GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7474

Hazus-MH 2.1 Canada
User and Technical Manual:
Earthquake Module

M. Ulmi, C.L. Wagner, M. Wojtarowicz, J.L. Bancroft, N.L. Hastings, W. Chow, J.R. Rivard, J. Prieto, J.M. Journeay, L.C. Struik, and M. Nastev

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Natural Resources Canada
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Canada

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

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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 the summer of 2013. See www.hazuscanada.ca for any updates.

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The work was completed within the context of a Technical Annex signed by NRCan, DRDC and FEMA as part of a Cooperative Activity Agreement between the USA and Canada in risk-related domains. 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

National seismic parameters for Hazus Canada were developed through the work of the seismic hazards group at Natural Resources Canada, including John Adams, John Cassidy, and Stephen Halchuk, and the work of the civil engineering group at the University of British Columbia, including Carlos Ventura and Liam Finn.

Code adaptation for Hazus Canada was completed by NRCan under contract with Atkins Limited.

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The Canadian Hazus User Group (CanHUG, www.hazuscanada.ca) was canvassed for ideas that contributed to this guide. Through this and other engagements, this guide was developed with input from users.

Chapter 1 Introduction

1.1 Hazus Canada

Damage and loss estimation models combine authoritative information about hazard potential 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 the insurance, geotechnical engineering, emergency management, and municipal planning sectors.

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. On its own, 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 section 8.1 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. Section 5.2 profiles potential cases for using certain Hazus analyses and results.

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 existing methods and tools for use in Canada. This has resulted in a release of Hazus that permits users to create study regions in Canada based on Statistics Canada 2006 census boundaries and data.

1.2 A Business Case for Hazus Canada

Hazus Canada is a tool that provides municipalities, regional districts, provinces or consultants a standards-based approach to various aspects of emergency planning, including planning for mitigation, response and recovery. It can provide estimates of damage before, during or after an earthquake event, offering benefit to many aspects of emergency 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 the targeted, evidence-based approach to mitigation for hazards.

Using Hazus Canada, Canadian jurisdictions can better:

- identify areas at risk from seismic 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.

1.3 Scope of Manual

This manual was created for the Canadian GIS user who has acquired Hazus Canada and wants to run a loss estimation scenario. It is intended to be used as a complement to existing Hazus manuals, including FEMA's *Hazus-MH 2.1 Earthquake Model Technical Manual*, *Hazus-MH 2.1 Earthquake Model User Manual*, and *Using Hazus-MH for Risk Assessment: How-To Guide*. These and other reference documents can be found 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 7.1.1 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 earthquake loss estimation analysis for Canada, with chapter references for this manual, is shown in Figure 1.1. The chart is fairly simple for a Default analysis (on the left), and more complex for a User-Refined analysis, where the process to add and modify data and parameters is described (on the right). Under the heading for each step is the number of the chapter of this manual that will provide guidance for that section.

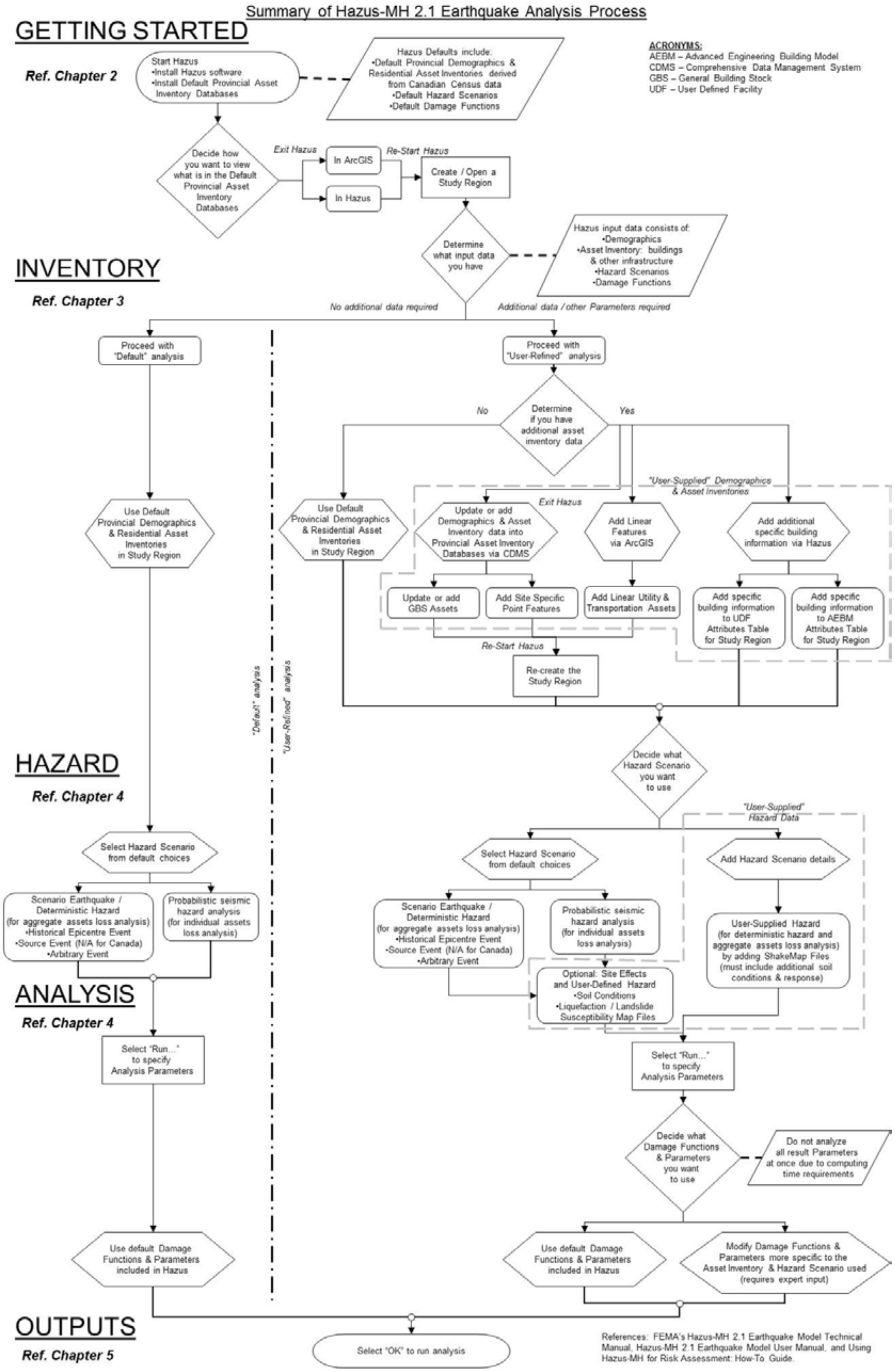


Figure 1.1: Hazus earthquake analysis process.

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 are being 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 only been adapted for the earthquake module, although the flood module is currently being adapted for use in Canada, for possible release in 2014. 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.

The following is a summary of the modifications that were made to the US version in order to create the first Canadian version of Hazus and CDMS.

Modifications to Hazus-MH for Canada:

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

2. Seismic hazard data for Canada was added to the hazards library for the US:

   a) catalogue of historic earthquakes of Moment Magnitude 5 or greater occurring between 1638 and 2010 in and around Canada; and

   b) probabilistic seismic hazard assessment maps for the Canadian National Building Code 2010, for multiple return periods.

3. Default Soil Type was set to Class C.

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

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

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

Note:

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

- No modification was done to fragility curves to reflect Canadian building codes or construction materials.

- Catalogue of active faults in Canada is not yet available.

Modifications to Census Canada Inventory Data for Canadian Provincial databases:

1. Census Canada 2006 census units were used as database geographic units.

2. Census Canada 2006 demographic information was used for census units.

3. Census Canada 2006 residential information was used to calculate general building stock properties for RES occupancy codes.

Note:

- No information was available to calculate building stock properties for non-RES occupancy codes.

- 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:

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

2. 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.

3. 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 Canadian version of Hazus has been modified to reflect the 2006 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.

The Hazus application is accompanied by a national inventory database of residential building information, providing aggregated information on building square footage, building types and counts, and replacement costs for all residential buildings across Canada. In general, residential buildings represent approximately 85% of the total building stock (as documented for Quebec City in Nollet et al., 2013). A national demographics distribution layer is provided as well. 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 is standardised across the country. It is anticipated that as additional asset inventory - such as commercial and industrial buildings, essential facilities, and infrastructure - become available, they will be added to the Canadian Provincial Database. The integration of the industrial and commercial buildings' information into the Canadian Provincial Database is underway and will be included in a future release of Hazus Canada.

Canadian users have the option to choose from the default Hazus inventory database, or to refine the exposure information and supply local inventory data. Local data are of much better quality with respect to with respect to occupancy, building construction type, earthquake design code, building replacement value, and square footage. Demographics data are also provided and can be further refined through imports to the provincial databases.

Hazus uses a standardised inventory data (built environment and demographics) which includes 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). The relative distribution of occupancies varies by census area and is computed directly from the specific occupancy class square footage inventory. 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 comprises of modules focused on various natural hazards. The initial focus of adapting Hazus for use in Canada has been 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.

This manual assists a user in creating a study region and running an earthquake hazard scenario for Canada.

1.4.3 Flood Module

There is currently no flood module available for Canada in the Canadian version of Hazus. In consultation with Environment Canada, NRCan is adapting the Hazus flood module at the time of publication of this document, for release expected in 2014. To run a Hazus analysis for floods, a Canadian user could alter a state boundary within the US version to mimic a Canadian study region and enter their own asset inventory and hazard scenarios. See Appendix A for instructions.

1.4.4 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 state boundary within the US version to mimic a Canadian study region and enter their own asset inventory and hazard scenarios. See Appendix A for instructions.

1.4.5 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.

1.4.6 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 *The Role of Hazus MH in the Canadian National Disaster Mitigation Strategy*.)

The Emergency Management Act of 2007 (S.C. 2007, c.15) defines the roles and responsibilities for all federal departments across the full spectrum of emergency management including prevention/mitigation, preparedness, response and recovery, and critical infrastructure. With Public Safety Canada playing a leadership and coordination role, departments are directed by the Act to identify the risks from natural disasters that are related to their sphere of responsibility and to develop an emergency management plan and supporting strategies appropriate to their responsibilities. In response to this mandate, Natural Resources Canada (NRCan) investigated the development and implementation of tools designed to conduct quantitative risk assessments (QRA) for geological hazard threats. After extensive research, NRCan identified a number of tools that can assist in producing these assessments including Hazus-MH (Hazus), a geographic information systems (GIS) based tool developed by the United States Federal Emergency Management Agency (FEMA).

In August 2011, NRCan entered into an agreement with FEMA to employ Hazus by adapting it for use in Canada as a QRA 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 proposed National Disaster Mitigation Program.

In 2011, NRCan contracted the Polis Center at Indiana University Purdue University-Indianapolis (Polis IUPUI) to support a number of educational objectives and make recommendations to better incorporate Hazus as a loss estimation tool for Canada and maximise its potential in contributing to risk reduction. Many challenges were recognised by the report, the most significant being the stewardship and management of the tool for use in Canada as NRCan's current mandate in adaptation comes to a close in 2014.

Further recommendations can be found in the report, and include developing strategies to improve streaming the necessary asset inventory and hazard inputs into the tool, establishing one agency to oversee management of Hazus, and creating extensive user support and education.

Chapter 2 Getting Started

2.1 Order Hazus Canada

To order Hazus Canada, please 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.

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

2.2 GIS Knowledge Requirements

To use Hazus Canada, you will need a standard level of GIS knowledge and expertise. The required expertise is shown in Table 2.1.

Table 2.1: Knowledge and expertise required to run Hazus.

Level of Hazus Analysis	Knowledge Base
Standard	ArcGIS knowledge.
Intermediate	ArcGIS and knowledge of local hazards and hazard inventories.
Expert	ArcGIS and participation by earth scientists, structural engineers, land use planners and/or emergency managers in risk assessment to provide an accurate inventory and assessment of community vulnerability.

2.3 System and Software Requirements

In order for Hazus to run properly, your system must meet certain minimum requirements (Figure 2.1). 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 earthquake 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 want 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 2.1: 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 2.2).

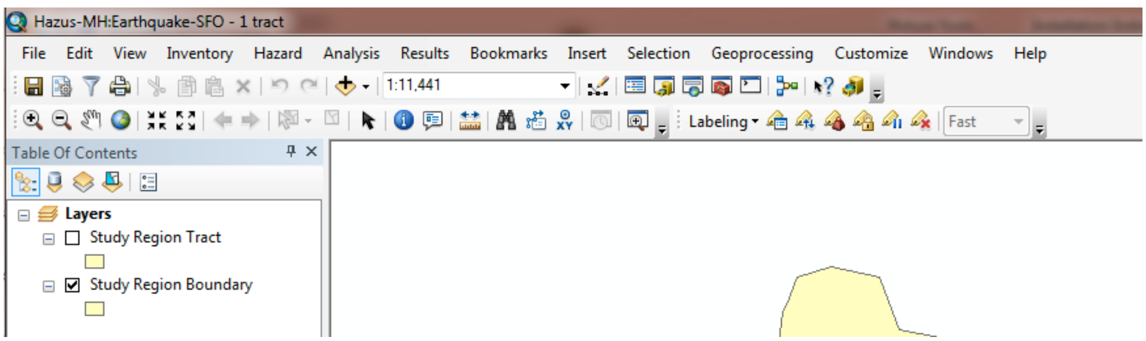


Figure 2.2: Hazus bar adds functions to ArcMap.

ArcGIS can be purchased by contacting ESRI, Incorporated 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.

2.4 Installation

2.4.1 Adjust System Settings

To install Hazus, follow the steps outlined below:

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 following Local Security rights (Table 2.2):

Table 2.2: Local security policy requirements.

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

Windows XP: From the **Start** menu, select **Run**, type **secpol.msc / s**, and click **OK**. In the Local Security Policy tool (Figure 2.3), grant access to the *Debug Programs* and *Manage auditing and security log*.

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 2.3), grant access to the *Debug Programs* and *Manage auditing and security log*.

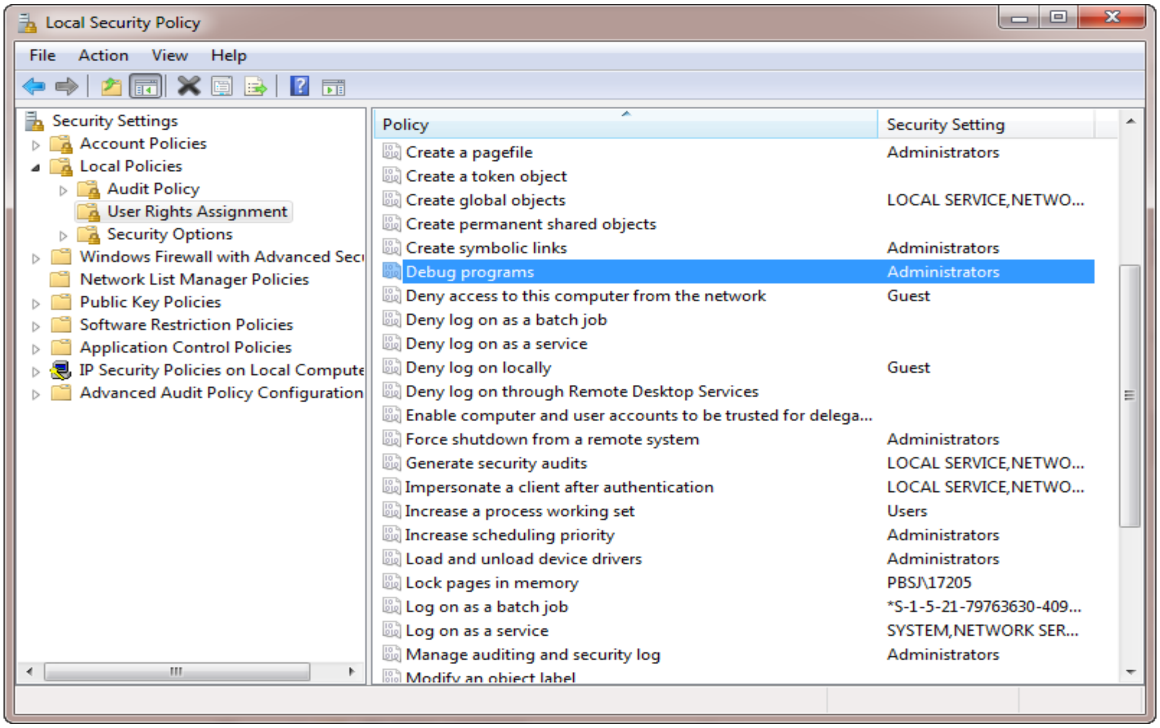


Figure 2.3: Local Security Policy tool.

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 XP: Navigate to **Control Panel** and then to **Regional and Language Options**. Under the **Regional Options** tab, select **English (United States)** from the drop-down menu (Figure 2.4). If applicable, repeat the process in the **Advanced** tab for the Language for non-Unicode programs (Figure 2.5). Click **OK**.

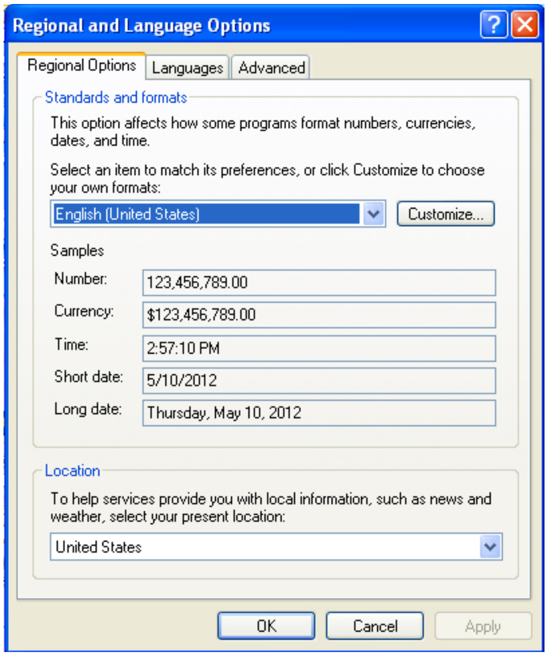


Figure 2.4: Windows XP Regional and Language Options settings, Regional Options tab.

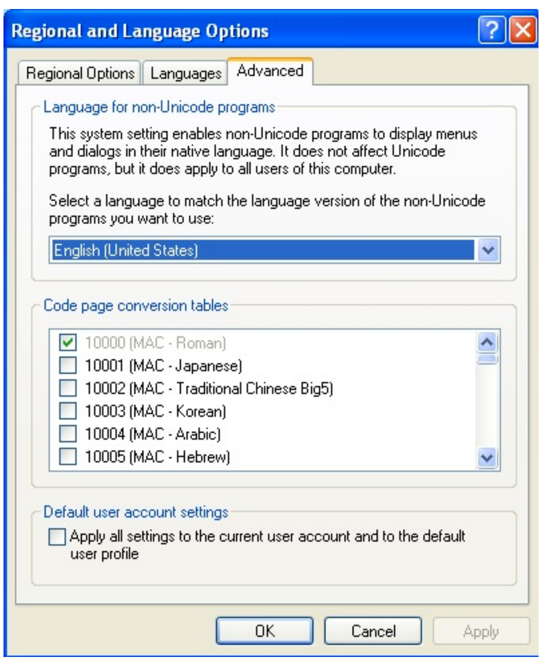


Figure 2.5: Windows XP Regional and Language Options settings, Advanced tab.

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 2.6). In the **Administrative** tab, click **Change system locale…** (Figure 2.7) and select **English (United States)** from the drop-down menu (Figure 2.8). Click **OK**. Windows will prompt you to restart your computer (Figure 2.9); click **Restart now**.

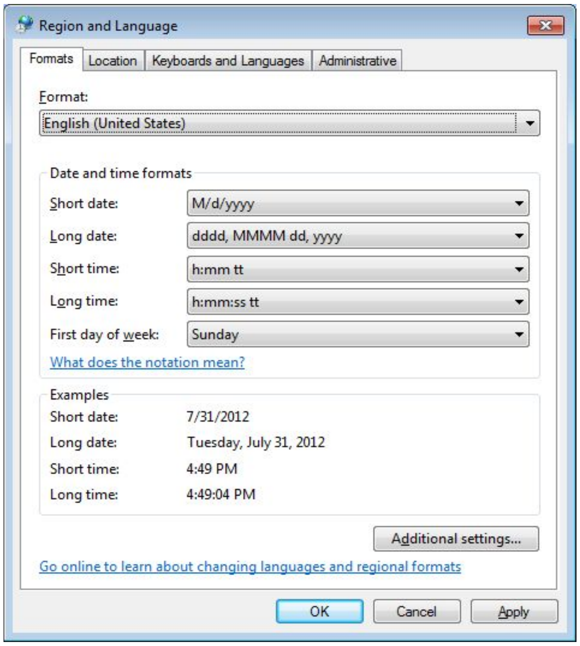


Figure 2.6: Windows 7 Region and Language settings, Formats tab.

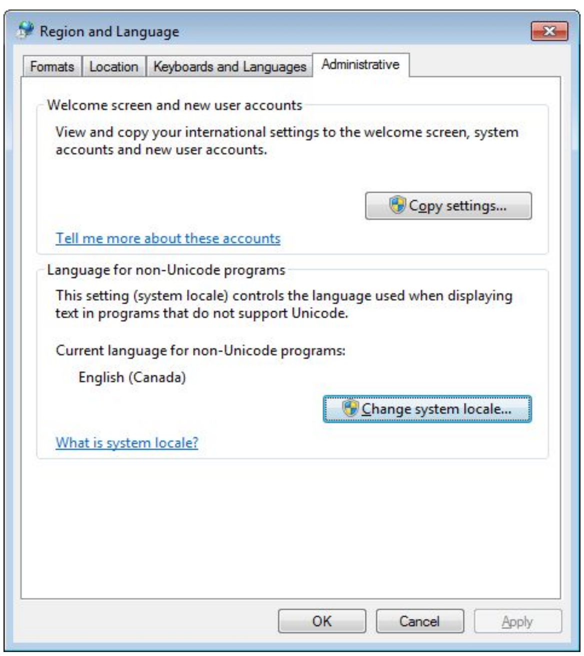


Figure 2.7: Windows 7 Region and Language settings, Administrative tab.

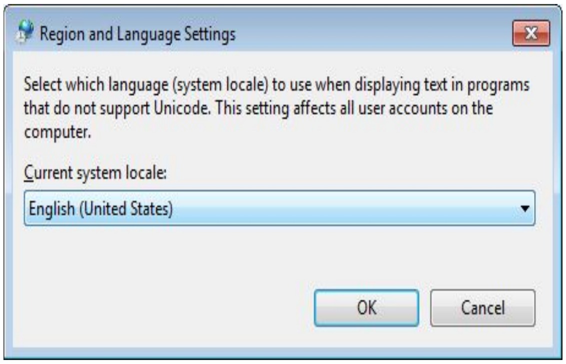


Figure 2.8: Windows 7 Region and Language settings, change Current system locale.

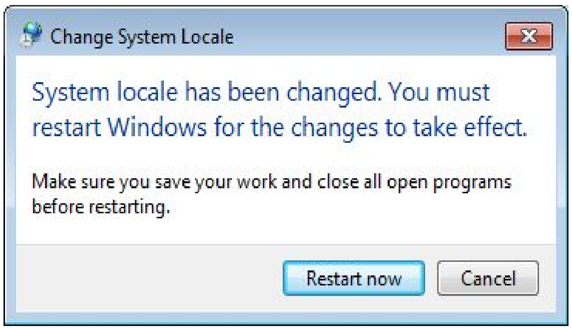


Figure 2.9: Windows 7 Region and Language settings, Restart now.

2.4.2 Install Hazus

1. Uninstall any prior versions of Hazus.
2. Click on the link to the Hazus application you received when you ordered Hazus Canada.

   Note: The file is large and may take a while to open.

3. Launch the installation program.

Windows XP: Double-click **setup.exe** to start the installation.

Windows 7: Right-click **setup.exe** and select **Run as administrator** (Figure 2.10). 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**.

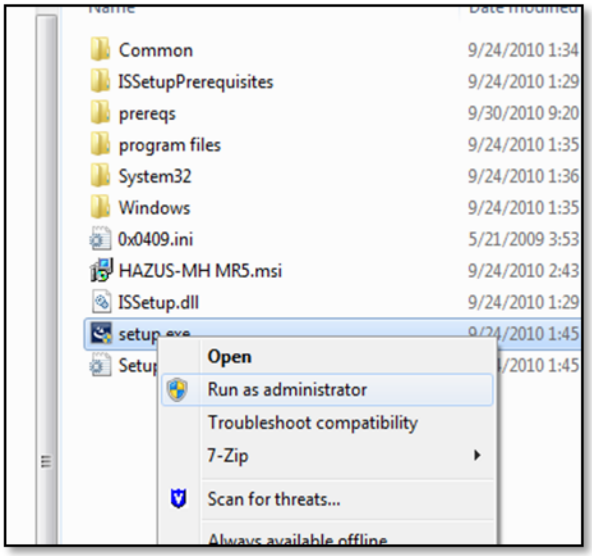


Figure 2.10: Launching Hazus setup with Windows 7.

4. The setup program will initially install the Hazus database (SQL Server Express 2008 R2). Next, the requirements screen will appear (Figure 2.1) and then the setup program startup screen (Figure 2.11). Click **Next** to continue.

Figure 2.11: Startup screen of the Hazus installation program.

5. Enter your **User Name** and **Company (or Agency)** information. Select the appropriate program access permissions choice for your needs (Figure 2.12) – allow access for all users or only for the installing user (excluding other users). Click **Next** to continue.

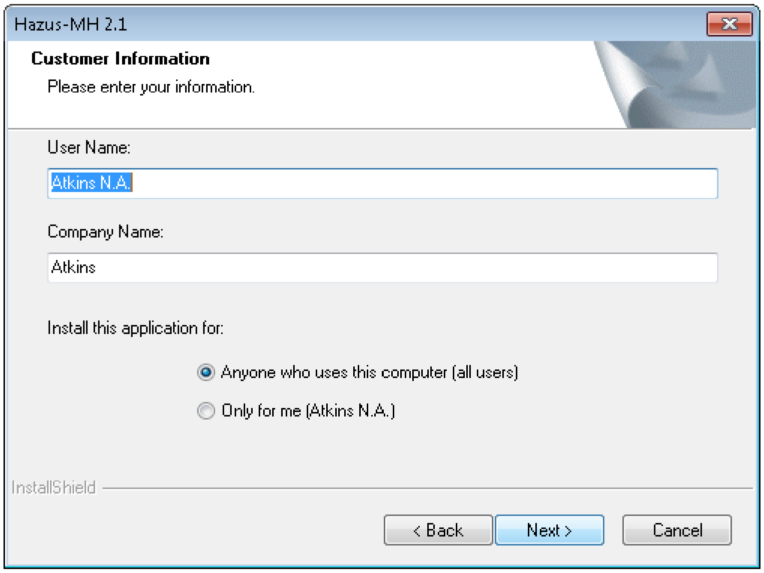


Figure 2.12: Register user name and program permissions.

6. In the **Select Features** dialogue, specify the hazard module(s) to be installed (Figure 2.13). As of this release, only the earthquake module is certified for use in Canada. The flood module has not been certified for Canada and is included only for testing. The Comprehensive Data Management System (CDMS) is needed for inputting data into Hazus and must be installed.

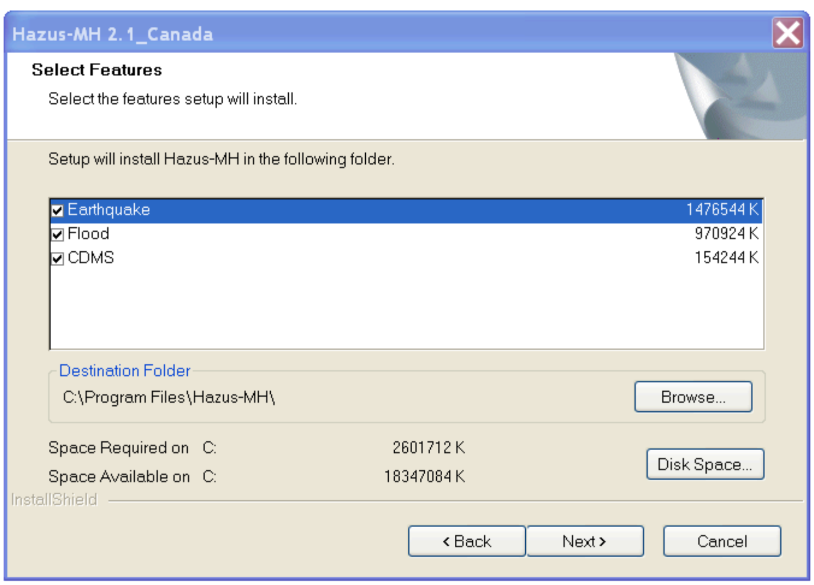


Figure 2.13: The modules to be installed.

7. The default installation directory (Destination Folder) is **C:\Program Files\Hazus-MH** (Figure 2.14). 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.

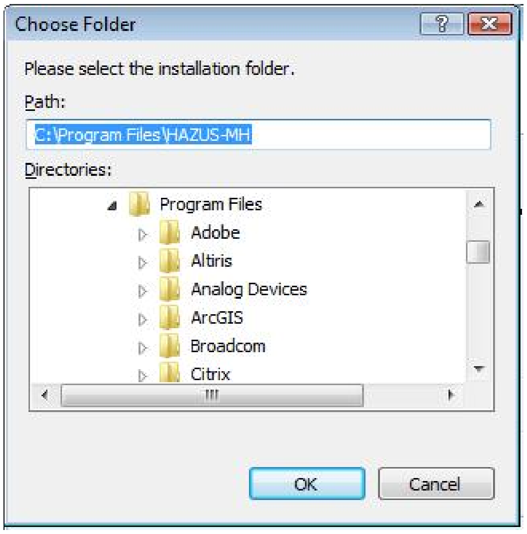


Figure 2.14: Specify the path of the Hazus installation directory.

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 2.15). Accept the default directory or click **Browse** to choose an alternative directory. Click **Next** to continue the installation.

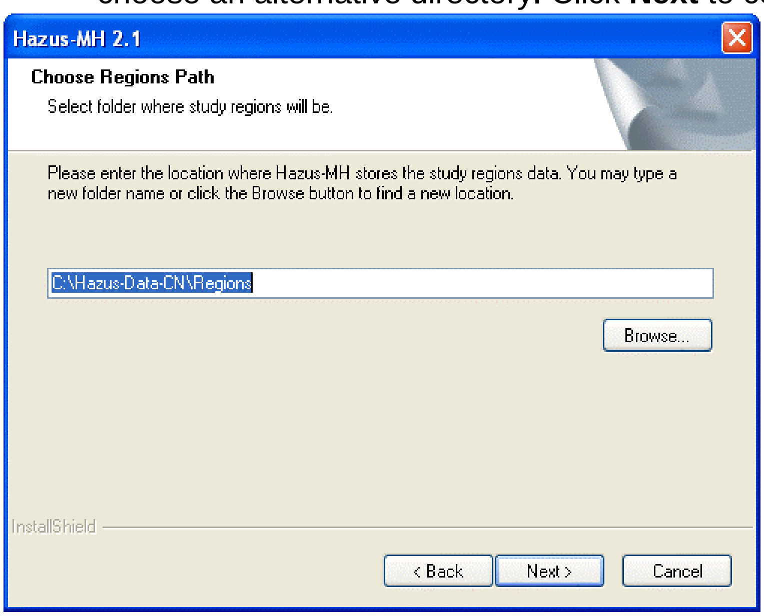


Figure 2.15: Default directory for study region files.

9. The default directory for storing inventory data (**Data Path**) is **C:\Hazus-Data-CN\Inventory** (Figure 2.16). 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 2.4.3 for instructions on how to import inventory data.

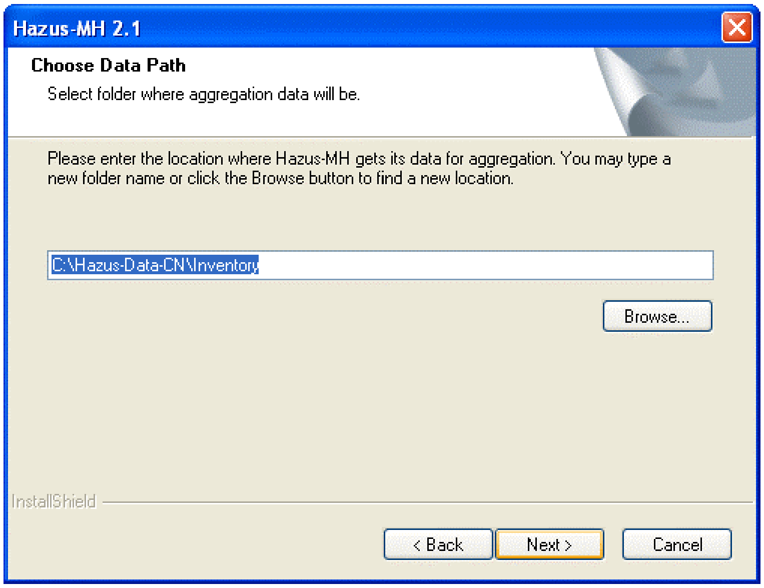


Figure 2.16: Default directory for inventory data.

10. The next screen (Figure 2.17) 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.

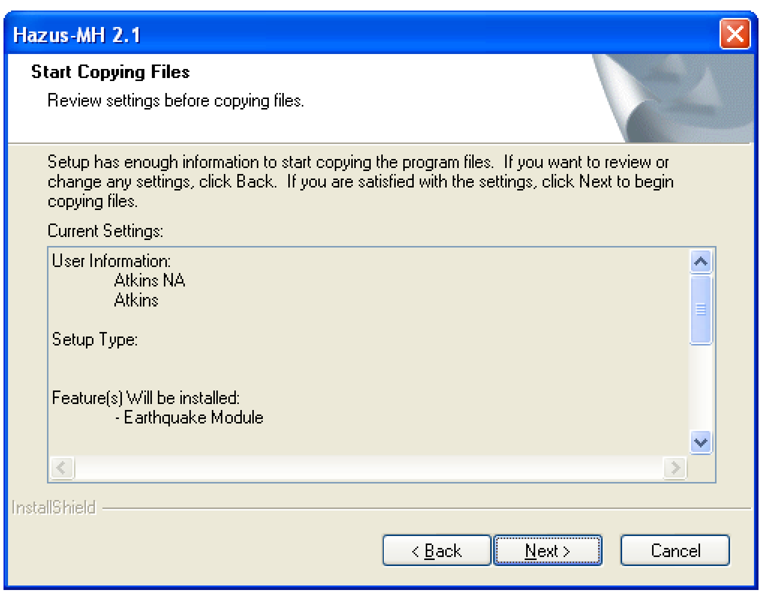


Figure 2.17: Confirmation of installation settings.

11. The installation may take several minutes. When it is complete, the **InstallShield Wizard Complete** dialog box (Figure 2.18) will appear and an automatic Hazus shortcut will be created on your desktop. Click **Finish** to return to Windows. If not automatically prompted, manually restart your computer.

Figure 2.18: Dialogue box indicating successful Hazus installation.

2.4.3 Loading Canadian Inventory Data

Default inventory data for Canada is included with the application files. The data for each province/territory is grouped in a folder named simply with the corresponding provincial or territory code (for example, data for British Columbia is in a folder named BC).

To create study regions, Hazus reads the inventory from the files within the provincial/territorial folders in the **Data Path** directory, which was set during the installation process (Figure 2.16). You must copy and paste the appropriate province/territory inventory folder containing several files to the **Data Path** directory on your local drive. Each province/territory will be a folder within the **Data Path** directory. It is best to copy only the province/territory folders you require. Copying all of the province/territory inventory data will require a large amount of space on your hard drive.

Check that the file syBoundary.mdb is also 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.

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 7.1 for more assistance.

2.5 Program Basics

2.5.1 Starting the Program

The installation program creates a Hazus icon/shortcut on your computer's desktop. To start the program, double-click the Hazus icon (Figure 2.19).

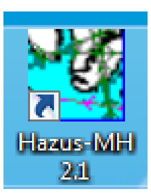


Figure 2.19: Hazus icon.

The first window of Hazus allows the user to create, open, or backup a study region. Refer to section 4.3 for information on creating a study region. Once a study region has been opened, the ArcGIS window will appear.

2.5.2 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 2.3, and include: **Inventory** (Figure 2.20), **Hazard** (Figure 2.21), **Analysis** (Figure 2.22) and **Results** (Figure 2.23).

Table 2.3: 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.

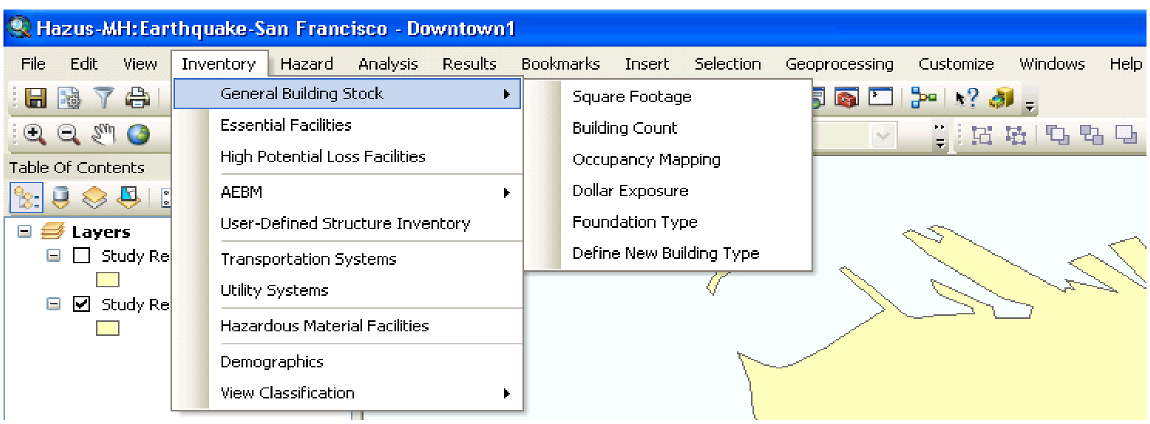


Figure 2.20: Hazus Inventory menu.

Figure 2.21: Hazus Hazard menu.

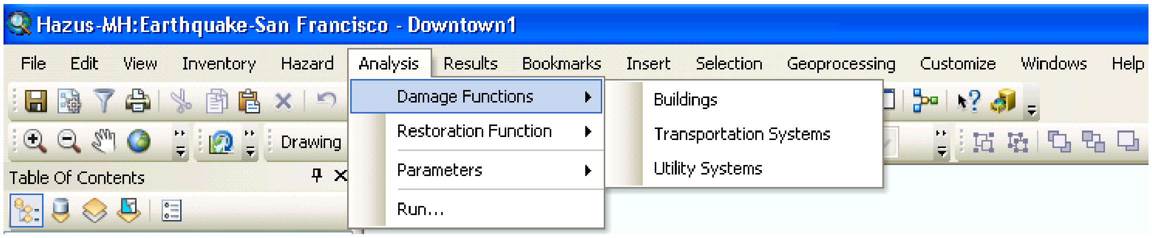


Figure 2.22: Hazus Analysis menu.

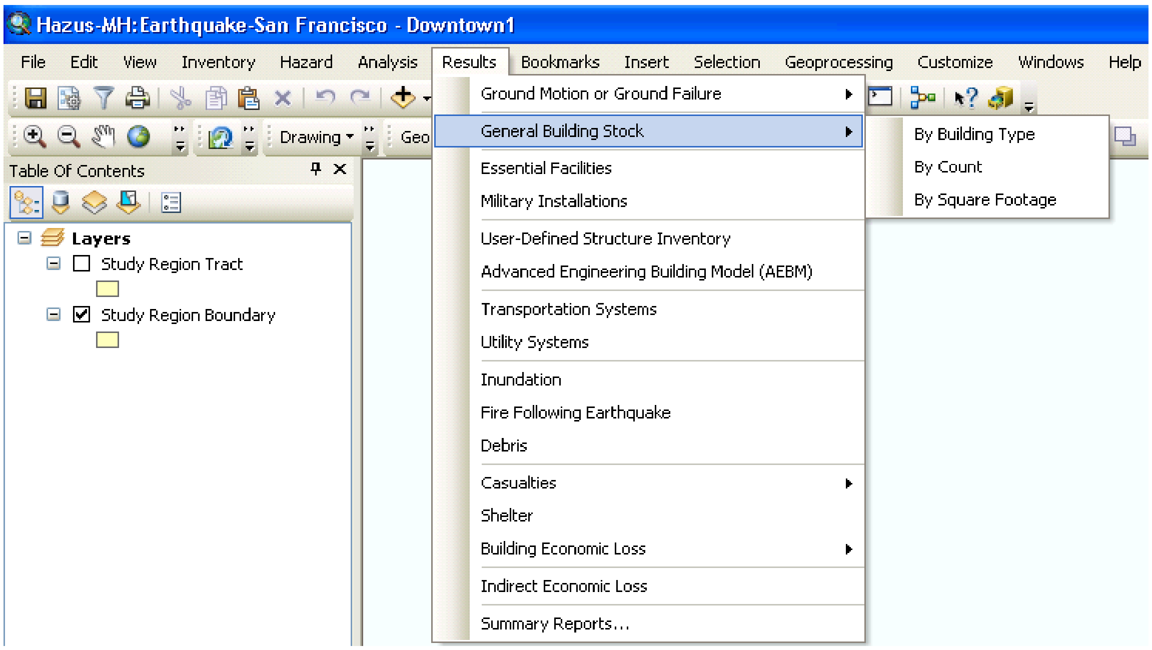


Figure 2.23: Hazus Results menu.

2.5.3 Uninstalling Hazus-MH

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

Windows XP:

1. From the **Start** menu, select **Settings** and launch the **Control Panel**.
2. Double-click **Add/Remove Programs**.
3. When prompted by the **Add/Remove Programs** window (Figure 2.24), highlight Hazus-MH. Double-click **Change** or **Remove**.

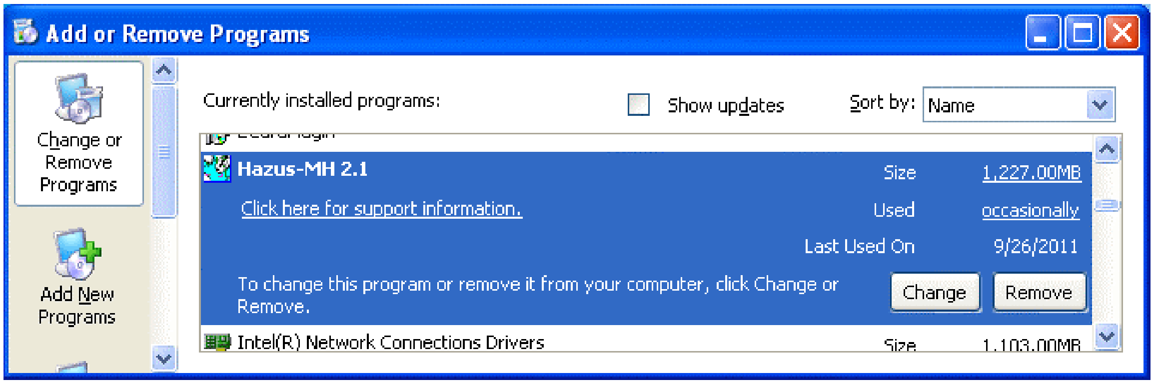


Figure 2.24: Uninstall Hazus-MH.

4. 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.
5. Select Remove and click **Next** to uninstall Hazus-MH.
6. 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 2.25). Select the **Uninstall** option from the pop-up menu and then select **Remove**.

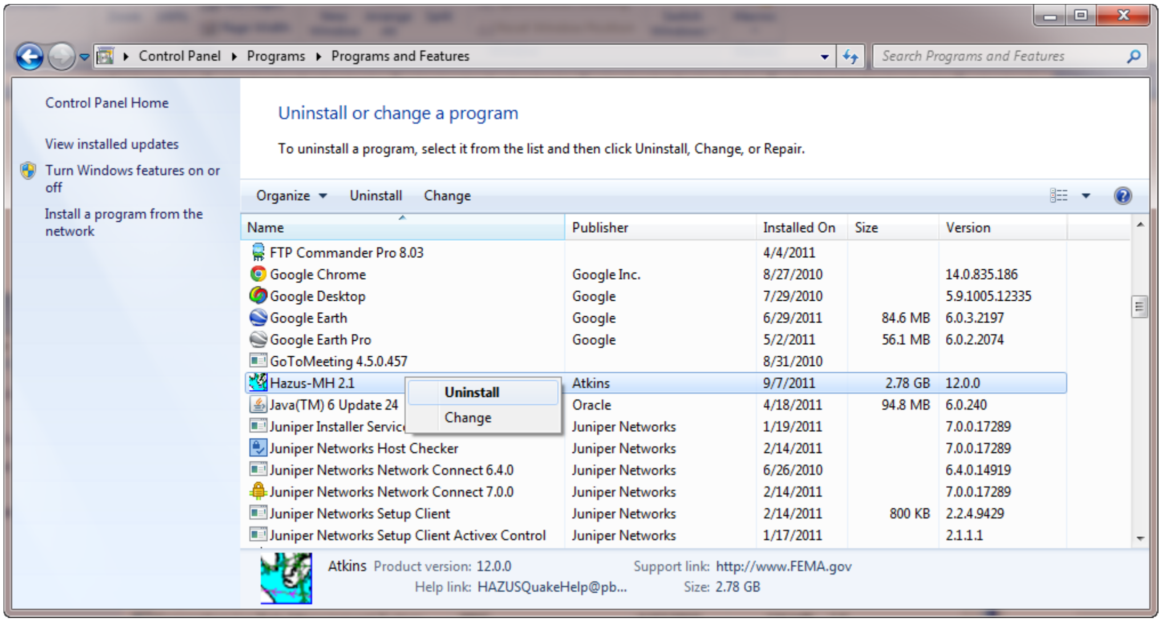


Figure 2.25: Uninstall screen for Windows 7.

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.

To re-install or modify Hazus, launch the **Installation Wizard** from the Control Panel:

Windows XP: Click **Add/Remove Programs**, highlight Hazus-MH and click **Change** or **Remove**.

Windows 7: Right-click Hazus-MH and then click **Change**.

From the **Installation Wizard**, select **Modify** your previous installation to add or remove hazard modules, or select **Repair program components** to reinstall Hazus-MH.

2.5.4 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 stopped successfully.

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

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

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

2.6 Limitations

Software limitations could result from large database sizes and from the processing environment itself. Specific solutions are suggested below. As an indication of the time required to process, analyse and produce loss estimates for a large study region, a study region of 1000 to 2000 census tracts could take an hour to complete.

2.6.1 SQL Service Limitations

The database management system of Hazus-MH 2.1 is SQL 2008 Express R2. This system has a size limit of 8 GB per database, which limits the size of the region that can be created. To work around this, the full version of Microsoft SQL Server 2008 R2 must be used. Two alternative solutions to work around this 8 GB database limit include:

1. If running an earthquake-only region, the *Large Region* option (new in Hazus-MH 2.1) option can be used.

   (Also refer to Appendix O of the *Hazus-MH 2.1 Earthquake Model User Manual*.)

2. See instructions below on how to change the size of the allocated virtual memory.

To maximise the size of the study region that may be analysed, set the virtual memory size from a minimum of 2048 MB to a maximum of 4096 MB. For the earthquake model, the virtual memory size may be increased from a minimum of 1024 MB to a maximum of 2048 MB for optimal operation.

To adjust the virtual memory size settings in **Windows XP** do the following:

1. Click on **Start | Settings | Control Panel | System**.
2. Click on the **Advanced** tab.
3. Click on the **Settings** button under Performance.
4. Click the **Advanced** tab.
5. Click on the **Change** button under Virtual Memory.
6. Replace the initial and maximum values.
7. Click **Set** then **OK** three times to exit to the main screen.

For **Windows 7**, it is recommended to leave the setting ‘Automatically manage paging size file for all drive’ as is. To view/edit the settings do the following:

1. Click on **Start** and right-click **My Computer** and select **Properties**.
2. Click **Advanced System Settings** (on the left panel bar).
3. Click **Settings** under Performance.
4. Click the **Advanced** tab.
5. Click **Change…** button under Virtual memory.
6. Uncheck **Automatically manage paging file size for all drives**.
7. Select **Custom size** option and replace the initial and maximum values.
8. Click **Set** then **OK** four times to exit to the main screen (Windows 7 needs to reboot for the changes to take effect).

Chapter 3 Inventory Data Inputs for Hazus Use in Canada

(Also refer to Chapter 1.3 and Chapter 1.4 of the *Hazus-MH 2.1 Earthquake User Manual*.)

The basic requirements for analysis using Hazus are Inventory data (also referred to as Asset Inventory data) and Hazard event information. The inventory data represents the built environment upon which a hazard event occurs. Hazard events are described in Chapter 4.

3.1 Default Asset Inventory

The default asset inventory is contained within each provincial database that is supplied with Hazus Canada. See section 2.4.3 for information regarding the loading of the inventory data. The default provincial databases include demographics and aggregated residential building stock derived from the 2006 Statistics Canada Census. Additional metadata information for the default Canadian Inventory data is provided in Appendix B and Appendix C. 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.

The Hazus Canada earthquake model uses this census data to estimate direct social losses including displaced households, casualties (injuries and deaths), and loss of building space that can be occupied. The model estimates only injuries and deaths caused by building and bridge damage. The demographic data is used to better understand who might be living in a study region, where they might be during the modelled event, and how vulnerable they are.

(Also refer to Chapter 13.1.1 of the *Hazus-MH 2.1 Earthquake Model Technical Manual* for more information on methodology for estimating casualties.)

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. Class names starting with *eq* are files with specific information for Earthquakes; *fl* files are for Floods; and *hu* files are for Hurricanes.

All buildings are included in the aggregated General Building Stock inventory. Specific buildings of special interest, such as schools, hospitals, etc., are also listed individually in the Essential Facilities database. Other specific facilities, such as dams, public utility facilities, etc., are listed individually in the appropriate database.

The earthquake module provincial geodatabase includes databases listed in Table 3.1.

Table 3.1: Earthquake Module Provincial Geodatabases

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
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.)

3.1.2 Data in the Canadian Provincial Databases

3.1.2.1 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 Subdivision (in non-urban areas) (CSUID), Census Tract (in urban areas) (CTUID), Dissemination Area (DAUID), Dissemination Block (DBUID). There is no information publicly available (and therefore not in the database accompanying Hazus Canada) for the Dissemination Blocks, due to privacy issues. 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. See Appendix B for detailed information on the conversion of Census Canada units to Hazus units.

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
DAUID - Dissemination Area ID	CensusBlock
CTUID - Census Tract ID (used for major urban areas) CSDUID - Census Subdivision ID (used for 'rural' areas)	Tract
CDUID - Census Division ID	County
PRUID - Province ID	State

3.1.2.2 Census Canada Demographics 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. See Appendix C for detailed information.

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.

See Appendix B and Appendix C for Statistics Canada to Hazus conversions of spatial units, unit identification numbers, and attribute data. See Appendix D for details of the process used to create the default provincial databases.

