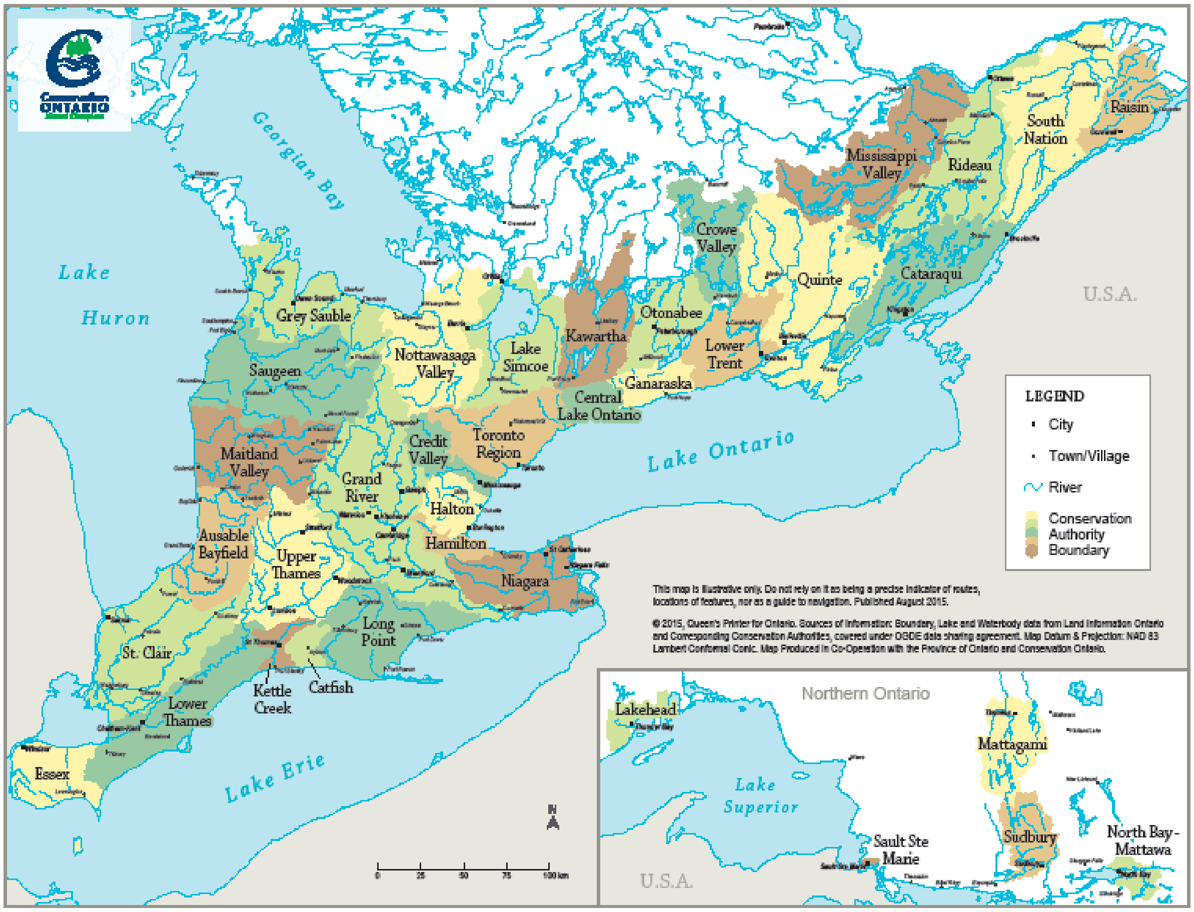


Figure 1.1: Conservation Authorities of Ontario (Conservation Ontario, 2015)

1.1 Project Background

The Metadata Inventory of Existing Conservation Authority Flood Mapping project was initiated by the MNRF and Conservation Ontario (CO) in response to the federal NDMP program. The purpose of the project was to advance the understanding of floodplain mapping within the province to better position the MNRF and CAs in anticipation of federal funding for floodplain mapping. In addition, the floodplain mapping inventory will serve CO's business case for strategic re-investment in Ontario's flood management programs, services and infrastructure (CO Flood Business Case) which includes:

- Accurately documenting floodplain mapping needs, and support associated cost estimates towards the development of a floodplain mapping strategy;

- Provide input into new floodplain mapping initiatives;

- Accurately communicating where we are with floodplain mapping in Ontario; and

- Informing the development of funding proposals for floodplain mapping from Public Safety Canada's National Disaster Mitigation Program (NDMP)

http://www.conservation-ontario.on.ca/documents/CO%202013%20Flood%20Business%20Case_Oct.pdf

http://www.conservation-ontario.on.ca/documents/Phase-in%20Approach%20-%20Addendum%20to%20CO%20Flood%20Bz%20Case_Dec%202%202013%20FINAL.pdf

A concurrent project was also completed by the MNRF for those areas outside of CA jurisdiction, thus creating a comprehensive inventory of all floodplain mapping within the province. Funding for this project has been provided by the MNRF.

1.2 Project Roles

The project team was primarily made up of staff from the Ganaraska Region Conservation Authority (GRCA), Otonabee Region Conservation Authority (ORCA) and Conservation Ontario, with support and guidance from staff at the MNRF and other CAs who formed the Flood Business Case Technical Committee. The Project Team consisted of the following individuals:

- Mark Peacock, P. Eng., Director of Watershed Services, GRCA
- Cody Brown, GIS Specialist, GRCA
- Ian Boland, C.E.T., Engineering Technologist, ORCA
- Jo-Anne Rzadki, MSc, Business Development and Partnerships, CO
- Rick Wilson, Information Management Coordinator, CO

The GRCA was responsible for the project administration, database design, data management, CA interviews and report preparation. ORCA was responsible for and assisted with the database design, data management, interview organization, CA interviews and report preparation. Lastly, CO was responsible for project support; including liaison with Ontario's CAs to build support for the project and addressing CA concerns, organizing and facilitating meetings, database design, data management and report review.

1.3 Project Process

To compile the inventory, and to collect data in an efficient and simple format, the project was broken down into four primary tasks. A breakdown of each of the four tasks is as follows:

<u>Task #1</u>

The initial task involved the collection and review of existing inventories created by CO and the MNRF in 2007, and the national floodplain mapping assessment conducted by MMM Group Limited for Public Safety Canada in 2014. To avoid duplication of efforts when compiling new information, any data that was applicable from past inventories/databases was carried over. All of the existing data that was carried over was analyzed and reviewed for completeness, consistency, gaps and correctness. A general review of each of the previous inventories/databases was undertaken to look for issues related to accuracy and consistency, to ensure that the updated inventory was completed accurately, and created reliable information.

Task #2

The second task was to determine the metadata to be collected that would serve the needs of the MNRF, CO and CAs. To do this, the project team created seven generalized questions that cover all areas of floodplain mapping, with a specific emphasis on the accuracy, age and standard to which flood maps were created. The seven questions are as follows:

1. To what standard is the base mapping of the project (accuracy and acquisition method)?
2. To what standard is the hydrology analysis used in the project?
3. To what standard is the hydraulics analysis used in the project?
4. Is the modelling or mapping out of date?
5. Can the models be used to analyze other conditions (e.g. different flows)?
6. What extents and portion of the urban and rural areas (based on low, medium and high risk) are mapped?
7. What extents and portion of the urban and rural areas (based on low, medium and high risk) need to be mapped?

In developing attributes for the inventory database, the project team solicited input from the CO Flood Business Case technical committee. The technical committee is comprised of a group of individuals from CAs, CO and the MNRF, with a broad range of skills related to floodplain mapping. The final inventory contained a total of 94 attributes, divided into four sub-categories; general project information, imagery and elevation data, hydrology, and hydraulics. The 94 attributes were used to collect a broad range of flood mapping metadata, which is required to answer the generalized questions mentioned above. All of the attributes and their descriptions are defined in **Section 2.1** below.

Task #3

The third task comprised the collection of data from each of the 36 CAs. For simplicity, each CA was provided a copy of the inventory in an Excel format. CAs were tasked with compiling their floodplain inventory to the greatest extent possible, data that was provided previously for the 2007 and 2014 inventories was used to pre-populate the spreadsheets.

To ensure there was a thorough understanding of the required data and to ensure consistency in the reported data, in person interviews were arranged with CA staff to explain and assist in populating the data. Interviews were conducted over approximately 3 months and included visits from one or two members of the project team. This aspect of the project was considered crucial as one of the primary shortfalls of previous inventories was the inconsistency in the data reported. The in person interviews also allowed the project team to gain a better understanding of the needs of each CA, including an in depth review of the type of floodplain products being created across the province.

Task #4

The final task involved completing the collection of data from each CA. This included reengaging CAs as required to answer questions and to provide assistance where required. The Excel spreadsheets were reviewed for their relative accuracy and completeness and transferred to a Structured Query Language (SQL) database.

Complete collection of all data was sporadically collected over six months, all 36 CAs provided data in the requisite spreadsheet for use in the project. A series of queries was performed on the data to provide input to, and understanding of, floodplain mapping for the MNRF, CO and CAs. The results and analysis of the data collected can be found in **Section 3.0** of this report.

2.0 Floodplain Mapping Metadata

2.1 Parameter Description

The inventory includes a total of 94 attributes that were presented in a survey format to collect pertinent metadata regarding floodplain mapping projects at CAs. CAs were tasked with compiling a spreadsheet to answer questions related to each floodplain project currently used as regulatory floodplain mapping within their jurisdictions. All of the attributes contained in the inventory are indicated below. A brief description of the data requested is also provided.

To ensure consistency and the ability to easily make comparisons between the data provided across all CAs, some fields included limited selectable responses in the form of a selectable dropdown list. The attribute descriptions provided below also include possible responses for each field. Where the response indicates "*Open Field*", entries were not limited to a selectable choice; these fields generally contain descriptions, unique names or numerical data.

Project ID
Used as a unique identifier to link the projects to a spatial database.

Response:
To be determined

Project Name
Unique name given to each project, this can be the title of a report or identify a section of watercourse.
Response:
Open field

Flood Hazard Standard
The regulatory zone and standard applied to a particular project.
Response:
Zone 1-Hazel, Zone 1-100yr, Zone 1-Other, Zone 2-100yr, Zone 2-Other, Zone 3-Timmins, Zone 3-100yr, Zone 3-Other

Official Watercourse Name
The name of the primary watercourse or waterbody.
Response:
Open field

Watershed
The name of the primary watershed applicable to the project.
Response:
Open field

Undertaking: CA
Used to identify if the project was managed by the CA, if the response was yes, the name of the CA is entered.
Response:
Open field

Undertaking: Municipality
Used to identify if the project was partially or wholly funded by the Municipality, if the response was yes, the name of the Municipality is entered.
Response:
Open field

Undertaking: Private
Used to identify if the project was partially or wholly funded by a private entity, if the response was yes, the name of the organization is entered.
Response:
Open Field

Undertaking: Other
Used to identify if the project was partially or wholly funded by an "other" agency, if the response was yes, the name of the agency is entered.
Response:
Open field

Report Year
This is the recorded year of the latest version of the report (if there was no report then the year of the mapping was entered).
Response:
Open field

Floodline Dataset Status
Used to identify the status of the floodline mapping project, this allows for near complete projects to be entered.
Response:
Complete, Ongoing, Planned

Project Update Frequency
A description of how often the project is planned to be updated.
Response:
As-needed, Never, 1-5 years, 5-10 years, 10-20 years

Partially Updated
Provides an indication if portions of the project have been updated. This would only include small updates done for such things as culvert replacements, development, etc., that do not affect the majority of the project.
Response:
Yes, No

Update Currently Required

Provides an indication as to whether an update to the floodplain mapping is currently required. Responses are to be based on staff knowledge and responses to subsequent questions.
Response:
Yes, No

Required Update Purpose
Provides a description of why an update is currently required. Multiple reasons could be entered, with the following suggestions provided; Age-Mapping, Quality-Mapping, Age-Modeling, Quality-Modeling, Development, New Data or Other.
Response:
Open field

Project Category
An indication of the type of floodplain mapping project.
Response:
Watercourse, Inland Waterbody, Great Lakes Shoreline, Great Lakes Connecting Channel, Other Natural Hazard Project

Drainage Area
The total drainage area for the reported project from the downstream most point. If area was unknown, the OFAT III tool was used to estimate.
Response:
Open field

Summary Report Available
Used to identify if a project summary report is available for the study that provides pertinent background information.
Response:
Yes, No

Update Since Original
Provides an indication if the floodplain mapping has been updated since the original mapping was created. Original generally defined as being the FDRP mapping
Response:
Yes, No

Local Watercourse Name
An additional field to allow for the name of a watercourse or waterbody as it is locally known if it differs from the official watercourse name.
Response:
Open field

FDRP Project
Used to identify if the project was completed under the FDRP program.
Response:
Yes, No

Watercourse Length
Identifies the length of mapped watercourse or shoreline within the hydraulic portion of the floodplain.
Response:
Open field

Widest Cross Section Width
The width of the widest mapped cross section on the floodplain map. Can be used to estimate floodplain extent if digital data does not exist to estimate.
Response:
Open field

Maximum Floodplain Extent
The actual mapped area or inundation area if known *(area of the floodplain, not map sheet area)*. If the area is not known the watercourse length is multiplied by the widest cross section measurement (within reason).
Response:
Open field

Percent High Hazard
Provides an approximate percentage of the floodplain extent covering an area considered to be high hazard. Refer to **Section 3.2.1** for a description of "high hazard".
Response:
Open field

Percent Medium Hazard
Provides an approximate percentage of the floodplain extent covering an area considered to be medium hazard. Refer to **Section 3.2.1** for a description of "high hazard".
Response:
Open field

Percent Low Hazard
Provides an approximate percentage of the floodplain extent covering an area considered to be high hazard. Refer to **Section 3.2.1** for a description of "low hazard".
Response:
Open field

Urban Flood Concerns
General indication of the potential for flood input from urban infrastructure *(urban overland flow)*. High being probable input, medium being possible or uncertain input, and low being no input.
Response:
High, Medium, Low

Planning Designation 2-Zone
Used to indicate if all or a portion of the project area is a designated two-zone area.
Response:
Yes, No,

Planning Designation SPA
Used to indicate if all or a portion of the project area is a designated special policy area.
Response:
Yes, No

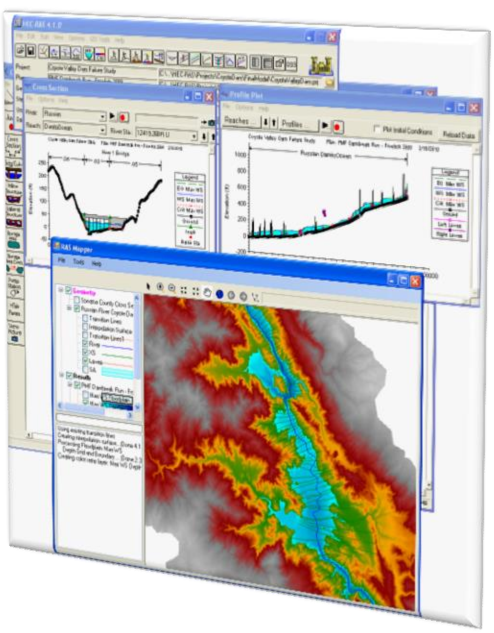
Major Event Since FDRP
Indication of whether or not there has been a major flood event within this project area since the FDRP was completed *(typically defined as a flood with greater than 50yr return period).*
Response:
Yes, No

Structures Within the Floodplain
If the data was available, respondents entered the number of structures along the watercourse within the floodplain, structures include bridges, culverts and dams *(only counted hydraulic structures that would be included in modelling).*
Response:
Open field

Buildings At Risk
If the data was available, respondents entered the number of buildings within the regulatory floodplain that would be at risk of flooding during such an event.
Response:
Open field

Other Event Buildings At Risk
If the data was available, respondents indicated if an analysis was undertaken to determine the number of buildings at risk during other events (ie. 2 to 100yr floods).
Response:
Yes, No

