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GEOLOGICAL SURVEY OF CANADA
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Hazus-MH 2.1 Canada user and technical manual: flood module

N.L. Hastings, C.L. Wagner, W. Chow, C.F. Sidwell, and R.A.L. White

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Publications in this series have not been edited; they are released as submitted by the author.

Table of Contents

List of Tables

List of Figures

Notes and Acknowledgements

Notes for Hazus Manual

Every reasonable effort was made to ensure the accuracy of the information contained in this manual, but Natural Resources Canada does not assume any liability for errors that may occur. This manual was current as of January 2016. See www.hazuscanada.ca for any updates. This manual accompanies the Hazus Canada software Open File 7811.

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The work was completed within the context of a Technical Annex signed by NRCan, DRDC and the US Federal Emergency Management Agency (FEMA) as part of a Cooperative Activity Agreement between the USA and Canada in risk-related domains. The Hazus Canada adaptation team recognises the partnership, contributions and ongoing support of FEMA staff, including Eric Berman, Doug Bausch, Jesse Rozelle, and Kelly Stone, as well as Kevin Mickey and Dave Coats of the Polis Center at Indiana University Purdue University-Indianapolis.

Technical Contributions

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The authors recognise and appreciate the review of the manual by M. Ulmi.

Chapter 1 Introduction

1.1 Hazus Canada

Damage and loss estimation models combine authoritative information about hazards and system vulnerabilities to estimate potential impacts and likely consequences of credible hazard events on people and the things they value. They provide a capability to anticipate and plan for a wide range of hazard event scenarios, thereby increasing situational awareness of the environment at risk and the effectiveness of mitigation, response and recovery operations.

Hazus was developed by the US National Institute of Building Science (NIBS), in partnership with the Federal Emergency Management Agency (FEMA), to provide a national standard methodology for modelling the potential physical, economic and social impacts from earthquakes, hurricanes, and floods. It is a GIS-based software tool that allows users to visualise the relationship between natural hazards and the people and infrastructure they threaten. Hazus analyses and outputs have many practical applications. They have been used in a variety of sectors, including insurance, geotechnical engineering, emergency management, and municipal planning.

Hazus encompasses an integrated suite of analytical models, spatial decision support tools, and procedural guidelines for hazard identification and quantitative loss analysis. The methods are based on state-of-the-art scientific and engineering knowledge and follow industry standards for quantitative risk assessment. Hazus provides a robust and standardised approach to loss estimation that is being adopted by governments and organisations worldwide.

Hazus is a quantitative loss estimation methodology and software tool that presents results in terms of the potential consequences of natural hazards on the built environment and its inhabitants. Although Hazus supports risk-based planning activities, it does not quantify the losses in risk terms. The Glossary in Appendix C defines risk assessment and the difference between loss and risk. In its current form, Hazus does not fully integrate the uncertainties and probabilities of those losses within the model. These parameters are essential to transform scenario-based consequences into measures of risk for the modelled scenarios. For these reasons, utilisation of Hazus results (i.e., losses) is more suitable for pre-event planning than for post-event resource allocation. However, even with these limitations, Hazus supports the planning process and decision-making better than some less systematic approaches currently used.

The Earth Sciences Sector of Natural Resources Canada (NRCan/ESS) identified Hazus as a best practice methodology for quantitative loss estimation. NRCan/ESS engaged in collaborative research and development activities with FEMA and its partners to adapt the tool for use in Canada. This manual builds upon the Hazus-MH 2.1 Canada User and Technical Manual: earthquake module, Open File 7474. The

collaboration between FEMA and NRCan/ESS has resulted in a release of Hazus that permits users to create study regions in Canada based on Statistics Canada 2011 census boundaries and data for modelling losses for earthquakes and floods in Canada.

1.2 Use of Hazus Outputs

(Refer to Chapter 10 of the *Hazus-MH 2.1 Flood Model User Manual* (US version) for details on the various Hazus reports and outputs, and their background, value and limitations. See also *NRCan Open File 7772* (Struik, L.C. et al., 2015) on how outputs can be used.)

Hazus Canada is a tool that provides municipalities, regional districts, provinces or consultants with a standards-based approach to various aspects of emergency planning, including planning for mitigation, response and recovery. It can provide estimates of damage and loss before, during, or after a hazard event, offering benefit to many aspects of disaster risk management. The Hazus application allows users to identify vulnerable areas, buildings, populations, and infrastructure. Different approaches to mitigation can then be compared, and the costs and benefits of each option can be measured. This leads to increased effectiveness and cost savings in a targeted, evidence-based approach to mitigation for hazards.

Using Hazus Canada, Canadian jurisdictions can better:

- identify areas at risk from flood hazards that may require changes in land use;
- assess the vulnerability of homes and essential facilities;
- prioritise mitigation projects;
- educate communities about their risk; and
- develop map-based mitigation, preparedness, response and recovery plans.

The Geological Survey of Canada has published a risk-based land-use guide that can be used for all potential hazard events (Struik, L.C. et al., 2015). Figure 1-1, taken from this publication, gives a framework for the processes involved in identifying and assessing potential losses from a hazard event and how to integrate this into mitigation and monitoring decisions.

As outputs of a powerful loss estimation method, Hazus results can be used and reported in different contexts and formats, depending on the purpose of the assessment. On a broad perspective, outputs are needed for:

- emergency management;
- land use planning;
- engineering design; and
- analyses of mitigation strategies.

The outputs of Hazus for flood impact assessment include those highlighted in Figure 1-2. Each of these outputs can provide useful information for a variety of users. Hazus

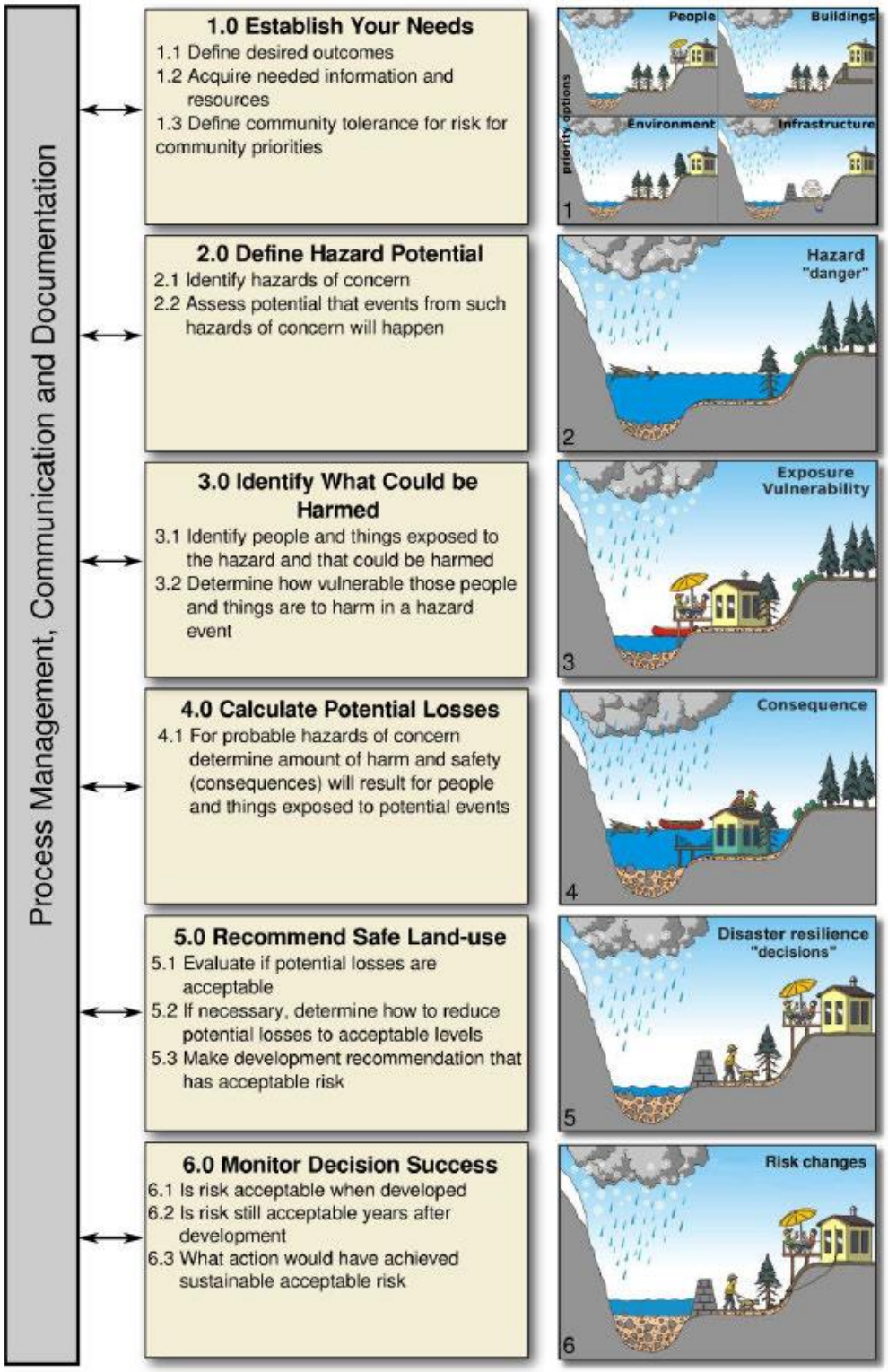


Figure 1-1 Overview of land-use risk management process (Struik et al., 2015).

users can have a range of backgrounds, perspectives and functions. For example, while decision-makers such as city council members, may require only summaries of losses for a region, emergency managers may wish to see the geographical distribution of all losses for different flood scenarios. On the other hand, expert risk analysts may want to see how each input variable affects results and how the uncertainties can be represented, while engineers may wish to see the effects of different design alternatives for mitigation purposes. In addition, economic loss information can be used to motivate policy-makers to consider the cost-benefit implications of mitigation activities and alternatives.

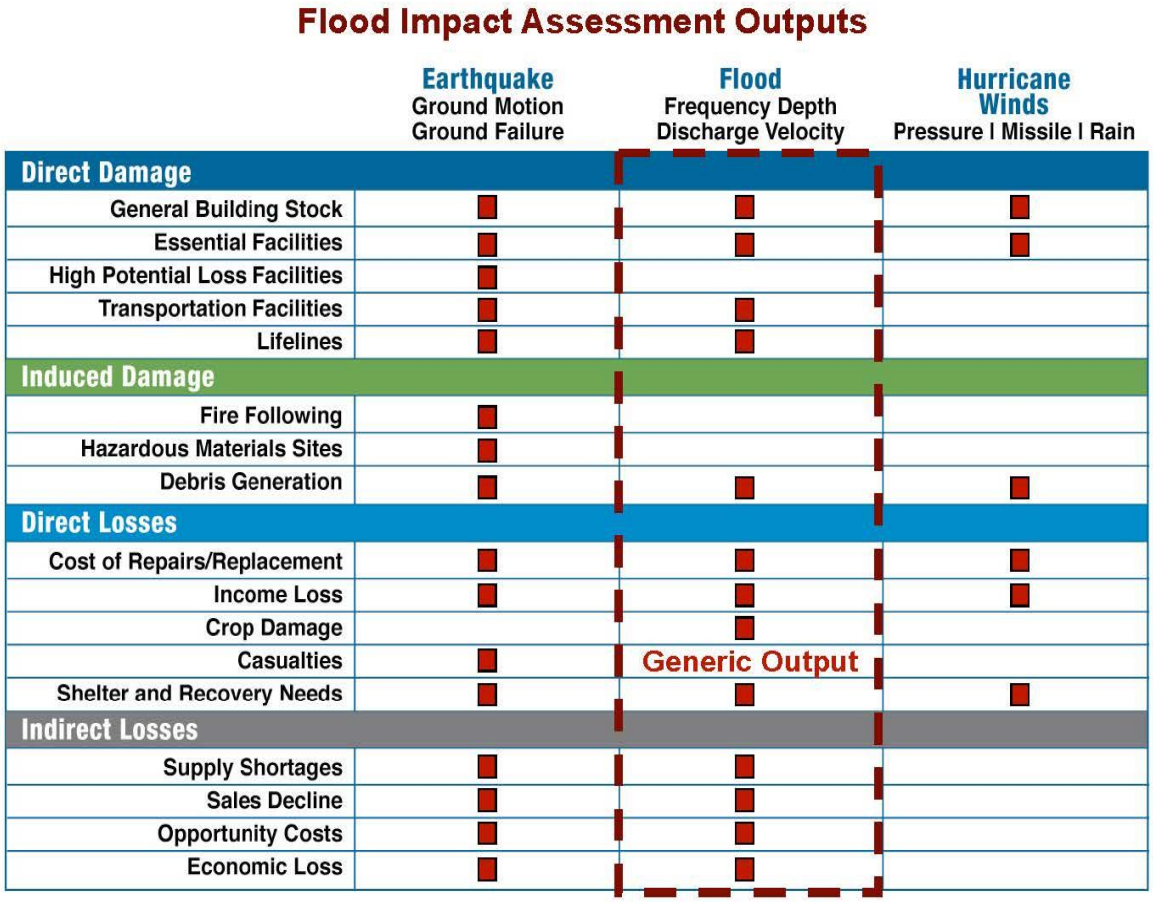


Figure 1-2 Flood impact assessment outputs.

Hazus outputs for Canada, as for the US, are primarily communicated in terms of loss estimates and damage impacts, rather than in terms of risk estimates. Currently, Hazus reports partial probabilities (i.e., related only to building response characteristics) for both aggregate and individual asset analyses. Additional models outside of Hazus are needed to calculate and express model results in terms of risk. This is the case in both Hazus Canada and the US version of the program.

1.3 Scope of Manual

This manual was created for the Canadian GIS user who has acquired Hazus Canada and wishes to run a loss estimation scenario. It is intended to be used as a complement to existing Hazus manuals, including *NRCan Open File 7474, Hazus-MH 2.1 Canada user and technical manual: earthquake module*; and FEMA's *Hazus-MH 2.1 Flood Model Technical Manual*, *Hazus-MH 2.1 Flood Model User Manual*, and *Using Hazus-MH for Risk Assessment: How-To Guide*. These and other reference documents can be found through GEOSCAN (http://geoscan.nrcan.gc.ca/) and in the FEMA library at http://www.fema.gov/library/index.jsp. Updates to Hazus Canada and to this manual will be available at http://www.hazuscanada.ca.

This document will provide guidance on the differences and adaptations for the Canadian user and provide support to enable the running of Hazus in a Canadian study region. To better understand the practical application of Hazus and its use for practitioners, refer to case study reports on the use of Hazus in the District of North Vancouver and in the Ottawa-Quebec City infrastructure corridor. See Section 6.1.1 for more information about these case studies. FEMA's Hazus site also profiles the use of Hazus by states and communities in support of their risk reduction programs for planning, mitigation, response, and preparedness.

A flowchart outlining the process for running a Hazus flood loss estimation

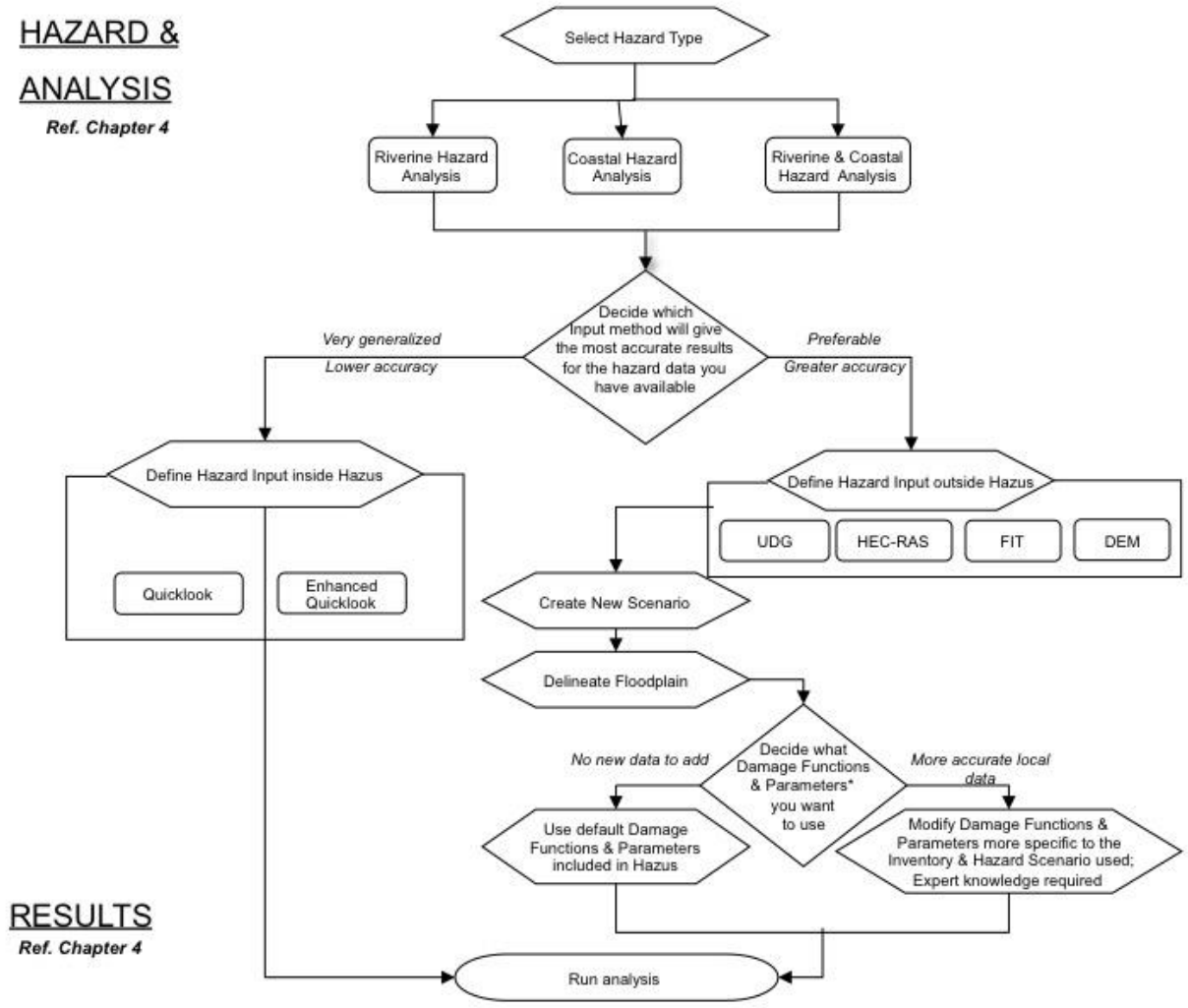


Figure 1-3.

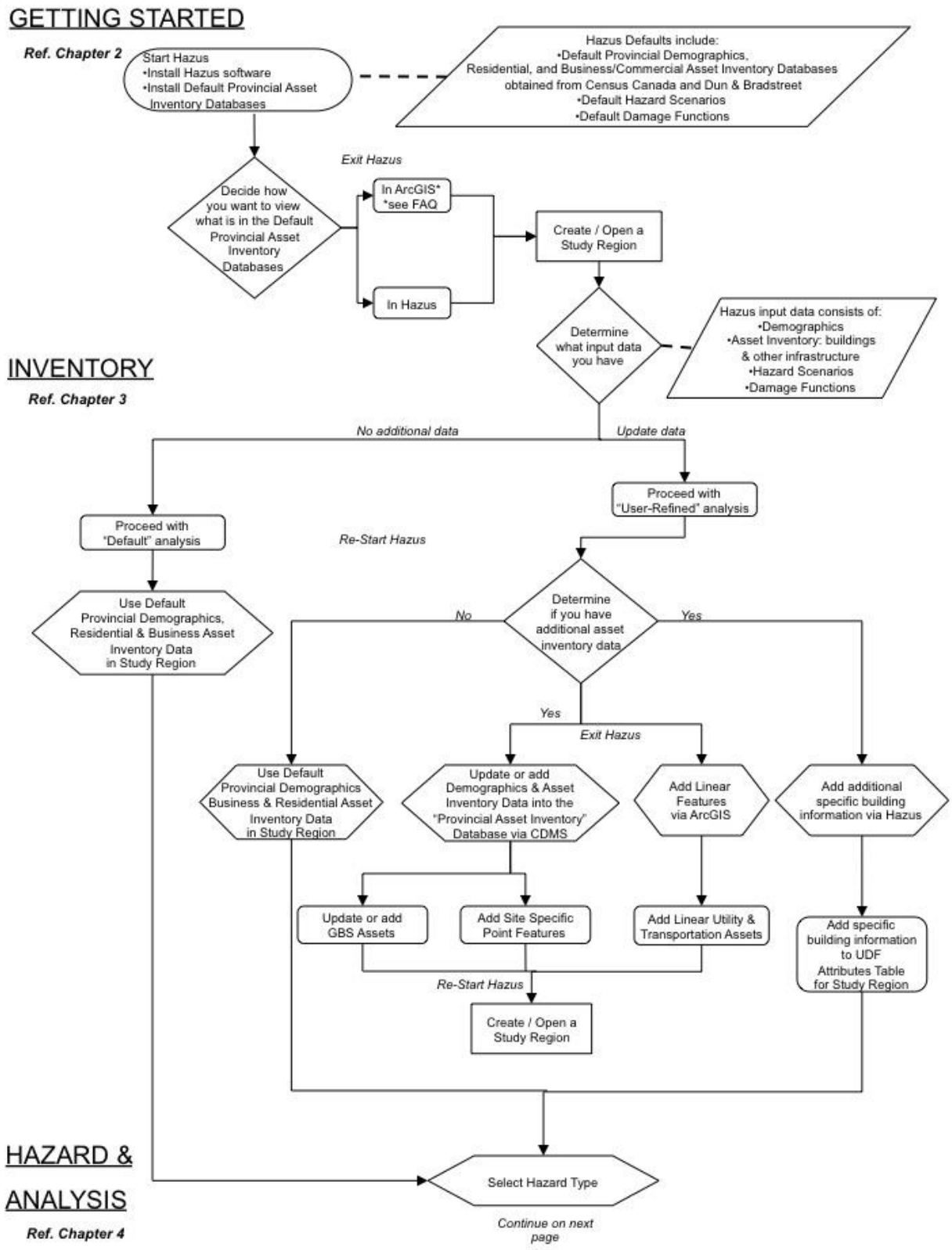
1.4 Overview of Differences between Canadian and US Versions of Hazus

There have been discussions between NRCan and FEMA about a unified North American version, but at this time, Hazus versions for Canada and for the US have been developed as two separate applications. The Canadian version of Hazus has been designed from the US version 2.1 of Hazus-MH. Currently, the application has

been adapted for the earthquake and the flood module. A Canadian version of the Comprehensive Data Management System (CDMS) application has also been adapted from the US version of CDMS, and is included with the Canadian version of Hazus.

Modifications to Hazus-MH for Canada:

- Hydrologic and hydraulic analysis is NOT available in Hazus Canada. Stream discharge and gauge information is not as widely available in Canada as in the US, resulting in the recommendation of Environment Canada that this function not be included in the Flood Module of Hazus Canada.


GETTING STARTED
Ref. Chapter 2
Start Hazus
•Install Hazus software
•Install Default Provincial Asset Inventory Databases
Hazus Defaults include:
•Default Provincial Demographics,
Residential, and Business/Commercial Asset Inventory Databases
obtained from Census Canada and Dun & Bradstreet
•Default Hazard Scenarios
•Default Damage Functions
Exit Hazus
Decide how you want to view what is in the Default Provincial Asset Inventory Databases
In ArcGIS* *see FAQ
In Hazus
Create / Open a Study Region
Determine what input data you have
Hazus input data consists of:
•Demographics
•Asset Inventory: buildings & other infrastructure
•Hazard Scenarios
•Damage Functions
INVENTORY
Ref. Chapter 3
No additional data
Update data
Proceed with "User-Refined" analysis
Proceed with "Default" analysis
Re-Start Hazus
Use Default Provincial Demographics, Residential & Business Asset Inventory Data in Study Region
No
Determine if you have additional asset inventory data
Yes
Yes
Exit Hazus
Use Default Provincial Demographics Business & Residential Asset Inventory Data in Study Region
Update or add Demographics & Asset Inventory Data into the "Provincial Asset Inventory" Database via CDMS
Add Linear Features via ArcGIS
Add additional specific building information via Hazus
Update or add GBS Assets
Add Site Specific Point Features
Add Linear Utility & Transportation Assets
Add specific building information to UDF Attributes Table for Study Region
Re-Start Hazus
Create / Open a Study Region
HAZARD & ANALYSIS
Ref. Chapter 4
Select Hazard Type
Continue on next page

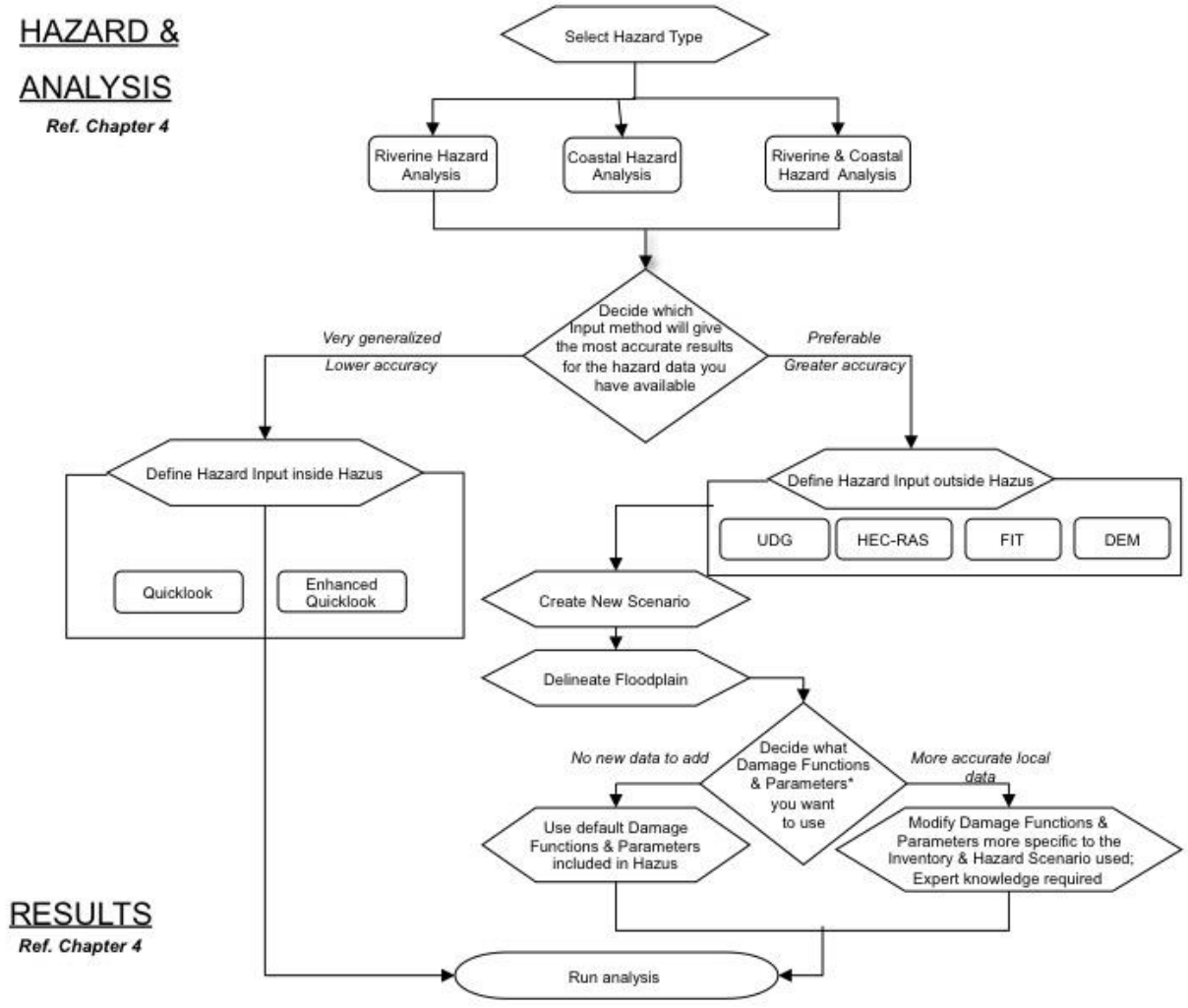


Figure 1-3 Flow chart showing Hazus flood analysis process.

- Canadian provincial datasets were updated for the new version of Hazus Canada using 2011 Census Canada data for residential buildings, and business and commercial information from Dun & Bradstreet purchased in 2013.

- Hazus Tracts and Blocks are geographically smaller than the previous version of Hazus Canada.

- Canadian coastal shorelines have been included in the Flood Module data so that coastal analysis can be performed. Shorelines have been generalized.

- Modifications were made to the Hazus-MH code to enable reading and processing of provincial databases for Canada.

- Occupancy Mapping Schemes for each province/territory were copied from the nearest US state.

- Modifications were made to the Hazus-MH summary reports in order to reflect Canadian terminology (e.g., “Province/Territory” instead of “State”).

- Hazus Canada Flood Model will allow for FIT, UDG, HEC-RAS input which will bypass flood hazard determination.

Note: No modification was done to algorithms or assumptions that are used in the calculation of damage or loss estimates.

Modifications to Census Canada Inventory Data for Canadian Provincial databases:

- Census Canada 2011 census units were used as database geographic units.

- Census Canada 2011 demographic information was used for census units.

- Census Canada 2011 residential information was used to calculate general building stock properties for RES occupancy codes.

Notes:

- Building stock properties for non-RES occupancy codes were calculated for this new version of Hazus Canada using business and commercial information from Dun and Bradstreet purchased in 2013.

- No information was processed for other building and infrastructure inventory that can be added to the provincial databases.

Modifications to CDMS for Hazus-MH for Canada:

- Modifications were made to CDMS to enable reading and processing of provincial databases for Canada.

- Modifications were made to the *Repository* list when the **View** button is used. The list displays the database fields that contain Census Canada codes for Census Subdivision/Tract and Dissemination Area, instead of the fields with the Hazus Tract / Block ID codes.

- Modifications were made to the CDMS user interface in order to reflect Canadian terminology (e.g., “Province/Territory” instead of “State”).

The following Sections elaborate on the Canadian Hazus adaptations.

1.4.1 *Built Environment and Demography*

The new Canadian version of Hazus has been modified to reflect the 2011 Census Canada geographic boundaries. As in the US, this provides a capability of creating a study region anywhere in Canada based on a geographic, census-based region.

In Canada, demographics data are collected and distributed by Statistics Canada via the Census Program (http://www.statcan.gc.ca/). This data is updated every five years and standardised across the country. The 2011 Census Canada data was used to build the demographic tables that are in the provincial databases accompanying the Hazus application. Population, age groups, and income parameters per Census unit are available in the demographics table.

The provincial database also includes information about the buildings, aggregated to Census units and based on the occupancy (or use) of the buildings. Parameters include the number of buildings per occupancy code, the total square footage per occupancy code, and the calculated replacement cost of the buildings per occupancy code. The 2011 Census Canada residential information was used to calculate general building stock properties for the RES occupancy codes

Building stock properties for commercial and industrial buildings have been integrated into the Canadian Provincial Databases using business and commercial information purchased from Dun and Bradstreet 2013. The data was manipulated to correspond with the building occupancies used in the Hazus database format.

The databases provided with Hazus Canada are provided as a starting point for analysis. The user is strongly encouraged to update the General Building Stock inventory, as well as specific inventory and infrastructure, by using local data. Local data are of much better quality with respect to occupancy, building construction type, building replacement value, and square footage.

Hazus building inventory uses five basic construction classifications (wood, concrete, steel, masonry, and manufactured housing) and seven general occupancy categories (residential, commercial, industrial, agricultural, religious/non-profit, governmental, and educational buildings). In addition, Hazus can consider essential facilities (hospitals, schools, police, fire stations, and emergency operation centres), transportation systems (highway, railway, airport, bus, ferry and port), utilities (communication, electrical power, natural gas, oil, potable water and waste water), agriculture products, vehicles, and high potential loss facilities if these assets are entered by the user.

1.4.2 *Earthquake Module*

Hazus is comprised of modules focused on various natural hazards. The initial focus of adapting Hazus for use in Canada was on the earthquake module. The methodology has been adapted to allow for analytical capability of probabilistic, deterministic, user-defined and historic earthquake events across Canada. The latest version of the earthquake module can be downloaded from www.hazuscanada.ca or accessed as Open File 7811 on http://www.geoscan.gc.ca.

1.4.3 *Hurricane Module*

There is currently no hurricane module available for Canada in the Canadian version of Hazus. To run a Hazus analysis for hurricanes, a Canadian user could alter a Canadian provincial database to mimic a US jurisdiction and enter their own asset inventory and hazard scenarios. See Appendix A for instructions.

1.4.4 *Storm Surge Module*

The storm surge module combines outputs from the flood and hurricane module to estimate losses from storm surge events. This module is not available for Canada.

1.4.5 *Tsunami Module*

FEMA is currently developing a module to model the losses from earthquake-triggered tsunami events. It is anticipated that this module could eventually be adapted for Canada.

1.5 The Development and Role of Hazus in Canada

(Also refer to Open File 7152, Mickey and Coats, 2013)

NRCan identified a number of tools that can assist in producing quantitative risk assessments including Hazus-MH (Hazus), a geographic information system (GIS) based tool developed by the United States Federal Emergency Management Agency (FEMA) and adapted by NRCan's quantifying geohazard risk project.

In August 2011, NRCan entered into an agreement with FEMA to employ Hazus by adapting it for use in Canada as a quantitative risk analysis tool. NRCan has subsequently interacted with the developers of Hazus in the US to create a very similar tool for Canada that, while not yet fully developed and lacking many of the datasets that are provided to US users, is capable of demonstrating some of the outputs and reports that make Hazus such a valuable risk analysis tool in the US. In tests of the tool, NRCan has demonstrated how existing Canadian inventory and hazard-related data can be utilised to produce even better results.

Although developed for use in the United States, Hazus is also a potentially useful tool for quantifying risks in Canada from earthquakes, riverine and coastal flooding, storm surges, and hurricanes. Hazus could play a significant role in supporting the objectives of Public Safety Canada's National Disaster Mitigation Program.

1.6 Issues and Workarounds for Hazus Canada

During the development of Hazus Canada, many tests were performed to ensure the functionality and accuracy of the analyses and results. Although the testing was extensive, it has been found that there still exist some issues with Hazus Canada in general; the Hazus Canada earthquake module, the Hazus Canada flood module, and the CDMS import process. At the time of this publication, Natural Resources Canada does not have the capacity to correct these issues. The issues and suggested workarounds are listed in Chapter 5.

Chapter 2 Getting Started

(Also refer to Chapter 2 of the *Hazus-MH 2.1 Flood Model User Manual*.)

This chapter goes over the necessary steps for a user to get set up with Hazus Canada. Refer to Figure 2-1, with section references, for an overview of the steps depending on whether a previous Hazus Canada application is already in place, or if a user is starting a completely new installation.

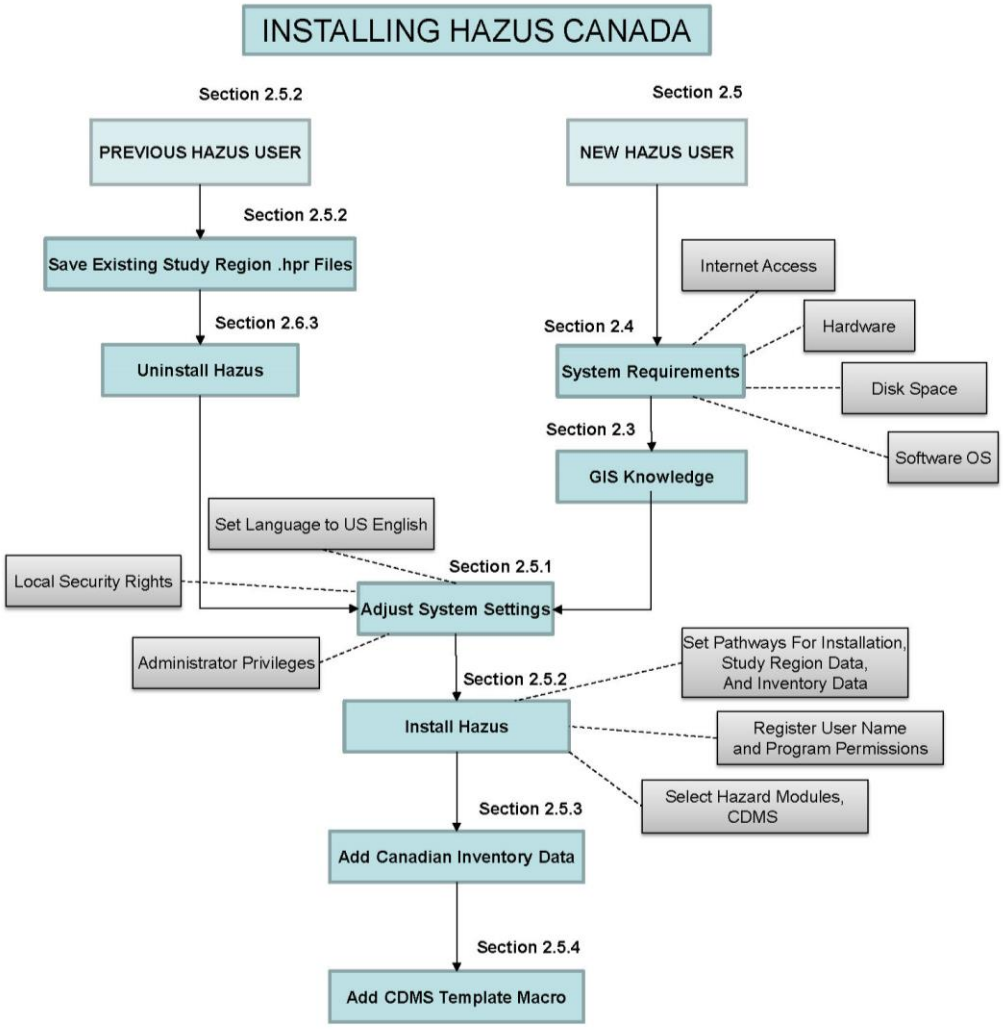


Figure 2-1 Chapter Flow Chart for Installing Hazus Canada.