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)		RES1 (1)
Movable dwelling (1)		RES2 (1)
Semi-detached house (2)		RES3A (2)
Apartment, duplex (2)		RES3A (2)
Rowhouse (3~10)	30%	RES3B (3-4)
Rowhouse (3~10)	70%	RES3C (5-9)
Apartment, building has fewer than five storeys (6~32)	70%	RES3D (10-19)
Apartment, building has fewer than five storeys (6~32)	30%	RES3E (20-49)
Apartment, building that has five or more storeys (20~)	30%	RES3E (20-49)
Apartment, building that has five or more storeys (20~)	70%	RES3F (50+)

3.1.2.3 Non-residential Data in Canadian Provincial Databases

Commercial, industrial, and buildings with other non-residential occupancy codes are not currently included in the default provincial databases. This data will be added as sources become available. It is highly recommended that users update the provincial database using their own sources of information.

3.2 User-Refined Asset Inventory

Improving your asset inventory to run a more 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 inventory can be used by municipal and regional authorities to support a variety of functions within the field of public safety, including quantitative risk assessment.

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
- knowledge of the application of building codes for structures.

For examples of User-Refined Asset Inventory, refer to the datasets compiled for case study reports on the use of Hazus in the District of North Vancouver and in the Ottawa-Quebec City infrastructure corridor.

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.

(Also refer to Chapter 8 of the *Hazus-MH 2.1 Earthquake Model User Manual* and the *CDMS Data Dictionary*. The Help menu in the CDMS program is also useful.)

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.

3.2.1 General Building Stock Parameters

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.

Table 3.4 shows a list of the basic parameters needed for the General Building Stock and the sources for descriptions and units for these parameters.

Table 3.4: Building inventory parameters and manual references.

Input Parameter Per Building	Manual Reference
Occupancy code (1 of 33 Hazus building occupancy classes: residential, commercial, etc.)	Table A.1 of Appendix A of the *CDMS Data Dictionary* or Table 3.2 of the *Hazus-MH 2.1 Earthquake Model Technical Manual*.
Construction type (1 of 36 Hazus building structure types: wood, brick, concrete, etc.)	Tables B.2 and B.8 in Appendix B of the *CDMS Data Dictionary* or Table 5.1 of the *Hazus-MH 2.1 Earthquake Model Technical Manual*.
Location: Latitude and Longitude	**(based on NAD83 projection)**
Design Level (may be based on known seismic code, or deduced from year built and building type)	Tables B.6 and B.11 in Appendix B of the *CDMS Data Dictionary*, and section 3.2.3 of this manual.
Total Area	**(in thousand square feet)**
Number of stories	
Year Built, Age or Building Quality	
Replacement cost (in thousands of dollars)	RSMeans is a company that provides construction costs, and these values can be used for specific building types. The 2002 RSMeans values per occupancy class are found in Tables 3.6 and 3.7 of the *Hazus –MH 2.1 Earthquake Model Technical Manual*. The 2006 RSMeans values per occupancy class are found in the file ProgramFiles\Hazus-MH\Data\HzAnalParams.mdb, in tables hzReplacementCosts and hzRes1ReplCost, or in Tables 14.1 to 14.3 of the *Hazus-MH 2.1 Flood Model Technical Manual*.
Content replacement cost (in thousands of dollars)	Calculated as percentages of building replacement cost based on occupancy class. Refer to Table 3.10 of the *Hazus-MH 2.1 Earthquake Model Technical Manual*.

3.2.2 Specific Building and Other Inventory Parameters

For Essential Facilities (schools, fire stations, police stations, medical care centres, emergency operation centres), the basic parameters listed Table 3.4 (except Occupancy) are required. Additional information for Essential Facilities includes:

- facility type as per Hazus classification; and

  (Refer to Table A.2 in Appendix A of the *CDMS Data Dictionary* or Table 3.11 in the *Hazus-MH 2.1 Earthquake Model Technical Manual*.)

- number of students or beds, and shelter capacity (optional, and if applicable).

For Utilities (potable water, waste water, electrical, natural gas, oil and communication facilities) the following parameters are required:

- latitude and longitude;
- name;
- facility type as per Hazus classification; and

  (Refer to Tables A.11 to A.16 in Appendix A of the *CDMS Data Dictionary* or Tables 3.20 to 3.25 in the *Hazus-MH 2.1 Earthquake Model Technical Manual*.)

- building type and replacement cost.

Other facilities, such as transportation or high potential loss facilities can be added, if available. (Refer to the *CDMS Data Dictionary* for other parameters for specific buildings and other inventory facilities.)

3.2.3 Other Parameters for Buildings in Canada

3.2.3.1 Design Level

When the actual seismic design level to which a building had been constructed is not known, the seismic design level could be assigned for the building based on year of construction and building type. Table 3.5 provides a general guideline for assigning Hazus seismic design levels (as a design code) to building stock in Canada.

Table 3.5: Guidelines for Selection of Seismic Design Levels for Typical Buildings Based on Year of Construction and Building Type

	Year Built				
Building Type	**2005-Onward**	**1990-2004**	**1970-1989**	**1941-1969**	**Pre-1941**
Wood, Steel, or Concrete		**HS** (Special High-Code)	**MS** (Special Moderate-Code)	**LS** (Special Low-Code)	
Masonry, Mobile, Others		**HC** (High-Code)	**MC** (Moderate-Code)	**LC** (Low-Code)	
All Building Types	**HS** (Special High-Code)				**PC** (Pre-Code)

Note: If the user enters asset inventory information through CDMS and does not assign a seismic design level, CDMS assigns a default Low-Code designation.

Note: Expert users are advised to refine seismic design levels and corresponding building damage functions for specific regions where local hazard and inventory data is available. It is advised that refinements follow the methodology indicated in Chapter 5.4.1, Chapter 5.7.1, Chapter 6.4.1, and Chapter 6.7.1 of the *Hazus-MH 2.1 Earthquake Model Technical Manual*.

(Also refer to *CDMS Data Dictionary* for a detailed list of all asset inventory parameters and data formats accepted by Hazus.)

3.2.3.2 Occupancy Mapping Schemes

Hazus uses Occupancy Mapping Schemes to describe the aggregated building stock by occupancy, building 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 3.6 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.

(Also refer to Chapter 3.2.1.2 of the *Hazus-MH 2.1 Earthquake Model Technical Manual* and Chapter 7.3 of the *Hazus-MH 2.1 Earthquake Model User Manual*.)

Table 3.6: 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	Massachusetts
Newfoundland	Massachusetts
New Brunswick	Massachusetts
Nova Scotia	Massachusetts
Prince Edward Island	Massachusetts
Yukon	Alaska
Northwest Territories	Alaska
Nunavut	Alaska

3.2.4 Other Inventory Data

3.2.4.1 Linear Data

Linear data (pipelines, roads, railways) cannot be imported into the provincial databases using CDMS. It is suggested that ArcGIS tools be used. See section 3.3.3 of this manual.

For pipelines, the required parameters are the Hazus pipeline class, pipe diameter in inches, and the length of pipe (in kilometres) (refer to Tables 3.20 to 3.23 of the *Hazus-MH 2.1 Earthquake Model Technical Manual*).

For roads and railways, the parameters include Hazus segment class, length of segment (in kilometres), and replacement cost (refer to Tables 3.13 and 3.14 of the *Hazus-MH 2.1 Earthquake Model Technical Manual*).

3.2.5 Conclusion

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

(Also refer to *The Role of Hazus-MH in the Canadian Natural Disaster Management Strategy* for recommendations on data stewardship for Canada.)

3.2.6 Individual Building Inventory

Analysis can be done on individual buildings using either the User Defined Facility (UDF) or Advanced Engineering Building Model (AEBM) modules available for earthquakes in Hazus. For these modules, the information must be entered after a study region has been created, rather than beforehand to the provincial databases. See section 4.7 for information on inputting the inventory for these methods and running the analysis.

3.3 Data Import Tools

Inventory data can be added to either your provincial database (as aggregated data for Hazus Tract and Block units) or to your study region (as individual buildings). 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, on the other hand, 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. You can use the Comprehensive Data Management System tool (CDMS), the Inventory import menu option in Hazus, or the load tool in ArcGIS.

Use Table 3.7 as a guide in selecting the best method for adding data to Hazus.

Table 3.7: Data import methods.

Import Tool	Function
Comprehensive Data Management System	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 tool is not customised for Hazus, so you will need to know the exact attribute qualities of an updated field.
Inventory import options in Hazus	Use to add building or facility specific data to a study region for User Defined Facilities inventory, Advanced Engineering Building Module inventory, or for facilities under EF, TRN, UTIL or HPLF.

3.3.1 Comprehensive Data Management System

(Also refer to Chapter 8 of the *Hazus-MH 2.1 Earthquake Model User Manual* and the *CDMS Data Dictionary*. The Help menu in the CDMS program is also useful.)

Hazus Canada contains aggregated residential buildings and demographics information from Canada's 2006 Census. Municipalities, however, 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.

Use **CDMS** to convert your inventory files into Hazus format then to transfer them into your provincial database. CDMS can be used to update and overwrite the aggregated building stock in the provincial database and also to add inventory for the building facilities under EF, TRN, UTIL, and HPLF. 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.

For more information, refer to Chapter 8.6 of the *Hazus-MH 2.1 Earthquake Model User Manual* for importing and aggregating General Building Stock data. Refer to Chapter 8.5 of the *Hazus-MH 2.1 Earthquake Model User Manual* for importing data for site specific buildings.

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**.

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

To upload your inventory files into CDMS, your input data must specify the following infrastructure attributes:

1. **Location**: latitude and longitude for building or facility.

2. **Occupancy Class** for all buildings to be included in the aggregate inventory.

   OR

   Facility Class for particular facilities in EF, TRN, UTIL or HPLF.

For buildings to be included in the aggregate inventory, it is recommended that you also include in your input data:

1. **Replacement Cost**: in thousand dollars (used for economic loss estimation). See Table 3.4 for information on values that can be used.

2. **Seismic Code**: Pre-, Low (default), Medium, High. See section 3.2.3.

3. **Building Type**: 36 possible types. See Table 3.4.

For facilities in EF, TRN, UTIL and HPLF there are other attributes that are specific to the type of facility which should be included in your input data. (Refer to the *CDMS Data Dictionary*.)

CDMS only accepts point infrastructure inventory files. Linear infrastructure data can be imported into your provincial database using ArcGIS functions.

3.3.2 Inventory Import Menu in Hazus

(Also refer to Chapter 6 of the *Hazus-MH 2.1 Earthquake Model User Manual*.)

Use the **Inventory** menu option to import site-specific (e.g., schools, hospitals) data files to Hazus. Import the data files from either geodatabase or shapefile format.

3.3.3 ArcGIS Load Tools

(Also refer to Chapter 6.5 of the *Hazus-MH 2.1 Earthquake Model User Manual* for data requirements, standardisation, and classification.)

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:

1. In **Arc Tools**, select **Data Management Tools**, then **General**, and then **Append** (Figure 3.1).

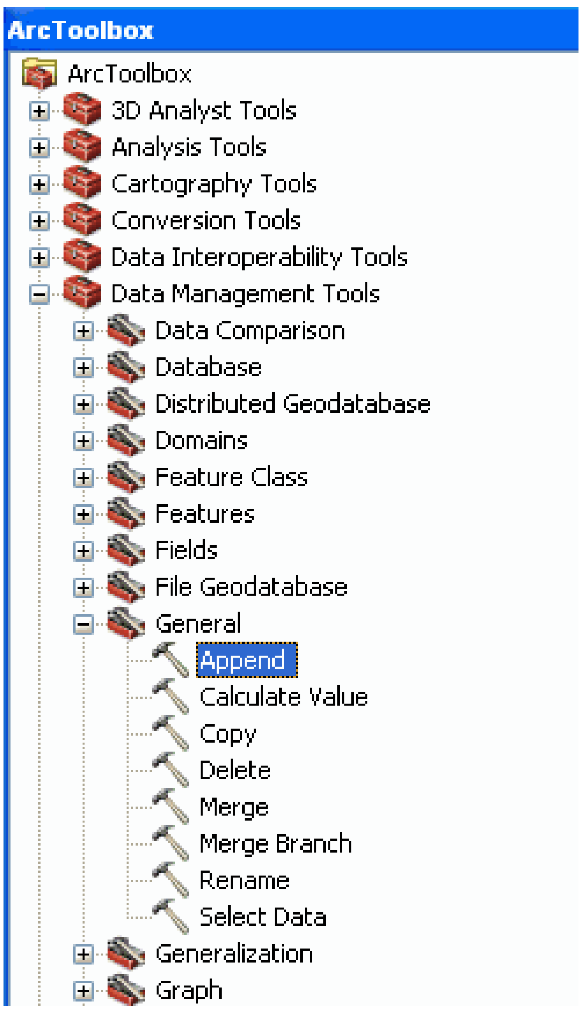


Figure 3.1: Import linear infrastructure data using Arc Tools.

2. In **ArcCatalog**, select the class folder (e.g., Highways) in your provincial database. Right-click on the class folder, select **Load**, and then **Load data** (Figure 3.2).

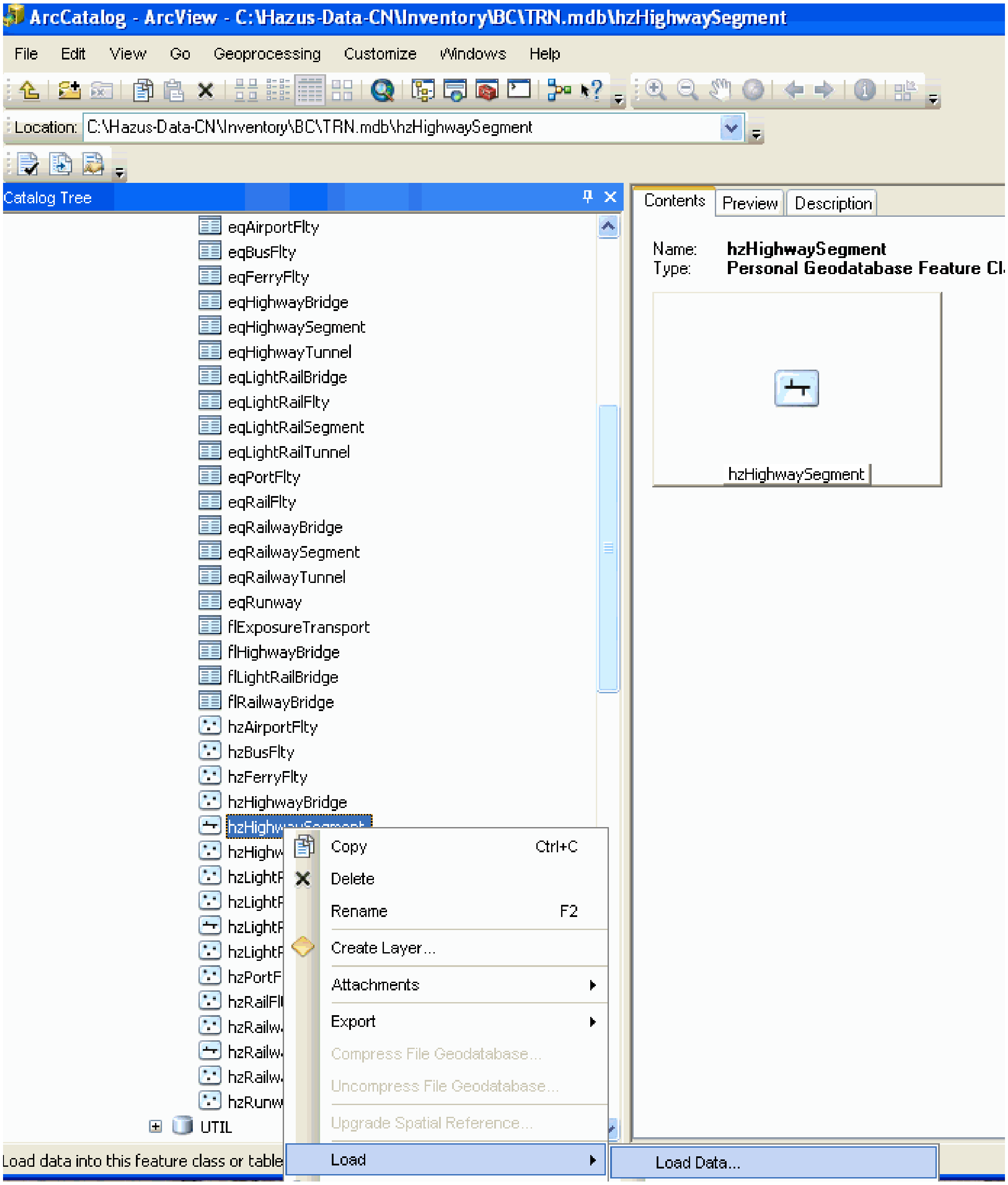


Figure 3.2: Import linear infrastructure data using ArcCatalog.

Chapter 4 Hazard Event Inputs and Running Analysis

This chapter provides a description of the seismic hazard events that can be analysed with Hazus Canada. This chapter also provides information on the creation of a study region in Hazus Canada and the running of an analysis in that study region.

4.1 Overview of Hazus Analysis

Hazus permits various levels of analysis. However, the underlying methodology and the types of outputs do not change from one level of analysis to another. Rather, the increased level of detail for input parameters used for modelling refines the analysis results (i.e., damage/loss amounts).

Table 4.1 compares the inputs and expertise needed for a Default analysis and those required to progress to a more detailed level of analysis (i.e., User-Refined analysis). With the addition of user-supplied data, the information available about the region modelled is further refined and more complete. Modelling at a more detailed level of analysis may reduce the inherent uncertainties, present more detailed information, and provide more comprehensive estimates.

The US version of Hazus includes robust datasets for asset inventories and hazards for the entire country, while the Canadian version has more limited default asset inventory and Canadian seismic hazard selection. This means that more effort is required by the Canadian user for the same level of analysis as one performed by a US user.

Note: Caution should be used when making assumptions that more detailed input information gives more accurate results. This may not always be true, as the more detailed information may be based on faulty assumptions or inaccurate science.

See Chapter 5 for a more complete discussion on limitations and assumptions.

Table 4.1: Input for Default and User-Refined analysis in Hazus Canada.

Analysis Level & Expertise Requirements	Analysis Input		
	Asset Inventory	**Hazard Scenario**	**Fragility Functions and Occupancy Mapping Schemes**
Default • **GIS expertise** • **Some hazard assessment knowledge by decision-makers**	Hazus default provincial database which includes 2006 Statistics Canada residential building stock and demographics	Hazus default hazard scenario – select one	Hazus default fragility functions and general mapping schemes
User-Refined • **GIS expertise** • **Hazard assessment knowledge by decision-makers** **And/or:** • **Geotechnical and geological expertise** **And/or:** • **Earthquake structural engineering expertise**	Updated provincial database with infrastructure, and/or non-residential building stock, and/or additional individual buildings	ShakeMap* files added by user (ShakeMaps can have basic assumptions, or include soil types, susceptibility to ground deformation, liquefaction and landslide, and other geotechnical aspects)	Optional: Additional fragility functions updated to reflect updated provincial database and/or ShakeMap files, and specific occupancy mapping schemes

* ShakeMap consists of four ground motion maps (PGA, PGV, SA 1.0 second, SA 0.3 second) for a specific earthquake event; ground motion maps are also referred to as seismic hazard maps.

A **Default** analysis is the simplest type of analysis requiring minimum effort by the user as it is based mostly on input provided with the methodology (e.g., census information, semi-empirical-based approach for hazard quantification, default vulnerability modelling assumptions, etc.). The user is not expected to have extensive technical knowledge. While the method requires the user to select certain options from several choices in order to run an analysis, the user's selections can be guided by referring to published information. At this level, estimates will be crude, and will likely be appropriate only as initial loss estimates to determine where more detailed analyses are warranted.

Note: For the purposes of this manual, a Default analysis refers to a Hazus Canada loss estimation analysis using only:

- the inventory data that accompanies the Hazus Canada application in the provincial database (i.e., default inventory, described in section 3.1); and

- the earthquake hazard information that is a part of the application (i.e., in the hazards library, described in section 4.4).

A **User-Refined** analysis is intended to improve the results from a Default analysis by considering additional data available for the study region. More extensive inventory and/or hazard event data is required from the user for a User-Refined analysis than for a Default analysis. There is no standardised User-Refined analysis. If you have more current or more detailed information than the data included in the provincial databases and the hazards library provided with Hazus Canada, then your analysis can be improved through the incorporation of this additional data. The quality and detail of the results depend on the level of effort and detail of the input data. The purpose of refining the inputs from the Default analysis is to provide the best estimates of damage/loss that can be obtained.

Note: A User-Refined analysis can use a combination of default and user-supplied inventory and hazard data. Depending on the availability of additional data to the user, the user may choose to analyse:

- a default inventory (section 3.1) and a user-supplied hazard (section 4.5); or

- a user-supplied inventory (section 3.2) and a default hazard; or

- a user-supplied inventory (section 3.2) and a user-supplied hazard (section 4.5).

4.2 Seismic Hazard Scenarios in Hazus

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

The seismic hazard types that can be defined in Hazus are shown in Figure 4.1.

Note: Although hazard types are sometimes referred to as hazard scenarios, probabilistic hazard analyses are not technically scenarios in the same way that deterministic hazard analyses are. However, for consistency with certain Hazus terminology and for ease of classification, probabilistic hazard analysis is treated as one of the hazard scenario options that can be selected for running a loss estimation analysis.

Hazus allows users to provide detailed inputs to specify the seismic hazard they would like to model. Depending on the type of scenario you choose to run, you may be required to specify some or all of the following parameters:

- earthquake magnitude;

  Note: Hazus uses the moment magnitude scale for earthquake quantification.

- location of the earthquake epicentre (using latitude and longitude coordinate or visual placement on a map);

- attenuation function; and/or

  Note: Unless otherwise specified or provided, in Hazus Canada the default National Earthquake Hazard Reduction Program (NEHRP) soil type C (very dense soil and soft rock) per FEMA (2009) is applied uniformly to the entire study region.

- fault rupture dip and orientation of the earthquake.

  Note: Catalogue of active faults in Canada is not yet available.

The types of seismic analysis you can run in Hazus fall into two categories: deterministic and probabilistic. Deterministic scenario analyses rely on the earthquake parameters you specify and on calculations of ground shaking performed in Hazus. To run a deterministic scenario, you will need geological knowledge, or will need to consult with a geologist. Probabilistic analyses, on the other hand, are based on cumulative history of measured past earthquakes for a specific location.

Note: See Table 4.2 for guidance on the uses and constraints of the various seismic hazard analysis types.

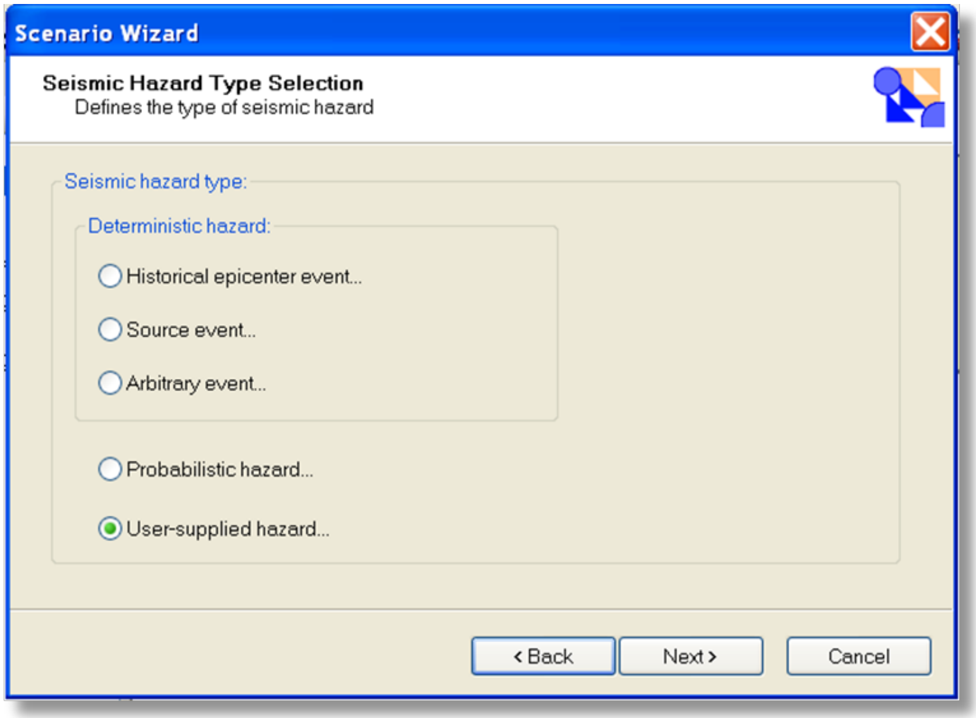


Figure 4.1:Seismic hazard type selection options in Hazus.

The seismic hazard types include:

1. ***Historical epicenter event:*** Hazus Canada contains information for 640 historic earthquakes of Moment Magnitude 5 or greater occurring between 1638 and 2010 in and around Canada (marked **CN** in the StateID column of the Epicentre Event Database in Hazus Canada). A user can choose an event from a list of historic earthquakes and Hazus will model the effects of that event. This type of event is referred to as a deterministic hazard.

   Note: Unless the user supplies additional hazard information (e.g., soil types, susceptibility to liquefaction and/or landslide, and other geotechnical aspects), Hazus will only model the effects of ground motions from these events.

2. ***Source event:*** There is no active fault database for Canada, so there are no options to be modelled from this selection. This type of event is referred to as a deterministic hazard.

3. ***Arbitrary event:*** The user can create an event and input the associated parameters: location, magnitude, epicenter depth, rupture orientation, and rupture length. This option requires the expert input of a seismologist with knowledge of attenuation functions. This type of event is referred to as a deterministic hazard.

4. ***Probabilistic hazard:*** The user can choose from eight different return periods: 100, 250, 500, 750, 1000, 1500, 2000, and 2500 years. These seismic hazard values were generated for use with Hazus Canada by the Canadian Hazards Information Service of Natural Resources Canada, using a 10 km spaced grid of points covering all of Canada and its nearby territorial waters. Mean values were determined for each return period. Refer to Halchuk (2011) for more information.

   Note: Although the name “Probabilistic” may imply that the modelled results will include a measure of the uncertainties (or probabilities) associated with the results, both probabilistic and deterministic hazard analyses from Hazus provide only the mean (average) loss values for individual structures and aggregated assets. Hazus does not quantify the probability of loss. For individual structures, partial probabilities (i.e., related only to building response characteristics) are provided by Hazus, but the model does not quantify the complete probability of the resultant loss. See section 5.4 and section 5.5 for more discussion about dealing with model uncertainty and probability related to the calculated losses.

   Note: Hazus uses probabilistic ground motions that are different from the standard values used by the National Building Code of Canada (NBCC). The NBCC provides peak ground acceleration (PGA), spectral acceleration (SA) at 0.2, 0.5, 1.0 and 2 seconds natural period, and spectral accelerations (at a given period) corresponding to return periods of 100, 475, 1000, and 2475 years. The hazard model developed for the 2005 and 2010 versions of the NBCC use median values. In contrast, Hazus uses the mean values obtained from the hazard model for PGA, SA (0.3 second), SA (1 second), and peak ground velocity (PGV) corresponding to eight return periods (100, 250, 500, 750, 1000, 2000, and 2500 years). Refer to Halchuk (2011) for more information.

5. ***User-supplied hazard:*** It is recommended that any user-supplied scenario be developed by a seismologist and geologist as it requires significant information about the potential rupture of a fault and the dispersal of energy through bedrock and unconsolidated sedimentary basins. Development of such earthquake scenarios is useful for the analysis of likely events and those potentially of most concern to a community.

Additional details for each seismic hazard type are shown in Table 4.2.

Note: Natural Resources Canada scientists and engineers strongly recommend that you consult with a seismologist when selecting a hazard scenario and defining the characteristics of that hazard.

Table 4.2: Seismic hazard type purposes and constraints.

Seismic Hazard Type	Purpose	Constraints	Level of Seismic Expertise
Historical Epicentre Event	Can be used for individual structures and aggregate analysis to provide reasonable estimate of potential losses, and to allow for historical comparisons and/or model calibration. The historical record for earthquakes dates back to 1638.	Past events do not commonly reflect possible near-future events.	Consult with a seismologist to interpret the loss estimation results.
Source Event	This option is not currently available in Hazus Canada.	Canada does not have a fault database.	Requires seismic expertise to create.
Arbitrary Event	Can be used for individual structures and aggregate analysis for reasonable estimate of potential losses from a hypothetical event.	Hazard inputs and analysis results need to be clearly understood to be of value for planning.	Can run this scenario using default inventory data, but it is recommended that users consult with a seismologist.
Probabilistic Hazard	Can be used to estimate the potential damage to individual structures and aggregate inventory.	Estimates are presented as mean (average) loss values. Hazus does not quantify the probability of loss.	Consult with a seismologist to interpret the loss estimation results.
User-Supplied Hazard	Requires ShakeMap scenarios either custom-made by seismologists or obtained from library of archived scenarios (e.g., http://earthquake.usgs.gov/earthquakes/shakemap/).	Soil conditions and response must be included in the ShakeMap, as this cannot be added in Hazus.	Requires seismic expertise to create, unless archived scenarios are available.

Differences and similarities between the information in Hazus Canada and in Hazus US on seismic hazard types are summarised in Table 4.3.

Table 4.3: Comparison of Canadian and US seismic hazard input parameters.

Seismic Hazard Type	Hazus Canada	Hazus US (Refer to Chapter 9.2 of the *Hazus-MH 2.1 Earthquake Model User Manual*.)	Type of Damage & Loss Modelled
Historical Epicentre Event	Same as in Hazus US except Canadian historical seismic events should be selected from the Hazus database (State ID = CN).	Select the desired event from the Hazus database of 3,500 historical events. The user can override the magnitude and depth of the event.	Specific to scenario.
Source Event	N/A – no sufficient information is available for Canada on seismic faults.	For the Western US, select the desired fault source from the Hazus database of faults. The user defines the location of the epicentre on the fault and can override the fault characteristics.	N/A for Canada.
Arbitrary Event	Same as in Hazus US, except for a lack of sufficient information for Canada on seismic faults.	The user specifies the location of the epicentre, the magnitude and depth of the event, and the type, rupture orientation and length of the fault (for the Western US); Hazus calculates the ground motions.	Specific to scenario.
Probabilistic Hazard	Same as in Hazus US except Canadian ground shaking values are referenced.	The user specifies the magnitude and return period of the event.	Annualized losses, building performance.
User-Supplied Hazard	Same as in Hazus US.	The user supplies ShakeMaps that define the earthquake hazard.	Specific to scenario.

4.3 Create a Study Region

From the Hazus Startup Menu (Figure 4.2), you can create, open, delete, duplicate, export, or import a study region.

Refer to Chapter 3.2, Chapter 3.3, and Chapter 3.4 of the *Hazus-MH 2.1 Earthquake Model User Manual* for instructions on how work with a study region.

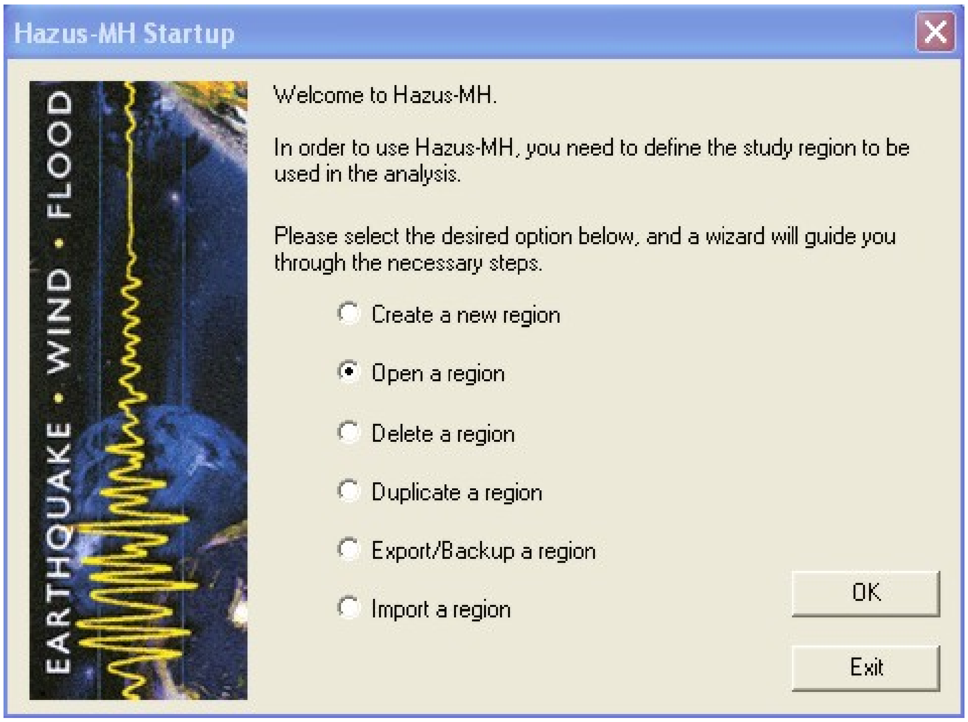


Figure 4.2: Hazus Startup menu.

4.3.1 Create a New Study Region

(Also refer to Chapter 3.1 of the *Hazus-MH 2.1 Earthquake Model User Manual*.)

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 2.6 for database limitations.

Before creating a study region, you must install the desired provincial database(s) onto your computer. See Chapter 2 for instructions on how to install your provincial database(s).

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

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

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, you will have to create a new study region and re-run your analysis.

Note: Flood Analysis module is not currently available.

Note: Hurricane Analysis is not currently available.

The level of aggregation used in Hazus Canada is different from that used in the US application of the program. The spatial units used in Hazus Canada are based on Canada's 2006 Census of Population. For an explanation of the Canadian spatial units for its geographic areas, refer to the *2006 Census Dictionary*, available on the Statistics Canada website. For their equivalent census units used in Hazus Canada, see section 3.1.2.1 of this manual. Generally, the tracts in the Canadian provincial databases, referred to in Figure 4.3 as Census tract, are spatially larger than tracts in the US state databases.

Note: The tract is the smallest unit on which Hazus earthquake analysis can be performed.

- **Province/Territory**: Perform an analysis of an entire province or territory.
- **Census Subdivision**: Perform an analysis of one or more regions within a province or territory.
- **Census Tract**: Perform an analysis of one or more individual census tracts.

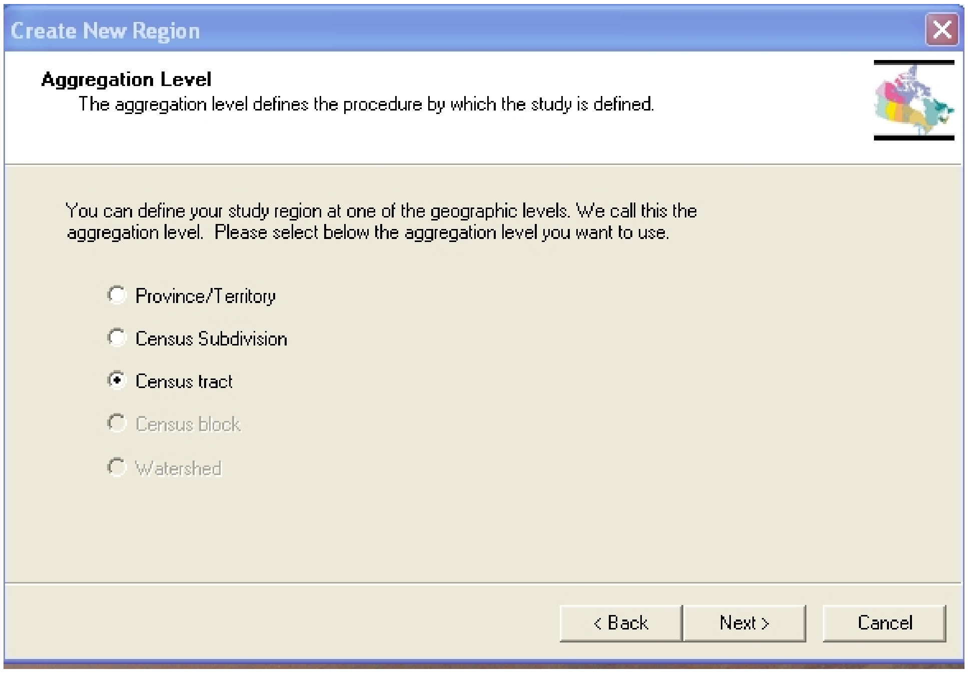


Figure 4.3: Aggregation level for analysis

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.

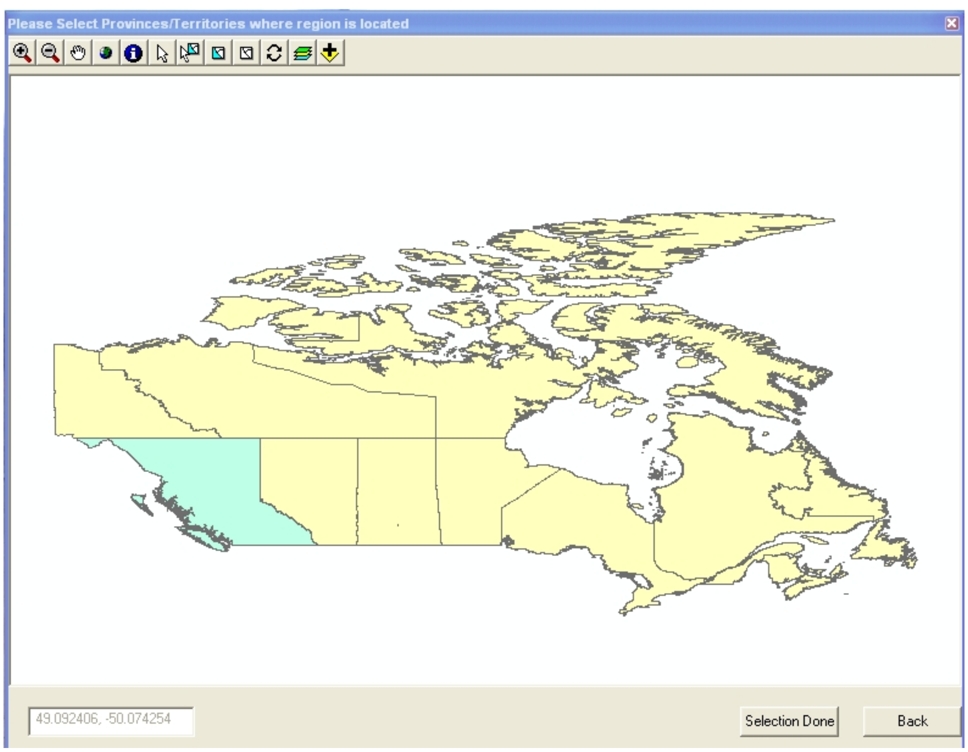


Figure 4.4: Province/Territory selection from map.

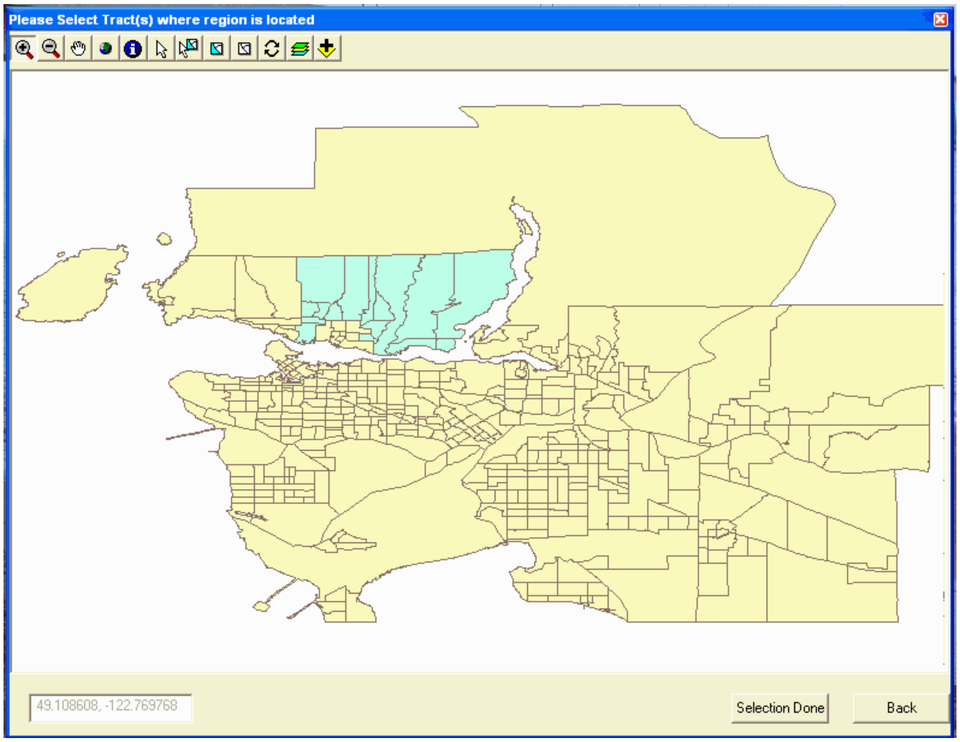


Figure 4.5: Census Tract selection from map.

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.

4.3.2 Open a Study Region

(Also refer to Chapter 3.3 of the *Hazus-MH 2.1 Earthquake Model User Manual*.)

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 of the study region. Study regions are saved at any point in the analysis and can be reopened at a later time.

4.3.3 Review Your Study Region Inventory

(Also refer to Chapter 3.2 of the *Hazus-MH 2.1 Earthquake Model Technical Manual* and Chapter 3.5 of the *Hazus-MH 2.1 Earthquake Model User Manual*.)

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 or AEBM analysis, see section 4.7 for information.

4.4 Run Analysis Using Default Hazard Choices

The following sections describe how to run a Hazus analysis using the hazard information that comes with the application and with little or no assistance from subject matter experts. See section 4.2 for more information on the various seismic hazard types and inputs.

(Also refer to Chapter 3.6 and Chapter 9.2 of the *Hazus-MH 2.1 Earthquake Model User Manual* for the steps to define an earthquake hazard.)

As described in these sections in the *Hazus-MH 2.1 Earthquake Model User Manual*, specifying an earthquake hazard can be done with the help of the Scenario Wizard accessible from the **Hazard** menu, by selecting the **Scenario…** option. To define a new scenario, select the **Define a new scenario** option.

4.4.1 Select a Probabilistic Hazard

(Also refer to Chapter 9.2.3 of the *Hazus-MH 2.1 Earthquake Model User Manual*.)

To run the Probabilistic hazard analysis, you will need to select either a **Return period** or an **Annualized loss**. If selecting a Return period, the **Moment magnitude** defaults to 5.0 (Figure 4.6). Although this value may be changed by the user, modifying it will have no effect on the results, because this value is not used in the analysis of a probabilistic event.

Consulting with an expert, such as a seismologist, for advice on whether to select a Return period or Annualized loss, and whether to change the default moment magnitude of the event, can help with improved interpretation of your results. To provide a comprehensive context of the potential probabilistic hazard losses, multiple analyses could be run, each with a different return Period and/or Moment magnitude.

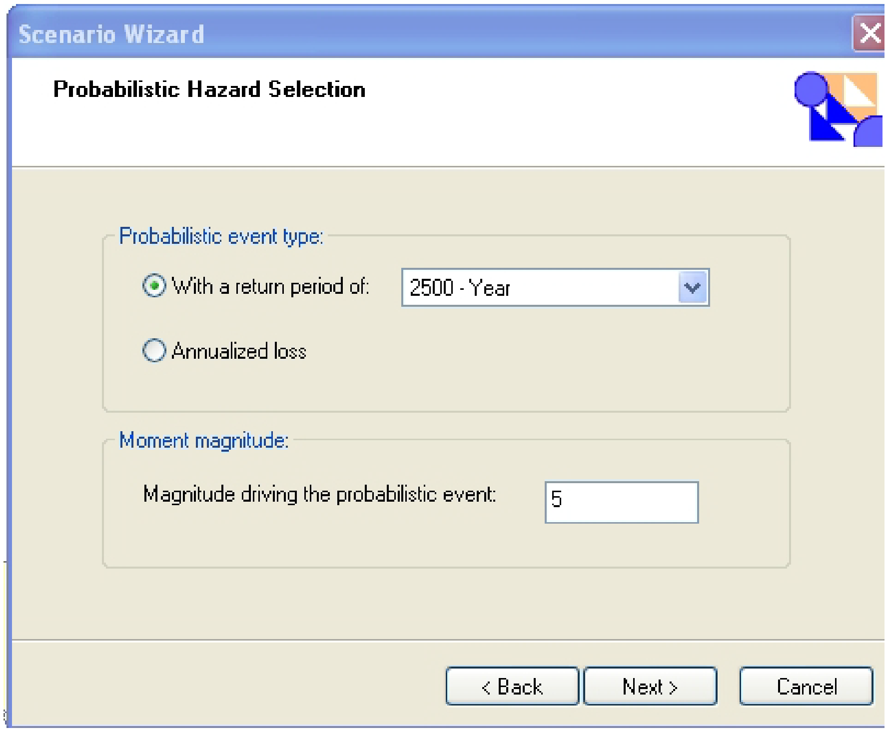


Figure 4.6: Probabilistic Hazard Selection window.

Provide a descriptive name for your Probabilistic hazard 'scenario' and click **Next**. Check the summary of your hazard definition, and click **Finish** to complete the process of defining a probabilistic hazard.

Save your 'scenario' so that you can always return to and modify a pre-existing scenario. To retrieve a pre-defined scenario, from the **Hazard** menu in Hazus, select **Scenario…** and choose **Use an already pre-defined scenario**.

Proceed to section 4.6 to run the analysis.

4.4.2 Select a Historical Epicentre Event Scenario

Choosing a historical epicentre event consists of selecting an event from a database of 640 historical Canadian earthquakes that occurred between 1638 and 2010. The database includes an event magnitude and depth.

(Refer to Chapter 9.2.2.1 of the *Hazus-MH 2.1 Earthquake Model User Manual* for instructions on how to run an historical epicentre event.)

Following are comments on using the epicentre event list for study regions in Canada.

The Canadian epicentre events are identified as **CN** in the **StateID** column of the historical event database. Right-click **StateID** to sort the states alphabetically and look for the **CN** state (Figure 4.7).

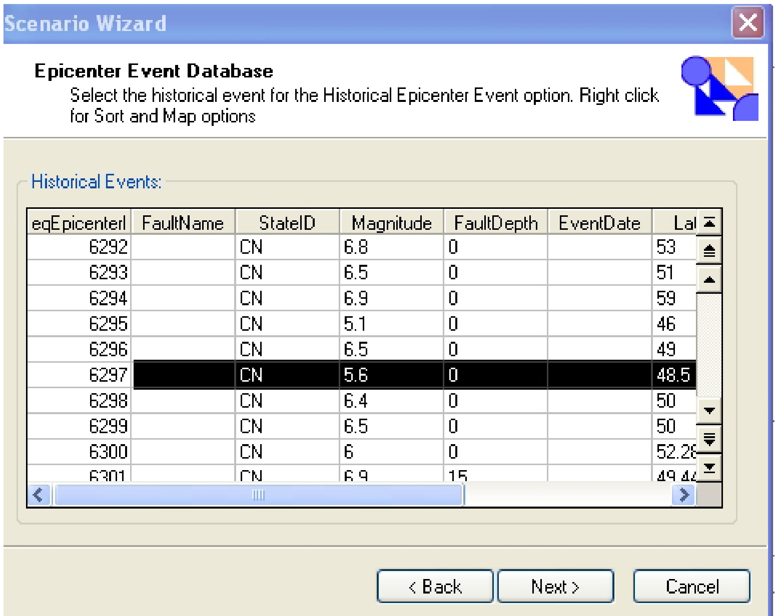


Figure 4.7: Select a Canadian historical seismic event (StateID CN).

Hazus supplies eight Western United States (WUS) and five Central & Eastern United States (CEUS) attenuation functions. The WUS attenuation functions should be used for study regions located in, or west of, the Rocky Mountains, Hawaii, and Alaska. The CEUS attenuation relationships should be used for study regions located east of the Rocky Mountains.

Canadian users are advised to select an attenuation function that is appropriate for their study region. For example, if your study region is in the province of British Columbia, select one of the Pacific Northwest Attenuation functions.

For more information about Canadian seismic hazard maps, refer to *Natural Resources Canada's Seismic Hazard Calculations* at http://www.earthquakescanada.nrcan.gc.ca/hazard-alea/zoning/haz-eng.php.

Consult with a seismologist for advice on selecting an appropriate attenuation function for your area.

You can choose to edit the **Epicentre Event Parameters** and to override the provided earthquake subsurface length and surface length (Figure 4.8). If you want to change any of the default parameters, it is best to do so only with the advice of a seismologist.

(Also refer to Chapter 4.1.2.1 of the *Hazus-MH 2.1 Earthquake Model Technical Manual*.)

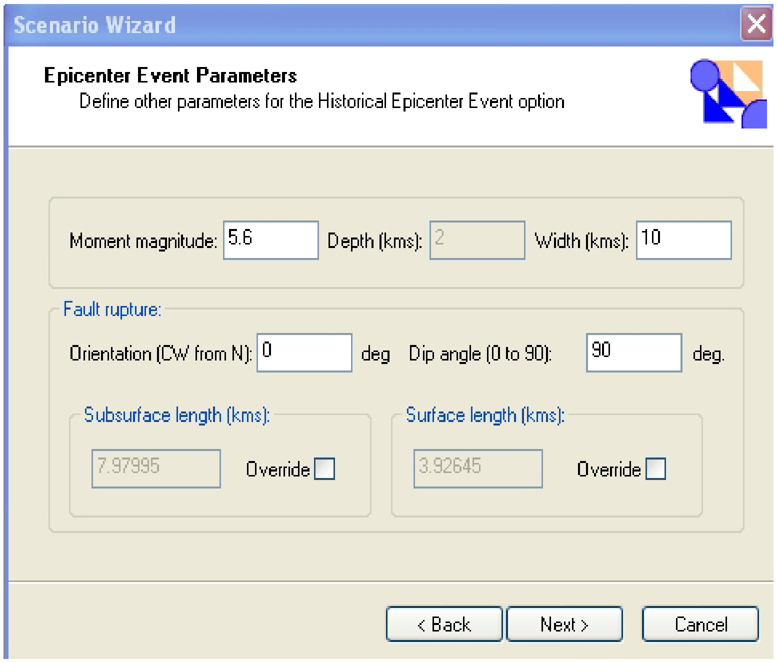


Figure 4.8: Epicentre event parameters.

The Scenario Wizard will present you with a summary of your hazard definition. Click **Finish** to complete the process of creating a historic epicentre event scenario.

See section 4.6 for steps on running the analysis.

4.4.3 Select an Arbitrary Event Scenario

Running an arbitrary event analysis allows you to define all the characteristics of your earthquake scenario. You will need to select an attenuation function, earthquake location, magnitude, epicentre depth, and possibly also a rupture orientation and rupture length.

Consult a seismologist for selecting an appropriate hazard definition for your area.

(Also refer to Chapter 9.2.2.3 of the *Hazus-MH 2.1 Earthquake Model User Manual* for instructions on how to run an arbitrary event analysis, using default data.)

4.5 Run Analysis Using User-Supplied Hazard Data

Data that can be incorporated into a user-supplied hazard include:

- ShakeMap (also known as ground motion maps or seismic hazard maps);
- soils map;
- liquefaction susceptibility map; and
- landslide susceptibility map.

User-supplied hazard data combined with detailed information about the buildings, infrastructure, and people (i.e., user-supplied asset inventory, described in section 3.2), can give reasonable estimates of potential earthquake losses for aggregated assets, specific facilities, and infrastructure.