General Comments Project
This is an open field where any additional information about the project or data can be provided.
Response:
Open field



Imagery Information

Project ID
Used as a unique identifier to link the projects to a spatial database.
Response:
To be determined

Year of Acquisition
This is the recorded year in which the imagery was obtained *(orthophotography)*.
Response:
Open field

Data Description
Provides any descriptive information about the imagery data. *(eg. orthophotography, RGB bands, GeoTiff, etc.).*
Response:
Open field

Season of Acquisition
Used to indicate the season imagery data was actually captured.
Response:
Spring, Summer, Fall, Winter

Horizontal Reference
This field defines the horizontal reference system if known.
Response:
NAD27, NAD83, Other

Vertical Reference
This field defines the horizontal reference system if known.
Response:
CGVD28, CGVD28-Pre1978

Stated Horizontal Accuracy
This field defines the horizontal accuracy if known. Limited information was available from CAs to define the accuracy of imagery data.
Response:
Open field

Accuracy Derivation Method
This field provides the accuracy derivation method if known. Limited information was available from CAs to define the accuracy of imagery data.
Response:
RMSE, CMAS, LMAS, NMAS, NSSDA, FVA, SVA, CVA, Other

Spatial Resolution
Used to provide the imagery data raster resolution. Typically this data was only available for data captured in the past ten years.
Response:
Open field

Peer Review
Indication if the imagery products were independently verified (QA/QC) by an external entity.
Response:
Yes, No

General Comments Imagery
This is an open field where any additional information about the imagery product can be provided.
Response:
Open field

Elevation Information

Project ID
Used as a unique identifier to link the projects to a spatial database.
Response:
To be determined

Digital Data
This field provides an indication if the elevation data is available digitally. Digital elevation data does not include scanned map sheets or floodlines only.
Response:
Yes, No

Data Format
Provides the format in which the data is available (elevation data only).
Response:
Raster, Contour, TIN, Point, Hardcopy, Scanned

Primary Data Source
Provides the data source of the primary base elevation data.
Response:
LiDaR, Photogrammetry, Radar, Sonar, Satellite, UAV, GPS, Ground Survey

Elevation Data Owner
Indicates the custodian of the elevation data, usually an organization who has complete usage rights for the data. If known, respondents entered the name of the organization.
Response:
Open field

Horizontal Reference
This field defines the horizontal reference system of the elevation data, if known.
Response:
NAD27, NAD83, Other

Vertical Reference
This field defines the vertical reference system of the elevation data, if known.
Response:
CGVD28, CGVD28-Pre1978

Stated Horizontal Accuracy
This field defines the horizontal accuracy of the elevation data, if known. Horizontal accuracy of elevation data was typically unavailable from CAs.
Response:
Open field

Stated Vertical Accuracy
This field defines the vertical accuracy of the elevation data, if known.
Response:
Open field

Accuracy Derivation Method
Used to provide a description of the method used to derive the accuracy of the elevation data *(vertical)*. Typically, accuracy was derived using FDRP methods, which were not a selectable option for this survey.
Response:
RMSE, CMAS, LMAS, NMAS, NSSDA, FVA, SVA, CVA, Other

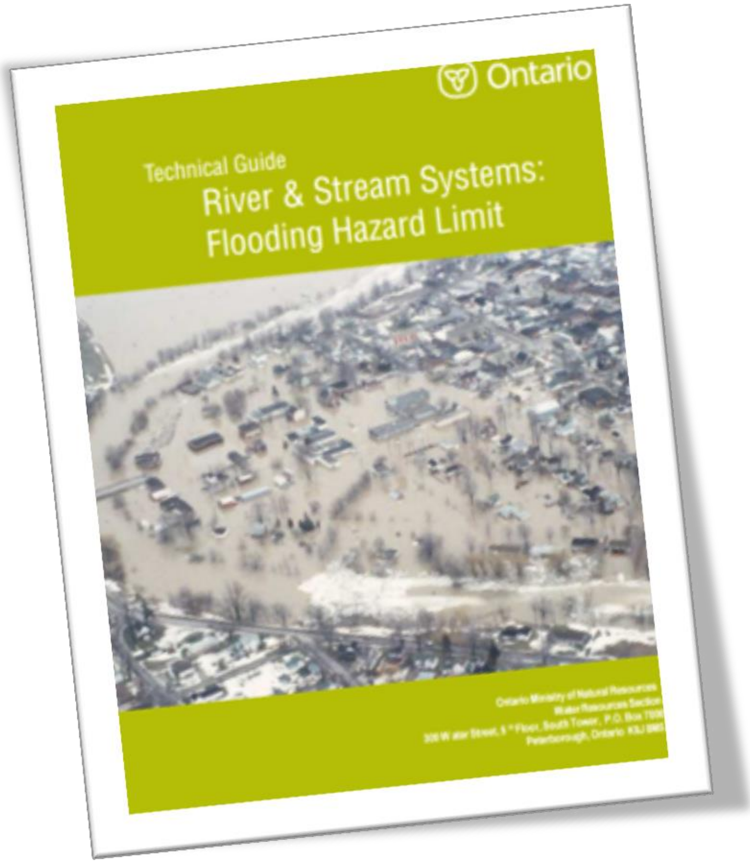
Spatial Resolution
Provides the elevation data resolution, which is dependent on the type of data. Data entered can be a raster or point density, or a contour interval. Typically data entered was a contour interval.
Response:
Open field

Secondary Data Source
Where applicable, respondents provided the secondary data source used for the base mapping. This does not include ground surveys for hydraulic cross sections unless they have been fused

with the primary underlying elevation data.
Response:
LiDaR, Photogrammetry, Radar, Sonar, Satellite, UAV, GPS, Ground Survey

Peer Review
Indication if the elevation products were independently verified (QA/QC) by an external entity.
Response:
Yes, No

General Comments Elevation
This is an open field where any additional information about the elevation product can be provided.
Response:
Open field



Hydrology Information

Project ID
Used as a unique identifier to link the projects to a spatial database.
Response:
To be determined

Hydrology Method or Model
Provides the name of the hydrology model or method used to derive the regulatory flow.
Response:
SSFFA, RFA, IFM, MTOMFIM, Water Level FA, HYMO, SWMM, HEC-HMS, MIKE, GAWSER, MIDUSS, Other

Year of Hydrology
Indicates the latest year the model was run in determining regulatory flows for the project, or, the latest year in the dataset for a flood frequency type analysis.
Response:
Open field

Years in Dataset
The total number of years in the dataset (eg. 27), applicable only to flood frequency type analysis or long term simulation.
Response:
Open field

Events Modeled
Provides a description of other return period events that were modeled or analyzed as part of this project. *(eg. 2, 5, 10, 25, 50, 100).*
Response:
Open field

Calibrated Model
Provides a general indication if the hydrology model has been calibrated with rainfall/water level/flow measurements or other forms of verification.
Response:
Yes, No

Hydrology Quality of Calibration
Provides an indication of the quality of the calibration/verification. Provided examples include: High – Modeled flows were confirmed with gauged data during significant event, Medium – Small dataset of gauged flows/levels, Low – Model calibrated on similar watershed.
Response:
High, Medium, Low

Hydrology Quality of Input Parameters
Provides a general indication of the quality of the input parameters, such as runoff coefficients, curve numbers, etc., or such things as rating curves for gauged stations. This is a subjective response, respondents entered 'Low' if not known.
Response:
High, Medium, Low

Hydrology Quality of Input Comments
This field provides for any comments about the quality of the input parameters to support the selection above
Response:
Open field

Planning Horizon
If known, this field provides the year the model represents. This indicates if the model took into account proposed planning scenarios *(ie. official plan build-out, if the model assumed full build-out of a 20 year OP in 1995, users entered '2015').*
Response:
Open field

Snowmelt Incorporated
Provides an indication of whether or not the effect of snowmelt has been considered in determining peak flows for this project *(Regulatory flow)*.
Response:
Yes, No

Peak or Volume Reduction
Provides an Indication if there are any artificial structures such as dams, levees, berms, large SWM ponds, etc. that provide a reduction in the natural peak flow or volume of flood waters, and what type of flow is used for regulatory purposes.
Response:
Yes-Regulated Flow, Yes-Unregulated Flow, Yes-Flow Assuming Failure, Yes-Other, No

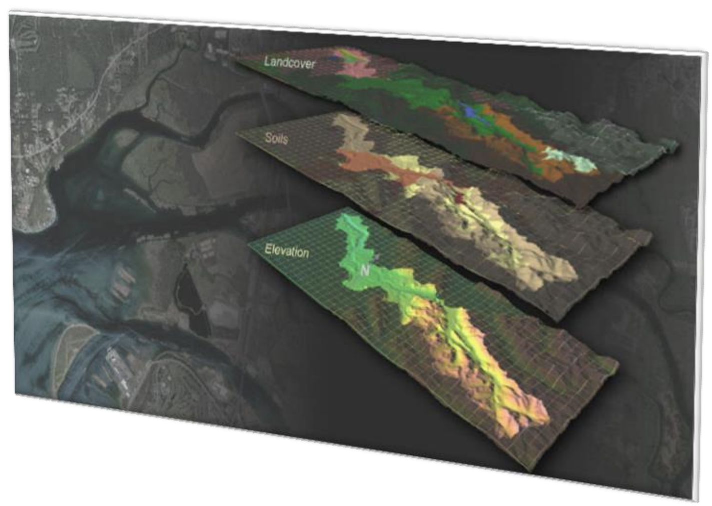
Catchments Discretized
Indicates if the model was properly discretized or if lumped catchments were used.
Response:
Yes, No

Adequate Supporting Documentation
Indicates if there is adequate supporting documentation/reports to support the hydrology *(ie. sufficient information that a qualified person could fully understand and reproduce the results).*
Response:
Yes, No

Climate Change Considered
Provides an indication if any consideration for climate change was used in developing the hydrologic model or peak flows used for regulatory purposes. No definition of climate change was provided.
Response:
Yes, No

Peer Review
Indication if the hydrology products were independently verified (QA/QC) by an external entity.
Response:
Yes, No

General Comments Hydrology
This is an open field where any additional information about the hydrology product can be provided.
Response:
Open field



Hydraulics Information

Project ID
Used as a unique identifier to link the projects to a spatial database.
Response:
To be determined

Year of Model Run
Indicates the latest year the model was run in determining regulatory elevations for the project, or the date elevations were derived.
Response:
Open field

Hydraulic Model
Provides the name of the hydraulic model or method used to derive regulatory elevations.
Response:
HEC-2, HEC-RAS, SWMM(PCSWMM), Mike 11/21/Flood, Estimated, Gauged FA

Flow Condition
Indicates the flow regime in which the hydraulic model was run.
Response:
Sub-Critical, Super-Critical, Mixed

Calibration Process
Provides a general indication as to whether a process was undertaken to calibrate the model, perform sensitivity analysis or verify the model *('Yes', indicates that at least one of the three processes was undertaken)*.
Response:
Yes, No

Hydraulics Quality of Calibration
If a calibration process was undertaken, this field represents the quality of that process. Example: High-calibrated with significant gauged data, Medium-Sensitivity analysis, with verification of high water marks, Low-Sensitivity analysis only.
Response:
High, Medium, Low

Hydraulics Quality of Input Parameters
Provides a general indication of the quality of the input parameters, such as manning's, reach lengths, etc. This is a subjective response, respondents entered 'Low' if not known.
Response:
High, Medium, Low

Hydraulics Quality of Input Comments
This field provides for any comments about the quality of the input parameters to support the selection above
Response:
Open field

Estimated Floodline
This field indicates if the regulatory floodline for this project is estimated. A floodline is considered to be estimated when it was derived using methods that do not meet the FDRP or 2002 MNRF standard.
Response:
Yes, No

Adequate Supporting Documentation
Indicates if there is adequate supporting documentation/reports to support the hydraulics *(ie. sufficient information that a qualified person could fully understand and reproduce the results).*
Response:
Yes, No

Elevation Source
Indicates the source of the elevation data used within the hydraulic model *(ie. data for cross sections)*.
Response:
Ground Survey-GPS, Ground Survey-Total Station, Ground Survey-Leveling, Ground Survey and Base Elevation Data, Base Elevation Data, Other

1D Modeling Appropriate
Provides a general indication as to whether 1-dimensional modeling is appropriate for all or part of the project area. 1D modeling is considered appropriate when flow is uni-directional and non-complex *(ie. limited urban inputs/street flow/buildings)*. This is a somewhat subjective response.
Response:
Yes, Partial, No

Peer Review
Indication if the hydraulic products were independently verified (QA/QC) by an external entity.
Response:
Yes, No

General Comments Hydrology
This is an open field where any additional information about the hydraulics product can be provided.
Response:
Open field

2.2 Data Limitations

The data reported in this inventory has been reviewed and assessed by the project team for general accuracy, such that outlying data or unreasonable data has been removed, confirmed or adjusted. The project team is unable to confirm the absolute accuracy of the information submitted, and relied primarily on each CA submitting information they believe to be reasonable and accurate. Due to the age of a number of floodplain mapping projects, there may have been limited or inaccurate information available.

The data reported in the subsequent sections of this report is based solely on that submitted for this inventory. As certain sections of the inventory were not completed in full for each individual project, not all of the reported lengths, areas and general tallies will be comparable. Considering this, the project team reviewed and assessed all reported data and determined it to be within reason for the analysis undertaken for the purposes of this project.

3.0 Results

3.1 Summary of Key Findings

There are 36 Conservation Authorities (CAs) in the Province of Ontario. All 36 CAs have provided information regarding the status of floodplain studies (projects) in their jurisdiction. This is the first time that this amount of floodplain information from CAs has been gathered into one inventory. The analysis of this data provides insights into the state of Ontario’s floodplain mapping that was not possible in the past. The results of these interviews are summarized in the following section. The inventory is based on each CA providing data related to a series of 94 questions regarding each floodplain project completed in their watershed area.

As the data was received from each CA it was reviewed for completeness, accurate interpretation of the questions and conflicting data. Conservation Authorities were contacted to clarify questions, assist in the interpretation and analysis of the information and address any concerns. All CAs voluntarily provided information and in some instances were unable to fully compile all data required for the inventory. Reasons for this included a number of cases where the requested data was not available due to the age of the existing information and projects. However, on average the submissions provided by CAs were 94.2% complete.

The following figure shows the completeness of the data submitted per Conservation Authority.