2.1 Order Hazus Canada

To order Hazus Canada, complete the Hazus Canada Application Request form on the http://www.hazuscanada.ca website or contact info@hazuscanada.ca. You will be provided a link to the application and instructions for installing the program file on your local drive. Hazus Canada can also be found for download at http://geoscan.nrcan.gc.ca through a search for "Hazus Canada flood module".

For more information on the Hazus methodology and software, and to find the latest news and updates, visit http://www.hazuscanada.ca.

2.2 Provincial Database

The Hazus Canada 2014 release includes a set of provincial/territorial inventory databases. These databases provide information on the population, buildings, and infrastructure for each province/territory. The Demographic and Residential data were generated using Canada Census 2011 data. Business data have been generated from data obtained from Dun & Bradstreet and added to the General Building Stock information. These data, aggregated to the Census Blocks and Tracts, are contained in the tables within the Bndrygbs.mdb file. For information on how the values for the aggregated datasets were calculated, see the appropriate .rtf files in the Documentation directory accompanying the software package. (Metadata information is also located in the Hazus program files within the Hazus-MH\Data directory.) There are no data in the province/territory inventory files other than the aggregated General Building Stock in the Bndrygbs.mdb file.

The provincial databases are included with the Hazus Canada software as a courtesy for users. The data from Canada census and Dun & Bradstreet have been manipulated to conform to the categories that Hazus uses. It is strongly recommended that users update the provincial database with more accurate information from their municipality or region of interest.

2.3 GIS Knowledge and Hazard Expertise Requirements

To use Hazus Canada, the user will need a standard level of GIS knowledge and hazard expertise. It is recommended that the user consult with flood hazard experts for the use of appropriate flood input data.

2.4 System and Software Requirements

In order for Hazus Canada to run properly, your system must meet certain minimum requirements (Figure 2-2). System requirements are directly related to the volume of data to be used in the analysis. Reasonable processing times can be expected when using a computer system that meets the requirements and analysing multiple flood

scenarios for large cities (population > 500,000). The operator is assumed to be working on an Intel PC.

Note: ArcGIS is a PC based program and the basis for Hazus. If you wish to run Hazus and ArcGIS on a Mac, you will need to use a virtual PC on the Mac operating system.

Computer Speed	2.2 GHz dual core or higher. 2 GB or higher of memory/RAM.
Disk Space	Approximately 10 GB of disk space is needed to store one multi-hazard large urban study region. Inventory data size varies by state; for the entire U.S., 30 GB are needed.
Video/Graphics Adapter	24-bit capable video card with at least 128 MB of video memory. A resolution of 1078 x 768 or higher is recommended.
Supporting Software	Microsoft Windows XP SP3 32-bit or Windows 7 Professional/Enterprise 32-bit or 64-bit. Only US English versions are supported* ESRI ArcGIS 10 SP2 Spatial Analyst extension required with flood model *Hazus-MH installation will allow user to install Hazus-MH on other operating systems/service packs, but Hazus-MH is not certified to work as well with those operating systems/service packs.

Figure 2-2 Hardware and software requirements for Hazus.

Hazus-MH is an ArcGIS-based program, with a standard Windows interface, and resides on top of ArcMap. Buttons are added to the ArcMap menu bar to perform hazard risk analysis and loss modelling functions (Figure 2-3).

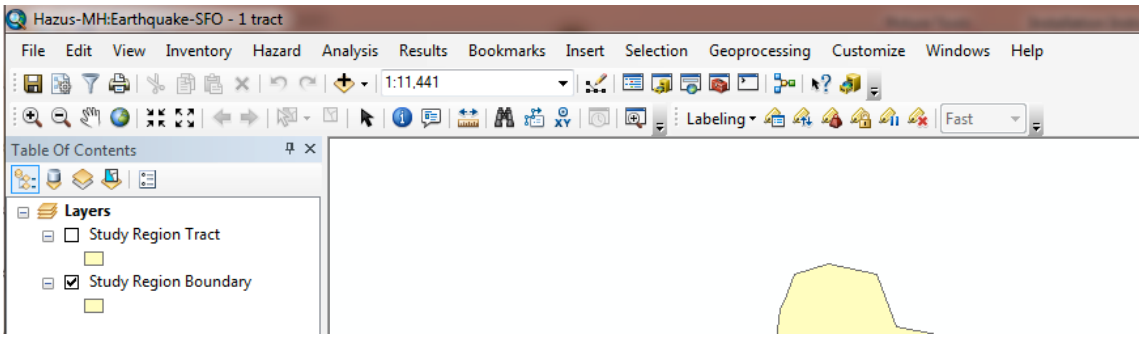


Figure 2-3 Hazus bar adds functions to ArcMap.

ArcGIS can be purchased by contacting Esri at **1-800-447-9778**, or online at http://www.esricanada.com. ArcGIS must be updated to Service Pack 2, available online at http://support.esri.com/en/downloads/patches-servicepacks.

Note: Hazus is not guaranteed to work with ArcGIS 10.0 Service Pack 3. Due to differences in data structures, Hazus will not work with ArcGIS 10.1 or later versions. Hazus databases are built as personal geodatabases and versions of ArcGIS that are newer than 10.0 do not support personal geodatabases. Future versions of Hazus may address this limitation.

Internet access is highly recommended in order to access additional data sources, technical support, software patches, and program status reports.

2.5 New Hazus Software Installation

Transfer the Hazus software program .exe file to your computer. Follow the steps in Section 2.5.1 before installing Hazus. Then proceed to Section 2.5.2 for step-by-step instructions for the installation. The install will create a Hazus-MH directory within the Programs directory and a Hazus-Data-CN directory on the C: drive. (These are the default locations. The user may specify other locations but it is recommended to use the defaults.)

2.5.1 *Adjust System Settings*

Follow the steps outlined below to adjust the system settings before Hazus Installation:

1. Start Windows and log in with an account with full Administrator privileges.

2. Confirm that in addition to having Administrator rights, you also have the Local Security rights listed in Table 2-1.

Table 2-1 Local security policy requirements.

Local Policy Object Display Name	User Right
Debug Programs	SeDebugPrivilege
Manage auditing and security log	SeSecurityPrivilege

Windows 7: From the **Start** menu, type **secpol.msc / s** in the *search programs and files* box, and click **Enter**. In the Local Security Policy tool (Figure 2-4), grant access to the *Debug Programs* and *Manage auditing and security log*.

3. Set your computer language, region, and locale settings to **English (United States)**. Hazus will not work with the language set to English (Canada).

Note: Changing these settings may impact other programs, particularly by setting default units to imperial measurements for scientific and mathematical programs.

Windows 7: Navigate to **Control Panel** and then to **Region and Language** settings. In the **Formats** tab, select **English (United States)** from the drop-down menu (Figure

2-5). In the **Administrative** tab, click **Change system locale…** (Figure 2-6) and select **English (United States)** from the drop-down menu (Figure 2-7). Click **OK**. Windows will prompt you to restart your computer (Figure 2-8); click **Restart now**.

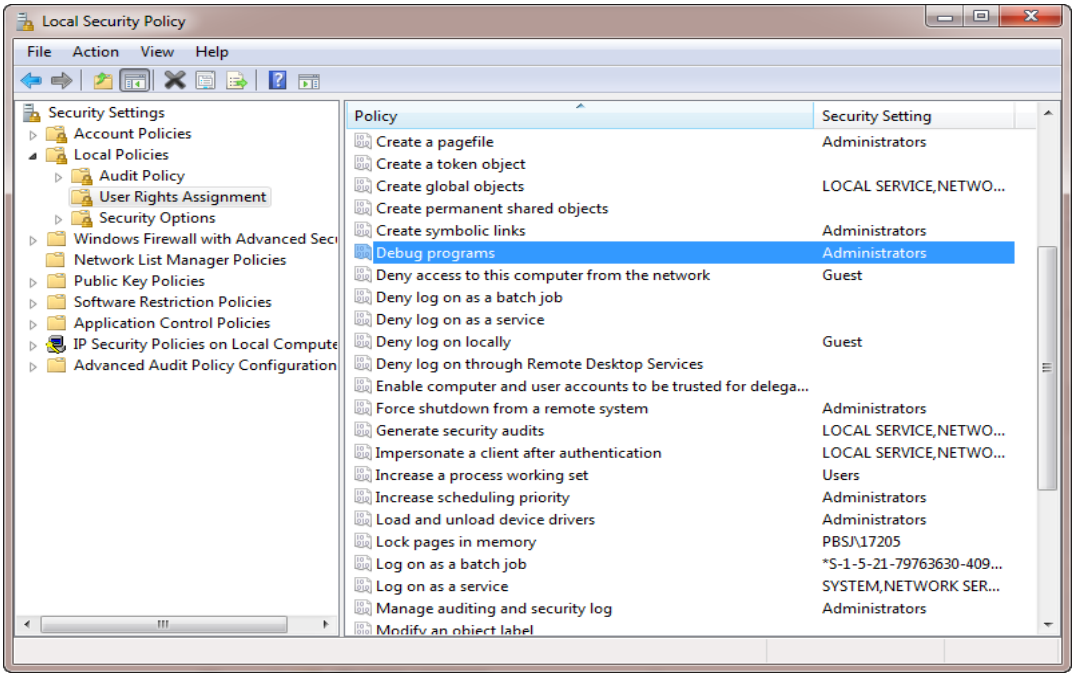


Figure 2-4 Local security policy tool.

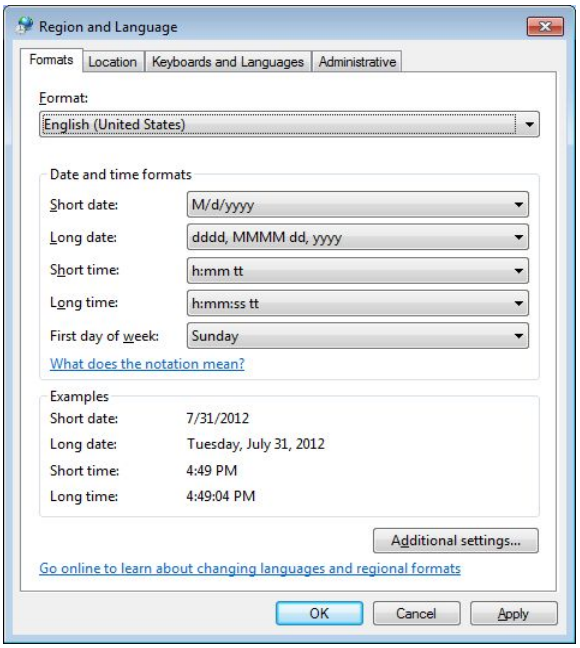


Figure 2-5 Windows 7 Region and Language settings, Formats tab.

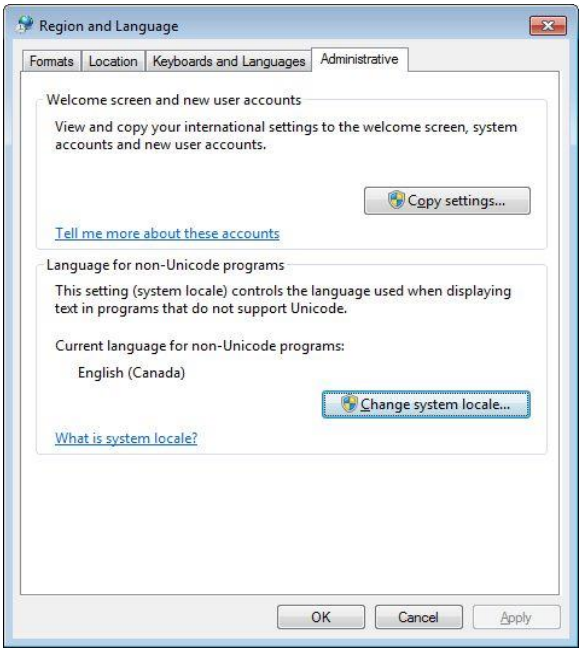


Figure 2-6 Windows 7 Region and Language settings, Administrative tab.

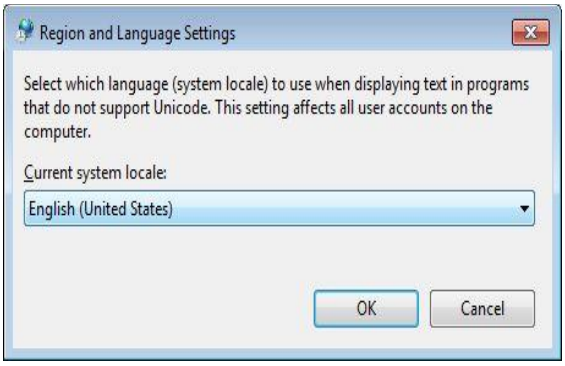


Figure 2-7 Windows 7 Region and Language settings, change Current system locale.

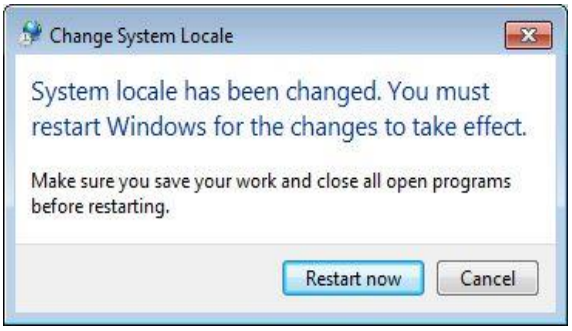


Figure 2-8 Windows 7 Region and Language settings, Restart now.

2.5.2 *Install Hazus*

1. Uninstall any prior versions of Hazus. Before uninstalling your old Hazus software, export any study regions you want to keep. Uninstalling and reinstalling Hazus will not delete the existing Hazus-Data-CN directory, but the new Hazus software will not recognize the pre-existing study regions. Export the existing study regions to .hpr files and then re-import them with the new Hazus program. The suggested procedure is:

    - Export the study regions you want to keep
    - Clean up the existing Hazus-Data-CN/Regions directory by deleting the regions (so it's not confusing when you see regions in the file directory but not in the Hazus regions list)
    - Uninstall Hazus
    - Reinstall new Hazus
    - Import the saved .hpr files when you want them

(See Section 2.6.3 of this Chapter for instructions on uninstalling Hazus-MH).

2. Download the Hazus application .exe file. This file is large and may take a while to transfer. Double-click on the file and installation files will self-extract to the directory specified in the first pop-up window.

3. Launch the installation program by performing the following steps.

Windows 7: Right-click **setup.exe** and select **Run as administrator** (Figure 2-9). If Windows 7 UAC (User Access Control) is not lowered, you will be prompted to allow an 'Unknown Publisher' to make changes to the computer, select **Yes**.

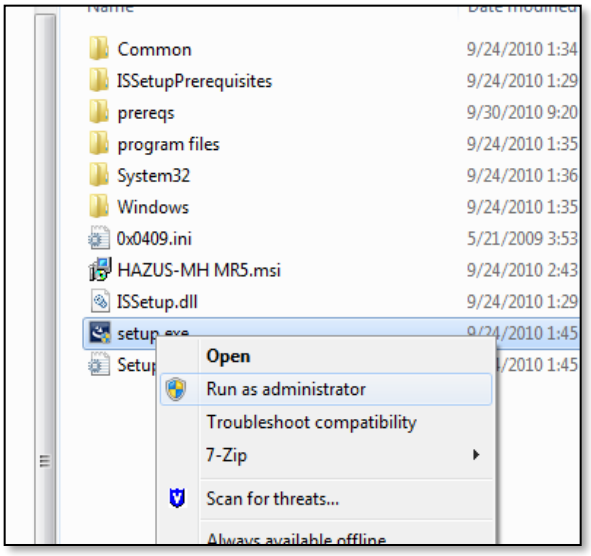


Figure 2-9 Launching Hazus setup with Windows 7.

4. The setup program will initially install the Hazus database (SQL Server Express 2008 R2). Next, the requirements screen will appear (Figure 2-2), and then the setup program startup screen (Figure 2-10). Click **Next** to continue.

Figure 2-10 Startup screen of the Hazus installation program.

5. Enter your **User Name** and **Company (or Agency)** information. Select the appropriate program access permissions option for your needs (Figure 2-11); allow access for all users or only for the installing user (excluding other users). Click **Next** to continue.

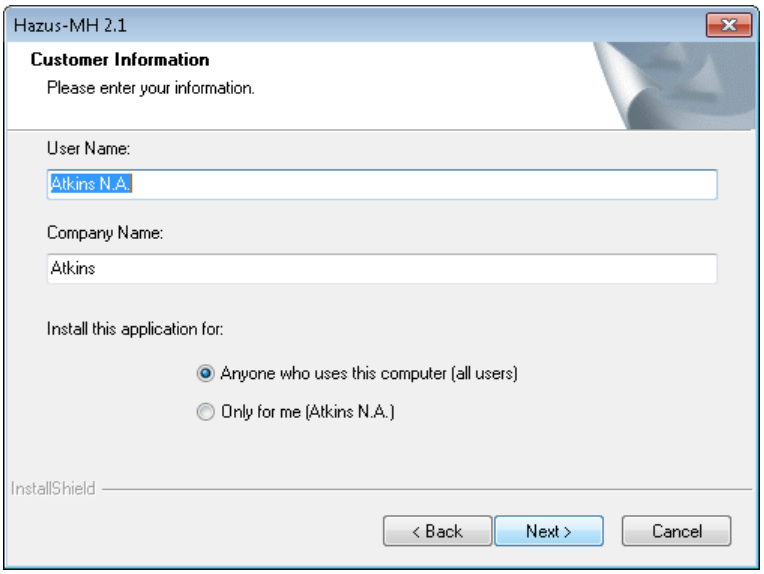


Figure 2-11 Register user name and program permissions.

6. In the **Select Features** dialogue, specify the hazard module(s) to be installed (Figure 2-12). As of this release, only the earthquake module and the flood module are certified for use in Canada. The Comprehensive Data Management System (CDMS) is needed for inputting data into Hazus and must be installed.

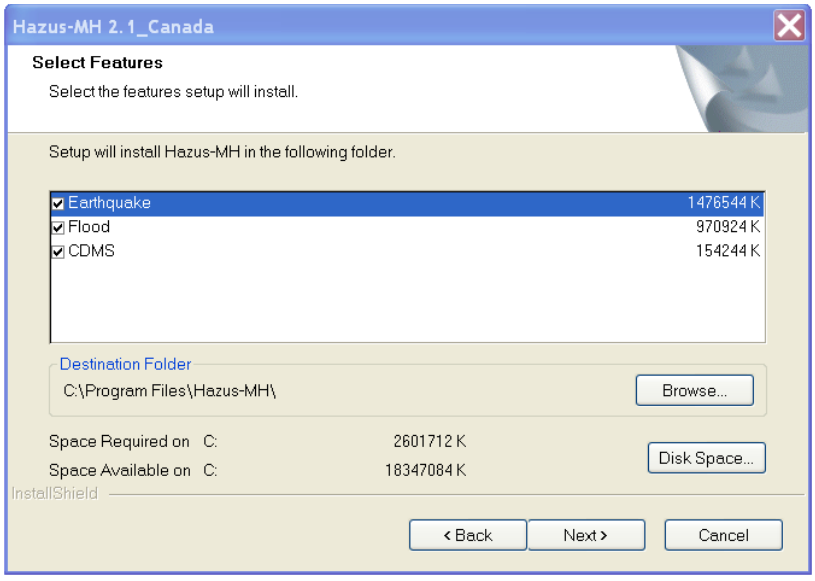


Figure 2-12 The modules to be installed.

7. The default installation directory (Destination Folder) is **C:\Program Files\Hazus-MH** (Figure 2-13). If you accept the default destination directory, click **Next** to continue the installation. Otherwise, click **Browse** to choose an

alternative installation directory. Click **OK** to return to the **Select Features** dialogue. Confirm that your custom path is listed as the Destination Folder and click **Next** to continue the installation.

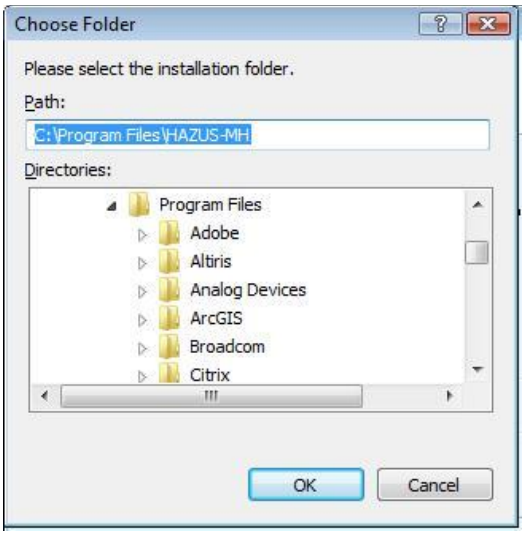


Figure 2-13 Specify the path of the Hazus installation directory.

8. Folders will be created for the data files associated with your study regions. The default directory to store study region data files (Regions Path) is **C:\Hazus-Data-CN\Regions** (Figure 2-14). Accept the default directory or click **Browse** to choose an alternative directory. Click **Next** to continue the installation.

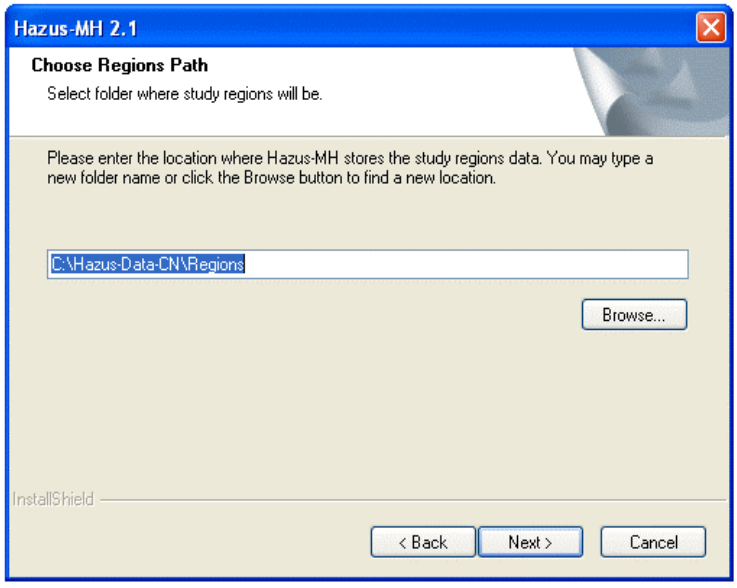


Figure 2-14 Default directory for study region files.

9. The default directory for storing inventory data (**Data Path**) is **C:\Hazus-Data-CN\Inventory** (Figure 2-15). Accept the default directory or click **Browse** to choose an alternative directory. Click **Next** to continue the installation.

   Note: The selected **Data Path** specifies only the directory where the default inventory data will be copied after the installation is complete. It does not copy the data to the specified folder. You must manually transfer the data after the installation. See Section 2.5.3 for instructions on importing inventory data.

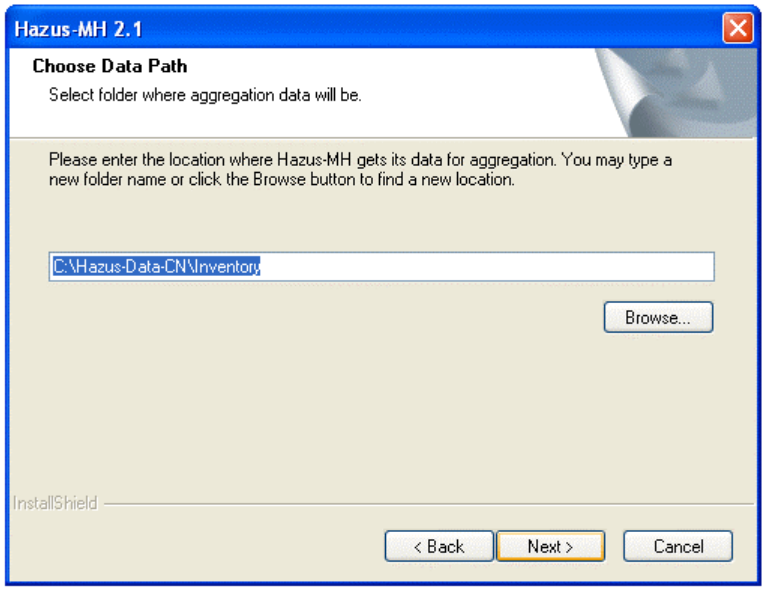


Figure 2-15 Default directory for inventory data.

10. The next screen (Figure 2-16) will display your selected installation settings and directory paths. Review the settings. Click **Next** to continue the installation with the specified settings, or click **Back** to edit your selections.

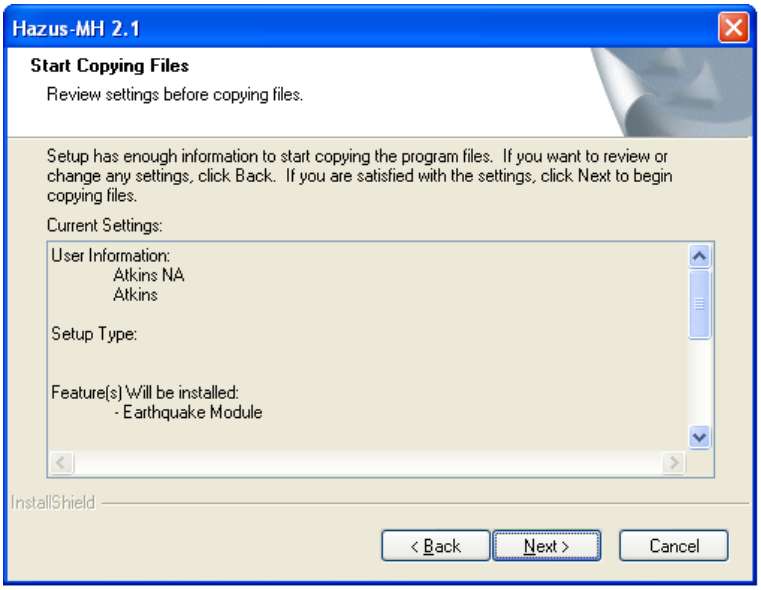


Figure 2-16 Confirmation of installation settings.

11. The installation may take several minutes. When it is complete, the **InstallShield Wizard Complete** dialog box (Figure 2-17) will appear and an automatic Hazus shortcut will be created on your desktop (Figure 2-18). Click **Finish** to return to Windows. If not automatically prompted, manually restart your computer.

Figure 2-17 Dialogue box indicating successful Hazus installation.

2.5.3 *Loading Provincial Inventory Data*

Default inventory data for Canada is included with the application files. The provincial databases are in .exe file format.

To create study regions, Hazus reads spatial information for the Census units from the syBoundary.mdb file and then reads the inventory for those Census units from the files within the provincial/territorial inventory databases. Check that the syBoundary.mdb file is located in the **Data Path** directory. This file is installed automatically when Hazus is installed and contains the spatial information for the census units for all of Canada.

The province/territory databases must be loaded into the **Data Path** directory, which was set during the installation process (Figure 2-15). There is one .exe file for each province/territory. Double click on the .exe file and the data will be automatically extracted and placed in the default **Data Path** directory. If the Data Path was changed by the user during installation, the data will need to be moved to the correct Data Path directory. Each province/territory will be a folder within the **Data Path** directory. It is best to extract only the province/territory folders you require. Extracting all of the province/territory inventory data will require a large amount of space on your hard drive.

If you used the default **Data Path** for storing inventory data, your folder directory hierarchy should appear as follows, using AB and SK as examples:

Data Path	C:\Hazus-Data-CN\Inventory
File with Census units	syBoundary.mdb
Province Folder	AB
Province Files within AB folder	bndrygbs.mdb
	EF.mdb
	flAg.mdb
	flVeh.mdb
	HPFL.mdb
	MSH.mdb
	TRN.mdb
	UTIL.mdb
Province Folder	SK
Province Files within SK folder	bndrygbs.mdb
	EF.mdb
	flAg.mdb
	flVeh.mdb
	HPFL.mdb
	MSH.mdb
	TRN.mdb
	UTIL.mdb

If errors are generated when creating a study region, confirm that the inventory data is in the correct location. If you are still experiencing difficulties, see Section 6.1 for more assistance.

2.5.4 *CDMS for Hazus Canada*

CDMS (Comprehensive Data Management System) is a program used to update provincial databases with local information. It is one of the features that are selected when Hazus is installed.

There is a known issue with the CDMS program. When updating a provincial database with local data, the CDMS option to “Import Site Specific Data to Aggregate Data” will not aggregate individual building data into the Block tables. A workaround has been developed which will aggregate the user’s data and prepare a file that can be imported through CDMS as an “Aggregated Data” file. This workaround, CDMS_Building_Aggregate_Template.mdb, is a personal geodatabase which the user will need to fill in with the data about the local buildings. The geodatabase has a Macro which will aggregate the local data and prepare it for import into CDMS. The geodatabase can be found in the Templates directory of the installation files. There are specific instructions for using this geodatabase which are found in the file “Using_CDMS_Building_Aggregate_Template.docx”.

(Refer to Section 3.3.1 of this manual for more on the CDMS Building Template)

2.6 Program Basics

2.6.1 *Starting the Program*

The installation program creates a Hazus icon/shortcut on your computer desktop. To start the program, double-click the Hazus icon (Figure 2-18).

Figure 2-18 Hazus icon.

The first window of Hazus allows the user to create, open, or backup a study region. Refer to Section 4.1 for information on creating a study region. Once a study region has been opened, the ArcGIS window will appear.

2.6.2 *Hazus ArcGIS Menu Bar*

Hazus adds hazard risk analysis and loss modelling functions to ArcMap. All other Hazus features are identical to standard ArcMap functions. The Hazus user interface is comprised of a menu bar, tool bar, and various screens and windows.

In addition to the general ArcMap menus, there are four additional Hazus functional menus. These additional menu items are described in Table 2-2 Additional menus items in Hazus.and include: **Inventory** (Figure 2-19), **Hazard** (Figure 2-20), **Analysis** (Figure 2-21) and **Results** (Figure 2-22).

Table 2-2 Additional menus items in Hazus.

Additional Menu Item	Description
Inventory	View the data inventory and add, edit, delete and copy inventory information.
Hazard	Select hazard scenario and input maps as required.
Analysis	Modify analysis parameters, perform an analysis.
Results	View and map analysis results.

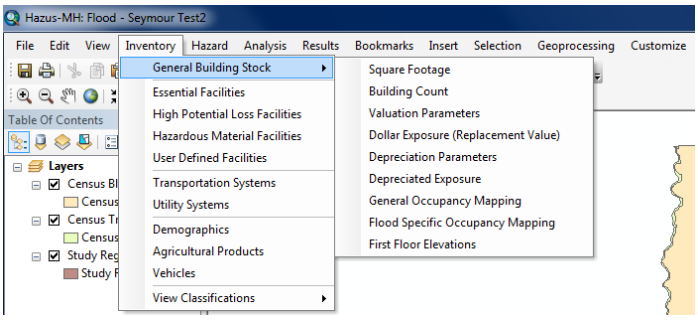


Figure 2-19 Hazus Inventory menu.

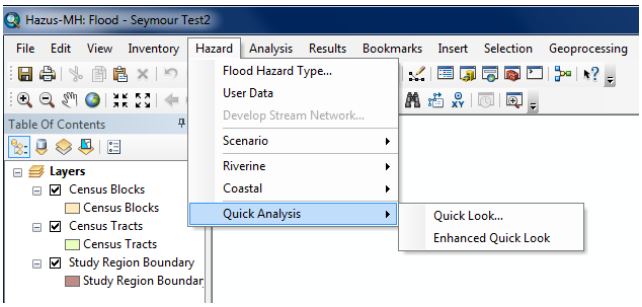


Figure 2-20 Hazus Hazard menu.

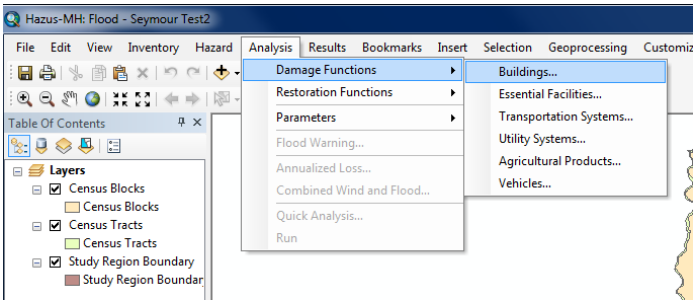


Figure 2-21 Hazus Analysis menu.

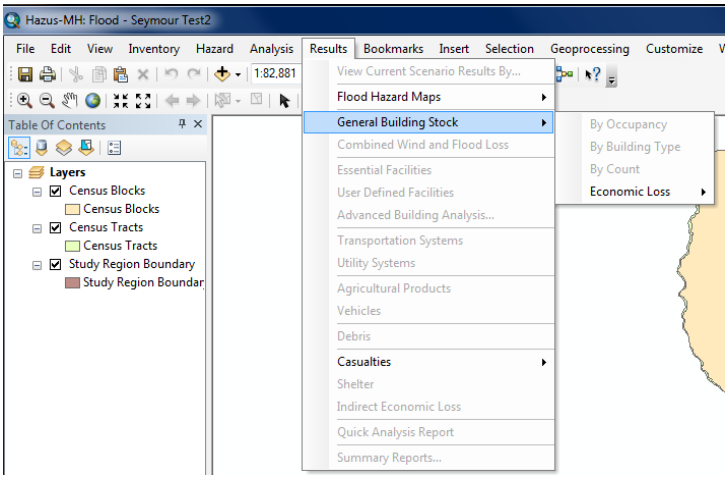


Figure 2-22 Hazus Results menu.

2.6.3 *Uninstalling Hazus-MH*

To uninstall Hazus-MH, the user must log into Windows with full Administrator privileges. Follow the steps below:

1. The install wizard will launch and provide you with three uninstall options:

a) **Modify** your previous installation (e.g., Add tools);

b) **Repair** (reinstall) program components; and

c) **Remove** all program features.

2. Select **Remove** and click **Next** to uninstall Hazus-MH.

3. When prompted, click **OK** to confirm the program removal.

Windows 7:

1. From the **Start** menu, select **Control Panel** and then select **Uninstall a program**.

2. Right-click on Hazus-MH (Figure 2-23). Select the **Uninstall** option from the pop-up menu and then select **Remove**.

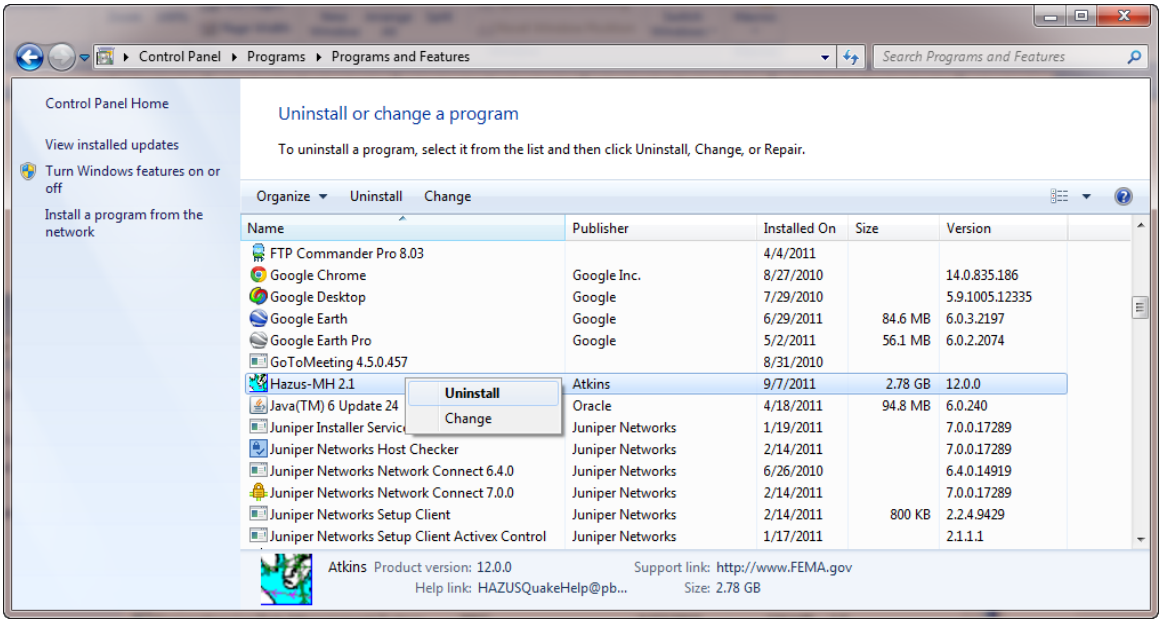


Figure 2-23 Uninstall screen for Windows 7.