Note: ShakeMap files must be added to a Hazus study region before they can be applied to a user-supplied scenario. A ShakeMap consists of four maps: Potential Ground Velocity (PGV), Potential Ground Acceleration (PGA), Spectral Acceleration at 1.0 second (SA1.0), and Spectral Acceleration at 0.3 second (SA0.3).

Note: The soils map must include the NEHRP classification (soil types A through E).

Note: 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. Hazus expects units for the Potential Ground Velocity (PGV) map to be inches per second (not cm/sec).

4.5.1 Sources of ShakeMaps

Existing ShakeMap scenarios are credible sources of historical earthquake ground motion and shaking intensity scenarios that have been created by seismologists and are obtainable from a library of archived scenarios (e.g., http://earthquake.usgs.gov/earthquakes/shakemap/). ShakeMap scenarios can also be custom-made by seismologists for specific purposes.

As an outcome of case studies, some ShakeMaps will be available from Natural Resources Canada for the Metro Vancouver area and the Ottawa-Quebec City infrastructure corridor. University research groups may have others available. These resources are available at http://www.hazuscanada.ca. ShakeMaps developed by the USGS, such as shown in Figure 4.9, are available at http://earthquake.usgs.gov/earthquakes/shakemap/.

(Also refer to Appendix J of the *Hazus-MH 2.1 Earthquake Model User Manual* for instructions on how to convert USGS shape file maps to geodatabase files that can be imported into Hazus.)

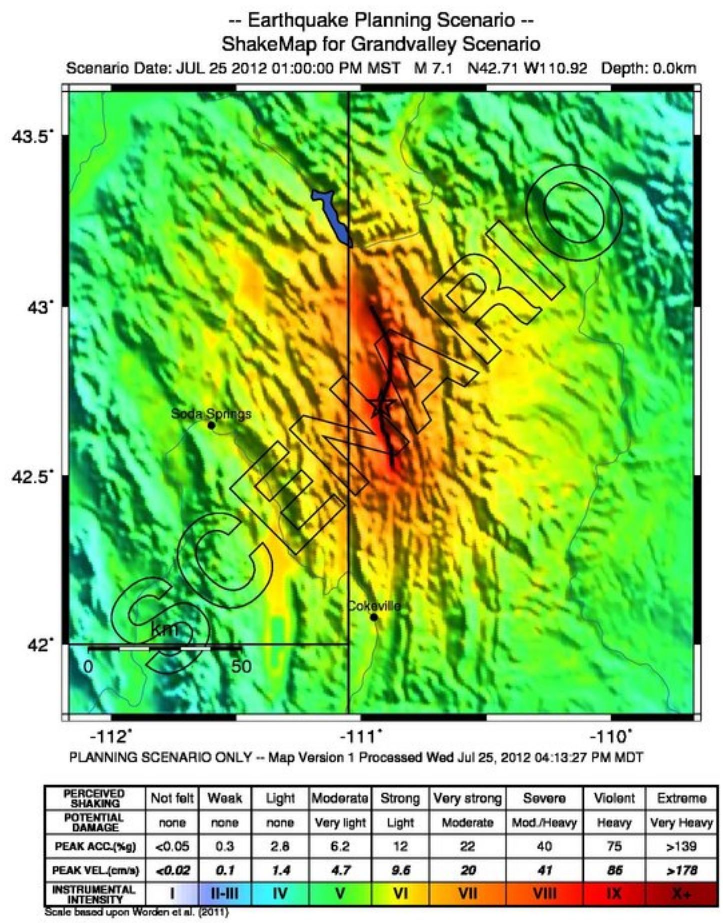


Figure 4.9: Sample US scenario ShakeMap as user-supplied Hazus input.

(Ref. http://earthquake.usgs.gov/earthquakes/shakemap/global/shake/grandvalley_se/)

4.5.2 Importing a ShakeMap

To import ShakeMap files (and other geotechnical maps) to Hazus, follow the steps outlined below:

1. Click on the **Hazard** menu and select **Data Maps** (Figure 4.10).

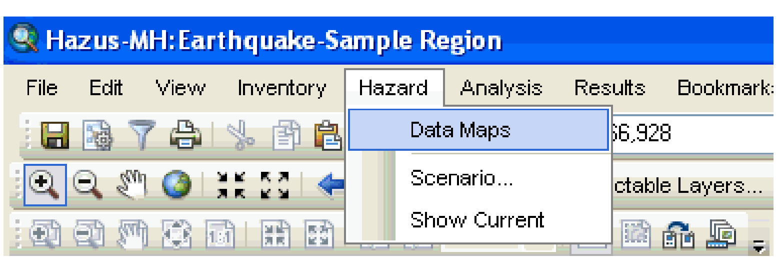


Figure 4.10: Select Data Maps.

2. The **Data Maps Dialog** window will open. If you are adding a ShakeMap to this study region for the first time, the window will be empty. Click **Add map to list** (Figure 4.11).

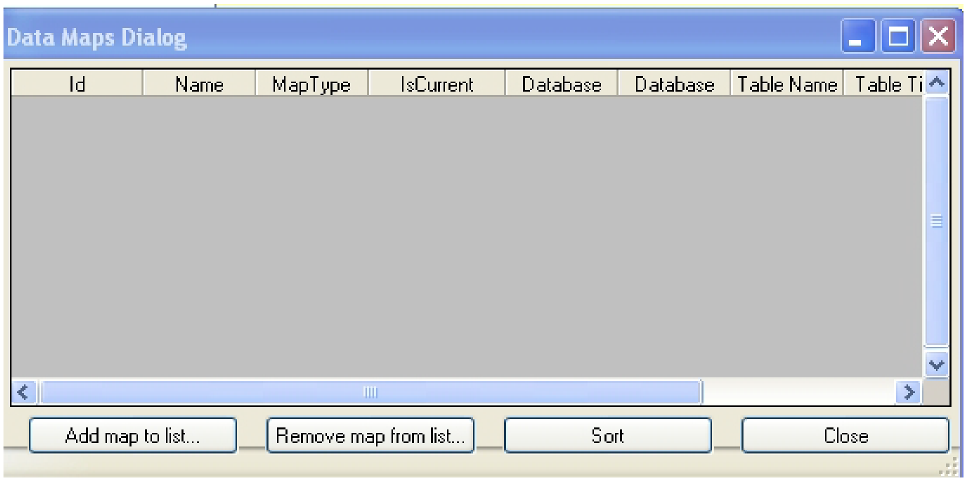


Figure 4.11: Data Maps Dialog window showing the Add map to list button.

3. Browse for a ShakeMap on your computer. The ShakeMap must be in a personal geodatabase (*.mdb*) file format. The ground motion values in each table must be in a field named *ParamValue* with Floating data format.

   You must add four maps (PGV, PGA, SA 1.0 second and SA 0.3 second) to run an earthquake scenario. For each map, you must specify a **Map name**, **Map type** and its source **Table name**.

   Use Table 4.4 as a guide in filling in the requested information and adding a map to the list.

Table 4.4: Ground motion map input examples.

Map Name Example	**Georgia PGV**	**Georgia PGA**	**Georgia SA 1 second**	**Georgia SA 0.3 second**
Map Type (select from drop-down menu)	User-defined for pgv	User-defined for pga	User-defined at period = 1.0 secs	User-defined at period = 0.3 secs
Table Name Example (select from your file)	Georgia_PGV	Georgia_PGA	GeorgiaSA_1s	GeorgiaSA_3s

4. Double-click the ShakeMap geodatabase to open the **Data Map Attributes** window. Enter a **Map name** and select the **Map type** and **Table name**. Click **OK** to continue (Figure 4.12).

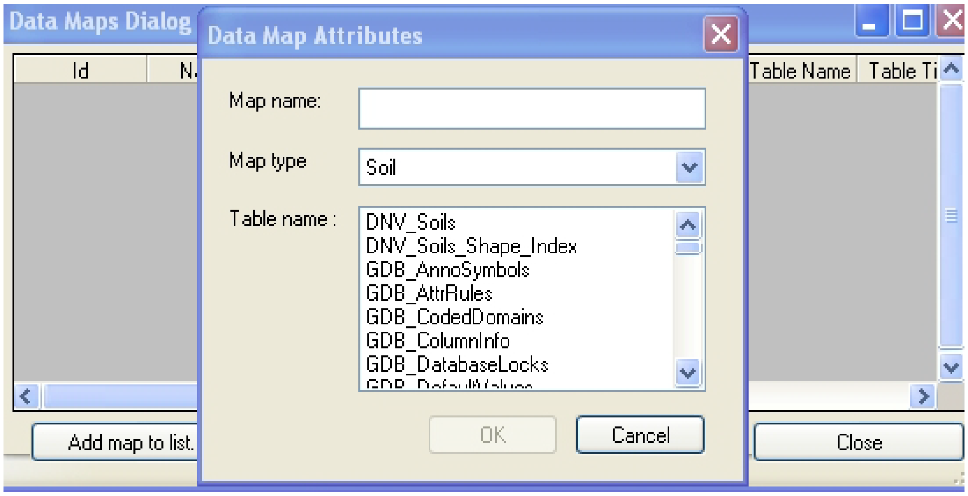


Figure 4.12: Data Map Attributes window.

5. You will now see your added map listed in the **Data Maps Dialog** window. (Figure 4.13) Click **Add map to list** to add your second map.

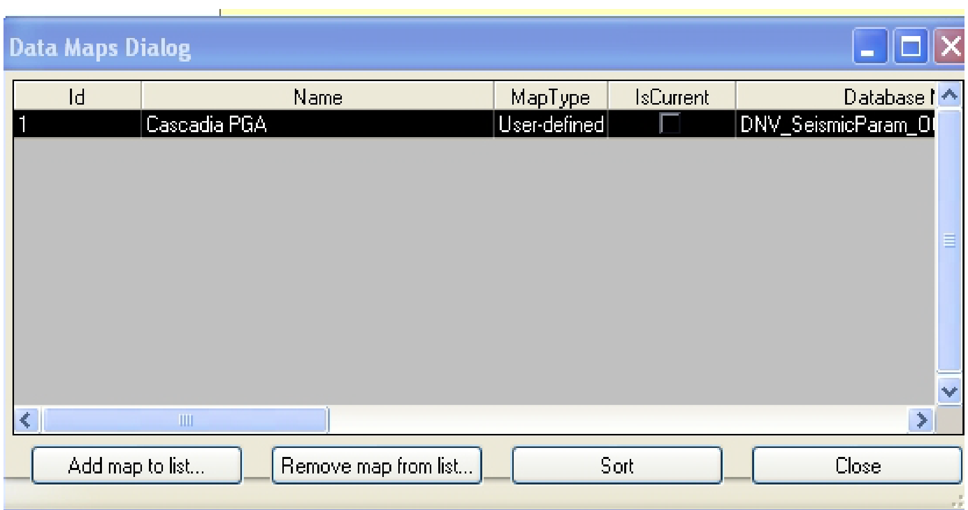


Figure 4.13: Data Maps Dialog window with added map in Data Maps list.

6. Repeat the process of adding a map and specifying its attributes until all four of your maps have been added to the list. Click **Close** once you have finished adding maps for your scenario into Hazus (Figure 4.14)

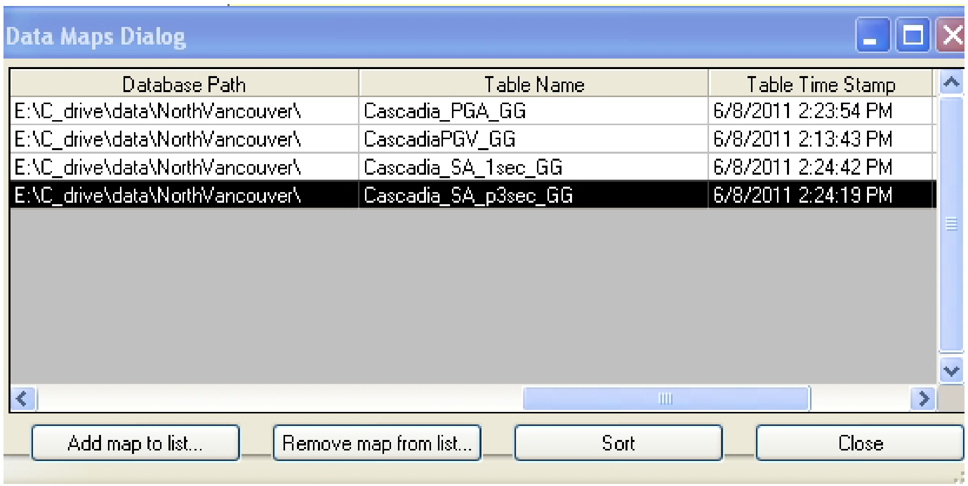


Figure 4.14: Data Maps Dialog window with all required maps in the Data Maps list.

7. Proceed to section 4.6 to run the analysis.

4.5.3 Apply ShakeMap to Create User-Supplied Hazard Scenario

To create the earthquake scenario using an imported ShakeMap, follow the steps outlined below:

1. Click on the **Hazard** menu and select **Scenario** (Figure 4.15).

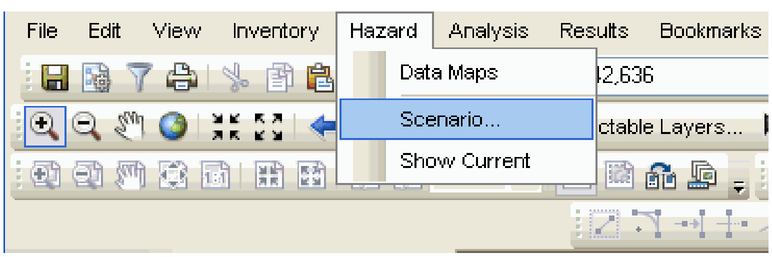


Figure 4.15: Select Scenario.

2. In the **Scenario Wizard** window, select **User-supplied hazard** from the list of seismic hazard types (Figure 4.16).

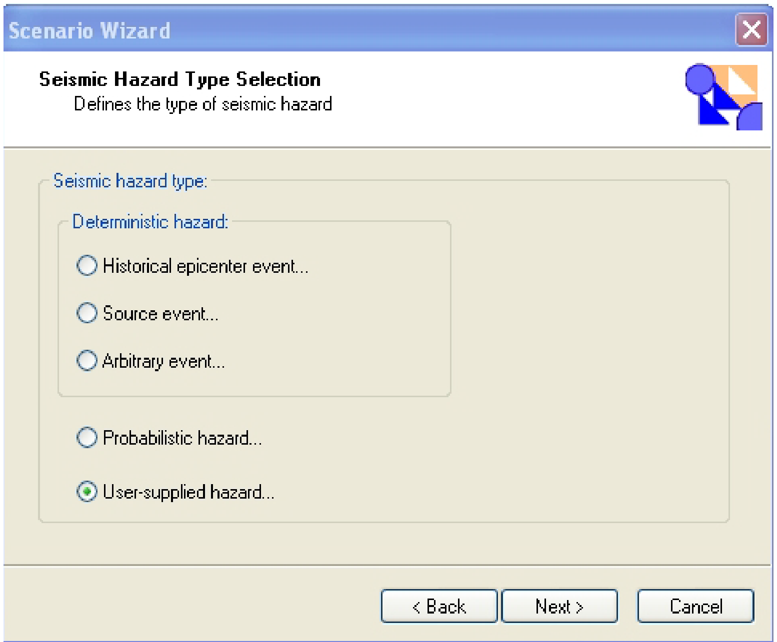


Figure 4.16: Select a User-supplied hazard.

3. The **User-defined Hazard Option** window will open. Select the maps from the drop-down menus and enter a **Magnitude** for the earthquake event.

   Note: For maps to be available here, they must have been imported into Hazus beforehand. See section 4.5.1 for information on importing ShakeMaps.

   Click **Next** to continue (Figure 4.17). Select the **Liquefaction** and **Landslide** maps if these maps have been input to the hazard map list.

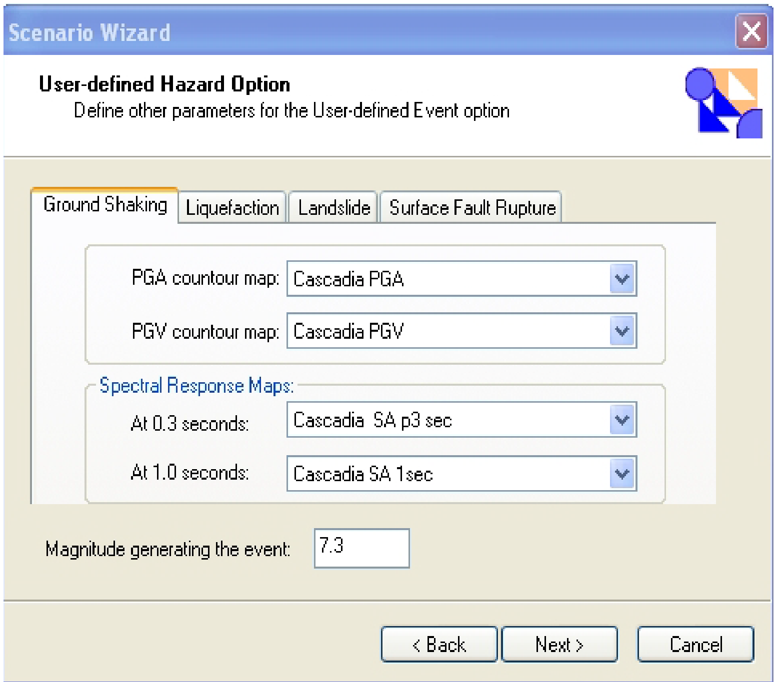


Figure 4.17: User-defined hazard parameters.

4. Enter a name for your earthquake scenario and click **Next** (Figure 4.18).

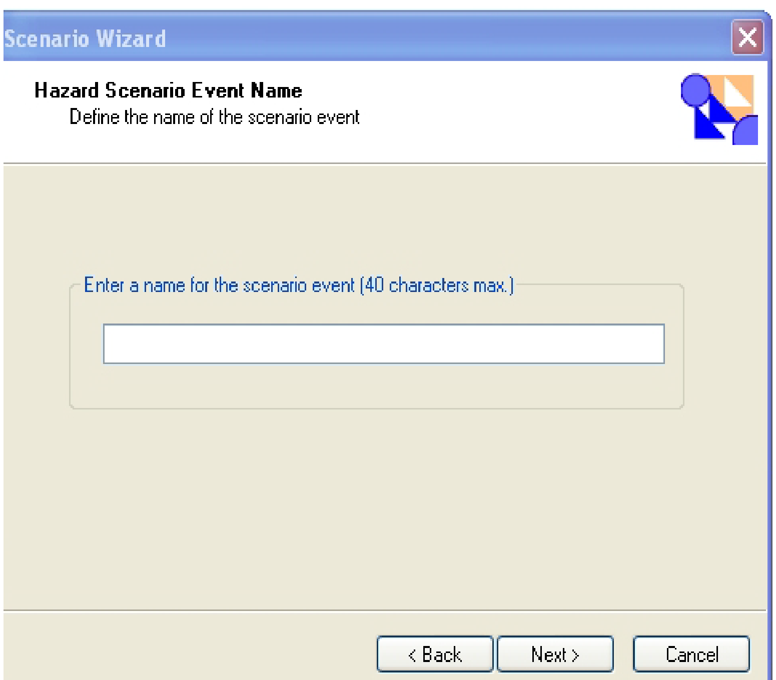


Figure 4.18: Hazard scenario event name.

5. Click **Finish** to close the **Scenario Wizard**.

6. To verify your **Current Scenario** and **Current Hazard Maps**, click on the **Hazard** menu and select **Show Current** (Figure 4.19). Verification can also be done by selecting the **Hazard menu**, and then **Data Maps**. The current maps will have a checkmark beside them.

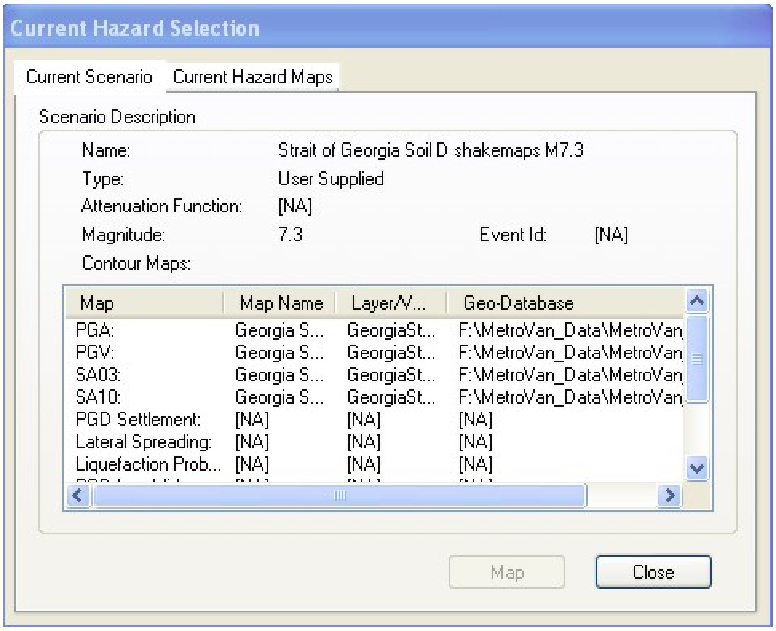


Figure 4.19: Current Hazard Selection.

See section 4.6 for steps on running the analysis

4.5.4 Add Site Effects and User-Defined Hazard Data

(Also refer to Chapter 9.2.4 and Chapter 9.2.8 of the *Hazus-MH 2.1 Earthquake Model User Manual*.)

Expert users are encouraged to add **Soil maps**, **Liquefaction maps**, **Landslide maps** and **Surface Fault Rupture maps** to run a more realistic and relevant scenario.

If the data is available, the user can add maps in the same manner as the ground shaking maps are added. See section 4.5.1 for more information.

1. In the Data Maps Dialog window, click **Add map to list** to add **Soil**, **Liquefaction** and/or **Landslide susceptibility maps**

   The table for the **Soil map** must have the NEHRP soil classes (A to E) in the **Type** field.

   The tables for the **Liquefaction** and **Landslide Susceptibility maps** must have a minimal number of fields. The susceptibility values must be in a Short Integer (or Byte) field named **Type**. The only other fields should be those that are default to the file structure (for example, ObjdectID and Shape).

Default ground motion and ground failure parameters can be modified, although it is advised that you only do so after consulting with a seismologist.

2. From the Hazus menu bar, click on the **Analysis** menu, select **Parameters**, and then the **Hazard** option (Figure 4.20).

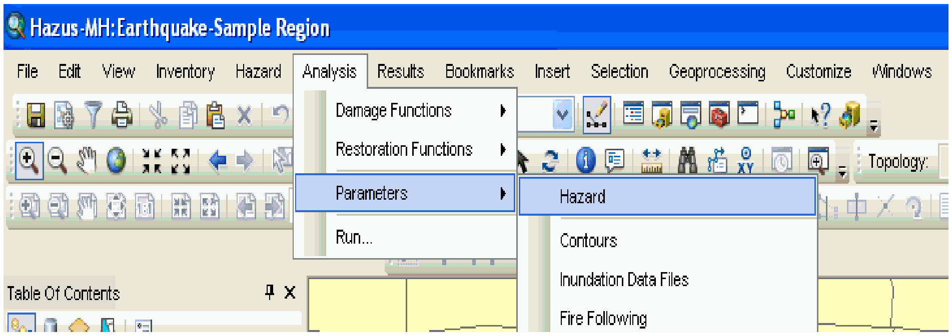


Figure 4.20: Modify ground motion and ground failure parameters.

You can modify **Soil Amplification Factors**, **Liquefaction** and **Landslide**. Soil amplification factors can be adjusted for Peak Ground Acceleration (PGA), Peak Ground Velocity (PGV) and for Spectral Acceleration at periods of 0.3 and 1.0 second. Select the table type that you would like to modify (Figure 4.21).

Note: Do not modify soil amplification factors without consulting a seismologist or a geotechnical engineer.

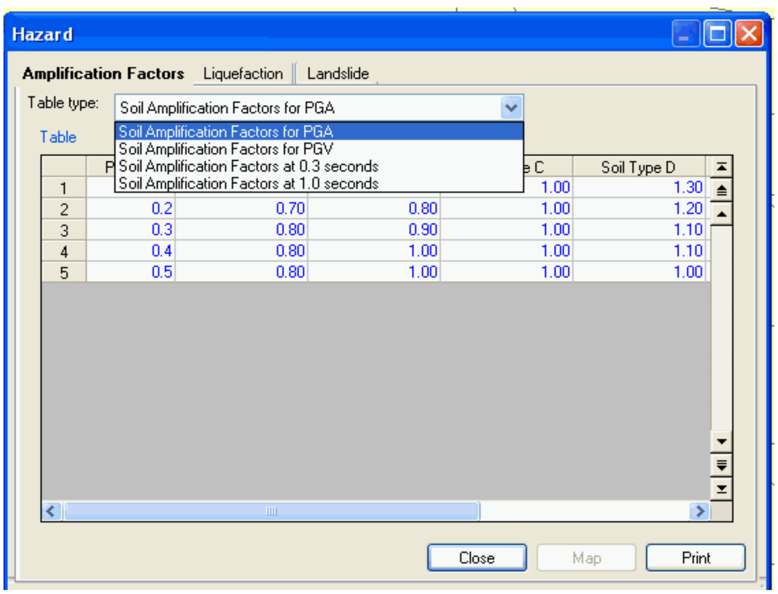


Figure 4.21: Soil amplification factors.

3. Right-click on the table and select **Start Editing** to modify soil amplification factors (Figure 4.22).

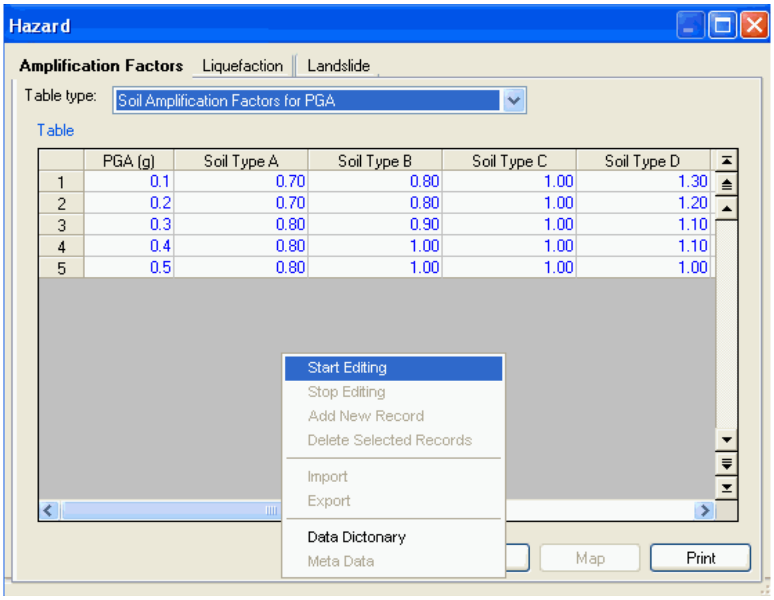


Figure 4.22: Modifying soil amplification factors.

4.5.5 Modify Fragility Curves

(Also refer to Chapter 5.4.3 of the *Hazus-MH 2.1 Earthquake Model Technical Manual*, Chapter 9.3.4 and Chapter 9.3.6 of the *Hazus-MH 2.1 Earthquake Model User Manual* and Chapter 6 of the *Hazus-MH 2.1 Advanced Engineering Building Module (AEBM) Technical and User's Manual*.)

Fragility curves describe the probability that a component or system (e.g., Building) will sustain a damage state as a result of the intensity of a particular hazard parameter (e.g., flood velocity, ground motions, etc.).

Default fragility curves for earthquakes were developed for each building type and incorporated to Hazus. Fragility curves are available for three seismic design levels and three construction standards for structural and non-structural damage. They are available for both PGA and PGD related damage. At present, Hazus Canada has available the same default fragility curves for earthquakes as those used in the US version of Hazus.

One issue for Canadian users of Hazus is that the default fragility curves do not adequately represent the damage sustained by stone masonry structures as a result of earthquakes. Stone masonry buildings are a common feature of the Eastern Canadian landscape. The Geological Survey of Canada is currently in the process of developing and refining fragility curves for earthquakes to be included in Hazus Canada at a later date.

Fragility curves can be modified in Hazus (refer to Chapter 9.3.6 of the *Hazus-MH 2.1 Earthquake Model User Manual*), but it is strongly recommended that this is only attempted by users with expertise in developing fragility curves.

With the help of an expert, you can modify fragility by following the steps outlined below:

1. Click on the **Analysis** menu and select **Damage Functions** and **Buildings** (Figure 4.23).

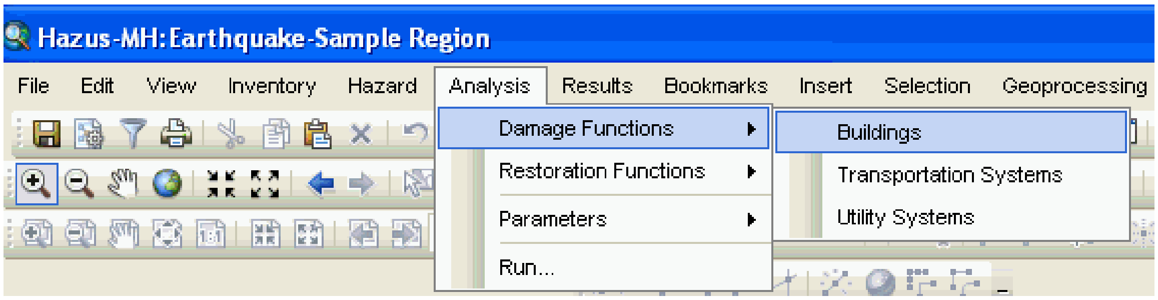


Figure 4.23: Select Damage Functions from the Analysis menu.

2. In the **Buildings Damage Functions** window, right-click on a record and select **Start Editing**. You can change the mean, beta, and other parameters in this window. Click **Close** when finished (Figure 4.24).

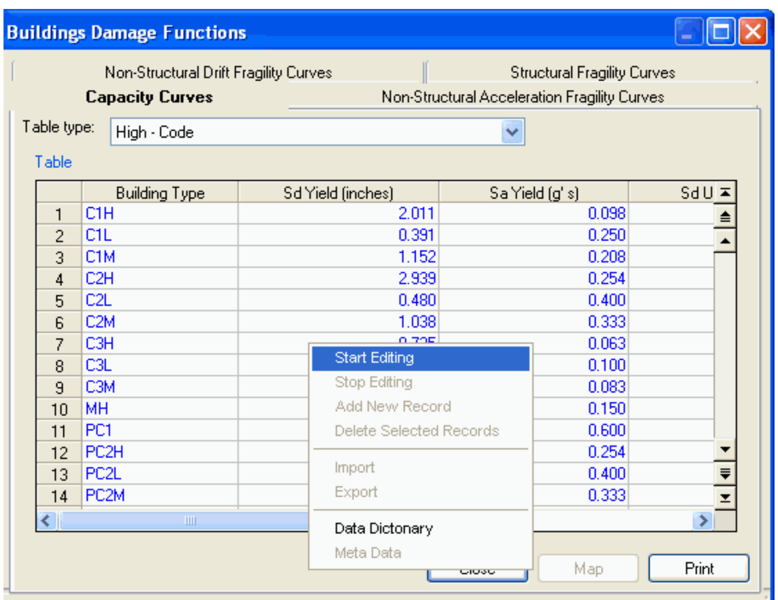


Figure 4.24: Modifying fragility curves.

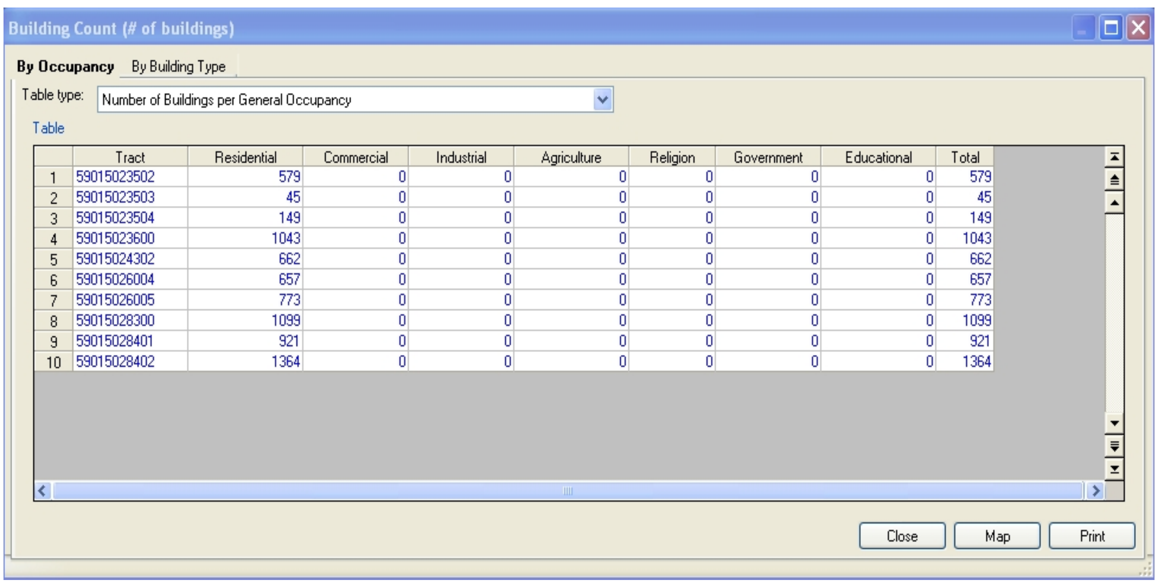
4.5.6 Modify Mapping Occupancy Schemes

(Also refer to Chapter 3.2.1 of the *Hazus-MH 2.1 Earthquake Model Technical Manual* and Chapter 4.2.2 and Chapter 7.3 of the *Hazus-MH 2.1 Earthquake Model User Manual*.)

General building stock in Hazus is categorised into **general occupancy** and **specific occupancy** classes. There are seven groups of general occupancy building stock (Residential, Commercial, Industrial, Agriculture, Religion, Government, and Education), and 33 specific occupancy classes.

General building stock data is stored by Census Tract. As can be seen in Figure 4.25, Hazus Canada currently only contains residential default inventory data.

In the **Inventory** menu, click on **General Building Stock**, click on **Building Count**, select the table, click on the column heading, and then click on **Map** to graphically display the residential buildings by Census Tract.



	Tract	Residential	Commercial	Industrial	Agriculture	Religion	Government	Educational	Total
1	59015023502	579	0	0	0	0	0	0	579
2	59015023503	45	0	0	0	0	0	0	45
3	59015023504	149	0	0	0	0	0	0	149
4	59015023600	1043	0	0	0	0	0	0	1043
5	59015024302	662	0	0	0	0	0	0	662
6	59015026004	657	0	0	0	0	0	0	657
7	59015026005	773	0	0	0	0	0	0	773
8	59015028300	1099	0	0	0	0	0	0	1099
9	59015028401	921	0	0	0	0	0	0	921
10	59015028402	1364	0	0	0	0	0	0	1364

Figure 4.25: Residential inventory data.

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

1. Click on the Inventory menu and select **General Building Stock** and then **Occupancy Mapping** (Figure 4.26).

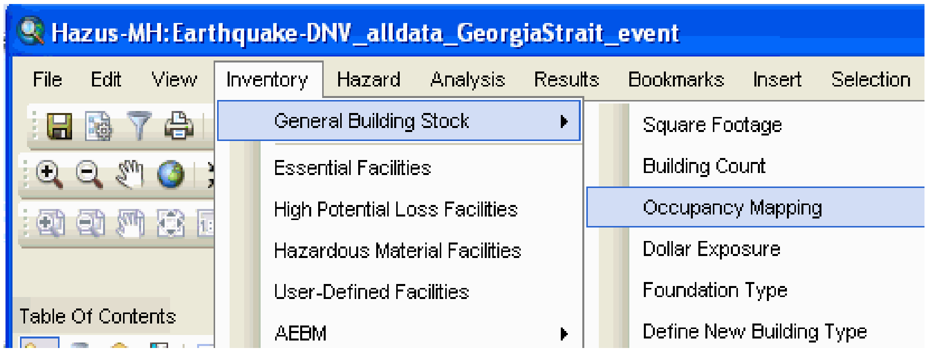


Figure 4.26: General Building Stock Occupancy Mapping.

2. A window will open with a table listing all the default occupancy mapping schemes for your region. Blue text indicates that the default mapping schemes cannot be edited. You can view, print, delete, or copy and then edit schemes.

   Highlight an occupancy mapping scheme and right-click on it with your mouse. Select **New** from the menu. This will create a duplicate of the existing occupancy mapping scheme that you can edit (Figure 4.27).

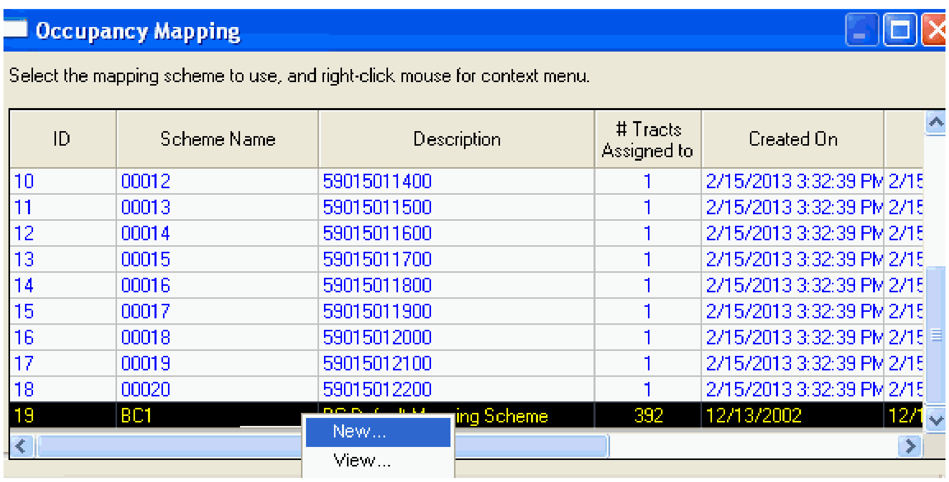


Figure 4.27: Occupancy Mapping Schemes list.

3. Provide a descriptive name for your new mapping scheme (Figure 4.28).

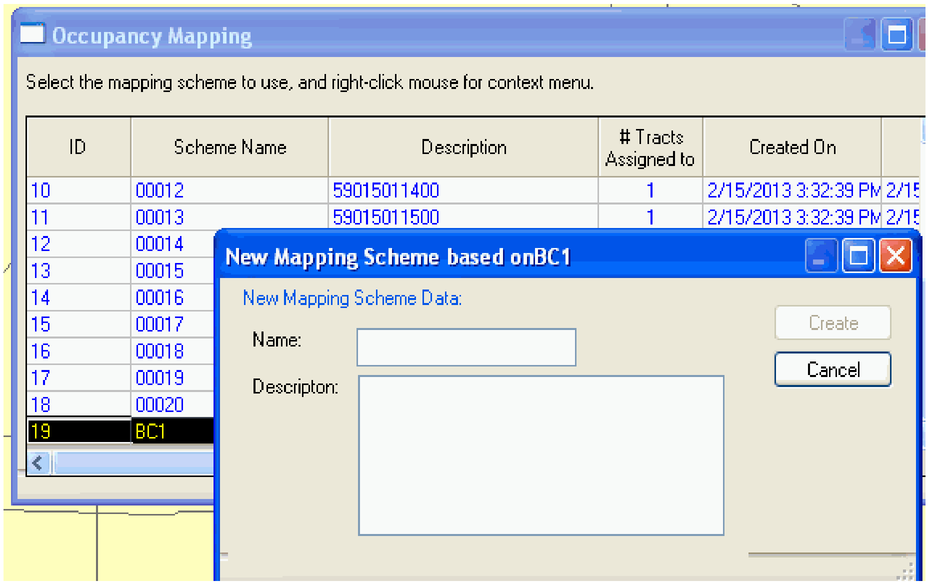


Figure 4.28: Name your new Occupancy Mapping Scheme.

4. Select your new scheme to edit. The schemes show the distribution (%) of building type for the occupancy classes within a Hazus tract. The yellow colour indicates that the spreadsheet cells can be edited (Figure 4.29).

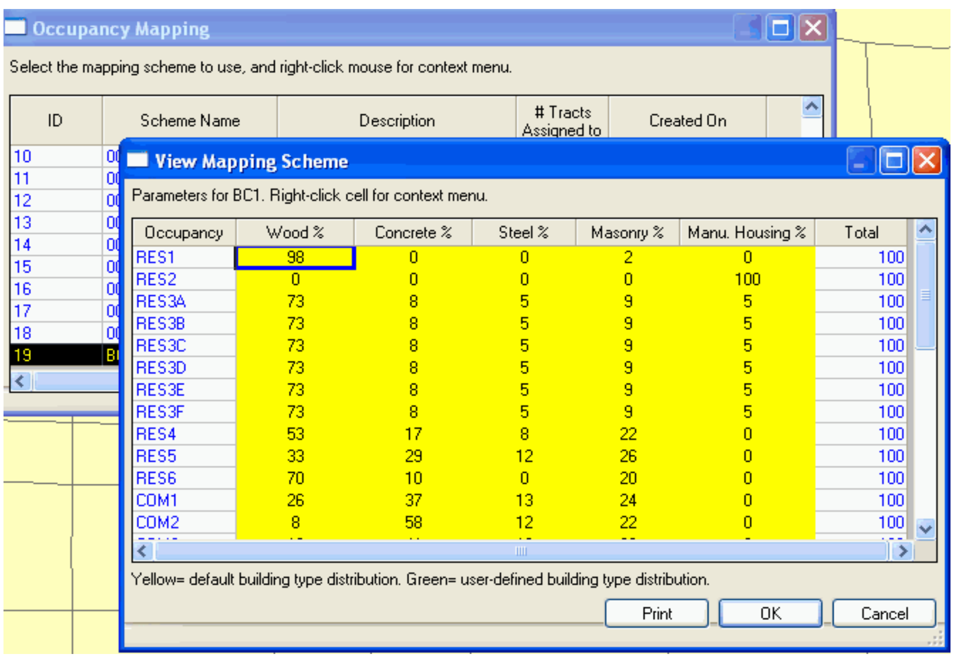


Figure 4.29: Edit spreadsheet cells in the Occupancy Mapping Scheme.

5. Right-click a cell and select **View current building type distribution** to view the assigned **Design Level** for a particular occupancy and building type (Figure 4.30).

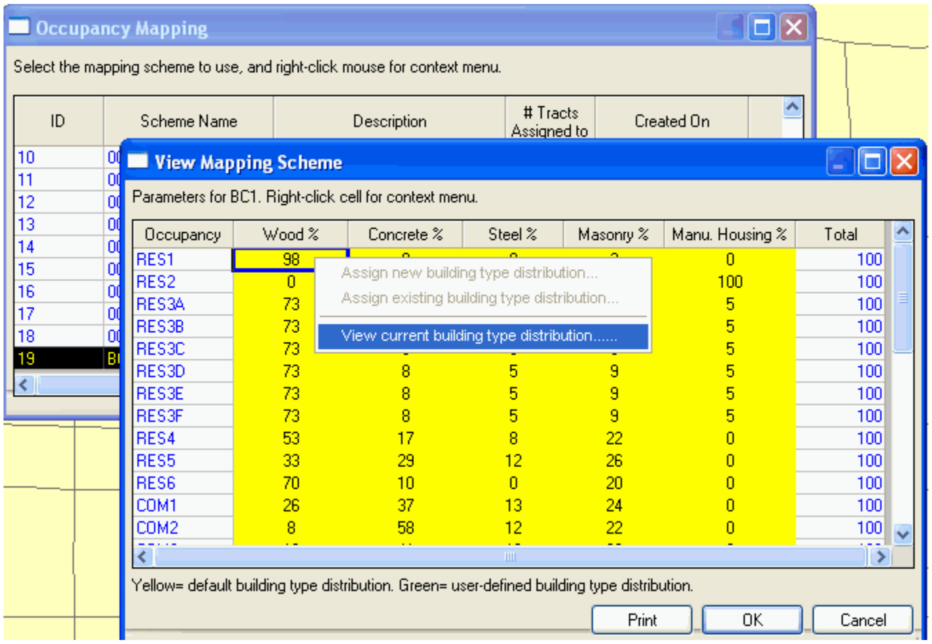


Figure 4.30: View the building type distribution.

6. Check the building **Design Level**. Click **OK** to continue editing the mapping scheme values (Figure 4.31).

   The **Design Level** code relates to the vulnerability to damage of a structure. You can choose a mix of design levels for each building type.

   (Also refer to Chapter 7.3.1 of the *Hazus-MH 2.1 Earthquake Model User Manual* for more details.)

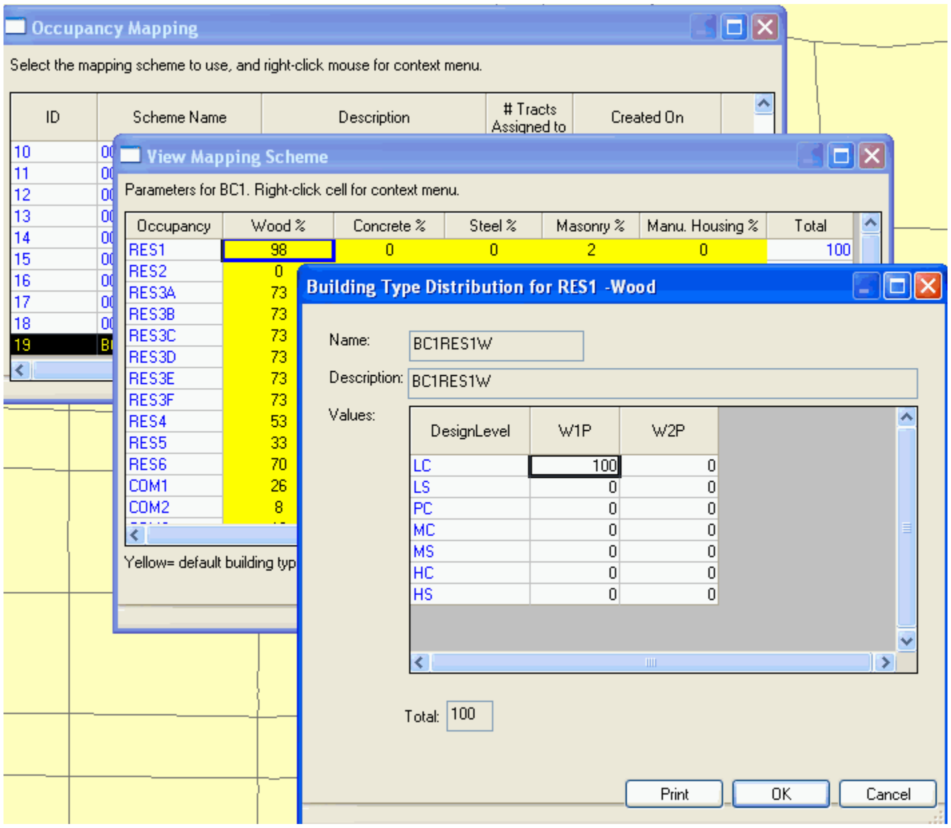


Figure 4.31: Building type distributions for RES1 – Wood.

4.6 Run the Analysis

(Also refer to Chapter 3.7 of the *Hazus-MH 2.1 Earthquake Model User Manual*.)

To run an earthquake scenario analysis, follow the steps outlined below.

1. Select the **Analysis** menu and click **Run** (Figure 4.32).

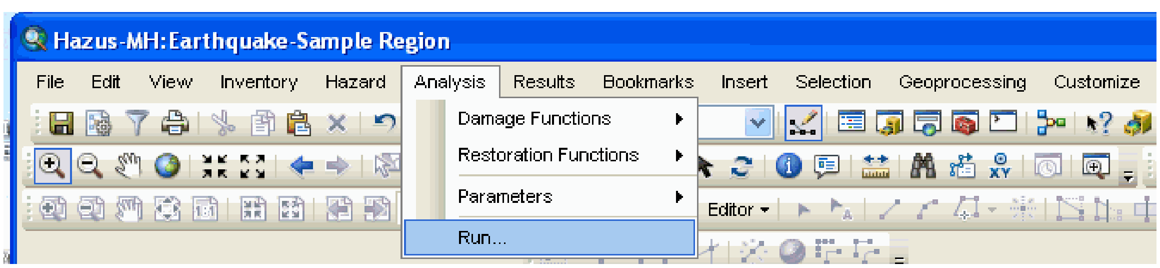


Figure 4.32: Select Run from the Analysis menu.

2. The **Analysis Options** window will open (Figure 4.33). Click on the plus sign to expand each Inventory item. Check the Inventory categories that apply and that you would like to analyse. 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.

Note: Do not select the *Contour Maps* option as this can be very time consuming to generate. *Contour Maps* are generated for viewing only and are not used by the analysis.

The number of modules you select will be indicated near the bottom of the window.

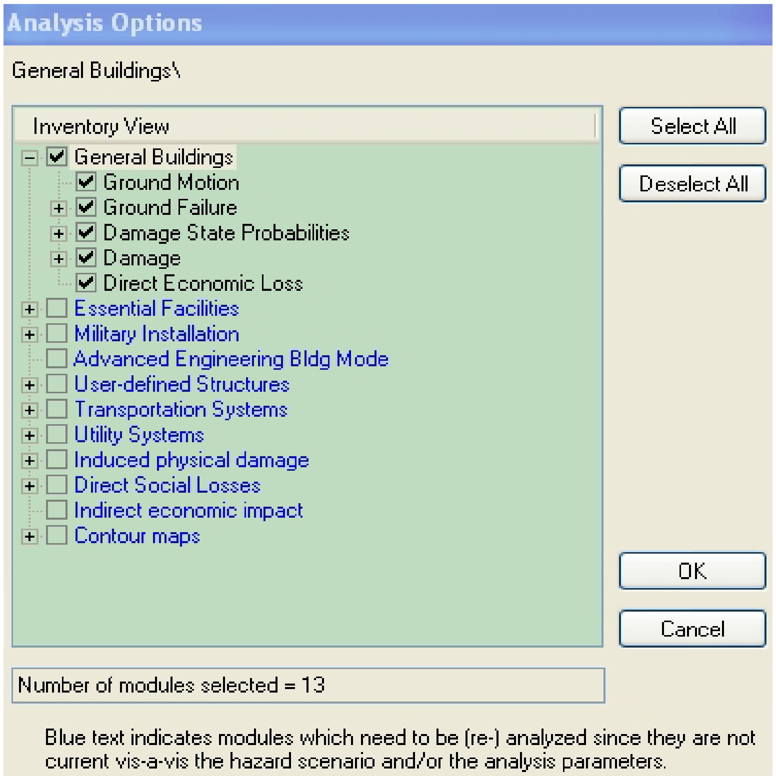


Figure 4.33: Analysis options.

3. Click **OK** to run your analysis.

See Chapter 5 for a discussion on Hazus analysis results and outputs.

(Also refer to Chapter 4 of the *Hazus-MH 2.1 Earthquake Model Technical Manual*.)

4.7 Enter AEBM or UDF Data and Run Analysis

The **Advanced Engineering Building Module** provides the ability to calculate losses for specific structures based on their seismic engineering characteristics. The **User-Defined Facilities** analysis tool also provides the ability to calculate losses for specific structures but does not contain information about their seismic engineering characteristics. Both modules are optional and permit further detailed modelling of potential losses.

4.7.1 Enter AEBM Data

(Also refer to Chapter 1, Chapter 3 and Chapter 8.3 of the *Hazus-MH 2.1 Advanced Engineering Building Module (AEBM) Technical and User's Manual*.)