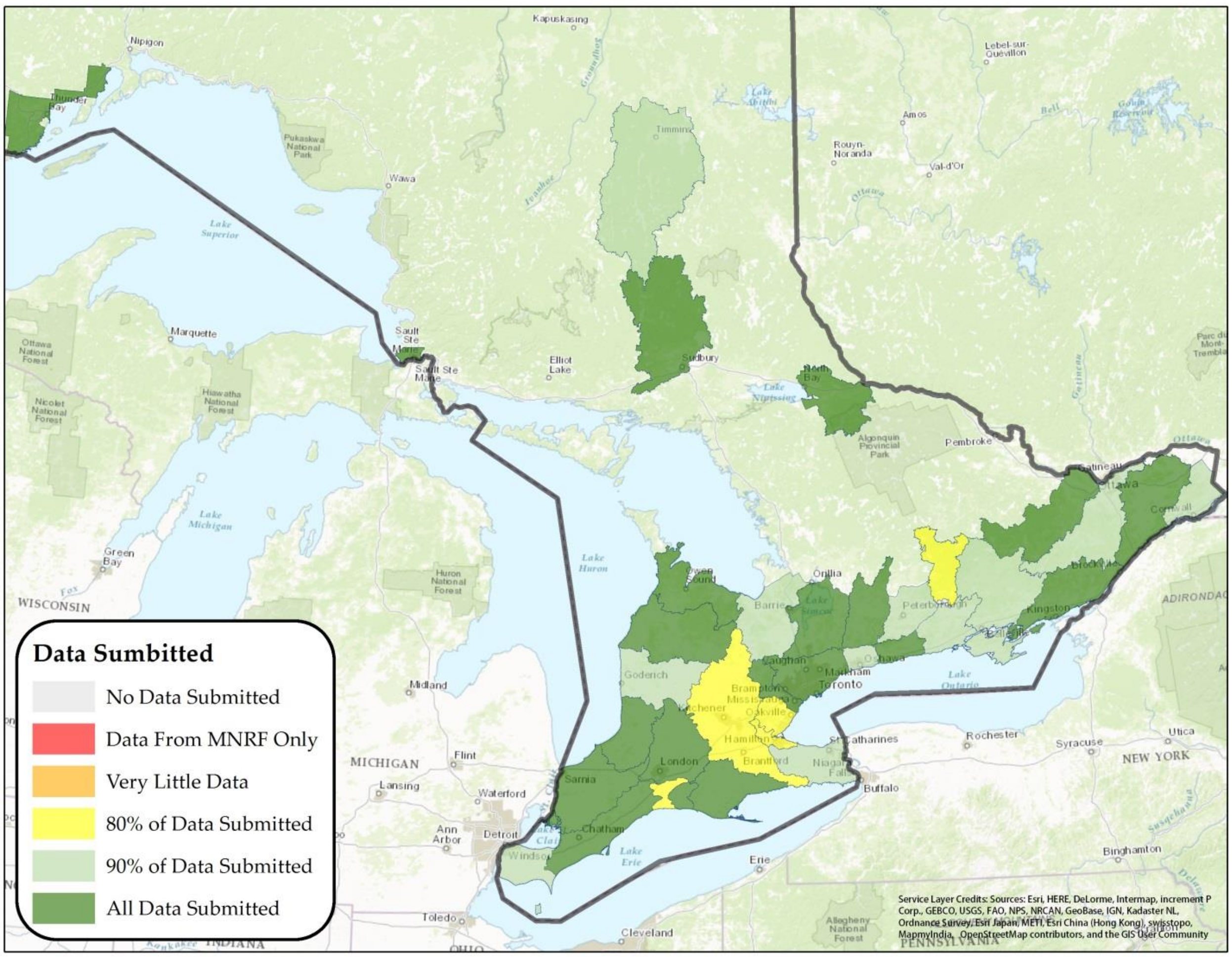
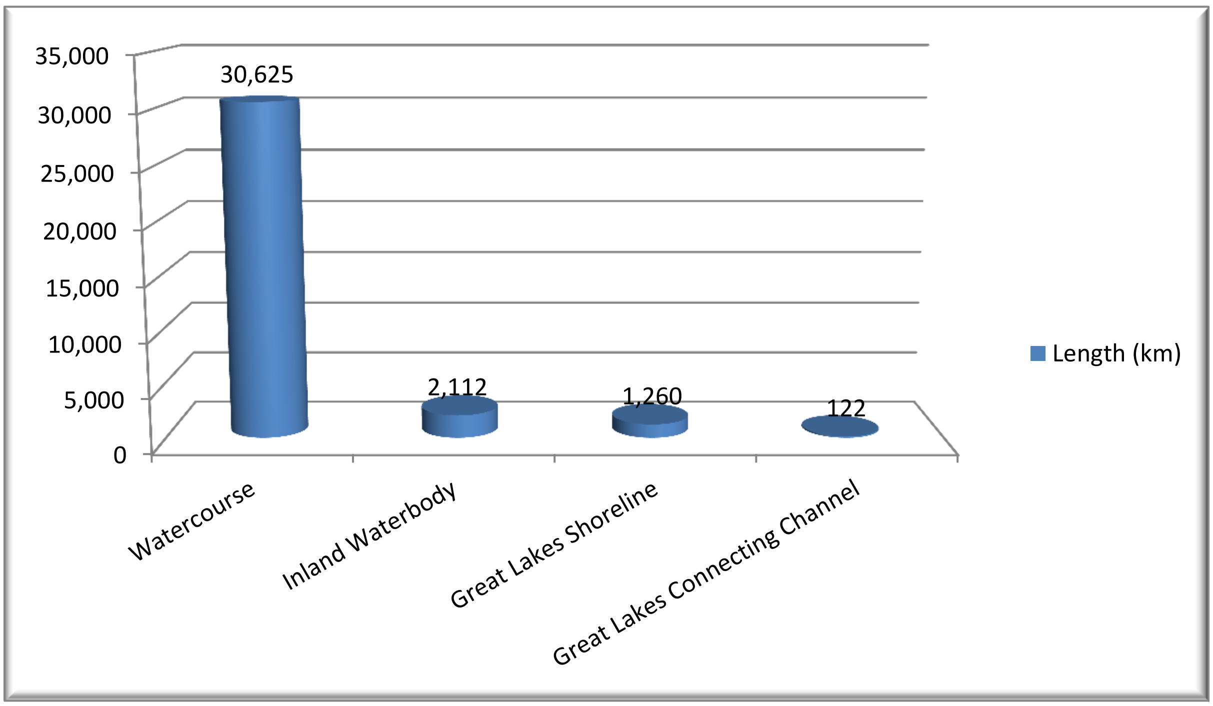


Figure 3.1: Completeness of Data Submitted by Conservation Authority

3.1.1 Total Quantity and Type of Projects

The number of floodplain mapping projects included in the database is 739. In some cases, CAs lumped a number of smaller projects into one if they were continuous along a stream or river reach. These projects represented 30,625 km of watercourse mapping, 1260 km of Great Lakes shoreline mapping, 122 km of Great Lakes connecting channel mapping and 2,112km of inland waterbody shoreline mapping. Approximately 89% of all floodplain mapping held at Ontario Conservation Authorities is watercourse mapping. CAs reported approximately 18,136km^2 in total area of inundation resulting from the regulatory standard.



Watercourse	Inland Waterbody	Great Lakes Shoreline	Great Lakes Connecting Channel	Unknown
89.4%	6.2%	3.7%	0.4%	0.5%

Figure 3.2: Type of Floodplain Mapping by Length (km)

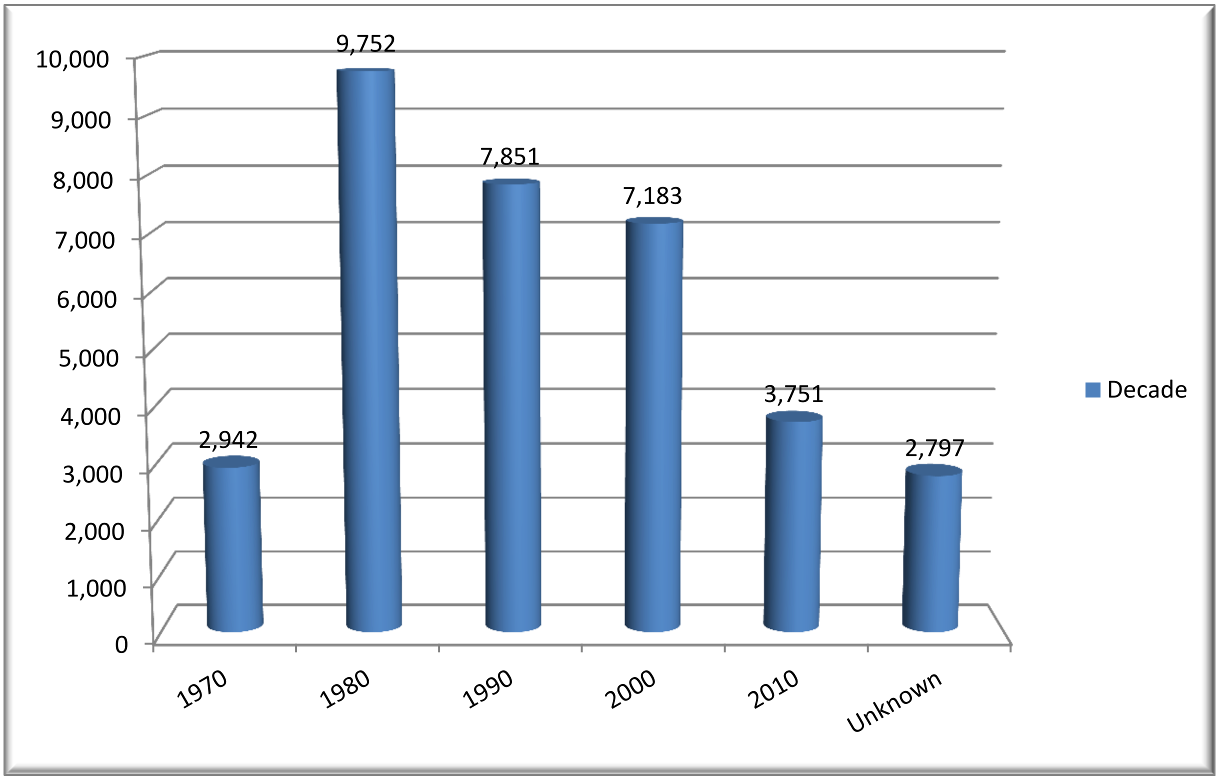
3.1.2 Age of Reports

The age of the reported mapping is of great significance. The most recent floodplain project was completed in 2015 and the oldest was completed in1971. The average year of completion for all projects submitted was 1991. This means that the average age of floodplain mapping in the Province of Ontario is 24 years. When averaging the age of floodplain mapping on a CA basis, the most recent average reported by a CA was 2004. When averaging the age of floodplain mapping on a CA basis, the oldest average age reported by a CA was 1981. This particular Conservation Authority's mapping was on average 36 years old.

There is additional information to be gathered in order gain an appreciation of the utility of currently available floodplain mapping. In Ontario much of the floodplain mapping dates to the 1980s and 1990s. To appreciate the complete implications of the age of this mapping, one must remember that mapping projects are made of three main components. These components are:

1. Imagery and Elevation Data – the data used in the modelling and for displaying the final results;
2. Hydrology – generally, the estimation of the peak flow during a given event; and
3. Hydraulics – generally, the estimation of the extent of flood inundation during a given event

The age of any of these components affects the final result of the project. Generally, when a project is undertaken, all three components are completed. However, often the project uses imagery and elevation data from earlier times. This is often due to the prohibitive cost of acquiring updated data. When considering the age of a floodplain mapping product, it is often important to understand the age of the imagery and elevation data as separate from the other two components. The following figure shows the length (km) of floodplain mapping conducted and held by Ontario's Conservation Authorities per decade. Approximately 37% of the total length of floodplain mapping used at CAs is from the 1970s and 1980s.



1970's	1980's	1990's	2000's	2010's	Unknown
9%	28%	23%	21%	11%	8%

Figure 3.3: Length (km) of Floodplain Mapping by Decade

The age distribution of floodplain mapping projects is also of interest. **Figure 3.4** shows the average age of floodplain mapping by CA across the province. It is evident that CAs near large urban centers such as the Greater Toronto Area and the Cities of Ottawa and London have been able to update mapping where other more rural CAs have not. This would be a direct result of greater municipal funding available to more urban CAs, where rural CAs rely heavily on provincial funding and limited grants and self-generated revenue.

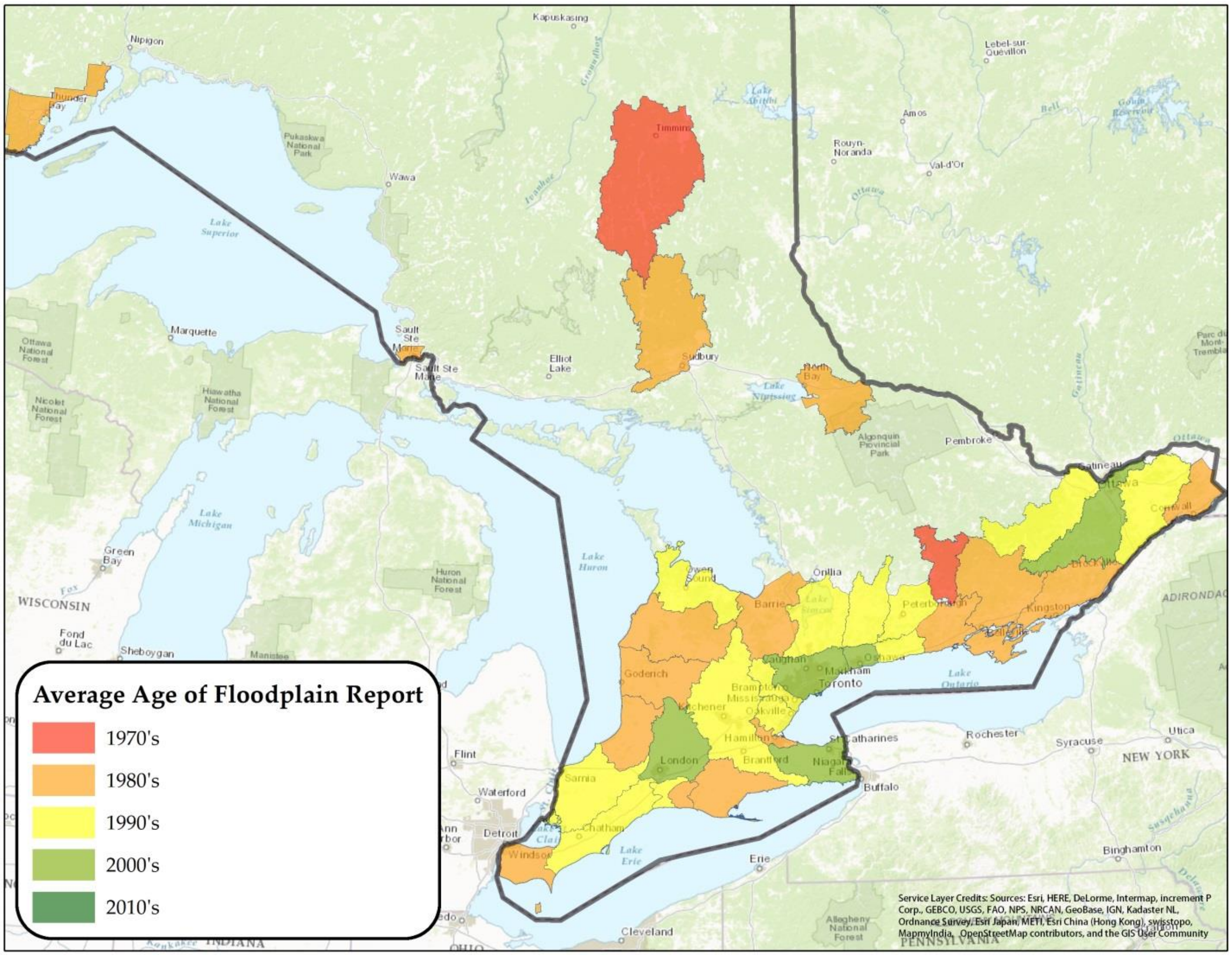
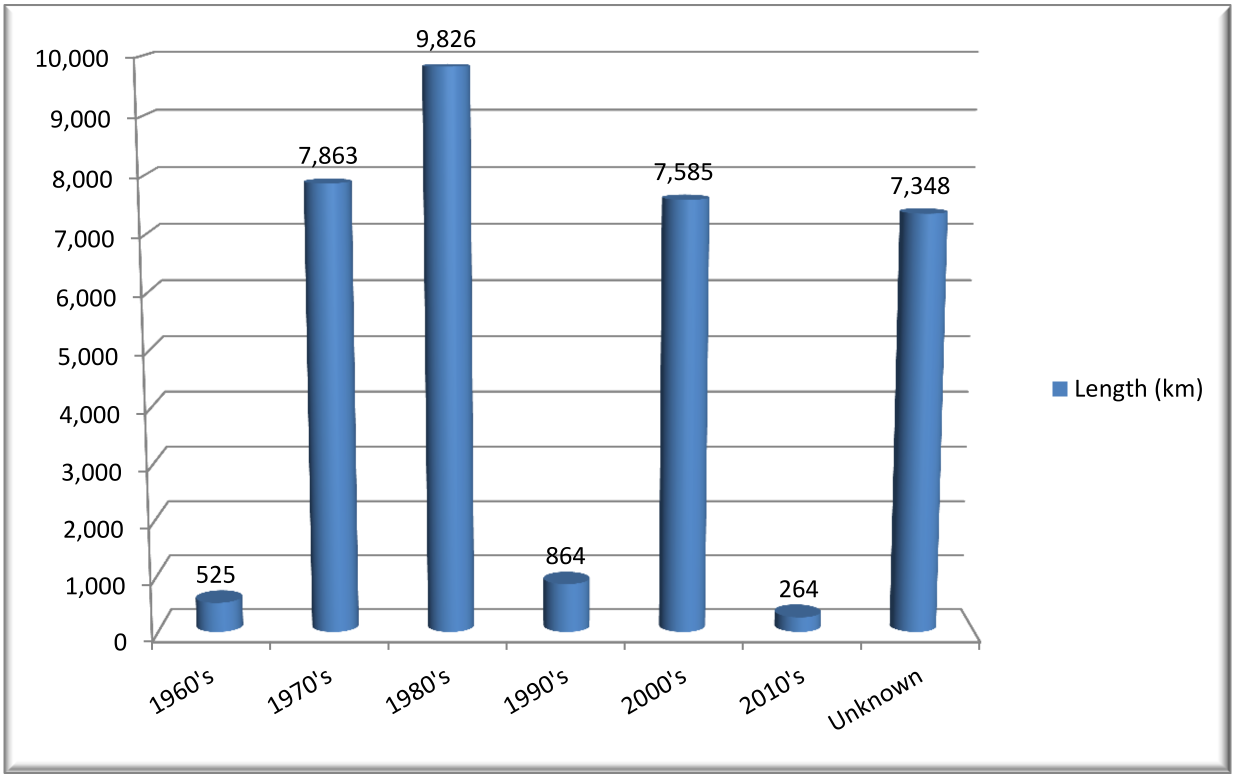


Figure 3.4: Average Age of Floodplain Reports

3.1.3 Age of Imagery

As noted above, it is important to understand the age of imagery used in the inventoried floodplain reports/projects to be able to assess their value. Even though 37% of the length of floodplain mapping in the inventory was created in the 1980s and 1970s, 52% of the imagery used to create that mapping is from the 1980s or older.