3. The installation wizard will provide you with three uninstall options:

a) **Modify** your previous installation (e.g., Add tools);

b) **Repair** (reinstall) program components; and

c) **Remove** all program features.

4. Select Remove and click **Next** to uninstall Hazus-MH.

5. When prompted, click **OK** to confirm program removal.

2.6.1 *Freeing Memory Using SQL Server Manager*

SQL Server can often lock memory as a working set. Because memory is locked, Hazus or other applications might receive 'out of memory' errors or run slower. To work around this problem, restart the SQL Server service by following ***one*** of the steps below:

1. Restart your computer; ***or***

2. Restart SQL Server using the **SQL Service Manager**. Follow the steps below to open the SQL Server Service Manager (SQL SSM) and restart the service:

   a) Close Hazus-MH, if it is running.

   b) Open a Command window (**Start | Run | cmd**).

   c) Type NET START MSSQL$HAZUSPLUSSRVR and click **Enter**.

      Note: You should see a message about the service having stopped successfully.

   d) Type NET START MSSQL$HAZUSPLUSSRVR and click **Enter**.

      Note: You should see a message about the service having started successfully.

   e) Close the Command window by typing **Exit**.

2.7 Limitations

Software limitations could result from large database sizes and from the processing environment itself. As an indication of the time required for processing, analysing and producing loss estimates for a large study region, a study region of 1000 to 2000 census tracts could take an hour to complete.

2.7.1 *SQL Service Limitations*

The database management system of Hazus-MH 2.1 is SQL 2008 Express R2. This system has a size limit of 10 GB per database, which limits the size of the region that can be created. To work around this, a full version of Microsoft SQL Server 2008 R2

must be used. Many functions take a long time to run. The speed of study region aggregation can be increased by copying the database to the local hard disk.

Chapter 3 Inventory Data Inputs for Hazus Use in Canada

(Also refer to Chapters 1, Section 1.3; 3, Section 3.2; 4, Section 4.1; 5, 6 and 7 of the *Hazus-MH 2.1 Flood Model User Manual* for more information on asset inventory data.)

The basic requirements for analysis using Hazus are inventory data and hazard event information. The inventory data represents the built environment upon which a hazard event occurs. This chapter gives an overview of inventory data types and the tools used for adding additional and/or updated data. See Figure 3-1 for a chapter flow chart with section references.

3.1 Default Asset Inventory

The default asset inventory is contained within each provincial database that is supplied with Hazus Canada. See Section 2.5.3 for information regarding the loading of the inventory data. The default provincial databases include demographics and aggregated residential building stock derived from the 2011 Statistics Canada Census data, and business and commercial data derived from data obtained from Dun and Bradstreet in 2013. Section 3.1.2 provides information on how the data was processed to create the provincial databases.

Note: Provincial database is a term used in Hazus Canada that refers to databases for provincial and territorial inventories.

3.1.1 *Provincial Database Structure*

The provincial database is a folder containing specific personal geodatabases with specific feature classes. The class files starting with *hz* are used for all hazards and contain inventory information. File names starting with *eq* are files with specific information for Earthquakes; *fl* files are for Floods; and *hu* files are for Hurricanes.

The General Building Stock inventory contains information for buildings aggregated to a census dissemination block. This inventory contains aggregated information for residential, commercial and industrial buildings. Specific buildings of special interest, such as schools, hospitals, etc., can be updated in the Essential Facilities database. Dams, public utility facilities, etc., can be updated in the appropriate database.

The flood module provincial geodatabase includes databases listed in Table 3-1

3.1.2 ***Data in the Canadian Provincial Databases***

Census Canada Geographic Areas

Census Canada uses the following spatial units for its geographic areas, listed from largest to smallest area: Province (PRUID), Census Division (CDUID), Census

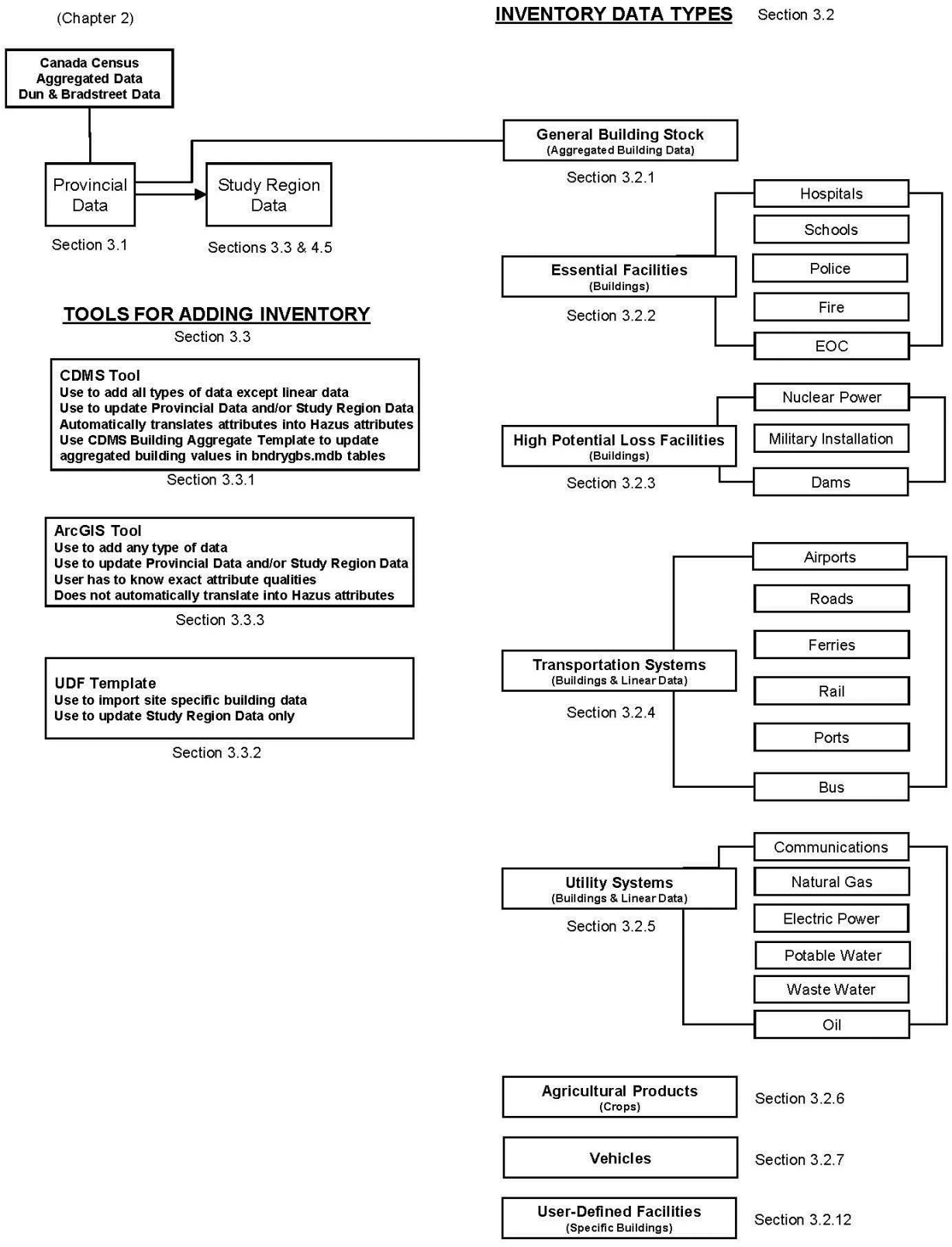


Figure 3-1 Chapter flow chart of inventory data types and tools.

Table 3-1 Provincial geodatabase files.

Database File Name	Database Content
Bndrygbs.mdb	County, tract, and block polygon features; all the demographic and general building stock information aggregated per census block and per census tract Note: Square footage and dollar values are in thousands.
EF.mdb	Essential Facilities: medical care facilities, emergency operation centres, fire stations, police stations, and schools
flAG.mdb	Polygon features outlining agricultural areas with associated data Note: As agricultural data is not available for use in Hazus Canada this geodatabase contains no data
flVeh.mdb	Vehicle inventory: contains information about the number, type, and value of vehicles Note: As vehicle inventory data is not available for use in Hazus Canada this geodatabase contains no data
HPLF.mdb	High Potential Loss Facilities: dams, Hazmat locations, levees, military facilities, nuclear facilities
MSH.mdb	Mapping Schemes: contains additional information about the general building stock that is generated when data is imported into the database
TRN.mdb	Transportation Facilities: road, rail, airport, bus, ferry, port
UTIL.mdb	Utility Facilities: electricity, natural gas, potable water, waste water, oil, communication

(Also refer to the *CDMS Data Dictionary* for more detailed information about the content of the provincial databases.)

Subdivision (in non-urban areas) (CSUID), Census Tract (in urban areas) (CTUID), Dissemination Area (DAUID), Dissemination Block (DBUID). The Census Canada

spatial units and their unique identifying numbers were converted to unit names and identifying numbers compatible for use in Hazus.

Table 3-2 shows the spatial unit conversion equivalents.

Note: Census tracts in Canada range in size from a few city blocks (in urban areas) to several hundred square kilometres (in rural areas). Their boundaries have a unique identification number, which may change slightly with each census. The Census Tract boundaries never cross and are nested within the larger divisions.

Table 3-2 Statistics Canada spatial units and equivalent Hazus units.

Statistics Canada ID	Equivalent Hazus format ID
DBUID - Dissemination Block ID	CensusBlock
DAUID – Dissemination Area ID	Tract
CDUID - Census Division ID	County
PRUID - Province ID	State

Census Canada Demographic and Residential Data

The demographic information in the Census Canada spatial units were converted to the Hazus equivalent units. Some fields, such as Total Population per Tract, could be transferred directly. Other fields, such as Population per Age group, needed to be calculated from the Census Canada fields since the categories were not equivalent to the Hazus categories.

The residential building stock information was converted to fit the Hazus occupancy codes. In order to assign Hazus Occupancy Codes to the Statistics Canada building classifications, conversions based on common features were used. Table 3-3 details how the conversions were applied.

The replacement costs for residential buildings were derived from the construction costs provided by RSMeans tables. The 2006 RSMeans values per occupancy class are found in:

- The file ProgramFiles\Hazus-MH\Data\HzAnalParams.mdb, Tables hzReplacementCosts and hzRes1ReplCost, or
- Tables 14.1 to 14.3 of the *Hazus-MH 2.1 Flood Model Technical Manual*.

Table 3-3 Conversion from Statistics Canada classes to Hazus occupancy codes.

StatsCan Classification (estimated range of number of units)		Hazus Occupancy Code (range of number of units)
Single-detached house (1)		RES1 (1)
Other single attached (1)		
Movable dwelling (1)		RES2 (1)
Semi-detached house (2)		RES3A (2)
Apartment, duplex (2)		
Rowhouse (3~10)	30%	RES3B (3-4)
	70%	RES3C (5-9)
Apartment, building has fewer than five storeys (6~32)	70%	RES3D (10-19)
	30%	RES3E (20-49)
Apartment, building that has five or more storeys (20~)	30%	
	70%	RES3F (50+)

Non-residential Data in Canadian Provincial Databases

To populate data for commercial and industrial Hazus occupancies, NRCan acquired the Dun and Bradstreet 2013 business data, including:

- Latitude, longitude
- US NAICS Code and description
- Employees
- Square footage
- Latitude/Longitude Accuracy Code
- Physical Address and Business Name

Individual businesses were amalgamated into buildings, and this data aggregated into Census boundaries. RSMeans 2006 values (See Tables 14.1 and 14.2 of the *Hazus-MH 2.1 Flood Model Technical Manual*) were used to calculate building and content replacement costs. It is highly recommended that users update the provincial database using their own sources of information.

3.2 Updating the Provincial Asset Inventory

Improving your asset inventory to run a more accurate and comprehensive analysis is relatively simple, as the data likely already exists for your jurisdiction, even if it requires

consolidation and conversion into Hazus parameters. Preparing your data to update the provincial database is done outside of Hazus, through the application-specific Comprehensive Data Management System (CDMS) which accompanies Hazus Canada; or, by using data interoperability functions within ArcGIS.

The user may need to determine parameters from published reports or maps as inputs to the model, or to seek technical experts to acquire data, perform detailed analyses, assess damage/loss, and assist the user in gathering more extensive inventories. Participation by local utilities and special facilities owners may be warranted to create a more comprehensive systems analysis.

Data sources that could be used to support this level of analysis may include:

- provincial assessment data;
- provincial and/or municipal critical infrastructure data;
- national databases (such as NRCan's CanVec, available from GeoGratis);
- expertise from geologists, engineers;
- emergency managers' knowledge and expertise; and
- building code application for structures.

(Refer to http://www.hazuscanada.ca for examples of case studies using Hazus Canada).

CDMS supports the seamless transfer and validation of local data into the Hazus databases, and reads *.mdb*, *.shp*, *.csv* and *.xls* file formats.

Note: Where applicable, attribute fields must be defined correctly in terms of field types (text, integer, double number, etc.) and field lengths.

(Refer to Chapters 5, 6 and 7 of the *Hazus-MH 2.1 Flood Model User Manual*; the *CDMS Data Dictionary*; and the Help menu in the CDMS program.)

The following Sections provide information on the parameters that Hazus expects for each inventory type.

Note: Hazus Canada uses square feet for building area. If the source information is in square metres and the replacement cost is in price per square metre, then it is suggested that the calculation of the replacement cost of a feature be done before converting the area to square feet units. Some features in Hazus use kilometres, such as length of pipeline, roads, and railway tracks. Care needs to be taken to provide user-supplied information in the appropriate units. Documentation of units in the US Hazus manuals and the Hazus software is incomplete. Units often need to be interpreted from source data when not explicitly stated.

3.2.1 *General Building Stock Parameters (GBS)*

The General Building Stock (GBS) is building data aggregated per geographic unit. To update the GBS, the user should gather as much information as possible for each building in their area of interest and use that as the import for CDMS. The CDMS program will overlay the user's inventory with the corresponding geographic files and will aggregate the values and transfer them to the provincial database.

For a complete and detailed list of these parameters refer to the *CDMS Data Dictionary* (page 43 and 44 for general building information, and page 46 for flood related information). Note that the Flood Insurance Rate Maps (FIRM) are not applicable in Canada. (For more information on FIRM refer to http://www.fema.gov/.)

3.2.2 *Essential Facilities (EF)*

Essential facilities are those that are important to be functional after a flood event as they provide essential services to the community affected. Hospitals, schools, fire and police stations are all considered essential facilities.

For updating refer to the *CDMS Data Dictionary;* Chapters 3 (Section 3.2.3), 5, 6, and 7 (Section 7.2) of the *Hazus-MH 2.1 Flood Model User Manual,* and Chapter 3 (Section 3.2.2) of the *Hazus-MH 2.1 Flood Model Technical Manual.*

3.2.3 *High Potential Loss Facilities (HPLF)*

High potential loss facilities are those that are likely to cause heavy losses if damaged by a hazard event. Nuclear power plants, dams, and some military installations would be considered as HPLF. Note that HPLF are not included in the damage and loss estimation calculation in the flood module, but knowing the locations of such facilities the user can ascertain the potential for problems if a flood scenario were to occur.

For updating refer to the *CDMS Data Dictionary;* Chapters 3 (Section 3.2.4), 5, 6, and 7 (Section 7.2) of the *Hazus-MH 2.1 Flood Model User Manual;* and, Chapter 3 (Section 3.2.3) of the *Hazus-MH 2.1 Flood Model Technical Manual.*

3.2.4 *Transportation Systems (TRN)*

Transportation systems include highways, railways, light rail, bus facilities, ports, ferries and airports. These systems affect the movement of people and goods from one location to another. In Hazus, the transportation systems include linear features, such as roads and railways, plus individual point features such as bridges, tunnels, and building depots or stations. The flood model will only analyze losses to point features, such as bridges for roads, rail and light rail (pedestrian bridges are not included in the inventory). Hazus flood model does not analyze damage to the linear features. however, information on the other components can be added into the databases for reference.

For updating, refer to the *CDMS Data Dictionary*; Chapters 3 (Section 3.2.6), 5, 6 and 7 (Section 7.2) of the *Hazus-MH 2.1 Flood Model User Manual*; and, Chapter 3 (Section 3.3) of the *Hazus-MH 2.1 Flood Model Technical Manual*.

3.2.5 ***Utility Systems (UTIL)***

Utilities are essential service systems vital for economic and social well-being and include communication, electric power, natural gas, oil, potable water and wastewater. These service systems consist of building facilities as well as pipelines and wells. The Flood Model will only use the building data for analysis, but any information on the other components can be added into the databases for reference purposes.

For updating refer to the *CDMS Data Dictionary;* Chapters 3 (Section 3.2.7), 5, 6 and 7 (Section 7.2) of the *Hazus-MH 2.1 Flood Model User Manual;* and, Chapter 3 (Section 3.4) of the *Hazus-MH 2.1 Flood Model Technical Manual.*

3.2.6 ***Agricultural Products (AGR)***

Agricultural products deal specifically with crops grown in the study area. Crop type, geographic locations, current market value, and planting season data are part of the default agricultural products base. The date of the flood and the duration of the flood are important factors needed for the prediction of the potential losses that could occur to planted cropland in the event of a flood. These data are used to determine damage functions. The existing damage functions in Hazus are based on US crops and growing seasons. To improve modelling accuracy it is suggested to update crop information and modify the damage functions.

For updating and modifying agricultural data and modifying damage functions refer to the *CDMS Data Dictionary;* Chapters 3 (Section 3.2.10), 5, 6, 7 and 10 of the *Hazus-MH 2.1 Flood Model User Manual;* and, Chapters 3 (Section 3.5) and 9 of the *Hazus-MH 2.1 Flood Model Technical Manual.*

3.2.7 ***Vehicles (VEH)***

Vehicle damage can be significant in the event of a flood. Local information on number of vehicles in the study area, their location, and any dealerships or other information is used by the Flood Model for estimating the cost of flood related damages to motor vehicles. This information has not been populated for Canada.

To input vehicle data and modify damage functions refer to the *CDMS Data Dictionary;* Chapters 3 (Section 3.2.11), 5, 6, 7 and 10 of the *Hazus-MH 2.1 Flood Model User Manual;* and, Chapters 3 (Section 3.6) and 8 of the *Hazus-MH 2.1 Flood Model Technical Manual.*

3.2.8 *Importing Linear Data into Hazus*

The Hazus Flood model does NOT analyse impacts to linear transportation or utility features (roads, railways, pipelines). These features are not currently included in the province/territory databases. These features can be added by the user for reference or visual purposes. The CDMS program cannot be used to import linear features into the database. It is suggested that ArcGIS tools be used (see Section 3.3.3).

3.2.9 *Data Stewardship*

To ensure that inventory data is current and maintained, it would be ideal to define data stewards and establish agreements with those stewards for seamless data sharing.

(Refer to The Polis Center's *The Role of Hazus-MH in the Canadian Natural Disaster Management Strategy, GSC Open File 7152,* for recommendations on data stewardship for Canada.)

3.2.10 *Individual Building Inventory*

Analysis can be performed on individual buildings using the *User Defined Facility* (UDF) module available in Hazus. This module is used to add information after a study region has been created. See Section Inventory Import Menu in Hazus 3.3.2 of this Chapter for information on adding individual building data to a study region.

3.2.11 *Design Level*

Hazus uses the approximate time period a building was built as an indicator of the design level. Those time periods are outlined based on the year in which the US Flood Insurance Rate Map (FIRM) was introduced in a given jurisdiction. Buildings are then assigned either a Pre-FIRM or Post-FIRM designation indicating a low or high design level.

Hazus Canada does not use FIRM and therefore the design level of all buildings in the general building stock are assigned the design level of Pre-FIRM.

3.2.12 *Occupancy Mapping Schemes*

Hazus uses Occupancy Mapping Schemes to describe the aggregated building stock by occupancy, building construction type, and location. The default Occupancy Mapping Schemes in Hazus Canada were adapted for each province or territory from a comparable neighbouring US state. Table 3-4 indicates the proxy states used for occupancy mapping schemes in Hazus Canada.

A user can update these Occupancy Mapping Schemes if there is access to knowledge of construction norms in the area of interest. This can be done manually within Hazus

using the occupancy mapping function in the **Inventory** functional menu (see Table 3-3 for occupancy code conversion guidance), or it is done automatically if using CDMS to overwrite data in the Provincial dataset. If the Occupancy Mapping Schemes are modified, the local construction will be more accurately reflected in the analysis. More information on modifying the mapping schemes is given in Section 4.6.6 of this manual.

(Also refer to Chapter 3, Section 3.2.1.3 of the *Hazus-MH 2.1 Flood Model Technical Manual*, and Chapter 7 of the *Hazus-MH 2.1 Flood Model User Manual*.)

Table 3-4 Occupancy Mapping Scheme proxy states for Hazus Canada

Province / Territory	State used for Occupancy Mapping Scheme proxy
British Columbia	Washington
Alberta	Montana
Saskatchewan	Montana
Manitoba	North Dakota
Ontario	Michigan
Quebec	Maine
Newfoundland	Maine
New Brunswick	Maine
Nova Scotia	Maine
Prince Edward Island	Maine
Yukon	Alaska
Northwest Territories	Alaska
Nunavut	Alaska

3.3 Data Import Tools

Inventory data can be added to either your provincial dataset or to your study region. Adding data to your study region means that the data can only be used in that one study region. If you create a new study region, the data you added to the previous study region will not be updated in the new study region. In this case, you will need to add the same data again to your new study region.
If you add data to your provincial database, all new study regions you create will automatically extract the data from your expanded provincial database.

There are three ways to import inventory data into Hazus: the Comprehensive Data Management System tool (CDMS), the Inventory import menu option in Hazus, or the load tool in ArcGIS.

Use Table 3.5 below as a guide to selecting the best method for adding data to Hazus.

(Also refer to Chapter 6 of the *Hazus-MH 2.1 Flood Model User Manual* for data requirements, standardisation, and classification.)

Table 3-5 Data import methods.

Import Tool	Function
Comprehensive Data Management System (CDMS)	Use to update datasets in the provincial database for **aggregated general building stock** or for facilities under EF, HPLF, TRN, or UTIL. The CDMS program only imports point data or tables.
ArcGIS load tools	This is an ArcGIS tool. You will need to know the exact attribute qualities of an updated field. Must be used if importing linear data.
Inventory import options in Hazus	Use to add building or facility specific data to a study region for User Defined Facilities inventory, or for facilities under EF, TRN, UTIL or HPLF.

3.3.1 *Comprehensive Data Management System*

(Refer to Chapter 8 of the *Hazus-MH 2.1 Earthquake Model User Manual*; the *CDMS Data Dictionary*; and, the Help menu in the *CDMS* program.)

Municipalities often have more up-to-date data on residential, commercial and industrial buildings. It is ideal to update the default inventory data in Hazus Canada with local data.

The Comprehensive Data Management System (CDMS) software is used to read a user-supplied list of buildings and update the tables of aggregated information in a provincial database. CDMS will read MS Access files and personal geodatabases (.mdb), ESRI Shape files (.shp), comma delimited text files (.csv), and MS Excel files

(.xls). All attribute fields must be in the correct format (text, integer, double number, etc.) and field size.

Note: It is recommended that users set up the data they wish to import into CDMS with all required fields for both Earthquake and Flood hazards and subsequently import the data for both hazard types. This will help minimize importing errors that arise when importing data for a single hazard type.

Currently, CDMS will not aggregate the buildings to the Block tables. A workaround has been created to aggregate the buildings before using CDMS. The user-generated aggregated values are then input through CDMS and the values are transferred to the provincial database. The personal geodatabase **CDMS_Building_Aggregate_Template.mdb** was created to generate the aggregated values (see below). CDMS for Canada will be fixed in the future.

Note: The CDMS and Hazus programs work only with provincial databases with the corresponding two letter codes. To ensure that CDMS is accessing the correct provincial database, use the CDMS **Tools** menu, then **Specify Hazus MH Data Location** (Figure 3-2).

Figure 3-2 Specify Hazus MH data location.

Important: Before updating the provincial database, make a copy of the original database and rename it appropriately.

CDMS Building Aggregate Template

1. In *Microsoft Access* ensure that the **Action queries** option is turned off.

    - *Access 2003*: **Tools** -> **Options** -> **Edit/Find** -> **Confirm** -> uncheck **Action query** (Figure 3-3).
    - *Access 2010*: check **Help** for "Turn action query confirmation messages off for a database."

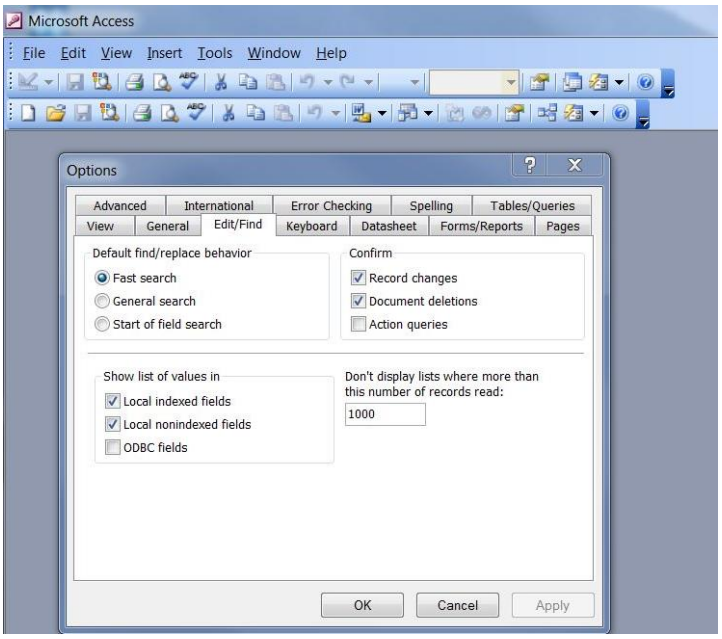


Figure 3-3 Ensure 'Action' queries option is turned off.

2. Using the **CDMS_Building_Aggregate_Template.mdb**, populate the **Buildings** table with buildings for your province/study region. The fields in the Building feature class that are **required** for the aggregation are (Figure 3-4):

    - **CensusBlock** (15 character Block number)
    - **Occupancy** (ie. RES1, IND1, COM1 etc.)
    - **Th_SqFt** (total square footage in thousands)
    - **Th_RplCost** (total replacement cost in thousand dollars)
    - **Th_Content** (total content cost in thousand dollars)

The other fields are for identification purposes for the user. Do not change the field names of the required fields. View the **Buildings** table in **Design** mode to see comments and domains for the fields (Figure 3-5).

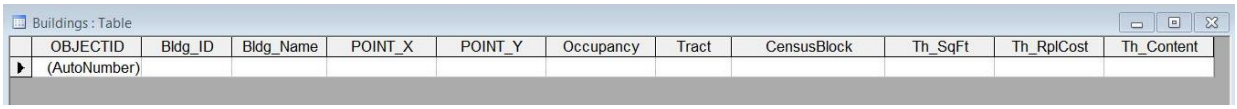


Figure 3-4 Buildings table.

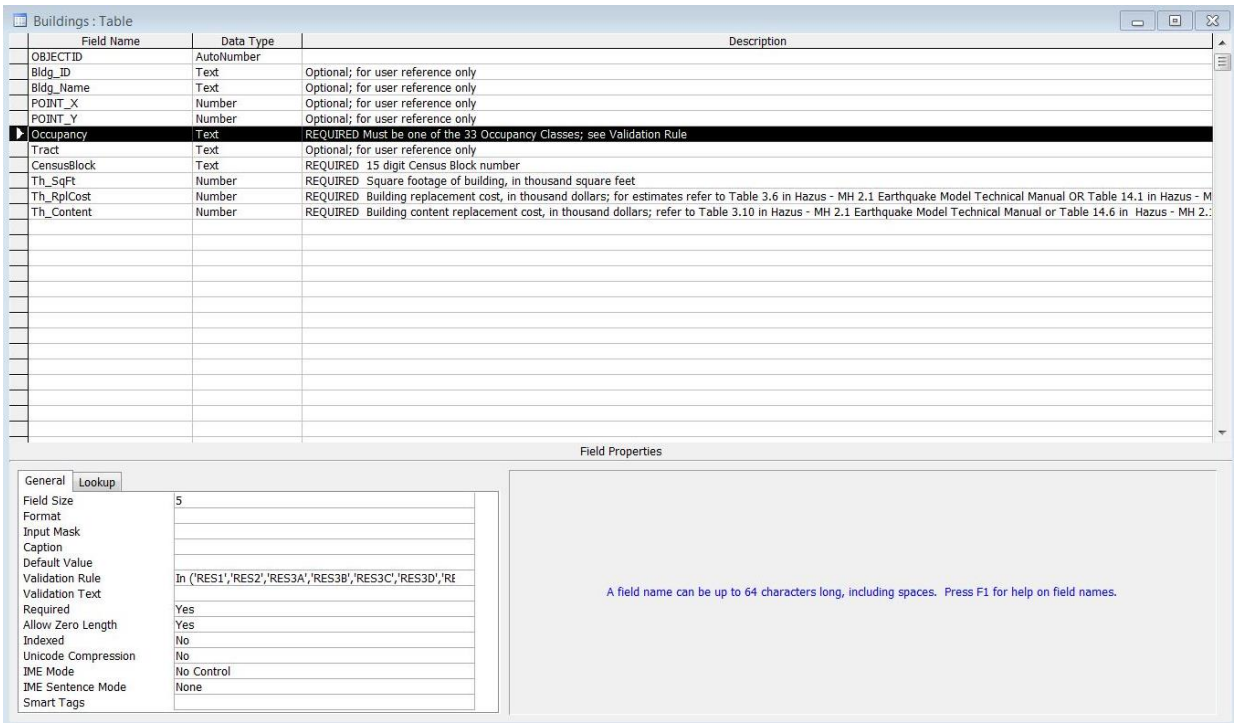


Figure 3-5 View of buildings table in design mode.

3. **Run the Macro** named **A - Create and Populate Tables** (Figure 3-6 and Figure 3-7). Select **Yes** for the five pop-up windows that occur (Figure 3-8). This macro will populate the **BldgCountOccupB**, **ExposureContentOccupB**, **ExposureOccupB**, and **SqFootageOccupB** tables with the aggregated values calculated from your **Buildings** table. Another table, **Occupancy_Info**, is also populated with a summary of the aggregated information. View the five tables to check for any inconsistencies in values.

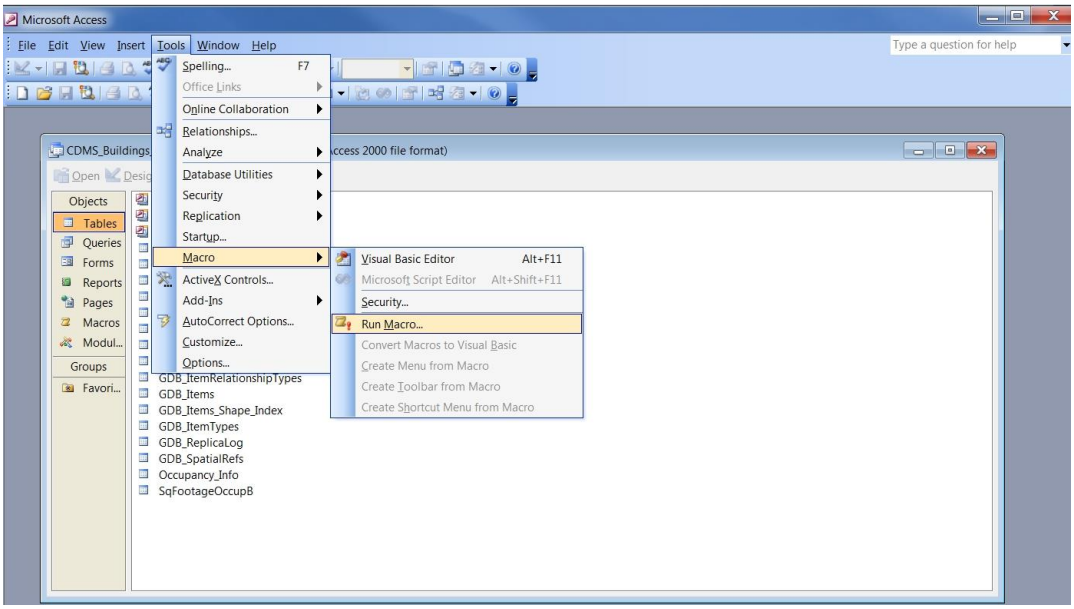


Figure 3-6 Select Run Macro.

Figure 3-7 Choose Macro A - Create and Populate Tables.

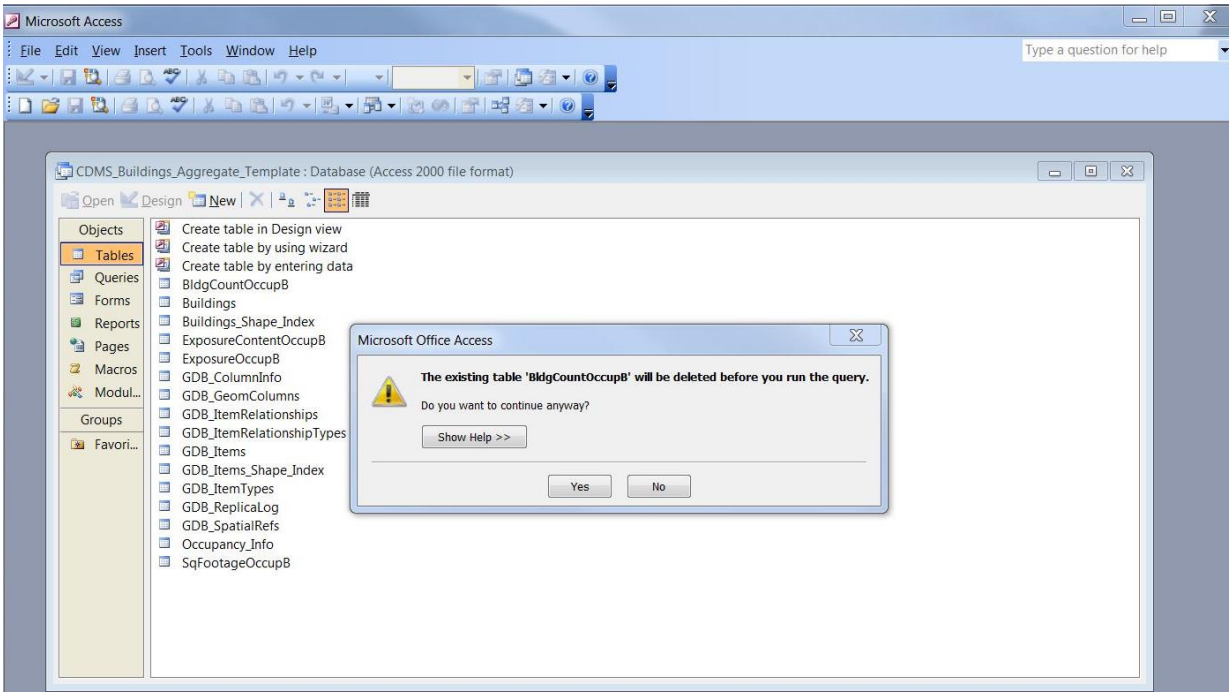


Figure 3-8 One of five pop-up windows. Select Yes.

4. Each of the aggregated tables created in Step 3 can now be imported into CDMS to populate the aggregated Block level tables in the provincial database. CDMS will also aggregate all the blocks within each tract and update the Tract level tables in the provincial database. Open CDMS and complete the following steps for each of the four aggregate tables created in Step 3:

    - Select the **Import into CDMS Repository from File** button (Figure 3-9).

    - Under **Select a file for Import:** choose the .mdb containing the aggregated tables created in step 3 (Figure 3-9).

    - Under the **Select Hazus-MH Inventory Category** dropdown menu select **Aggregated Data** (Figure 3-9)

    - Under **Select Hazus-MH Inventory Dataset (Layer)** select one of the following (Figure 3-9):

      Building Counts by Dissemination Area
      Building Square Footage by Dissemination Area
      Structure Exposure by Dissemination Area
      Exposure Content by Dissemination Area

    - Hit **Continue** to proceed to next window.

- Under **Select Import Table** select the appropriate table from your import file (Figure 3-10).

- Under **Select DAUID Field** select the Census Block field in your table (Figure 3-10).

- Hit **Continue** to proceed to next window.

All fields will be automatically matched (Figure 3-11). Continue with the CDMS process.