Advanced Engineering Building Module data is not contained within the provincial database, so you will need to import the inventory of your AEBM data into your study region. Data may be input manually as individual records or read from a personal database (*.mdb*).

The AEBM module has two main components or databases: **AEBM Inventory** and **AEBM Profiles**. To run the AEBM module, each building in the **AEBM Inventory** must be linked to an **AEBM Profile**. To create the list of **AEBM Profiles**, you select parameters based on building characteristics. Then you can enter individual buildings into the **AEBM Inventory**. These are defined by their location (latitude/longitude), number of occupants, size and replacement cost, as well as by a specific AEBM profile. The AEBM Profiles must be added before the AEBM Inventory records.

(Also refer to Chapter 8.3.4 of the *Hazus-MH 2.1 Advanced Engineering Building Module (AEBM) Technical and User's Manual* for an explanation of the profile parameters.)

To add AEBM data in Hazus, follow the steps outlined below:

1. Click on **Inventory** and then select the **AEBM Profiles** option (Figure 4.34).

   AEBM Profiles are the parameters that you apply to each building and are based on the building occupancy, the building materials, and the building's seismic code.

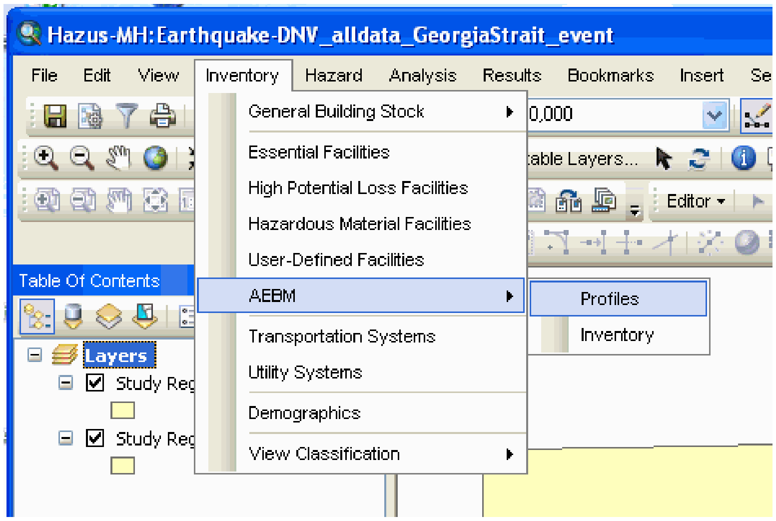


Figure 4.34: Select AEBM profiles from Inventory menu.

2. On the **Building Profile name** window, enter a **Profile Name**, **Occupancy**, **Building Type** and **Design Level** (Figure 4.35). For easy recognition, it is recommended that you enter a Profile Name reflecting the parameters that are assigned to it (example; RES1_W1_MC).

   Based on the parameters you select, Hazus automatically assigns values for other fields (e.g., **Spectral Displament@Yield**, **Spectral Acceleration@Yield**, etc.). AEBM Profiles data, such as actual building capacity, damage and loss parameters, can be modified.

   (Refer to Chapter 8.4 of the *Hazus-MH 2.1 Advanced Engineering Building Module (AEBM) Technical and User's Manual* for instructions on how to modify default AEBM Profile data.)

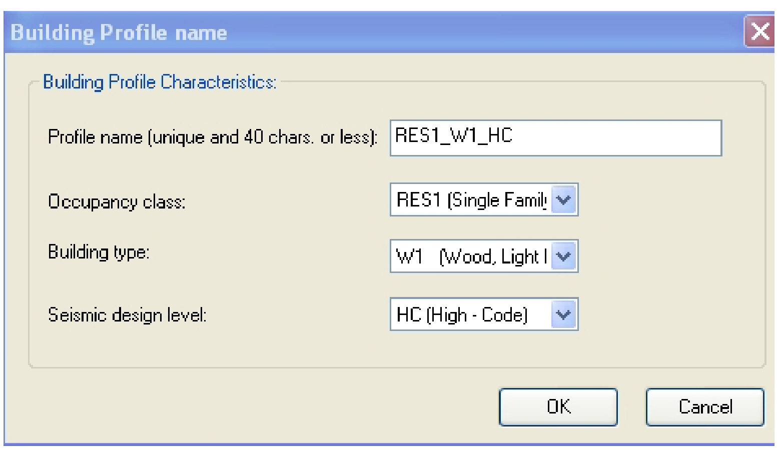


Figure 4.35: Building profile characteristics.

3. Click **OK** to continue. The AEBM Profiles window will open to display the one record in the table.

4. Right-click on the one record in the table to bring up a menu with options for adding a profile, deleting a profile, assigning to default capacity and fragility curves or viewing the **Data Dictionary** (Figure 4.36).

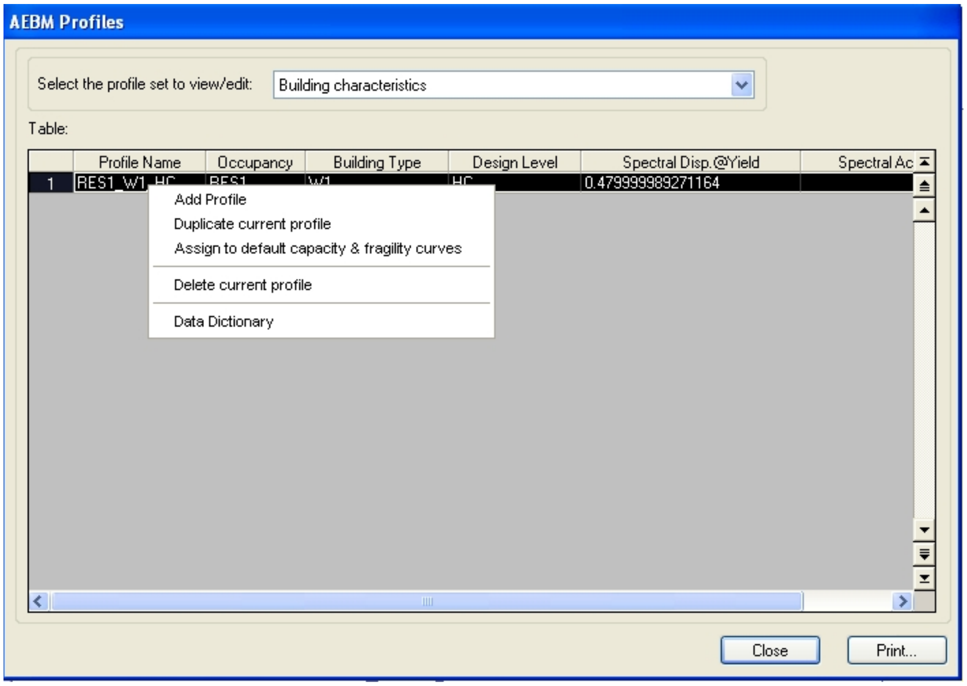


Figure 4.36: AEBM profiles.

The **Data Dictionary** will provide you with a list of formats for each field in the AEBM Profiles table.

Enter each AEBM Profile manually. Once you have finished adding profiles, you can view all your. Your **AEBM Profiles** database may contain hundreds of records.

Enter each AEBM Profile manually. As you select the combination of Occupancy, Building Type, and Seismic Design Level, the software will apply appropriate values for the profile characteristics. It is recommended to save often while adding profiles. Once you have finished adding profiles, you can view all your **AEBM Profiles** listed in a table (Figure 4.37). Your **AEBM Profiles** database may contain between 1 and 8,316 records (depending on how many combinations of Occupancy (33), Building Type (36), and Seismic Design Level (7) are required for your inventory).

(Also refer to Chapter 3.3 and Chapter 8.3.3 of the *Hazus-MH 2.1 Advanced Engineering Building Module (AEBM) Technical and User's Manual.)*

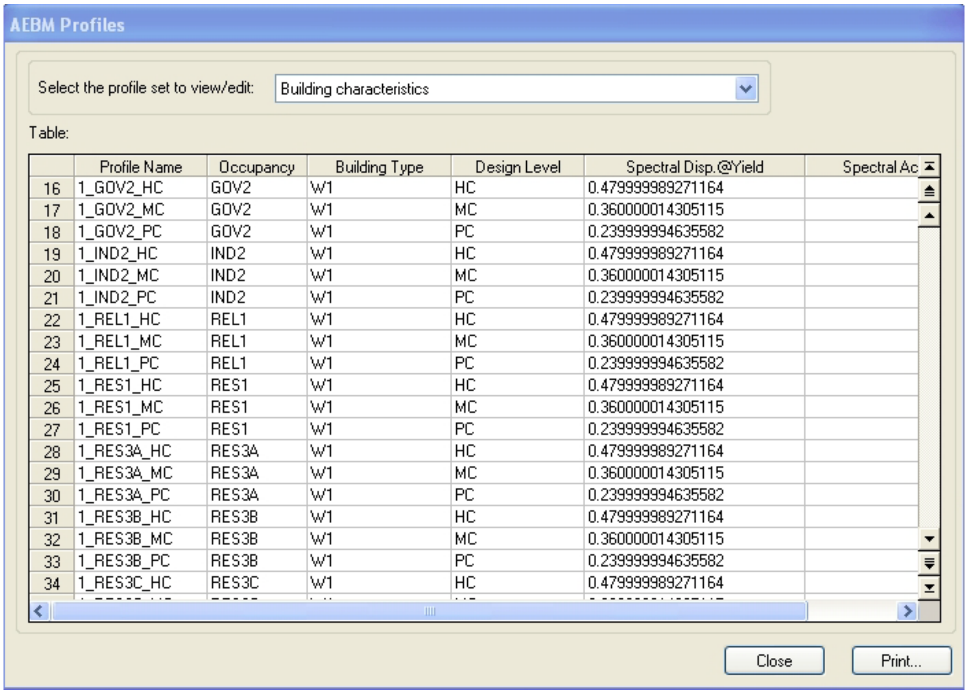


Figure 4.37: List of profiles in your AEBM Profiles database.

5. To add buildings to the **AEBM Inventory**, click on **Inventory** menu, select **AEBM,** then select the **AEBM Inventory** option (Figure 4.38). Right-click within the window and select **Start Editing** (Figure 4.39).

   Note: If the co-ordinates for a building are outside the boundary for the study region, the record will not be added to the AEBM Inventory.

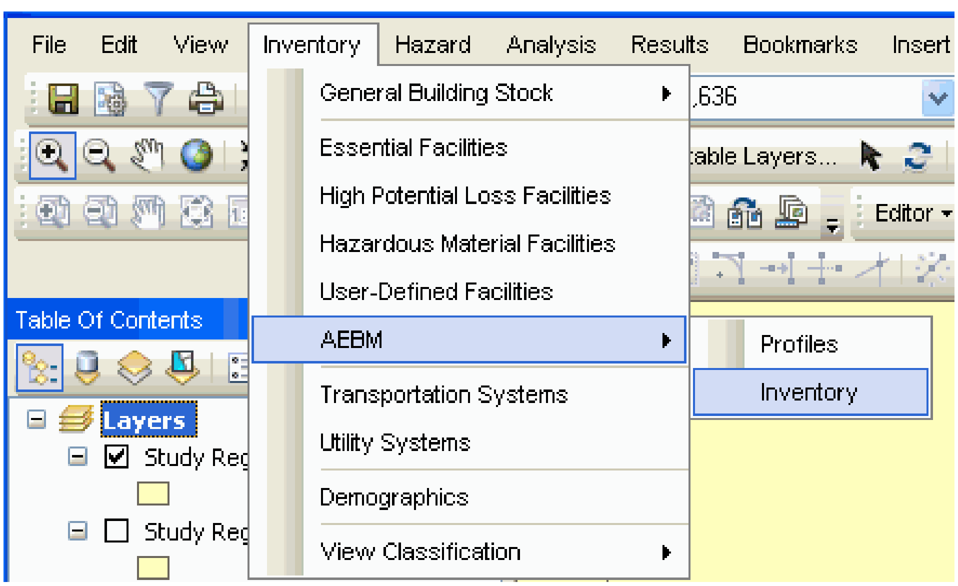


Figure 4.38: Select AEBM inventory from the Inventory menu.

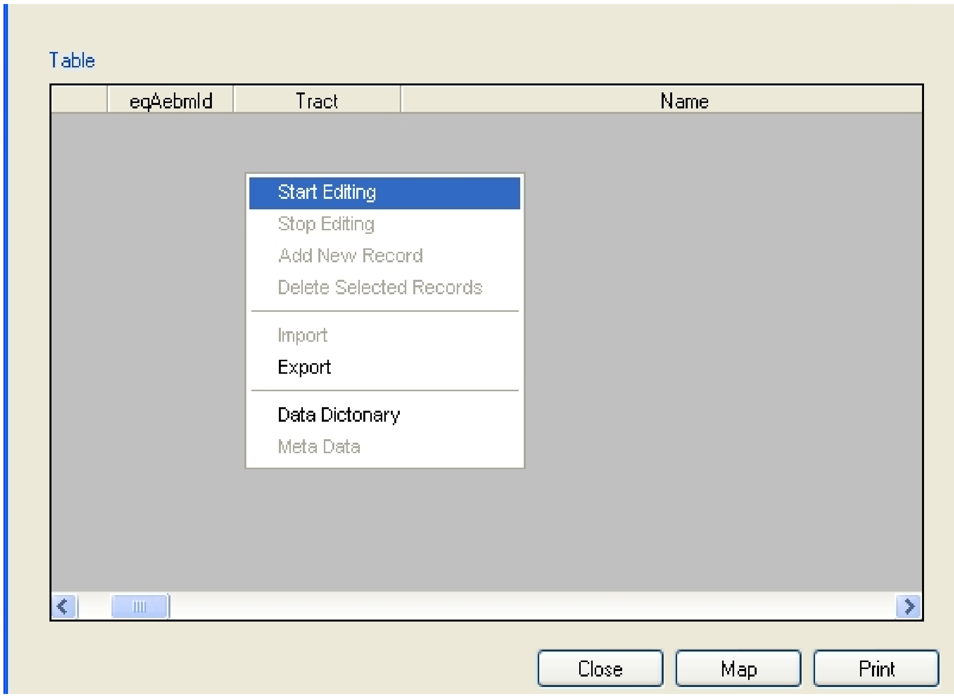


Figure 4.39: Start Editing AEBM inventory.

6. To add individual records to the AEBM Inventory individually, right-click again and select **Add New Record**. Enter a latitude and longitude value for the building, click **OK**, and then type in the parameters for the building.

7. To add many records choose **Import** (Figure 4.40) and look for your source file containing the records for the AEBM Inventory. The source file is generated outside of Hazus and must be in *.mdb* format, with field formats matching those of the target file.

   To view the field formats, right-click the Inventory window and select the option **Data Dictionary**. View both the Common Attribute tab and the Earthquake Attribute tab. All profiles in your **AEBM Inventory** must also be in your **AEBM Profiles** database.

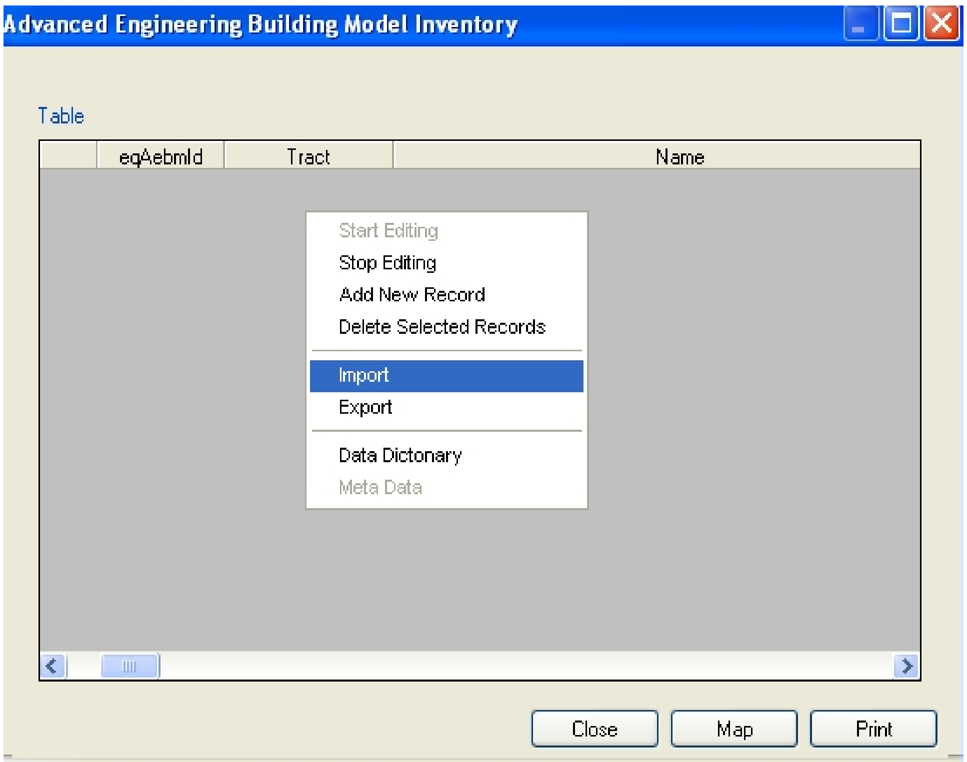


Figure 4.40: Import AEBM inventory.

8. When your source file is ready, Select **Import**, browse for the file, and then select the table within your source file to be imported (Figure 4.41). Match the **Source** fields to the **Target** fields, and then click **Add** to add the matches to the **Mapping Result** list. When the list is complete click **OK** to import the data for the buildings into the AEBM inventory.

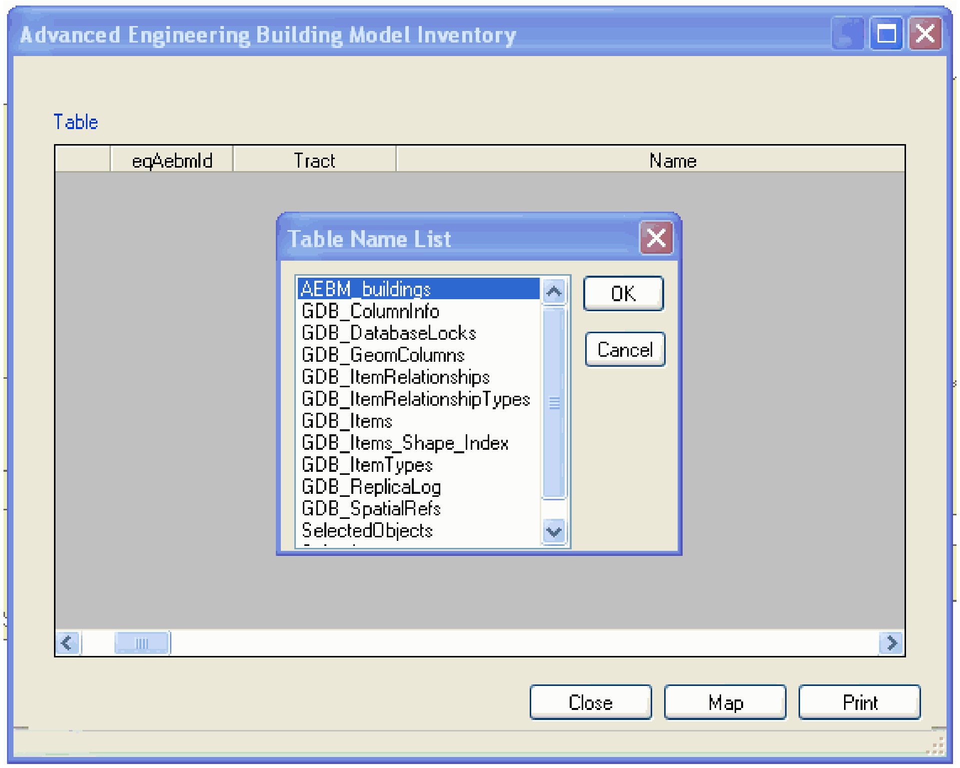


Figure 4.41: Select source table.

9. If an error message appears when matching fields (Figure 4.42) your source file may need to be edited. Exit from Hazus and edit the source file by:

   a) changing data format of field; and/or
   b) changing field size; and/or
   c) removing extra fields.

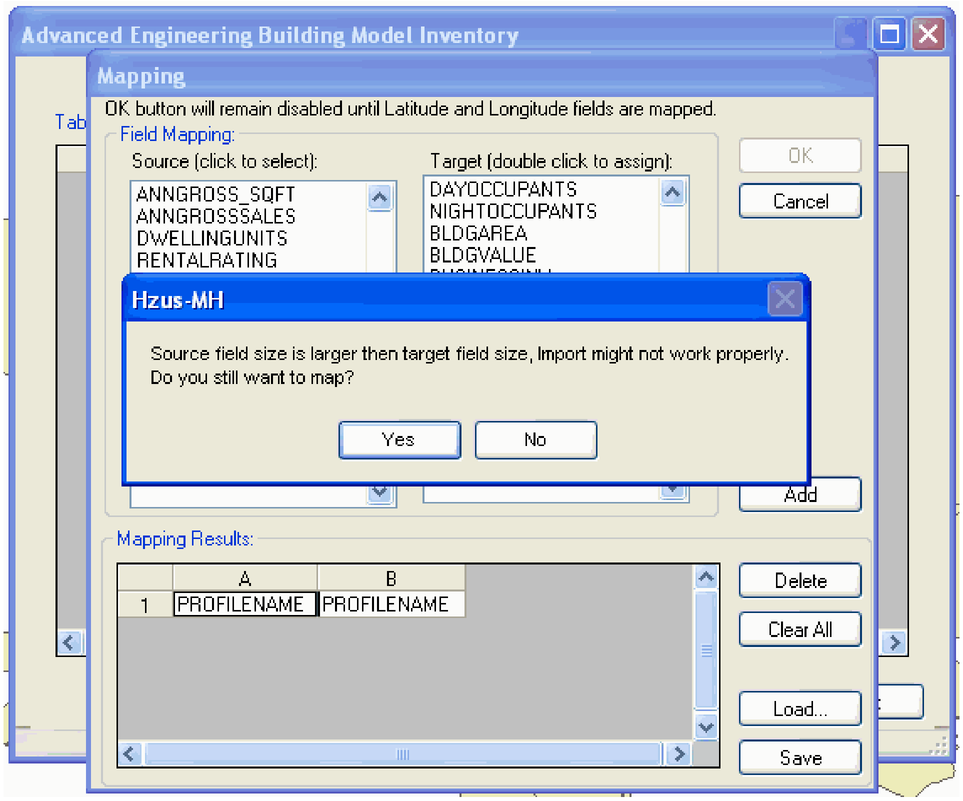
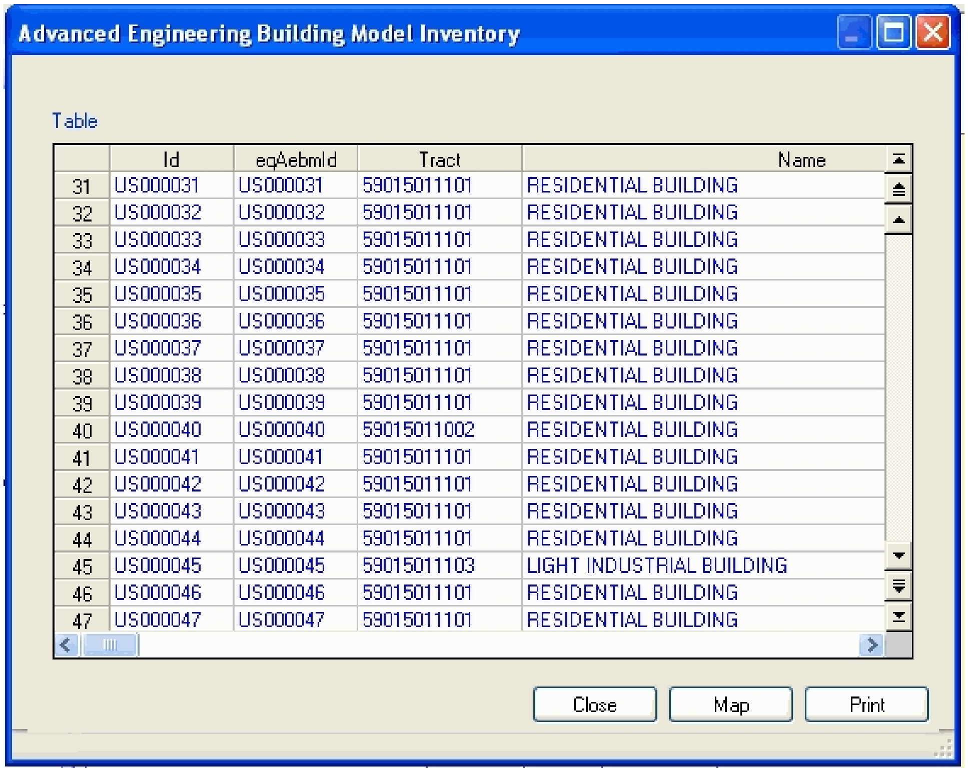


Figure 4.42: Error message when field matching.

10. Building records may be viewed and edited after Import is complete. (Figure 4.43). Any text that is black can be edited.

    Note: The **Advanced Engineering Building Model Inventory** window has a limited number of rows that appear (approximately 4100). However, if the inventory contains more inventory records, those records will appear in the window as you continue to scroll down.

11. Click **Stop Editing** when the input of building records is finished.



	Id	eqAebmId	Tract	Name
31	US000031	US000031	59015011101	RESIDENTIAL BUILDING
32	US000032	US000032	59015011101	RESIDENTIAL BUILDING
33	US000033	US000033	59015011101	RESIDENTIAL BUILDING
34	US000034	US000034	59015011101	RESIDENTIAL BUILDING
35	US000035	US000035	59015011101	RESIDENTIAL BUILDING
36	US000036	US000036	59015011101	RESIDENTIAL BUILDING
37	US000037	US000037	59015011101	RESIDENTIAL BUILDING
38	US000038	US000038	59015011101	RESIDENTIAL BUILDING
39	US000039	US000039	59015011101	RESIDENTIAL BUILDING
40	US000040	US000040	59015011002	RESIDENTIAL BUILDING
41	US000041	US000041	59015011101	RESIDENTIAL BUILDING
42	US000042	US000042	59015011101	RESIDENTIAL BUILDING
43	US000043	US000043	59015011101	RESIDENTIAL BUILDING
44	US000044	US000044	59015011101	RESIDENTIAL BUILDING
45	US000045	US000045	59015011103	LIGHT INDUSTRIAL BUILDING
46	US000046	US000046	59015011101	RESIDENTIAL BUILDING
47	US000047	US000047	59015011101	RESIDENTIAL BUILDING

Figure 4.43: Example of AEBM inventory.

4.7.2 Run an AEBM Analysis

(Refer to Chapter 8.3.5 of the *Hazus-MH 2.1 Advanced Engineering Building Module (AEBM) Technical and User's Manual* for information on running an AEBM analysis and selecting and viewing the results.)

4.7.3 Enter UDF Data

User-Defined Facilities data is not contained within the provincial database so you will need to import the inventory of your UDF data, as a personal database (*.mdb*), into your study region.

1. Click on **Inventory** and then select **User-Defined Facilities** (Figure 4.44).

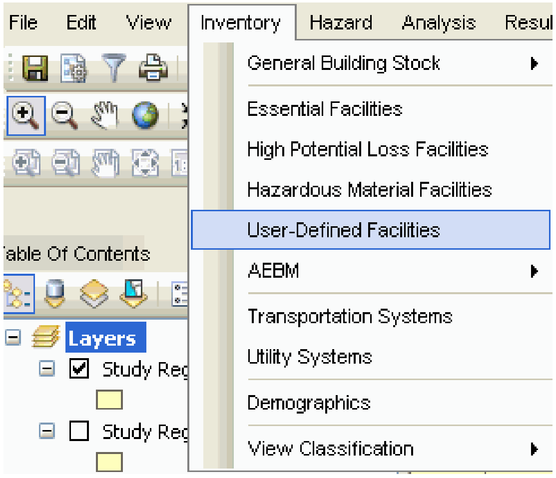


Figure 4.44: Select UDF from Inventory menu.

2. To add buildings to the **UDF Inventory** right-click the **User-Defined Structure Inventory** window to select **Start Editing** (Figure 4.45). Select **Add New Record** to enter data for individual records, or select **Import** (Figure 4.46).

   Note: If the co-ordinates for a building are outside the boundary for the study region, the record will not be added to the UDF Inventory.

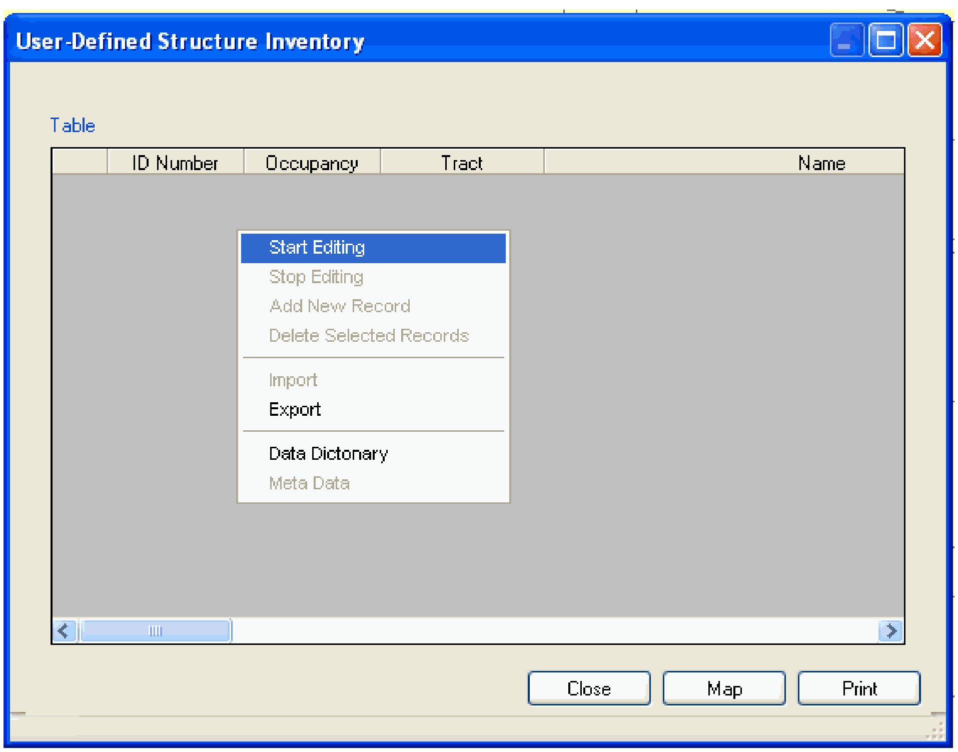


Figure 4.45: Edit UDF inventory.

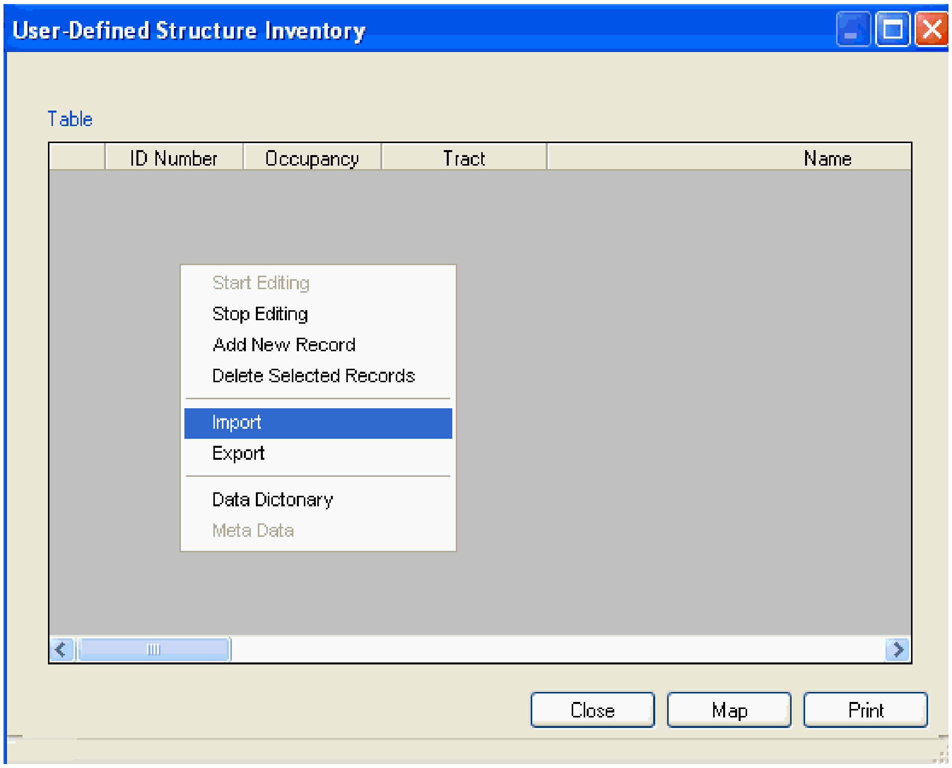


Figure 4.46: Import UDF inventory.

3. To add individual records to the UDF Inventory individually select **Add New Record**. Enter a latitude and longitude value for the building, click **OK**, and then type in the parameters for the building.

4. To add many records, choose **Import** (Figure 4.46) and look for your source file containing the records for the UDF Inventory. The source file must be in *.mdb* format with field formats matching those of the target file. Before generating your source file outside of Hazus, it is recommended that you view the list of information required.

   To view the field formats, right-click within the User-Defined Structure Inventory window, and select **Data Dictionary** (Figure 4.47). View both the Common Attribute tab (Figure 4.48) and the Earthquake Attribute tab (Figure 4.49).

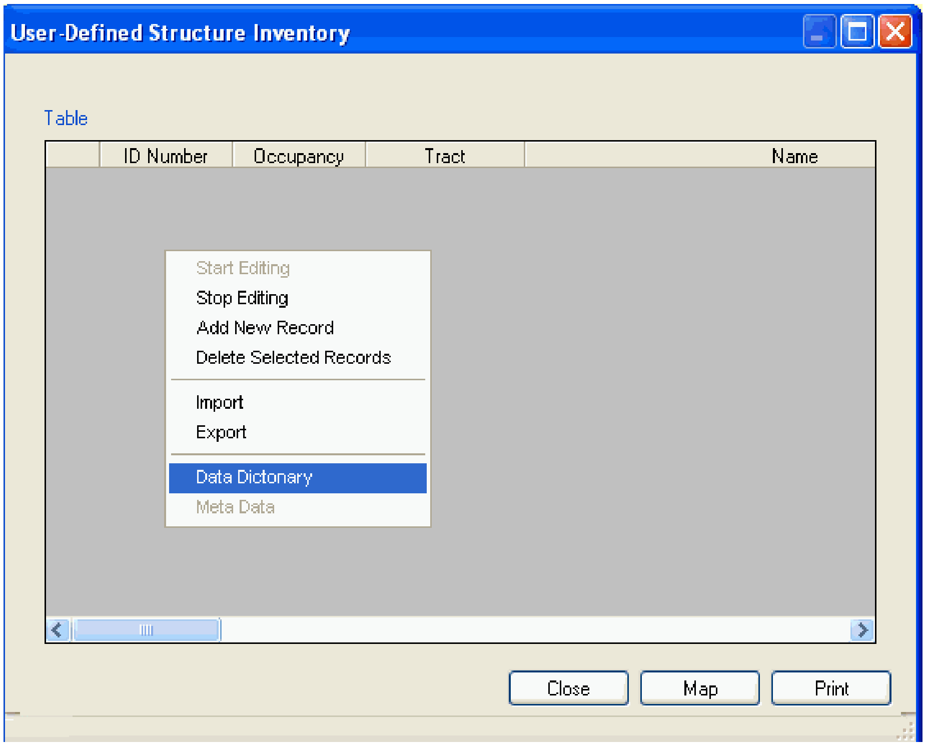


Figure 4.47: Open Data Dictionary.

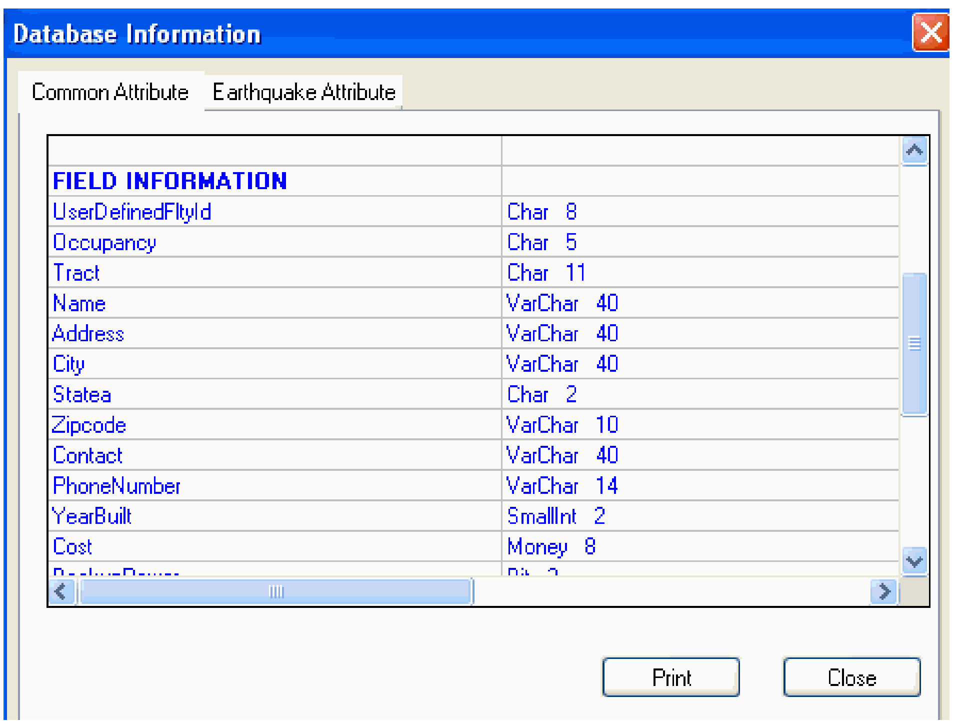


Figure 4.48: Review Common Attribute field information.

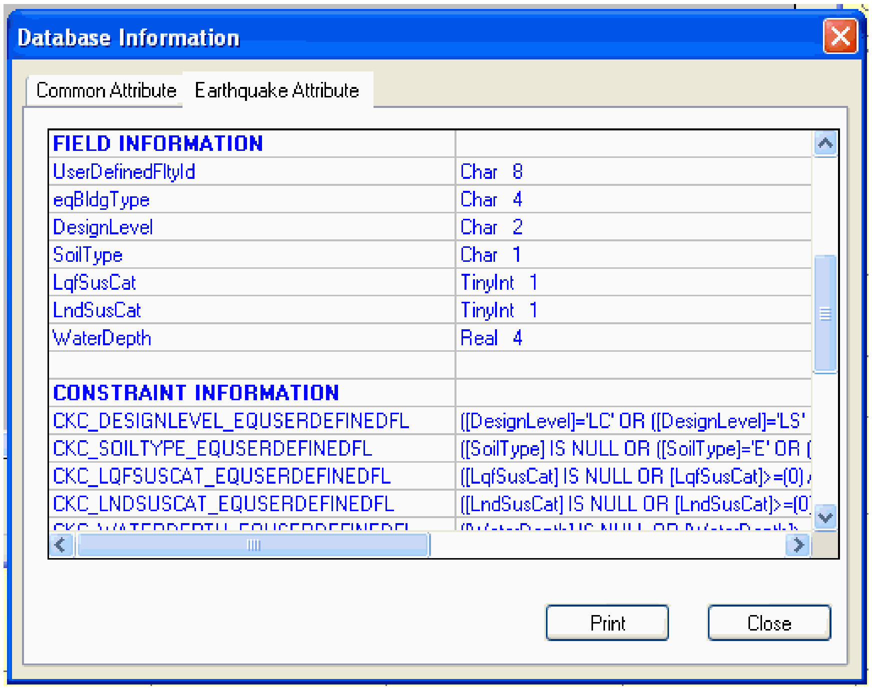


Figure 4.49: Review Earthquake Attribute field Information.

5. When your source file is ready, Select **Import**, browse for your source file, and then select the table to be imported (Figure 4.50).

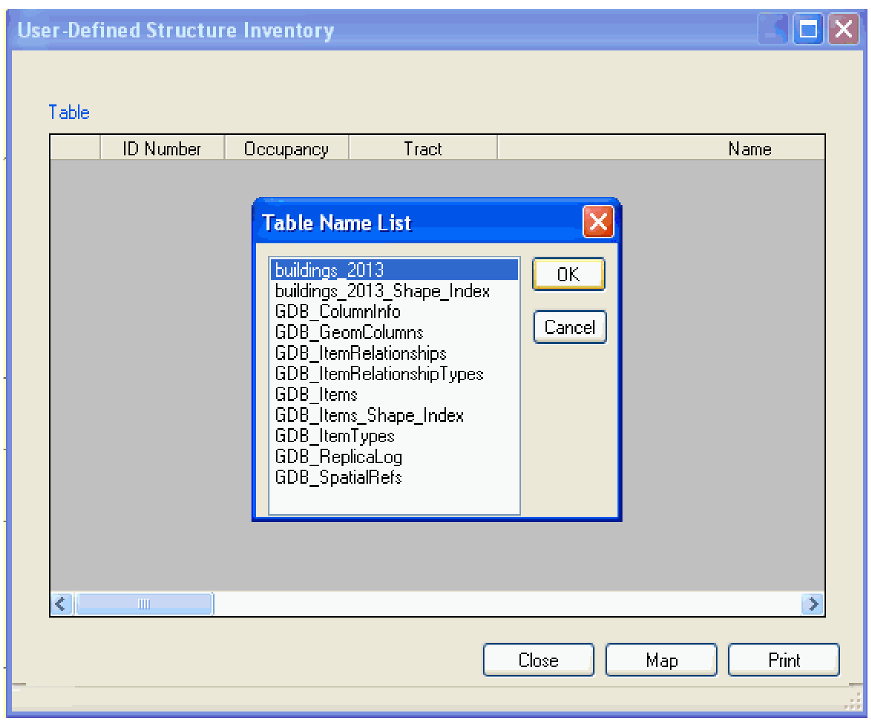


Figure 4.50: Select source table.

6. Match the **Source** fields to the **Target** fields to import records, and then click **Add** to add the matches to the **Mapping Results** list (Figure 4.51). When the list is complete click **OK** to import all the data for the buildings into the UDF inventory.

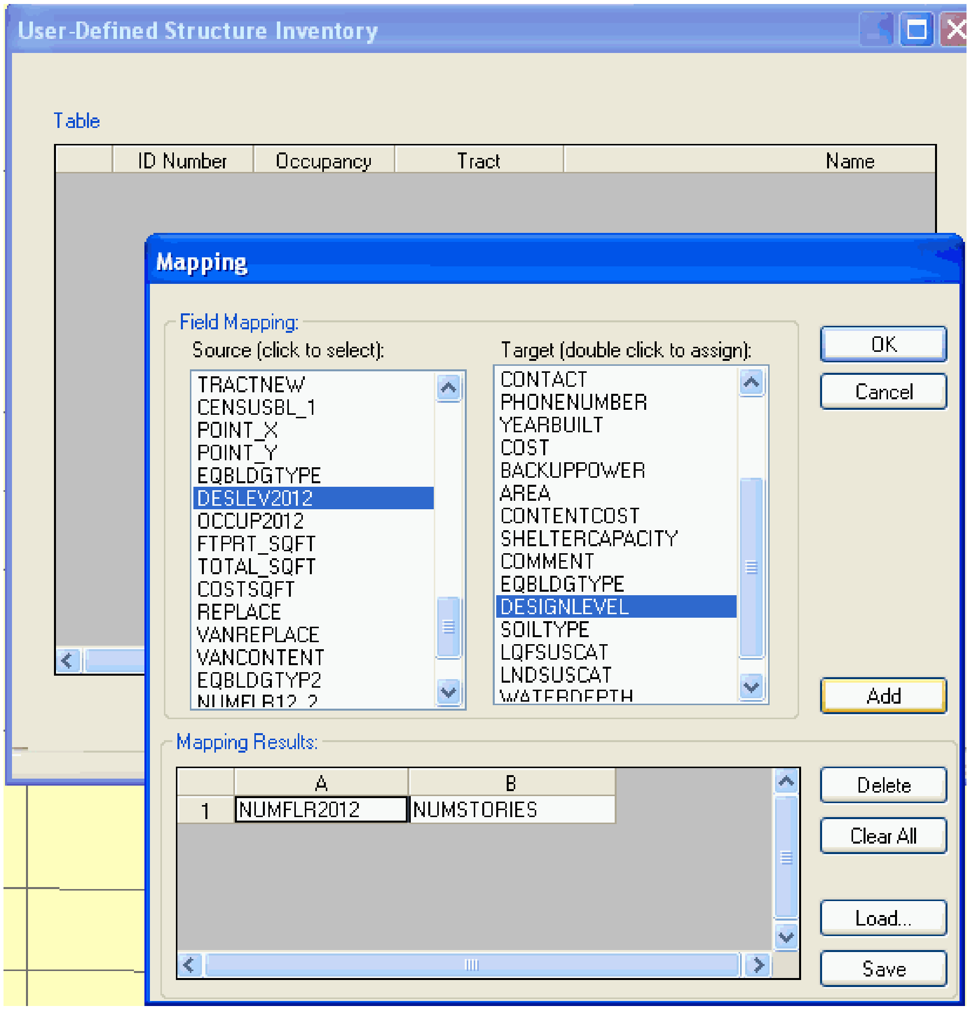


Figure 4.51: Map Source to Target fields.

7. If an error message appears, the source file may need to be edited. Figure 4.52 shows one possible error message. Exit from Hazus and edit the source file by:

   a) changing data format of field; and/or
   b) changing field size; and/or
   c) removing extra fields.

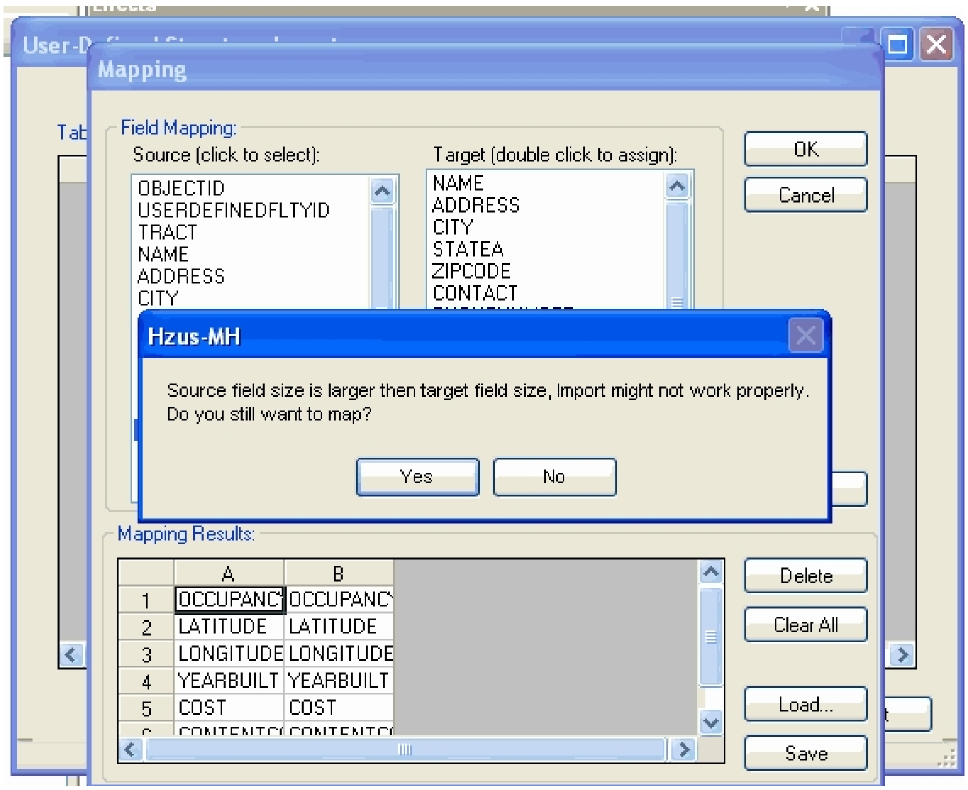


Figure 4.52: Error message when field matching.

8. Records may be viewed and edited after Import is completed. (Figure 4.53) Any text that is black can be edited.

   Note: The **User Defined Structure Inventory** window has a limited number of rows that appear (approximately 4100). However, if the inventory contains more inventory records, those records will appear in the window as you continue to scroll down.

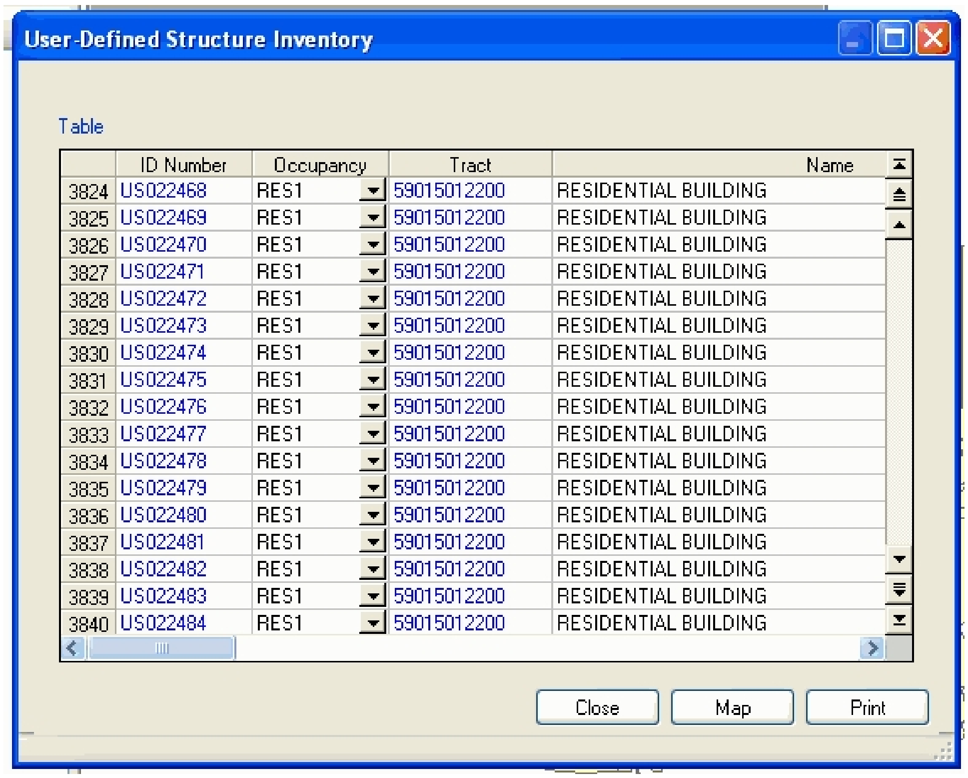


Figure 4.53 Example of UDF inventory.