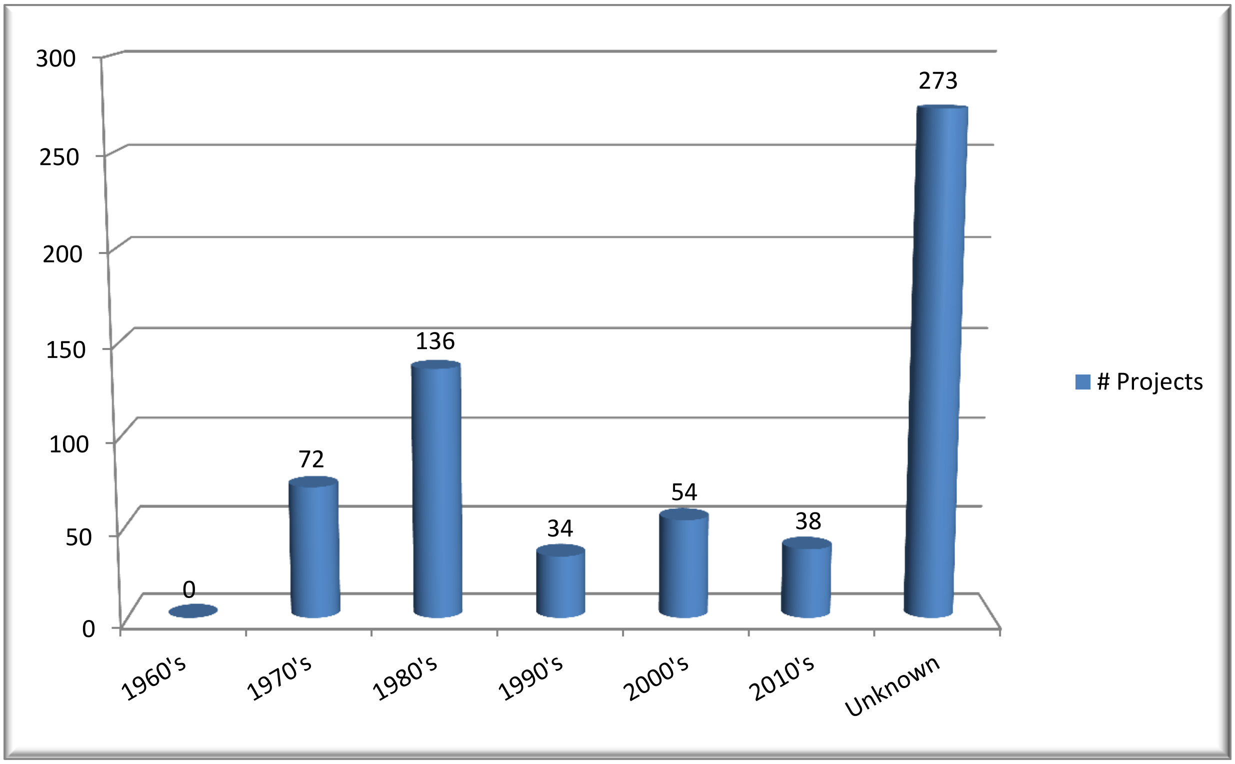


1960's	1970's	1980's	1990's	2000's	2010's	Unknown
2%	23%	29%	3%	22%	1%	21%

Figure 3.5: Age of Imagery by Floodplain Length

3.1.4 Planning Horizon of Hydrology Models

Another important element to investigate regarding age is the planning horizon of the hydrology model. A water resources engineer considers land use as one of the most important inputs in hydrology models. In order to ensure that the model properly reflects the potential build out of a given catchment, it is common practice to consider the land use as defined in the Official Plan of the municipality in which the watershed rests. Generally, the Official Plan reflects a 20 year future scenario of development. This approach ensures that the calculated flows do not underestimate actual future development. If the hydrology model is not updated to at least current conditions, it is quite possible that the model is underestimating flows being used to define the floodplain. The results shown in **Figure 3.6** below, clearly demonstrates that the hydrology defining floodplains in Ontario is severely out of date. Only 6% of the hydrology models inventoried can be confirmed as representing current conditions.



1960's	1970's	1980's	1990's	2000's	2010's	Unknown
0%	12%	22%	6%	9%	6%	45%

Figure 3.6: Planning Horizon of Hydrology Models by Project

3.1.5 Flood Damage Reduction Program

The aim of the Flood Damage Reduction Program (FDRP) was to discourage future flood vulnerable development. The federal government initiated this program in 1975 to curtail escalating disaster assistance payments in known flood risk areas, as well as the reliance on costly structural measures. The FDRP was carried out jointly with the provinces under cost sharing agreements. Municipalities were required to also pay into the program. Municipal Planning Authorities were encouraged to zone on the basis of the identified flood risk.

The FDRP, undertaken jointly with the provinces, consisted of identifying, mapping and designating flood risk areas, and then applying policies to discourage future flood prone development in those areas. Under the FDRP additional activities may have included establishing flood forecasting and warning systems. In addition, some structural controls were supported as long as they were cost efficient and supported the non-structural components of the program.

All provinces and territories except Prince Edward Island and the Yukon participated in this national program through a series of cost sharing agreements. For some provinces this approach was new, while in others, such as Ontario, Alberta and British Columbia, it was an extension of mapping programs dating back, in some cases, to the 1950s. The program was completed in Ontario in the early 1990s. *The above paraphrased from an archived Federal web site:* https://www.ec.gc.ca/eau-water/default.asp?lang=En&n=0365F5C2-1

In Ontario many CAs still use floodplain mapping that was prepared as part of the FDRP program. Although a significant amount of the FDRP mapping has been replaced, 25% or 8,206km of mapping being used for regulatory purposes at Ontario's Conservation Authorities is from the FDRP program. The distribution of this mapping throughout the CAs is shown in **Figure 3.7** below.

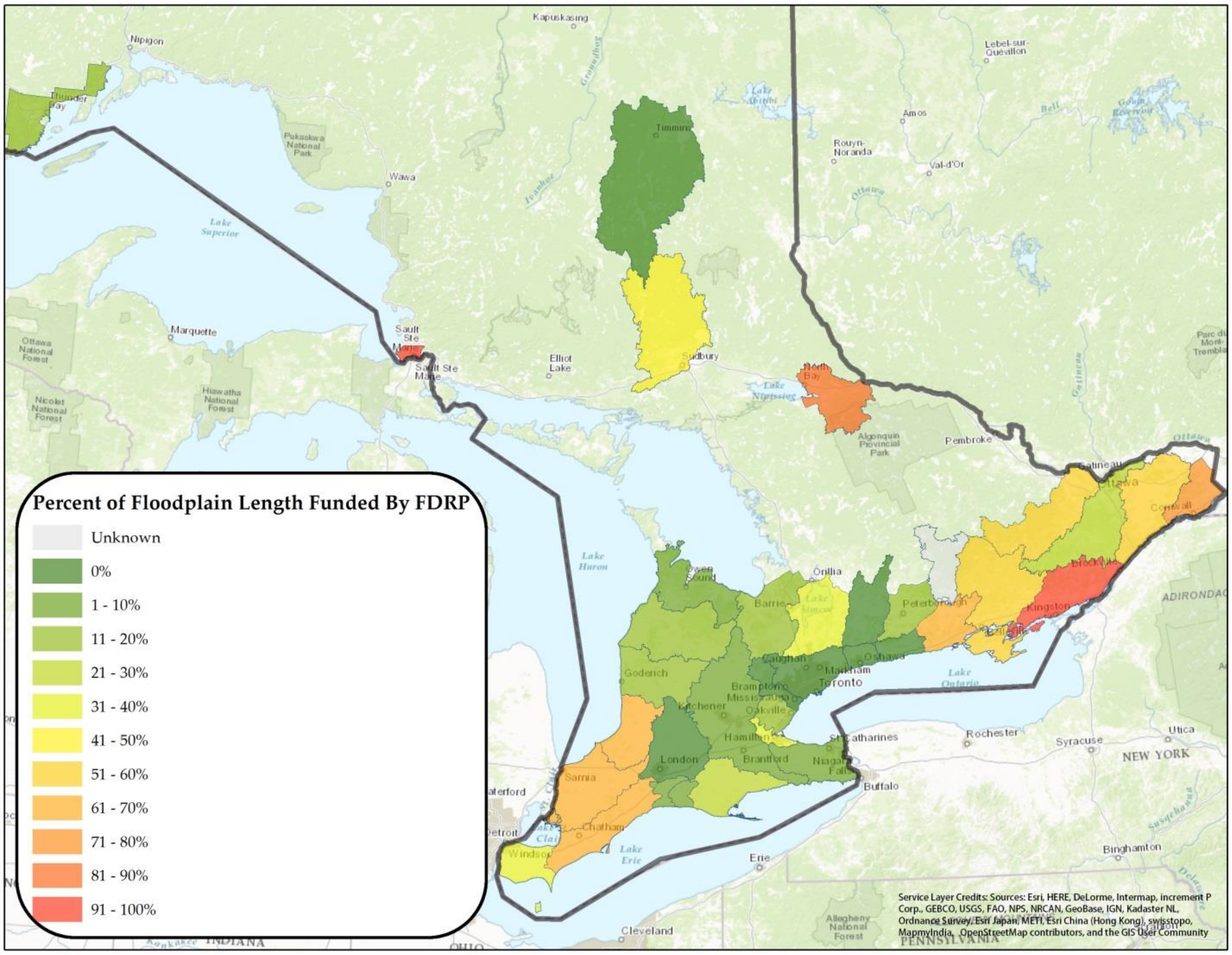


Figure 3.7: Percentage of Floodplains by Length Funded by FDRP

3.1.6 Results Based on Flood Hazard Zones

Flooding hazards means the inundation, under specified conditions, of areas adjacent to a river system (that are not ordinarily covered by water). The limits of flood hazards are defined differently within areas (or Zones) of Ontario based on what type of conditions might occur in those areas. Ontario is broken into 3 zones defined within the MNRF's Technical Guidelines, River and Stream Systems: Flood Hazard Limit (2002). The following description of the zones and tables of storm depths are taken from the above noted guidelines.

Zone 1:

In Zone 1, the flooding hazard limit is defined as the greater of:

i. the flood resulting from a rainfall actually experienced by the Hurricane Hazel storm (1954) transposed over a specific watershed and combined with the local conditions. The rainfall depths used for this event are shown in **Table 3.1** below;
ii. the one hundred year flood; or
iii. a flood which is greater than i) or ii) which was actually experienced on a particular watershed or portion thereof as approved by the Ministry of Natural Resources and Forestry. An example is a portion of Southwestern Ontario where a critical event that occurred in 1937 is considered the flood hazard standard

Zone 2:

In Zone 2 the flooding hazard limit is defined as:

i. the one hundred year flood; or
ii. a flood which is greater than i) which was actually experienced on a particular watershed or portion thereof as approved by the Ministry of Natural Resources and Forestry.

Zone 3:

In Zone 3, the flooding hazard limit is defined as the greater of:

i. the flood resulting from a rainfall actually experienced during the Timmins storm (1961) transposed over a specific watershed and combined with the local conditions The rainfall depths used for this event are shown in **Table 3.2** below;
ii. the one hundred year flood; or
iii. a flood which is greater than i) or ii) which was actually experienced on a particular watershed or portion thereof as approved by the Ministry of Natural Resources. An example is a portion of Southwestern Ontario where an event that occurred in 1937, is used as flood hazard standard.

TABLE D-2			
	Hurricane Hazel Rainfall Depths		
	Mm	inches	Percent of last 12 hrs
First 36 hours	73	2.9	-
37th hour	6	0.25	3
38th hour	4	0.17	2
39th hour	6	0.25	3
40th hour	13	0.5	6
41st hour	17	0.66	8
42nd hour	13	0.5	6
43rd hour	23	0.91	11
44th hour	13	0.5	6
45th hour	13	0.5	6
46th hour	53	2.08	25
47th hour	38	1.49	18
48th hour	13	0.5	6
Total	285	11.21	100

Table 3-1: Hurricane Hazel Rainfall Depths

Table D-4			
	Timmins Rainfall depth		
	mm	inches	Percent of last 12 hrs
1st	15	0.6	8
2nd	20	0.8	10
3rd	10	0.4	6
4th	3	0.1	1
5th	5	0.2	3
6th	20	0.8	10
7th	43	1.7	23
8th	20	0.8	10
9th	23	0.9	12
10th	13	0.5	6
11th	13	0.5	7
12th	8	0.3	4
Total	193	7.6	

Table 3-2: Timmins Storm Rainfall Depths

Exceptions:

The exception is where the use of an actually experienced event is used as the flood standard for a specific watershed, even though it does not exceed the Hazel or Timmins event, has been approved by the Minister of Natural Resources and Forestry, (where past history of flooding supports the lowering of the standard).