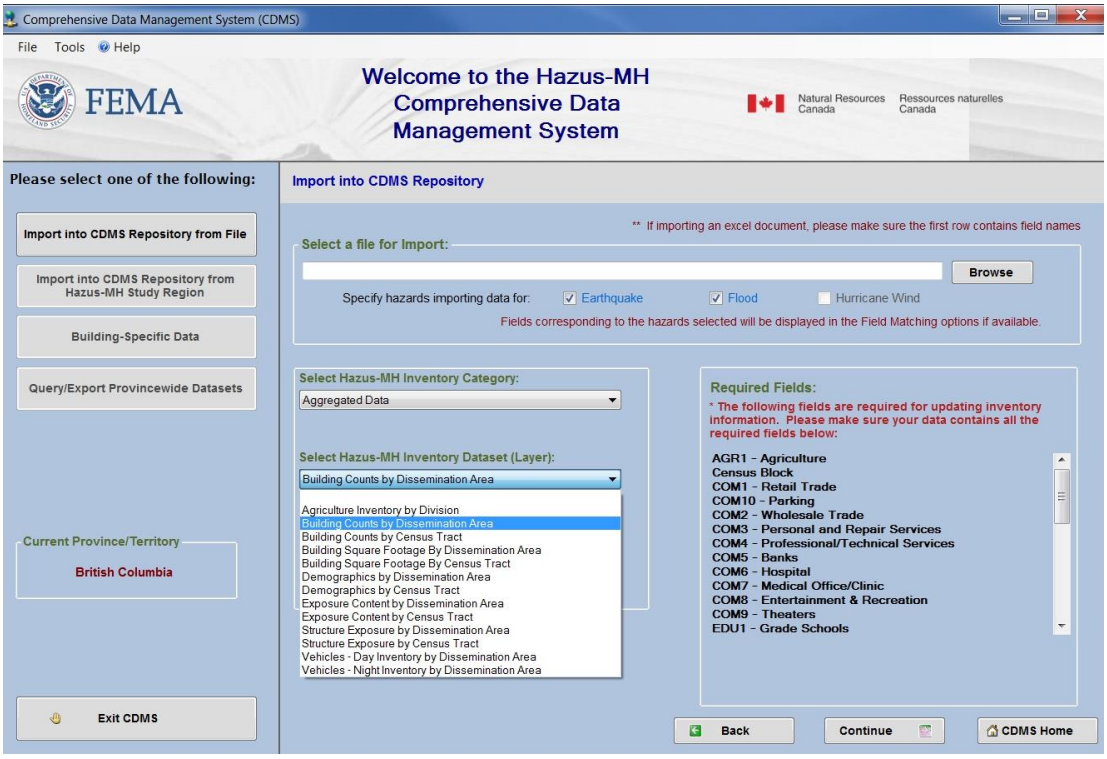


Figure 3-9 CDMS window showing Import into CDMS Repository from File options.

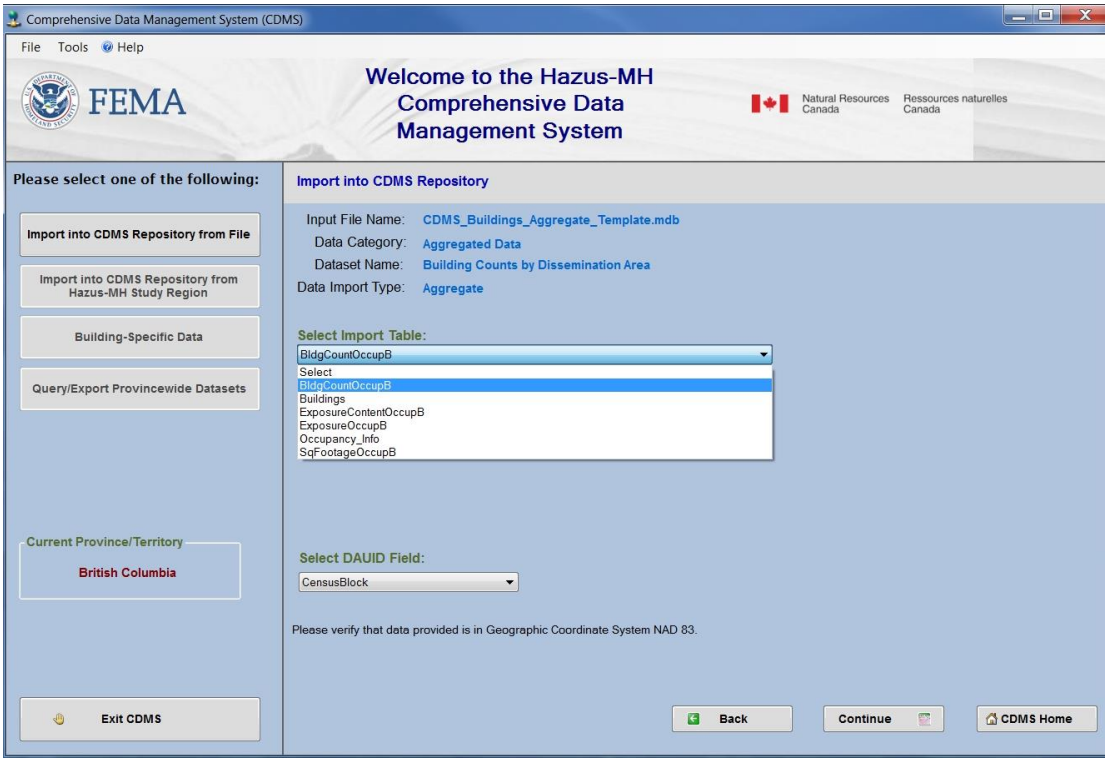


Figure 3-10 Select appropriate table from Select Import Table and select CensusBlock.

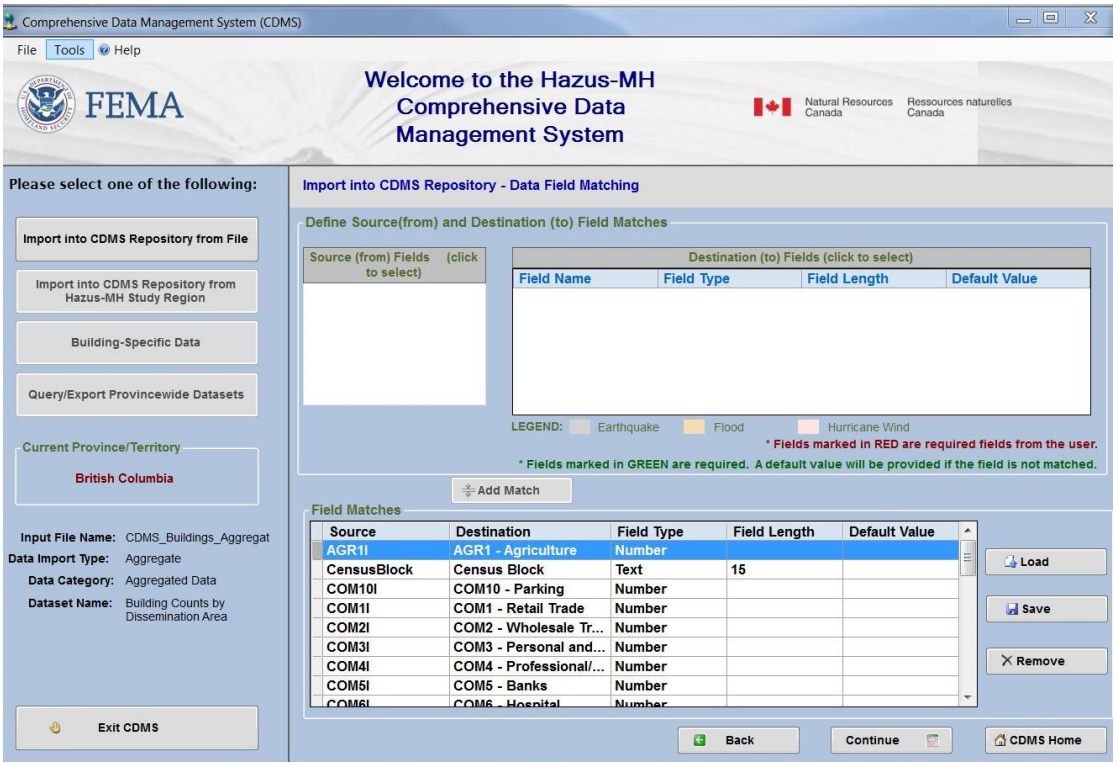


Figure 3-11 All fields will be automatically matched.

3.3.2 *Inventory Import Menu in Hazus*

Use the **Inventory** menu option to import site-specific (e.g., schools, hospitals) data files to a Hazus study region. Select **User Defined Facilities** (Figure 3-12) and then right-click on the empty table and choose **Add New Record** to input the Latitude and Longitude location of the building (Figure 3-13). The record will be added to the table and supplementary data may be added using proper formatting. This is a tedious task if a lot of data is to be added. The recommended way to import a lot of new data is to first build a table using the **User-Defined Facilities (UDF) Template** provided.

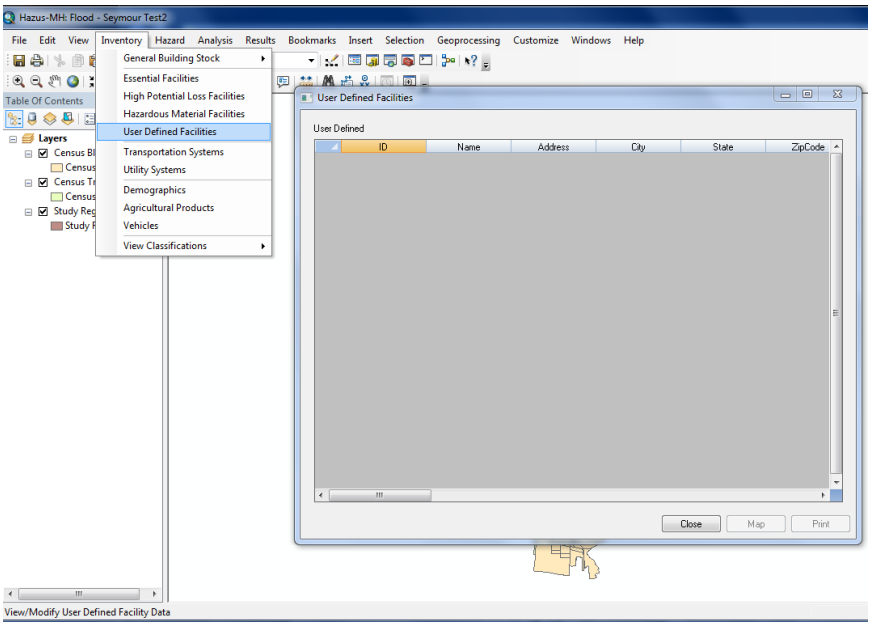


Figure 3-12 Window for manual input of inventory into Hazus.

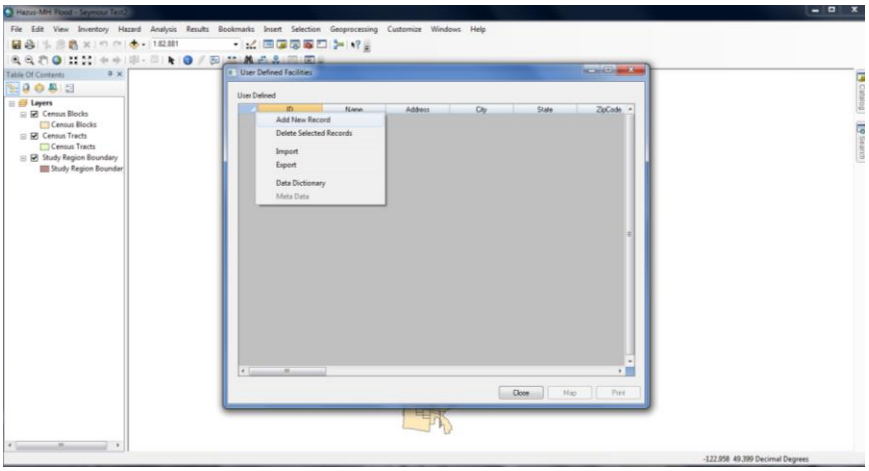


Figure 3-13 Add New Record by right-clicking on empty window.

The User Defined Facilities (UDF) Template

Importing building data to the User Defined Facilities inventory in an existing study region using the **UDF_Template_Floods.mdb** provided is a better way to ensure that proper data field formats are followed. The table **UserDefinedSample** provides the fields and input parameters that are required or optional to import buildings into the UDF inventory (Figure 3-14 and Figure 3-15). In *Microsoft Access*, look at the **UserDefinedSample** table in the *Design* mode to view the information about each field (Figure 3-16).

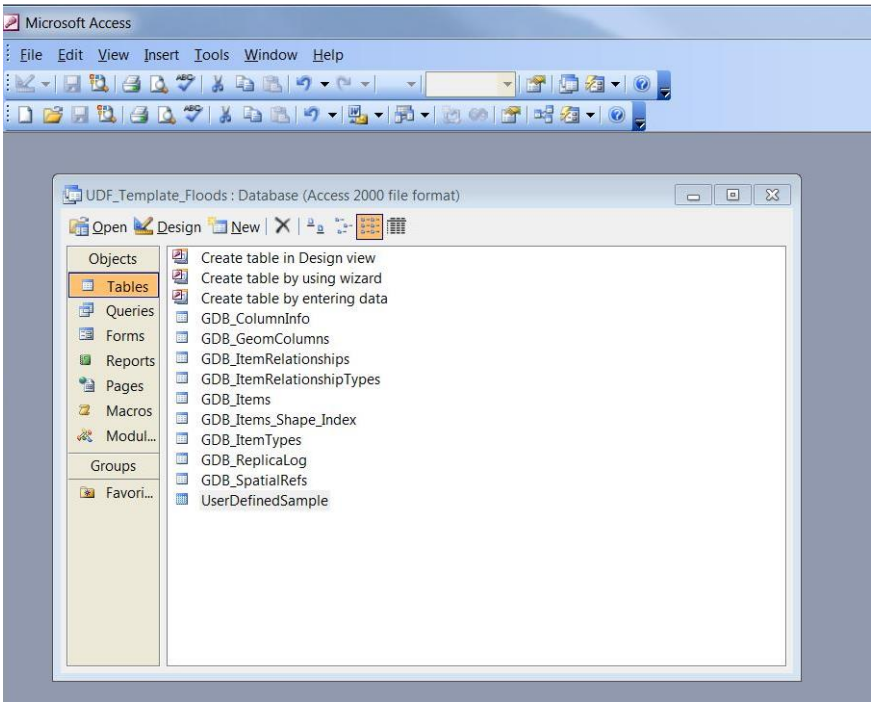


Figure 3-14 Choose the UserDefinedSample Table.

Figure 3-15 UserDefinedSample Table.

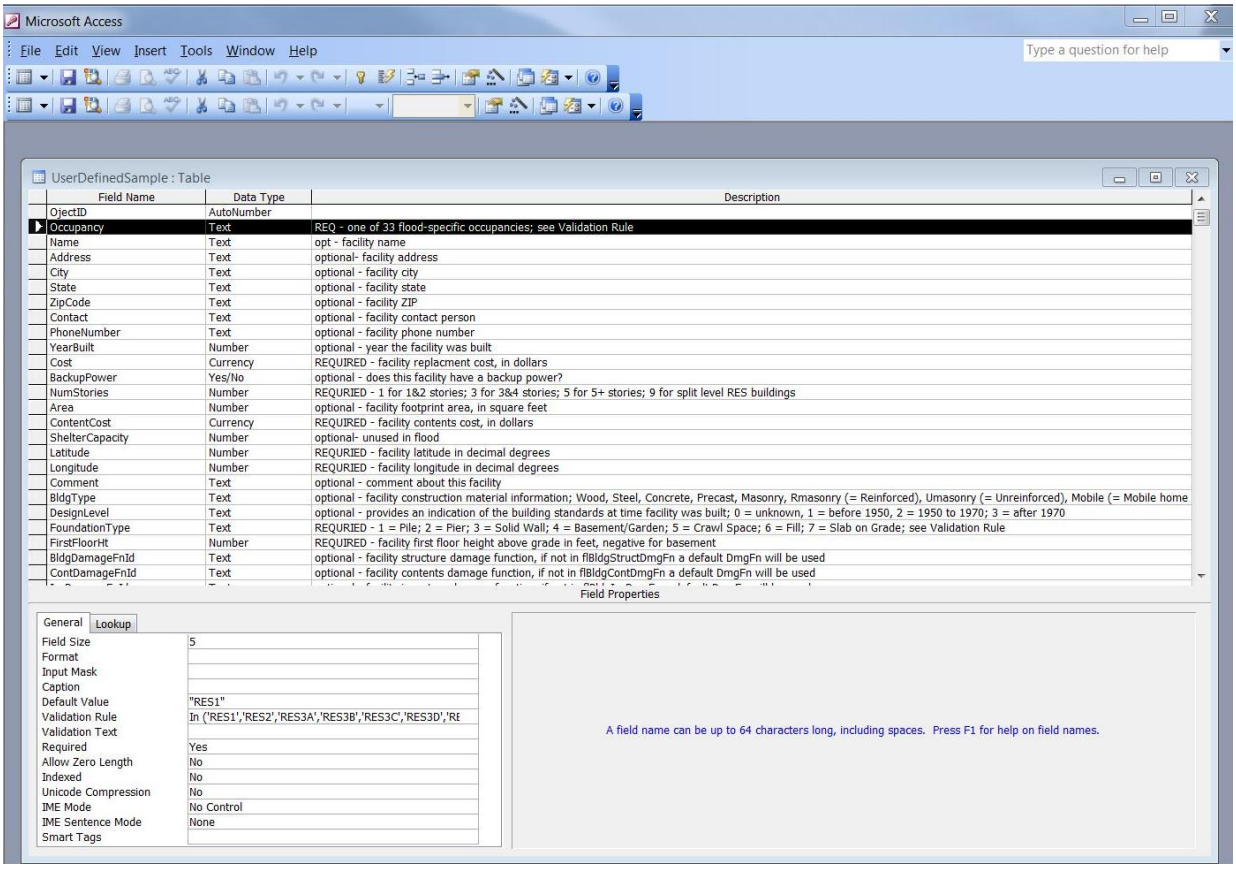


Figure 3-16 UserDefinedSample Table in design view.

The following steps provide guidance to import a list of buildings into the UDF inventory. The import file must be an .mdb database file. The file must be located on the local drive (not a network drive).

1. Create a study region using the provincial database aggregated inventory.

2. Make a copy of the study region in case it is needed. Reopen the original study region.

3. Select **Inventory** -> **User Defined Facilities** (Figure 3-12).

4. Right click empty window, select **Import**, and hit **OK** (Figure 3-17).

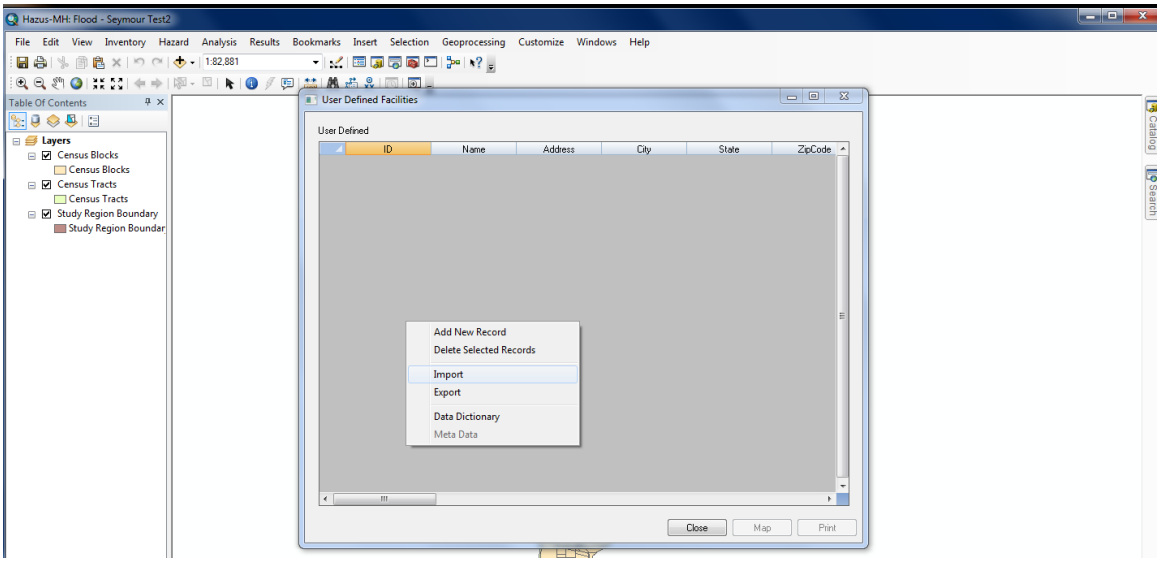


Figure 3-17 Select Import to import mdb file.

5. Locate the .mdb file with the input list of buildings and select the table within the .mdb file.

6. Match source (input) fields to target (output) fields and select **Add** for each pair (Figure 3-18).

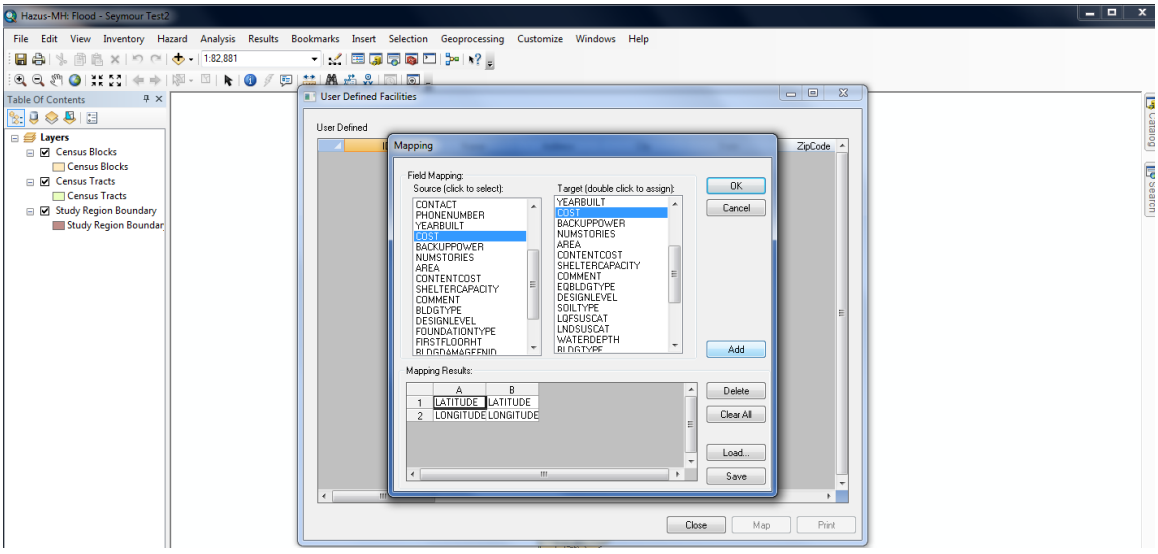


Figure 3-18 Match Source Fields to Target Fields.

7. Optional: Use the **Save** button to save the list of matched fields. It can be reloaded if the process has to be repeated.

8. Hit **OK** when all fields are matched. The process may take a long time, depending on the number of buildings in the input list.

9. If an error is experienced during the import process, it is recommended to NOT redo the import with the existing study region but to start the import again using a copy of the original study region.

10. Note: Any buildings outside the study region will NOT be added to the inventory. A warning message will be displayed.

11. Check the inventory list to ensure accuracy before doing analysis.

3.3.3 *ArcGIS Load Tools*

Import linear infrastructure data (e.g., railways) through ArcGIS load tools. Prepare your geodatabase files with the Hazus-required attribute fields and field formats. Then append the data to your provincial database and match the fields.

Note: The *CDMS Data Dictionary* does not provide parameter lists for linear features. An earlier version of this document, *Hazus-MH Inventory Documentation HAZUS-MH MR3,* written for FEMA in 2006 by the Polis Center at Indiana University Purdue University-Indianapolis (Polis IUPUI), does provide parameter details for linear features in the state (provincial) database. However, this earlier document is not readily available.

You can import linear infrastructure data using two ArcGIS tools, **ArcTools** and **ArcCatalog**:

In **ArcTools**, select **Data Management Tools**, then **General**, and then **Append** (Figure 3-19).

In **ArcCatalog**, select the inventory folder (e.g., TRN.mdb) in your provincial database. Right-click on the file (e.g., hzHighwaySegment), select **Load**, and then **Load data** (Figure 3-20).

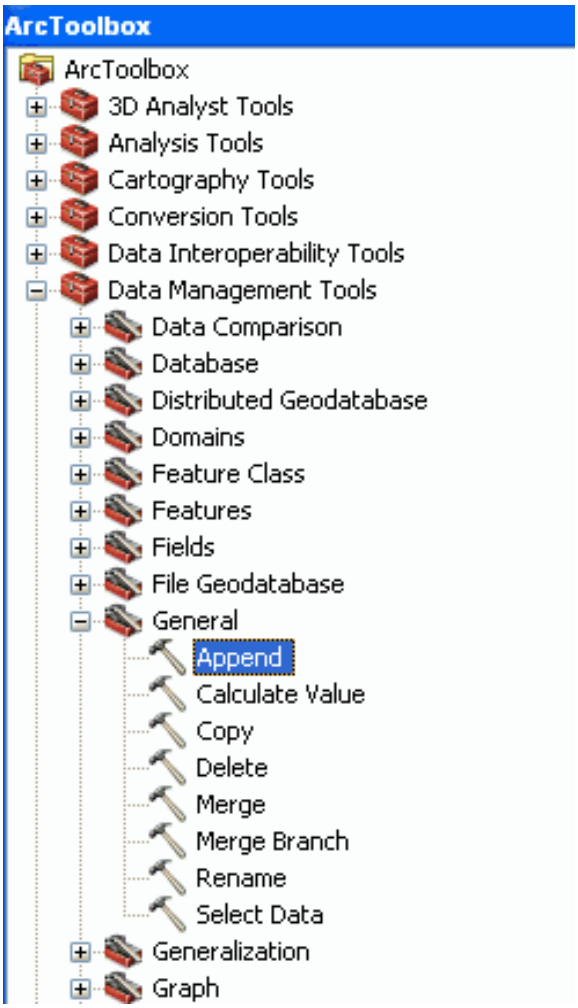


Figure 3-19 Import linear infrastructure data using Arc Tools.

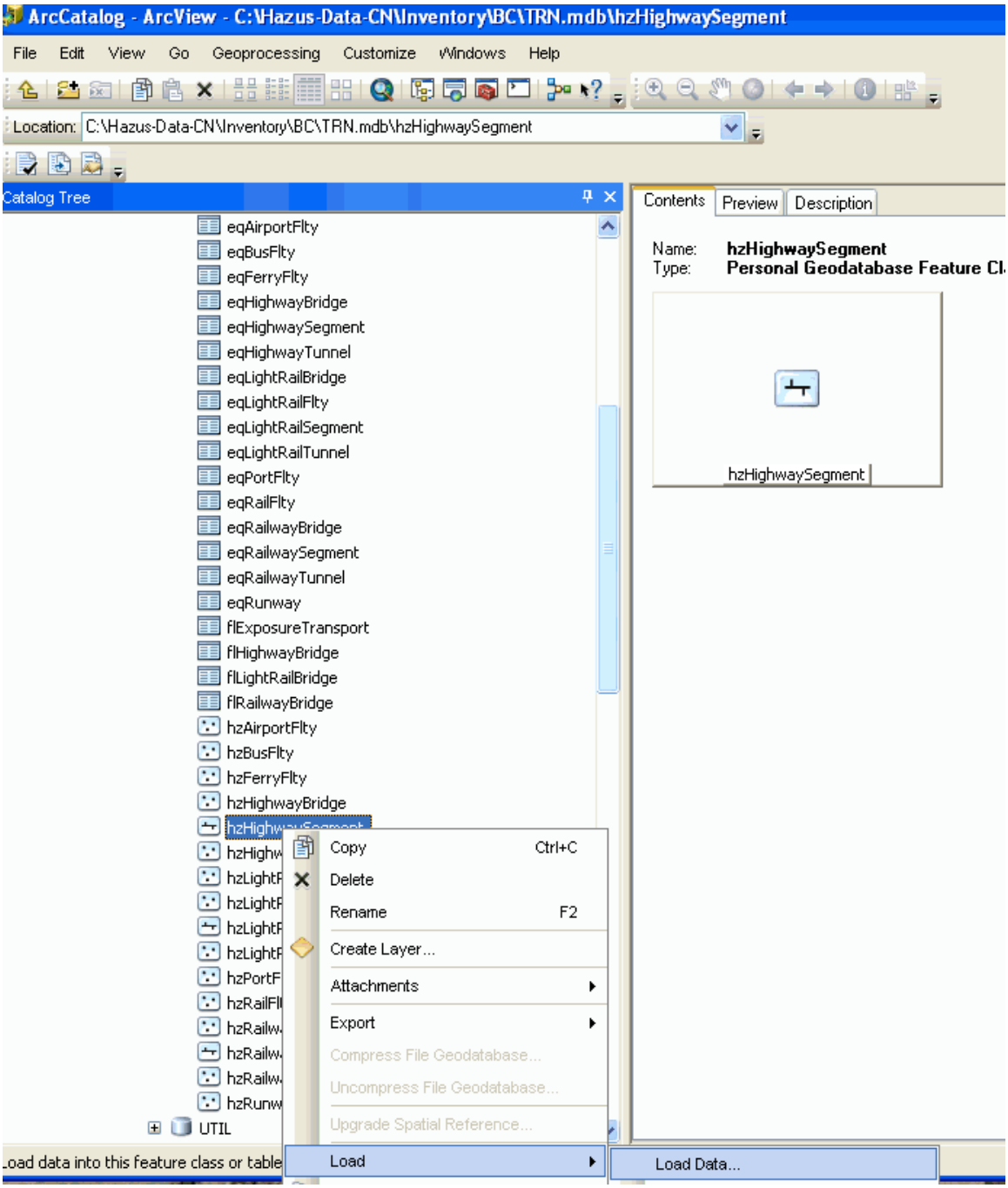


Figure 3-20 Import linear infrastructure data using ArcCatalog.

Chapter 4 Hazard Event Inputs, Analysis and Results

This chapter provides a description of the flood hazard events that can be analysed with Hazus Canada, providing information on creating a study region and a hazard scenario. The functions and parameters required for running a loss estimation analysis, and the viewing and interpreting of the results are also discussed. See Figure 4.1 for a chapter flow chart with section references.
]

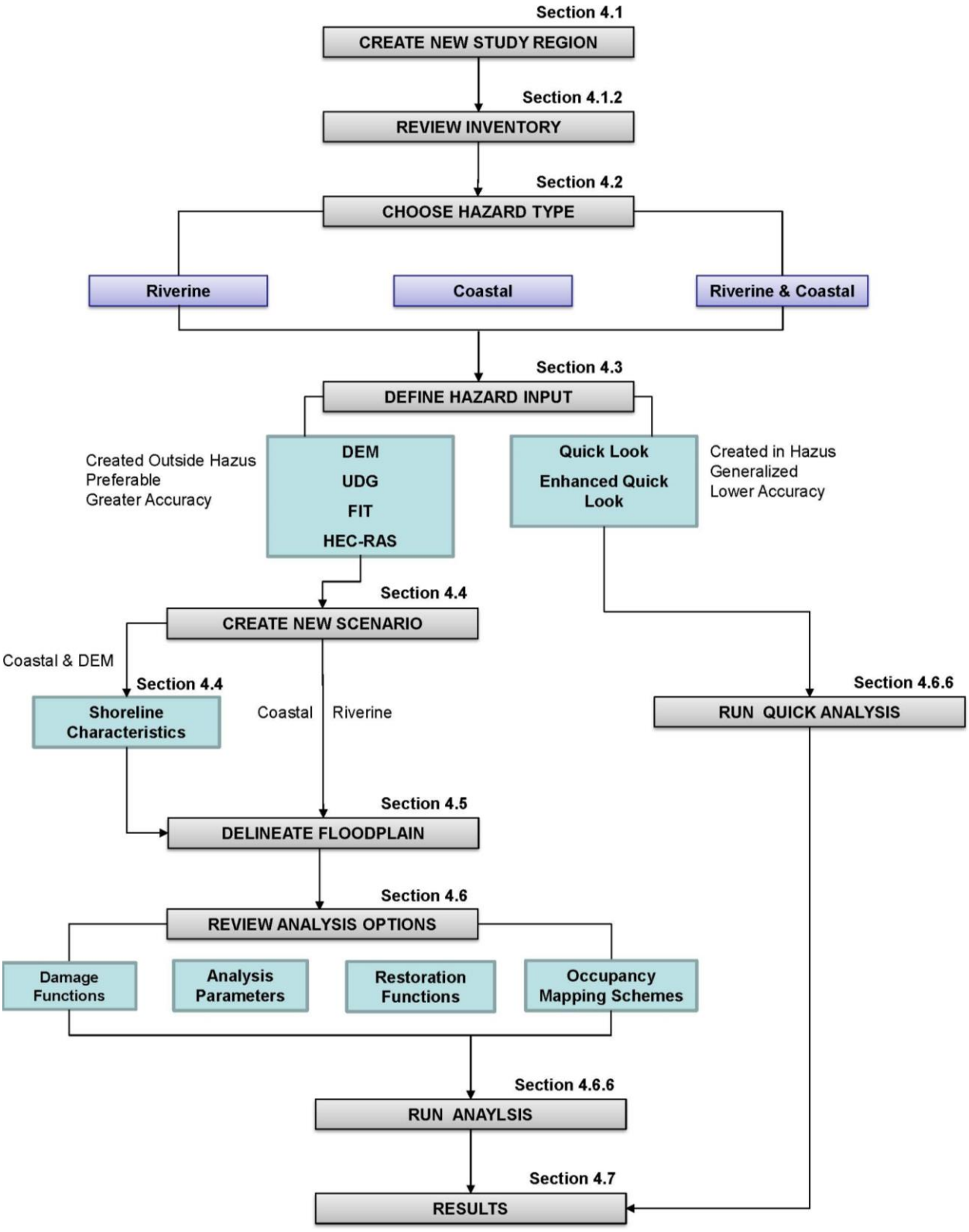


Figure 4-1 Chapter flow chart of flood hazard events, inputs and analysis.

4.1 Define a Study Region

The first step in running any Hazus scenario is to create a study region. A study region is the area for which you intend to conduct a loss estimation analysis. It is essentially a copy of the relevant information from your provincial database(s). The study region copy of the provincial database file is not linked to the original provincial database file. Any changes to one file are not automatically reflected in the other file, including updates using CDMS.

You can select your whole province/territory, one or more census subdivisions (regional areas), or one or multiple individual census tracts to form your study region. However, keep in mind that selecting an entire province/territory can slow down the speed of your analysis. See Section 2.7 of this manual for database limitations.

Before creating a study region, you must install the desired provincial database(s) onto your computer. Refer to Section 2.5.3 of this manual for instructions on how to install the provincial database(s).

Consider the following questions before deciding on the boundaries of your study region:

- What type of hazard(s) are you modelling?
- What areas is the hazard likely to impact?
- What populations and structures is the hazard likely to impact?
- Do you need to understand impacts outside your immediate jurisdiction?

Note: It is recommended that the user creates a study region with both Earthquake and Flood hazards selected as this can help in minimizing errors associated with importing or updating inventory data.

Once you have created a study region, the area of your study region cannot be modified. If you later update any information in your provincial database inventory or you wish to increase or decrease the size of your study region, you will have to create a new study region and re-run your analysis.

From the Hazus **Startup** Menu (Figure 4-2), you can create, open, delete, duplicate, export, or import a study region.

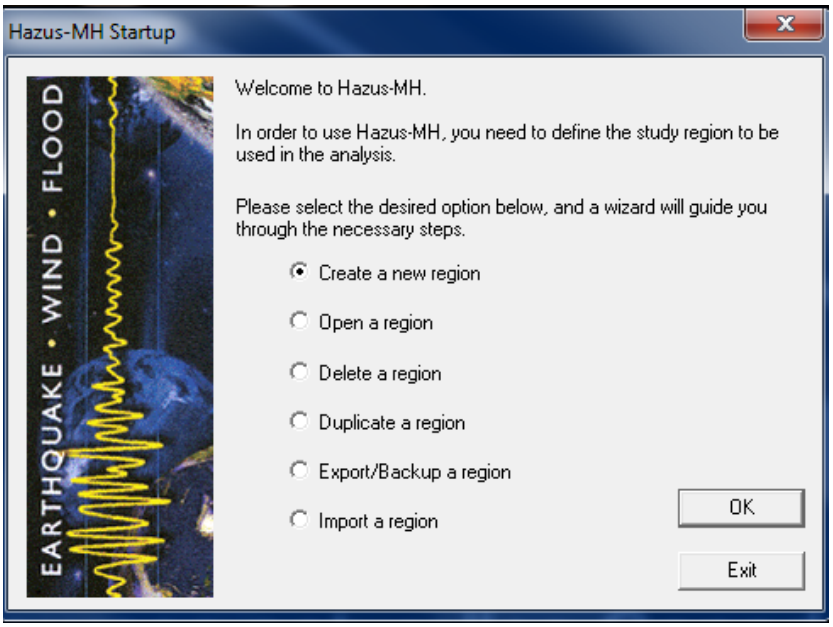


Figure 4-2 Hazus Startup menu.