9. Click **Stop Editing** when the input of building records is finished.

4.7.4 Run a UDF Analysis

1. Click on **Analysis** and select **Run** (Figure 4.54).

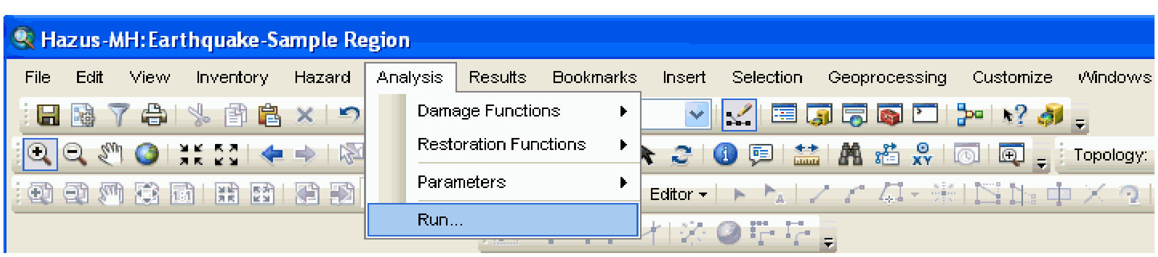


Figure 4.54: Select Run from the Analysis menu.

2. In the **Analysis Options** window, check the **User-defined Structures** and click **OK** (Figure 4.55).

   You can select a specific structure and generate a report for that structure.

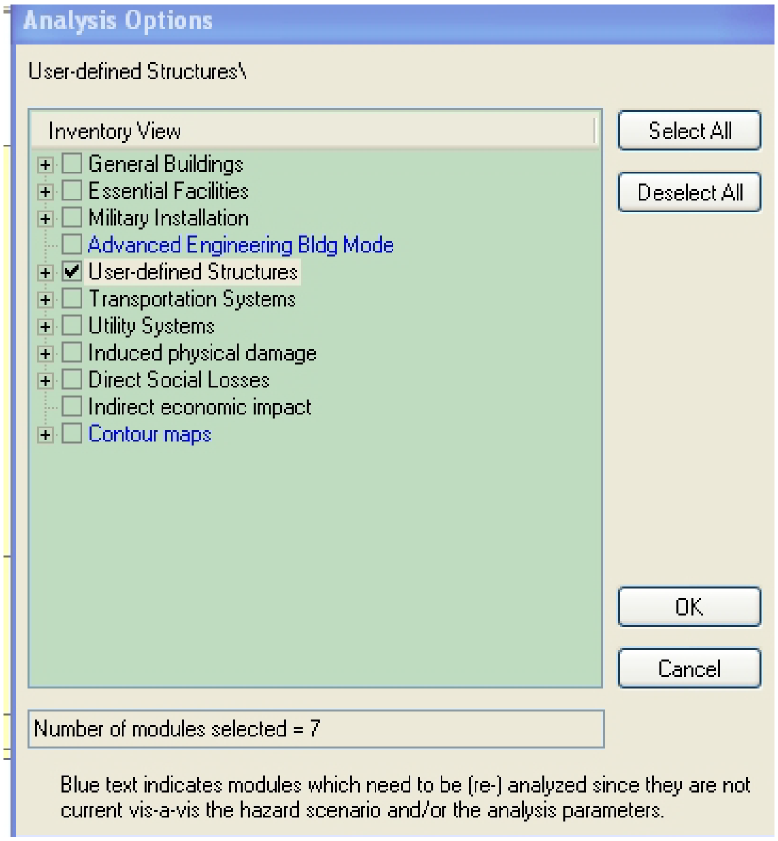


Figure 4.55: UDF analysis options.

3. To view UDF results, click on the **Results** menu and select **User-Defined Facilities** (Figure 4.56).

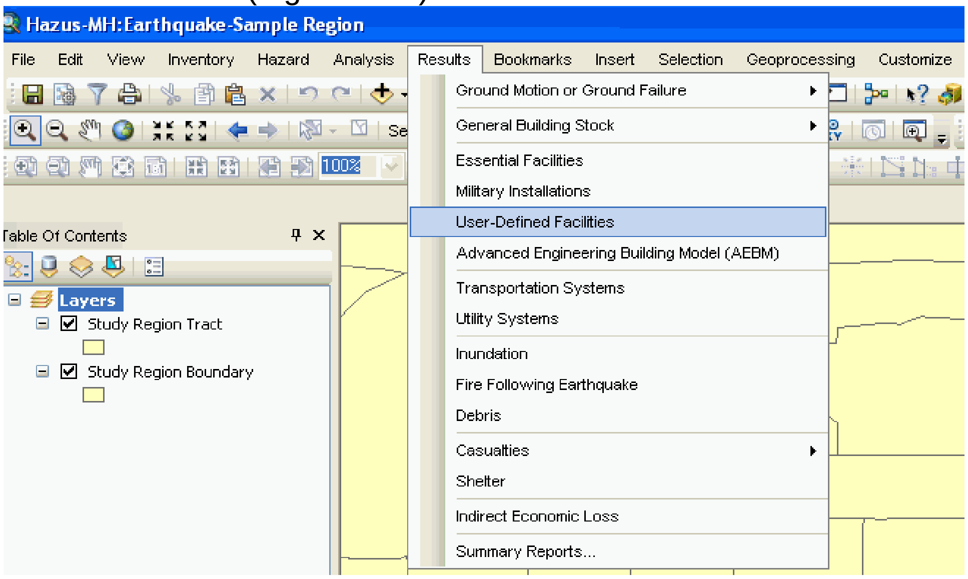


Figure 4.56: Select User-Defined Facilities from the Results menu.

4. View the UDF structure results for **Facility Damage**. You can view the damage per individual building and generate damage reports for every building. The damage is categorised as **Slight**, **Moderate**, **Extensive**, **Complete**, etc. (Figure 4.57).

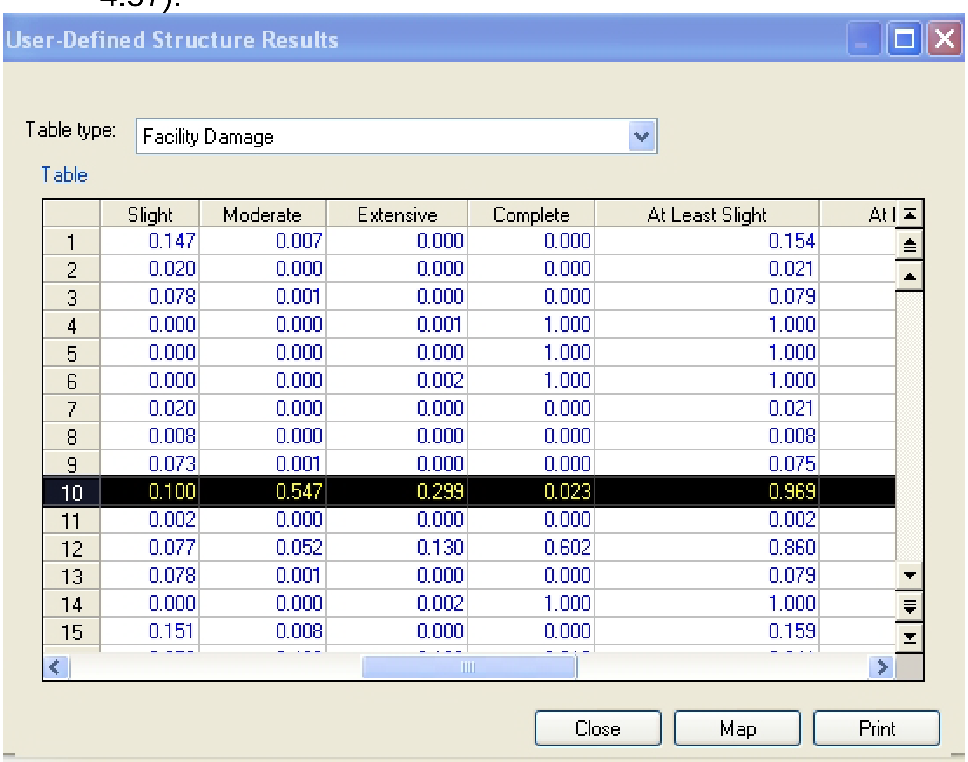


Figure 4.57: UDF Structure Results.

Chapter 5 Hazus Canada Outputs

5.1 Use and Scope of Hazus Outputs

(Also refer to Chapter 10 of the *Hazus-MH 2.1 Earthquake Model User Manual* for details on the various Hazus reports and outputs, and their background, value and limitations.)

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.

These activities can be framed within a general risk assessment process or risk-based planning (risk is mentioned here in the context of estimating social or economic losses from hazards plus an indication of their probabilities or uncertainties).

Hazus Canada, like the US Hazus, can be used to model a variety of earthquake hazard scenarios to obtain a range of possible impacts and to inform different types of decisions. Likewise, impacts can be modelled for a community over time and for potential future consequences of a number of alternative community planning decisions.

For example, Hazus can be used to assess the impacts for a region at the present time and for a specific (deterministic) earthquake hazard scenario. This assessment is useful as a baseline for planning emergency management exercises.

Impacts can be also assessed for individual buildings at the present time for a probabilistic earthquake hazard scenario, which accounts for the complete range of ground motions that can be expected at a specific site from all probable earthquakes over a given time horizon. This assessment is useful as a baseline for land use planning and engineering design of individual buildings.

For future loss, impact, and risk mitigation planning, a variety of potential decisions for building and infrastructure development can be modelled for one or more earthquake hazard scenarios (deterministic and/or probabilistic). This assessment allows decision-makers to compare the economic and social / human consequences of their impending decisions. This process results in better decision-making, and can lead to economic savings and prevention of life loss and injury.

The Canadian version of Hazus did not make any adaptations to the outputs of the US Hazus program (software code). Nonetheless, the outputs that can be retrieved from Hazus Canada depend on the inputs and assumptions that are unique to Canada. As such, the outputs obtainable from Hazus Canada will differ from the outputs available from the US Hazus.

During the process of adaptation and application of Hazus Canada, parts of the Hazus methodology were refined for Canada. These refinements may also benefit the application of Hazus for the United States. Work was also undertaken to demonstrate the integration of Hazus outputs with other computer programs. This new application development allows the results of Hazus modelling to be displayed and further developed within emergency management software, the Multi-Agency Situational Awareness System (MASAS), and community planning software, CommunityViz.

The Canadian outputs, assumptions, methodology refinements, and new application development work are summarised in this chapter.

5.2 Outputs and Reports Generated

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 Hazus Canada and the US version of the program. See section 5.4 and section 5.5 for more discussion about dealing with model uncertainty and probability associated with the calculated losses.

As with Hazus in the US, the outputs of Hazus Canada for the earthquake impact assessment include those highlighted in Figure 5.1.

Earthquake Impact Assessment Outputs

	Earthquake Ground Motion Ground Failure	Flood Frequency Depth Discharge Velocity	Hurricane Winds Pressure I Missile I Rain
Direct Damage			
General Building Stock	■	■	■
Essential Facilities	■	■	■
High Potential Loss Facilities	■		
Transportation Facilities	■	■	
Lifelines	■	■	
Induced Damage			
Fire Following	■		
Hazardous Materials Sites	■		
Debris Generation	■	■	■
Direct Losses			
Cost of Repairs/Replacement	■	■	■
Income Loss	■	■	■
Crop Damage		■	
Casualties	■	Generic Output	
Shelter and Recovery Needs	■	■	■
Indirect Losses			
Supply Shortages	■	■	
Sales Decline	■	■	
Opportunity Costs	■	■	
Economic Loss	■	■	

Figure 5.1: Earthquake impact assessment outputs.

In addition to the output in Figure 5.1, Hazus reports on the ground shaking response to the earthquake when Contour maps is selected in the Run Analysis Options. (Refer to Chapter 10.3 of the *Hazus-MH 2.1 Earthquake Model User Manual*.) Hazus earthquake module will generate ground motion maps for peak ground acceleration (PGA), peak ground velocity (PGV), and spectral acceleration (5% damping) at two structural periods (0.3 and 1.0 seconds).

For a Hazus default deterministic event, the module generates ground motion maps for the study region. For events using a User-defined ShakeMap, Hazus generates a copy of the input maps clipped to the study region and refers to them as ground motion maps. Hazus Canada does not generate ground motion maps for Hazus-defined probabilistic events.

Hazus also generates information concerning permanent ground deformation (PGD) for the earthquake event being analyzed. PGDs are important in estimating losses to and functionality of lifelines. Permanent ground deformation is defined as liquefaction, landslide, and surface fault rupture.

The ground motion maps generated by Hazus are for display purposes only. The maps can be accessed from **Results**, from the **Ground Motion or Ground Failure** menu. Ground motion maps can be views as contour maps or as census-tract based maps. The values assigned to each tract represent the ground motion at the tract centroid.

As is the case in Hazus US (refer to Chapter 10 of the *Hazus-MH 2.1 Earthquake Model User Manual*), the Hazus Canada version of the methodology does not model secondary effects of earthquakes, such as:

- secondary effects of earthquake triggered submarine landslides;

  (Also refer to Appendix I of the *Hazus-MH 2.1 Earthquake Model User Manual.*)

- inundation from earthquake triggered tsunamis or seiches, dam or levee (dyke) failures; and

- hazardous material release.

However, Hazus is still useful for these secondary effects in that it has the ability to spatially display overlays of information such that exposures can be semi-quantitatively estimated. Existing inundation maps and hazardous material locations and quantities can be imported into Hazus and overlaid with population density maps or maps of inventory to estimate exposed population and exposed inventory.

Hazus outputs can also be summarised and expressed as indicators of earthquake impacts, as shown in Figure 5.2. Where the likelihood of those impacts has been assessed and calculated for the set of assets being assessed, these indicators can be used to communicate earthquake risks.

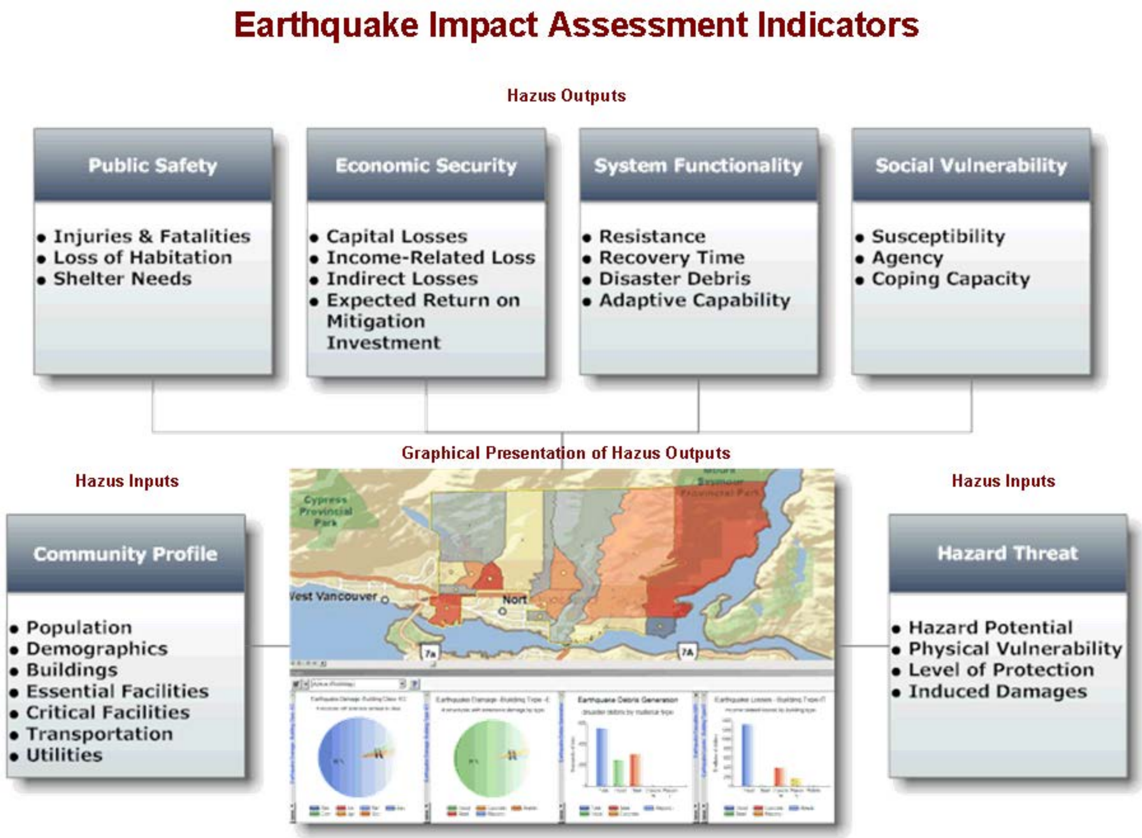


Figure 5.2: Earthquake impact assessment indicators.

Each of the outputs mentioned in Figure 5.1 and Figure 5.2 can provide useful information for a variety of users. Hazus users can have a range of backgrounds, perspectives and functions. Table 5.1 summarises basic case profiles that represent some roles involved in risk-based planning at a local or regional scale. These case profiles are displayed with the corresponding Hazus outputs that may support the functional requirements of their role.

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 earthquake 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.

Table 5.1: Case profiles guide to risk-based assessments and planning.

Case Profile	Functional Requirement	Hazus Output and Value Added Products
Land Use Planner / Community Planner	Guidelines for community risk assessments using best practice tools, a mechanism to prioritise risk management options.	- complete suite of direct and indirect damage in $, aggregated to tract level or larger, allowing for a comparison of losses with other earthquake scenarios or other hazard scenarios - probabilistic analysis that highlights the most vulnerable assets in a region for a full range of possible ground shaking levels
Emergency Manager	Guidelines for community risk assessments using best practice tools, inventory of vulnerable populations, community assets and critical infrastructure, assessment of current capabilities, situational awareness of risk environment to support response and recovery operations.	- site specific and spatial distribution of damage and loss estimates to buildings, essential facilities, transportation and utility lifelines, and population - debris generation, fire-following, casualties, and shelter requirements - deterministic scenario that highlights the potential losses from an event to provide a narrative for preparedness
Community Member	Information on potential impacts and consequences to assess the exposure of vulnerable people and assets, information to assist in emergency preparedness.	- direct and indirect damage, aggregated to tract level or larger, to provide a snapshot of vulnerabilities - deterministic scenario that highlights the potential losses from an event to provide a narrative for preparedness

Case Profile	Functional Requirement	Hazus Output and Value Added Products
Geotechnical Engineer	Capability to assess: physical and social vulnerabilities over time; probable impacts and socioeconomic losses caused by hazard threat; impacts of mitigation alternatives; cost-benefit analysis of mitigation alternatives.	- site specific and aggregate damage and loss estimates in $ to buildings, essential facilities, transportation and utility lifelines, and population - several deterministic and probabilistic analyses to reflect mitigation alternatives and changes in vulnerabilities over time for comparison
Scientist/Risk Analyst	Capability to assess: physical and social vulnerabilities over time; probable impacts and socioeconomic losses caused by hazard threat; impacts of mitigation alternatives; cost-benefit analysis of mitigation alternatives.	- site specific and aggregate damage and loss estimates in $ to buildings, essential facilities, transportation and utility lifelines, and population - several deterministic and probabilistic analyses to reflect mitigation alternatives and changes in vulnerabilities over time for comparison
Decision-Maker	Guidelines for community risk assessments using best practice tools, a mechanism to prioritise and rank risk management options.	- site specific and aggregate damage and loss estimates in $ to buildings, essential facilities, transportation and utility lifelines, and population - several deterministic and probabilistic analyses to reflect mitigation alternatives and changes in vulnerabilities over time for comparison

The Canadian Hazus Global Summary Report, which is organised as follows, was adopted from the US Hazus without any adaptations, other than to reflect Canadian terminology (e.g., “Province/Territory” instead of “State”).

1. General Description of the Region
2. Building and Lifeline Inventory
   a) Building Inventory
   b) Critical Facility Inventory
   c) Transportation and Utility Lifeline Inventory
3. Earthquake Scenario Parameters
4. Direct Earthquake Damage
   a) Buildings Damage
   b) Critical Facilities Damage
   c) Transportation and Utility Lifeline Damage
5. Induced Earthquake Damage
   a) Fire Following Earthquake
   b) Debris Generation
6. Social Impact
   a) Shelter Requirements
   b) Casualties
7. Economic Loss
   a) Building Losses
   b) Transportation and Utility Lifeline Losses
   c) Long-term Indirect Economic Impacts

The US version of Hazus allows for an All Hazards Combined Losses Summary Report which can be viewed if a user has run an Annualized loss analysis for all three hazards (earthquake, flood, and hurricane). The report will calculate the combined losses for the given multi-hazard region. This is not yet available in Canada as the flood and hurricane modules have not yet been enabled.

Note: Hazus Canada analysis that uses only the default inventory supplied with the Hazus Canada application will generate and display in the Global Summary Report building damage, casualty, debris, etc. results only for residential buildings.

5.3 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. These translators standardise and integrate Hazus outputs with the Canadian Multi-Agency Situational Awareness System (MASAS) and the interactive modelling software, CommunityViz.

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, we have developed a set of translators 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, we have developed translators to integrate Hazus with the national Multi-Agency Situational Awareness System (MASAS) for use by emergency managers in Canada, and with CommunityViz Scenario 360 – a scenario modelling and visualisation application used widely in North America for land use planning and decision-making.

5.3.1 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 5.3).

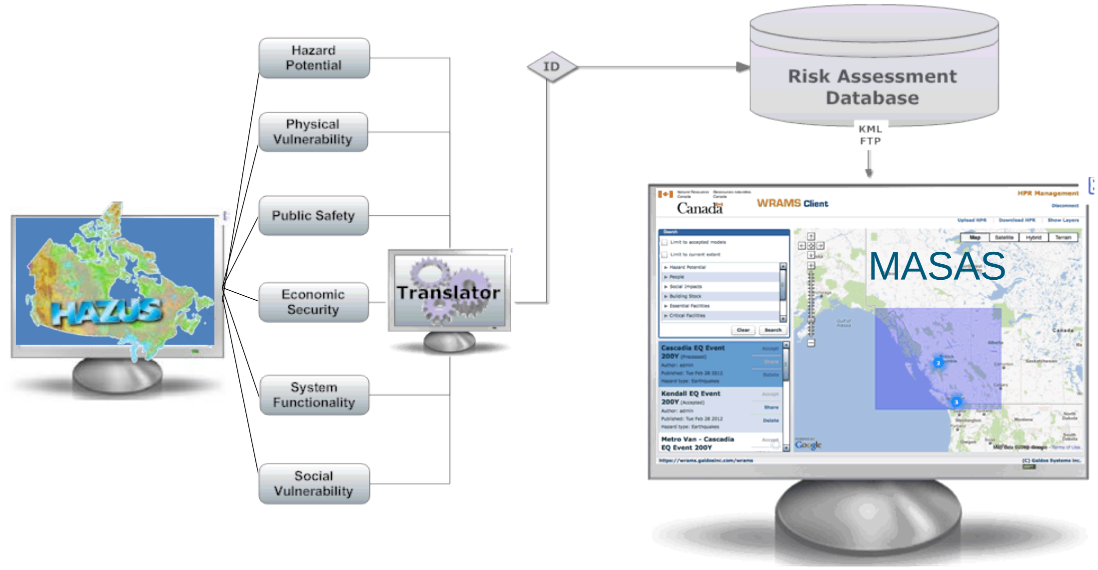


Figure 5.3: Integrating Hazus outputs within MASAS-X.

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 5.4) or within another viewer (Figure 5.5).

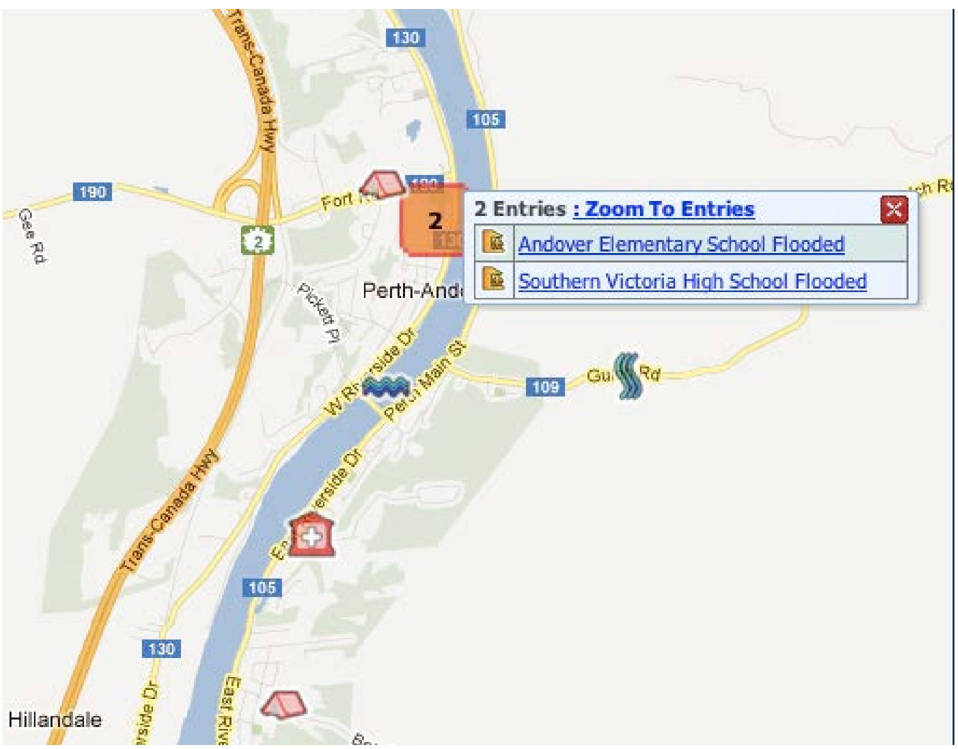


Figure 5.4: Local event in WRAMS client.

The MEFT tool then allows users to view these peer-reviewed and published Hazus outputs within MASAS-X (Figure 5.5).

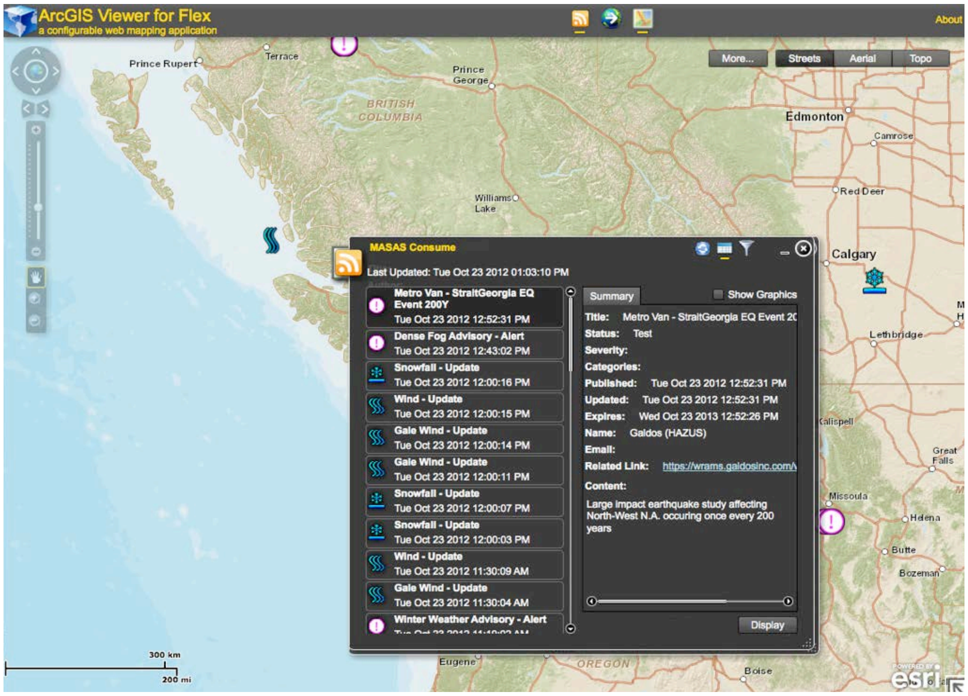


Figure 5.5: Viewing Hazus outputs in MASAS-X using the MEFT tool.

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/.

5.3.2 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 5.6). 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.

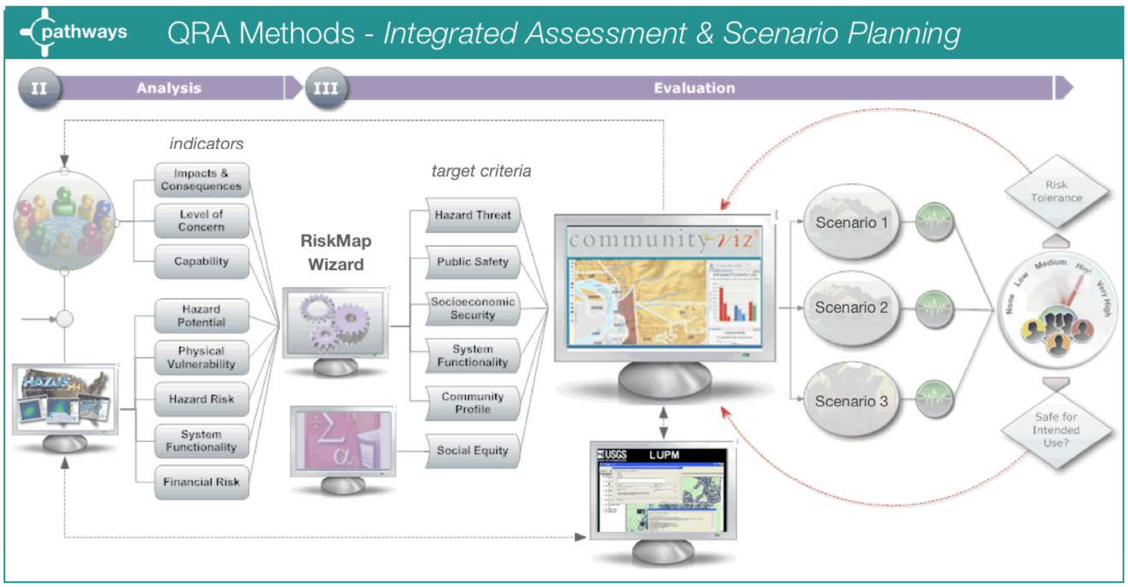


Figure 5.6: The Pathways framework.

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.).

The Risk Assessment Tool is available on the Scenario 360 Decision Tools toolbar. Clicking this button ( ) launches the Risk Assessment Wizard to allow users to pull data from Hazus into a Scenario 360 analysis geodatabase. See Appendix F for information on importing data from Hazus using this tool.

To start, users can import data sources from their Hazus Data Inventory (Figure 5.7), and then select a Hazus study region and hazard event (Figure 5.8).

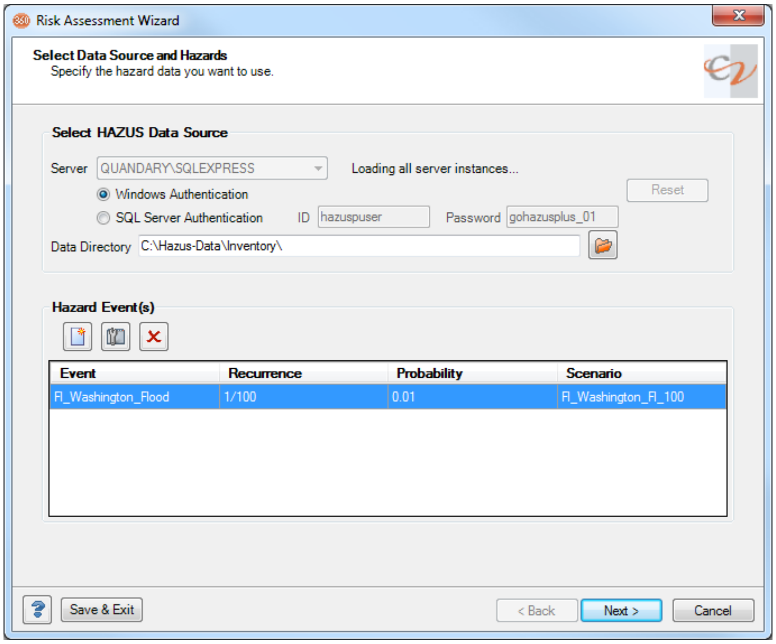


Figure 5.7: Select Data Source and Hazards.

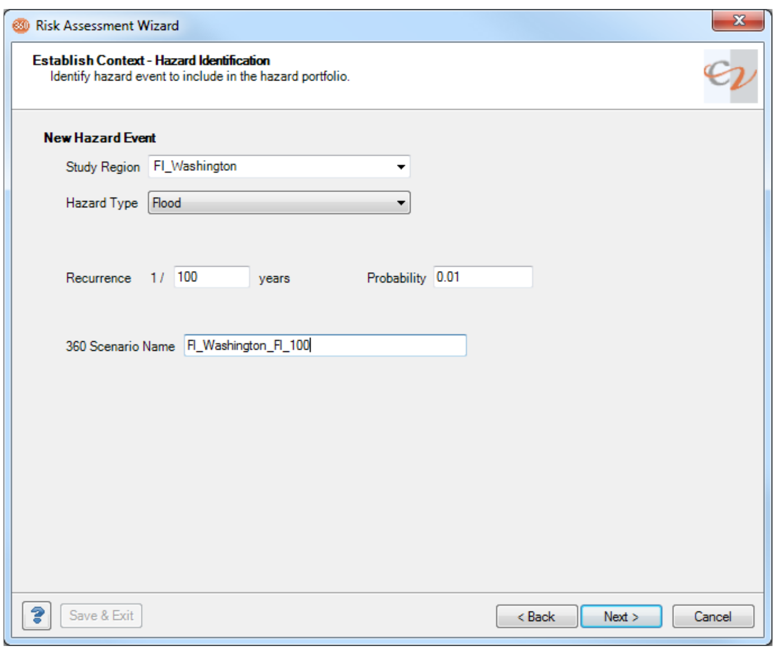


Figure 5.8: Establish Context – Hazard Identification.

Users will need to select the counties and census tracts of interest in the imported study region to run the Risk Assessment analysis in Scenario 360. They can also edit or delete details of the hazard event.

For the risk analysis, users will need to select the layers (e.g., geohazard potential, facilities, building impacts, social impacts, etc.) for which to evaluate thresholds of risk tolerance (Figure 5.9).

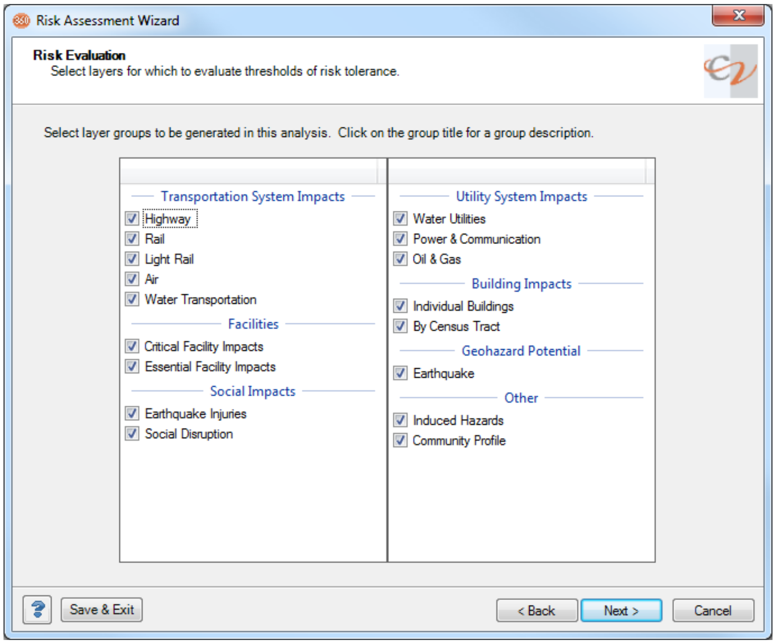


Figure 5.9: Risk Assessment Wizard.

Running the analysis will create relevant Scenario 360 components, and it will import data from Hazus into the analysis geodatabase. The results of the analysis can be exported to Hazus User Defined Facility (UDF) datasets for use in a Hazus analysis.

The user selects the layers for which to evaluate thresholds of risk tolerance. The output results (impacts) that were generated in a Hazus analysis are used as inputs into the CommunityViz Risk Assessment analysis. Using Hazus, users generate direct and indirect impacts, in terms of injuries, loss of shelter, replacement costs, and related impacts on employment and income. The Risk Assessment Tool module uses these impacts as inputs, and creates and/or updates risk assessment indicators (e.g., DS_OilFlty, eqAL_Utility).

Users can then export CommunityViz results (risk assessment indicators) to Hazus UDF datasets to run a Hazus analysis. Click the Export tool button () on the Scenario 360 Decision Tools toolbar to launch the Hazus Export to UDF wizard (Figure 5.10).

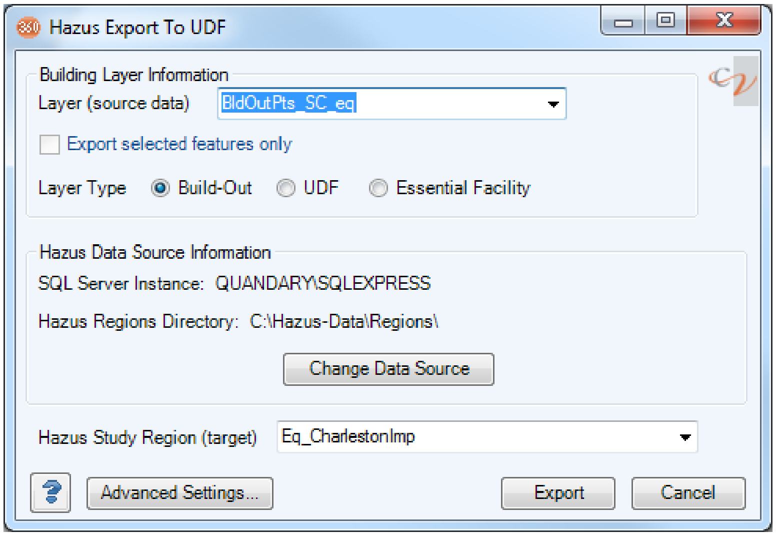


Figure 5.10: Hazus Export to UDF.

Inputs and settings from Scenario 360 are validated in Hazus. According to the *Hazus Risk Assessment and Export Tools User Documentation* in Appendix F, validation of inputs means:

1. The selected build-out layer is searched for required fields. If any of the required fields are not found, the export process stops.

2. The Hazus UDF facility feature class and SQL tables are identified. If they cannot be found, the user is notified and the process stops.

3. Each land use designation in the buildings layer must have a corresponding Hazus occupancy code. If one or more do not, the user is prompted to set them.

The CommunityViz Risk Assessment Tool, and the Pathways framework more generally, are available for use in the public domain to help emergency managers and land use planners manage potential risks resulting from natural hazards. The Pathways framework conforms to national and international standards for risk assessment.

The Risk Assessment Tool utilises an indicator framework and provides a means of transforming knowledge about the risk environment into actionable mitigation strategies that reduce risk and promote disaster resilience.

Scenario 360, with the accompanying Risk Assessment Tool and various decision support tools (landscape fragmentation analysis, spatial build out analysis, land use allocation, time-scope analysis and suitability analysis), can be purchased from the Placeways website: http://placeways.com/communityviz/productinfo/scenario360/.

5.4 Validating Results and Dealing with Uncertainty

(Also refer to Chapter 1.7 of the *Hazus-MH 2.1 Earthquake 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 initially needs to consider two main sources of uncertainty that arise from the Hazus methodology:

1. uncertainty related to ground motion attenuation relationships and other information about site amplification that are used to model ground shaking severities; and

2. building performance and response characteristics derived from available information about the type of construction and level of seismic design.

Both of these factors influence losses and their expected ranges. In other words, they impact the modelled consequences and their uncertainties. Subsequently, as suggested in section 5.4.3 and section 5.4.4, the user can choose a method to validate the estimated losses and their expected ranges.

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

5.4.1 Uncertainty Related to Attenuation Relationships

Comparisons of Hazus results with losses from past events show that the main source of uncertainty is related to the ground motion attenuation relationships used. Every ground shaking scenario uses a specific ground motion attenuation relationship.

When several earthquake ground shaking scenarios are considered in the Hazus analysis, a simple sensitivity analyses (or logic tree) can be performed, provided that the number of scenarios is not too high. For example, average losses can be obtained for a group of buildings and for a set of possible ground shaking scenarios. These can, then, be tabulated to illustrate the uncertainty. In this case, one Hazus analysis needs to be run for each ground motion attenuation relationship associated with the corresponding ground motion scenarios.

To estimate the uncertainty involved when considering a larger number of potential earthquakes, external software that applies Monte-Carlo-type simulations can be used.

5.4.2 Uncertainty Related to Building Performance and Response Characteristics

For a specific ground shaking scenario, the main source of uncertainty is the variability in the structural properties of a given building type. Individual buildings of a certain building type will be similar, but not identical. Therefore, in reality, each building of a given building type will respond somewhat differently to the same ground shaking.

This variability is accounted for by fragility curves, given for five damage states: none, slight, moderate, extensive, and complete. For each ground shaking scenario, the Advanced Engineering Building Module (AEBM) provides the probabilities that a building of a given building type could be in each damage state.

Additionally, each damage state has an associated representative typical loss for that building type. For example, a building with a Moderate Damage State may experience a 50% loss; a building in the Extensive Damage State may experience a 70% loss. Thus, for each building of a given building type, Hazus calculates the total expected loss by summing up the products of the probabilities of being at each damage state and the representative loss for that damage state.

(Refer to Chapter 9.3.2, Chapter 9.3.3, and Chapter 9.3.7 of the *Hazus-MH 2.1 Earthquake Model User Manual* and Chapter 2.5 and Chapter 2.8 of the *Hazus-MH 2.1 Advanced Engineering Building Module (AEBM) Technical and User's Manual* for definitions of the five damage states and the associated probabilities.)

Although an average loss for each building is estimated by this Hazus methodology, in reality, the loss that will occur for that building can result from any one of the four damage states where the probability of damage is greater than zero. Thus, for specific ground shaking, there is some probability (from 0 to 100%) that any of these four damage states and losses could occur in reality, regardless of the expected loss for that building calculated by the default Hazus methodology.

Alternatively, for example, a user could select the damage state with the highest probability as the modelled loss for a building, rather than accepting the expected loss provided by the program.

Note: The AEBM module utilises analytic fragility functions to estimate the probabilities of structural and non-structural building damage in each of the five states, but does not calculate the cumulative probability of expected loss for that building (i.e., for the average loss). Likewise, the probabilities of each building being in each of the five damage states do not take into account the probability of the ground shaking that could cause the building to be in these damage states.

Note: For the aggregate asset analysis, Hazus estimates probabilities for each of the five damage states at the Tract level, but does not provide any information about cumulative probabilities of damage or loss.

Note: The only probability that may be known with respect to the losses reported from Hazus would be the probability of the hazard occurring (if it is provided with the user-supplied hazard data). The probability of the resultant loss is different from the probability of the hazard occurring.

5.4.3 Results Validation by Real-World Events and Loss Ratios

A combination of uncertainty due to these two effects (i.e., the effect of ground motion attenuation relationships used in the model, and the variable effect of ground motion on individual buildings within a building type), helps to explain why average losses calculated in Hazus may differ from those recorded from past events.

Note: Event characteristics (e.g., ground motions; extent of regional built environment; construction type; etc.) and comprehensiveness of the range of model inputs (e.g., injuries from building damage only; inclusion or exclusion of injuries from fall and heart attacks; etc.) also need to be considered when comparing the loss ratio values among events. However, validation by real-world events and loss ratios is not a precise science.

A recent comparison of social and economic losses for the 1994 Northridge, California earthquake and those obtained using Hazus, was presented by Kircher (2012). According to this study, direct economic losses due to the earthquake for residential buildings were in the order of $12,700 million out of an exposure of $503,730 million. Using Hazus, the average losses, for the same type of buildings, vary from $9,083 million to $12,578 million, depending on the ground shaking values used. Similarly, for commercial buildings, direct economic losses after the event were in the order of $4,900 million, out of an exposure of $150,000 million. Using Hazus, the values obtained range between $3,285 million and $4,532 million, depending on ground shaking used.

After the Northridge earthquake, according to Kircher (2012), direct economic losses to all buildings were in the order of $18,500 million out of an exposure of $683,772 million. This means that the direct economic loss ratio for buildings was 18,500 / 683,772 = 0.027 = 2.7%.

Loss ratios are a simple way of comparing, or validating, Hazus results among various real-world events, provided that loss data is available and reliable. As an example, after the 1985 Mexico earthquake, loss ratios for zone C (soft soils zone) in Mexico City ranged between 6.2% and 15%, depending on the type of buildings (Smolka and Berz, 1989).

5.4.4 Results Validation by Subject Matter Experts

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.

During the development of Hazus Canada, case studies were used to adapt and demonstrate the application of Hazus Canada in a Canadian setting. The results from Hazus Canada were reviewed and validated by an expert panel of regional hazard and risk specialists. This could be done for any community or region using:

- national seismic hazard and risk public science institutions, such as the Geological Survey of Canada, part of Natural Resources Canada;
- similar provincial agencies, such as geological surveys;
- regional academic institutions, such as universities;
- geotechnical consultants;
- national or provincial seismic and risk assessment standards association committees; and
- regional or municipal seismic hazard and risk in-house specialists.

Such a group could be engaged on an as-needed basis, to validate the soundness of seismic hazard scenario inputs into the Hazus model, as well as to ensure that the Hazus loss estimates for specific consequence scenarios are reasonable.

5.5 Communicating Results and Assumptions

(Also refer to Chapter 10.1 of the *Hazus-MH 2.1 Earthquake 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 a Hazus analysis is run using default data, without providing user-supplied hazard details, the default values for the Hazus Canada earthquake module can be found in Table 5.2 and in section 4.2 of this manual. Users can select a default value, or they can provide their own inputs in order to create alternate scenarios and/or to enhance the detail and accuracy of the results. If user-supplied hazard inputs are used, these need to be noted with the results.

See Appendix E for some techniques to address current assumptions and simplifications of Hazus that were identified for future work.

Table 5.2: Default assumptions in Hazus Canada.

Assumption	Hazus CAN	Reference CAN	Hazus US	Reference US
Default soil class for default ground motions used in Hazus	NEHRP Class C	Halchuk (2011).	NEHRP Class D	Refer to Chapter 9.2.8 of the *Hazus-MH 2.1 Earthquake Model User Manual.*
Probabilistic hazard as defined by ground motions of certain return periods (e.g., 2500 yr return period = 2% probability of exceedance in 50 years)	Same as in Hazus US	Halchuk (2011).	8 return periods for ground motions resulting from earthquake shaking: 100, 250, 500, 750, 1000, 1500, 2000, and 2500 years	Refer to Chapter 4.1.1 and Chapter 17 of the *Hazus-MH 2.1 Earthquake Model Technical Manual.*
Building code details (year of revision, level of seismic design, building location)	Same as in Hazus US. Default defers to mapping scheme from neighbouring US state (see Table 3.6 of this manual)		High-Code, Moderate-Code, Low-Code and Pre-Code, plus Special versions (combination of Seismic Design Level and Building Quality)	Refer to Chapter 5.4.1 and Chapter 5.7.1 of the *Hazus-MH 2.1 Earthquake Model Technical Manual* and Chapter 7.3 and Chapter 15 of the *Hazus-MH 2.1 Earthquake Model User Manual.*

5.5.1 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 example is from a deterministic event scenario that was used for an exercise. The analysis used default settings. The disclaimer accompanied reports and maps generated by Hazus:

> **"**Disclaimer: Seismic impacts of an earthquake scenario have been modelled with Hazus Canada loss estimation software in consultation with other seismic risk assessment experts. Mapped impacts and losses are based on reasonable assumptions and simplifications, including:
>
> - uniform soil type for the region (e.g., Very Dense Soil and Soft Rock);
> - exclusion of potential impacts of landslides, liquefaction, topography, basin structure, and tsunamis;
> - demographic and infrastructure information limited to 2006 Statistics Canada data on residential buildings within a region; and
> - simplified building code details not necessarily reflective of local standards.
>
> The report and maps summarising the impacts of this scenario were prepared for a specific purpose (e.g., for an earthquake response exercise; for a community planning exercise; for a disaster mitigation exercise; for resource allocation analysis; etc.). The report and maps may be used as-is in other similar exercises, taking into considerations the stated limitations and original purpose of the report."

This example summarises both what was included in the modelling, and what was excluded. This is important, particularly if a single deterministic event is selected without an associated probability. This disclaimer could be extended to include all parameters entered in the case of a more advanced or detailed analysis.

Chapter 6 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 work-arounds can be found in this chapter.

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

6.1 Issues with Simple Solutions

6.1.1 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.

6.1.2 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.

6.1.3 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 **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.

6.1.4 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. The error message generated will be: "An error occurred during local report processing. The definition of the report 'C:\program files\HAZUS-MH\CDMS reports\LatLongErrors.rdlc' is invalid (…)".

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.

6.1.5 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.

6.2 Issues Requiring Further Investigation

6.2.1 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, 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.

6.2.2 Inconsistent Fire Following Earthquake Results

It has been noted that some results of the Fire Following Earthquake analysis are inconsistent with the methodology stated in Chapter 10.2 of the *Hazus-MH 2.1 Earthquake Model Technical Manual*. The issue appears to be that the Module calculates ignitions for some census tracts with population density of less than 3,000 persons per square kilometer, even though the methodology states that such census tracts are omitted from the calculation. Hazus ignition results per census tract are expressed as water demand in units of gallons per minute (gpm). Aggregate ignition results for the study area are presented in terms of:

- number of ignitions;
- total burned area;
- population exposed to the fires; and
- building value consumed by the fire.

Additional study of the results and the methodology is required.

6.2.3 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.

6.3 Issues Requiring Programming Solutions for Future Versions of Hazus Canada

6.3.1 Data Input Problem when Defining Hazard Maps

When integrating a data map via the **Hazard > Scenario…** menu, a permutation often affects the values in columns. This has been observed repeatedly with landslide susceptibility maps as well as with soil type maps. For example, even if a field titled **Type** (short integer, as prescribed) is used and all appears fine after the map import, the resulting map accessible via the **Hazard > ShowCurrent > CurrentHazardMaps** menu shows that another column with a different title was used to do the attribute mapping. In other cases, the values of the field titled **Type** ends up in the column **Shape_Length**, leaving no data in the **Type** field, or again, the **Type** field simply remains blank.

The current temporary solution is to try again to input the map with some attribute modifications, such as with duplicated columns with correct values and different field names, or again with an attribute table containing no superfluous fields and data, and then to verify again that the mapping was performed as expected. In one instance, it was noted that clipping the map to a bit more than the work extent, before import, did help.

When importing a landslide susceptibility map or soil type map, ensure that the map has an attribute table with no superfluous fields or data, as these may cause Hazus to use the incorrect columns for attribute mapping.

6.3.2 Missing Numeric Outputs in Summary Reports

In the expected damage to the transportation systems table (Table 6 of the Global Summary Report), the numbers related to highway segments' number of locations with 50% functionality after day 1 and after day 7 can show 0 erroneously, when other highway segments related results show correct data elsewhere in the same report as well as in map outputs.

In case of doubt concerning the results provided in Summary Reports, it is recommended to verify the results of analyses directly in the tables available in Hazus, rather than in the post-analysis generated Summary Reports.

6.3.3 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.

Looking further into it, we 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, we also noticed instances where hzTract and hzCounty where not perfectly coincident where common line segments should have been coincident.

As such, we believe that the problem could originate from the maps defining the different levels of aggregations 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 around the problem 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).

Chapter 7 Resources, Support and Training

7.1 Canadian Resources and User Support

All updated Hazus Canada resources will be available at http://www.hazuscanada.ca. This 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 Quantifying Geohazard Risk 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; 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. For technical support regarding minor issues of the installation of Hazus-MH, please contact the Hazus Help Desk at https://support.hazus.us/ or call **1-877-336-2627**. For assistance with installing Canadian inventory data, please contact info@hazuscanada.ca.