Figure 3.8 below shows the graphical extents of the flood hazard criteria zones in Ontario (from: *Technical Guide, River and Stream Systems, Flood Hazard Limit. Ministry of Natural Resources and Forestry, 2002*)

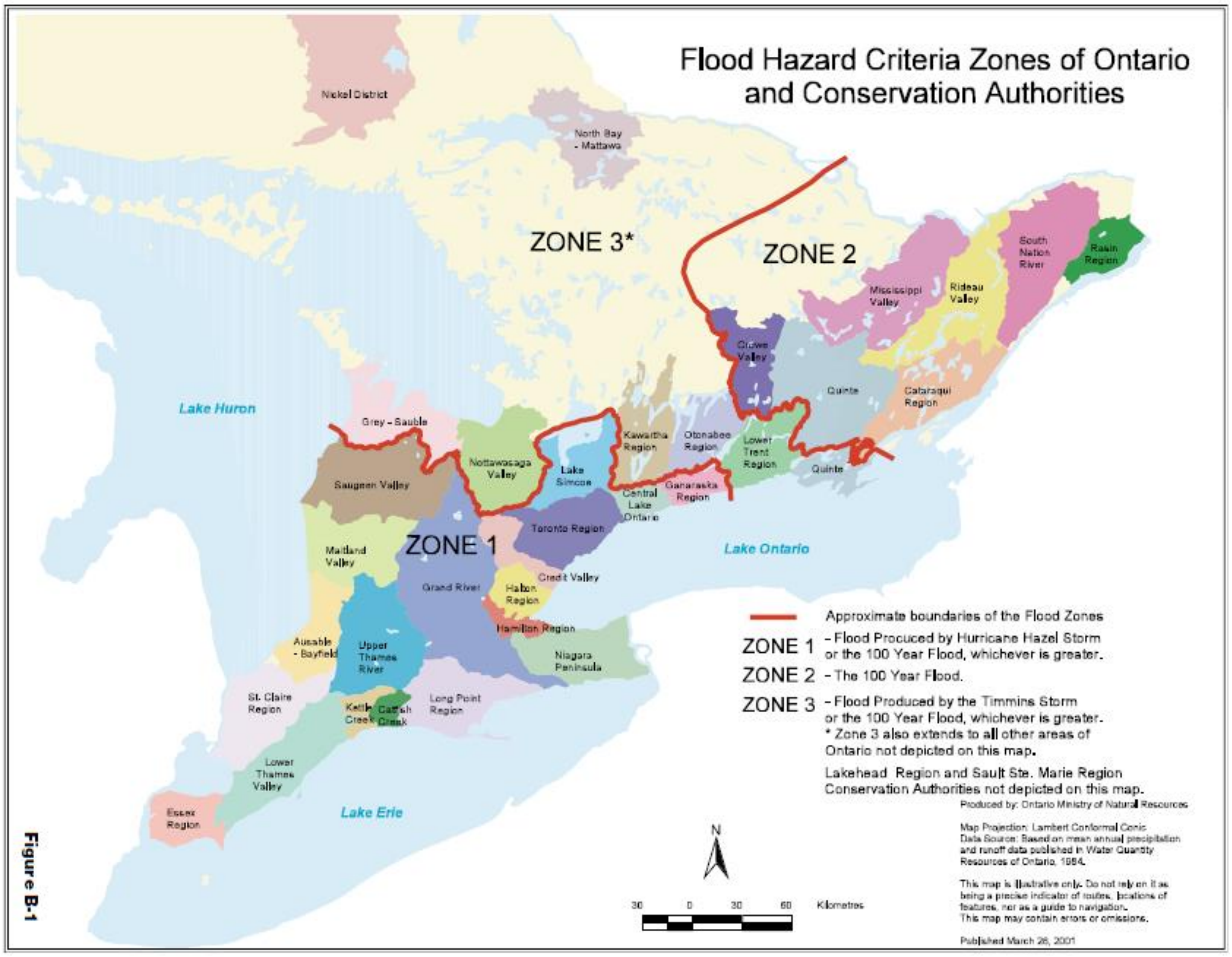


Figure 3.8: Flood Hazard Criteria Zones of Ontario and Conservation Authorities

The inventory asked CAs to define the standards used for floodplain mapping in their jurisdictions. By project, 52% of the floodplain projects use Hurricane Hazel as their standard, 6% used the Timmins Storm and 32% are based on the 100 year event. The following table shows the length of floodplain mapping by zone:

	Zone 1	Zone 2	Zone 3
Hazel	17,923km		
100yr	2,327km	7,726km	786 km
Timmins			2,143km
Other	2,078km	35km	615 km
Unknown	615km		

Table 3-3: Length of Floodplain Mapping by Zone

By length of floodplain, 65% of the floodplains delineated by CAs are found in Zone 1, 23% in Zone 2, and 10% in Zone 3

3.1.7 Mapping Updates

In the inventory, CAs were asked to estimate how much of the floodplain mapping they held needed updating. The CAs were asked to consider all elements of their projects in terms of age, limitations, accuracy, and currency. The data showed that 72% of the floodplain mapping required some form of an update. This is a significant number, but is consistent with many of the results provided in previous sections. The following two figures (**3.9 and 3.10**) illustrate responses to this question by length of floodplain mapping and by CA jurisdiction, respectively.

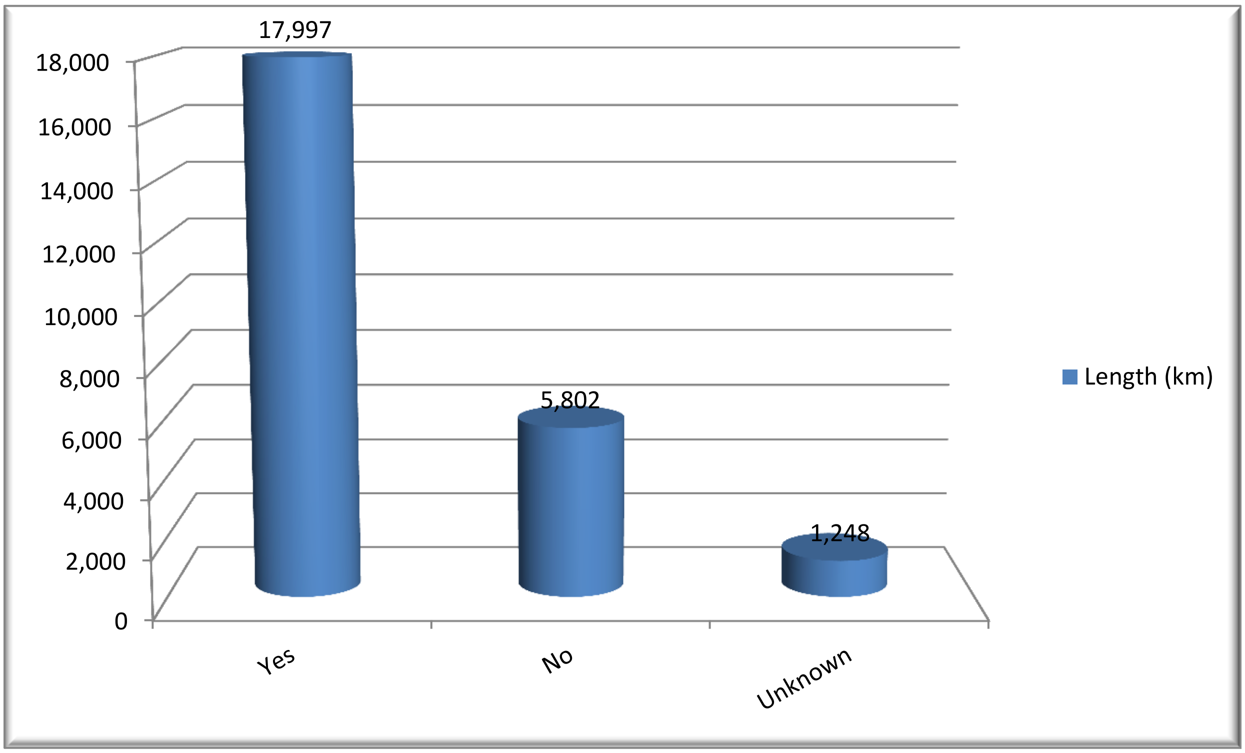


Figure 3.9: Update Currently Required by Length (km)

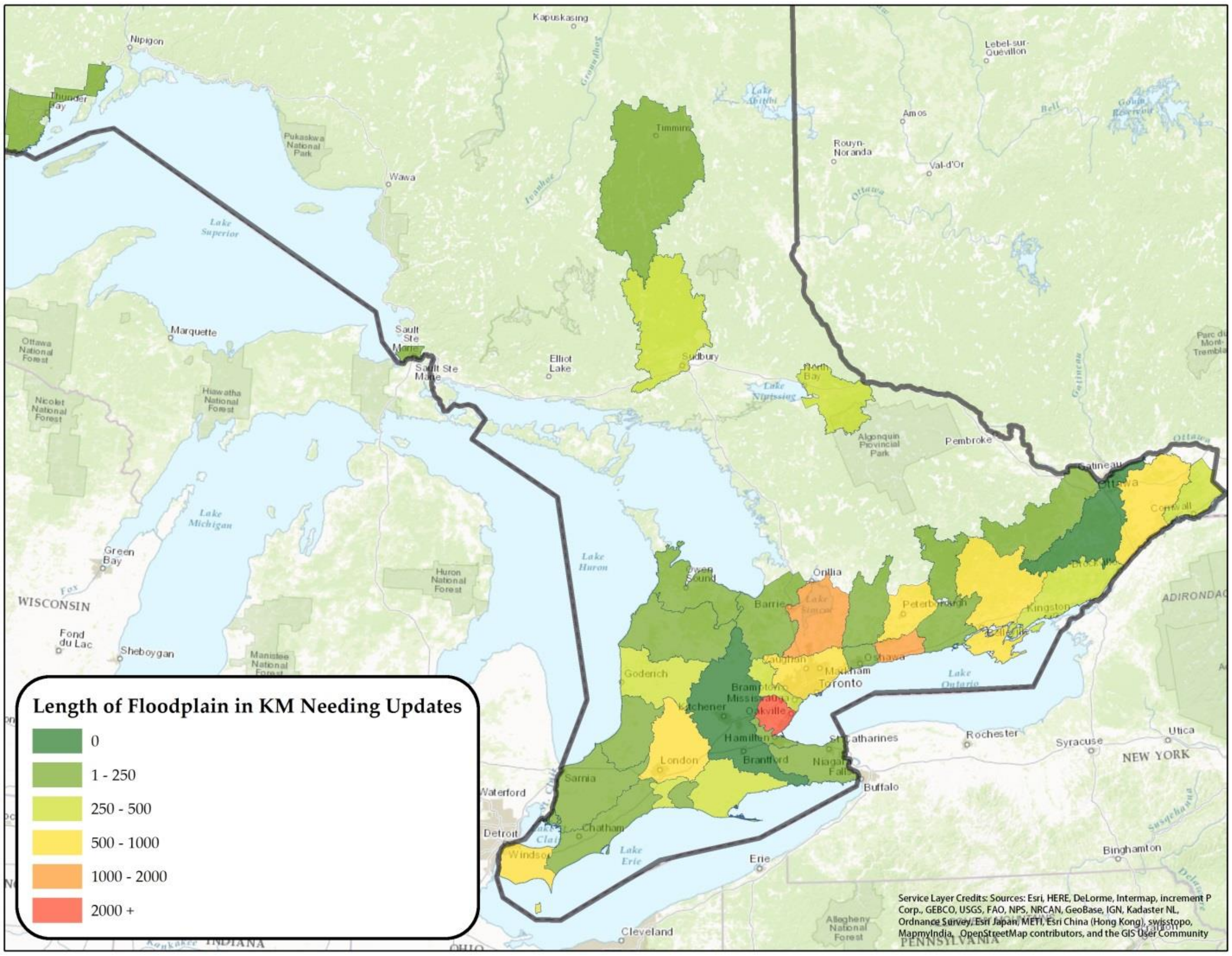
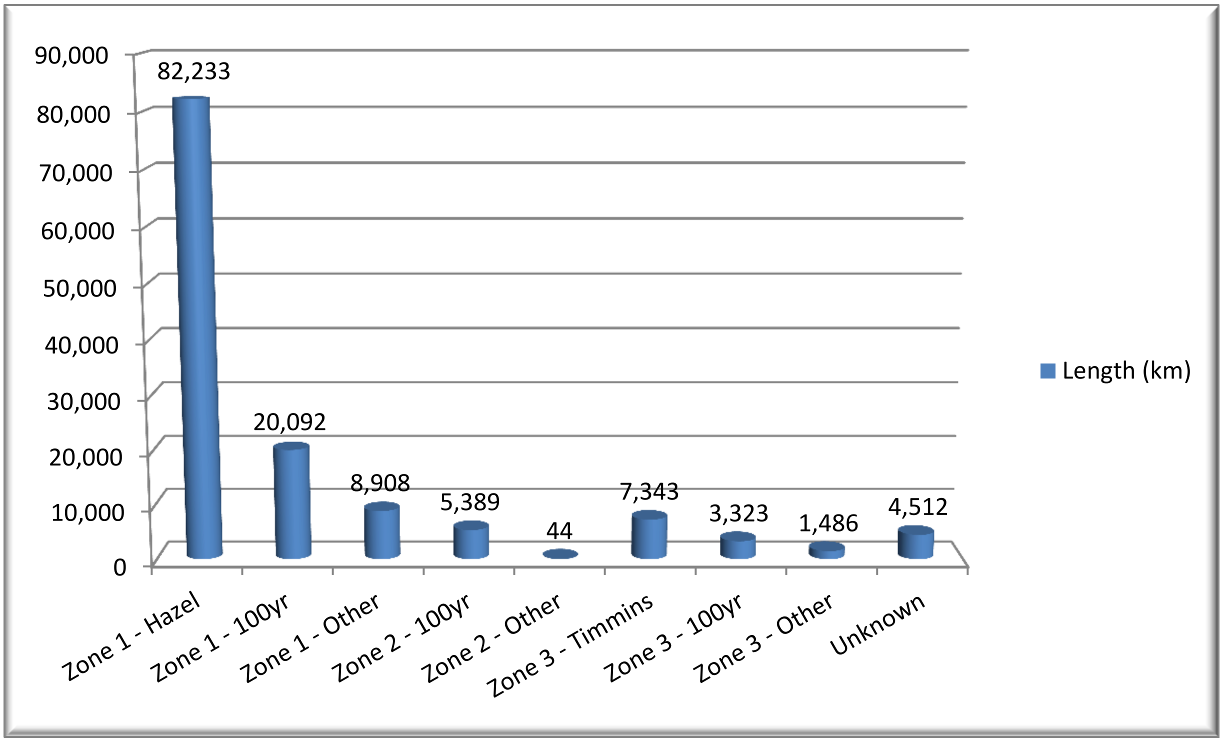


Figure 3.10: Update Currently Required by Length within CA Jurisdiction (km)

3.1.8 Buildings and Structures Identified in the Floodplain

The floodplain mapping inventory produced a great deal of data that until now has not been collected in the Province of Ontario. One of these numbers is the identified buildings in the regulatory floodplain. The inventory identifies 133,330 buildings in the floodplain. The data also provided the ability to relate the zone and standard used to identify the buildings. The breakdown of building per zone and standard is shown in **Figure 3.11** below. Additionally, 21,701 hydraulic structures, such as bridges and culverts, have been analysed in the inventoried floodplain models. Note there are a few CAs that did not have this data available and therefore, the reported results are an underestimation of the current status.