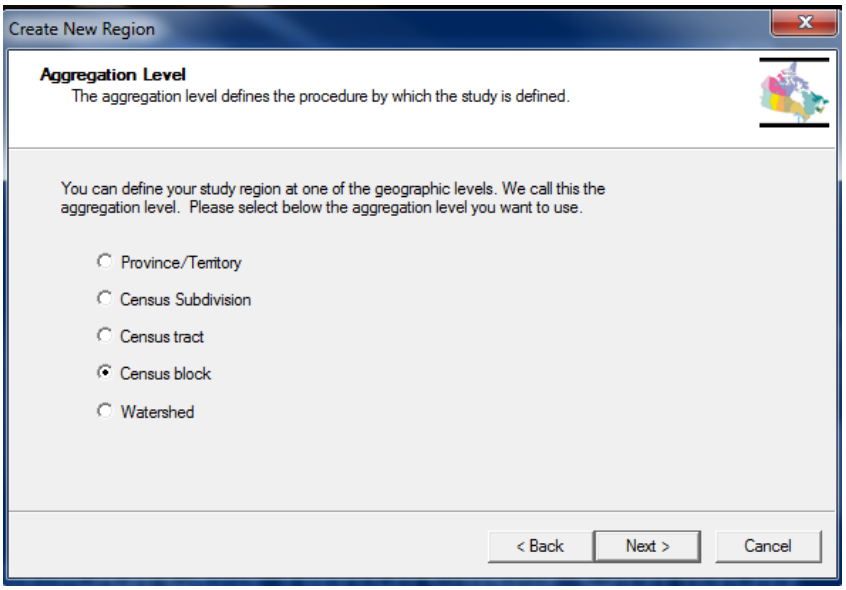


Figure 4-3 Aggregation level for analysis.

The geographical level you select for your study region analysis is called the aggregation level (Figure 4-3). The spatial units in the database can be selected by name or number from a list or by viewing a map using the **Show map** button. Figure 4-4 and Figure 4-5 show examples of the map selection for the Canadian dataset.

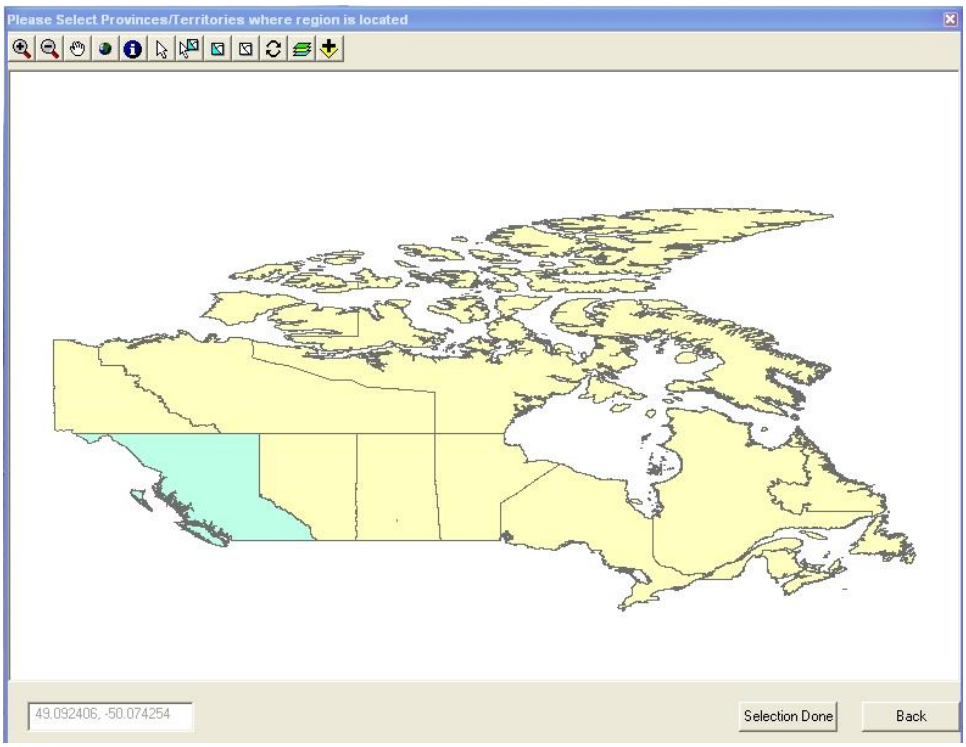


Figure 4-4 Province/Territory selection from map.

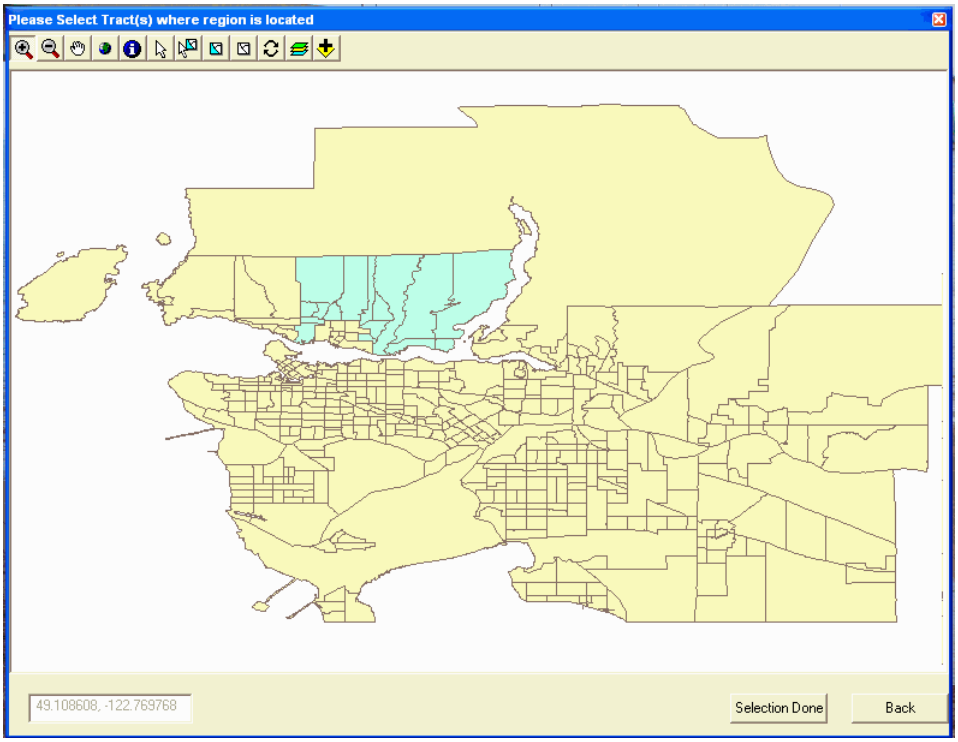


Figure 4-5 Census Tract selection from map.

The final step in creating a study region begins the process of extracting the information from the provincial database for your region. This step will take several seconds or several minutes to complete, depending on the size of your study region and the amount of detail in the inventory.

Note: When you create a study region, the data in the provincial database does not change. If you later update any information in the provincial database, you will have to create a new study region and re-run your analysis.

4.1.1 *Open the Study Region*

Once a study region has been successfully created it does not open automatically. The user needs to select **Open a Region** and then select the region in order to continue analysis. Study regions are saved at any point in the analysis and can be reopened at a later time.

4.1.2 *Review the Study Region Inventory*

When you open a study region in Hazus, it is advised that you review the inventory data. Remember the study region data is a copy of the data in the provincial database used to create the study region. If the user updated the provincial database using local information this update will be reflected in the General Building Stock inventory, the Specific Buildings inventory, the Occupancy Mapping Schemes, and/or the other infrastructure inventory.

Once you have reviewed your study region's Asset Inventory default data, you are ready to choose a hazard event. If you wish to add individual buildings for a UDF analysis, see Section 3.3.2 of this manual for information.

(Refer to Chapter 3, Section 3.1 of the *Hazus-MH 2.1 Flood Model User Manual* for instructions on how work with a study region.)

4.2 Choose a Flood Hazard Type

The flood hazard types that can be defined in Hazus are riverine, coastal, or riverine and coastal. Climate change impacts can be input into the modelling by altering future flood modelling scenarios and comparing with current flood hazards.

1. **Riverine**

A riverine flood occurs when there is an unusually high flow of water in a river or other channel, which causes an overtopping of the usual boundaries of the watercourse and subsequent inundation of the surrounding flood plain. Flooding is a common occurrence that can negatively impact human settlements commonly built in flood plain areas. There are a variety of forms of riverine flooding including long-duration flooding

along rivers draining large watersheds and flash flooding that happens suddenly sending a wall of water down a steep canyon. Riverine flooding can be due to the accumulation of runoff from rainfall or snowmelt and flow is always downstream due to gravity. Depth, duration, and velocity of a flood is influenced by the size and slope of the watershed, upstream development, soil types, vegetation, topography and storm characteristics.

2. Coastal

A coastal flood occurs when there is a rise in seawater level causing usually dry, low-lying land along the coast to be inundated with seawater. Larger freshwater lakes, like the Great Lakes also experience coastal flooding. Coastal flooding occurs due to high tides, storms, hurricanes, or tsunamis and is characterized by wind-driven waves. Shoreline characteristics, development, soil type, vegetation, topography and storm and wave characteristics influence flood depth, duration and velocity.

3. Riverine and Coastal

Sometimes the flooding that occurs in an area of interest due to a storm or climate change is from both a riverine and a coastal source and both systems of flooding must be taken into consideration for the analysis.

(Also refer to Chapter 4 of the *Hazus-MH 2.1 Flood Model Technical Manual* for details on Potential Earth Science Hazards.)

4.3 Define Flood Hazard Input

(Refer to Chapter 3, Section 3.3, of the *Hazus-MH 2.1 Flood Model User Manual*; Chapter 4 of the *Hazus-MH 2.1 Flood Model Technical Manual*; and Nastev & Todorov, 2013.)

The flood hazard is defined as the difference between the ground surface and the simulated flood surface resulting in a flood depth grid. The US version of Hazus has an embedded hydrologic and hydraulic analysis function that creates the flood depth grid from previously studied flood data, but as explained in Section 1.4 of this manual, the hydrologic and hydraulic analysis functions are NOT available in Hazus Canada.

The flood hazard for Hazus Canada must be created externally and imported into Hazus, except if using the Quick Look or Enhanced Quick Look features in Hazus (see Sections 4.2.4 and 4.2.5 below). Table 4.1 shows a comparison of some of the tools that may be used to calculate the flood hazard. Flood hazard characterization using these tools produces estimated flood depths for either riverine, coastal or a combination of both riverine and coastal flooding sources.

Table 4-1 Flood Hazard inputs

Source	Flood Hazard Input	Purpose	Constraints	Level of Detail
External	UDG	This input mode provides the most accurate representation of a flood hazard. All analysis output options are available.	User must create flood depth grid in external flood hazard modelling software.	
	HEC-RAS	Input from HEC-RAS flt file (flood hazard modelling software developed by the US Army Corps of Engineers) can be directly input into Hazus. All analysis output options are provided.	User must create flood depth grid in HEC-RAS.	
	FIT	Create flood depth grid using FIT tool provided with Hazus. All analysis output options are provided.	User must provide digital elevation model, flood cross-sections and floodplain boundary polygon.	
	DEM	Create flood depth grid for coastal or coastal and riverine flood scenario. All analysis options are provided.	User must define the units of elevation and vertical datum. Defining shoreline extents and characteristics is required before depth grid is created.	
Internal	Enhanced Quick Look	Estimates general building stock damage only. The hazard input is based on a flooded polygon and the elevation (DEM) data.	Results may contain a higher level of uncertainity . Only works for general building stock anaysis.	
	Quick Look	Estimates general building stock damage only assuming a uniform flood depth within a polygon.	Results may contain a high level of uncertainity and is best used for flat areas with constant flooding . Only works for general building stock anaysis.	

To import the externally created flood hazard, select **User Data** from the **Hazard** menu, choose the tab for the type of files you wish to import, and use **Browse** to locate the files. Other windows will prompt you for other information needed according to the different types of files. For example, after selecting the raster file for the depth grid you wish to use (Figure 4-6), you must select the **Set Parameters** button so you can set the units and the return period (Figure 4-7). Only after all the information needed for analysis is entered for each user data type, will the **OK** button become functional.

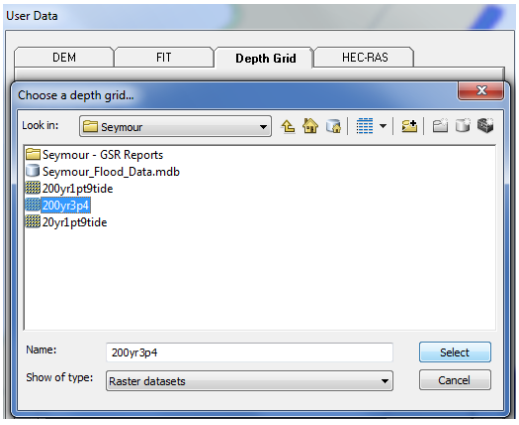


Figure 4-6 User Data window for importing flood hazard.

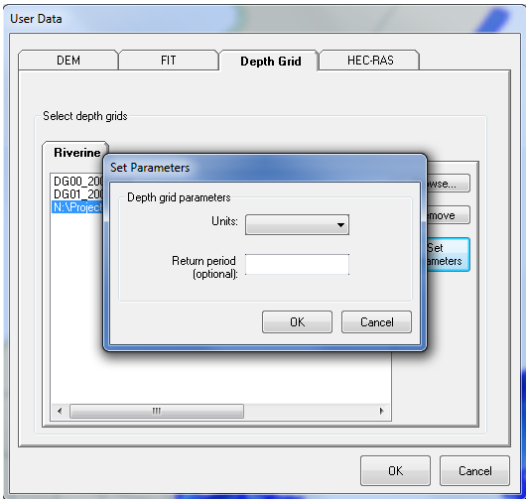


Figure 4-7 Set depth grid parameters.

4.3.1 *User Depth Grid (UDG)*

The user can create a flood depth grid outside of Hazus using appropriate methods. The flood depth grid must be in *ArcInfo* GRID format, in an appropriate projected coordinate system. Depth units and return period must be defined by the user. Supplying a detailed UDG and assigning it to a scenario is the most accurate representation of a flood hazard. Examples of some of the tools that may be used to create a UDG are *MIKE 11*, a 1-dimensional river model (http://www.mikepoweredbydhi.com/products/mike-11), and *FLO-2D,* a hydraulic and hydrologic model for flood routing (http://www.flo-2d.com/).

4.3.2 *Hydrologic Engineering Centers River Analysis System (HEC-RAS)*

Developed by the US Department of Defense, Army Corps of Engineers, this is a program that will model water flow through rivers and other channels. It performs one-dimensional hydraulic calculations. The .flt files generated can be directly input into Hazus. This is a good option for enhanced dam or levee analysis, although only stillwater damages will be computed in Hazus. Damages related to velocity from a dam or levee break are not calculated. The output will show flood boundaries. Link to the *HEC-RAS* homepage for more information and to download software: http://www.hec.usace.army.mil/software/hec-ras/.

4.3.3 *Flood Information Tool (FIT)*

The *Flood Information Tool* (FIT) is provided with Hazus Canada and is an ArcGIS extension, which processes user-supplied data into Hazus format. The data required to run the FIT is a Digital Elevation Model (DEM), a flood cross-section, and a floodplain boundary. This tool works the same as the US version of Hazus.

For more information on the FIT, refer to Chapter 8 of the *Hazus-MH 2.1 Flood Model User Manual; and* the *Hazus-MH Flood Information Tool User Manual, which* is available from *http://www.fema.gov/plan/prevent/hazus/.*

4.3.4 ***Digital Elevation Model (DEM)***

A digital elevation model (DEM) can be used in Hazus to generate a depth grid for a coastal flood hazard scenario. The DEM is required to be in an *ArcInfo GRID* format. Elevation units and vertical datum of the DEM are required to be defined. Using a DEM will provide the user with an analysis that may not be as detailed as other inputs therefore a *User Depth Grid*, *HEC-RAS* or *FIT* inputs are recommended to be used.

Note: It is important for the user to consider the resolution of a DEM before creating a depth grid as a depth grid created from a DEM will have the same resolution as the DEM.

For more information on using a DEM, refer to Chapter 3 of the *Hazus-MH 2.1 Flood Model User Manual*
.

4.3.5 ***Quick Look***

Quick Look is a feature in Hazus that is performed only on the GBS inventory and gives a rough estimate of flooding damage assuming a uniform flood depth within the flood boundary polygon. The user creates the flood boundary and specifies the flood depth.

(Refer to Chapter 3, Sections 3.3.10 and 3.4.6, of the *Hazus-MH 2.1 Flood Model User Manual.)*

4.3.6 ***Enhanced Quick Look***

Enhanced Quick Look allows the user to input a flood boundary polygon and a DEM to create a uniform flood depth grid. This tool allows a slightly increased level of detail over *Quick Look*, but still provides only a rough estimate of flood damage to the GBS inventory only.

(Refer to Chapter 3, Sections 3.3.11 and 3.4.6, of the *Hazus-MH 2.1 Flood Model User Manual.)*

Note: If using *Quick Look* or *Enhanced Quick Look* available from the **Hazard** menu in Hazus, go directly to the **Analysis** menu to run a **Quick Analysis**. Section 4.4, *Create a New Scenario*, and Section 4.5, *Delineate the Floodplain*, are not applicable.

4.4 Create a New Scenario

(Refer to Chapter 3, Sections 3.3.6. to 3.3.8, of the *Hazus-MH 2.1 Flood Model User Manual.)*

The scenario defines the specific depth grid or length of coastline and the hydrologic/hydraulic characteristics that the user wants to include in the analysis. From the **Hazard** menu, select **Scenario**, then select **New**. Once you have created a scenario it may be saved and opened in the future from this menu.

After naming the scenario, a window will open that will allow you to select the shorelines (Coastal) that will be included in the study case, as well as, the user defined depth grid and/or FIT data (Figure 4-8). Select the **+** button to **Add to selection**, then, click the areas on the map that you wish to include and click on the button for **Save selection**.

When you have picked all the areas on the map you wish to include in the study area click **OK**. If you are doing a riverine analysis only, this step is completed and you can move on to delineate the floodplain (See Section 4.5 below).

Note: The **Develop Stream Network** option in the **Hazard** menu is not available in Hazus Canada. This step is accomplished through using the external tools discussed in Section 4.3 above.

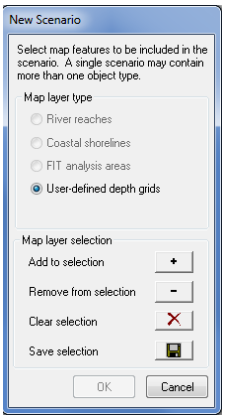


Figure 4-8 New Scenario window.

Shoreline Characterization

(Refer to Chapter 3, Section 3.3.7.1, of the *Hazus-MH 2.1 Flood Model User Manual.)*

If you generated a depth grid with a DEM for a coastal analysis or for an analysis that includes both riverine and coastal, the *Shoreline Limits* window will open automatically where you can segment the shoreline according to its differing characteristics (Figure 4.9). Define where you would like the shoreline to be analysed by selecting the start

and end points; then choose the break lines where the geographic characteristics of the shoreline change.

Once you have chosen the segments, click **Next**. The *Shoreline Characteristics* window will now open to allow you to characterize the 100-year flood conditions (Figure 4.10). Here you must enter the 100-year stillwater elevation (in feet) and indicate whether or not the elevation includes the wave setup. If you indicate that it does include the wave setup, you must enter the wave setup height (also in feet). The vertical datum is also required information. The other stillwater elevations are populated automatically and the significant wave height at shore (in feet) is optional. You have the option to apply this data to the whole of the shoreline by choosing **Apply to all Segments**, or you can go through each segment and enter different data as applicable.

Note: The *Shoreline Characteristics* window in Hazus Canada does not include the additional tab, which allows the segments to be categorized into a shoreline type. This step must be completed in the Flood Information Tool (FIT) and then imported. Refer to the *Hazus-MH Flood Information Tool User Manual* for instructions on characterizing shoreline types.

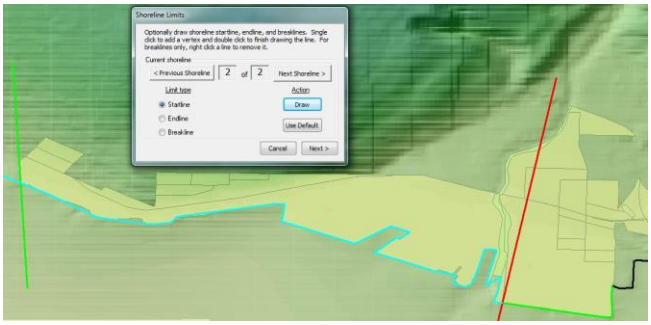


Figure 4-9 Shoreline Limits window

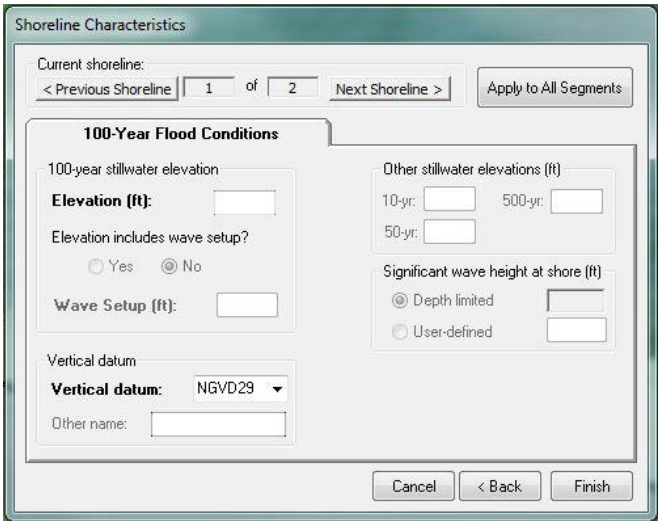


Figure 4-10 Shoreline Characteristics window

4.5 Delineate the Floodplain.

(Refer to Chapter 3, Sections 3.3.6.4 and 3.3.7.2, of the *Hazus-MH 2.1 Flood Model User Manual.)*

In the **Hazard** menu select **Coastal** or **Riverine,** depending on which hazard type you are analysing, and then select **Delineate Floodplain** (Figure 4-11) which opens a window where the analysis type, output cell size, and the return period for each depth grid can be edited (Figure 4-12). Once this step is completed the map will show the details of the flooding hazard (Figure 4-13).

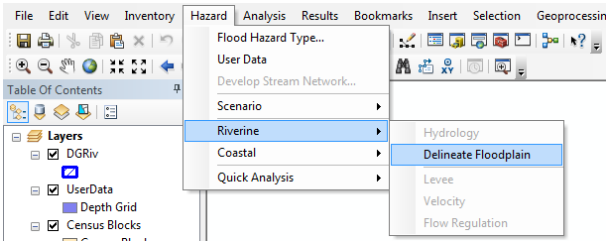


Figure 4-11 Delineate Floodplain.

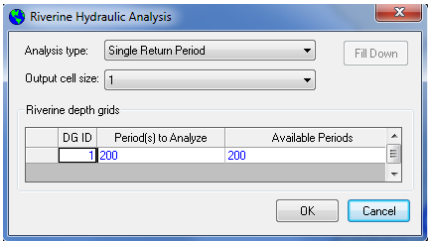


Figure 4-12 Delineate floodplain options window.

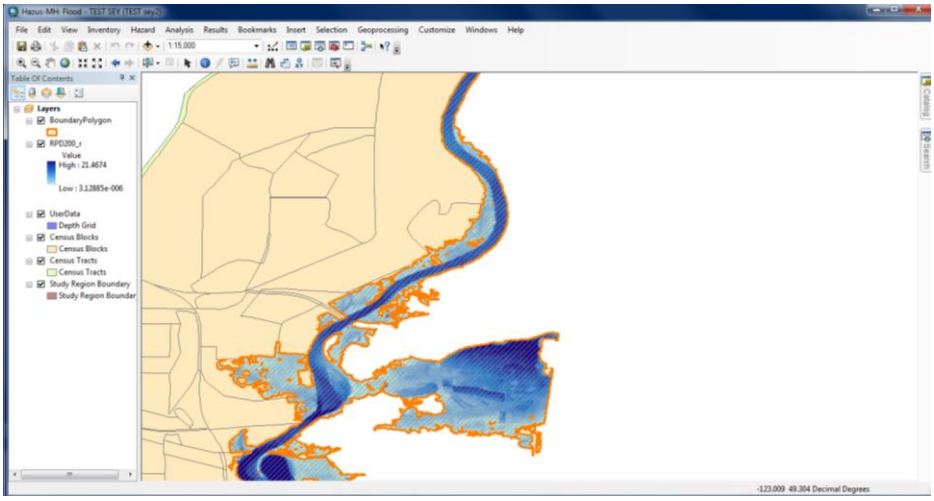


Figure 4-13 Map of flood hazard

4.6 Analysis, Methodology and Options

(Refer to Chapter 3, Section 3.4, of the *Hazus-MH 2.1 Flood Model User Manual.)*

Once the Flood Hazard has been defined and a hazard scenario created, a loss analysis can be run. The analysis uses the hazard, the asset information, and the vulnerability of those assets (both people and buildings) to estimate potential social and economic losses. The types of data provided for a study region will limit the analysis modules that can be run. An analysis can be re-run after changes have been made to inventory, but the new analysis overwrites previous results.

4.6.1 *Damage Functions*

(Refer to Chapter 3, Section 3.4.1, and Chapter 9, Section 9.4, of the *Hazus-MH 2.1 Flood Model User Manual.)*

Depth-damage curves are used to estimate damage to buildings and infrastructure based on the flood depth (Figure 4-14). Hazus has a library of damage functions for buildings, essential facilities, transportation and utility facilities, agricultural crops, and vehicles. The user may add custom damage functions if they have an understanding of flooding parameters, structural characteristics, and local conditions.

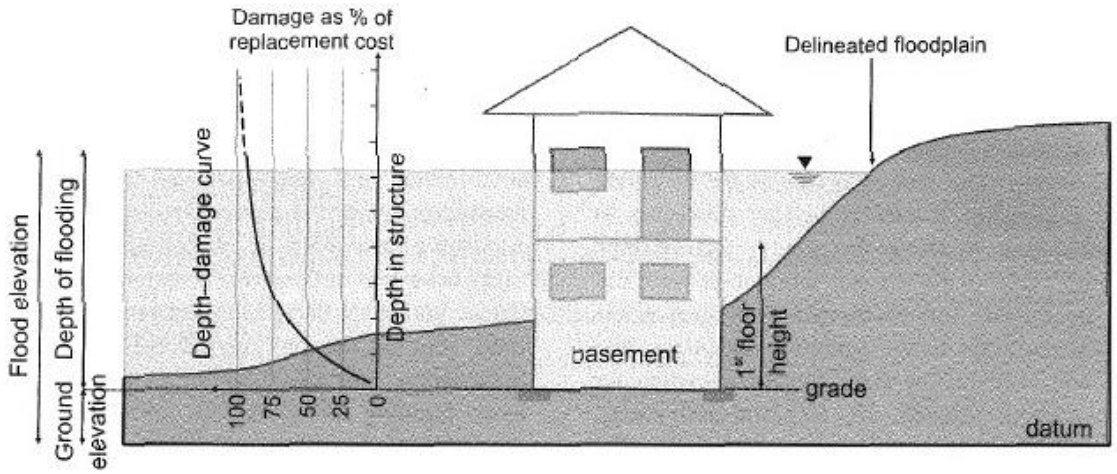


Figure 4-14 Depth-damage curve and hazard parameters for a typical Canadian house (from Nastev and Todorov, 2013, page 228).

Damage curves are viewed and modified from the **Analysis** menu (Figure 4-15). By clicking the **Library** button shown in Figure 4-15, the damage curve library can be accessed (Figure 4-16); and, using the **User Defined** button, the user has the option to modify the damage curves (Figure 4-17).

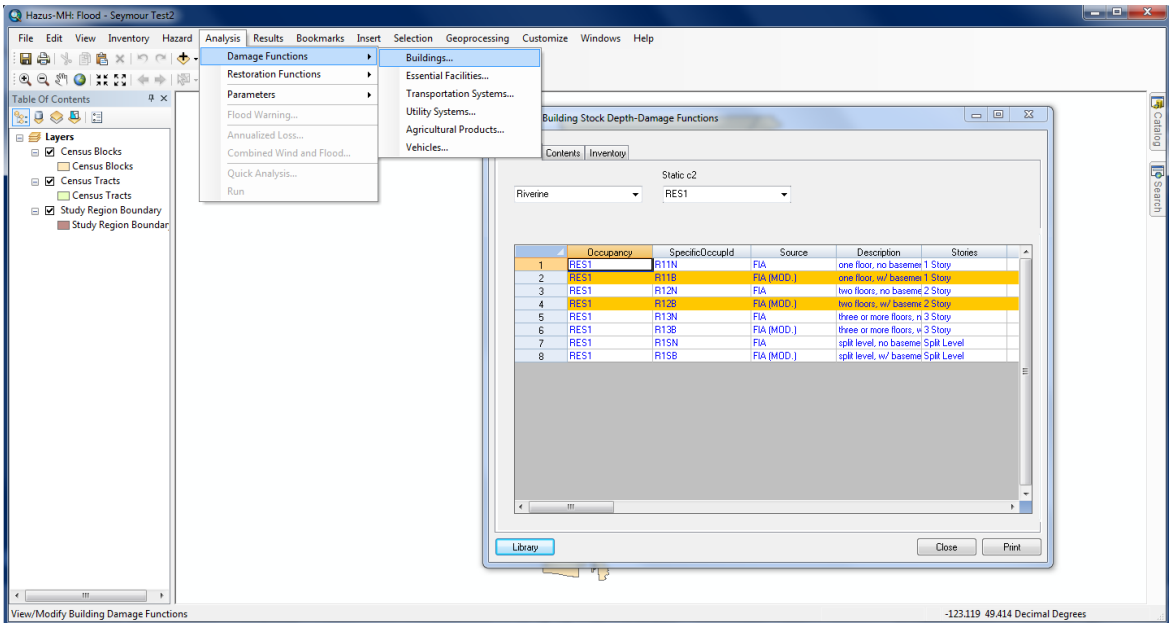


Figure 4-15 Damage functions viewed from the Analysis menu.

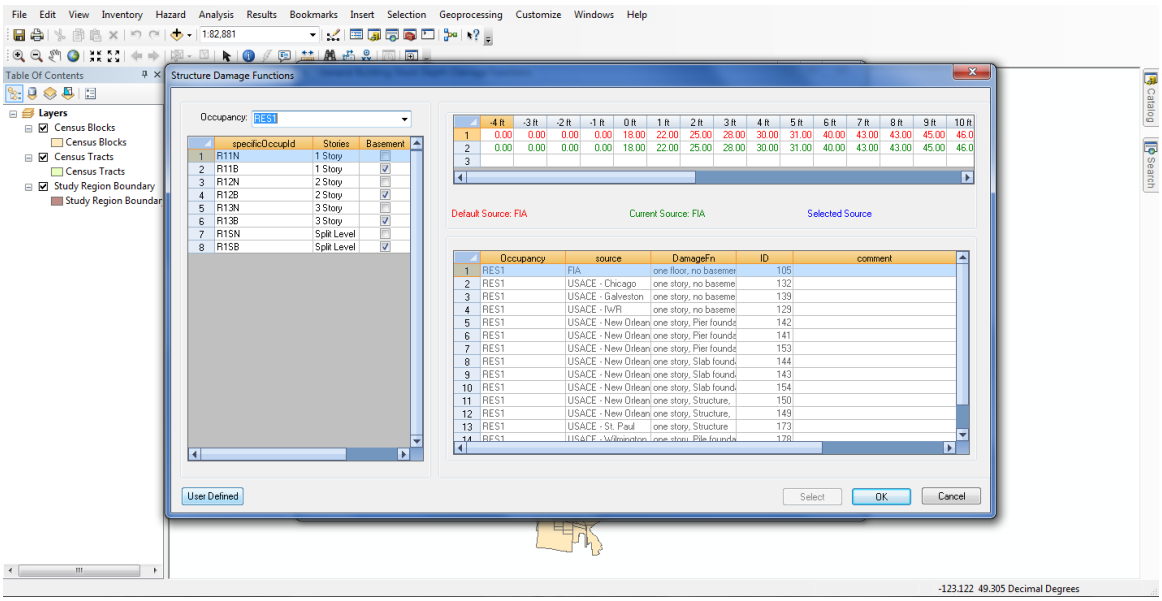


Figure 4-16 Building damage curve library.

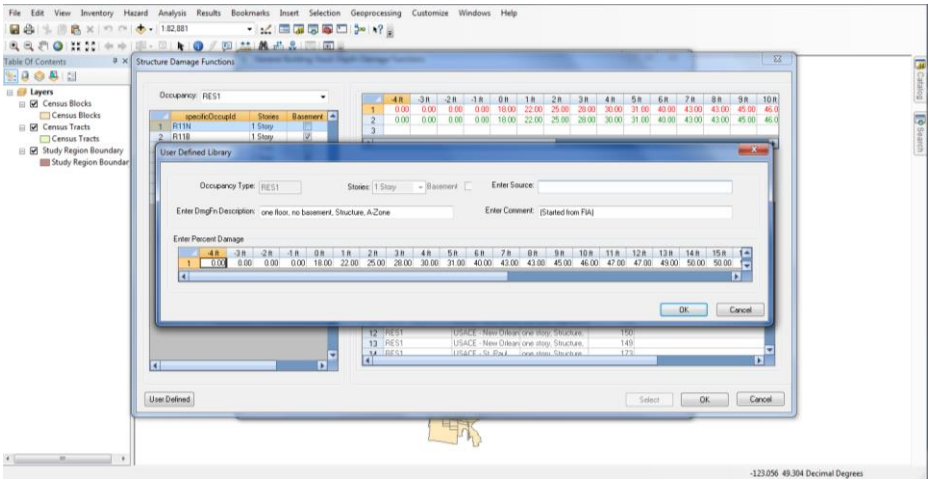


Figure 4-17 Damage curve editing window.

Damage functions are associated with specific occupancy classes in the case of the General Building Stock (GBS). An area-weighted assessment of flood damage is performed by the model, which counts the number of grid cells at a given depth and divides this by the total number of cells in the census block. The result is a 'weight' damage given at that flood depth for each occupancy class. Analysing the census block in this way is the most accurate for large areas.

Damage functions for structure, contents and inventory are available and Hazus Canada has added cost benefit analysis damage functions, which are not available in the US Version. Other buildings, such as essential facilities, use the same damage curves as similar GBS facilities.

Damage functions have been developed for transportation (bridges only), utility facilities, and vehicles. Bridge damage is based on the return period and the probability of failure due to scour. Selected utility facilities damage is based on the damage to critical flood-vulnerable components and the average height of equipment. Vehicle damage functions are based on the average height of three types of vehicles (car, light truck, heavy truck) and the flood depth.

In the case of agricultural products, the damage is determined by date of flooding, flood duration, and crop type. The model assumes a short duration and a slow rise of floodwater, and that it is the areal extent (not the depth) of the flood that is damaging.

4.6.2 ***Analysis Parameters***

(Refer to Chapter 3, Section 3.4.3 and Chapter 9, Section 9.6, of the *Hazus-MH 2.1 Flood Model User Manual* for more information on Analysis Parameters; and, to Chapters 14 and 15 of the *Hazus-MH 2.1 Flood Model Technical Manual* for more information on Direct and Indirect Economic Loss specifically).

Hazus has built-in parameters that are used for analysis which can be viewed and modified by the user using the **Analysis** menu (*see* Figure 4-19). These include factors such as finishes, structures, and foundation weight that will affect how flood debris will affect a building (Debris Estimation). Also included are parameters affecting the number of people who will be displaced and who will require emergency shelter. These parameters include functionality of utilities, income, age, ethnicity, and home ownership status of the people (Casualties and Shelter). The user may also refine parameters that directly impact the economy such as wages, income, or the maximum restoration time for buildings (Direct Economic and Indirect Economic).

Agricultural Parameters

For agricultural products, the user must input the date when the flooding occurs (Figure 4-18). The analysis uses this information along with the built-in crop growth season information to determine the extent of damage.

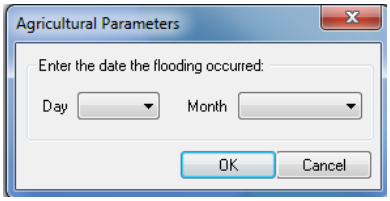


Figure 4-18 Date of flooding is required for Agricultural Parameters.

Debris Parameters

Debris estimation in the flood model identifies building components that will require replacement at various flood depths and estimates their weight. Vegetation, sediment and building contents are not analysed. Debris parameters are organized by foundation type and specific occupancy (Figure 4-19).

Casualty Parameters

The casualty information available for floods is limited to fatalities, as injury information is not widely available and drowning fatality data is dominated by people driving into flooded areas. Due to the fact that the source data is from only a few storm events, is not validated with the same level of scientific vigor as the rest of the flood model, and that the number of flood casualties is not nearly as significant as earthquake casualties, the proposed fatality model for floods has been deferred in both the US and Canada Hazus model software. At this time, the flood model does not provide estimates for flood related casualties.