7.1.1 Documents

The Role of Hazus-MH in the Canadian Natural Disaster Management Strategy. Authors Mickey, K. and Coats, D. 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. In-progress at the time of completion of this manual, 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.

7.2 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.

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.

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.

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

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.

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.

7.3 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 http://www.fema.gov/hazus-training/new-virtual-courses-let-you-master-hazus-multi-hazard-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/gateway/index.cfm?fa=catalog.webCourseDetail&courseid=2057 and http://training.esri.com/gateway/index.cfm?fa=catalog.webCourseDetail&courseid=2197.

7.4 Other Resources

Guidelines for Developing an Earthquake Scenario. This manual is a short publication by the Earthquake Engineering Research Institute that places Hazus in context in the development of an earthquake scenario for planning, preparedness and response purposes. It offers examples of scenarios undertaken in US jurisdictions and tips on putting together a credible and effective scenario for any group or area.

Canadian Soil Information Service. Soil databases are available for Canada at various scales from Agriculture and Agri-Food Canada.

Shear Wave Guidelines for Non-Technical Users. These guidelines can be found in in a technical document from Natural Resources Canada, entitled *Shear Wave Velocity Measurement Guidelines for Canadian Seismic Site Characterisation in Soil and Rock*. This subset of the Guidelines is directed towards non-technical professionals who may be required to review seismic site classification reports for municipal applications or engineering studies. It provides a brief review of seismic waves, the use of average shear wave velocity to 30 m depth (Vs30) to account for site effects during earthquake shaking, and a summary of methods that can be used to measure Vs30. It also offers some guidance on the various types of information that may be contained, or asked for, in a contractor's technical report.

BC Assessment Translation to Hazus. In addition to Statics 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, Appendix G provides a reference to assist users in translating provincial assessment authority data into Hazus database format.

Chapter 8 Glossary and Acronyms

8.1 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 shows 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 Appendix H 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 Canada User and Technical Manual (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:

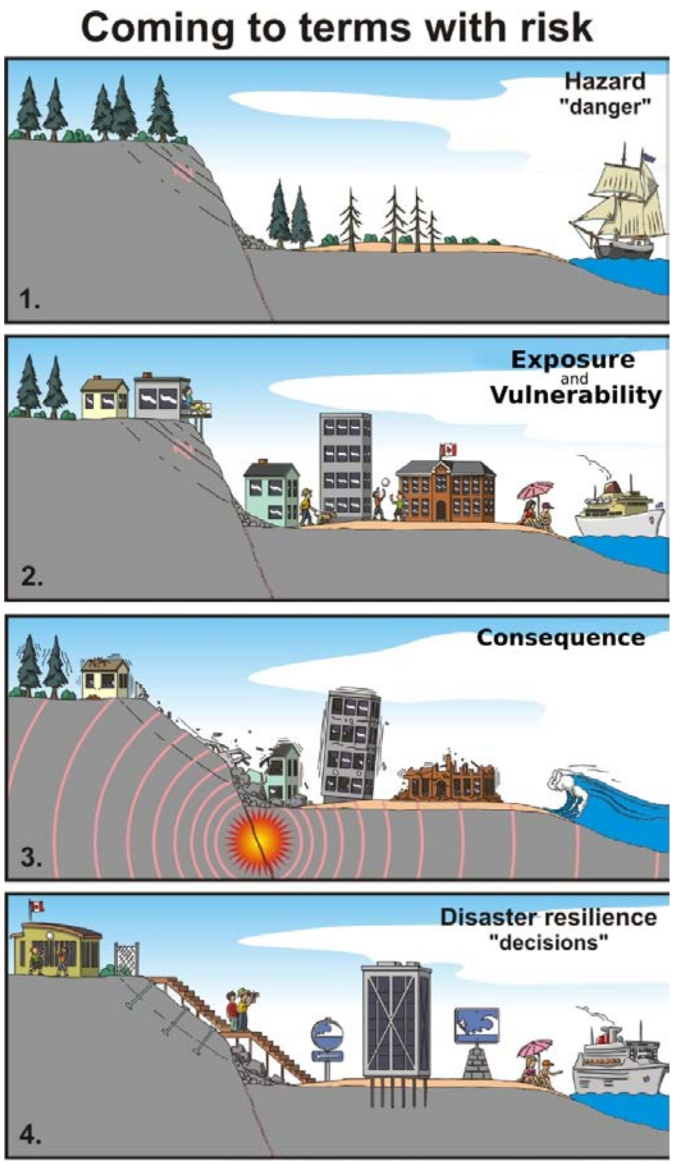
- had widespread acceptance and use,
- were nationally and internationally recognised, and
- were endorsed by an organisation or association representing a community of practice (e.g., Association of Professional Engineers and Geoscientists of BC).

8.2 Pictorial Glossary of Geohazard Risk

The 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 Appendix H, the pictorial glossary in this section is a subset of the master pictorial glossary provided as a separate GSC publication. The illustrations in Figure 8.1 show examples of the use of terms within the context of an earthquake 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 diagrams and in doing so, this publication and Natural Resources Canada must be acknowledged as the source of the diagrams. Modifications to the diagrams must be clearly stated in a description of the diagram that appears with the diagram.



1. Defines the earthquake hazard as the geological elements present that will create an earthquake. The recurrence interval of those earthquakes is what defines the probability of an earthquake of a certain magnitude occurring.

2. Depicts how people have put elements of their society at risk by exposing them to the earthquake hazard and by constructing structures with various vulnerability to earthquake shaking. Vulnerability in this usage is the potential for damage that a structure or a person or others things of concern to people may suffer during an earthquake.

3. Depicts the consequence of an earthquake, which results from the exposing vulnerable people, buildings and infrastructure to shaking, shaking induced landslides and a tsunami generated by the earthquake.

4. Shows examples of how earthquake risk can be reduced through mitigation of the hazard (rock bolts to stabilize landslide potential), mitigation of the exposure (tsunami warning signs, reduction of buildings in the tsunami runup zone) and mitigation of vulnerability (strengthening buildings, setback of building from steep slope).

Figure 8.1: A risk and resilience scenario in the context of an earthquake hazard.

8.3 Acronyms

AAFG Agriculture and Agri-Food Canada

AEBM Advanced Engineering Building Module

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

DBUID Statistics Canada Unique ID for Dissemination Block

DHS Department of Homeland Security

DRDC Defence Research and Development Canada

EERI Earthquake Engineering Research Institute

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
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
NEHRP	National Earthquake Hazard Reduction Program
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
PGA	Peak Ground Acceleration
PGD	Permanent Ground Deformations

PGV Peak Ground Velocity

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

SA Spectral Acceleration

ShakeMap USGS product consisting of four ground motion maps (PGA, PGV, SA 1.0 second, SA 0.3 second) for a specific earthquake event; ground motion maps are also referred to as seismic hazard maps; ShakeMap is often also in a generic sense for similar products developed by others for their purposes

StatsCan Statistics Canada

UAC User Access Control

UDF User-Defined Facilities

UN ISDR United Nations International Strategy for Disaster Reduction

USGS United States Geological Survey

WRAMS Web-based Risk Assessment Data Management System

WUS Western United States

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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 an American state database to mimic a Canadian jurisdiction. At the time of publication of this manual, the flood and hurricane modules were not available for use with the Canada dataset. By altering a state database, a Canadian user can apply these modules. 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't 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. In:

   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: Hazus SyBoundary Geodatabase Development for Canada

The Hazus program analyses inventory within spatial units. In the US version of Hazus, the spatial units are based on US Census units and are referred to as Blocks, Tracts, Counties, and States. For the Canadian version of Hazus comparable spatial units had to be generated and 2006 Census Canada units were used. All Census Canada information was obtained from Statistics Canada.

The following documents the process undertaken to create the spatial unit database for Canada that will function in Hazus. The inventory for each unit was generated using 2006 Census Canada information. The process used to generate the inventory for the spatial units is described in Appendix C.

B.1 Background Information

The SyBoundary.mdb file is the main Geodatabase that consists of the spatial feature classes for the geographic units. In the US version of Hazus, the SyBoundary file includes only data for the area within the United States. If Hazus users outside of US were to use Hazus for their own region, they would need to create their own SyBoundary.

The files within SyBoundary.mdb are SyState, SyCounty, and SyTract. The spatial units for census blocks are located in each state's own Geodatabase, not in SyBoundary.

The first step was to obtain Canada's census boundaries and see how the units would match up compared to SyBoundary's formatting.

Census Canada information are divided by Province, Census Division (CD), Census Subdivision (CSD), Census Tract (CT) (only available in populated areas), Dissemination Area (DA), and Dissemination Block (DB). Dissemination Block is the smallest unit available but there is no demographic data available to such a small area.

Therefore the best possible match between Statistics Canada boundaries and the SyBoundary format would be:

Province = SyState
Census Division = SyCounty
Census Subdivision = SyTract
Census Tracts (where applicable) = SyTract
Dissemination Area = HzCensusBlock

This documentation provides detailed steps on the creation of SyBoundary for British Columbia; these same steps are also used for creation of SyBoundary of other provinces.

B.2 Steps

Datasets used:

SyBoundary.mdb	Used for reference to fields needed, obtained from Hazus installation CD
Census Boundary data	Contains all census boundary data for Canada down to dissemination block
Census Subdivision Boundary data	Similar data to census boundary data, but only showing up to Census Subdivision(CSD), also contains a field with the CD name and CSD name which is not contained in the census boundary data. Name is useful in the Hazus program when selecting different counties.

<http://geodepot.statcan.gc.ca/2006/040120011618150421032019/031904_05-eng.jsp>

Description of fields within each table:

SyCounty attribute table

CountyFips	5 digit unique County ID
CountyFips3	last 3 digits of CountyFips
CountyName	Name of County
State	State name
Statefips	State ID
Numtracts	Number of tracts in county

SyTract attribute table

Tract	11 digit unique tract ID
CountyFips	county ID
Tract6	last 6 digits of tract ID
Tractarea	area of tract [sq/km]
Cenlongit	longitude of tract centre
Cenlat	latitude of tract centre

Statistics Canada Census Boundary attribute table

Note: Only fields useful for creation of Canadian SyBoundary are be listed below.

DAUID	Dissemination area unique ID
CSDUID	Census subdivision unique ID
CDUID	Census division unique ID
PRUID	Province unique ID
CTUID	Census tract unique ID

Key links between SyBoundary and Statistics Canada fields

StateFips = PRUID; 2 digit state = 2 digit province

CountyFips = CDUID; 5 digit county ID vs. 4 digit CD ID; **manipulation required**

Tract = CSDUID or CSDUID and CTUID combination, depending on areas with CTUID division; **manipulation required**

Creating SyState feature class

1. Use national census boundary and PRUID = 59 as a definition query. This will query up all entries within BC. Export data to a different feature class.

2. Use dissolve tool to dissolve all polygons into one whole state polygon using PRUID as a dissolve field. *

3. Add the additional appropriate fields into the feature class listed below.

SyState attribute table

StateFips
2 digit unique State ID, **Short**
use PRUID value, i.e., 59

State
2 letter State abbreviation, **String, Length 2**
use Province abbreviation, i.e., BC

StateName
Full name of State, **String, Length 40**
use Province Name, i.e., British Columbia

Region
West or East, 1 = West, 2= East, **Short**
enter the region for the province i.e., BC = 1

NumCounties
Number of counties in this state, **Short**
Leave this field empty at first, and then fill in the number of counties once you find out the total number of counties after creating SyCounty in the next step. i.e., BC has 28 counties.

HUState
Hurricane State, 0 = No, 1 = Yes, **Short**
If province has a chance of hurricanes, i.e., BC = 0

Comment

Optional field, used for comments, **String, Length 100**

<u>* Problematic areas in national BC census data</u>

There are 2 problematic areas that were encountered during the dissolve process used in creating feature classes for SyState, SyCounty, and SyTract. These specific areas are CDUID 5949 CSDUID 5949020 and CDUID 5907 CSDUID 5907022. These errors are most likely due to the digitisation errors caused in the original data. When trying to use the dissolve tool, an error would state a topological error.

Fixing the errors required:

1. Select a definition query of problematic area.

2. Create an empty feature class and use Editor Toolbar to trace the entire region. Copy traced features over to target feature class (SyState, SyTract, etc.). Copy appropriate tables over.

3. Run the Dissolve/Merge tool.

<u>Creating SyCounty feature class</u>

1. Use national census boundary and PRUID=59 as a definition query. This will query up all entries within BC. Export data to a different feature class.

2. Use dissolve tool to dissolve all polygons into CD polygons using CDUID as a dissolve field. *

3. Add the additional appropriate fields into the feature class listed below.

<u>SyCounty attribute table</u>

CountyFips

5 digit unique County ID. **String, Length 5.**
Use CDUID (4 digits), this will be used to generate a 5 digit CountyFips using the Field Calculator (Pre-Logic VBA Script Code) in ArcMap:

```
dim PR as double
dim CD as double
dim Final as string
PR = Left( [CDUID] ,2)*1000
CD = MID( [CDUID] ,3,2)
Final = PR+CD
CountyFips = Final
```

Example, CDUID = 5901, Script will add a 0 in the middle making it 59001.

CountyFips3

Last 3 digits of CountyFips. **String, Length 3.**
Use Field calculator to calculate this field based on CountyFips.

CountyFips3 = Right([CountyFips],3)

CountyName

Name of County, **String, Length 40.**
CD names will be used in this field. Use Census Subdivision Boundary data for reference. Use join table and join both data common ID such as CDUID. Use Field Calculator to copy CD names over to CountyName field.

State

State name, **String, Length 2.**
Use 'BC' for British Columbia

Statefips

State ID, **Short**
Same as PRUID. i.e., BC = 59

NumAggrTracts

Number of tracts in county, **Long**
Leave this field empty at first and then fill in the number of tracts once SyTract class has been created.

Use SyTract – layer properties – symbology – categories – unique values and set value field to CountyFips. Match the numbers of tracts that are in each CountyFips and fill in the appropriate value in the NumTracts field for each CountyFips entry.

Another method would be to use Microsoft ACCESS, using SyCounty and SyTract fields and setting a primary key link between CountyFips. You can then create a query using CountyFips and Tract (using count function).

Comment

Optional field, used for comments, **String, Length 100**

<u>Creating SyTract feature class</u>

1. Use national census boundary and PRUID = 59 as a definition query. This will query up all entries within BC. Export data to a different feature class. With the new feature class, create another definition query for areas with CT divisions using CTUID: [CTUID] IS NOT NULL or [CTUID] = ' ' . Export to another feature class.

2. Use dissolve tool to dissolve first feature class containing all CSD into CSD polygons using CSDUID as a dissolve field. Use second feature class containing all CTUID to dissolve into CTUID polygons using CTUID **and CDUID** as a dissolve field.

3. Areas with a valid CTUID in the second exported feature need to replace the areas in the first exported feature class. Start an editing session and use select by location query to filter out all the areas. Erase those features and copy and paste the CTUID polygons into the areas.

4. Add the additional appropriate fields into the feature class listed below.

SyTract attribute table

Tract

11 digit unique tract ID, **String, Length 11.**
Tracts with / without CTUID have different tract labelling methods. To start with CSDUID, definition query was set so only non CTUID polygons would show up: [CTUID] is NULL OR [CTUID] = ' '
Run the field calculator with the following script:

```
dim PR as double
dim CD as double
dim Tract as double
dim Final as string

PR = Left( [CSDUID] ,2)*1000000000
CD = MID( [CSDUID] ,3,2)*1000000
Tract = Right( [CSDUID] ,4)
Final = PR+CD+Tract
Tract=Final
```

Example: Takes CSDUID (7 digits) entry and manipulates the value so it confirms with Hazus standard (11 digits). 5909020 = 59007007809

Another method was used for tracts with CTUID. Definition query was set to [CTUID] is not null AND [CTUID] not in (' ') to display all polygons with CTUID entries.

Run the field calculator with the following script:

```
dim PR as double
dim CD as double
dim CTUID as double
dim Final as string
```

PR = Left([CDUID] ,2)*1000000000
CD = Right([CDUID] ,2)*1000000
CTUID = Right([CTUID] ,6)*100
Final = PR+CD+CTUID
Tract=Final

Example: CDUID 5909 becomes 59000900000 and CTUID 9300018.00 becomes 1800 therefore Tract = 59009001800

Note: CSDUID units are not correct for areas with CTUID because there are more CTs in CSD, therefore making more than one identical CSDUID. These entries were deleted.

CountyFips

county ID, **String, Length 5.**
See procedure under **Creating SyCounty feature class** for SyCounty

Tract6

last 6 digits of tract ID, **String, Length 6.**
Use Field Calculator to calculate.
Tract6 = Right([Tract], 6)

Tractarea

area of tract [sq/km], **Float**
Default projection is in GCS, which cannot be used to calculate area. ArcMap projection was changed to “Canada Lambert Conformal”. Right-click on Tractarea under attribute table and select Calculate Geometry – Area – Use coordinate system of data frame – units [sq km]

Cenlongit / Cenlat

Longitude/Latitude of tract center, **Double**
Need to first find the center for each polygon. ET Geowizards add on for ArcMap was used since it has a function to convert polygons to center points and display X and Y coordinates.
Once points are created, a join table command was used to join the points and SyTract table with common key Tract. Field Calculator was used to copy the XY fields over to the Cenlongit / Cenlat fields.

TrackMods

Used to tract if changes were made to numbering scheme of tract/censusblock. Y = yes, N = no. **String, 1**

BldgSchemesld

Building Schemes ID, **String, 10**
Fill the table as default, Province code + 1, i.e., BC = BC1

Length

Leave as 0, **Float**

Comment

Optional field, used for comments, **String, Length 100**

Checking for Tract duplicates

Tracts were checked for duplicates IDs because in some areas, the CDUID and CTUID are similar and only change by 1 number which would cause the tract ID to be identical.

Example, CDUID = 5909, CTUID = 93**2**0006.00, therefore Tract = 5900900600
CDUID=5909, CTUID = 93**0**0006.00, therefore Tract = 5900900600

In ArcMap use Layer Properties - Symbology-Categories - Unique values set to Tract to identify tracts that had more than 1 entry. Entries with more than 1 identical tract were manually changed by adding +1 to the Tract ID. The changes were recorded in an additional field "TrackMods" either designated with a Y for Yes or N for No.

Example, CDUID = 5909, CTUID = 93**2**0006.00, therefore Tract = 5900900600
CDUID=5909, CTUID = 93**0**0006.00, therefore Tract = 5900900601 (TrackMods = Y)

Note: For SyTract for BC, there were 10 duplicate entries that were changed.

Creating HzCensusBlock feature class

HZCensusBlock is the feature class that will be used in the state/provincial folder.

1. Use national census boundary and PRUID = 59 as a definition query. This will query up all entries within BC. Export data to a different feature class

2. Use dissolve tool to dissolve first feature class containing all DAUID into DA polygons using DAUID as a dissolve field. Additional fields were created to be used as reference. These included CSDUID, CDUID, and CTUID. Tables were joined and appropriate fields copied over via Field Calculator. *

3. Add the additional appropriate fields into the feature class listed below.

HzCensusBlock attribute table within provincial database

BlockArea

Area of block [sq km]
See procedure under **Creating SyTract feature class** for TractArea

CenLat/CenLongit

See procedure under **Creating SyTract feature class**

BldgSchemesId

Building Schemes ID, **String, 10**
Fill the table as default, Province code + 1, i.e., for BC, value = BC1

BlockType

Block type, R = riverine, C = coast, L = lake. **String, length 1**
Blocktype Lakes are only defined in the areas surrounding the Great Lakes. Coast can be defined as blocks that are located along coastlines and Riverine is used for all other blocks. In order to approximate and define blocks that have a coast type, a coastline layer of North America was used. In ArcMap, Select by Location – select features from HzCensusBlock that intersect Coastline with a 1km buffer. All selected features were classified as C for Coast. The rest were classified as Riverine except for areas surrounding the Great Lakes in Ontario.

Tract

See procedure under **Creating SyTract feature class**

CensusBlock

CensusBlock ID, **String, length 15**
Manipulation of Tract and DAUID.
Ran the Field Calculator with the following script:

```
dim TractID as double
dim TractID2 as double
dim Final as string

TractID= [Tract] *10000
TractID2=Right( [DAUID] ,4)
Final = TractID+TractID2
CensusBlock=Final
```

Example: DAUID = 59010126 becomes 0126 and Tract = 59001000126 becomes 59001000126000 therefore CensusBlock becomes 590010001260126.

Tracts that were edited for duplicates in SyTract had to be changed in the HzCensusBlock as well. See guidance on Checking for Census Block duplicates below in this section.

Other Fields

Note: The format for all other fields below is **short**. No information was available in Census Canada for these attributes at the time of creation, so these tables were created and records left blank.

PctWithBase
Pct2StoryRes1
Pct3StoryRes1
PctSplitLvlRes1
Pct1to2StryRes3
Pct3to4StryRes3
Pct5StryplusRes3
PctLowRiseOther
PctMidRiseOther
PctHighRiseOther
Pct1CarGarage
Pct2CarGarage
Pct3CarGarage
PctCarPort
PctNoGarage
IncomeRatio

Checking for Census Block duplicates

Similar to checking for Tract duplicates, entries that were changed (+01 to the end) needed to be changed in HzCensusBlock. Tract numbers were recorded and then modified accordingly. A TrackMods and Comment field were added to keep track of entries that were changed and for additional comments. After this step was finished, the Census block scripts were ran to finish off the CensusBlock ID.

Note: For HzCensusBlock, a total of 51 entries were changed.

To see if there are still any duplicate entries, in ArcMap use Layer Properties - Symbology-Categories-Unique values set to Tract to identify tracts that had more than 1 entry.

Creating the rest of SyBoundary for the other provinces

The same procedures were used to create the SyBoundaries for all of the other provinces. Once these boundaries were created, they were all merged into one complete SyBoundary containing the SyState, SyCounty, and SyTract for all of Canada. HzCensusBlocks for each province remained in their own individual Province dataset.

Appendix C: Creating Hazus Datasets for Each Province

C.1 Preparing Provincial dataset feature classes and tables

Each province has its own dataset which is used in Hazus to create specific study regions (similar to US having individual datasets for each state). For each province dataset, the closest corresponding state dataset was copied and the features were set to zero and repopulated.

Note: Most datasets for each province are not complete due to lack of data access for each province. Currently all provinces only contain demographic and residential building data obtained from 2006 census.

Table C.1 indicates the state datasets that were copied to create each province/territory.

Table C.1: Data proxy states for Hazus Canada.

Province / Territory	State Used for Province / Territory Data Preparation
British Columbia	Washington
Alberta	Montana
Saskatchewan	Montana
Manitoba	North Dakota
Ontario	Michigan
Quebec	Massachusetts
Newfoundland	Massachusetts
New Brunswick	Massachusetts
Nova Scotia	Massachusetts
Prince Edward Island	Massachusetts
Yukon	Alaska
Northwest Territories	Alaska
Nunavut	Alaska

Within each dataset there are several mdb files and tables.

Bndrygbs.mdb

hzBldgCountOccupB, hzBldgCountOccupT
Building counts for each Occupancy category for each Block (*B) and Tract (*T).

hzExposureContentOccupB, hzExposureContentOccupT
The total value of the building contents for each Occupancy category for each Block and Tract. Values in Thousand Dollars.

hzExposureOccupB, hzExposureOccupT
The total value of the building replacement for each Occupancy category for each Block and Tract. Values in Thousand Dollars.

hzSqFootageOccupB, hzSqFootageOccupT
The total number of Square Feet of the buildings in each Occupancy category for each Block and Tract. Values in Thousand Square Feet.

hzDemographicsB, hzDemographicsT
The values for each demographic category for each Block and Tract.

hzCensusBlock, hzCounty, hzTract
Feature classes of the censusblock, county, and tract of BC were copied over from SyBoundary.mdb and files names were changed replacing “sy” with “hz”.

All tables within the Bndrygbs.mdb database require a record for each census block and census tract. The census block/tract ID numbers need to be added to each table and all other fields in the table set to zero. The tables were partially filled using the processes described in sections C.2, C.3, 0, C.5 and C.6. The program Comprehensive Database Management System (CDMS) can be used by a user to update each table when better data is available for the user’s area of interest.

EF.mdb

List and parameters for Essential Facilities buildings including Hospitals, Schools, Fire Stations, Police Stations, and Emergency Operations Centres.
All tables/feature classes in this mdb can be updated through CDMS if data is available.

flAG.mdb

Agricultural information used for Flood analysis.
All tables/feature classes in this mdb can be updated through CDMS if data is available.

flVeh.mdb

flDayVehicleInv, flNightVehicleInv
Number of vehicles information used for Flood analysis.

HPLF.mdb

List and parameters for High Potential Loss Facilities including Dams, Military buildings, Nuclear facilities, and Hazmat facilities.
All tables/feature classes in this mdb can be updated through CDMS if data is available.

MSH.mdb

Tables in the MSH.mdb were not cleared out but are default MSH tables from the corresponding state dataset. All the fields that are in the MSH.mdb that had a state prefix were altered to reflect the province prefix, i.e., WA256 (WA = Washington) = BC256 (BC = British Columbia).

There is no documentation on the tables that are in the MSH.mdb so it would be best to just leave the data as it is. When updating building specific data using CDMS, MSH tables will be regenerated to reflect the new changes.

TRN.mdb

Remove all records from the tables in the file.

Files for transportation facilities, bridges, and tunnel are point feature classes in this mdb; these files can be updated through CDMS if data are available.

hzHighwaySegment, hzLightRailSegment, hzRailwaySegment
These are line feature classes which need to be manually imported into the TRN.mdb (as CDMS only accepts point feature class imports).

UTIL.mdb

Remove all records from the tables in the file.

Files for utility facilities are point feature classes in this mdb; these files can be updated using CDMS if data are available.

eqnaturalGasDL, eqNaturalGasDL, eqPotableWaterDL, eqWasteWaterDL are summary tables which need to be updated manually.

hzNaturalGasPl, hzOilPl, hzPotableWaterPl, hzWasteWaterPl
These are line feature classes which need to be manually imported into the TRN.mdb (as CDMS only accepts point feature class imports).

As a recap of the information presented in Appendix B regarding Census Canada identification numbers and Hazus provincial dataset identification numbers:

SyState

StateFips = **PRUID**

SyCounty

CountyFips = **CDUID**

SyTract

Tract = manipulation of CSDUID or manipulation of CDUID/CTUID where applicable.

If a Tract entry contains a NULL or empty value for CTUID, then CSDUID is used for Tract.

IE Tract = 59007007049, CTUID = Null
Use **CSDUID** = 5907049

IE Tract =59021001100, CTUID = 9380011.00
Use **CTUID** = 9380011.00

HzCensusBlock

CensusBlock = manipulation of tract and DAUID

IE CensusBlock = 590010001230123
Use **DAUID** = 59010123

C.2 Generating Canadian Demographic Data

This data set provides distributions of population, demographics, income, occupancies, and housing units extracted from the 2006 Census Canada data. The most appropriate matches to the Hazus demographic database attributes were copied to the hzDemographicsB table. Some attributes values had to be calculated since there was no direct match to the Canadian Census data. For detailed information on how the Census Canada inventory was converted to Hazus categories, please see Appendix D.

The data is calculated at the census Block level (dissemination area in Census Canada). The block data is then aggregated to the Tract level.

Calculation of Hazus provincial database attributes using Census Canada attributes are shown in Table C.2.

Table C.2: Transformation of Census Canada attributes into Hazus Canada format.

Hazus Canada Provincial Database Attribute	Description	Calculation of Census Canada Attributes
Population	Total Census Block Population	"Population, 2006"
Households	Total Census Block Households	"Total number of private households"
GroupQuarters	Population in Group Quarters	"Non-family households"
MaleLess16	Males less than 16-yrs old	Males Ages, "0+4"+5-9"+10-14"+ (1/5 * "15-19")
Male16to65	Males between 16 and 65	Male Ages, (4/5*"15-19")+"20-24"+"25-29"+"30-34"+"35-39"+"40-44"+"45-49"+"50-54"+"55-59"+"60-64"+ (1/5*"65-69")
MaleOver65	Males over 65-yrs old	Male Ages, (4/5*"65-69") +"70-74"+"75-79"+"80-84"+">85"
FemaleLess16	Females less than 16-yrs old	Female Ages, "0+4"+5-9"+10-14"+ (1/5 * "15-19")
Female16to65	Females between 16 and 65	Female Ages, (4/5*"15-19")+"20-24"+"25-29"+"30-34"+"35-39"+"40-44"+"45-49"+"50-54"+"55-59"+"60-64"+ (1/5*"65-69")
FemaleOver65	Females over 65-yrs Old	Female Ages, (4/5*"65-69") +"70-74"+"75-79"+"80-84"+">85"
MalePopulation	Total Male Population	"Male, total"
FemalePopulation	Total Female Population	"Female, total"

Hazus Canada Provincial Database Attribute	Description	Calculation of Census Canada Attributes
White	Population Stating White	“Total population” – “Total Aboriginal” – “Total visible minority”
Black	Population Stating Black	“Visible minority – Black”
NativeAmerican	Population Stating Native American	“Total Aboriginal identify population”
Asian	Population Stating Asian	“West Asian origins” + “South Asian origins” + “East and Southeast Asian origins”
Hispanic	Population Stating Hispanic	“Latin American”
PacifiIslander	Population Stating Pacific Islander	“Pacific Island origins”
OtherRaceOnly	Population Stating Other Race Only	“Visible minority, n.i.e.”
IncLess10	Number of Households with Income Less than 10K	“Under $10,000”
Inc10to20	Number of Households with Income between 10K and 20K	“$10,000 to $19,999”
Inc20to30	Number of Households with Income between 20K and 30K	“$20,000 to $29,999”
Inc30to40	Number of Households with Income between 30K and 40K	“$30,000 to $39,999”

Hazus Canada Provincial Database Attribute	Description	Calculation of Census Canada Attributes
Inc40to50	Number of Households with Income between 40K and 50K	“$40,000 to $49,999”
Inc50to60	Number of Households with Income between 50K and 60K	“$50,000 to $59,999”
Inc60to75	Number of Households with Income between 60K and 75K	“$60,000 to $69,999’ + (1/2 * “70,000 to $79,999”)
Inc 75to100	Number of Households with Income between 75K and 100K	(1/2*”$70,000 - $79,999”) + “$80,000 - $89,999” + “$90,000 - $99,999”
IncOver100	Number of Households with Income over 100K	“$100,000 and over”
ResidDay	Population Residing by Day	((0.70)*(0.75)*(DRES)) + (0.30)*(0.75)*(DRES) Refer to section 13.1.3 of the *Hazus-MH 2.1 Earthquake Model Technical Manua*l.
ResidNight	Population Residing by Night	“Total number of persons in private households”
Hotel	Population in Hotels	Data not available
Visitor	Visitor Population	Data not available

Hazus Canada Provincial Database Attribute	Description	Calculation of Census Canada Attributes
WorkingCom	Total Population Working in Commercial Industry	[(0.99)*(0.98)*(COMW)] + [(0.80)*(0.20)*(DRES)] + [(0.80)*(0)] + [(0.80)*0] + [(0.01)*(0.98)*(COMW)]+ [(0.20)*(0.20)*(DRES)] + [(0.20)*(0)] + [(1-PRLF)*(0.05)*(POP)] Refer to section 13.1.3 of the *Hazus-MH 2.1 Earthquake Model Technical Manua*l.
WorkingInd	Total Population Working in Industrial Industry	[(0.90)*(0.80)*(INDW)] + [(0.10)*(0.80)*(INDW)] Refer to section 13.1.3 of the *Hazus-MH 2.1 Earthquake Model Technical Manua*l.
Commuting5PM	Population Commuting at 5pm	[(PRFIL)*[(0.05)*(POP) + (1.0)*(COMM)]] + [(0.50)*(1-PRFIL)*[(0.05)*(POP) + (1.0)*(COMM)]] Refer to section 13.1.3 of the *Hazus-MH 2.1 Earthquake Model Technical Manua*l.
OwnerSingleUnits	Total Owner Occupied Single Family Units	Actual data not available. Calculation based on closest US State statistics.
OwnerMultUnits	Total Owner Occupied Multi-Family Units	Actual data not available. Calculation based on closest US State statistics.
OwnerMultStructs	Total Owner Occupied Multi-Family Structures	Data not available.
OnwerMHs	Total Owner Occupied Manufactured Housing	Data not available.
RenterSingleUnits	Total Renter Occupied Single Family Units	Actual data not available. Calculation based on closest US State statistics.

Hazus Canada Provincial Database Attribute	Description	Calculation of Census Canada Attributes
RenterMultUnits	Total Renter Occupied Multi-Family Units	Actual data not available. Calculation based on closest US State statistics.
RenterMultStructs	Total Renter Occupied Multi-Family Structures	Data not available.
RenterMHs	Total Renter Occupied Manufactured Housing	Data not available.
VacantSingleUnits	Total Number Vacant Single Family Units	Actual data not available. Calculation based on closest US State statistics.
VancantMultUnits	Total Number Vacant Multi-Family Units	Actual data not available. Calculation based on closest US State statistics.
VacantMultStructs	Total Number Vacant Multi-Family Structures	Data not available.
VacantMHs	Total Number Vacant Manufactured Housing	Data not available.
BuiltBefore40	Number of Units Built Before 1940	"Period of construction before 1946"
Built40to49	Number of Units Built Between 1940 and 1949	1/2 * "Period of construction, 1946 to 1960"
Built50to59	Number of Units Built Between 1950 and 1959	1/2 * "Period of construction, 1946 to 1960"
Built60to69	Number of Units Built Between 1960 and 1969	"Period of construction, 1960 to 1970 "
Built70to79	Number of Units Built Between 1970 and 1979	"Period of construction, 1971 to 1980"
Built80to89	Number of Units Built Between 1980 and 1989	"Period of construction, 1981 to 1985." + "Period of construction, 1986 to 1990.**"**

Hazus Canada Provincial Database Attribute	Description	Calculation of Census Canada Attributes
Built90to98	Number of Units Built Between 1990 and 1998	"Period of construction, 1991 to 1995." + "Period of construction, 1996 to 2000."
BuiltAfter98	Number of Units Built After 1998	"Period of construction, 2001 to 2006"
MedianYearBuilt	Median Year Built (Units)	Use weighted average of construction periods to calculate the median year. Period of construction years were averaged out to 1940, 1945, 1955, 1965, 1975, 1985, 1995, and 2002 were used for the calculation.
AvgRent	Average Cash Rent	“Average gross rent $”
AvgValue	Average Home Value	“Average value of dwelling $”
SchoolEnrollment Kto12	Total School Enrollment up to High School	“5 to 9 years” + “10 to 14 years” + “15 to 19 years” * 0.8 Refer to section 13.1.3 of the *Hazus-MH 2.1 Earthquake Model Technical Manua*l.
SchoolEnrollment College	Total College and University Enrollment	Data not available.

The other variables used in the calculation of Hazus provincial database attributes using Census Canada attributes are shown in Table C.3.

Table C.3: Other variables used in Census Canada attribute transformation.

Census Canada Attribute	Description
POP	“Population, 2006”
DRES	“Total number of persons in private households” – [COMW + INDW]

Census Canada Attribute	Description
NRES	“Total number of persons in private households”
COMM	“Total employed labour force 15 years and over with usual place of work or no fixed workplace address by mode of transportation”
COMW	Total of all the following fields: “41 Wholesale trade”, “44-45 Retail trade”, “48-49 Transportation and warehousing”, “51 Information and cultural industries”, “52 Finance and insurance”, “53 Real estate and rental and leasing”, “54 Professional, scientific and technical services”, “55 Management of companies and enterprises”, “56 Administrative and support, waste management and remediation services”, “61 Educational services”, “62 Health care and social assistance”, “71 Arts, entertainment and recreation”, “72 Accommodation and food services”, “81 Other services (except public administration)”, “91 Public administration”
INDW	Total of all the following fields: “11 Agriculture, forestry, fishing and hunting”, “21 Mining and oil and gas extraction”, “22 Utilities, “23 Construction”, “31-33 Manufacturing”
PRLF	(“Car, truck, van, as driver” + “Car, truck, van, as passenger”) / “Total employed labour force 15 years and over with usual place of work or no fixed workplace address by mode of transportation”

C.3 Generating Building Count Data

This data set provides a count of buildings for each Hazus specific occupancy classification developed from the 2006 Census Canada data. The most appropriate matches to the Hazus database attributes were used to calculate values for the building counts. The Census data for the Dissemination Areas (blocks) from the three categories “Row house”, “Apartment, building that has fewer than five storeys", and "Apartment, building that has five or more storeys” were divided into four of the Hazus RES multifamily categories. The percentages used to separate the categories were based on estimates using Level 2 building counts from one study area. These values are shown in the following table. This approach provides RES3 values that are assumed to be more representative of reality than leaving one of the RES3 codes with a null value.

The data is calculated at the census Block level (dissemination area in Census Canada). The block data is then aggregated to the Tract level.

The Census Canada data contains the number of units for each of its residential categories per census block. To calculate the number of buildings for each RES occupancy code, the number of units needs to be converted to number of buildings. For single detached home, the number of units equals the number of buildings. For multifamily homes, the number of buildings was calculated from the number of units using the equation:

Number of Buildings	=	*Number of units*	/	*Average number of units per building*

where the assumed Average number of units per building is indicated in Table C.4.

Table C.4: Conversion from Statistics Canada classifications to Hazus Occupancy Codes.

Census Canada Classification (Estimated Range of Number of Units)		Hazus Occupancy Code (Number of Units)	Average Number of Units per Building Class	Conversion from Census units to Hazus Buildings
Single-detached house (1)	100%	RES1 (1)	1	Units / 1
Other single attached (1)	100%			
Movable dwelling (1)	100%	RES2 (1)	1	Units / 1
Semi-detached house (2)	100%	RES3A (2)	2	Units / 2
Apartment, duplex (2)	100%			
Rowhouse (3~10)	30%	RES3B (3-4)	3.5	Units / 3.5
	70%	RES3C (5-9)	7	Units / 7
Apartment, building has fewer than five storeys (6~32)	70%	RES3D (10-19)	15	Units / 15
	30%	RES3E (20-49)	30	Units / 30
Apartment, building that has five or more storeys (20~)	30%			
	70%	RES3F (50+)	75	Units / 75

C.4 Generating Building Square Footage Data

This data set provides distributions of floor area, in thousand square foot units, for the Hazus specific occupancy classes developed from the 2006 Census Canada data. Square footage values by occupancy class are included in the Canadian dataset for residential categories from RES1 to RES3F. Commercial, industrial, governmental, educational, as well as some other residential building classes are excluded due to the current unavailability of appropriate data formats for these categories. The following is the process for populating the included residential classes (RES1, RES2, RES3A, RES3B, RES3C, RES3D, RES3E, RES3F).

The data is calculated at the census Block level (dissemination area in Census Canada). The block data is then aggregated to the Tract level.

The Canada Census data provided number of units per census residential category per dissemination area. For a discussion on the method to convert the census categories to the Hazus Occupancy codes, see section C3.

To obtain the square footage values, a multiplication was performed of *the number of units in each occupancy class* by a value of the *average square footage for that type of unit*.

total units in occupancy class within census block	X	*average square footage of that type of unit*	/	1000	=	*total square footage (thousand sq ft) of occupancy class within census block*

Determining the average square footage per unit was based on several sources. Table 3.6 in the *Hazus-MH 2.1 Earthquake Model Technical Manual* provides a list of average square footages per RES building occupancies, which was used as a base. These values were compared with several other available sources on average residential unit sizes (listed under *References* for this appendix), and in some cases, small adjustments were made to the Hazus default values to reflect the further research and some apparent minor variations between Canadian and US average unit sizes.

Table C.5 lists the average square footage per unit for the included Occupancy classes that were used.

Table C.5: Occupancy Class square footages used in Hazus Canada.

Occupancy Class	Description	Average Square Footage per Unit
RES1	Single Family Dwelling	2000
RES2	Manufactured Housing	1000
RES3A	Multi Family Dwelling – Duplex	1500
RES3B	Multi Family Dwelling – Triplex/Quads	1200
RES3C	Multi Family Dwelling – 5-9 units	900
RES3D	Multi Family Dwelling – 10-19 units	900
RES3E	Multi Family Dwelling – 20-49 units	900
RES3F	Multi Family Dwelling – 50+ units	900

References:

The following sources were consulted in conjunction with Table 3.6 from the *Hazus-MH 2.1 Earthquake Model Technical Manual*.

CitySpaces Consulting, 2009. Vancouver Condominium Rental Study: prepared for the City of Vancouver; CitySpaces, <http://vancouver.ca/docs/policy/housing-role-rented-condo-stock.pdf> [accessed December 24, 2013].

"Table 1.2: 2001 Statistics for the condominium apartment stock in Vancouver."

- “Average unit floor area 874 to 894 sq ft”

Spengler, John D., Samet, Jonathan M., and McCarthy, John F., 2001. Indoor Air Quality Handbook: An Overview of the U.S. Building Stock; AccessEngineering, <http://accessengineeringlibrary.com/browse/indoor-air-quality-handbook/p2000a9b699706_3001> [accessed December 24, 2013].

- “average existing single-family home … total of 2,280 square feet”
- “average existing multifamily dwelling … total of 970 square feet”
- “average existing mobile home … total of 980 square feet”

C.5 Generating Building Exposure Cost Data

This data set provides the building replacement valuation, in thousand dollar units, for each Hazus specific occupancy classification developed from the 2006 Census Canada.

The data is calculated at the census Block level (dissemination area in Census Canada). The block data was then aggregated to the Tract level.

Exposure values were calculated using the RSMeans 2006 values for RES occupancy codes. The values for RES2 and RES3 codes are found in table *hzReplacementCost* in file *hzAnalParams.mdb* in the Hazus program file path. For RES1 buildings, the RSMeans 2006 values are found in table *hzRes1ReplCost* in file *hzAnalParams.mdb.* The value used for RES1 code is for the Average Construction Scheme, 2 storey height, average basement cost ($90.15).

ExposureOccup (Thousands of $)	=	*square footage*	X	RSMeans Cost for 2006	/	*1000*

C.6 Generating Building Content Exposure Cost Data

This data set provides the content replacement valuation, in thousand dollar units, for each Hazus specific occupancy classification developed from the 2006 Canadian Census**.**

The data is calculated at the census Block level (dissemination area in Census Canada). The block data was then aggregated to the Tract level.

The content values are calculated based on a percentage of the building exposure cost. Building exposure cost calculations are described in section G5. The percentage values are listed in Table 3.10 of the *Hazus-MH 2.1 Earthquake Model Technical Manual.*

Exposure content values for RES occupancy codes are 50% of Exposure values

ExposureOccup (Thousands of $)	=	*0.5*	X	*square footage*	X	RSMeans Cost for 2006	/	*1000*

Appendix D: Detailed Guide to Creating Canadian Provincial Demographic Spreadsheets for Hazus

This appendix documents in detail the process used to create demographic spreadsheets for each Canadian province which were then used in the Comprehensive Database Management System (CDMS) program to update province datasets. Two tables in the bndrygbs database, *hzDemographicsB, hzDemographics*) are updated from the spreadsheets.

This guide will use British Columbia as an example. This same method was applied to the rest of the provinces.

D.1 Obtaining RAW Census Data

All Canadian census data is from Statistic Canada's 2006 Census. The program that comes with the bundled data is *Beyond 20/20*.

Province codes:
10 Newfoundland and Labrador
11 Prince Edward Island
12 Nova Scotia
13 New Brunswick
24 Quebec
35 Ontario
46 Manitoba
47 Saskatchewan
48 Alberta
59 British Columbia
60 Yukon
61 Northwest Territories
62 Nunavut

Each province has a specific province code, these province codes will be used to identify DA (dissemination area) that belong in each province. For example, DAUID = **59**123456 would be a DA that belongs in British Columbia.

Open *Beyond 20/20* and open the second table (94-581-XCB-2006002) which contains "*Profile for Canada, Provinces, Territories, Census Divisions, Census Subdivisions, and Dissemination Areas, 2006 Census*". Since the Canadian SyBoundary makes use of the DAUID (dissemination areas), all dissemination areas for each province will have to be extracted from the program.

In the profile, the census data for each province needs to be extracted. In the search function (Figure D.1), select "Unof. / Non-of" and in the textbox enter the province name that is currently being worked on.

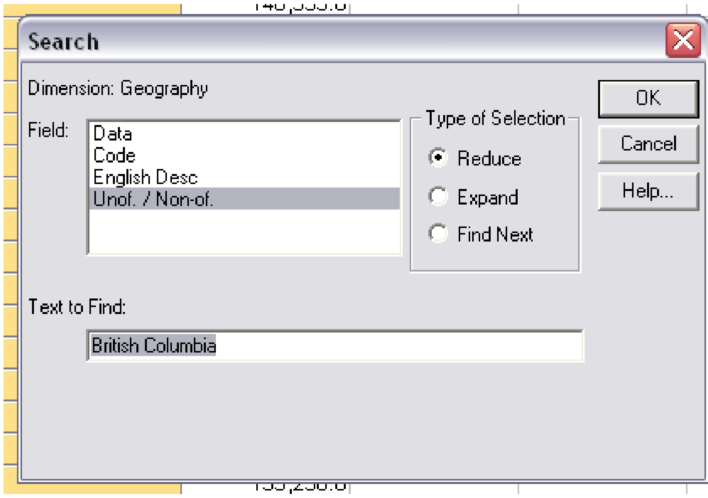


Figure D.1: Search function of beyond 20/20.

This will query the column containing “British Columbia”. The query only shows the items with “British Columbia”. Right-click on the column and select show all to display the rest of the results. For this example, in order to select all of BC, with “British Columbia” still being selected, scroll all the way to the right until the next province Yukon (PR=60). Once the last DA for BC is found, hold **SHIFT** while clicking on the last column will select all the DA’s for BC.

Right-click the selection and select **SHOW** to now only display DA’s within BC. The data can now be exported as a CSV file. **File – Save As – Comma Separated (*.csv)**. (Figure D.2)

Note: The goal is to eventually get the data into an excel spreadsheet, however, Excel 2003 and earlier only supports up to 256 columns and all the provinces have more columns (i.e., BC has over 7000 alone). Importing into CSV and into Excel 2007 and newer would be the only available method of exporting that amount of data, into a workable spreadsheet. CSV files also have a limited number of columns and therefore bigger provinces like Quebec and Ontario would need multiple CSV files in order to export all the data.

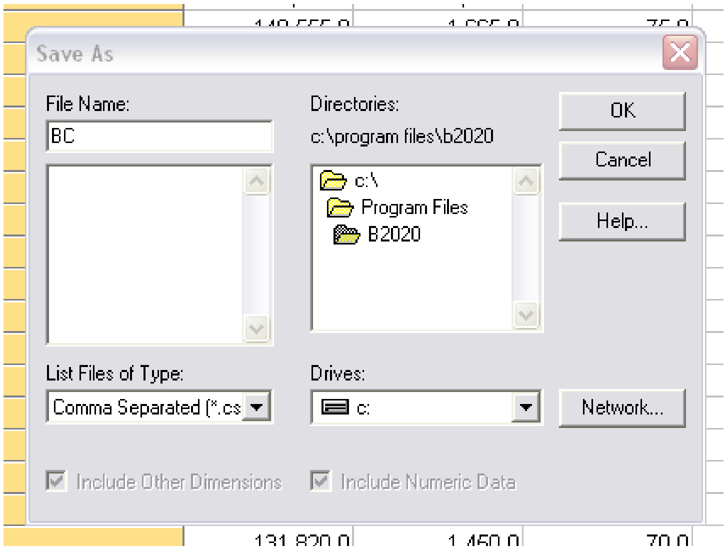
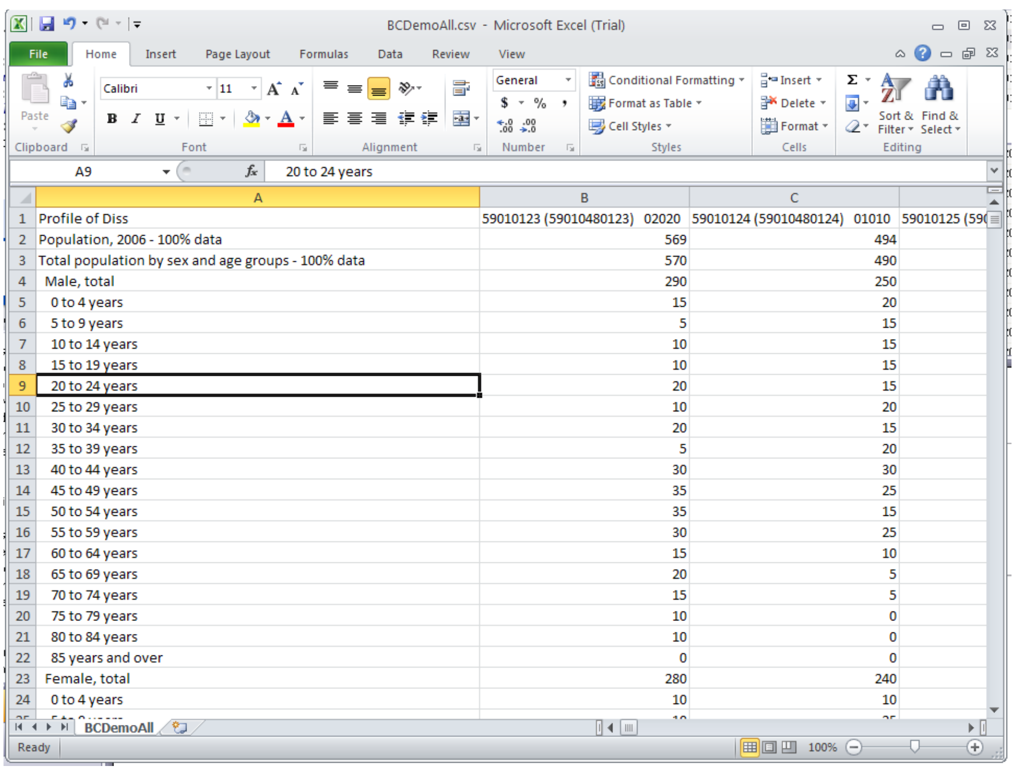


Figure D.2: Save the file as a CSV file.

D.2 Spreadsheet Preparation 1

Using Excel 2007 or newer (Excel 2010 was used for this case), open up the CSV file. Excel will automatically extract and sort out the columns. (Figure D.3)



	A	B	C
1	Profile of Diss	59010123 (59010480123) 02020	59010124 (59010480124) 01010
2	Population, 2006 - 100% data	569	494
3	Total population by sex and age groups - 100% data	570	490
4	Male, total	290	250
5	0 to 4 years	15	20
6	5 to 9 years	5	15
7	10 to 14 years	10	15
8	15 to 19 years	10	15
9	20 to 24 years	20	15
10	25 to 29 years	10	20
11	30 to 34 years	20	15
12	35 to 39 years	5	20
13	40 to 44 years	30	30
14	45 to 49 years	35	25
15	50 to 54 years	35	15
16	55 to 59 years	30	25
17	60 to 64 years	15	10
18	65 to 69 years	20	5
19	70 to 74 years	15	5
20	75 to 79 years	10	0
21	80 to 84 years	10	0
22	85 years and over	0	0
23	Female, total	280	240
24	0 to 4 years	10	10

Figure D.3: Excel 2010 automatically extracts all the columns from the CSV file.