Zone 1 - Hazel	Zone 1 - 100yr	Zone 1 - Other	Zone 2 - 100yr	Zone 2 - Other	Zone 3 - Timmins	Zone 3 - 100yr	Zone 3 - Other	Unknown
61.7%	15.1%	6.7%	4.0%	0.0%	5.5%	2.5%	1.1%	3.4%

Figure 3.11: Buildings Identified in the Floodplain by Zone

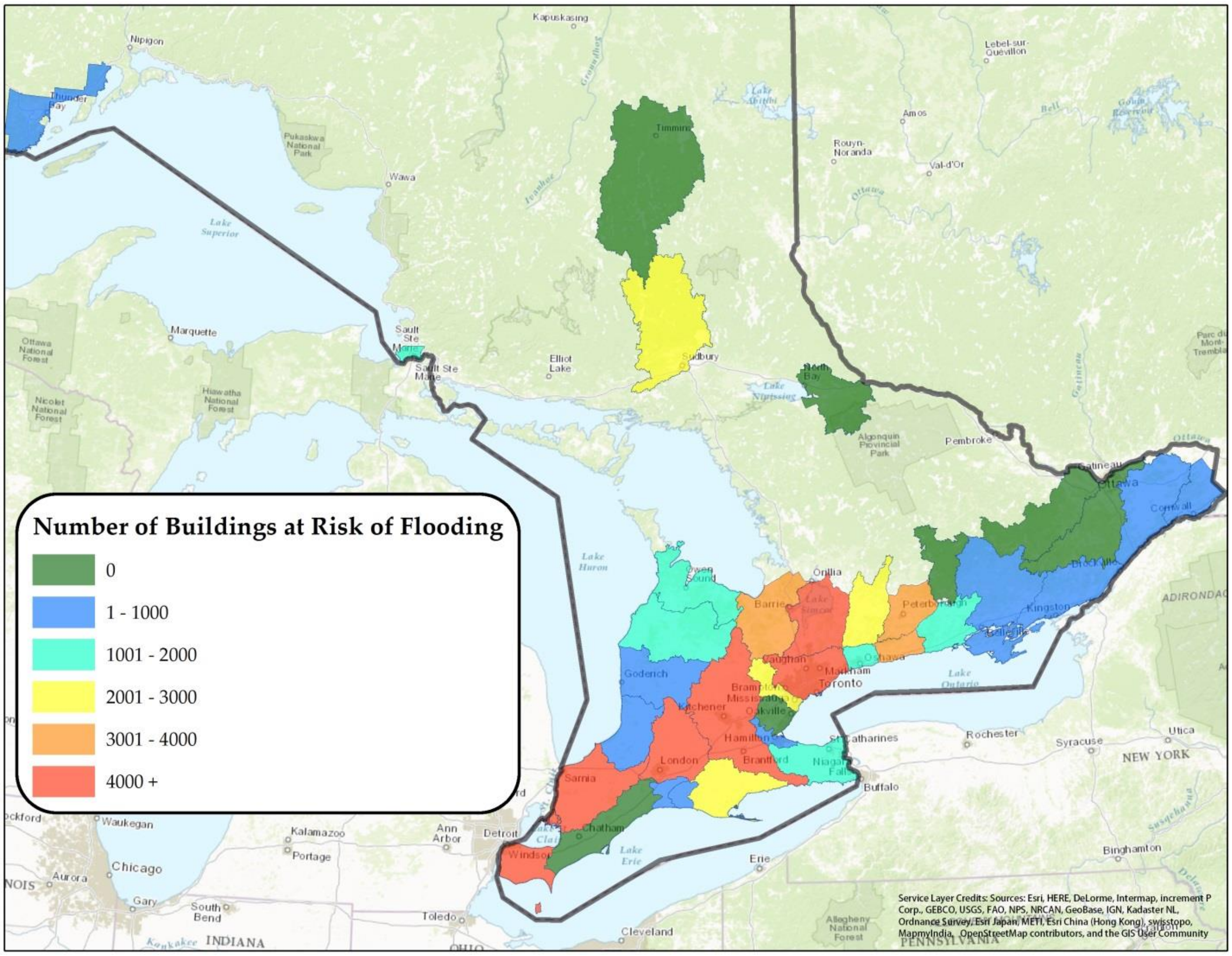


Figure 3.12: Buildings Identified in the Floodplain by CA

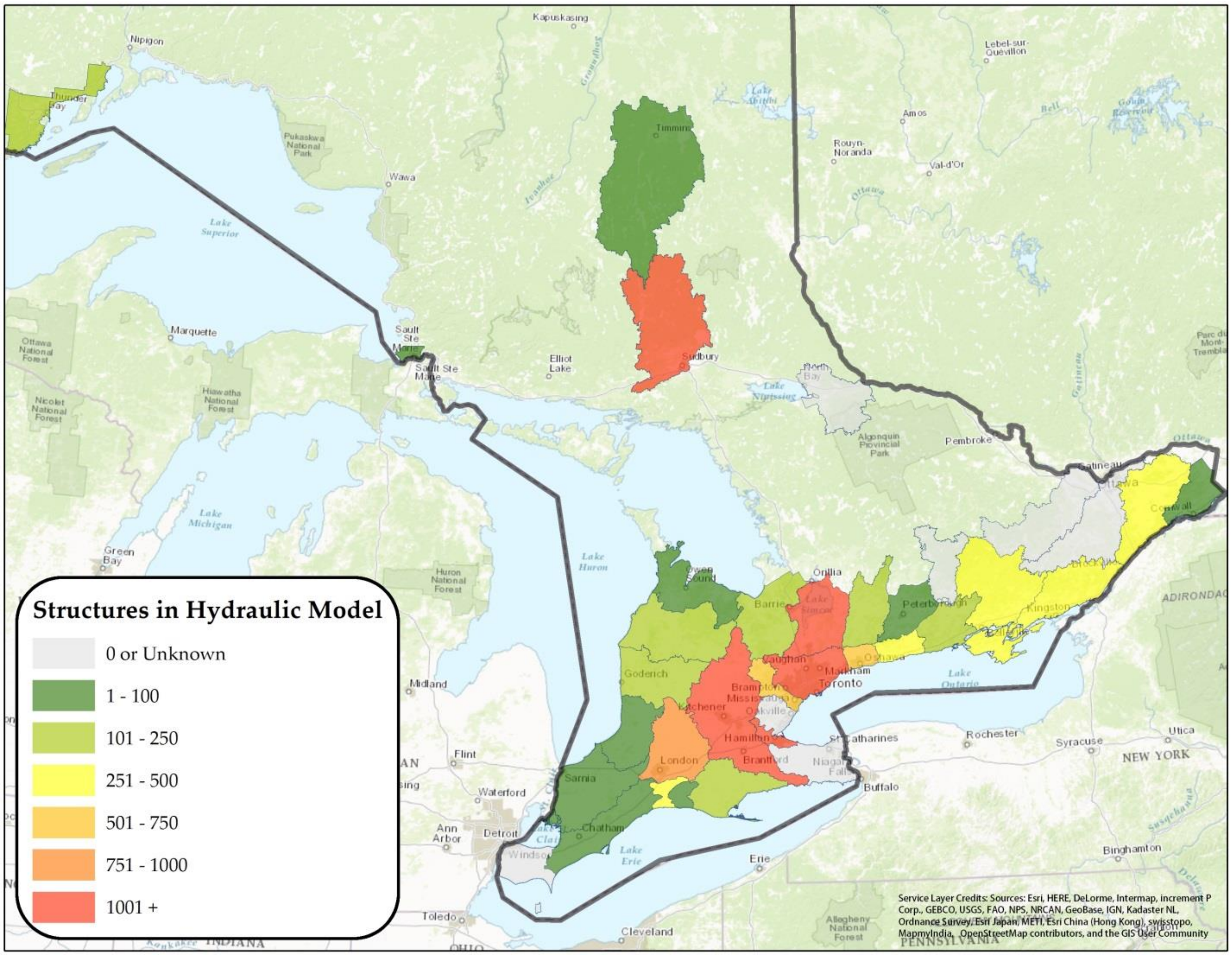


Figure 3.13: Hydraulic Structures (Bridges, Culverts, etc.) within Models by CA

3.1.9 Hydrology Models with Multiple Events Modeled

The National Disaster Mitigation Program (NDMP) was launched in 2015 to address floodplain management in Canada given the significant rise in flooding events and both insured and uninsured losses associated with those events. In order to clearly understand risk within the floodplain and exposure of residents to damage, it is important to not only understand the extent of flooding for extreme events such as Hurricane Hazel, it is critical that other shorter return period flooding be understood (eg: 1 in 2 to 1 in 100 year events). To begin understanding whether current modelling could begin to address this need, the inventory asked if project hydrology models included multiple return period scenarios. The data collected shows that just over 50% of models considered scenarios less than that of the flood hazard standard. The results are shown in **Figure 3.14** below. Where data is reported as unknown, this was typically the result of hydrology models themselves not being available. Therefore CAs were unable to confirm if other events were modeled.

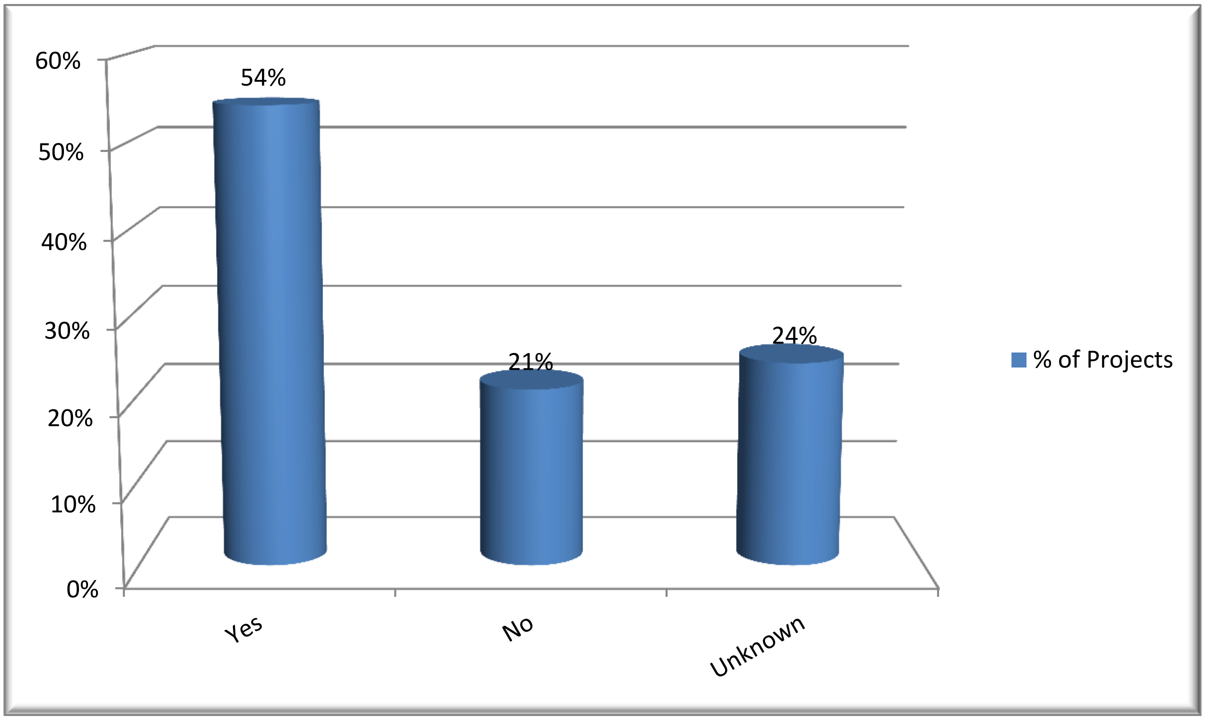


Figure 3.14: Percentage of Floodplain Projects with Multiple Events Modelled

3.1.10 Hydraulic Modeling – 1-D vs. 2-D

When developing floodplain mapping, most engineers in Ontario use the HEC-RAS (Hydrologic Engineering Centre River Analysis System) computer program developed by the United States Army Corp of Engineers, Hydrologic Engineering Centre. This software allows the water resources engineer to perform one-dimensional steady flow and unsteady flow calculations. The basic analysis is founded on the solution of the one dimensional energy equation. Energy losses are evaluated by friction (Manning's Equation) and contraction/expansion (coefficient multiplied by change in velocity head). Momentum equations are used to solve situations where the water surface profile is rapidly changing such as hydraulic jumps, bridge hydraulics and river confluences. An older more limited program, HEC-2, also developed by the Hydrologic Engineering Centre was the main program used to solve one dimensional steady flow calculations in mapping products created in Ontario in previous decades.

The HEC-RAS program calculates an energy balance between two sections along a river channel. It assumes that flows are moving directly down the channel and perpendicular to the channel section. However, when flows do not exhibit these flow characteristics, a different modelling approach may be required. See **Figure 3.15** for a representation of the 1-D flow model approach.

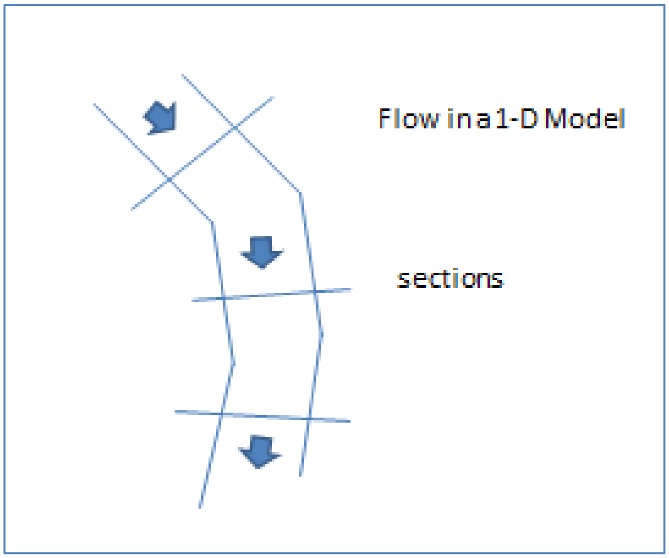


Figure 3.15: Flow in a 1-D model

Where flow in a floodplain is not moving directly down the channel, it may be flowing away from the channel (eg. down a street that is perpendicular to the watercourse or around a building). When the majority of flow is diverging from the channel a two dimensional (2-D) approach may be more appropriate. Often the channel 1-D model is linked to a 2-D model that analyses this divergent flow. A 2-D model is based on a grid of cells that allow flow in many directions through the cell. See **Figure 3.16** for a representation of this approach.

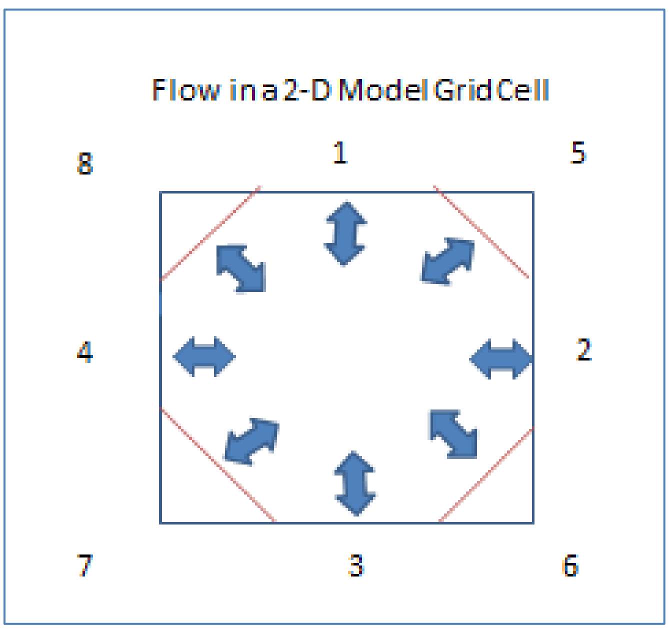
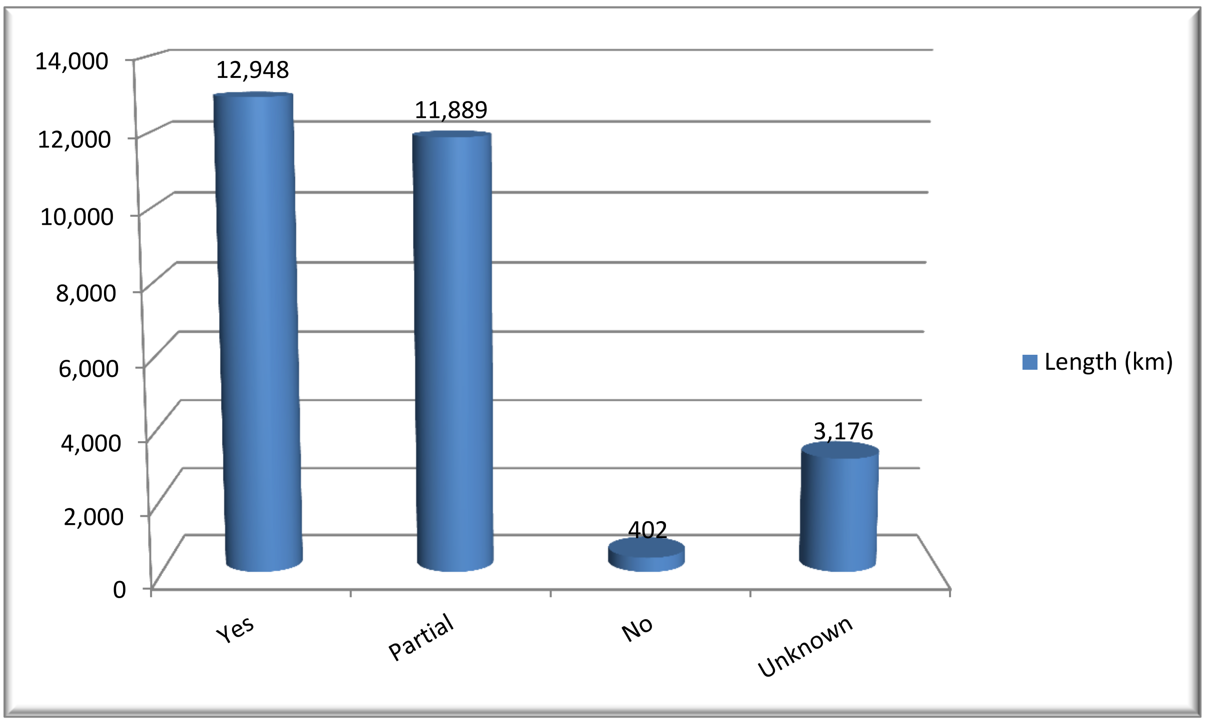


Figure 3.16: Flow in a 2-D Model Grid Cell

When urban flooding is a concern, often only 2-D models can fully represent the impact of complex flows in and around buildings. To understand urban flooding that is associated with river flows the water resource engineer can establish a 2-D overland flow model followed by coupling the 1-D and 2-D model components to simulate the fully integrated flow dynamics between main rivers and surrounding urban floodplain areas.