(For more information on proposed models for flood casualties refer to Chapter 12 of the *Hazus-MH 2.1 Flood Model Technical Manual.)*

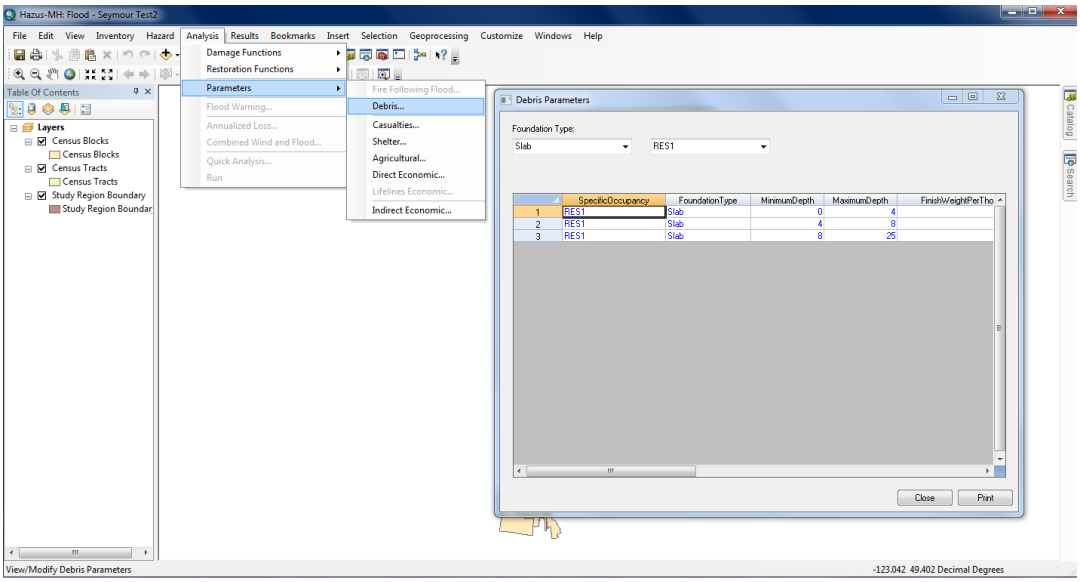


Figure 4-19 Debris estimation parameters organized by foundation type and specific occupancy.

Shelter Parameters

Shelter parameters are the factors that affect the number of people who are displaced and who will require short-term shelter.

The **Evacuation** tab allows you to identify the flood depth at which people are no longer allowed into or out of the flooded area, and to specify a buffer area around the floodplain polygon (Figure 4-20). Note: The flood depth you input will not affect the results but is included to encourage you to think about the local plans and controls that might need to be in place.

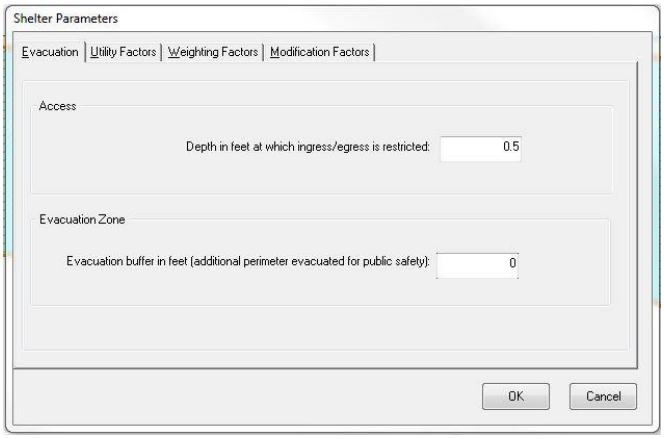


Figure 4-20 Evacuation parameters

The **Utility Factors** tab allows you to input the percentage of affected households and is used to determine short-term shelter needs (Figure 4-21). The lack of fully functional utilities will prevent some of the displaced people from returning to their homes immediately.

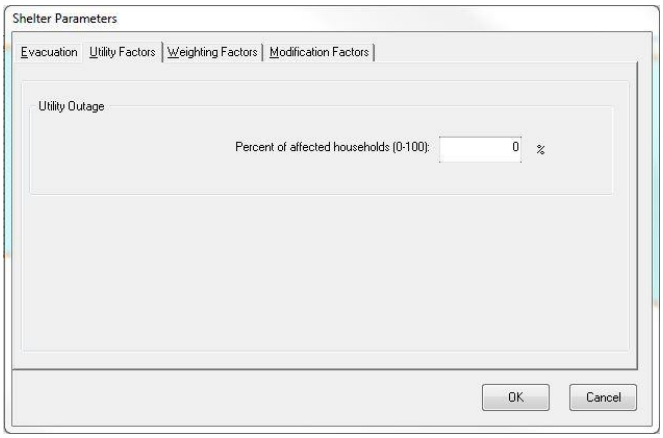


Figure 4-21 Utility factors parameters

The **Weighting Factors** tab allows you to modify the default weighting factor applied to the demographic characteristics of income, age, ethnicity, and home ownership (Figure 4-22).

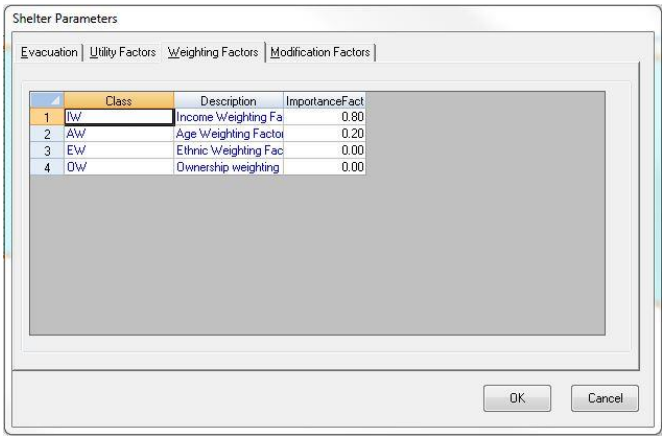


Figure 4-22 Weighting factors parameters

Finally, the **Modification Factors** tab allows you to further modify the weighting factors for specific age and income characteristics (Figure 4-23).

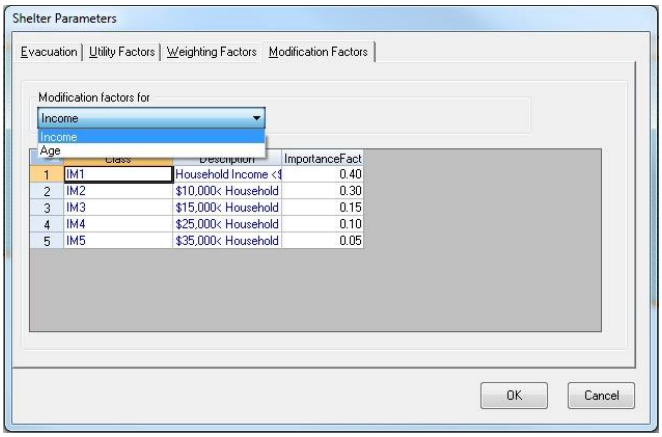


Figure 4-23 Modification Factors Parameters

Direct Economic Loss Estimates

The key inventory elements considered in direct economic loss estimates are:

- Content values (as percent of building replacement cost) by occupancy
- Annual gross sales by occupancy
- Rental costs
- Relocation expenses
- Income by occupancy
- Replacement values for various transportation and utility facilities

Note that the direct economic loss estimates are for the general building stock only.

Business inventory estimates are based on 2006 US dollars and can be viewed either as Annual Gross Sales in dollars per square foot, or as the percentage of Gross Annual Sales for each specific occupancy (Figure 4-24).

Restoration time is defined as the anticipated time needed for repair and restoration before the population can move back in. Restoration times are based on building damage and clean up required, in addition to inspection, permit approval, and contractor availability (Figure 4-25).

Income loss is dependent on the restoration time and involves relocation expenses and loss of income (Figure 4-26).

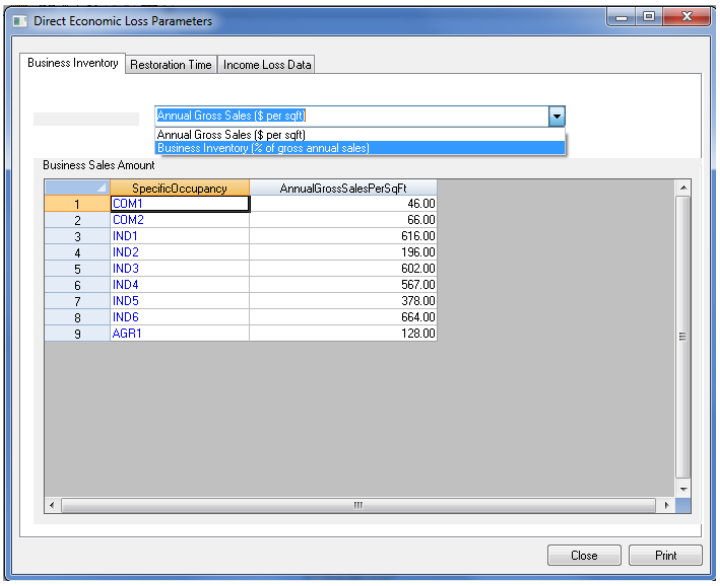


Figure 4-24 Direct economic inventory loss parameters.

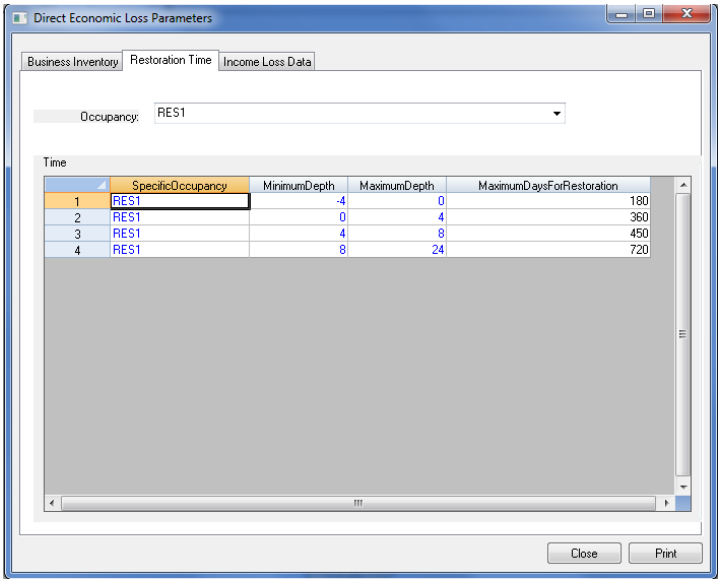


Figure 4-25 Restoration time parameters.

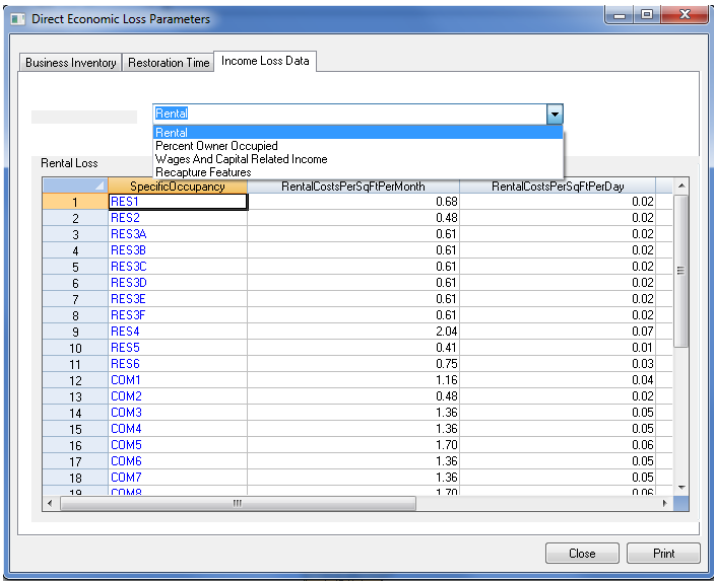


Figure 4-26 Income loss parameters.

Indirect Economic Loss Parameters

The only type of indirect economic loss analysis performed in the Hazus Canada flood model is for a synthetic economy (Figure 4-27). Note that the output of indirect damage assessments for a small study region (i.e. Census Block level) could be meaningless since the analysis will be scaled to county (Census Division) level.

The synthetic economies contained in Hazus are based on aggregated characteristics from a number of regional economies around the country. From these many regional economies, three economy types have been created:

- Primarily manufacturing
- Primarily service with manufacturing as the secondary sector, and
- Primarily service with trade as the secondary sector.

Based on the type of economy and size of the economy (number of employees) selected by the user, Hazus will select the appropriate synthetic economy to use for your study region (Figure 4-28).

After the synthetic economy has been defined, the user can view and/or modify the global and economic factors that will influence the economy's ability to achieve restoration (Figure 4-29, Figure 4-30, Figure 4-31, Figure 4-32, and Figure 4-33).

Note that the percentage of rebuilding accounts for the fact that not all damaged structures may be repaired or replaced. The interest rate is for commercial loans.

The final window (Figure 4-34) gives the user a chance to review all parameters carefully to ensure that they accurately reflect the conditions within the study region.

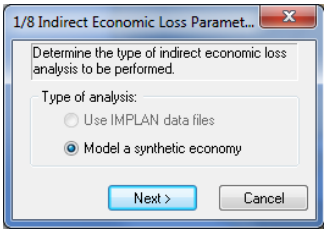


Figure 4-27 Model a synthetic economy is only option.

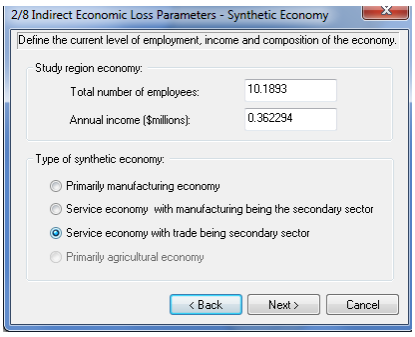


Figure 4-28 Economic factors.

Figure 4-29 Global factors.

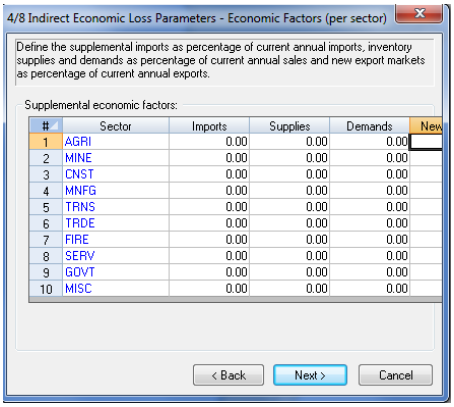


Figure 4-30 Economic factors per sector.

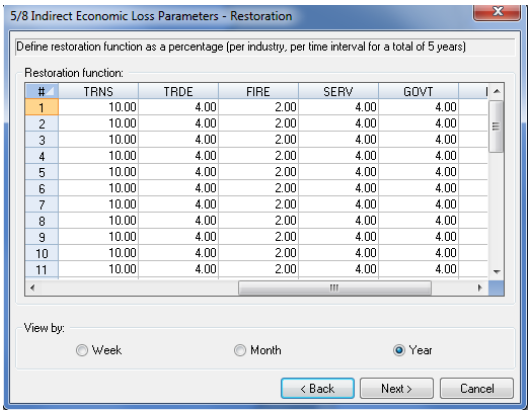


Figure 4-31 Restoration factors per sector and per time interval.

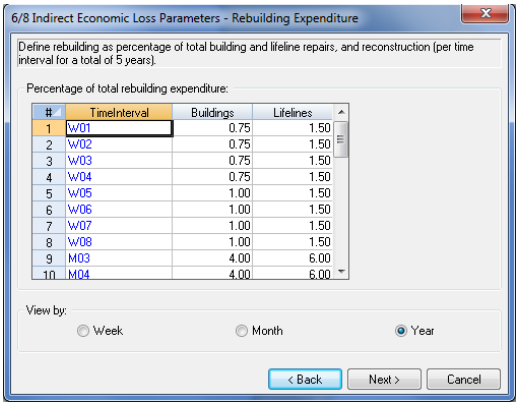


Figure 4-32 Rebuilding expenditure.

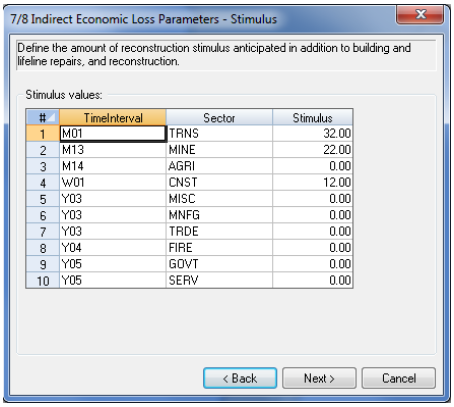


Figure 4-33 Stimulus factors.

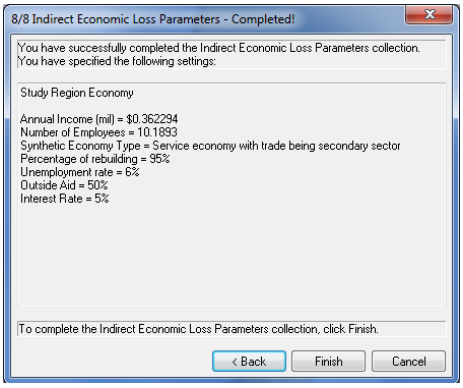


Figure 4-34 Review parameters.

4.6.3 ***Restoration Functions***

(Refer to Chapter 3, Section 3.4.2, and, Chapter 9, Section 9.5, of the *Hazus-MH 2.1 Flood Model User Manual.)*

Restoration functions provide information on the maximum restoration time needed for individual facilities (EF, TRN, and UTIL) to be at 100% functionality. The user can view and make changes to the maximum days to restoration and to the functional depth of flooding at a specific facility (Figure 4-35). The curves generated from this information describe the fraction of facilities expected to be open or operational as a function of time following the flood.

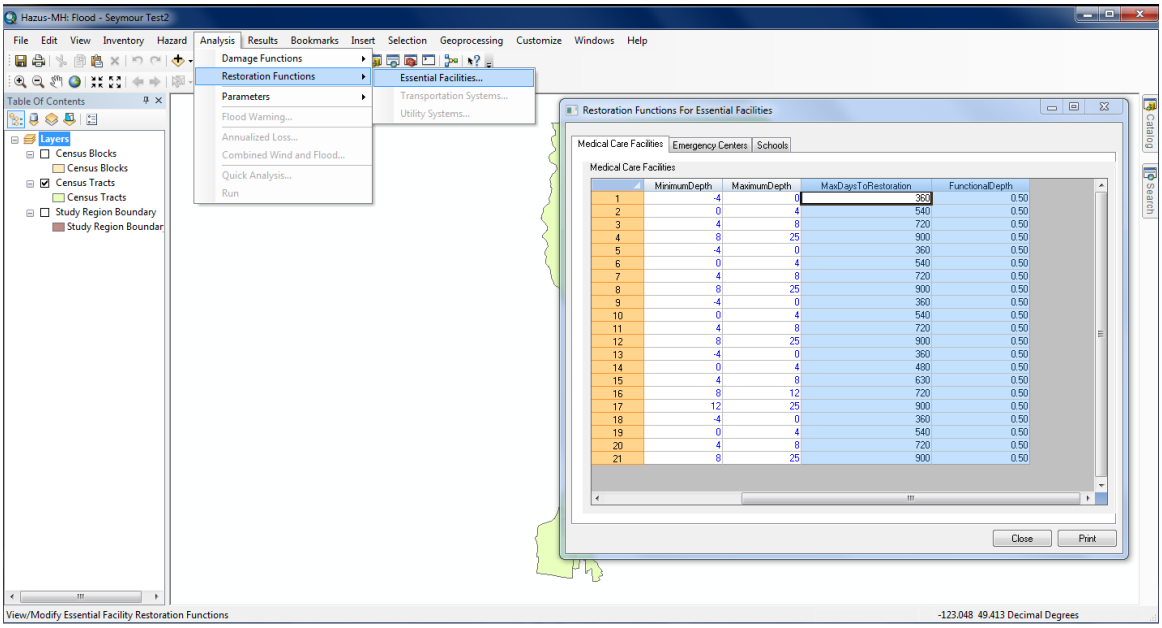


Figure 4-35 Window for viewing and modifying Restoration Functions.

4.6.4 *Flood Warning*

Flood Warning Parameters are not available in Hazus Canada at this time.

(Refer to Chapter 3, Section 3.4.4, of the *Hazus-MH 2.1 Flood Model User Manual.)*

4.6.5 *Annualized Loss*

Annualized loss assessment is not available in Hazus Canada at this time.

(Refer to Chapter 3, Section 3.4.5, of the *Hazus-MH 2.1 Flood Model User Manual.)*

4.6.6 *Modify Occupancy Mapping Schemes*

(Refer to Chapter 7, Sections 7.1.5 and 7.1.6, of the *Hazus-MH 2.1 Flood Model User Manual.*)

General Building Stock in Hazus can be categorized into **general occupancy** and **specific occupancy** classes and viewed by Census Block. There are seven general occupancy-building classes (Residential, Commercial, Industrial, Agriculture, Religion, Government, and Education) and 33 specific occupancy classes.
In the **Inventory** menu, click on General Building Stock and click on Building Count (**Figure 4.36**) to view tables. **These tables show the number of buildings existing in each Census Block for each building occupancy class.** Specific columns can be

mapped by clicking on the column heading, and then clicking **the Map button** to graphically display the number of buildings by Census Block ((**Figure 4.37**).

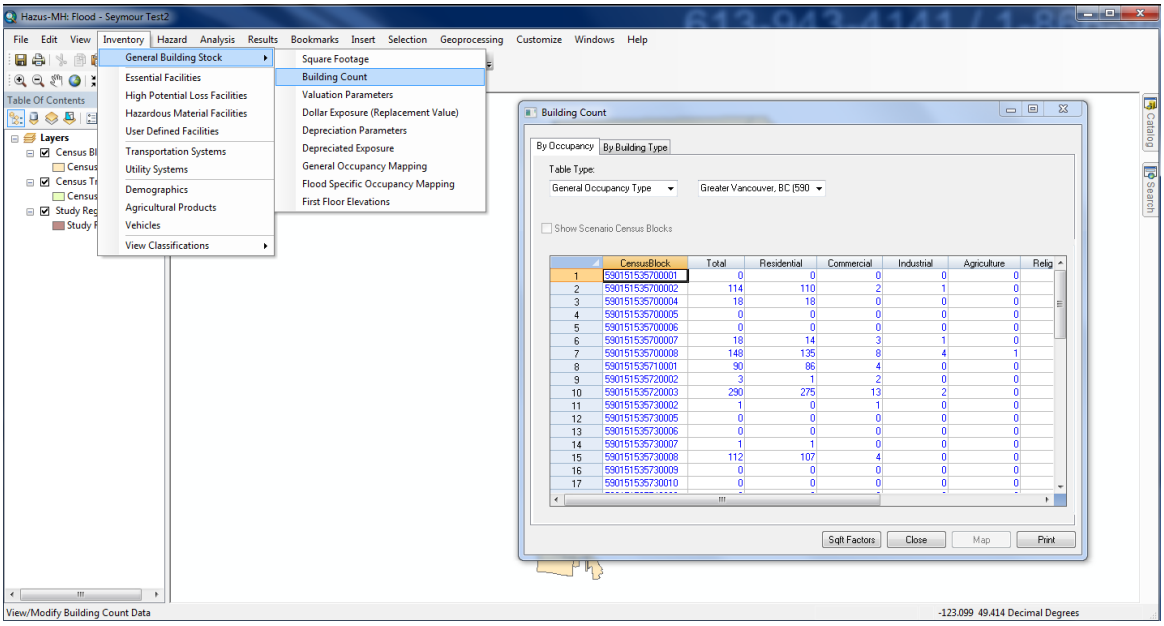


Figure 4-36 Viewing General Building Stock counts

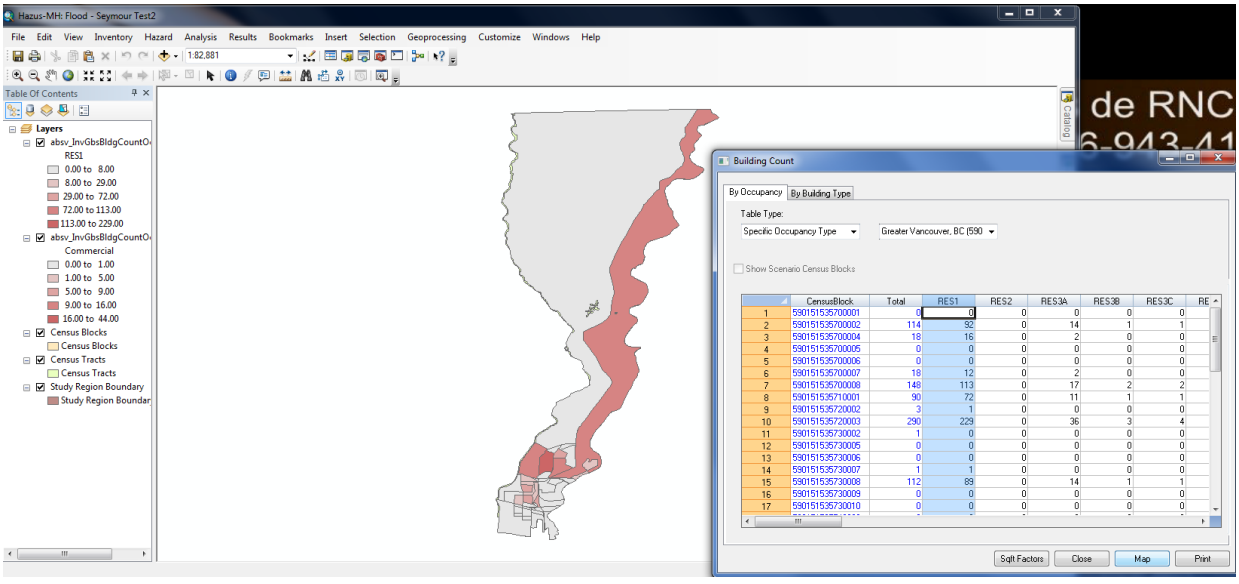


Figure 4-37 Mapping General Building Stock counts

General Occupancy Mapping

As stated in Section 3.2.12, Hazus uses Occupancy Mapping Schemes to describe the aggregated building stock by occupancy, building construction type, and location. A user can update these Occupancy Mapping Schemes if there is access to knowledge of construction norms in the area of interest.

Follow the instructions outlined below to modify the mapping occupancy schemes for a study region:

1. Click on the **Inventory** menu and select **General Building Stock** and then **Occupancy Mapping** (Figure 4-38).

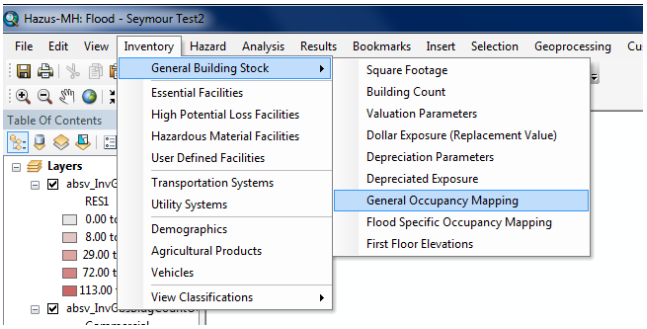


Figure 4-38 General Building Stock Occupancy Mapping.

2. At the top right is the default scheme assigned to each census block in the study region (Figure 4-39). By selecting a census block and mapping scheme in the table and then pressing **View,** the details of the mapping scheme can be reviewed, or by pressing **Copy,** a copy of the mapping scheme can then be edited.

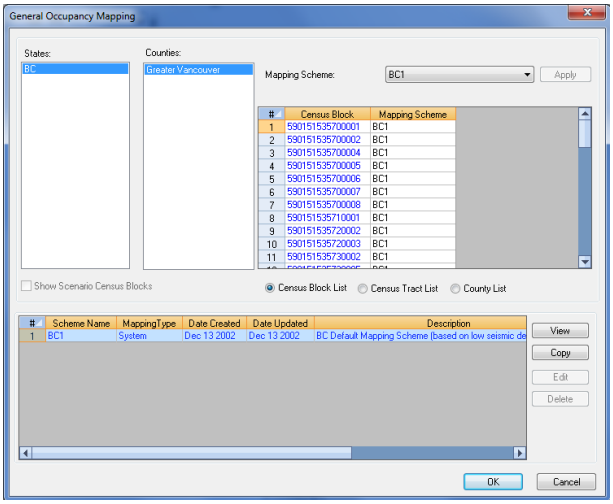


Figure 4-39 Default Occupancy Mapping Scheme.

3. A new window will pop-up prompting you to name the new, editable mapping scheme created (Figure 4-40). The pull-down menu at the bottom of the *New Mapping Scheme* window allows selection of a default mapping scheme as a starting point for creating a new one. Click **OK**.

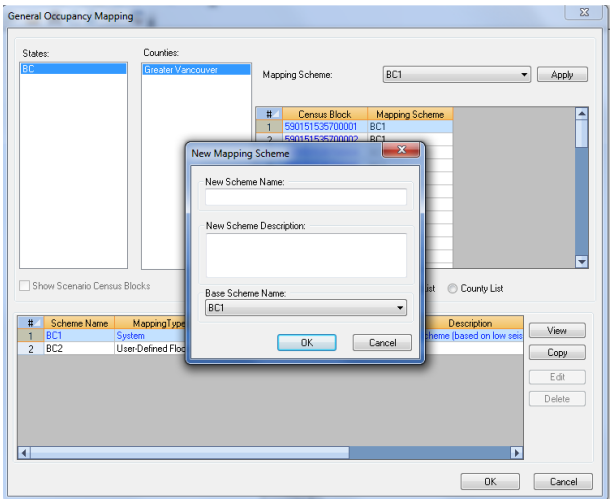


Figure 4-40 Name your new Occupancy Mapping Scheme.

4. Select your new scheme which will now be listed in the lower table and press **Edit** to bring up the general occupancy mapping details (Figure 4-41). Here you can select the occupancy types and edit the distribution of buildings by type. Click **OK** when finished.

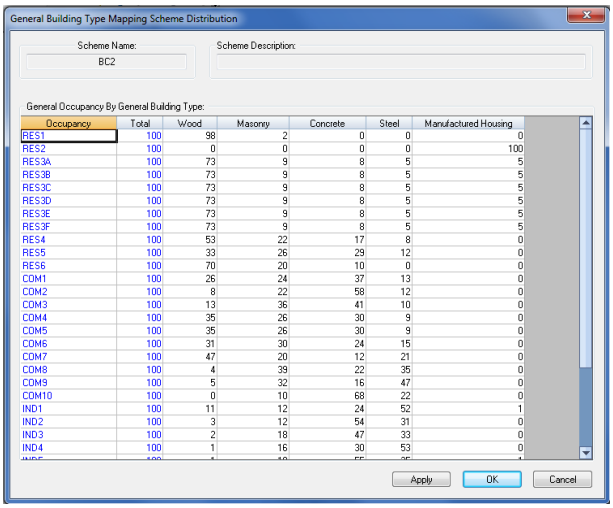


Figure 4-41 Edit general Occupancy Mapping details.

5. The new mapping scheme created will now appear in the *Mapping Scheme* pull-down menu in the top right corner of the *General Occupancy Mapping* window. Select the new mapping scheme and then highlight all of the census blocks that the new mapping scheme will be assigned to and click **Apply** (Figure 4-42). The mapping scheme should change for these census blocks. To assign the new mapping scheme to the entire study region select **County List**, select the new scheme from the *Mapping Scheme* pull-down menu, highlight the row(s) in the table and click **Apply**.

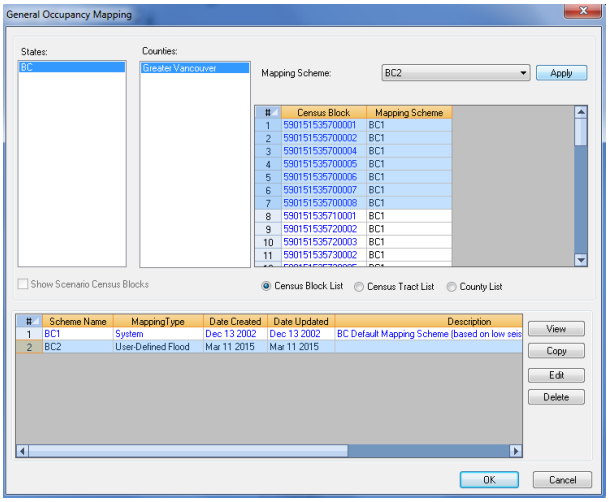


Figure 4-42 Assign new mapping scheme to relevant areas in the study region.

Flood Specific Occupancy Mapping

Flood specific occupancy mapping is based on the types of foundations and the average heights of the first floors for each specific occupancy type. There are three default flood-mapping schemes in Hazus – Riverine, Coastal, and Great Lakes. Each census block is assigned to one of these.

Follow the instructions outlined below to modify the flood specific occupancy mapping schemes for a study region:

1. Click on the **Inventory** menu and select **General Building Stock** and then **Flood Specific Occupancy Mapping** (Figure 4-43).

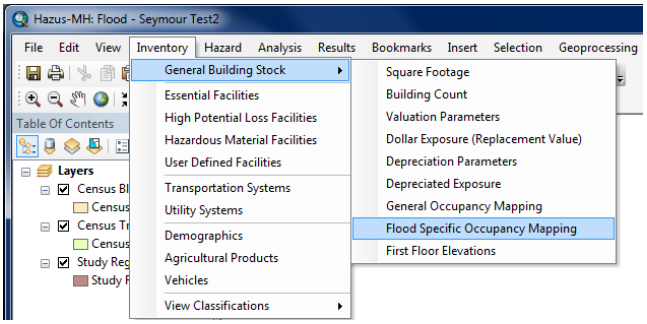


Figure 4-43 Flood Specific Occupancy Mapping

2. The top right table allows you to view the default schemes assigned to each census block and, by selecting a default scheme listed in the lower table and pressing **View,** the details of the mapping scheme can be viewed. By pressing **Copy** a naming window pops up and you can create a new mapping scheme (Figure 4-44). The pull-down menu at the bottom allows you to choose which default scheme you would like to use as a starting point. Click **OK**.

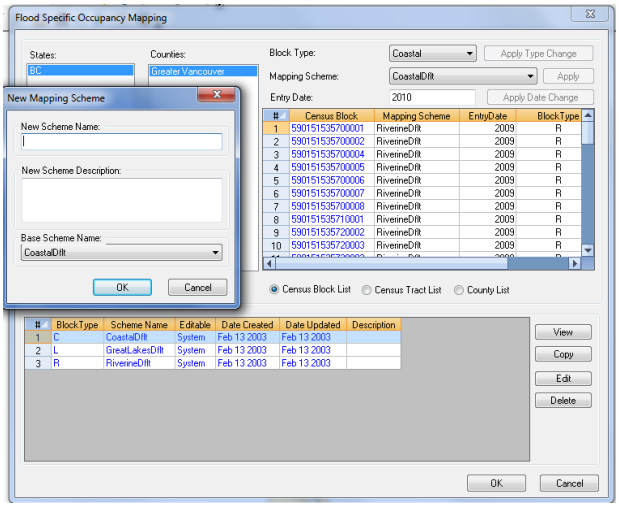


Figure 4-44 Creating a new mapping scheme.

3. Highlight the new scheme in the bottom window of the *Flood Specific Occupancy Mapping* window and click **Edit** to modify the details of the mapping scheme. Each specific occupancy type can be selected and the distribution of foundation types can be edited (Figure 4-45). Click **OK**.

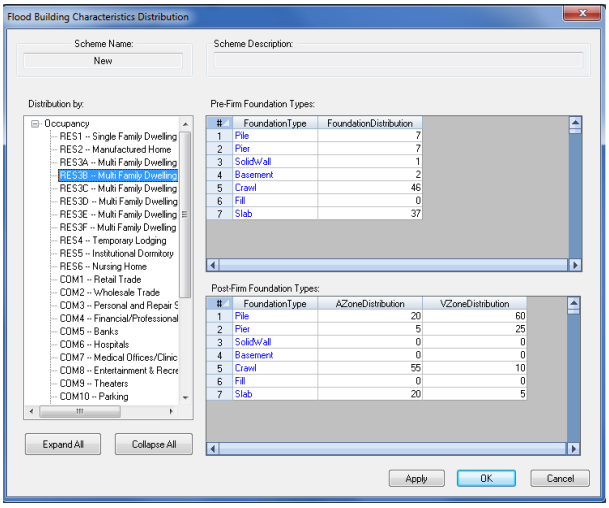


Figure 4-45 Create new specific occupancy mapping scheme.

4. Select the new mapping scheme from the *Mapping Scheme* pull-down menu (Figure 4-46) and highlight the census blocks that the new mapping scheme will be applied to. Click **Apply**. This will change the mapping scheme for these census blocks. To change the whole study region to this new mapping scheme, click on **County List**, select the new scheme, and highlight the row shown in the table then click **Apply**.

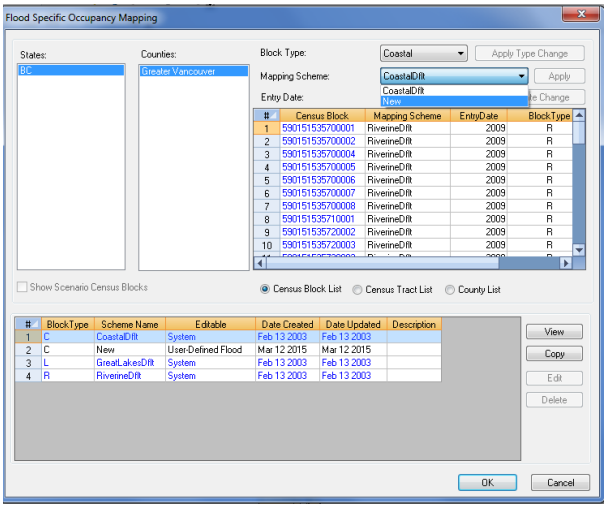


Figure 4-46 Apply the new mapping scheme to the census blocks.