Each column contains all the census data for each Dissemination Area ID (DAUID). The DAUIDs need to be sorted from smallest value to highest value. Select all the DAUIDs in the spreadsheet. In the Home tab, click on **Sort & Filter – Custom Sort – Options** and select left to right and sort by Row 1. (Figure D.4)

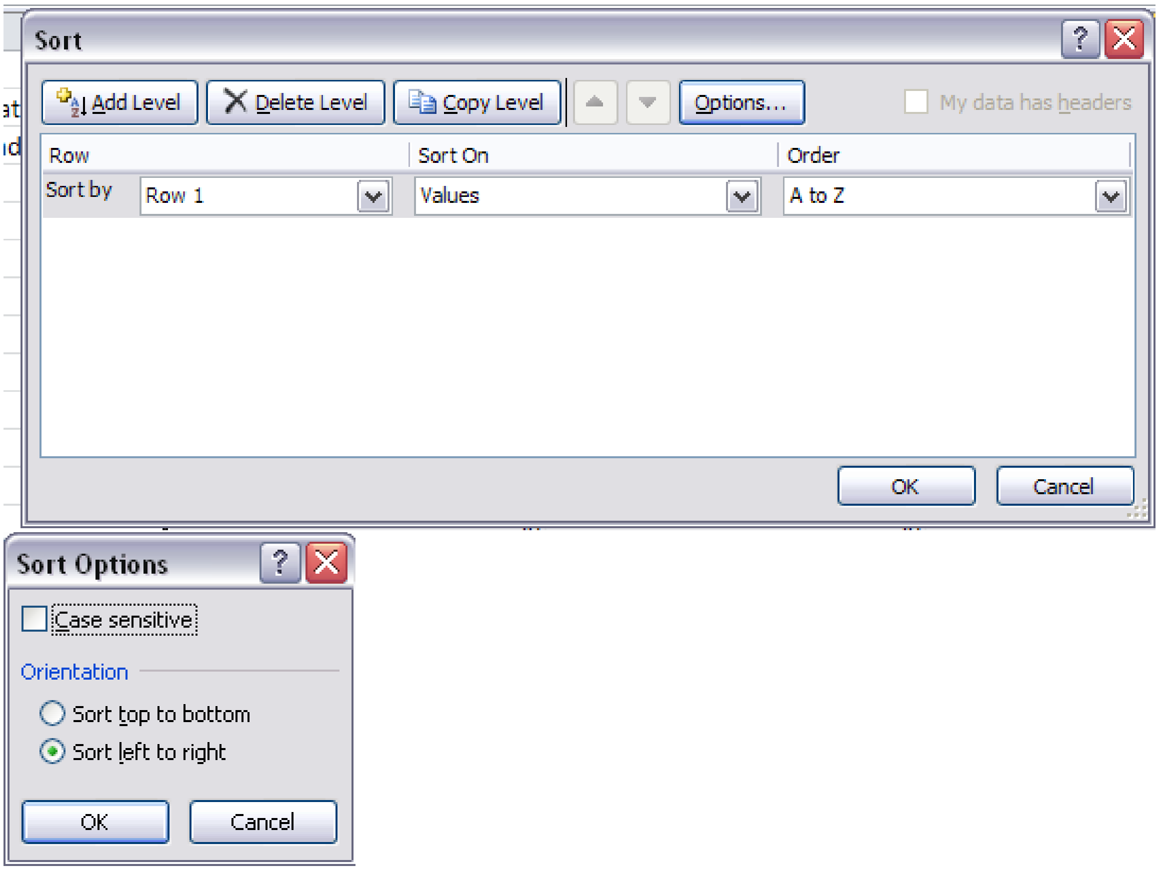


Figure D.4: Sorting the columns from left to right.

Insert a new spreadsheet where preparation work will be done. The DAUIDs will need to be transposed so that it is for each row instead of column. Select the first top row containing all the DAUIDs. Ctrl-C to make a copy, in the new sheet, on any cell, right-click **paste special** and select **transpose**. (Figure D.5) Inspect the list to make sure everything is in order, near the end of the list are rows that start with the names instead of the DAUIDs, they are not used and should be erased. (Figure D.6)

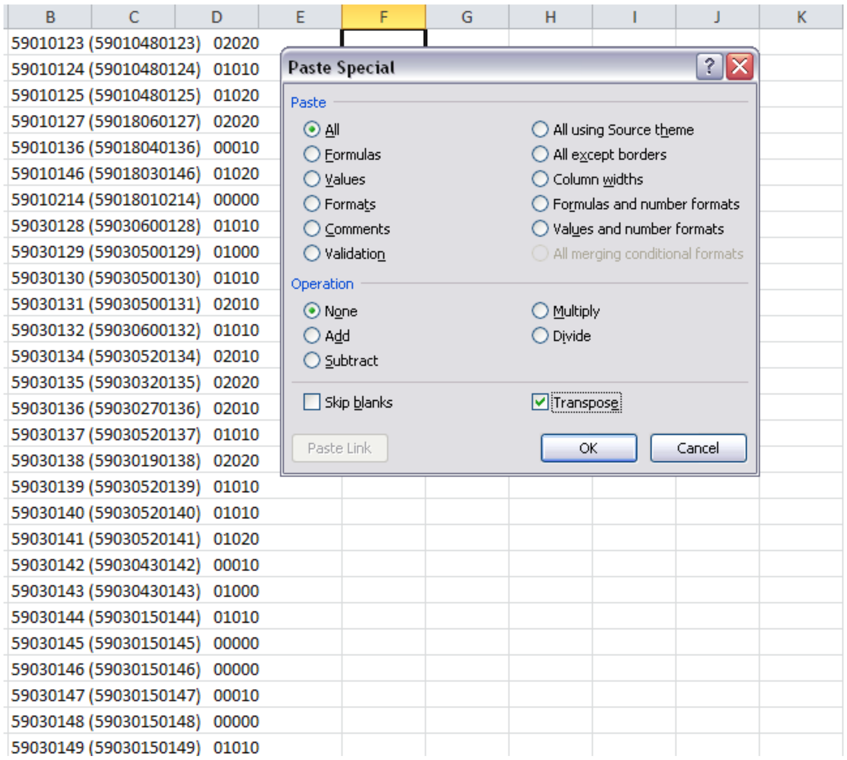


Figure D.5: Transposing the values to get from columns to rows.

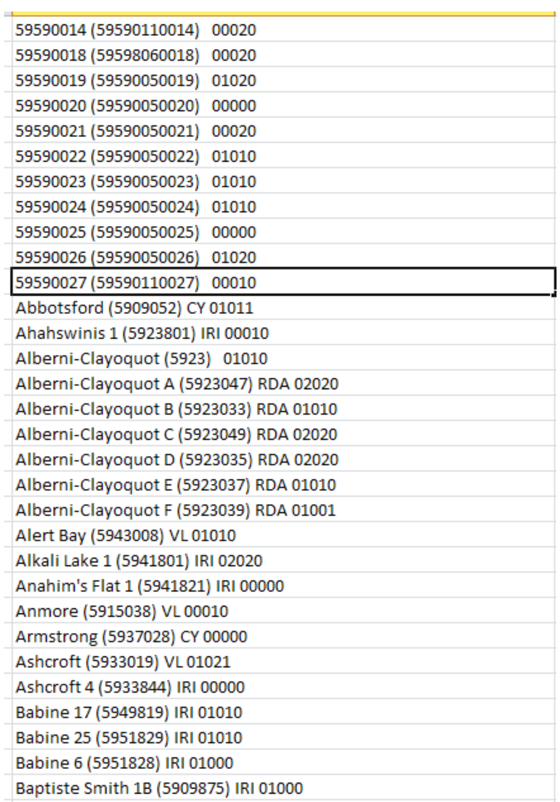


Figure D.6: Rows starting with names to be erased.

Near the end of the column where there are names instead of DA's, these areas should be erased since they will not be used.

These cells contain numbers besides the DAUID which will not be needed. Another field containing the DAUID values only will be needed (Only the first 8 digits in the cell are the DAUID). In the next adjacent cell, this formula can be used to truncate the remaining characters, "**=LEFT([target cell], 8)**". Select the current calculated cell, and find the last DAUID column number (For BC, it is 6978). In the Clipboard, type in the current cell and the last column number with the DAUID. (Figure D.7) This will highlight all the selected cells within the given range. In the **Fill** command, select **Down**. This will automatically calculate all the selected fields in range with the supplied formula.

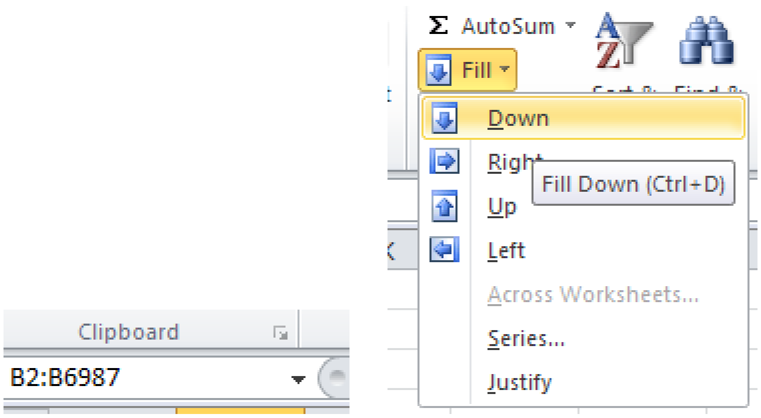


Figure D.7: Clipboard and Fill command.

Use clipboard to select all cells that will be used for finding the DAUID. Use the **Fill – Down** command to calculate the values within the given range.

The next step is to connect the associated DAUID to its corresponding CensusBlock ID found in the HzCensusBlock table in the bndrygbs.mdb for each individual Province.

In the census data, there is often less DAUIDs compared to HzCensusBlock DAUIDs. In the census data, if there is not enough population or there are quality concerns on the data for the specific Dissemination Area, there will be no results. Hence for the case of British Columbia, there are a total of 7xxx DAUID/CensusBlocks compared to 69xx entries in which there contains census data.

To make this DAUID / CensusBlock match, two separate worksheets one containing the DAUID from the census data and another containing the DAUID / CensusBlock ID from the HzCensusBlock table has to be created. These tables will be imported into Microsoft Access tables, and a query would be applied to make the matches.

From the census data, select the column of DAUID and copy it to another spreadsheet. Save the spreadsheet. In Access, open up the bndrygbs.mdb, locate the HZCensusBlock table. Right-click to export the table, save the table as a XLS (Excel 97-2003) format.

D.3 Using Access to Make a Query

In Access, create a new blank database, and save the file. In Tables, select New Table and Import Table to import the 2 spreadsheets created earlier. In the import spreadsheet wizard (Figure D.8), make sure to click **"First Row Contains Column Headings"**. Accept the default values for throughout the rest of the wizard except when asked **to "Let Access add primary key."** Switch and select **"No primary Key"** instead.

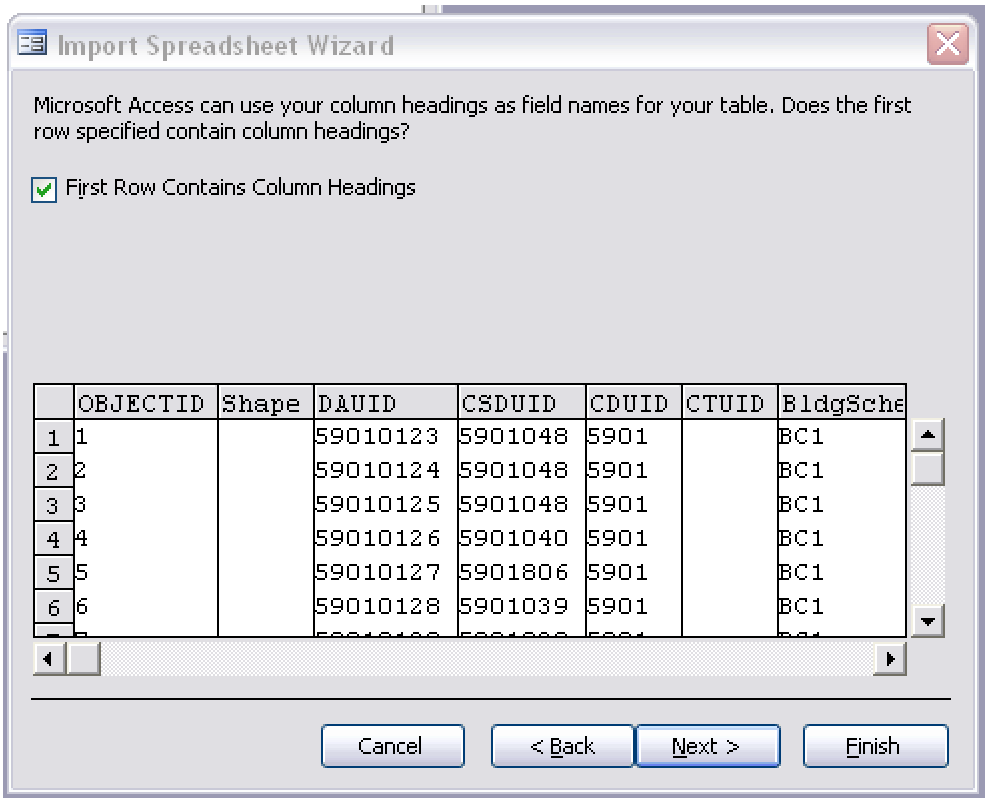


Figure D.8: Using import table wizard to create an Access table.

Once the 2 tables are created, select the Queries tab and select **Create query in Design view**. Import both tables into the query. Make a linkage between both tables by dragging "DAUID" from one table and "DAUID" in the other table. Select DAUID as a field, and HZCensusBlock as the second field. (Figure D.9) Once these steps are completed, select **datasheet view** to view the results of the query. All the DAUIDs from the census data will now have a matching CensusBlock ID

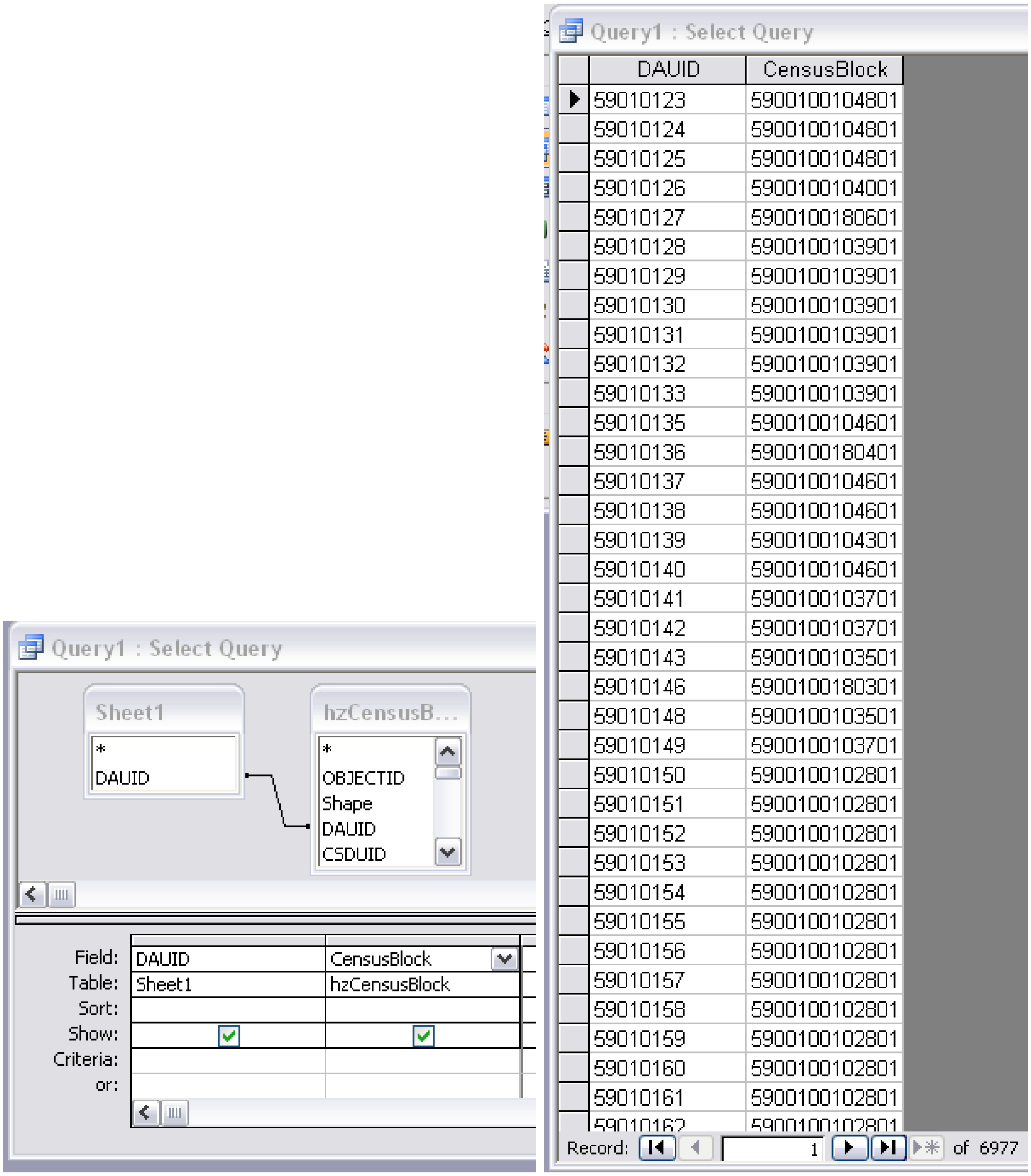


Figure D.9: Creating a query in Access to make the linkage between DAUID and CensusBlock.

Select both columns in the query and make a copy. Paste the columns into another worksheet using paste special – text. Make the CensusBlock field a number field with 0 decimal places (**Format Cells, Number, Decimal places** = 0). (Figure D.10) Make sure the DAUID is sorted from smallest to highest and apply a sort and filter function again for the whole selection.

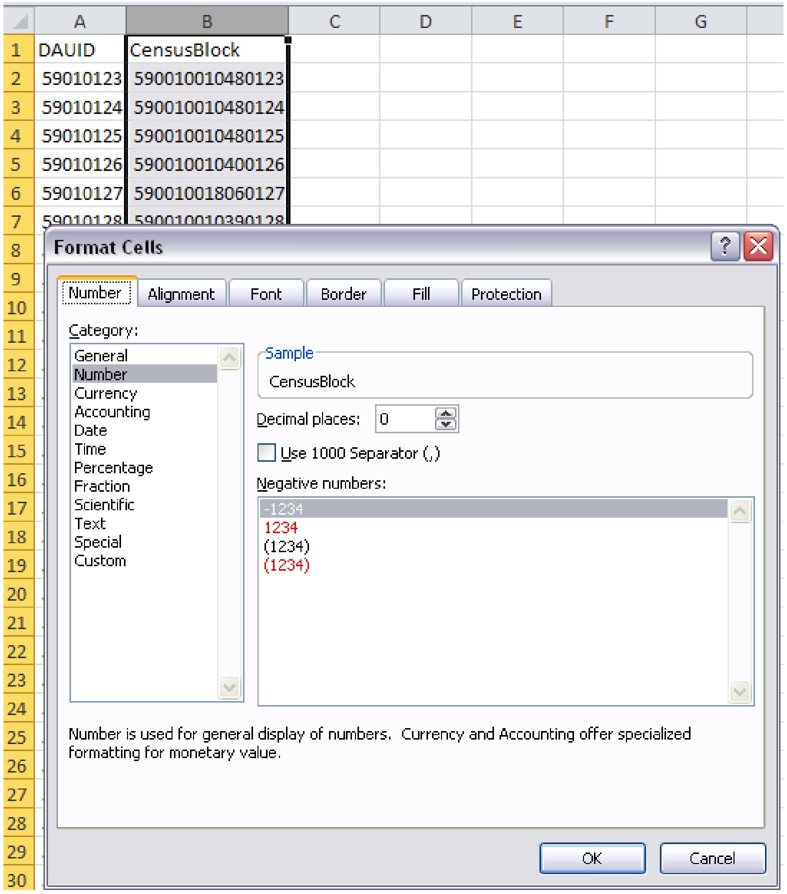


Figure D.10: Changing the cell format to display the all the numbers in the CensusBlock.

D.4 Spreadsheet Preparation 2

A spreadsheet with the following columns must be created in order to import the data into CDMS successfully.

DAUID
CensusBlock
Population
Households
GroupQuarters
MaleLess16
Male16to65
MaleOver65
FemaleLess16
Female16to65
FemaleOver65
MalePopulation
FemalePopulation
White
Black
NativeAmerican
Asian
Hispanic
PacifiIslander
OtherRaceOnly
IncLess10
Inc10to20
Inc20to30
Inc30to40
Inc40to50
Inc50to60
Inc60to75
Inc75to100
IncOver100
ResidDay
ResidNight
Hotel
Visitor
WorkingCom
WorkingInd
Commuting5PM
OwnerSingleUnits
OwnerMultUnits
OwnerMultStructs
OnwerMHs
RenterSingleUnits
RenterMultUnits
RenterMultStructs
RenterMHs
VacantSIngleUnits
VacantMultUnits
VacantMultStructs
VacantMHs
BuiltBefore40
Built40to49
Built50to59
Built60to69
Built70to79
Built80to89
Built90to98
BuiltAfter98
MedianYearBuilt
AvgRent
AvgValue
SchoolEnrollmentKto12
SchoolEnrollmentCollege

A lot of the variables listed will need to be calculated based on the different formulas derived from the census data. The census data is in rows and will need to be transposed to columns in order for the calculations to be made. <u>The goal is to have each row as a DAUID and each column as a variable for columns listed above in this section and as shown in Figure D.11.</u> Create each column and follow the methods listed in section D.5. A detailed explanation of each variable can be found in section 0. Each **[#]** means the specific row where the data can be found in the census data spreadsheet. Verify the row number with the name description.

	B	C	D	E	F	G	H	I	J	K	L	M	N
1	DAUID	CensusBlock	Population	Households	GroupQuarters	MaleLess16	Male16to65	MaleOver65	FemaleLess16	Female16to65	FemaleOver65	MalePopulation	FemalePo
2	59010123	590010010480123	569	250	24	32	212	51	33	206	46	290	
3	59010124	590010010480124	494	205	4	53	188	9	57	159	14	250	
4	59010125	590010010480125	500	215	0	40	174	46	39	159	37	260	
5	59010126	590010010400126	735	285	75	64	251	60	63	250	47	370	
6	59010127	590010018060127	169	65	4	11	60	9	16	59	5	85	
7	59010128	590010010390128	507	220	0	39	169	32	44	187	39	230	
8	59010129	590010010390129	386	165	0	33	153	19	42	144	24	190	
9	59010130	590010010390130	588	230	118	37	171	67	37	157	121	265	
10	59010131	590010010390131	422	170	2	47	120	18	42	150	23	190	
11	59010132	590010010390132	482	175	0	58	149	23	60	171	14	240	
12	59010133	590010010390133	617	230	2	62	225	33	55	227	38	315	
13	59010135	590010010460135	476	195	1	37	174	29	34	184	22	240	
14	59010136	590010018040136	153	55	3	21	50	9	11	44	10	85	
15	59010137	590010010460137	565	255	5	29	205	66	32	198	60	280	
16	59010138	590010010460138	536	225	0	51	193	56	33	166	41	295	
17	59010139	590010010430139	700	290	5	65	242	53	69	239	37	365	
18	59010140	590010010460140	542	215	2	42	192	36	48	186	26	275	
19	59010141	590010010370141	407	185	2	31	128	41	27	150	28	215	
20	59010142	590010010370142	479	230	4	33	174	48	23	174	38	255	
21	59010143	590010010350143	541	220	6	45	189	56	43	185	37	280	
22	59010146	590010018030146	159	50	0	17	58	0	17	53	0	85	
23	59010148	590010010350148	559	225	0	48	196	36	34	200	41	285	
24	59010149	590010010370149	450	185	0	38	165	27	29	179	22	230	
25	59010150	590010010280150	489	200	0	54	163	38	42	151	37	260	
26	59010151	590010010280151	476	220	1	34	154	47	38	150	52	240	
27	59010152	590010010280152	556	245	0	44	180	51	44	195	46	275	

Figure D.11: Example spreadsheet for importing into CDMS.

Census data needs to be transposed like the following.

D.5 Fields to be Included in Spreadsheet

DAUID

CensusBlock

Population

“Population, 2006” **[2]**

Households

“Total number of private households”, **[129]**

GroupQuarters

“Non-family households”, **[140]**

MaleLess16

“0+4”+5-9”+10-14”+ (1/5 * “15-19”), **[5] + [6] + [7] +1/5*[8]**

Male16to65

(4/5*”15-19”)+”20-24”+”25-29”+”30-34”+”35-39”+”40-44”+”45-49”+”50-54”+”55-59”+”60-64”+ (1/5*”65-69”), **4/5*[8] + [9] + [10] + [11] + [12] + [13] + [14] + [15] + [16] + [17] + 1/5*[18]**

MaleOver65

(4/5*”65-69”) +”70-74”+”75-79”+”80-84”+”>85”, **4/5*[18] + [19] + [20] + [21] + [22]**

FemaleLess16

“0+4”+5-9”+10-14”+ (1/5 * “15-19”), **[24] + [25] + [26] +1/5*[27]**

Female16to65

(4/5*”15-19”)+”20-24”+”25-29”+”30-34”+”35-39”+”40-44”+”45-49”+”50-54”+”55-59”+”60-64”+ (1/5*”65-69”), **4/5*[27] + [28] + [29] + [30] + [31] + [32] + [33] + [34] + [35] + [36] + 1/5*[37]**

FemaleOver65

(4/5*”65-69”) +”70-74”+”75-79”+”80-84”+”>85”, **4/5*[37] + [38] + [39] + [40] + [41]**

MalePopulation

“Male, total” **[4]**

FemalePopulation

“Female, total” **[23]**

White

“Total population” – “Total Aboriginal” – “Total visible minority”, **[2] – [566] – [1304]**

Black

“Visible minority – Black”, **[1307]**

NativeAmerican

“Total Aboriginal identify population”, **[566]**

Asian

“West Asian origins” + “South Asian origins” + “East and Southeast Asian origins”, **[1508] + [1521] + [1535]**

Hispanic

“Latin American”, **[1309]**

PacifiIslander

“Pacific Island origins”, **[1558]**

OtherRaceOnly

“Visible minority, n.i.e.” (n.i.e. = not included elsewhere), **[1315]**

IncLess10

“Under $10,000”, **[1990]**

Inc10to20

“$10,000 to $19,999”, **[1991]**

Inc20to30

“$20,000 to $29,999”, **[1992]**

Inc30to40

“$30,000 to $39,999”, **[1993]**

Inc40to50

“$40,000 to $49,999”, **[1994]**

Inc50to60

“$50,000 to $59,999”, **[1995]**

Inc60to75

“$60,000 to $69,999’ + (1/2 * “70,000 to $79,999”), **[1996] + [1/2*[1997]]**

Inc75to100

(1/2*”$70,000 - $79,999”) + “$80,000 - $89,999” + “$90,000 - $99,999”, **[1/2*[1997] + [1998] + [1999]**

IncOver100

“$100,000 and over”, **[2000]**

<u>For all calculations below with variables, please see section 0.</u>

ResidDay

((0.70)*(0.75)*(DRES)) + (0.30)*(0.75)*(DRES)

ResidNight

“Total number of persons in private households”, **[86]**

Hotel

Hotel occupants. Do not have access to national data to assess this variable. Leave all cells as 0.

Visitor

Visitor population. Do not have access to national data to assess this variable. Leave all cells as 0.

WorkingCom

[(0.99)*(0.98)*(COMW)] + [(0.80)*(0.20)*(DRES)] + [(0.80)*(0)] + [(0.80)*0] + [(0.01)*(0.98)*(COMW)]+ [(0.20)*(0.20)*(DRES)] + [(0.20)*(0)] + [(1-PRLF)*(0.05)*(POP)]

WorkingInd

[(0.90)*(0.80)*(INDW)] + [(0.10)*(0.80)*(INDW)]

Commuting5PM

[(PRFIL)*[(0.05)*(POP) + (1.0)*(COMM)]] + [(0.50)*(1-PRFIL)*[(0.05)*(POP) + (1.0)*(COMM)]]

OwnerSingleUnits

Owner-occupied single family units. Do not have access to national data to assess this variable. Leave all cells as 0.

OwnerMultUnits

Owner-occupied multi-family units. Do not have access to national data to assess this variable. Leave all cells as 0.

OwnerMultStructs

Owner-occupied multi-family structures. Do not have access to national data to assess this variable. Leave all cells as 0.

OnwerMHs

Owner-occupied manufactured housing. Note the spelling “Onwer”, it is misspelled in Hazus, and this mistake must be applied throughout in order to make the database run. Do not have access to national data to assess this variable. Leave all cells as 0.

RenterSingleUnits

Renter-occupied single family units. Do not have access to national data to assess this variable. Leave all cells as 0.

RenterMultUnits

Renter-occupied Multi-Family units. Do not have access to national data to assess this variable. Leave all cells as 0.

RenterMultStructs

Renter occupied multi-family structures. Do not have access to national data to assess this variable. Leave all cells as 0.

RenterMHs

Renter Occupied manufactured housing. Do not have access to national data to assess this variable. Leave all cells as 0.

VacantSingleUnits

Vacant Single Family Units. Do not have access to national data to assess this variable. Leave all cells as 0.

VancantMultUnits

Vacant Multi-Family Units. Do not have access to national data to assess this variable. Leave all cells as 0.

VacantMultStructs

Vacant Multi-Family Structures. Do not have access to national data to assess this variable. Leave all cells as 0.

VacantMHs

Vacant Manufactured Housing. Do not have access to national data to assess this variable. Leave all cells as 0.

BuiltBefore40

Period of construction before 1946, **[111]**

Built40to49

Period of construction, 1946 to 1960, **[112] * 0.5**

Built50to59

Period of construction, 1946 to 1960, **[112] * 0.5**

Built60to69

Period of construction, 1960 to 1970, **[113]**

Built70to79

Period of construction, 1971 to 1980, **[114]**

Built80to89

Period of construction, 1981 to 1985, Period of construction, 1986 to 1990, **[115]+ [116]**

Built90to98

Period of construction, 1991 to 1995, Period of construction, 1996 to 2000, **[117] + [118]**

BuiltAfter98

Period of construction, 2001 to 2006, **[119]**

MedianYearBuilt –

Median year housing built. **Use weighted average of construction periods above to calculate the median year. Period of construction years were averaged out to 1940, 1945, 1955, 1965, 1975, 1985, 1995, and 2002 were used for the calculation.**

AvgRent

"Average gross rent $", **[2051]**

AvgValue

“Average value of dwelling $”, **[2055]**

SchoolEnrollmentKto12

[GRADE]

SchoolEnrollmentCollege

College and university enrolment. Do not have access to national data to assess this variable. Leave all cells as 0.

Once these values are all filled, save the spreadsheet into XLS format. The XLS format can then be imported into the state wide dataset through CDMS. (Figure D.12)

	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	DAUID	CensusBlock	Population	Households	GroupQuarters	MaleLess16	Male16to65	MaleOver65	FemaleLess16	Female16to65	FemaleOver65	MalePopulation	FemalePopulation	White
2	59010123	590010010480123	569	250	24	32	212	51	33	206	46	290	280	550
3	59010124	590010010480124	494	205	4	53	188	9	57	159	14	250	240	450
4	59010125	590010010480125	500	215	0	40	174	46	39	159	37	260	235	430
5	59010126	590010010400126	735	285	75	64	251	60	63	250	47	370	360	650
6	59010127	590010018060127	169	65	4	11	60	9	16	59	5	85	85	100
7	59010128	590010010390128	507	220	0	39	169	32	44	187	39	230	275	470
8	59010129	590010010390129	386	165	0	33	153	19	42	144	24	190	195	375
9	59010130	590010010390130	588	230	118	37	171	67	37	157	121	265	325	565
10	59010131	590010010390131	422	170	2	47	120	18	42	150	23	190	230	390
11	59010132	590010010390132	482	175	0	58	149	23	60	171	14	240	245	470
12	59010133	590010010390133	617	230	2	62	225	33	55	227	38	315	305	540
13	59010135	590010010460135	476	195	1	37	174	29	34	184	22	240	235	465
14	59010136	590010018040136	153	55	3	21	50	9	11	44	10	85	70	20
15	59010137	590010010460137	565	255	5	29	205	66	32	198	60	280	285	515
16	59010138	590010010460138	536	225	0	51	193	56	33	166	41	295	245	505
17	59010139	590010010430139	700	290	5	65	242	53	69	239	37	365	335	655
18	59010140	590010010460140	542	215	2	42	192	36	48	186	26	275	265	505
19	59010141	590010010370141	407	185	2	31	128	41	27	150	28	215	195	365
20	59010142	590010010370142	479	230	4	33	174	48	23	174	38	255	225	460
21	59010143	590010010350143	541	220	6	45	189	56	43	185	37	280	260	0
22	59010146	590010018030146	159	50	0	17	58	0	17	53	0	85	75	10
23	59010148	590010010350148	559	225	0	48	196	36	34	200	41	285	275	525
24	59010149	590010010370149	450	185	0	38	165	27	29	179	22	230	225	450
25	59010150	590010010280150	489	200	0	54	163	38	42	151	37	260	230	480
26	59010151	590010010280151	476	220	1	34	154	47	38	150	52	240	240	445
27	59010152	590010010280152	556	245	0	44	180	51	44	195	46	275	280	525
28	59010153	590010010280153	555	280	0	43	166	66	38	167	85	270	290	530
29	59010154	590010010280154	487	210	7	43	154	28	37	160	23	240	245	435
30	59010155	590010010280155	425	220	0	22	135	38	37	145	53	195	235	410
31	59010156	590010010280156	619	330	4	23	182	75	42	212	76	285	330	590
32	59010157	590010010280157	453	225	3	34	158	33	33	124	43	235	215	450
33	59010158	590010010280158	471	225	1	33	155	32	23	171	46	235	235	475
34	59010159	590010010280159	443	175	78	32	114	39	38	115	102	190	250	360
35	59010160	590010010280160	392	175	2	32	150	28	37	140	23	195	200	370
36	59010161	590010010280161	391	160	26	38	134	38	28	129	23	200	185	390
37	59010162	590010010280162	382	160	0	42	114	19	33	134	28	190	195	380
38	59010163	590010010370163	395	185	0	28	169	18	27	155	23	200	190	350
39	59010164	590010010350164	981	400	6	87	368	60	85	358	32	505	470	915

Final2 | BC_Demographics_Final1 | BC_Demographics_Final | BCDemoAllSorted | CensusBlock Empty | Tract En

Ready 100%

Figure D.12: Example of final spreadsheet result ready to be imported into CDMS.

D.6 Acronyms and Variable Definitions

Variables used in calculating ResidDay, ResidNight, Workingcom, WorkingInd, Communting5PM, and SchoolEnrollmentKto12

POP

Population, 2006”, **[2]**

DRES

“Total number of persons in private households”, **[86] – [COMW + INDW]**

NRES

“Total number of persons in private households”, **[86]**

COMM

“Total employed labour force 15 years and over with usual place of work or no fixed workplace address by mode of transportation”, **[1101]**

COMW

“41 Wholesale trade” +
“44-45 Retail trade” +
“48-49 Transportation and warehousing” +
“51 Information and cultural industries” +
“52 Finance and insurance” +
“53 Real estate and rental and leasing” +
“54 Professional, scientific and technical services” +
“55 Management of companies and enterprises” +
“56 Administrative and support, waste management and remediation services” +
“61 Educational services” +
“62 Health care and social assistance” +
“71 Arts, entertainment and recreation” +
“72 Accommodation and food services” +
“81 Other services (except public administration)” +
“91 Public administration”

[1016]+ [1017]+ [1018]+ [1019]+ [1020]+ [1021]+ [1022]+ [1023]+ [1024]+ [1025]+ [1026]+ [1027]+ [1028]+ [1029]+ [1030]

INDW

“11 Agriculture, forestry, fishing and hunting” +
“21 Mining and oil and gas extraction” +
“22 Utilities” +
“23 Construction” +
“31-33 Manufacturing”

[1011]+ [1012] + [1013] + [1014] + [1015]

GRADE

“5 to 9 years” +
“10 to 14 years” +
“15 to 19 years” * 0.8

[[6] + [7] + [8] + [25] + [26] + [27]] * 0.80

PRLF

“Car, truck, van, as driver” +
“Car, truck, van, as passenger” /
“Total employed labour force 15 years and over with usual place of work or no fixed workplace address by mode of transportation”

([1102] + [1103] / [1101])

Table D.1: Statistics Canada Census 2006 to Hazus Data Comparability

<table>
<tr><th>Hazus variable</th><th>STATS CAN Variable</th><th>Hazus Variable Description / Details</th><th>STATS CAN Variable Description</th></tr>
<tr><td>"Tract"</td><td></td><td></td><td></td></tr>
<tr><td>"Population"</td><td>Population, 2006</td><td>Total Population in Census Tract</td><td></td></tr>
<tr><td rowspan="2">"Households"</td><td>Total number of private households</td><td>Total Household in Census Tract</td><td>Refers to a person or a group of persons (other than foreign residents) who occupy the same dwelling and do not have a usual place of residence elsewhere in Canada. It may consist of a family group (census family) with or without other persons, of two or more families sharing a dwelling, of a group of unrelated persons, or of one person living alone. Household members who are temporarily absent on Census Day (e.g., temporary residents elsewhere) are considered as part of their usual household. For census purposes, every person is a member of one and only one household. Unless otherwise specified, all data in household reports are for private households only.</td></tr>
<tr><td colspan="3">Details: A household includes all of the people who occupy a housing unit. (People not living in households are classified as living in group quarters.) A housing unit is a house, an apartment, a mobile home, a group of rooms, or a single room occupied (or if vacant, intended for occupancy) as separate living quarters. Separate living quarters are those in which the occupants live separately from any other people in the building and that have direct access from the outside of the building or through a common hall. The occupants may be a single family, one person living alone, two or more families living together, or any other group of related or unrelated people who share living quarters. In 100-percent tabulations, the count of households or householders always equals the count of occupied housing units. In sample tabulations, the numbers may differ as a result of the weighting process.</td></tr>
<tr><td rowspan="2">"GroupQuarters"</td><td>“total population” – “total people in private household”</td><td>Total Number of People in General Quarter</td><td>Refers to a person or a group of persons who occupy a collective dwelling and do not have a usual place of residence elsewhere in Canada. Data for collective households with foreign and/or temporary residents only are not shown.</td></tr>
<tr><td colspan="3">Details: The group quarters population includes all people not living in households. Two general categories of people in group quarters are recognised: (1) the institutionalised population and (2) the noninstitutionalised population.
Institutionalised population. The institutionalised population includes people under formally authorised, supervised care or custody in institutions at the time of enumeration; such as correctional institutions, nursing homes, and juvenile institutions.
Noninstitutionalised population. The noninstitutionalised population includes all people who live in group quarters other than institutions, such as college dormitories, military quarters, and group homes. Also, included are staffs residing at institutional group quarters.</td></tr>
<tr><td>"MaleLess16"</td><td>“0-4” + “5-9” + “10–14” + (1/5* “15-19”)</td><td></td><td></td></tr>
</table>

Hazus variable	STATS CAN Variable	Hazus Variable Description / Details	STATS CAN Variable Description
"Male16to65"	**(4/5* "15-19") + … + (1/5* "65-69")**		
"MaleOver65"	**(4/5* "65-69") + "70-74" +"75-79" + "80-84" + ">85")**		
"FemaleLess16"	**"0-4" + "5-9" + "10–14" + (1/5* "15-19")**		
"Female16to65"	**(4/5* "15-19") + … + (1/5* "65-69")**		
"FemaleOver65"	**(4/5* "65-69") + "70-74" +"75-79" + "80-84" + ">85")**		
"MalePopulation"	**"Male, total"**		
"FemalePopulation"	**"Female, total"**		
"White"	**"Total population" – "Total Aboriginal" – "Total visible minority"**		
"Black"	**"visible minority – Black"**		
"NativeAmerican"	**"Total Aboriginal identity population"**		
"Asian"	**"West Asian origins" + "South Asian origins" + "East and Southeast Asian origins"**		
"Hispanic"	**"Latin American"**		
"PacifiIslander"	**"Pacific Islands origins"**		
"OtherRaceOnly"	**"Visible minority, n.i.e." (n.i.e. = not included elsewhere)**		
"IncLess10"	**Households income (2005) "Under $10,000"**	Total # of Households with Income < $10,000	
"Inc10to20"	**Households income (2005) "$10,000 to $19,999"**	Total # of Households with Income $10 - $20K	
"Inc20to30"	**Households income (2005) "$20,000 to $29,999"**	Total # of Households with Income $20 - $30K	
"Inc30to40"	**Households income (2005) "$30,000 to $39,999"**	Total # of Households with Income $30 - $40K	
"Inc40to50"	**Households income (2005) "$40,000 to $49,999"**	Total # of Households with Income $40 - $50K	
"Inc50to60"	**Households income (2005) "$50,000 to $59,999"**	Total # of Households with Income $50 - $60K	
"Inc60to75"	**"$60,000 to $69,999" + (1/2* "$70,000 to $79,999"**	Total # of Households with Income $60 - $75K	
"Inc75to100"	**+ (1/2* "$70,000 to $79,999" + "$80,000 to $89,999" + "$90,000 to $99,999"**	Total # of Households with Income $75 - $100K	

Hazus variable	STATS CAN Variable	Hazus Variable Description / Details	STATS CAN Variable Description
"IncOver100"	**Households income (2005) “$100,000 and over”**	Total # of Households with Income > $100k	
"ResidDay"		Total in Residential Property during Day	
"ResidNight"		Total in Residential Property at Night	
"Hotel"		Hotel Occupants	
"Visitor"		Visitor Population	
"WorkingCom"		Total Working Population in Commercial Industry	
"WorkingInd"		Total Working Population in Industrial Industry	
"Commuting5PM"		Total Commuting at 5 PM	
"OwnerSingleUnits"		Total Owner Occupied - Single Household Units	
"OwnerMultUnits"		Total Owner Occupied - Multi-Household Units	
"OwnerMultStructs"		Total Owner Occupied - Multi-Household Structure	
"OnwerMHs"		Total Owner Occupied - Mobile Homes	
"RenterSingleUnits"		Total Renter Occupied - Single Household Units	
"RenterMultUnits"		Total Renter Occupied - Multi-Household Units	
"RenterMultStructs"		Total Renter Occupied - Multi-Household Structure	
"RenterMHs"		Total Renter Occupied - Mobile Homes	
"VacantSingleUnits"		Total Vacant - Single Household Units	
"VacantMultUnits"		Total Vacant - Multi-Household Units	
"VacantMultStructs"		Total Vacant - Multi-Household Structure	

Hazus variable	STATS CAN Variable	Hazus Variable Description / Details	STATS CAN Variable Description
"VacantMHs"		Total Vacant - Mobile Homes	
"BuiltBefore40"	Used data from BC Assessment. Building point's layer joined with census tract layer. Counts calculated using Pivot Table in Excel. (see file: "getting building age ranges.txt" for more info)		This refers to the period in which the building was originally built, not the time of any later remodelling, additions or conversions. Respondents were asked to indicate the period of construction, to the best of their knowledge.
"Built40to49"	See above		
"Built50to59"	See above		
"Built60to69"	See above		
"Built70to79"	See above		
"Built80to89"	See above		
"Built90to98"	See above		
"BuiltAfter98"	See above		
"MedianYearBuilt"	Used an Array formula in excel =MEDIAN(IF(A2:A??=E2,B2:B??))		(See file: "getting building age ranges.txt" for more info.)
"AvgRent"	**"Tenant-occupied private non-farm, non-reserve dwellings - Average gross rent $"**		
"AvgValue"	**"Owner-occupied private non-farm, non-reserve dwellings - Average value of dwelling $"**		
"SchoolEnrollmentKto12"	"Total population 15 to 24 years by highest certificate, diploma or degree – high school degree" + "Total population 65 years and over highest certificate, diploma or degree – high school degree" + "Total population 25 to 64 years by highest certificate, diploma or degree – high school degree"		
"SchoolEnrollmentCollege"	"Total population 15 to 24 years by highest certificate, diploma or degree – University certificate, diploma or degree" + "Total population 65 years and over highest certificate, diploma or degree – University certificate, diploma or degree" + "Total population 25 to 64 years by highest certificate, diploma or degree – University certificate, diploma or degree"		

Table D.2: Defining Hazus Population Variables

HAZUS Parameter	Description	Assessment Method	Comments
POP	population of census tract	[2 Population, 2006]	total populaiton for census tract
DRES	daytime residential population	([86] - (COMM)	(Total number of persons in private households) - (number of people working in commercial/industrial sectors)
NRES	nighttime residential population	[86]	Total number of persons in private households
COMM	number of people commuting	[1101]	Total employed labour force 15 years and over with usual place of work or no fixed workplace address by mode of transportation. (NB: If this total is not available in the database, will need to add rows (1102-1109)
COMW	number of people employed in commercial sector	[(1016) + (1017) + (1018) + (1019) + (1020) + (1021) +(1022) +(1023) +(1024) + (1025) +(1026) + (1027) + (1028) + (1029) +(1030)]	sum of individuals working in commercial sectors, as defined by North American Indusrtry Classification
INDW	number of people employed in industrial sector	[(1011) + (1012) + (1013) + (1014) + (1015)]	sum of individuals working in industry sectors, as defined by North American Indusrtry Classification
GRADE	number of students in grade school K-12)	[(6) + (7) + (8)] * 0.80	(number of children between the age of 5-19 years) * HAZUS correction factor that accounts for those too young to attend school, and those who are likely to be absent on a daily basis
COLLEGE	number of students on college and university campuses in the census tract	0	Do not currently have access to national data to assess this variable
HOTEL	number of people staying in hotels/motels in the census tract	0	Do not currently have access to national data to assess this variable
PRLF	proportion of commuters using automobiles	[(1102) + (1103)] / (1101)	numbers of employed individuals using automobiles/ total number of people commuting to work
VISIT	number of visitors in the census tract for shopping or entertainment	0	Do not currently have access to national data to assess this variable

Appendix E: Addressing Assumptions and Simplifications of Hazus

Based on input from John Cassidy, Seismologist, GSC-Sidney, NRCan
Received August, 2012

To provide more realistic and practical estimates to the planners and responders who would benefit from disaster risk scenarios, some techniques to address current assumptions and simplifications of Hazus were identified for future work. These techniques may include developing a suite of earthquake hazard and risk scenarios in order to better understand the uncertainties associated with each specific scenario.

The probability of earthquake hazards and the resultant impacts is also uncertain. With additional knowledge, these uncertainties could be better understood and reduced. Likewise, the uncertainties in the modelled impacts (for example, impacts on building and infrastructure damage, human injuries and fatalities, and economic costs of the damage) could be reduced by better understanding the limitations of the model's assumptions and simplifications. Some of the assumptions and simplifications of Hazus are summarised in Table E.1. The table identifies some techniques that could be developed and added to the model. By including this additional information in the model, the uncertainties in the modelled impacts could be better communicated and potentially reduced.

Table E.1: Select Assumptions and Techniques to Address Inherent Model Uncertainties

Assumption / Simplification	Technique to Address Limitation	Impact of Improvement on Model Results
Hazus results expressed as losses	Include corresponding probability of earthquake hazard and probability of resultant loss occurring	Results can be expressed as risks
Scenario earthquake is one arbitrary event	Generate models for various possible locations of the scenario earthquake epicentre relative to region of interest and relative to the length and direction of the seismic fault	Range of results can be presented for a region of interest
Scenario earthquake assumes specific seismic behaviour at the source	Generate models for various possible seismic fault mechanisms of the scenario earthquake	Range of results can be presented for a region of interest

Assumption / Simplification	Technique to Address Limitation	Impact of Improvement on Model Results
Scenario earthquake assumes no seismic fault rupture at ground surface	Include effects of ground displacement from surface rupture of scenario earthquake fault	Uncertainties in the results can be reduced
Uniform soil type assumed for a region of interest	Obtain information on the response of local soil types to shaking from earthquake waves	Uncertainties in the results can be reduced
Scenario earthquake assumes shaking in bedrock	Include landslide susceptibility and liquefaction potential in in the hazard model for the scenario earthquake	Uncertainties in the results can be reduced
Scenario earthquake assumes uniform topography in region of interest	Include effects of topography on soil response to earthquake shaking	Uncertainties in the results can be reduced
Scenario earthquake assumes region of interest is on relatively homogeneous landmass	Include effects of the sedimentary basin and soil response at the basin edge	Uncertainties in the results can be reduced
Default asset inventory is limited to residential buildings only	Refine the asset inventory used to represent the built environment	Uncertainties in the results can be reduced and results can be more comprehensive for more asset types in a region of interest
Default building code information for the default asset inventory assumes building age and quality of construction similar to those in comparable US cities	Refining the building code assumptions for the available asset inventory data	Uncertainties in the results can be reduced

Appendix F: Hazus Risk Assessment and Export Tool

The following instructions provide guidance in exporting Hazus datasets into a Scenario 360 database for use in value-added analyses such as CommunityViz.

F.1 Risk Assessment Tool (version 2)

The Risk Assessment tool pulls data from the Hazus database into a Scenario 360 analysis geodatabase. User-selected S360 components will be generated.

For the Risk Assessment button to be enabled, you must open or create a Scenario 360 analysis and verify that the data frame's spatial reference is set.

The Risk Assessment button ( ) is located on the Scenario 360 Decision Tools toolbar. Clicking this button launches the Risk Assessment Wizard. (Figure F.1)

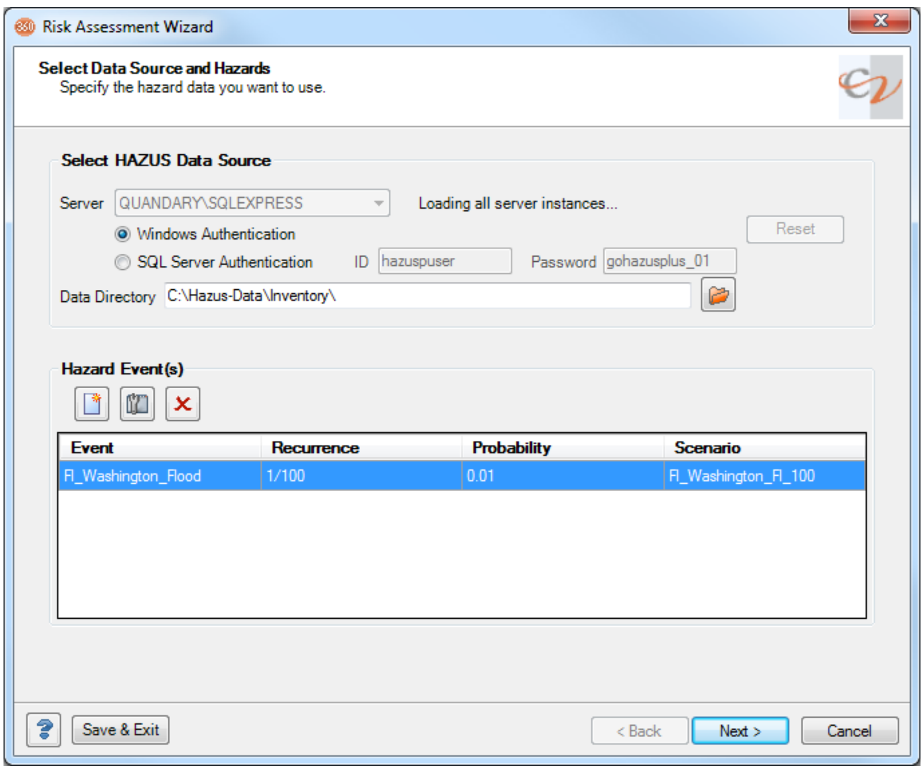


Figure F.1: Page 1 – Select Data Source and Hazards.