CAs were asked for each project if a 1-D model is appropriate for defining the flood hazard. The inventory avoided asking if 2-D would be necessary due to the complexities involved, one can however assume where 1-D is not appropriate a 2-D model could be employed. The results by length are shown in **Figure 3.17**. The cost of 2-D modelling is very hard to determine because many local factors determine costs, such as grid sizing and complexity of a riverine system. Generally, the cost of developing a 2-D model has been 2 to 5 times the cost of preparation of a 1-D model. This fact has great implications on overall costing to update floodplain mapping in Ontario.



Yes	Partial	No	Unknown
45.6%	41.8%	1.4%	11.2%

Figure 3.17: Length of Mapping where 1-D Hydraulic Modelling is Appropriate (km)

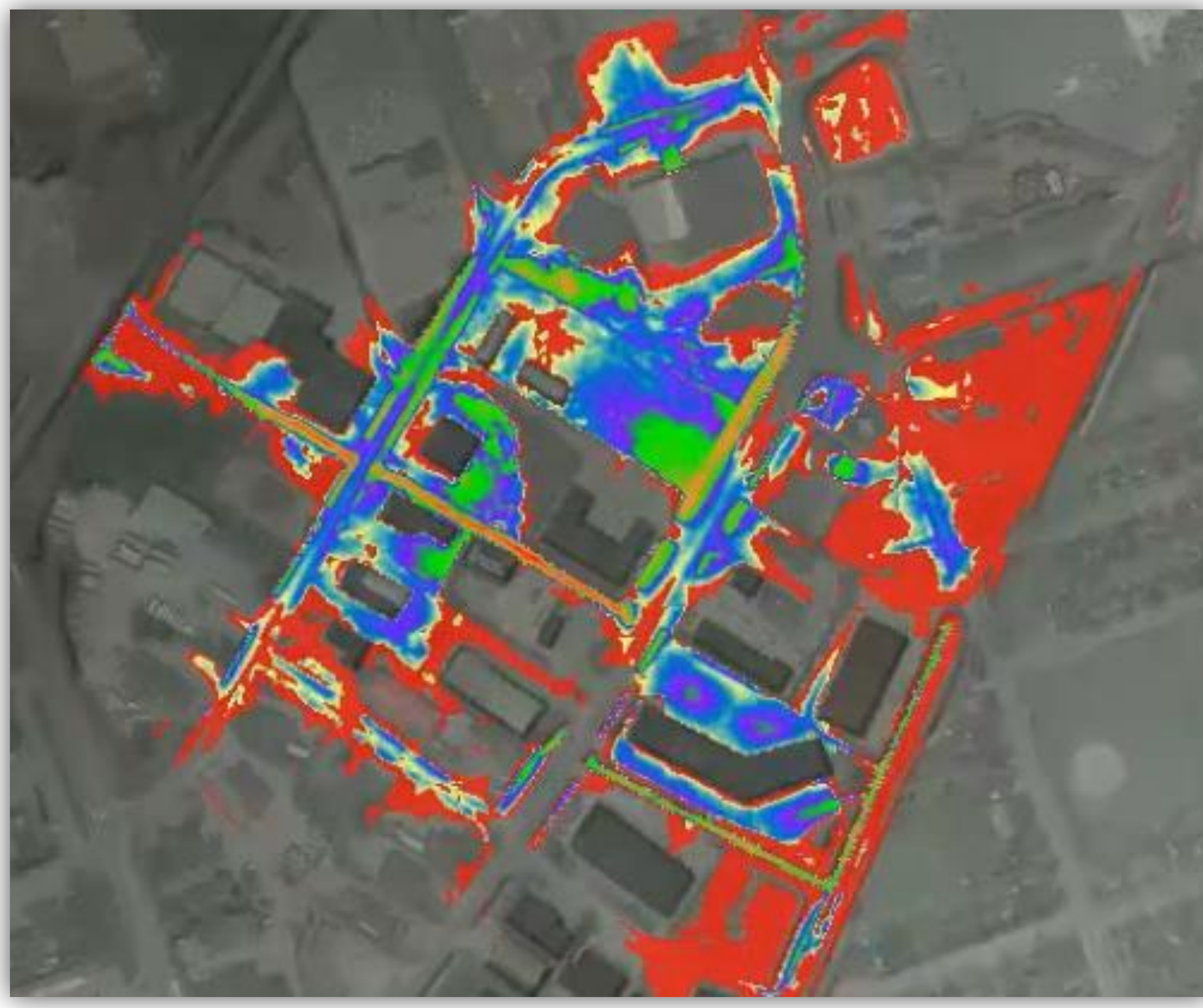


Figure 3.18: Example of Flood Inundation Calculated Using a 2-D Model

3.1.11 Area of Unmapped Floodplains

In Ontario, a number of rivers and streams do not currently have engineered floodplain mapping and therefore the flood hazard is typically unknown. CAs were asked to determine where floodplain mapping is necessary given development pressures and floodplain issues. This estimate was based on area and length estimates and is somewhat subjective given the time available to undertake this study and background information available to the CAs. **Figure 3.19** below shows the estimated areas (by jurisdiction) in which CAs noted floodplain mapping is required.

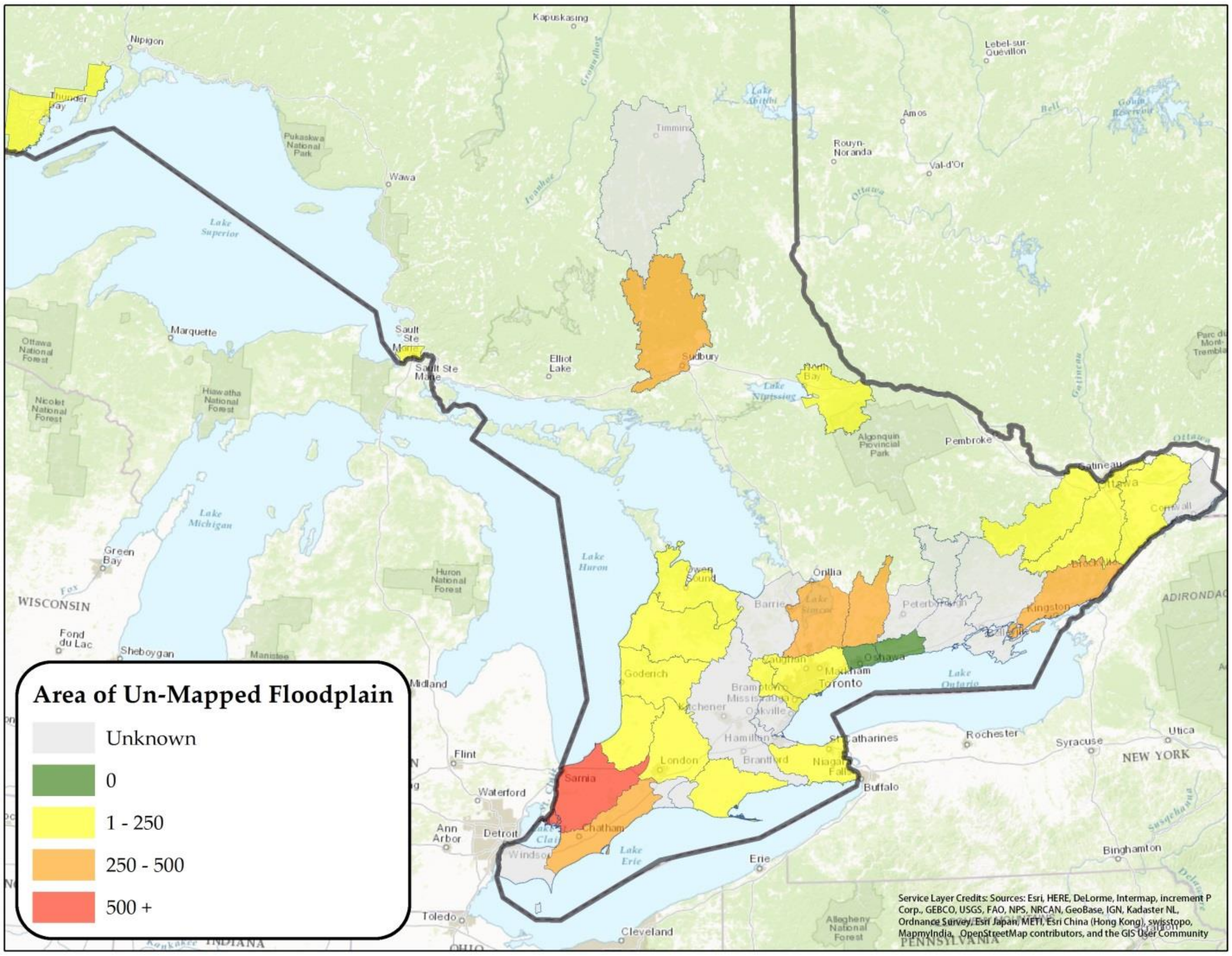


Figure 3.19: Area of Unmapped Floodplains (km²)

3.1.12 Calibration

Calibration is the process of adjusting parameters within the margins of acceptable limits to obtain a model that is a representation of the processes or output of interest as defined by historical data. These parameters are identified through a sensitivity analysis that determines what parameter most affects the process or output of interest.

The main output of concern for floodplain hydrology models is the peak flow to be routed in the hydraulic model. Generally, a modeller will adjust sensitive parameters to make the model replicate a known rainfall and peak flow. The inventory results show that only 40% of hydrology projects employed some form of hydrology calibration.

The inventory also showed that few hydraulic models were calibrated. This calibration would have used data such as high water marks for known events to adjust the parameters of the hydraulic model.

3.1.13 Climate Change Considerations in Floodplain Mapping

CAs across Ontario are working with their municipal partners to address Climate Change and its impacts on floodplains. Effective adaptation to Climate Change will require this consideration. A review of the inventory results show that only 2 projects out of the 739 projects (0.3%) considered Climate Change. This is an issue that needs to be addressed.

3.2 Preliminary Risk Assessment

3.2.1 Description

It was crucial to develop a high-level understanding of risk within each CA in order to assess the needs of CAs to and accurately estimate costs associated with updated mapping. It was acknowledged early in undertaking this project that while some CAs have the necessary resources to conduct detailed risk assessments, a number of CAs would not have the time or resources for such an undertaking. Therefore, when developing a preliminary risk assessment template for this project, the criteria was kept as straight forward and simple as possible. It was also understood that the level of risk may vary between urban CAs and rural CAs. The risk assessment criteria was developed to ensure equality between each CA, while recognizing there are significant risks associated with more rural areas. The criteria used within the inventory for the preliminary risk assessment are provided below.

Under the *Project* section of the inventory, there was an attribute to define the extent of floodplain area, and three hazard levels associated with that floodplain. This information was important in defining the level of risk, as well as in determining costs associated with new or updated mapping. The hazard classifications noted below are based on potential loss of life and property. The following guidelines were provided to CAs to assist in defining these attributes.

<u>Maximum Floodplain Extent</u>
This is the actual mapped regulatory floodplain area, if known. An attempt was made to directly measure this area if it was reasonably possible. If only hard copy or scanned copies of the mapping was available, the total watercourse length, multiplied by the widest cross section measurement (within reason) was used to determine the floodplain extent for the purposes of this inventory. Data was reported in square kilometres to two decimal places.

<u>Determining High/Medium/Low Hazard</u>

1) The initial step was to divide the watercourse (or shoreline) into rural, urban or future urban reaches. **Figure 3.20** below is an example of a creek divided by the three areas mentioned above, red representing urban, blue as future urban and brown as rural. For the purposes of this assessment, urban areas can be defined as any area within the boundaries of a City, Town, Hamlet or clustered development (approximated by greater than 10 habitable buildings per $0.5km^2$),

and a future urban area as any area that is designated for future growth within an official plan.

2) Each area was sub-classified as either high, medium or low risk using the following criteria:
    a. Within an urban area, a watercourse that is not part of a confined valley or other constraint*, where there are more than ten buildings* within or suspected to be within the floodplain, would be classified high hazard.
    b. Within an urban area, a watercourse where the floodplain is confined within a valley or other constraint*, and/or there are less than ten buildings within the floodplain, would be classified as medium hazard.
    c. Future urban areas, in which planning policies will restrict development to outside the floodplain, are classified as medium hazard.
    d. Future urban areas where past planning policies may permit development to occur within the floodplain through, for example, a two zone or SPA, are classified as high hazard.
    e. Within a rural area, a watercourse that is not part of a confined valley or other constraint*, where there are more than ten buildings within or suspected to be within the floodplain, would be classified medium hazard.
    f. Within a rural area, a watercourse where the floodplain is confined within a valley or other constraint*, and/or there are less than ten buildings within the floodplain, would be classified as low hazard.
    g. Within a rural area, where there are less than ten buildings within or suspected to be within the floodplain, but where flooding would cause appreciable economic hardship (>$3,000,000), would be classified as medium hazard.
    h. Within a rural area, where there are less than ten buildings within or suspected to be within the floodplain, but where flooding would cause appreciable economic hardship (>$30,000,000), would be classified as high hazard.

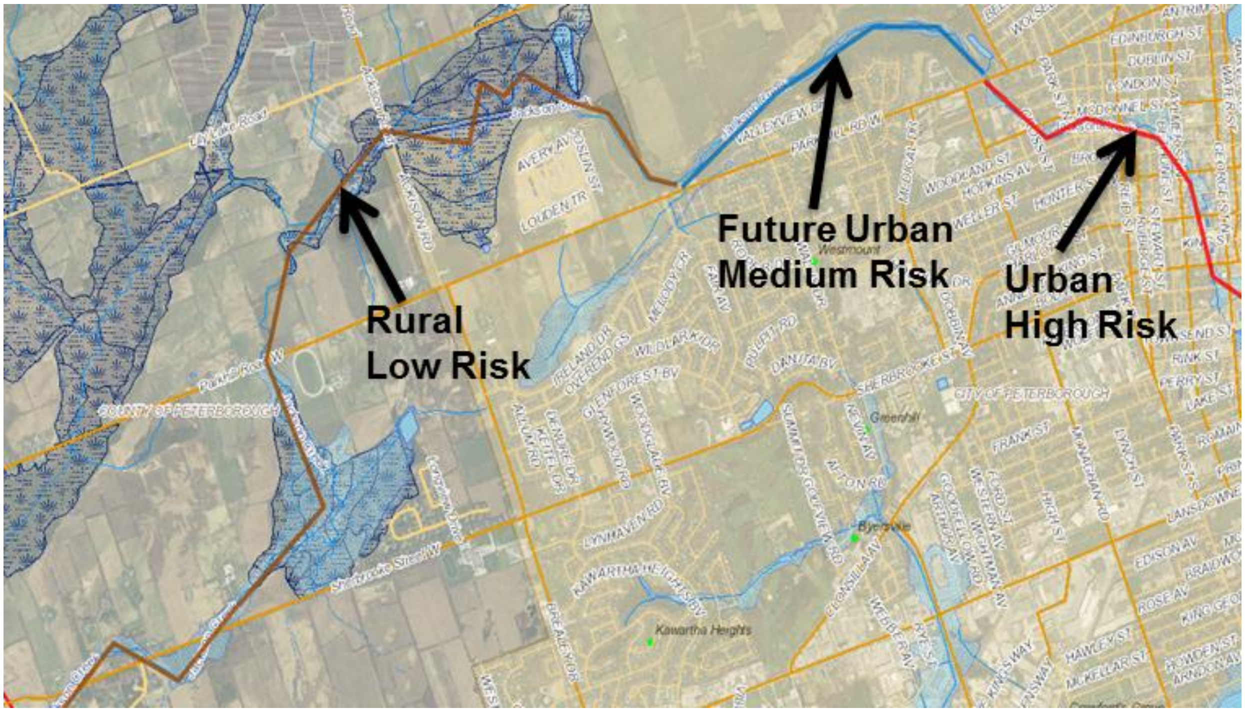


Figure 3.20: Watercourse Divided by Urban, Rural and Future Urban

If for any reason a particular area does not fit within the above categories, best judgment of the CA was used to classify the area as high, medium or low risk.