First Floor Elevations

A first floor elevation is the average height above ground level at which the first floor in a building is located. First floor elevations are assigned based on the foundation type a building possesses as well as the hazard type.

Follow the instructions outlined below to modify the first floor elevations for a study region:

1. Click on the **Inventory** menu and select **General Building Stock** and then **First Floor Elevations (Figure 4.47)**

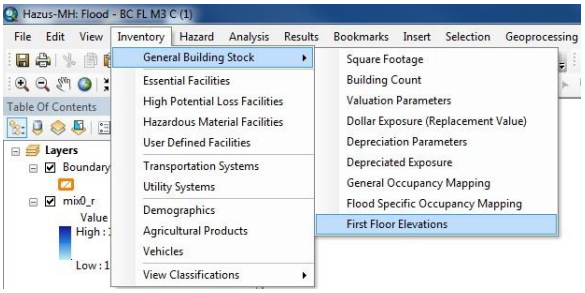


Figure 4-47 First Floor Elevations.

2. Select the **User-defined** tab in the **First Floor Elevations** window and modify the values in the **First Floor Height** column (Figure 4-48). Once the values are modified, click the box entitled **Use user defined values** and click **OK.**

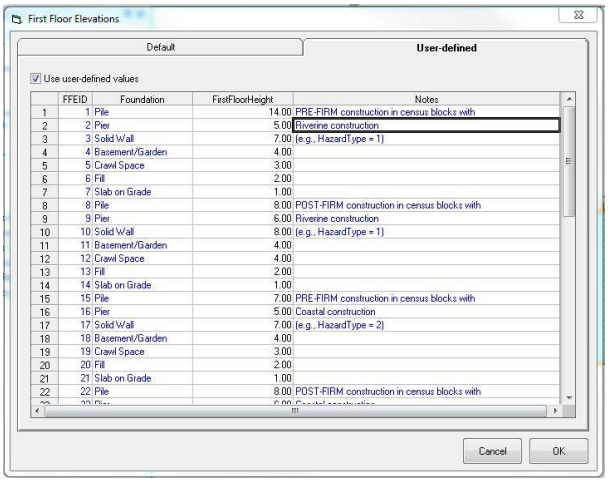


Figure 4-48 Modifying First Floor Elevations.

4.6.7 ***Run the Analysis***

(Refer to Chapter 3, Section 3.4.8, of the *Hazus-MH 2.1 Flood Model User Manual*.)

Once all functions and parameters have been selected and/or modified, a flood scenario analysis can be run.

Note: If using *Quick Look* or *Enhanced Quick Look*, select **Quick Analysis** from the **Analysis** menu (Figure 4-49).

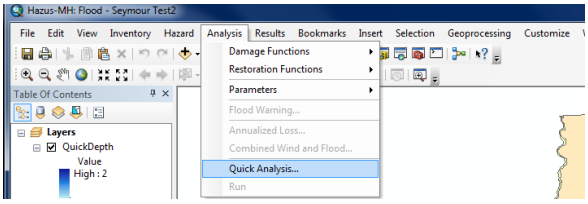


Figure 4-49 Quick Analysis option.

For all other types of hazard input select the **Analysis** menu and click **Run** (Figure 4-50).

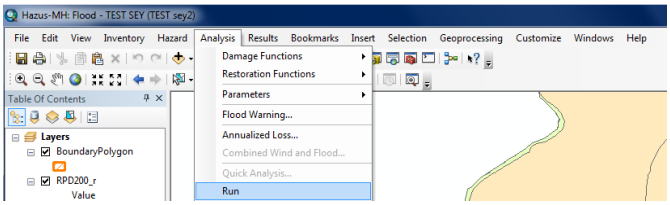


Figure 4-50 Select Run from the Analysis menu.

The **Analysis Options** window will open (Figure 4-51).

Check the analysis options that you would like to include. Some of the options chosen will automatically check pre-requisite options for you. You can select one option, several, or all options. Depending on the size of the study region and the amount of asset inventory, the analysis can take a few minutes to several hours. It is recommended that you run separate analyses for each option. Click **OK** to run your analysis.

Note: The analysis modules available depend on the types of data provided for your study region. If you decide to make changes to the inventory after running the analysis, the analysis can be re-run, but the new analysis will overwrite previous results.

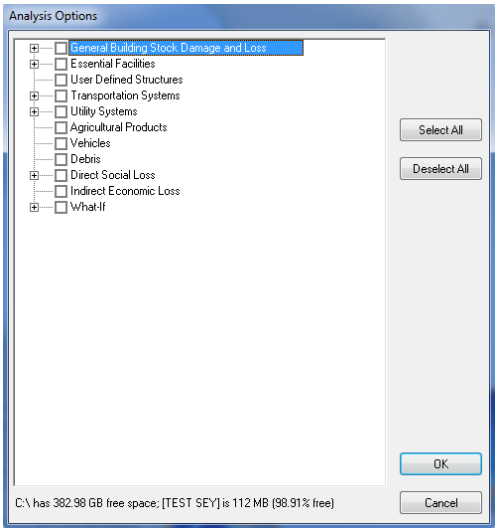


Figure 4-51 Analysis options.

4.7 Results

(Refer to Chapter 3, Sections 3.5 and 3.6; and Chapter 10 of the *Hazus-MH 2.1 Flood Model User Manual*.)

4.7.1 *Viewing Results*

Analysis results can be viewed from the **Results** menu and **View Current Scenario Results By…** option (Figure 4-52). Choose which results you want to view (Figure 4-53) and then open the **Results** menu again to see all the options now enabled (Figure 4-54). Results may be viewed and printed in tabular, map, or summary report formats.

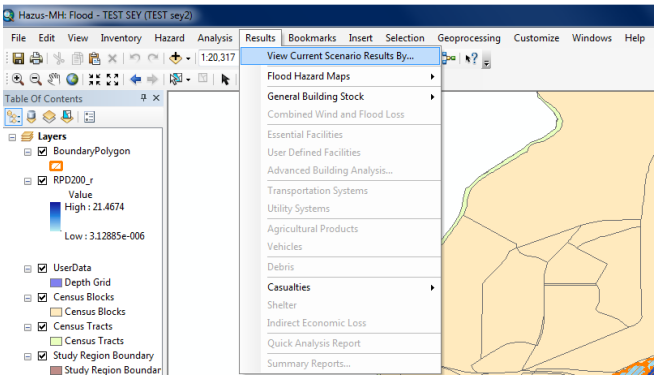


Figure 4-52 Results menu.

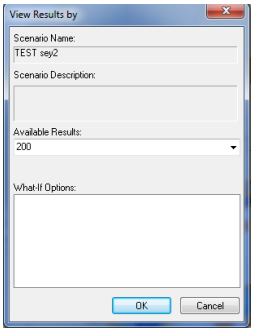


Figure 4-53 "View Results By" window.

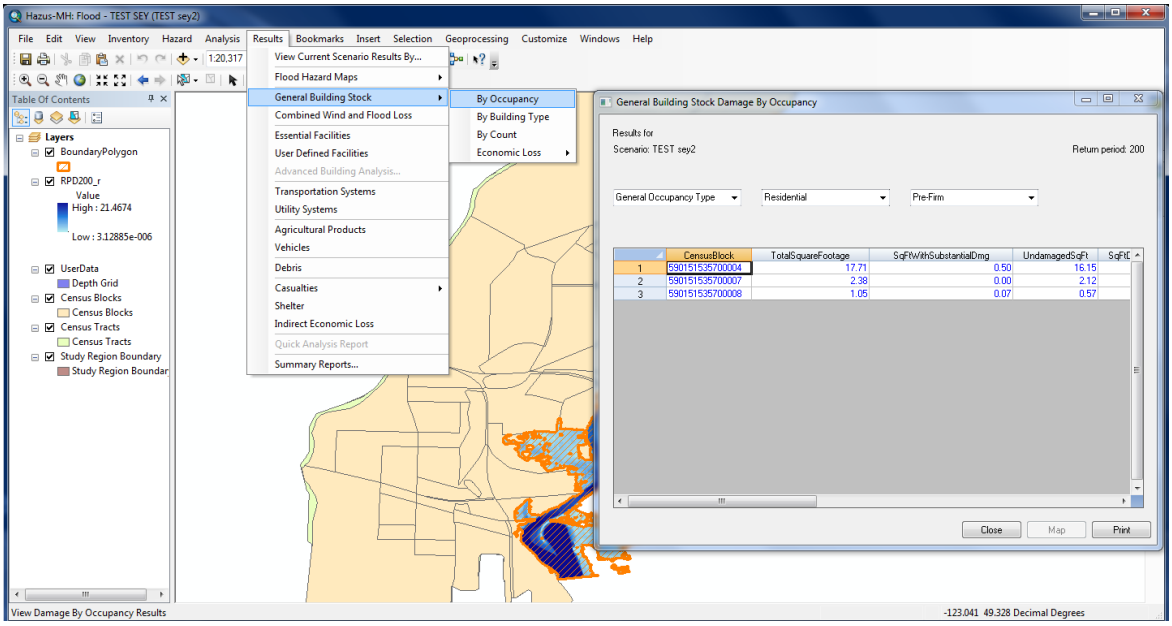


Figure 4-54 Results menu with enabled options.

4.7.2 *Interpretation of Results*

GBS Damage tables are populated only with the blocks that experience flooding. Results are shown for levels of percent of probable damage (0% to 10%, 11% to 20%, etc.). Anything over 50% is considered completely damaged (Substantial). Damage tables for individual facilities (from the Essential Facilities, Transportation, or Utility inventory) are populated only with the facilities that are within the flooded area.

Summary reports can be viewed by selecting **Summary Reports** from the **Results** menu. Note that the **Inventory** tab in the *Summary Reports* window (Figure 4-55) shows inventory exposure before damage (or total inventory assets), while all other tabs report losses. All of the reports show exposure for the whole study region, not the

specific scenario (Figure 4-56). Reports summarize all the census block values so you should review the actual results tables (Figure 4.54) since one census block can significantly alter the total loss estimation.

Reports can be printed or exported using the two icons in the top left corner of the report screen (Figure 4-56).

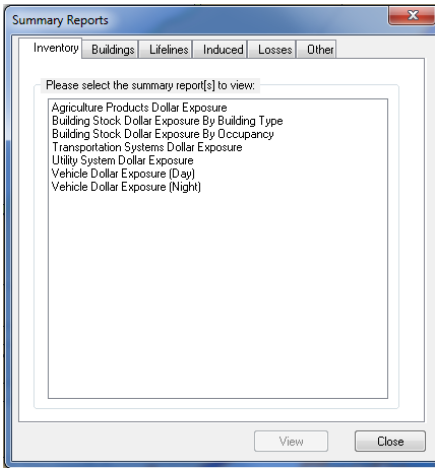


Figure 4-55 Window showing Summary Reports options.

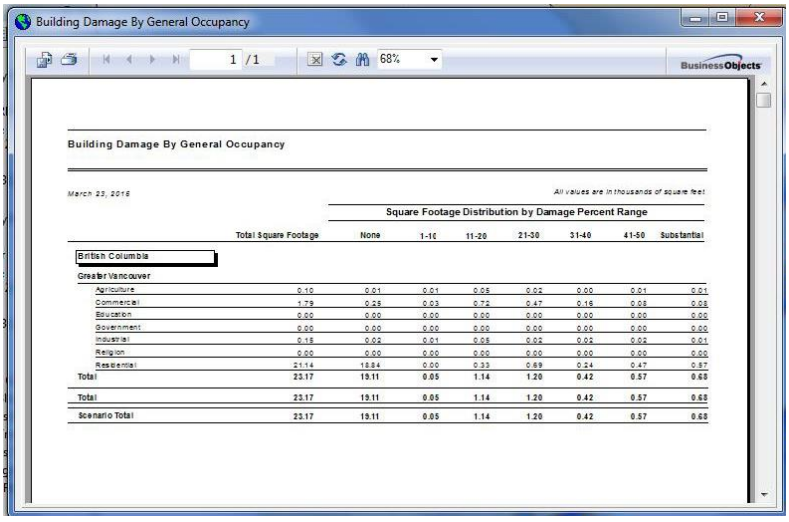


Figure 4-56 Example of Summary Report for Building Damage.

For a Global Summary Report, which gives an over-all report for the study region, select the **Other** tab in the *Summary Reports* window (Figure 4 57). This **Other** tab is also where you can access the Quick Assessment report if a *Quick Look* or *Enhanced Quick Look* analysis is run.

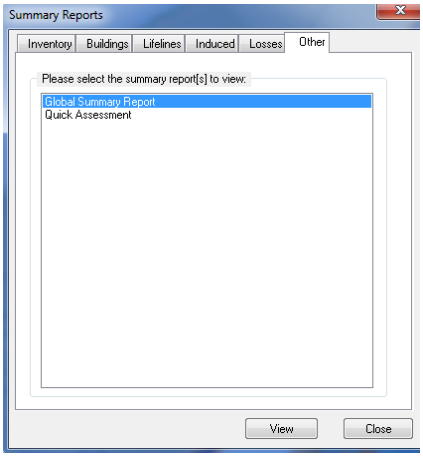


Figure 4-57 Global Summary Report.

Note: Loss estimations are influenced by the accuracy of the inventory and the hazard data as well as the reliability of the damage functions. Therefore, it is important to avoid quoting exact numbers from the tables and reports especially to people that are unfamiliar with how models work.

For best results, users are encouraged to develop a community-specific inventory that best describes the characteristics of their local study region, and to modify the default analysis parameters if better information is available. The default data provided with Hazus is only intended as a starting point and should only be used for initial estimates or for studies of large geographic areas.

4.7.3 *Dealing with Uncertainty*

(Also refer to Chapter 1, Section 1.8, of the *Hazus-MH 2.1 Flood Model User Manual*.)

When estimating social and economic losses of future events, users need to consider the uncertainties inherent in Hazus results and the extent to which they affect planning and mitigation work.

To address this issue, the user needs to consider that uncertainty can be introduced from a number of sources including:

- local conditions being represented by nationwide data
- simplifications in the model to allow for flexibility, and,
- errors of mathematical processing within software codes.

Also, the accuracy and completeness of the user data has a huge effect on the uncertainty of the results.

Note: As Hazus does not quantify the uncertainties and probabilities associated with reported losses, the user may choose to analyse several reasonable hazard scenarios to gain a sense of the range of possible losses.

4.7.4 *Communicating Results and Assumptions*

(Also refer to Chapter 10 of the Hazus-MH 2.1 Flood Model User Manual.)

In communicating the results of Hazus, it is important to be clear on what the estimates represent. It is also important to convey the level of detail and accuracy that went into the model to generate those results. This includes the asset inventory, the hazard and vulnerability inputs, and the scope of the loss or risk assessment methodology used. If user-supplied hazard inputs are used, these need to be noted with the results. A report disclaimer should accompany any results of a Hazus Canada analysis indicating any limitations, assumptions or simplifications, as well as, the specific purpose for which the analysis was performed.

4.7.5 *Use of Disclaimer to Communicate Model Results Assumptions and Limitation*

A sample disclaimer below is provided as an example of what could be adapted to accompany the results of a Hazus Canada analysis. This is an example of a disclaimer used by FEMA for a flood scenario for the Green River in King County, Washington:

"Disclaimer: The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific flood. These results can be improved by using enhanced inventory data and flood hazard information."

The disclaimer should include any assumptions that were made for the analysis and it could be extended to include all parameters entered in the case of a more advanced or detailed analysis.

4.7.6 *Validating Results*

Without corresponding real-world events to validate loss estimates, the use of subject matter experts to review results can provide credibility to model results. The objective of such a review is to establish reasonableness of model inputs and results, based on prior experience and general knowledge in this field of study.

4.8 Integrating Hazus with Emergency Management and Community Planning Software

While there is no difference in the modules and outputs between the Canadian and US versions of Hazus, additional translators have been developed to facilitate further manipulation of Hazus outputs within existing emergency management and community planning software programs. The Hazus methodology provides numeric outputs that can be used to calculate the essential dimensions of societal risk that are relevant for emergency management and land use decision-making. To support the full process of risk assessment, a set of translators has been developed that allow Hazus to be used in conjunction with other software applications that are specifically designed for scenario analysis and the evaluation of societal risk. These third-party applications provide a mechanism for translating numerical outputs of a Hazus analysis into a form that can be more readily incorporated into an operational context. To date, translators have been developed to integrate Hazus with the national Multi-Agency Situational Awareness System (MASAS) for use by emergency managers in Canada.

4.8.1 *Integrating Hazus with MASAS*

Natural Resources Canada (NRCan) partnered with Defence Research and Development Canada – Centre for Security Science (DRDC CSS) and Public Safety Canada (PSC) to make available the outputs of Hazus loss estimation scenarios for integration within the MASAS system.

The MASAS initiative enables the sharing and accessing of geospatial data and information between public safety and security community members in order to improve situational awareness. Situational awareness information provides context for an emergency event or disaster by describing what happened, where it happened, and what is being done about it. Emergency managers depend on situational awareness information to make decisions. The MASAS initiative creates a network of location-based geospatial event reporting systems to help emergency managers better prepare for and respond to emergencies.

As part of the MASAS initiative, the DRDC CSS launched the MASAS-X Pilot Project in November, 2011. MASAS-X is a national information exchange tool which supports the distribution of alerts and situational awareness information within the emergency management community.

NRCan contracted the services of Galdos Systems Inc., specialising in the development of applications for geographic information delivery, to develop a Hazus-MASAS translator. The translator is an open source Web-based Risk Assessment Data Management System (WRAMS) Service that integrates Hazus outputs within MASAS-X (Figure 4-58).

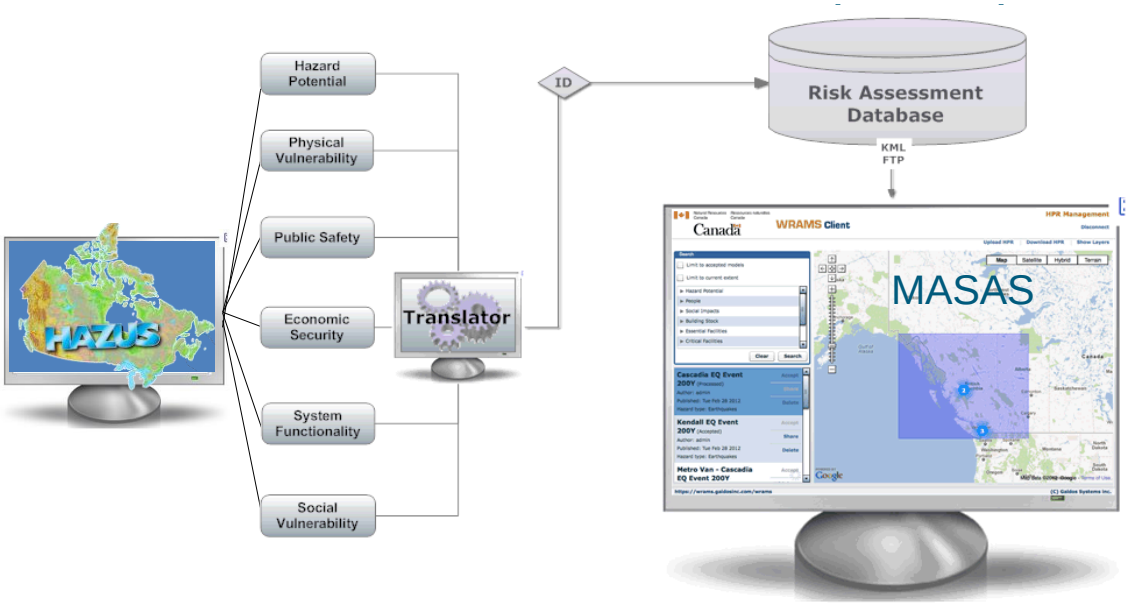


Figure 4-58 Integrating Hazus outputs within MASAS-X.

As part of the WRAMS Service, Galdos Systems developed and deployed the WRAMS client application and the MASAS ESRI Flex Tool (MEFT). The WRAMS client application allows users to search for or upload, peer-review, publish, and view Hazus outputs within its user interface (Figure 4-59) or within another viewer (Figure 4-60).

The MEFT tool then allows users to view these peer-reviewed and published Hazus outputs within MASAS-X (Figure 4-60).

These applications assist emergency managers in the mitigation of emergency events. By allowing emergency managers to access Hazus outputs and communicate situational awareness information, the national emergency management and public safety community is better prepared to respond to large scale events

Prior to the development of the WRAMS Hazus-MASAS translator, emergency managers would either not have had access to Hazus outputs, or would need to view them outside of the situational awareness information context. This would be more laborious, at best, or not all the pertinent information would be utilised in emergency management decision-making.

The WRAMS client application and the MEFT tool were developed and deployed but have not yet been adopted by a Canadian federal agency. More information about the MEFT tool is available at https://www.masas-x.ca/en/.

Figure 4-59 Local event in WRAMS client.

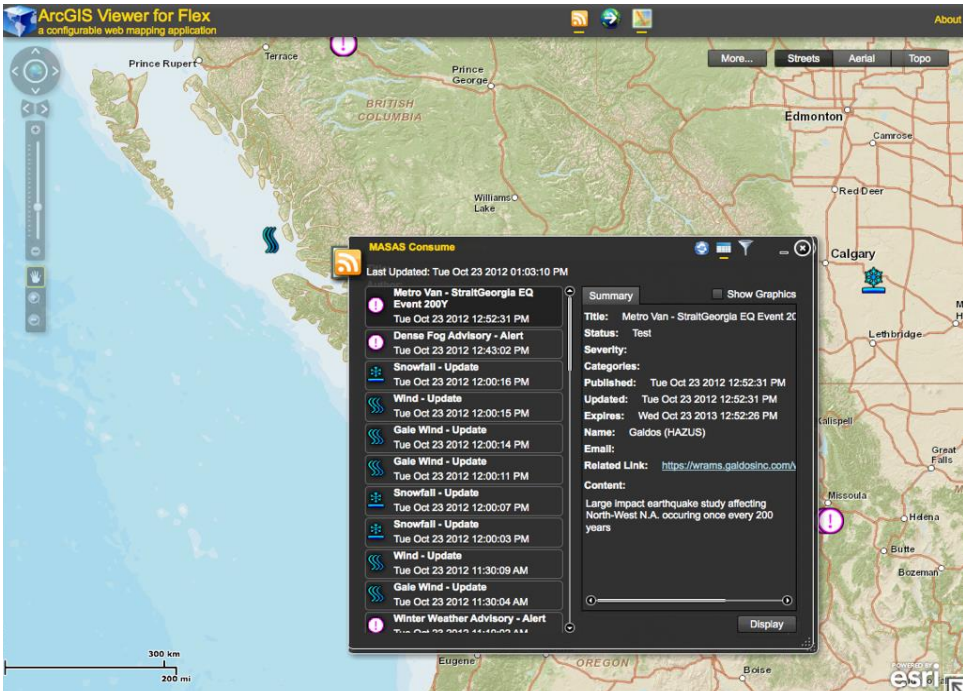


Figure 4-60 Viewing Hazus outputs in MASAS-X using the MEFT tool.

4.8.2 *Integrating Hazus with CommunityViz*

CommunityViz allows for visualisation of risk scenarios thanks to the development of the CommunityViz Risk Assessment Tool module. This module uses the Hazus inventory data to run separate scenarios that are useful to compare various hazard scenarios, weigh options in future build-outs of a community, or to evaluate disaster mitigation options. The history of its development for use with Hazus, and a guide to its use, follows.

Natural Resources Canada (NRCan) developed and tested a spatial decision support system for integrated risk assessment and disaster mitigation planning, known as Pathways. The Pathways risk assessment framework is composed of a risk analysis component and a risk evaluation component (Figure 4-61). The risk analysis component is implemented using the Hazus methodology and the Social Vulnerability Index model (also known as SoVI) for social vulnerability analysis. The risk evaluation component is implemented using the CommunityViz Scenario 360 and Scenario 3D modelling applications, and the United States Geological Survey (USGS) Land Use Portfolio Model (LUPM). Both components of the risk assessment framework utilise the new CommunityViz Risk Assessment Tool.

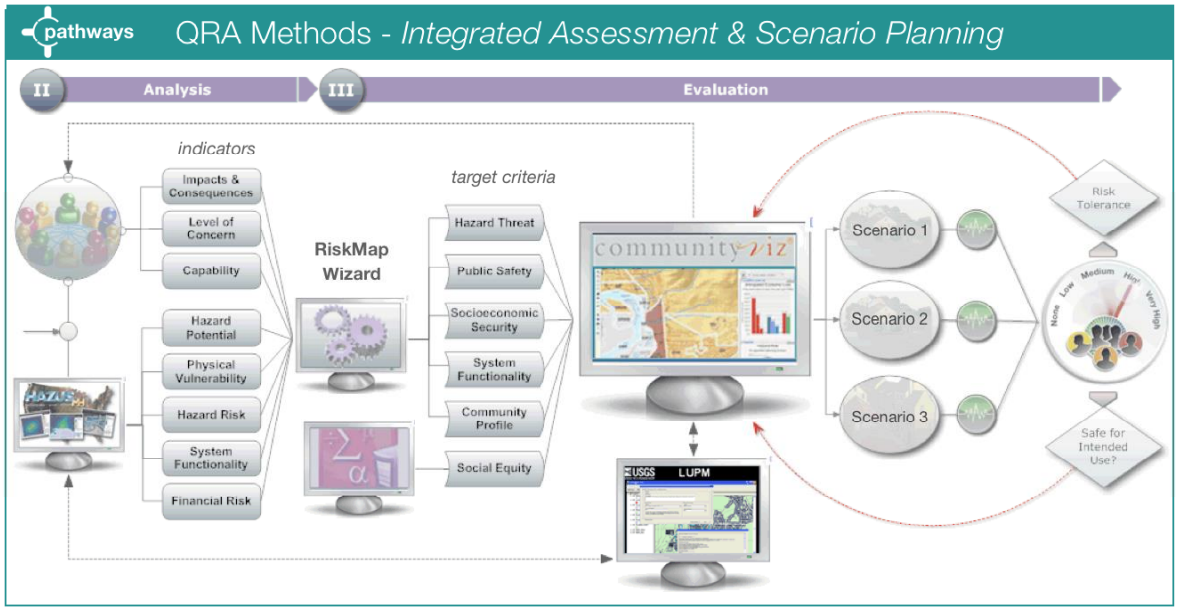


Figure 4-61 The Pathways framework.

NRCan developed the Risk Assessment Tool module of CommunityViz in partnership with Placeways LLC, a software firm specialising in GIS-based planning services and technology. This module is intended to assist planners and emergency managers evaluate the strengths and weaknesses of mitigation strategies, using risk indicators (e.g., public safety, socioeconomic security, etc.). Instructions for the Risk Assessment Tool are available in Apppendix F of Ulmi et al., 2014.

Chapter 5 Troubleshooting

Several issues have been encountered in the use of Hazus Canada. Some are very simple errors due to incorrect instructions in user manuals or uncommon displays, while others are issues in need of further investigation and programming solutions. The known issues and their solutions or workarounds can be found in this chapter.

Note: Please report any further issues for discussion through the Hazus Canada website http://www.hazuscanada.ca

5.1 Issues Specific to the Flood Module

5.1.1 *General Building Stock Re-Analysis Problem*

It has been observed that when re-analyzing the general building stock in a flood hazard scenario, the previously calculated value of losses for structural damage and building related direct economic losses will have been reduced in value. The issue arises when the user updates the study region with new or modified inventory data through CDMS using the “Update Study Region with Hazus-MH Data” option.

This issue is best avoided by ensuring all necessary inventory data is included in the Provincial Database before creating a study region. A secondary workaround is to import data directly into the window of the inventory dataset the user wishes to update from an external geodatabase after having created a study region.

5.1.2 *Editing Cost Field Problem*

Editing the cost field within an inventory window for *Essential Facilities* will not save any changes when a user creates new essential facility data. The issue can also occur with user-defined facilities, transportation systems, and utility systems when the data is imported into the inventory from an external geodatabase or through CDMS.

This issue is avoided by ensuring all necessary data is included in the Provincial Database before creating a study region. It can also be avoided by making modifications to cost data outside of Hazus and then importing the data directly into the inventory window within a previously created study region from an external geodatabase. If the user chooses to import the data directly into the study region all previous records in the inventory window should be removed ahead of time.

5.1.3 *Mapping Losses Problem*

When trying to map losses for various facilities (essential, user defined, etc.) and systems (transportation and utility) from the results menu, no loss values will be displayed.

To avoid this issue, it is recommended that the user map losses outside of the Hazus application in ArcGIS.

5.1.4 *Analysis of Bridges Problem*

On occasion it has been observed that the analysis of *Highway, Rail and Light Rail Bridges* will not run even though all the correct fields required for analysis have been populated. This issue arises when the user creates a new bridge within the inventory window of a previously created study region.

This issue is best avoided by ensuring all bridge inventory data is included in the Provincial Database before creating a study region. A secondary workaround is to import the data directly into the window of the transportation inventory dataset after having created a study region from an external geodatabase.

5.1.5 *Delineate Floodplain Tool Problem*

When running the delineate floodplain tool for a coastal flood scenario the Hazus application may freeze resulting in the failure of the tool.

To avoid this issue, before running the delineate floodplain tool, close and re-open the study region which contains the coastal flood scenario then run the tool.

5.1.6 *Flood Analysis Options that do not work*

The flood warning parameters do not work when incorporating them into an analysis.

Running annualized losses will not work even after running the required analysis for the general building stock.

All “What-if” analysis options do not work.

The flood module does not provide estimates for flood related casualties. This calculation has not been incorporated into the model.

5.2 Issues Specific to Hazus

5.2.1 *Documentation Problems*

For Railway Track Segments, field **SegmentClass** needs to be **RTR** and not **RTR1** as erroneously indicated in Tables 3.14 and 15.16 of the *Hazus-MH 2.1 Earthquake Model Technical Manual*.

The predecessor to the *CDMS Data Dictionary*, the *Hazus-MH Inventory Documentation HAZUS-MH MR3,* provides parameter information for linear features. It has been found that the units of field **Length** in table hzHighwaySegments and in hzRailwaySegments need to be kilometres, and not metres, as indicated in the document.

5.2.2 *Software Processing Status Display Problem*

When processing data such as region creation or input of data maps, the **Processing Status** window appears behind the other ArcGIS windows. This could mislead the operator that the program is hanging while necessary computing is taking place, particularly for large datasets.

To resolve the issue, it is recommended to reduce the windows to allow side-by-side display of all windows, in particular for the **Processing Status** window appearing very last after a processing request.

5.2.3 *Missing Results Following Analysis*

It has been observed that requested results sometimes are simply not computed and display 0 or NoData values in resulting tables and maps following analysis. These occur even if the items are visible in the inventory and the analysis was repeated (unsuccessfully) to correct the situation. This has been observed with Ground Motion contour maps available via the **Results** menu in the earthquake module, as well as with specific inventory items such as railway track segments and oil pipelines segments.

Current suggested solutions are to re-run the analysis for only the problematic items, to use a newly created study region that was not analysed beforehand, or to re-run the same analysis on a different computer system.

5.2.4 *Back-up .hpr File Creation*

It is possible that creating a backup .hpr file over the network fails, and fails again locally when using the suggested path and file name. Redoing it locally, using a different name, may offer a solution. These errors are neither consistent nor predictable, and were observed in many instances and with different files. Changing location and/or file naming for two or three other trials usually works.

Note: A disk drive that is too full may also disable the creation of back-up .hpr files, as the new .hpr file is also opened/checked post-creation for quality control

5.2.5 *Inventory Segment Input Problem (Tolerance Problem)*

Importing segments for inventory line features (such as highway roads, railway tracks, oil pipelines, etc.) is done outside of CDMS. This process requires line features to belong to specific geographic entities such as Counties or Tract, so that the analysis

can correctly compute loss estimates and report results appropriately at different geographic scales.

It was found that segments input to the inventory were problematic because post-analysis investigation showed that some segments overshot slightly the boundaries of Tracts or Counties, making their attribute information Tract or CountyFips erroneous at least in part. It is believed that this was causing Hazus to fail during region creation and during analysis. To confirm this, a few trials were done eliminating all segments within a determined buffer from any boundary, and this allowed analyses to complete and to provide the expected full range of loss estimates. Again confirming this, similar problems were also encountered with inventory point data located too close to boundaries.

Upon further examination, it was also noticed that in some instances the polygon layers syTract from the syBoundary.mdb database, hzTract from the provincial bndrygbs.mdb database, and a resulting hzTract from a created region RegionBndry.mdb database were not all perfectly spatially registered or coincident amongst themselves. Similarly, instances were also noticed where hzTract and hzCounty were not perfectly coincident where common line segments should have been coincident.

As such, it is believed that the problem could originate from the maps defining the different levels of aggregation contained in the syBoundaries.mdb as well as in those contained in the provincial bndrygbs.mdb databases. Ensuring that all these maps are coincident where they should be, or that all tolerance settings are constant at all scales, could provide a broad solution, but these options need to be further investigated. These avenues are being explored for future releases of Hazus Canada.

Nevertheless, with the current Hazus Canada 2.1 version, a solution is available with an increased error that can be controlled, and that is likely to be negligible depending on the scale of the study region. Every line feature destined for the inventory needs firstly to be segmented at the boundary of tracts as well as at the boundaries of counties (using **ArcToolbox > Analysis Tools > Overlay > Identity** menu path, followed by **Explode Multi-part features**). The faulty line features are then eliminated if they are falling outside syCounty, outside syTract, or outside the intended study region to be created, or again when they are wrongly identified in the attribute table (wrong province code, or when the **CountyFips** field value from syCounty differs from the **CountyFips** field value from syTract).

5.3 Issues Specific to CDMS

5.3.1 *Importing Flood Hazard Data Problem*

It has been observed that the importing of data specific only to a flood hazard will fail to import. This issue arises as an error message indicating that certain earthquake hazard information cannot have a null value when the user attempts to import any flood specific data.

The workaround for this issue is to ensure that all data is set up to be imported for both earthquake and flood hazards and subsequently imported into the provincial database for both hazard types.

5.3.2 *Duplication of Flood Foundation Type Fields*

When importing new or modified inventory data for a flood hazard, CDMS may ask to match up the required field of *Flood Foundation Type* twice. The user could attempt to match both fields or to match only one of the fields however in both cases the data will fail to import.

This issue can be avoided with the following steps:

1. In Hazus, create a study region with both earthquake and flood hazards selected
2. Exit Hazus
3. Set up the inventory data that is to be imported into CDMS with all relevant fields for an earthquake hazard only
4. Import the data into the Provincial Database through CDMS with only the earthquake hazard option selected. In this step, CDMS will automatically generate a table of default values for any flood specific information associated with the inventory data
5. Update the Study region with the newly imported data using the “Update Study Region with Hazus-MH Data” option
6. Open the previously created study region with the flood hazard option selected
7. Modify the newly imported inventory data within the inventory window as necessary

Note: The user may not be able to make any changes to the cost field in the inventory window unless the imported data already contained details about cost prior to step 4.

Another workaround is to import all data directly into the window of the inventory dataset the user wishes to modify after having a created a study region.

5.3.3 *Duplication during CDMS Import*

The CDMS data import process filters and controls the input data before it is transferred to the provincial inventory databases (point data only). The last window in the process, just before actually doing the transfer to the provincial database, asks to append/update OR replace records. Beware that without a **Hazus_ID** identifier, the append/update records will duplicate the dataset.

After an inventory update, it is recommended to check the updated .mdb provincial inventory files by creating a Hazus region, or directly, by accessing the data in Microsoft Access, to confirm that it has been done correctly.

Note: When updating provincial datasets, CDMS can only deal with one province at a time.

5.3.4 *CDMS Error: LatLongErrors.rdlc is Invalid*

When processing CDMS, the following error message may result: *"An error occurred during local report processing. The definition of the report 'C:\program files\HAZUS-MH\CDMS reports\LatLongErrors.rdlc' is invalid (…)"*.

Two possible problems may be:

1. There are input points outside the syBoundary for the province being updated.

2. The field parameters of the input data do not agree with the field parameters of the output file.

CDMS will not work if there are any input points outside of the syBoundary for the province being updated. This includes data points (buildings, bridges, etc.) that may be located in bodies of water.

Check that the latitude and longitude values of your buildings and structures are within the tract/province boundaries. Visually zoom in and check any of the points that may be very close to the boundary edge. You cannot change the province boundary so you may solve this problem by moving the point inside the tract/province. This may be an issue also if you have points inside but very close to the boundaries.

Note: Bridges or tunnels cannot have their point location placed at mid-span if this happens to be outside of a tract, over a body of water that is not part of Hazus' study boundaries. To be included in an inventory, the point for the bridge must be within the province outline.

CDMS is very particular about field formats. For text fields, check that the number of characters in your input filed does not exceed the maximum allowable. For number fields, check the format. If all formats appear correct and there is still an error generated, try creating new fields in your input file and copying the values from the previous fields to the new fields. Then use the new fields as the import source.

5.3.5 *Data Truncation in CDMS*

If an error stating that "*String of binary data would be truncated*" occurs during the updating of data in CDMS, check the length of text in each field. There are character maximums, and these have been exceeded if you receive this error. Some Canadian datasets may need to be modified to be entered.