**other constraints* could include wetlands (PSW's), unstable soils or slopes, or any natural hazard that may govern over flooding when defining the limits of regulation.
**Buildings* are defined as any habitable, commercial or institutional structures where one or more persons may be present during a flood."

3) Measured by stream or shoreline length, the total length of high hazard, medium hazard and low hazard was accumulated. Each length was converted to a percentage of the total stream length for the given project. The given percentages were input directly into the database as the approximate high/medium/low hazard percentage of the total floodplain extent.

As a secondary exercise, the survey also included a section devoted to the total estimated area of mapping <u>required</u> by a CA (ie. not currently mapped and not part of the project inventory). The same criteria identified above were utilized to estimate the percentage of high, medium and low hazard area for watercourse or shorelines not currently mapped.

3.2.2 Results

The preliminary results of the risk assessment indicate there is a significant portion (44%) of existing CA mapping projects within high risk areas. This result is to be expected considering historical mapping completed under the FDRP program was focused on flood damage centres and urban areas. Of particular note, is the presence of high risk areas in what would commonly be described as a rural area. This risk assessment allowed certain rural areas to be classified as urban, thereby allowing for a more appropriate approximation of risk. These areas can include small hamlets or housing clusters, or along the shorelines of inland waterbodies. The cost of revising floodplain mapping within high risk areas should generally be greater than those of low risk, as the requirement for greater detail in base mapping, hydrology and hydraulic models is more important. As presented in **Figure 3.21** below, the actual length of mapping that exists within high risk areas is significantly less than that of low risk areas.

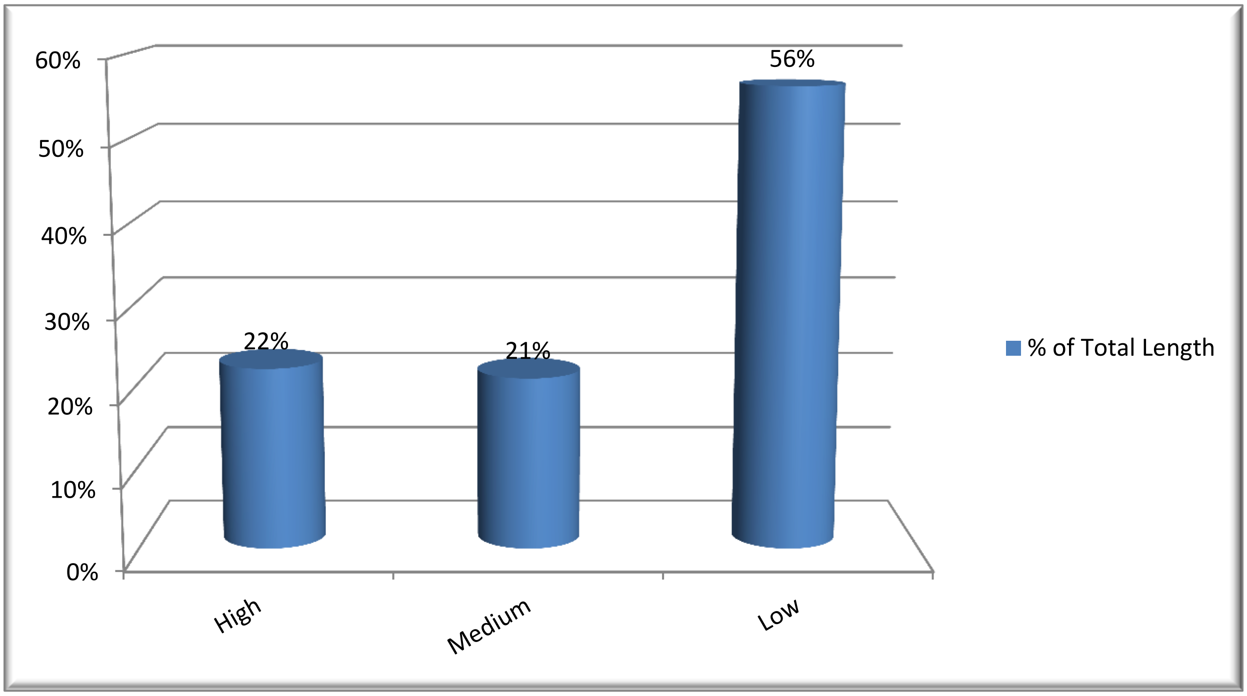


Figure 3.21: Risk Level of Floodplain Mapping by Length as a Percentage of Total

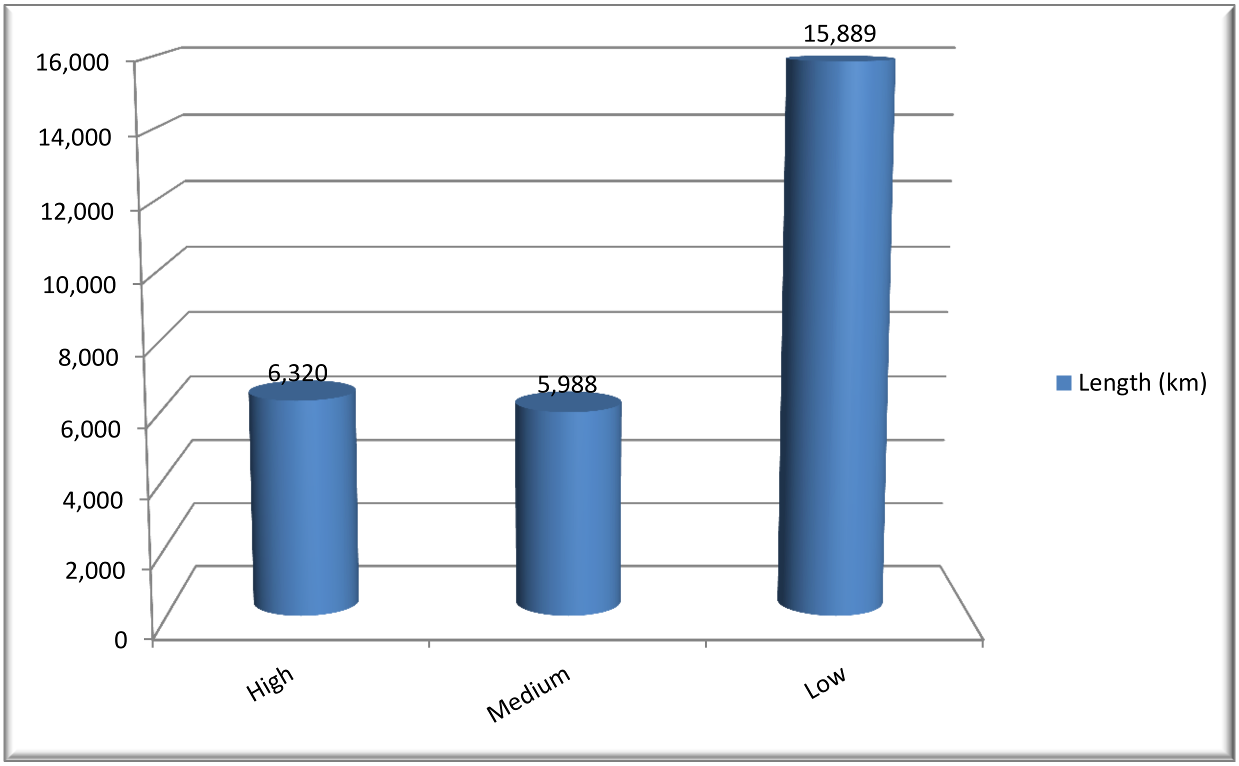


Figure 3.22: Risk Level of Floodplain Mapping by Length (km)

3.3 Summary Analysis

3.3.1 Preliminary Cost Estimates

The cost of developing floodplain mapping can generally be broken down into the 4 four main categories; base mapping (aerial photography and elevation data), hydrologic modeling, hydraulic modeling, and hazard mapping and reporting. The cost of developing these products for a given watercourse or shoreline can vary greatly depending on the availability of existing data, complexity of the reach and the type of modeling to be performed (ie. 1-D vs. 2-D). The cost estimates reported below include only the technical aspects of creating regulatory floodplain mapping products, they would not incorporate other items such as risk assessments as defined in the NDMP program. The following section provides a high level breakdown of costs associated with creating new floodplain mapping products based on the results of this inventory. The analysis presented below compares data from a report commissioned by Public Safety Canada (PSC) and completed by MMM Group Limited in 2014, titled 'National Floodplain Mapping Assessment – Final Report, 2014'. The MMM Group Limited report was completed at a national scale for all Provinces across the country, and is at coarser level of detail than that contained in this report. The cost estimates presented in the MMM Group Limited report may not be directly comparable to those contained in this assessment, but were the only current published estimates for floodplain mapping available.

1-D Modeling

As reported in the inventory, the majority of floodplain mapping projects was created with a one dimensional hydraulic model. The cost to update, create and/or replace this mapping is provided in **Table 3-4**. The unit costs per linear kilometer of mapping were taken from the MMM Group Limited 2014 floodplain mapping assessment study undertaken for the federal government. MMM Group Limited assigned two categories for costs associated with 1-D modeling in Canada, defined as either rural or urban. For this study, MMM Group Limited's urban and rural unit costs were applied to the high risk and medium risk categories, with an additional category of low risk included and an estimated unit cost applied. In addition, a second estimate was created with average costs per kilometer reported by a select few CAs who have undertaken recent floodplain mapping studies. The costs associated with updating or replacing existing floodplain mapping was determined as follows:

- Total floodplain mapping by length, less 2-D areas (as reported in **Figure 3.17**):

  = **28,013km**

- Length of 1-D mapping based on percentage High/Medium/Low risk:

  High (23%) = **6443km**

  Medium (21%) = **5883km**

  Low (56%) = **15687km**

- Assume 74% of the above, requires replacement or updates(as reported by CAs, see **Section 3.1.7**):
  High (74%) = **4768km**
  Medium (74%) = **4353km**
  Low (74%) = **11609km**

It is acknowledged that the above breakdown does employ a great deal of assumptions, such as the distribution of required updates between the three risk categories. The analysis will however, provide a reasonable estimate of the cost to update or replace existing mapping.

	1-D Cost/km (MMM Study)	1-D Cost/km (CAs)	Total Length (km)	Total Cost (MMM)	Total Cost (CAs)
High Risk	$ 10,500.00	$ 8,000.00	4768	$ 50,062,032	$ 38,142,501
Medium Risk	$ 7,500.00	$ 6,500.00	4353	$ 32,649,152	$ 28,295,931
Low Risk	$ 5,000.00	$ 5,000.00	11609	$ 58,042,936	$ 58,042,936

	Total (Rounded) =	$ 140,750,000	$ 124,480,000

Table 3-4: Preliminary 1-D Mapping Cost Estimate

<u>2-D Modeling</u>

The following table provides an estimated cost to create a 2-D mapping product. It was assumed that the full length of mapping reported as *"not appropriate for 1-D modeling"* would need to be replaced, a valid assumption considering no CAs are currently using 2-D models for <u>regulatory</u> floodplains. The cost associated with creating a 2-D derived floodplain mapping product was taken from the same MMM Group Limited report mentioned above. The average costs per kilometer, reported by select CAs who have undertaken recent floodplain mapping studies, were also used for comparison. All areas where 2-D modeling is needed was assumed to be high risk. The costs reported below may be underestimated as a significant number of CAs reported projects as being *"Partially"* appropriate for 1-D modeling. This generally means that a small portion of a subject reach may require a more advanced model with 2-D capabilities. The length associated with *"Partial"* responses was however lumped into the 1-D costs, as it was assumed that the majority of the study areas would be conducted in 1-D.

	2-D Cost/km (MMM Study)	2-D Cost/km (CAs)	Total Length (km)	Total Cost (MMM)	Total Cost (CAs)
High Risk	$ 50,000.00	$ 30,000.00	401	$ 20,050,000	$ 12,030,000
			Total =	$ 20,050,000	$ 12,030,000

Table 3-5: Preliminary 2-D Mapping Cost Estimate

3.3.2 Recommendations

During the process of meeting with CAs, and after analysing and reviewing their floodplain reports and submitted data, it has become evident there are a few areas for improvements and efficiencies related to floodplain mapping initiatives. The following are recommendations to support CAs in ensuring accurate updates of regulatory floodplain products which are critical to the comprehensive flood management program in Ontario and the continued protection of people and property from flood risk.

1) The inventory created for this project should be updated on an annual or bi-annual basis. A significant number of new projects may be forthcoming as a result of NDMP funding. All data should be kept in a geospatial database, with appropriate metadata linked to delineated floodplain areas. The creation of a geodatabase is ongoing at the time of publishing this report.

2) The inventory provides sufficient information to undertake a more detailed cost analysis than is provided within this report. It is recommended that more refined and targeted estimates be undertaken as part of COs update to the Flood Business Case.

3) Climate change should be a consideration in all future floodplain mapping products. A recommendation put forth within the MMM study, stated that climate change considerations be addressed within new Hydrology Technical Guidelines. It is recommended that within the Province of Ontario any climate change scenarios or requirements be included in a revised MNRF Technical Guideline for flood hazard limits.

4) The need for a large scale elevation data acquisition cannot be understated; it is further recommended that this acquisition be accelerated so that the data may be utilized within the NDMP timelines. It is estimated that 33 percent of mapping is within a low risk area, and while these areas may not be given the same priority as a high risk area, the need within CAs to have accurate and reliable information still exists. The unit costs per kilometer of floodplain mapping in low risk areas incorporates a base mapping acquisition, and the costs could be greatly reduced if a large scale acquisition were to be completed. It is unlikely that the necessary accuracy of elevation data acquired from a large scale acquisition would be sufficient for high risk areas. The elevation data may however be useful in medium risk areas as well, further reducing costs.

5) It is recommended that a Provincial Flood Risk Assessment Methodology be defined to enable all practitioners engaged in evaluating floodplains in Ontario to have a common definition of flood risk. This study evaluates floodplain mapping based on a very preliminary approach that could be significantly improved with input from water resources experts. This recommendation is timely given the National Disaster Mitigation Plan requirement for Risk Assessment as part of that funding program.

6) The most important recommendation from this inventory is that floodplain mapping in Ontario needs a major investment, as much of it needs to be updated. The MMM Group in their 2014 report, “National Floodplain Mapping Assessment – Final Report” suggests that urban floodplain mapping should be reviewed every 5 years and rural floodplain mapping should be reviewed every 15-20 years. This inventory provides a first step in that review. If a comprehensive update of Ontario floodplain mapping is to be realized, the results of this inventory could be expanded to create a meaningful path forward for that update.