Chapter 6 Resources, Support and Training

6.1 Canadian Resources and User Support

All updated Hazus Canada resources will be available at http://www.hazuscanada.ca. This site includes a community of Hazus user groups, news, training information, and publications. There are instructional presentations and videos available on the site that will help in initiating a Hazus analysis. It is recommended that users visit this site to find the latest in user support for Hazus Canada.

The Canadian Hazus Users Group (CanHUG) was formed in January, 2011 to provide a forum for Hazus users in Canada. CanHUG is facilitated by the National Scale Geohazard Risk Assessment Project of the Natural Resources Canada Program for Public Safety Geoscience. This group shares information about:

- the use of the Hazus software;
- Hazus applications in disaster risk reduction;
- Other risk assessment applications and methods; and
- the expansion of Hazus capability.

CanHUG holds monthly telephone meetings scheduled for the third Wednesday of every month from 10:30 to 11:30 PST. The monthly meeting agenda, minutes and presentations are posted on the CanHUG website. Visit CanHUG at http://hazuscanada.ca/group/canadian-hazus-users-group-canhug and sign up to receive event and resource notices, or contact info@hazuscanada.ca to participate in the monthly meetings. Join the Canadian Hazus Users Group also at http://www.linkedin.com/groups/Canadian-Hazus-Users-Group-4546481/about.

Note: Currently, the primary CanHUG management and resource sharing is conducted via http://www.hazuscanada.ca. The CanadianHUG on the UseHazus website http://www.usehazus.com/canadianhug/ is no longer regularly maintained.

The FEMA helpdesk is available to assist all Hazus users, but they support only Hazus-MH 2.2, and the Canadian version is based on Hazus-MH 2.1. For technical support regarding minor issues of the installation of Hazus-MH, please contact the Hazus Help Desk at https://support.hazus.us/ and www.fema.gov/hazus-help-desk-resource-and-solutions-page or call **1-877-336-2627**. For assistance with installing Canadian inventory data, please contact info@hazuscanada.ca.

6.1.1 *Documents*

The Role of Hazus-MH in the Canadian Natural Disaster Management Strategy. Authors K. Mickey and D. Coats are with the Polis Center at Indiana University Purdue University-Indianapolis (Polis IUPUI), and are experts in Hazus and its role in the US. This document was developed to support the adaptation of Hazus for use in Canada.

The document outlines a number of recommendations for Canadian use and stewardship of Hazus, and cites US examples in its use that could assist Canadian promoters of the application.

Case Study Documents. Available at www.geoscan.nrcan.gc.ca, the case study documentation of Natural Resources Canada's collaboration with municipalities and regions in Canada will provide real-life examples of Hazus use in Canada. NRCan worked with the District of North Vancouver and end-users in the Ottawa-Quebec City infrastructure corridor to apply Hazus to estimate losses from earthquakes and floods.

6.2 FEMA Manuals for US Hazus-MH

This document was intended to supplement the extensive documentation created by FEMA in support of Hazus. The following manuals are available for download from FEMA library at http://www.fema.gov/library/viewRecord.do?id=5120.

Getting Started with Hazus-MH 2.1. This manual gives step-by-step instructions on how to install and set-up Hazus-MH 2.1. It provides system and software requirements, and guidance on upgrading from previous versions, installation, settings, using the US inventory data, starting the program, program basics and menu, uninstalling, freeing memory, and server limitations.

Comprehensive Data Management System (CDMS) Data Dictionary: For Use with Hazus-MH Version 2.1. This manual provides users with lists of parameters and classifications for the inventory features in the statewide database. Using these parameters, the user can prepare an inventory of the building stock and specific buildings in their area of interest using local information sources. This inventory can be read using the CDMS program to update the statewide datasets, which are used to support analysis in Hazus software. The CDMS program has been adapted with Hazus Canada to allow users to manage Canadian datasets and upload them into provincial databases.

Hazus-MH 2.1 Flood Model Technical Manual and **Hazus-MH 2.1 Flood Model User Manual.** The flood hazard analysis module uses characteristics, such as frequency, discharge, and ground elevation to estimate flood depth, flood elevation, and flow velocity. The flood loss estimation module calculates physical damage and economic loss from the results of the hazard analysis. These manuals provide guidance for using the flood model in the US.

Flood Information Tool (FIT) User Manual. The Flood Information Tool (FIT) is an ArcGIS extension designed to process user-supplied flood hazard data into the format required by the Hazus-MH Flood Model. The FIT, when given user-supplied inputs (e.g., ground elevations, flood elevations, and floodplain boundary information), computes the extent, depth and elevation of flooding for riverine and coastal hazards. This manual provides guidance for using the FIT.

Hazus-MH 2.1 Earthquake Model Technical Manual and **Hazus-MH 2.1 Earthquake Model User Manual.** The Hazus-MH 2.1 Earthquake Model provides loss estimates based on deterministic scenario or probabilistic earthquakes. These manuals provide guidance on running the earthquake module and understanding the technical concepts behind it.

Advanced Engineering Building Module (AEBM) User Manual. This manual describes procedures for developing building-specific damage and loss functions for earthquake analysis.

Using Hazus-MH for Risk Assessment: How-To Guide. This manual is designed to help users prepare standardised, scientifically based risk assessments with Hazus software. It provides a broader approach to risk assessments than the technical and user manuals for the application. It is a good guide to use to better understand and position the application in the scope of a risk assessment.
Hazus-MH 2.1 Hurricane Model Technical Manual and **Hazus-MH 2.1 Hurricane Model User Manual.** These manuals provide guidance for using the hurricane wind model in the US.

6.3 Hazus Training

There are a variety of basic and advanced Hazus training opportunities available through http://www.hazuscanada.ca and Environmental Systems Research Institute (ESRI) virtual Hazus-MH courses and speaker series.

- For registration in ESRI virtual Hazus courses, visit https://www.fema.gov/virtual-courses-let-you-master-hazus-mh-your-timeline.

- To download the **ESRI speaker series** podcast, visit http://www.fema.gov/library/viewRecord.do?id=4402.

- For **ESRI free online Hazus courses**, visit http://training.esri.com/ and search “Hazus”.

6.4 Other Resources

BC Assessment Translation to Hazus. In addition to Statistics Canada, another public source of asset inventory would be Provincial and Territorial assessment authority data. Such source of data was briefly examined for use in Hazus Canada for BC. Although not incorporated into the default inventory datasets that accompany the Hazus Canada application, Appendi7 B provides a reference to assist users in translating provincial assessment authority data into Hazus database format.

Chapter 7 Glossary and Acronyms

7.1 Geohazard Risk Comparative Glossary of Terms

The glossary was compiled to ensure consistent usage of hazard-risk related terms in several manuscripts being produced by the Quantifying Geohazard Risk Project team of the Public Safety Geoscience Program of the Geological Survey of Canada (2009-2014). It compares definitions from nine different risk lexicons. The glossary layout demonstrates that no single lexicon captures the breadth of hazard risk terminology. It shows that each lexicon focussed on the key terms pertinent to the compiler's needs.

The glossary in Appendi8 C is a subset of the master glossary provided as a separate GSC publication. The abridged glossary provides definitions for over 130 disaster risk reduction terms that were used in the Hazus-MH 2.1 Canada User and Technical Manual: Earthquake Module (out of more than 200 terms in the master glossary). The definitions are drawn from nine respected English language international and national standards and guides.

The nine standards and guides were selected because they:

- had widespread acceptance and use,
- were nationally and internationally recognized, and
- were endorsed by an organisation or association representing a community of practice (e.g., Association of Professional Engineers and Geoscientists of BC).

7.2 Pictorial Glossary of Geohazard Risk

These pictures were designed to share how hazard-risk related terms are used by the Quantifying Geohazard Risk Project team of the Public Safety Geoscience Program of the Geological Survey of Canada (2009-2014). As with the glossary in Appendi8 C, the pictorial glossary in this Section is a subset of the master pictorial glossary provided as a separate GSC publication. The illustration in Figure 7-1 shows examples of the use of terms within the context of a flood hazard. The four panels define each of the components of risk management: hazard, exposure & vulnerability, consequence, and risk reduction or resilience building. The significance of the diagram features are explained in the diagram captions.

The concept and design were developed by M. Journey, N. Hastings, M. Ulmi, B. Struik and R. Turner, and imagined and drawn by R. Franklin.

Terms of use

You can use the diagram and in doing so, this publication and Natural Resources Canada must be acknowledged as the source of the diagrams. Modifications to the

diagram must be clearly stated in a description of the diagram that appears with the diagram.

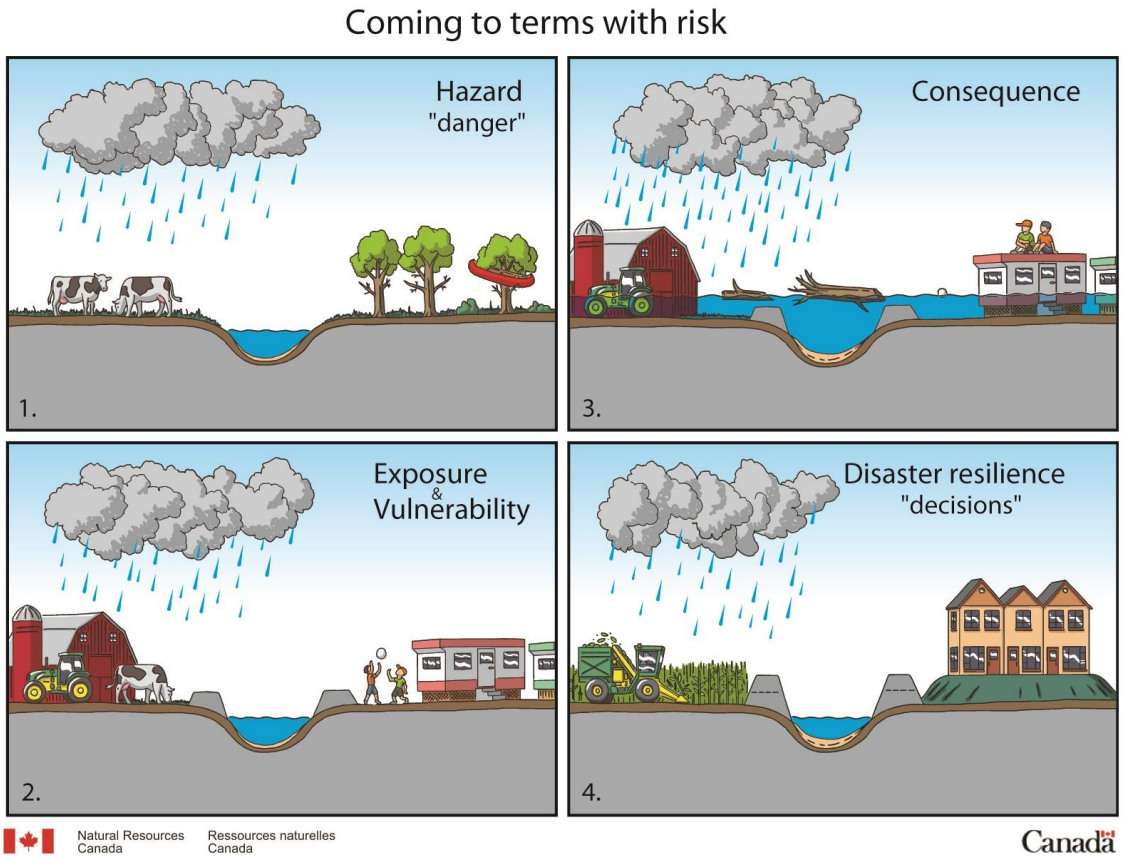


Figure 7-1 A risk and resilience scenario in the context of a flood hazard

1. Defines the flood hazard as the potential flood water depth. The recurrence interval of those floods is what defines the probability of a flood of a certain height occurring
2. Depicts how people have put elements of their society at risk by exposing them to the flood hazard and by constructing structures with vulnerability to flooding. Vulnerability in this usage is the potential for damage that a structure, a person or other things of concern to people may suffer during a flood event.
3. Depicts the consequence of flood, which results from exposing vulnerable people, buildings, and infrastructure to the inundation.
4. Shows examples of how flood risk can be reduced through mitigation of the hazard (construction of taller levees), mitigation of the exposure (land use change), and mitigation of vulnerability (construction of buildings above typical flood heights).

7.3 Acronyms

AAFG	Agriculture and Agri-Food Canada
AEBM	Advanced Engineering Building Module
AGR	Agricultural Products
AIMS	Asset Inventory Management System
APEGBC	Association of Professional Engineers and Geoscientists of British Columbia
CanHUG	Canadian Hazus Users Group
CDMS	Comprehensive Data Management System
CDUID	Statistics Canada Unique ID for Census Division
CEUS	Central & Eastern United States
CSA	Canadian Standards Association
CSD	Census Subdivision
CSS	Centre for Security Science
CSUID	Statistics Canada Unique ID for Census Subdivision (in non-urban areas)
CT	Census Tract
CTUID	Statistics Canada Unique ID for Census Tract (in urban areas)
DAUID	Statistics Canada Unique ID for Dissemination Area
Day Curve	Application by USACE of Harold Day's methods for consideration of warning time to the depth-damage relationship in the 1960s resulting in a curve relating damage reduction to forecast lead time
DBUID	Statistics Canada Unique ID for Dissemination Block
DHS	Department of Homeland Security
DRDC	Defence Research and Development Canada

EF	Essential Facilities
ESRI	Environmental Systems Research Institute
ESS	Earth Sciences Sector
FEMA	Federal Emergency Management Agency
FIT	Flood Information Tool
GBS	General Building Stock
GIS	Geographic Information Systems
GOC	Government of Canada
GSC	Geological Survey of Canada
Hazus	Hazards U.S.
Hazus-MH	Hazards U.S.–Multi-Hazard
HEC-RAS	Hydrologic Engineering Centers River Analysis System
HPLF	High Potential Loss Facilities
HRVA	Hazard, Risk and Vulnerability Analysis
HUG	Hazus-MH User Group
ISDR	International Strategy for Disaster Reduction, United Nations
ISO	International Organization for Standardization
LUPM	Land Use Portfolio Model
MASAS	Multi-Agency Situational Awareness System
MEFT	MASAS ESRI Flex Tool
NBCC	National Building Code of Canada
NIBS	US National Institute of Building Science
NRCan	Natural Resources Canada

NRCan/ESS	Earth Sciences Sector of Natural Resources Canada
PESH	Potential Earth Science Hazard
Polis IUPUI	The Polis Center at Indiana University Purdue University-Indianapolis
PRUID	Statistics Canada Unique ID for Province
PSC	Public Safety Canada
PSG	Public Safety Geoscience
PWGSC	Public Works and Government Services Canada
QRA	Quantitative Risk Assessment
StatsCan	Statistics Canada
TRN	Transportation Systems
UAC	User Access Control
UDF	User-Defined Facilities
UDG	User-Defined Grid
UN ISDR	United Nations International Strategy for Disaster Reduction
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
UTIL	Utility Systems
VEH	Vehicles
WRAMS	Web-based Risk Assessment Data Management System
WUS	Western United States

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Appendices

Appendix A Using the US Version of Hazus to Apply Modules Not Available in Canada

The following provides guidance for a Canadian user wanting to use modules only available with the US version of Hazus. The instructions will guide a user in altering a Canadian provincial database to mimic an American jurisdiction. At the time of publication of this manual the hurricane module was not available for use with the Canada dataset. By altering a provincial database, a Canadian user can apply this module. The following uses BC as an example of this process.

The two steps in the process are:

1. Change the BC provincial database tables provided with Hazus Canada (which contain the inventory for the geographic units) to be coded as Washington and give the database the name "WA".

2. Put the BC geography (spatial) units (State, County, Tract) into the US SyBoundary file and code the unit identification numbers as Washington.

A.1 Change the BC database tables

1. Make a copy of the BC database and rename it “BC_original” or other identifiable name.

2. Within the BC database there is an mdb file named "Bndrygbs" which contains several tables. All the records in each of these tables must have the identification numbers changed to the Washington code. It is suggested to use Microsoft Access, but use whatever software you have that will work. Using Access you can use the "Find and Replace" function to find all "59" (which is the BC code) AT THE START OF THE FIELD and replace it with "53" (which is the WA code).

Note: You don not want to change all the occurrences of 59, only the ones at the start of the record value.

Specifically in:

Tables hz****B
- change CensusBlock field values from 59* to 53*.

Tables hz****T
- change Tract field values from 59* to 53*.

Table hzCensusBlock
- change BldgSchemesID field values from BC1 to WA1;
- change Tract field values from 59* to 53*; and
- change CensusBlock field values from 59* to 53* (you do not have to change values in DAUID, CSDUID, or CDUID).

Table hzCounty
- change CountyFips field values from 59* to 53*;
- change State field from BC* to WA*; and
- change Statefips field values from 59* to 53*.

Table hzTract
- change Tract field values from 59* to 53*;
- change CountyFips values from 59* to 53*; and
- change BldgSchemesID field values from BC1* to WA1*.

Table hzMeansCountyLocationFactor
- change CountyFIPS field values from 59* to 53*.

**** represents specifics of a file name for various files named in similar format
* represents the remainder of the digits in the identification code

3. Within the BC database there is an mdb file named "flVeh" which contains 2 tables. Even though there are no data in these tables, the CensusBlock field values must be changed from 59* to 53* in each of these tables.

4. Within the BC database there is an mdb file named "MSH" (Mapping Schemes) which contains several tables. You can either:

   a) change all BC* values in all tables from BC* to WA*; or

   b) delete the MSH.mdb from the BC database and copy the MSH.mdb file from the original WA database (use ArcCatalog to copy and paste).

5. Within the BC database there is an mdb file named "UTIL" which contains several tables and feature class files. The following three tables contain a list of BC Tracts, with the other fields having values of 0. Even if the user is not doing earthquake analysis or adding pipelines to the database, it is suggested that these Tract values be changed so the entire database is completely converted. In the following earthquake specific tables.

   Table eqNaturalGasDL
   - change Tract field values from 59* to 53*.

   Table eqPotableWaterDL
   - change Tract field values from 59* to 53*.

   Table eqWasteWaterDL
   - change Tract field values from 59* to 53*.

6. Check that the data has been transferred. Use ArcMap or ArcCatalog to view the modified BC database and check all the tables and feature classes in Bndrygbs.mdb for the WA and 53 codes.

7. Change the database files as follows:

   a) copy and rename the original WA database to "WA_original" or other identifiable name;

   b) rename the modified BC database to "BC_as_WA" or "BCmodified" or some identifiable name; and

   c) copy the modified BC database, rename it WA, and use this for your analysis. Make sure this WA database is in C:\Hazus-Data-CN\Inventory (or wherever Hazus is looking for the inventory).

A.2 Put the BC geography (spatial) units into the syBoundary file

1. Make a copy of the US syBoundary.mdb file and rename it "syBoundaryUS_original" or other identifiable name.

   Note: In ArcMap it is suggested to load the syBoundary file for US, the syBoundary file for Canada, the hzCounty file from the modified BC database, and the hzTract file from the modified BC database. You will be modifying the file with the syBoundary for the US.

2. To modify feature class syState: remove the record for Washington. Copy and paste the record for BC, from the syState file in the Canadian file, to the US syState file. For that record, change the StateFips value to 53, change the State to WA; change the StateName to Washington.

3. To modify feature class syCounty: remove all records for Washington (all records with CountyFips starting with 53). Copy and paste (ArcMap) or Append (ArcTools) or Import (ArcCatalog) all the BC County records into the US syCounty file. You can use the "hzCounty" file from the BC database modified in section A.1 since all the field values have already been modified. (The extra fields in the hzCounty file will not be transferred.)

4. To modify feature class syTract: remove all records for Washington. Copy and paste (ArcMap) or Append (ArcTools) or Import (ArcCatalog) all the BC Tract records into the US syTract file. You can use the "hzTract" file from the BC database modified in section A.1. (The extra fields in the hzTract file will not be transferred.)

5. View the modified syBoundary files. It should have all of the US states except Washington plus show BC provincial outline and counties and tracts.

6. Change the database files as follows:

    a) rename this modified syBoundary to 'syBoundaryBC_as_WA" or other identifiable name;

    b) copy the modified syBoundary, rename it "syBoundary", and use this for your analysis. Make sure this syBounday.mdb file is in C:\Hazus-Data-CN\Inventory (or wherever Hazus is looking for the inventory).

Now you should be able to run Hazus US version. When you create a study region using "Washington", you will see the counties/tracts for BC. Before starting Hazus, you will want to view the tracts in ArcMap along with other geographic data so you can visually identify which tracts/blocks are within your area of interest.

Appendix B BC Assessment Translation to Hazus

Table B.1 is provided as a reference to assist users in translating provincial assessment authority data into Hazus database format. Provincial assessment authorities may collect and collate local data in different formats. In this example, the assessment data comes from the British Columbia assessment authority. The table is meant to guide users in how to translate data into Hazus. Use this translation at your discretion.

Note:

1. Those codes marked with a dash were deemed not to have a HAZUS equivalent and are not included in the HAZUS data.

2. The Hazus occupancy classification doesn't differentiate between agriculture types and therefore all agriculture is listed all as ”AGR”.

Table B.1 Hazus code translation guide for BC Assessment Data

Actual Use Code	Actual Use	Land Use	Hazus Code
0	SINGLE FAMILY DWELLING	Single Family	RES1
1	VACANT RESIDENTIAL LESS THAN 2 ACRES	Residential-Miscellaneous	RES1
2	PROPERTY SUBJECT TO SEC 19(8)	Residential-Miscellaneous	RES1
20	RESIDENTIAL OUTBUILDING ONLY	Residential-Miscellaneous	RES1
29	STRATA LOT - PARKING RESIDENTIAL	Residential-Miscellaneous	COM10
30	STRATA-LOT RESIDENCE (CONDOMINIUM)	Single Family	RES3D
31	STRATA-LOT SELF STORAGE-RES USE	Residential-Miscellaneous	COM1
32	SINGLE FAMILY DWELLING WITH BASEMENT SUITE	Single Family	RES1
33	DUPLEX	Multi- Family	RES3A
34	DUPLEX - UP & DOWN	Multi- Family	RES3A
35	DUPLEX - SINGLE UNIT OWNERSHIP	Multi- Family	RES3A
37	MANUFACTURED HOME - (WITHIN MANUFACTURED HOME PARK)	Single Family	RES2
38	MANUFACTURED HOME - (NOT IN MANUFACTURED HOME PARK)	Single Family	RES2
39	ROW HOUSING - SINGLE UNIT OWNERSHIP	Single Family	RES3C
40	SEASONAL DWELLING	Single Family	RES1
42	STRATA-LOT SEASONAL DWELLING (CONDOMINIUM)	Residential-Miscellaneous	RES3D
43	PARKING - LOT ONLY	Residential-Miscellaneous	COM10
47	TRIPLEX	Multi- Family	RES3B

Actual Use Code	Actual Use	Land Use	Hazus Code
49	FOURPLEX	Multi- Family	RES3B
50	MULTI-FAMILY - APARTMENT BLOCK	Multi- Family	RES3E
51	MULTI-FAMILY - VACANT	Residential-Miscellaneous	RES3A
52	MULTI-FAMILY - GARDEN APARTMENT & ROW HOUSING	Multi- Family	RES3C
53	MULTI-FAMILY - CONVERSION	Multi- Family	RES3A
54	MULTI-FAMILY - HIGH-RISE	Multi- Family	RES3F
55	MULTI-FAMILY - MINIMAL COMMERCIAL	Multi- Family	RES3D
56	MULTI-FAMILY - RESIDENTIAL HOTEL	Residential-Miscellaneous	RES4
57	STRATIFIED RENTAL TOWNHOUSE	Single Family	RES3C
58	STRATIFIED RENTAL APARTMENT - FRAME CONSTRUCTION	Multi- Family	RES3E
59	STRATIFIED RENTAL APARTMENT - HI-RISE CONSTRUCTION	Multi- Family	RES3F
60	2 ACRES OR MORE - SINGLE FAMILY DWELLING	Single Family	RES1
61	2 ACRES OR MORE - VACANT	Residential-Miscellaneous	RES1
62	2 ACRES OR MORE - SEASONAL DWELLING	Single Family	RES1
63	2 ACRES OR MORE - MANUFACTURED HOME	Single Family	RES2
70	2 ACRES OR MORE - OUTBUILDING	Residential-Miscellaneous	RES1
110	GRAIN & FORAGE	Agriculture	*AGR*
111	GRAIN & FORAGE - VACANT	Agriculture	*AGR*
120	VEGETABLE & TRUCK	Agriculture	*AGR*
121	VEGETABLE & TRUCK - VACANT	Agriculture	*AGR*
130	TREE FRUITS	Agriculture	*AGR*
131	TREE FRUITS - VACANT	Agriculture	*AGR*
140	SMALL FRUITS	Agriculture	*AGR*
141	SMALL FRUITS - VACANT	Agriculture	*AGR*
150	BEEF	Agriculture	*AGR*
151	BEEF - VACANT	Agriculture	*AGR*
160	DAIRY	Agriculture	*AGR*
161	DAIRY - VACANT	Agriculture	*AGR*
170	POULTRY	Agriculture	*AGR*
171	POULTRY - VACANT	Agriculture	*AGR*
180	MIXED	Agriculture-Mixed	*AGR*

Actual Use Code	Actual Use	Land Use	Hazus Code
181	MIXED - VACANT	Agriculture-Mixed	*AGR*
190	OTHER	Agriculture-Mixed	*AGR*
191	OTHER - VACANT	Agriculture-Mixed	*AGR*
200	STORE(S) AND SERVICE - COMMERCIAL	Commercial-Office	COM1
201	VACANT	Commercial-Vacant	COM1
202	STORE(S) AND LIVING QUARTERS	Commercial-Office	COM1
203	STORES AND/OR OFFICES WITH APARTMENTS	Commercial-Office	COM4
204	STORE(S) AND OFFICES	Commercial-Office	COM4
206	NEIGHBOURHOOD STORE	Commercial-Retail	COM1
208	OFFICE BUILDING (PRIMARY USE)	Commercial-Office	COM4
209	SHOPPING CENTRE - NEIGHBOURHOOD	Commercial-Retail	COM1
210	BANK	Commercial-Retail	COM5
211	SHOPPING CENTRE - COMMUNITY	Commercial-Retail	COM1
212	DEPARTMENT STORE	Commercial-Retail	COM1
213	SHOPPING CENTRE - REGIONAL	Commercial-Retail	COM1
214	SHOPPING CENTRE	Commercial-Retail	COM1
215	FOOD MARKET	Commercial-Retail	COM1
216	COMMERCIAL STRATA-LOT	Commercial-Miscellaneous	COM4
217	AIR SPACE TITLE	Commercial-Miscellaneous	COM1
218	STRATA-LOT SELF STORAGE-BUSINESS USE	Commercial-Miscellaneous	COM2
219	STRATA LOT - PARKING COMMERCIAL	Commercial-Miscellaneous	COM10
220	AUTOMOBILE DEALERSHIP	Commercial-Retail	COM1
222	SERVICE STATION	Commercial-Retail	COM3
224	SELF-SERVE SERVICE STATION	Commercial-Retail	COM3
225	CONVENIENCE STORE/SERVICE STATION	Commercial-Retail	COM1
226	CAR WASH	Commercial-Retail	COM3
227	AUTOMOBILE SALES (LOT)	Commercial-Retail	COM1
228	AUTOMOBILE PAINT SHOP	Commercial-Retail	COM3
230	HOTEL	Commercial-Service	RES4
232	MOTEL & AUTO COURT	Commercial-Service	RES4
233	INDIVIDUAL STRATA LOT - HOTEL/MOTEL	Commercial-Service	RES4

Actual Use Code	Actual Use	Land Use	Hazus Code
234	MANUFACTURED HOME PARK	Commercial-Service	RES2
236	CAMPGROUND (COMMERCIAL)	Commercial-Service	RES4
237	BED & BREAKFAST OPERATION 4 OR MORE UNITS	Commercial-Service	RES4
238	SEASONAL RESORT	Commercial-Service	RES4
239	BED & BREAKFAST OPERATION LESS THAN 4 UNITS	Commercial-Service	RES4
240	GREENHOUSES AND NURSERIES (NOT FARM CLASS)	Commercial-Service	COM1
250	THEATRE BUILDINGS	Commercial-Service	COM9
252	DRIVE-IN THEATRES	Commercial-Service	COM9
254	NEIGHBOURHOOD PUB	Commercial-Service	COM8
256	RESTAURANT ONLY	Commercial-Service	COM8
257	FAST FOOD RESTAURANTS	Commercial-Service	COM8
258	DRIVE-IN RESTAURANT	Commercial-Service	COM8
260	PARKING - LOT ONLY	Commercial-Miscellaneous	COM10
262	PARKING GARAGE	Commercial-Miscellaneous	COM10
266	BOWLING ALLEY	Commercial-Miscellaneous	COM8
270	HALL (COMMUNITY	Civic & Institutional	COM8
272	STORAGE & WAREHOUSING - OPEN	Commercial-Miscellaneous	IND2
273	STORAGE & WAREHOUSING - CLOSED	Commercial-Miscellaneous	IND2
274	STORAGE & WAREHOUSING - COLD	Commercial-Miscellaneous	IND2
276	LUMBER YARD OR BUILDING SUPPLIES	Commercial-Miscellaneous	IND1
280	MARINE FACILITIES - MARINA	Commercial-Retail	COM8
285	NURSING HOME	Health Care	RES6
286	CONGREGATE CARE FACILITY	Health Care	RES6
288	SIGN OR BILLBOARD ONLY	Commercial-Miscellaneous	COM4
400	FRUIT & VEGETABLE	Commercial-Retail	COM8
401	INDUSTRIAL - VACANT	Industrial	IND1
402	MEAT & POULTRY	Commercial-Retail	COM1
403	SEA FOOD	Commercial-Retail	COM1
404	DAIRY PRODUCTS	Commercial-Retail	COM1
405	BAKERY & BISCUIT MANUFACTURING	Commercial-Retail	COM1
406	CONFECTIONERY MANUFACTURING & SUGAR PROCESSING	Commercial-Retail	COM1

Actual Use Code	Actual Use	Land Use	Hazus Code
407	SOFT DRINK BOTTLING (GAL/SHIFT)	Commercial-Miscellaneous	IND1
408	BREWERY (BBL/YEAR)	Commercial-Miscellaneous	IND1
409	WINERY (BBL/YEAR)	Commercial-Miscellaneous	IND1
410	DISTILLERY (BBL/YEAR)	Commercial-Miscellaneous	IND1
412	FEED MANUFACTURING	Industrial	IND1
413	FLOUR MILLS & BREAKFAST CEREAL PRODUCTS	Industrial	IND1
414	MISCELLANEOUS (FOOD PROCESSING)	Industrial	IND1
415	SAWMILLS (M FBM/8HR)	Industrial	IND1
416	PLANER MILLS (WHEN SEPARATE FROM SAWMILL) (M FBM/8HR)	Industrial	IND1
417	PLYWOOD MILLS (SQ FT=1/4")	Industrial	IND1
418	SHINGLE MILLS (SQUARES)	Industrial	IND1
419	SASH & DOOR	Industrial	IND1
420	LUMBER REMANUFACTURING (WHEN SEPARATE FROM SAWMILL)	Industrial	IND1
421	VACANT	Industrial	IND1
424	PULP & PAPER MILLS (INCLUDING FINE PAPER	Industrial	IND1
425	PAPER BOX	Industrial	IND2
426	LOGGING OPERATIONS	Industrial	IND1
427	LOGGING ROADS & BRIDGES	Industrial	IND1
428	IMPROVED	Industrial	IND1
429	MISCELLANEOUS (FOREST AND ALLIED INDUSTRY)	Industrial	IND1
430	PETROLEUM AND GAS EXPLORATION (INCLUDING OIL AND GAS	Industrial	IND4
431	PRODUCTION PIPELINES	Industrial	IND1
432	OIL REFINING PLANTS (BBL/24HR)	Industrial	IND1
433	GAS SCRUBBING PLANTS (MCF/24HR)	Industrial	IND1
434	PETROLEUM BULK PLANTS (BBL OR GAL)	Industrial	IND1
435	LIQUID GAS STORAGE PLANTS	Industrial	IND1
436	OIL & GAS TRANSPORTATION PIPELINES	Industrial	IND1
437	OIL & GAS PUMPING & COMPRESSOR STATIONS	Industrial	IND1
438	MISCELLANEOUS (PETROLEUM INDUSTRY)	Industrial	IND1
440	MINING - COAL (TONS/8HR)	Industrial	IND1
442	MINING & MILLING – METALLIC (TONS/24HR)	Industrial	IND4

Actual Use Code	Actual Use	Land Use	Hazus Code
443	MINING & MILLING - NON-METALLIC (INCLUDING ASBESTOS)	Industrial	IND4
444	SMELTING & REFINING (0Z.LB.T/24HR)	Industrial	IND4
445	SAND & GRAVEL (VACANT AND IMPROVED) (TONS/SHIFT)	Industrial	IND4
446	CEMENT PLANTS (T.BBL/SHIFT)	Industrial	IND4
447	ASPHALT PLANTS (TONS CAP.)	Industrial	IND4
448	CONCRETE MIXING PLANTS (TONS CAP.)	Industrial	IND4
449	MISCELLANEOUS (MINING AND ALLIED INDUSTRIES)	Industrial	IND4
450	RUBBER & PLASTICS PRODUCTS	Industrial	IND4
452	LEATHER INDUSTRY	Industrial	IND2
454	TEXTILES & KNITTING MILLS	Industrial	IND2
456	CLOTHING INDUSTRY	Industrial	IND2
458	FURNITURE & FIXTURES INDUSTRY	Industrial	IND2
460	PRINTING & PUBLISHING INDUSTRY	Industrial	IND2
462	PRIMARY METAL INDUSTRIES (IRON & STEEL MILLS	Industrial	IND4
464	METAL FABRICATING INDUSTRIES	Industrial	IND4
466	MACHINERY MANUFACTURING (EXCLUDING ELECTRICAL)	Industrial	IND2
468	TRANSPORTATION EQUIPMENT INDUSTRY (INCLUDING AIRCRAFT	Industrial	IND5
470	ELECTRICAL & ELECTRONICS PRODUCTS INDUSTRY	Industrial	IND5
472	CHEMICAL & CHEMICAL PRODUCTS INDUSTRIES	Industrial	IND5
474	MISCELLANEOUS & (INDUSTRIAL OTHER)	Industrial	IND2
476	GRAIN ELEVATORS (BU CAP.)	Industrial	IND1
478	DOCKS & WHARVES	Industrial	IND1
480	SHIPYARDS	Industrial	IND1
488	STRATA-LOT SELF STORAGE-INDUSTRIAL USE	Industrial	COM2
490	PARKING LOT ONLY (PAVED OR GRAVEL)	Industrial	IND1
500	RAILWAY	Industrial	-
505	MARINE & NAVIGATIONAL FACILITIES (INCLUDES FERRY	Industrial	-
510	BUS COMPANY	Industrial-Services	-
515	AIRPORTS	Industrial-Services	-
520	TELEPHONE	Industrial-Services	-
525	FIBEROPTIC CONDUIT	Industrial-Services	-

Actual Use Code	Actual Use	Land Use	Hazus Code
530	TELECOMMUNICATIONS (OTHER THAN TELEPHONE)	Industrial-Services	-
540	COMMUNITY ANTENNA TELEVISION (CABLEVISION)	Industrial-Services	-
550	GAS DISTRIBUTION SYSTEMS	Industrial-Services	-
560	WATER DISTRIBUTION SYSTEMS	Industrial-Services	-
570	IRRIGATION SYSTEMS	Industrial-Services	-
580	ELECTRICAL POWER SYSTEMS (INCLUDING NON-UTILITY	Industrial-Services	-
590	MISCELLANEOUS (TRANSPORTATION & COMMUNICATION)	Industrial-Services	-
600	RECREATIONAL & CULTURAL BUILDINGS (INCLUDES CURLING	Commercial-Recreational	COM8
601	CIVIC	Civic & Institutional	GOV1
610	PARKS & PLAYING FIELDS	Civic & Institutional	COM8
612	GOLF COURSES (INCLUDES PUBLIC & PRIVATE)	Commercial-Recreational	COM8
614	CAMPGROUNDS (INCLUDES GOVERNMENT CAMPGROUNDS	Civic & Institutional	RES4
615	GOVERNMENT RESERVES (INCLUDES GREENBELTS (NOT IN FARM	Civic & Institutional	COM8
620	GOVERNMENT BUILDINGS (INCLUDES COURTHOUSE	Civic & Institutional	GOV1
622	ALRT		-
623	ALRT/MIXED USE		-
625	GARBAGE DUMPS	Civic & Institutional	-
630	WORKS YARDS	Civic & Institutional	IND6
632	RANGER STATION	Civic & Institutional	GOV2
634	GOVERNMENT RESEARCH CENTRES (INCLUDES NURSERIES &	Civic & Institutional	IND5
640	HOSPITALS (NURSING HOMES REFER TO COMMERCIAL SECTION).	Health Care	COM6
642	CEMETERIES (INCLUDES PUBLIC OR PRIVATE).	Civic & Institutional	COM3
650	SCHOOLS & UNIVERSITIES	Civic & Institutional	EDU
652	CHURCHES & BIBLE SCHOOLS	Civic & Institutional	REL1
654	RECREATIONAL CLUBS	Commercial-Recreational	COM8
660	LAND CLASSIFIED RECREATIONAL USED FOR	Commercial-Recreational	-