<u>Hazus Server/Data information</u>

- Server – This is populated with any SQL Server instances on the local network. The user must choose one.
- Method for connecting to the SQL Server instance. If SQL Server Authentication is chosen, the user must also supply:

- ID – User id for connecting to the SQL Server instance.
    - Password – User password for connecting to the SQL Server instance.

- Data Directory – Path to the directory where Hazus data are located.

Hazard Events

You must populate the ‘Hazard Event(s)’ table with at least one Hazus study region or specific event.

- To add an event to the table, click the ‘New Event’ button, which will open a new page (Figure F.2).

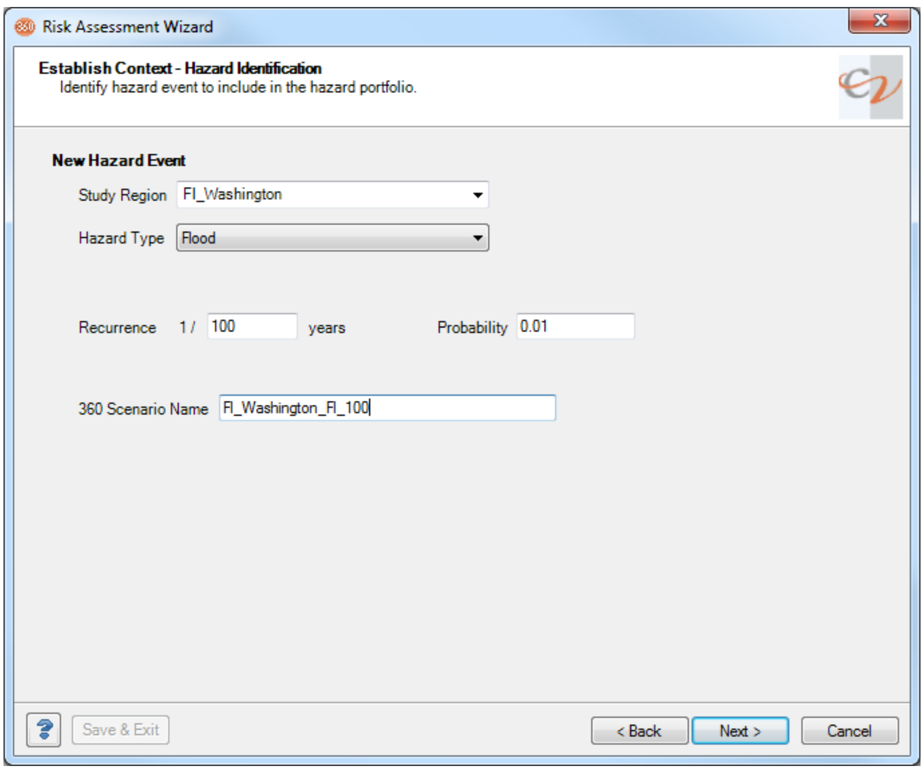


Figure F.2: Establish Context – Hazard Identification.

- Study Region – This is populated with Hazus study regions stored in the selected SQL server instance. The user must select one and only one.

- Hazard Type – The choices in this list are populated based on the selected Study Region.

- o Recurrence – Fill in a recurrence value that was used in the selected Hazus event. It may or may not be required (e.g., earthquake events). Recurrence and probability are related; setting one will automatically set the other.

- o 360 Scenario Name – A Scenario 360 scenario will be generated for every event, and the user has the option to modify the automatically generated scenario name here.

- You can click the 'Properties' button or double-click an item to view or edit details of an event in the table. It will open the same Hazard Identification page as in Figure F.2, but with information populated based on the selected item.

- Click the 'Delete' button to remove the selected event from this Risk Assessment analysis.

After at least one event has been added to the 'Hazard Event' table, you will be able to proceed to the next page of the wizard (Figure F.3).

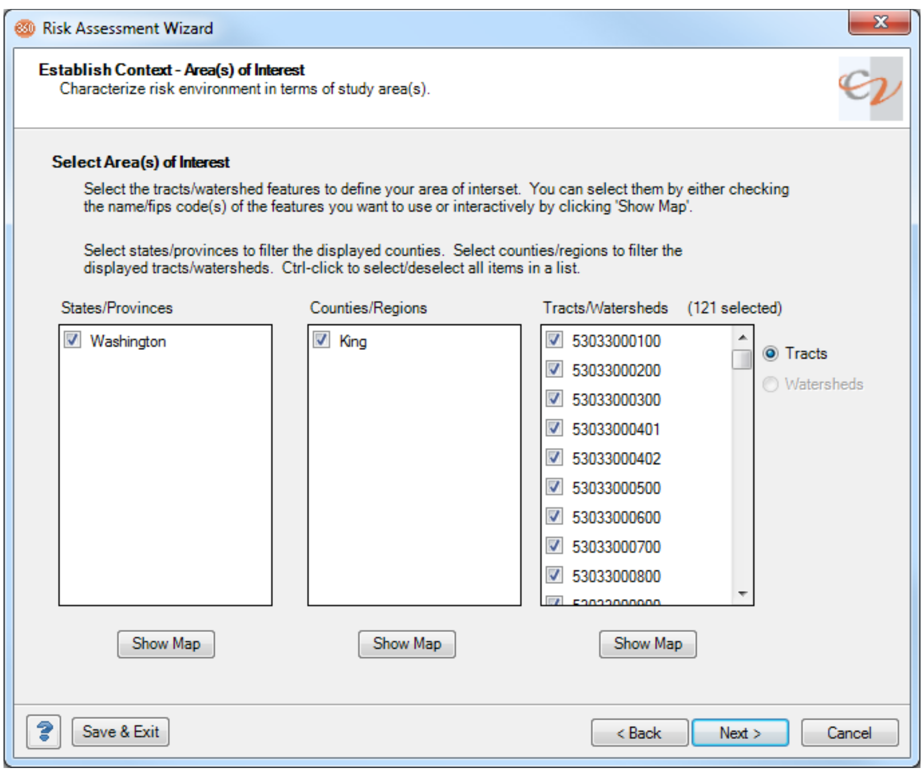


Figure F.3: Page 2 – Establish Context – Area(s) of Interest.

You must select one or more tracts (which are populated from those for which the Hazus analysis was run).

Clicking the ‘Show Map’ button opens a separate form with a simple map control that contains one layer (states/provinces, counties/regions, or tracts, depending on the list above the clicked button). You can interactively select one or more features through this form, if desired. (Figure F.4)

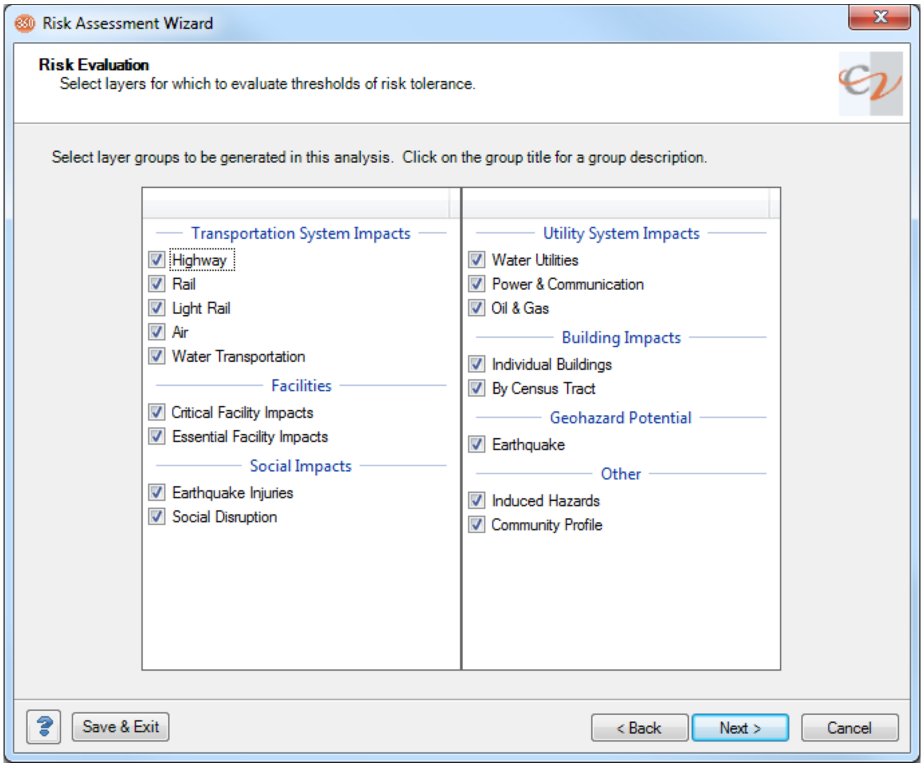


Figure F.4: Page 3 – Risk Evaluation.

The user must select one or more layer types to be generated. (Figure F.5) The layer groups shown in this list will vary based on the selected hazard event type(s). For instance, Critical Facility Impacts are only available for earthquake events.

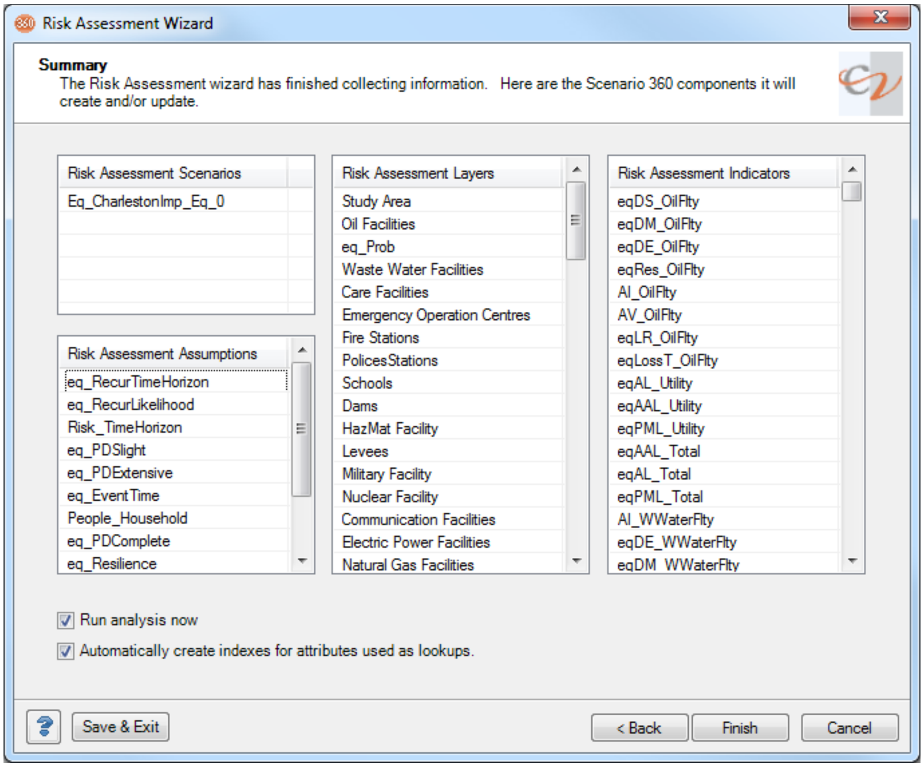


Figure F.5: Page 4 – Summary.

The lists shown here contain a summary of the 360 components that will be created, or modified if they already exist in this analysis. These lists are not editable; if you want to make changes, you will need to go back to the appropriate page in the wizard.

Clicking 'Finish' on the wizard:

1. Creates the relevant 360 components.
2. Imports data from Hazus into the analysis geodatabase.
3. Runs an update on all the new components, if you selected to do so.

This version of the tool differs from the earlier version of the tool in the following ways:

- it is compatible with Hazus 2.0 (ArcMap 10);
- instead of choosing indicators/groups of indicators to evaluate, the user chooses data/groups of layers; and
- the data model has been updated.

F.2 Export Tool

The Hazus Export tool exports data from a Scenario 360 point layer to Hazus user-defined facilities (UDF) datasets for use in a Hazus analysis run. The Export tool ( ) is found next to the Risk Assessment tool on the Scenario 360 Decision Tools toolbar. For the Export button to be enabled, a Scenario 360 analysis must be opened and the data frame must have a defined spatial reference. This tool is independent of the Hazus Risk Assessment tool.

Clicking the decisions toolbar button launches the Export tool and the Hazus Export To UDF form (Figure F.6).

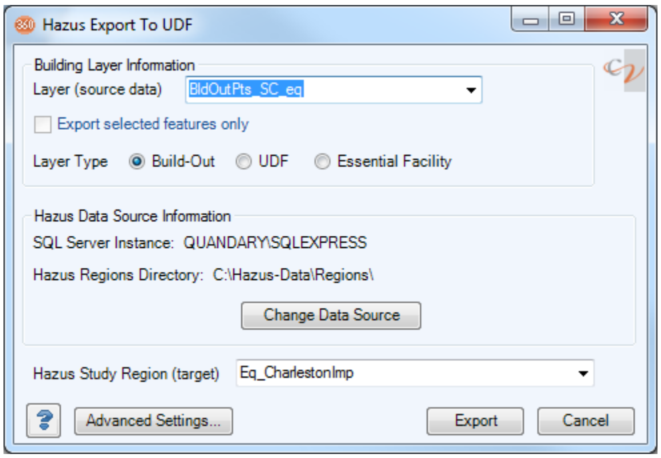


Figure F.6: Hazus Export To UDF.

<u>User Inputs</u>

1. Select a buildings layer (the source data) and an existing Hazus study area (the target dataset). The Buildings Layer drop-down box is populated with all point features in the Scenario 360 analysis that have one or more features in them in the active scenario.

2. Next, select the layer's corresponding type: build-out layer, UDF layer, or essential facilities layer. UDF and essential facilities layers are assumed to be those that could be created from running the Risk Assessment tool. All of these layer types have pre-defined schema requirements, so, if you have modified the attributes of a Build-out or Risk Assessment generated layer, the layer may not be accepted.

3. Verify that the Hazus data source information is correct. This is populated automatically with settings made when Hazus was installed, but you can change

the data source by clicking ‘Change Data Source’. Any changes made to the Hazus data locations are saved with the current analysis only.

4. Select a target Hazus study region to export the data to. The Hazus Study Region drop-down box is populated with all Hazus study regions found in the specified Hazus database server.

5. Optionally, click Advanced Settings to view the buildings point data to Hazus occupancy code mappings. This button is disabled if you have chosen a UDF layer. This opens another form where you can set Hazus types that correspond to your selected layer’s features land use designation, building use, and potentially dwelling units range. See below in this section for more information on the Advanced Settings Form.

Export Process

Once all inputs are set and verified, clicking ‘Export’ performs the following:

1. Inputs and settings are validated:

    a. The selected build-out layer is searched for required fields (seeFigure F.7). If any of the required fields are not found, the export process stops.

    b. The Hazus user-defined facility feature class and SQL tables are identified. If they cannot be found, you are notified and the process stops.

    c. Each land-use designation in the buildings layer must have a corresponding Hazus occupancy code. If one or more do not, you are prompted to set them.

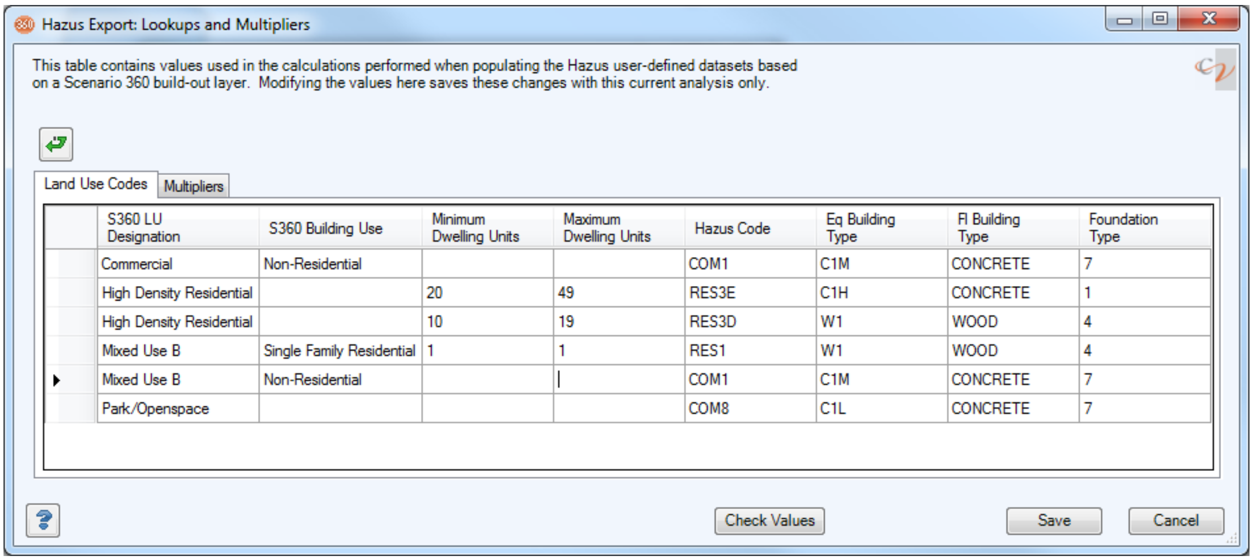
2. Building point features from the active scenario are copied to the feature class hzUserDefFlty in the UDS geodatabase, which is found in the selected Hazus study region folder. The tract id for each feature is determined spatially.

3. The sql tables are populated: hzUserDefinedFlty and the hazard-specific table (e.g., eqUserDefinedFlty).

Refer to the Community Viz Buildout to Hazus User Defined Facilities Data Conversion document for details on how these tables are populated and the system default settings.

Advanced Settings Form

The following screenshot is an example of the table generated for a build-out layer; it has different columns for an essential facilities layer.



Hazus Export: Lookups and Multipliers

This table contains values used in the calculations performed when populating the Hazus user-defined datasets based on a Scenario 360 build-out layer. Modifying the values here saves these changes with this current analysis only.

Land Use Codes | Multipliers

S360 LU Designation	S360 Building Use	Minimum Dwelling Units	Maximum Dwelling Units	Hazus Code	Eq Building Type	Fl Building Type	Foundation Type
Commercial	Non-Residential			COM1	C1M	CONCRETE	7
High Density Residential		20	49	RES3E	C1H	CONCRETE	1
High Density Residential		10	19	RES3D	W1	WOOD	4
Mixed Use B	Single Family Residential	1	1	RES1	W1	WOOD	4
Mixed Use B	Non-Residential			COM1	C1M	CONCRETE	7
Park/Openspace				COM8	C1L	CONCRETE	7

Check Values | Save | Cancel

Figure F.7: Hazus Export: Lookup and Multipliers.

The first two columns are not editable; they are the unique combination of the two in the selected buildings layer. This information is pre-populated from standard build-out land use types, but you can change the default settings. Also, some settings in your selected layer may not be captured in the default settings. If this is the case, you will be prompted to set the Hazus code and types in this form before proceeding with the export.

Clicking 'Check Values' in this form simply validates your inputs and verifies there are no duplications. The 'Restore' button resets any changes you made to system defaults. Click 'Save' to save your settings and return to the main export form.

The Multipliers tab contains multipliers for each Hazus occupancy code that are used to estimate costs based on floor area. Because build-out is the only layer type that does not have cost or content cost for each feature (the other two types should), this tab is only available if you have selected a build-out layer.

Required Fields

Following is a list of attribute names required for each layer type. Additional attribute information is written to the Hazus UDF tables if the fields are available.

Build-out

- Land Use Designation
- Building Use
- Dwelling Units
- Floor Area

UDF

- HzOccupCode
- UserDefinedFltyID
- EqBldgType
- EqDesignLevel
- DesignLevel

Essential Facilities

- EqBldgType
- FlDesignLevel

Appendix G: BC Assessment Translation to Hazus

Table G.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 decided not to have a HAZUS equivalent and are not included in the HAZUS data.

2. The classification didn't differentiate between agriculture and listed all as simply "AGR".

Table G.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
49	FOURPLEX	Multi- Family	RES3B

Actual Use Code	Actual Use	Land Use	Hazus Code
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*
181	MIXED - VACANT	Agriculture-Mixed	*AGR*

Actual Use Code	Actual Use	Land Use	Hazus Code
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
234	MANUFACTURED HOME PARK	Commercial-Service	RES2

Actual Use Code	Actual Use	Land Use	Hazus Code
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
407	SOFT DRINK BOTTLING (GAL/SHIFT)	Commercial-Miscellaneous	IND1

Actual Use Code	Actual Use	Land Use	Hazus Code
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
443	MINING & MILLING - NON-METALLIC (INCLUDING ASBESTOS)	Industrial	IND4

Actual Use Code	Actual Use	Land Use	Hazus Code
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	-
530	TELECOMMUNICATIONS (OTHER THAN TELEPHONE)	Industrial-Services	-

Actual Use Code	Actual Use	Land Use	Hazus Code
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	-

Appendix H: 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 shows 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 this appendix 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 Canada User and Technical Manual (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).

The glossary terms in this appendix are organised alphabetically in dictionary format, with each term explained by at least one definition, each from the source indicated in brackets. The definitions provided by the United Nations International Strategy for Disaster Reduction (UNISDR) are considered most commonly accepted and authoritative, however, the definitions from the selected sources allows users to understand how other fields might use the terms.

The sources, as they appear in the glossary, are:

UN ISDR: United Nations International Strategy for Disaster Reduction, 2009. 2009 UNISDR terminology on disaster risk reduction; The United Nations Office for Disaster Risk Reduction, http://www.unisdr.org/we/inform/publications/7817.

PSC EM Vocabulary: Public Safety Canada, 2012. Emergency management vocabulary; PWGSC of the Government of Canada, http://www.bt-tb.tpsgc-pwgsc.gc.ca/btb.php?lang=eng&cont=1142

ISO Guide 73: International Organization for Standardization, 2008. ISO/IEC Guide 73 Risk management – vocabulary, http://www.iso.org/iso/catalogue_detail?csnumber=44651.

CSA Q850-97: Canadian Standards Association, 1997. CAN/CSA-Q850-97 Risk management: guideline for decision-makers. The edition was reaffirmed in 2002.

EERI Glossary of Terms: EERI Committee on Seismic Risk, 1984. Glossary of terms for probabilistic seismic-risk and hazard analysis; Earthquake Spectra, v. 1. no. 1 p. 33-40.

APEGBC Guidelines: Association of Professional Engineers and Geoscientists of British Columbia (APEGBC); 2010, Guidelines for legislated landslide assessments for proposed residential developments in BC; and 2012, Professional practice guidelines – legislated flood assessments in a changing climate in BC; APEGBC, http://www.apeg.bc.ca/ppractice/ppdocs.html.

Australian Emergency Management Glossary: Emergency Management Australia, 1998. Australian emergency management glossary; Commonwealth of Australia, http://www.ema.gov.au/www/emaweb/rwpattach.nsf/VAP/(3273BD3F76A7A5DEDAE36942A54D7D90)~Manual03-AEMGlossary.PDF/$file/Manual03-AEMGlossary.PDF.

DHS Risk Lexicon: Department of Homeland Security, 2008. DHS risk lexicon; US Department of Homeland Security, http://www.dhs.gov/xlibrary/assets/dhs-risk-lexicon-2010.pdf.

FEMA's Hazus: Federal Emergency Management Agency, 2012. Hazus-MH 2.1 earthquake model user manual; http://www.fema.gov/library/viewRecord.do?id=5120.

Glossary terms:

Active fault

1. A fault that on the basis of historical, seismological, or geological evidence has a high probability of producing an earthquake.
   Alternate: a fault that may produce an earthquake within a specified exposure time, given the assumptions adopted for a specific seismic-risk analysis. ***(EERI Glossary of Terms)***

2. A fault along which slip has occurred in historical (or Holocene) time, or on which earthquake foci are located. ***(Australian Emergency Management Glossary)***

Asset

1. A person, structure, facility, information, material or process that has value. ***(PSC EM Vocabulary)***

2. Person, structure, facility, information, material, or process that has value.
   Example: Some organizations use an asset inventory to plan protective security activities.
   Extended Definition: includes: contracts, facilities, property, records, unobligated or unexpended balances of appropriations, and other funds or resources, personnel, intelligence, technology, or physical infrastructure, or anything useful that contributes to the success of something, such as an organizational mission; assets are things of value or properties to which value can be assigned; from an intelligence standpoint, includes any resource – person, group, relationship, instrument, installation, or supply – at the disposal of an intelligence organization for use in an operational or support role.
   Annotation: In some domains, capabilities and activities may be considered assets as well. In the context of the National Infrastructure Protection Plan, people are not considered assets. ***(DHS Risk Lexicon)***

3. Any manmade or natural feature that has value, including people; buildings; infrastructure such as bridges, roads, and sewer and water systems; lifelines such as electricity and communication resources; and environmental, cultural, or recreational features such as parks, dunes, wetlands, and landmarks. ***(FEMA's Hazus)***

Base map

1. A map that graphically presents your study region. Base map layers might include the study region boundary, jurisdictional boundaries, and geographic frames of reference, including roads, water bodies, hospitals, and schools. ***(FEMA's Hazus)***

Building code

1. A set of ordinances or regulations and associated standards intended to control aspects of the design, construction, materials, alteration and occupancy of structures that are necessary to ensure human safety and welfare, including resistance to collapse and damage.
   Comment: Building codes can include both technical and functional standards. They should incorporate the lessons of international experience and should be tailored to national and local circumstances. A systematic regime of enforcement is a critical supporting requirement for effective implementation of building codes. ***(UN ISDR)***

Community

1. A group with a commonality of association and generally defined by location, shared experience, or function. A social group which has a number of things in common, such as shared experience, locality, culture, heritage, language, ethnicity, pastimes, occupation, workplace, etc. ***(Australian Emergency Management Glossary)***

Consequence

1. Outcome of an event affecting objectives.
   Note 1: An event can lead to a range of consequences.
   Note 2: A consequence can be certain or uncertain and can have positive or negative effects on objectives.
   Note 3: Consequences can be expressed qualitatively or quantitatively. ***(ISO Guide 73)***

2. A result or effect on human well-being, property or the environment due to a landslide occurring. The outcomes or potential outcomes arising from the occurrence of a flood expressed qualitatively or quantitatively in terms of loss, disadvantage or gain, damage, injury or loss of life. ***(APEGBC Guidelines 2010, 2012)***

3. The outcome of an event or situation expressed qualitatively or quantitatively, being a loss, injury, disadvantage or gain. The outcome of an event or situation expressed qualitatively or quantitatively. In the emergency risk management context, consequences are generally described as the effects on persons, society, the environment and the economy. ***(Australian Emergency Management Glossary)***

4. Effect of an event, incident, or occurrence.
   Example: One consequence of the explosion was the loss of over 50 lives.
   Annotation: Consequence is commonly measured in four ways: human, economic, mission, and psychological, but may also include other factors such as impact on the environment. ***(DHS Risk Lexicon)***

Consequence analysis/assessment

1. The process of identifying and evaluating the potential or actual effects of an event or incident. ***(PSC EM Vocabulary)***

2. The estimation of the effect of potential hazardous events. ***(Australian Emergency Management Glossary)***

3. Process of identifying or evaluating the potential or actual effects of an event, incident, or occurrence.
   Example: The consequence assessment for the hurricane included estimates for human casualties and property damage caused by the landfall of the hurricane and cascading effects. ***(DHS Risk Lexicon)***

Consequence management

1. The coordination and implementation of measures and activities undertaken to alleviate the damage, loss, hardship and suffering caused by an emergency.
   Note: Consequence management also includes measures to restore essential government services, protect public health and provide emergency relief to affected governments, businesses and populations. ***(PSC EM Vocabulary)***

Critical asset

1. An asset whose compromise would result in a high degree of injury to the health, safety, security or economic well-being of Canadians or to the effective functioning of the Government of Canada. ***(PSC EM Vocabulary)***

Critical facility

1. The primary physical structures, technical facilities and systems which are socially, economically or operationally essential to the functioning of a society or community, both in routine circumstances and in the extreme circumstances of an emergency.
   Comment: Critical facilities are elements of the infrastructure that support essential services in a society. They include such things as transport systems, air and sea ports, electricity, water and communications systems, hospitals and health clinics, and centres for fire, police and public administration services. ***(UN ISDR)***

2. Facilities that are critical to the health and welfare of the population and that are especially important following hazard events. Critical facilities include essential facilities, transportation systems, lifeline utility systems, high potential loss facilities, and hazardous material facilities. ***(FEMA's Hazus)***

Critical infrastructure

1. The processes, systems, facilities, technologies, networks, assets and services essential to the health, safety, security or economic well-being of Canadians and to the effective functioning of government.
   Note: Critical infrastructure can be stand-alone or interconnected and interdependent within and across provinces, territories and national borders. Disruptions of critical infrastructure could result in catastrophic loss of life, adverse economic effects and significant harm to public confidence. ***(PSC EM Vocabulary)***

Damage

1. Any economic loss or destruction caused by earthquakes. ***(EERI Glossary of Terms)***

Damage assessment

1. A report on the extent of damage caused by an event. ***(Australian Emergency Management Glossary)***

Deterministic / Deterministic analysis

1. Leading to reasonably clear-cut solutions on the basis of prescriptive rules. The process of determining the probable maximum flood is an example of a deterministic process. Deterministic contrasts with probabilistic. ***(Australian Emergency Management Glossary)***

2. Relies on the laws of physics or on correlations developed through experience or testing to predict the outcome of a particular hazard scenario. ***(FEMA's Hazus)***

Disaster

1. A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources.
   Comment: Disasters are often described as a result of the combination of: the exposure to a hazard; the conditions of vulnerability that are present; and insufficient capacity or measures to reduce or cope with the potential negative consequences. Disaster impacts may include loss of life, injury, disease and other negative effects on human physical, mental and social well-being, together with damage to property, destruction of assets, loss of services, social and economic disruption and environmental degradation. ***(UN ISDR)***

2. An event that results when a hazard impacts a vulnerable community in a way that exceeds or overwhelms the community's ability to cope and may cause serious harm to the safety, health or welfare of people, or damage to property or the environment.
   Note: A disaster may be triggered by a naturally occurring phenomenon that has its origins within the geophysical or biological environment or by human action or error, whether malicious or unintentional, including technological failures and terrorist acts. ***(PSC EM Vocabulary)***

3. A serious disruption to community life which threatens or causes death or injury in that community and/or damage to property which is beyond the day-to-day capacity of the prescribed statutory authorities and which requires special mobilisation and organisation of resources other than those normally available to those authorities. ***(Australian Emergency Management Glossary)***

Disaster risk

1. The potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period.
   Comment: The definition of disaster risk reflects the concept of disasters as the outcome of continuously present conditions of risk. Disaster risk comprises different types of potential losses which are often difficult to quantify. Nevertheless, with knowledge of the prevailing hazards and the patterns of population and socio-economic development, disaster risks can be assessed and mapped, in broad terms at least. ***(UN ISDR)***

Disaster risk management

1. The systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster.
   Comment: This term is an extension of the more general term "risk management" to address the specific issue of disaster risks. Disaster risk management aims to avoid, lessen or transfer the adverse effects of hazards through activities and measures for prevention, mitigation and preparedness. ***(UN ISDR)***

Disaster risk reduction

1. The concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events.
   Comment: A comprehensive approach to reduce disaster risks is set out in the United Nations-endorsed Hyogo Framework for Action, adopted in 2005, whose expected outcome is "The substantial reduction of disaster losses, in lives and the social, economic and environmental assets of communities and countries." The International Strategy for Disaster Reduction (ISDR) system provides a vehicle for cooperation among Governments, organisations and civil society actors to assist in the implementation of the Framework. Note that while the term "disaster reduction" is sometimes used, the term "disaster risk reduction" provides a better recognition of the ongoing potential to reduce these risks. ***(UN ISDR)***

2. The concept and practice of reducing disaster risks through systematic efforts to analyze and manage the causal factors of disasters.
   Note: Disaster risk reduction includes implementing measures for the mitigation and prevention of exposure to hazards, decreasing the vulnerability of individuals and society, the strategic management of land and the environment, improved preparedness for disaster risks, coordinated responses and planning and the establishment of forward-looking recovery measures. ***(PSC EM Vocabulary)***

Disaster risk reduction plan

1. A document prepared by an authority, sector, organization or enterprise that sets out goals and specific objectives for reducing disaster risks together with related actions to accomplish these objectives.
   Comment: Disaster risk reduction plans should be guided by the Hyogo Framework and considered and coordinated within relevant development plans, resource allocations and programme activities. National level plans needs to be specific to each level of administrative responsibility and adapted to the different social and geographical circumstances that are present. The time frame and responsibilities for implementation and the sources of funding should be specified in the plan. Linkages to climate change adaptation plans should be made where possible. ***(UN ISDR)***

Displacement time

1. The average time (in days) that a building's occupants typically must operate from a temporary location while repairs are being made to the building because of damages resulting from a hazard event. ***(FEMA's Hazus)***

Duration

1. A qualitative or quantitative description of the length of time during which ground motion at a site shows certain characteristics (perceptibility, violent shaking, etc.). ***(EERI Glossary of Terms)***

Earthquake

1. A sudden motion or vibration in the earth caused by the abrupt release of energy in the earth's lithosphere. The wave motion may range from violent at some locations to imperceptible at others. ***(EERI Glossary of Terms)***

2. The vibrations of the Earth caused by the passage of seismic waves radiating from some source of elastic energy. ***(Australian Emergency Management Glossary)***

3. A sudden motion or trembling of the earth's crust that is caused by a release of strain accumulated within or along the edge of the earth's tectonic plates. ***(FEMA's Hazus)***

Earthquake intensity

1. A measure of ground shaking obtained from the damage done to structures built by humans, changes in the Earth's surface and felt reports. ***(Australian Emergency Management Glossary)***

Earthquake magnitude

1. A quantity that is characteristic of the total energy released by an earthquake, in contrast to 'intensity' which subjectively describes earthquake effects at a particular place. Richter in 1935 devised the logarithmic magnitude scale in current use to define local magnitude (ML) in terms of the motion that would be measured by a standard type of seismograph located 100 kilometres from the epicentre of an earthquake. Several other magnitude scales are also in use, for example body-wave magnitude (MB) and surface-wave magnitude (MS) which use body waves and surface waves respectively. The scale is open-ended but the largest known earthquake magnitudes are about MS 8.5. ***(Australian Emergency Management Glossary)***

Earthquake risk

1. The relative risk is the comparative earthquake hazard from one site to another. The probabilistic risk is the odds of earthquake occurrence within a given time interval and region. ***(Australian Emergency Management Glossary)***

Economic consequence

1. Effect of an incident, event, or occurrence on the value of property or on the production, trade, distribution, or use of income, wealth, or commodities.
   Example: The loss of the company's entire trucking fleet was an economic consequence of the tornado.
   Annotation: When measuring economic consequence in the context of homeland security risk, consequences are usually assessed as negative and measured in monetary units. ***(DHS Risk Lexicon)***

Emergency

1. A present or imminent event that requires prompt coordination of actions concerning persons or property to protect the health, safety or welfare of people, or to limit damage to property or the environment.
   Note: The terms "crisis" and "emergency" are not interchangeable. However, a crisis may become an emergency. For example, civil unrest over an unpopular government policy may spark widespread riots. ***(PSC EM Vocabulary)***

2. An event, actual or imminent, which endangers or threatens to endanger life, property or the environment, and which requires a significant and coordinated response. Any event which arises internally or from external sources which may adversely affect the safety of persons in a building or the community in general and requires immediate response by the occupants. An unplanned situation arising, through accident or error, in which people and/or property are exposed to potential danger from the hazards of dangerous goods. Such emergencies will normally arise from vehicle accident, spillage or leakage of material or from a fire. In terms of dam operation, any condition which develops unexpectedly, endangers the integrity of the dam or downstream property and life and requires immediate action. ***(Australian Emergency Management Glossary)***

Emergency management

1. The organization and management of resources and responsibilities for addressing all aspects of emergencies, in particular preparedness, response and initial recovery steps.
   Comment: A crisis or emergency is a threatening condition that requires urgent action. Effective emergency action can avoid the escalation of an event into a disaster. Emergency management involves plans and institutional arrangements to engage and guide the efforts of government, non-government, voluntary and private agencies in comprehensive and coordinated ways to respond to the entire spectrum of emergency needs. The expression “disaster management” is sometimes used instead of emergency management. ***(UN ISDR)***

2. The management of emergencies concerning all hazards, including all activities and risk management measures related to prevention and mitigation, preparedness, response and recovery. ***(PSC EM Vocabulary)***

3. A range of measures to manage risks to communities and the environment. The organisation and management of resources for dealing with all aspects of emergencies. Emergency management involves the plans, structures and arrangements which are established to bring together the normal endeavours of government, voluntary and private agencies in a comprehensive and coordinated way to deal with the whole spectrum of emergency needs including prevention, response and recovery. ***(Australian Emergency Management Glossary)***

Emergency management planning

1. A process through which emergency management plans, policies and procedures are developed, validated and maintained. ***(PSC EM Vocabulary)***

Emergency mitigation plan

1. An emergency plan that describes actions and procedures that apply to the mitigation phase of emergency management. ***(PSC EM Vocabulary)***

Emergency plan

1. A plan that describes assigned responsibilities, actions and procedures required in the event of an emergency. ***(PSC EM Vocabulary)***

2. A documented scheme of assigned responsibilities, actions and procedures, required in the event of an emergency. ***(Australian Emergency Management Glossary)***

Essential facility

1. A facility that is important to a full recovery of a community or state following a hazard event. Essential facilities include government functions; major employers; banks; schools; and certain commercial establishments such as grocery stores, hardware stores, and gasoline stations. ***(FEMA's Hazus)***

Evaluation

1. The process of examining and measuring how well an entity, procedure or action has met or is meeting stated objectives. ***(PSC EM Vocabulary)***

2. Post-disaster appraisal of all aspects of the disaster and its effects. ***(Australian Emergency Management Glossary)***

3. Process of examining, measuring and/or judging how well an entity, procedure, or action has met or is meeting stated objectives.
   Example: After increasing the number of sensors at the port, the team conducted an evaluation to determine how the sensors reduced risks to the facility.
   Annotation: Evaluation is the step in the risk management cycle that measures the effectiveness of an implemented risk management option. ***(DHS Risk Lexicon)***

Event

1. A significant occurrence that may or may not be planned and may impact the safety and security of Canadians.
   Note: An unplanned event can usually be foreseen or expected, for example a meteorological event. Examples of planned events include conferences, concerts, parades or sporting events. ***(PSC EM Vocabulary)***

2. Occurrence or change of a particular set of circumstances.
   Note 1: Nature, likelihood, and consequence of an event can not be fully knowable.
   Note 2: An event can be one or more occurrences, and can have several causes.
   Note 3: Likelihood associated with the event can be determined.
   Note 4: An event can consist of a non-occurrence of one or more circumstances.
   Note 5: An event with a consequence is sometimes referred to as "incident."
   Note 6: An event where no loss occurs may also be referred to as a "near miss," "near hit," "close call" or "dangerous occurrence." ***(ISO Guide 73)***

3. An incident or situation, which occurs in a particular place during a particular interval of time. ***(Australian Emergency Management Glossary)***

Exceedance probability

1. The probability that a specified level of ground motion or specified social or economic consequences of earthquakes will be exceeded at a site or in a region during a specified exposure time. ***(EERI Glossary of Terms)***

2. The probability that an event of a given magnitude, or any greater magnitude, will occur. Exceedance probability relates to a given time period, commonly one year. ***(Australian Emergency Management Glossary)***

Exercise

1. In emergency management, a simulated scenario in which an organization practises its response activities to test its emergency plan.
   Note: The scenario should reflect reality as far as is practicable. The outcome of an exercise allows an organization to reveal planning weaknesses or gaps in resources, improve organizational coordination and communications, clarify roles and responsibilities, improve individual performance and satisfy regulatory requirements. ***(PSC EM Vocabulary)***

2. Simulation of emergency management events, through discussion or actual deployment of personnel, in order:
   - to train personnel;
   - to review/test the planning process or other procedures;
   - to identify needs and/or weaknesses;
   - to demonstrate capabilities; and
   - to practice people in working together. ***(Australian Emergency Management Glossary)***

Expected loss

1. The expected number of lives lost, persons injured, damage to property and disruption of essential services and economic activity due to the impact of a particular natural or man-made hazard. It includes physical, social, functional and economic effects. ***(Australian Emergency Management Glossary)***

Exposure

1. People, property, systems, or other elements present in hazard zones that are thereby subject to potential losses.
   Comment: Measures of exposure can include the number of people or types of assets in an area. These can be combined with the specific vulnerability of the exposed elements to any particular hazard to estimate the quantitative risks associated with that hazard in the area of interest. ***(UN ISDR)***

2. Extent to which an organization is subject to an event. ***(ISO Guide 73)***

3. The potential economic loss to all or a certain subset of structures as a result of one or more earthquakes in an area. This term usually refers to the insured value of structures carried by one or more insurers. ***(EERI Glossary of Terms)***

4. Either: the circumstance of being exposed to radiation, or: a defined dosimetric quantity now no longer used for radiation protection purposes. ***(Australian Emergency Management Glossary)***

Flood

1. The overflowing by water of the normal confines of a stream or other body of water, or the accumulation of water by drainage over areas which are not normally submerged. ***(Australian Emergency Management Glossary)***

2. A general and temporary condition of partial or complete inundation of normally dry land areas resulting from (1) overflow of inland or tidal waters, (2) unusual and rapid accumulation or runoff of surface waters from any source, or (3) mudflows or the sudden collapse of shoreline land. ***(FEMA's Hazus)***

Flood damage

1. The tangible and intangible costs of flooding. Tangible costs can be quantified in monetary terms, eg. damage to goods and possessions, loss of income or services during the flood aftermath, etc. Intangible damages represent the increased levels of physical, emotional and psychological illness in flood affected people attributed to a flooding episode and are less easy to quantify in monetary terms. ***(Australian Emergency Management Glossary)***

Flood hazard

1. The potential for loss of life or injury and potential damage to property resulting from flooding. The degree of flood hazard varies with circumstances across the full range of floods. ***(APEGBC Guidelines 2010, 2012)***

2. The potential loss of life, property and services which can be directly attributed to a flood. ***(Australian Emergency Management Glossary)***

Flood hazard map

1. A map that includes historic as well as potential future flood events of variable probability, illustrating the intensity and magnitude of the hazard at an appropriate scale. A flood hazard map forms the basis of considerations and determinations in land use control with respect to potential flooding, floodproofing of construction and flood awareness and preparedness. ***(APEGBC Guidelines 2010, 2012)***

Flood information tool (FIT)

1. A tool designed to process and convert locally available flood information into data that can be used by the Hazards U.S. (HAZUS) flood module. The FIT is a system of instructions, tutorials, and GIS scripts. When provided with user-supplied inputs (e.g. ground elevations, flood elevations, and floodplain boundary information), the FIT calculates flood depths and elevations for riverine and coastal flood hazards. ***(FEMA's Hazus)***

Flood risk

1. The combination of the probability of a flood event and the potential adverse consequences to human health, the environment and economic activity associated with a flood event. ***(APEGBC Guidelines 2010, 2012)***

2. The probability of losses occurring due to flooding. The chance of failure of the dam over its life due to inadequate spillway capacity and freeboard provisions. ***(Australian Emergency Management Glossary)***

Flood risk map

1. A map that combines the consequences of a flood with a flood hazard. For example, a flood risk map can show the likely economic losses for a 500-year return period event under a given hazard scenario (dike overtopping or dike breaches). A flood risk map could also show the population at risk for a given return period flood, or show likely fatalities for evacuated and non-evacuated hazard scenarios. ***(APEGBC Guidelines 2010, 2012)***

Fragility curve

1. A function that defines the probability of failure as a function of an applied load level. ***(Australian Emergency Management Glossary)***

Frequency – See also **Likelihood**; **Probability**

1. The number of occurrences of an event in a defined period of time. ***(PSC EM Vocabulary)***

2. Measure of the likelihood of an event expressed as a number of events or outcomes per defined unit of time. ***(ISO Guide 73)***

3. A measure of likelihood expressed as the number of occurrences of an event in a given time. See also Likelihood; Probability ***(Australian Emergency Management Glossary)***

4. A measure of how often events of a particular magnitude are expected to occur. Frequency describes how often a hazard of a specific magnitude, duration, or extent typically occurs. Statistically, a hazard with a 100-year recurrence interval is expected to occur once every 100 years on average and has a 1 percent chance (its probability) of happening in any given year. The reliability of frequency information varies depending on the kind of hazard being considered. ***(FEMA's Hazus)***

Function loss

1. Functional downtime costs + displacement time costs. ***(FEMA's Hazus)***

General building stock

1. General building types and occupancy classes. ***(FEMA's Hazus)***

Geohazard / Geologic(al) hazard – See also **Natural hazard**

1. Geological process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage. ***(UN ISDR)***

2. A geologic process (e.g. landsliding, liquefaction soils, active faulting) that during an earthquake or other natural event may produce adverse effects in structures. ***(EERI Glossary of Terms)***

3. A geologic process (e.g., landsliding, liquefaction soils, active faulting) that during an earthquake or other natural event may produce adverse effects in structures. ***(APEGBC Guidelines 2010, 2012)***

4. A natural earth surface process which may interfere adversely with human activity, including processes of a geological, geomorphological, geophysical, hydrogeological, geographical, physiographical or geotechnical nature. ***(Australian Emergency Management Glossary)***

Ground motion

1. A general term for all seismic related motions of the ground, including ground acceleration, slope displacement and stress and strain. ***(APEGBC Guidelines 2010, 2012)***

2. Seismic vibration of the ground at a particular point, recorded by accelerograph or seismograph in order to determine the vibrational characteristics of an earthquake or explosion. ***(Australian Emergency Management Glossary)***

Harm

1. A physical injury or damage to health, property or the environment. ***(Australian Emergency Management Glossary)***

Hazard – See also **Threat**

1. A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.
   Comment: The hazards of concern to disaster risk reduction as stated in footnote 3 of the Hyogo Framework are "… hazards of natural origin and related environmental and technological hazards and risks." Such hazards arise from a variety of geological, meteorological, hydrological, oceanic, biological, and technological sources, sometimes acting in combination. In technical settings, hazards are described quantitatively by the likely frequency of occurrence of different intensities for different areas, as determined from historical data or scientific analysis. A potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. ***(UN ISDR)***

2. Potential source of harm. ***(PSC EM Vocabulary)***

3. A source of potential harm, or a situation with a potential for causing harm, in terms of human injury; damage to health, property, the environment, and other things of value; or some combination of these. ***(CSA Q850-97)***

4. A source of potential harm or a situation with a potential to cause loss. A potential or existing condition that may cause harm to people or damage to property or the environment. An intrinsic capacity associated with an agent or process capable of causing harm. ***(Australian Emergency Management Glossary)***

5. Natural or man-made source or cause of harm or difficulty.
   Example: Improperly maintained or protected chemical storage tanks present a potential hazard.
   Annotation:
   1) A hazard differs from a threat in that a threat is directed at an entity, asset, system, network, or geographic area, while a hazard is not directed.
   2) A hazard can be actual or potential. ***(DHS Risk Lexicon)***

6. A source of potential danger or adverse conditions. Hazards in this How-To Guide include natural events such as floods, earthquakes, tornadoes, tsunamis, coastal storms, landslides, and wildfires that strike populated areas. A natural event is a hazard when it has the potential to harm people or property. ***(FEMA's Hazus)***

Hazard analysis – See also **Risk analysis**; **Risk assessment**

1. That part of the overall planning process which identifies and describes hazards and their effects upon the community. ***(Australian Emergency Management Glossary)***

<u>Hazard area</u>

1. Geographic area within your study region where specific hazard events are likely to occur or be more intense. ***(FEMA's Hazus)***

<u>Hazard data</u>

1. Data on natural hazards that might threaten your study region. ***(FEMA's Hazus)***

<u>Hazard event</u>

1. A specific occurrence of a particular type of hazard. ***(FEMA's Hazus)***

<u>Hazard identification</u>

1. The process of identifying, characterizing and validating hazards.
   Note: Hazard identification looks at the type, the properties and the potential effects of hazards and is part of hazard assessment. ***(PSC EM Vocabulary)***

2. The process of recognizing that a hazard exists and defining its characteristics. ***(CSA Q850-97)***

3. The process of recognising that a hazard exists and defining its characteristics. ***(Australian Emergency Management Glossary)***

4. The process of identifying the hazards that threaten an area. ***(FEMA's Hazus)***

<u>Hazard mapping</u>

1. The process of establishing geographically where and to what extent particular phenomena are likely to pose a threat to people, property, infrastructure, and economic activities. Hazard mapping represents the result of hazard assessment on a map, showing the frequency/probability of occurrences of various magnitudes or durations. ***(Australian Emergency Management Glossary)***

<u>Hazard mitigation</u> – See also **<u>Mitigation</u>**

1. Sustained actions taken to reduce or eliminate the long-term risks associated with hazards and their effects. ***(FEMA's Hazus)***

<u>Hazard profile</u>

1. A description of the physical characteristics of hazards and a presentation of various hazard descriptors, including magnitude, duration, frequency, probability, and extent. In most cases, a community can most easily use these descriptors when they are displayed on maps. ***(FEMA's Hazus)***

<u>Hazard scenario</u>

1. A specific scenario that could lead to an undesirable consequence (flooding, boulder impact, scour). As an example, a hazard scenario can be a dike breach for a specified return period or a glacial lake outburst flood. ***(APEGBC Guidelines 2010, 2012)***

<u>Hazardous situation</u> – See **<u>Hazardous event</u>**

Hazards U.S. (HAZUS)

1. A GIS-based, nationally standardized earthquake loss estimation tool developed by FEMA. ***(FEMA's Hazus)***

Hazards U.S. – Multi-Hazard (HAZUS-MH)

1. A GIS-based, nationally standardized earthquake, flood, and wind loss estimation tool developed by FEMA. ***(FEMA's Hazus)***

HAZUS-MH analysis

1. An analysis involving use of default data or local data integrated in HAZUS-MH and performed using a computer. This analysis is used for earthquake, flood, and wind hazards if they are priority concerns in a study region. ***(FEMA's Hazus)***

HAZUS-MH-driven analysis

1. An analysis involving use of inventory data in HAZUS-MH combined with knowledge about potentially exposed areas or expected impact areas and knowledge of the likelihood of hazard event occurrence. ***(FEMA's Hazus)***

High potential loss facility

1. Facilities that would present a high loss if they were damaged by a hazard event. These facilities include nuclear power plants, dams, and military installations. ***(FEMA's Hazus)***

Human consequence

1. Effect of an incident, event, or occurrence that results in injury, illness, or loss of life. **Example:** The human consequence of the attack was 20 fatalities and 50 injured persons. **Annotation:** When measuring human consequence in the context of homeland security risk, consequence is assessed as negative and can include loss of life or limb, or other short-term or long-term bodily harm or illness. ***(DHS Risk Lexicon)***

Infrastructure

1. The public services of a community that have a direct impact on the quality of life. Infrastructure includes communication technologies (e.g. telephone lines and Internet access); vital services (e.g., public water supplies and sewer treatment facilities); transportation system components (e.g., airways, airports, and heliports); highways, (e.g., bridges, tunnels, roadbeds, overpasses, railways, rail yards, and depots); and waterways (e.g., canals, locks, seaports, ferries, harbors, drydocks, piers, and regional dams). ***(FEMA's Hazus)***

Intensity

1. A qualitative or quantitative measure of the severity of seismic ground motion at a specific site (e.g. Modified Mercalli intensity, Rossi-Forel intensity, Housner Spectral intensity, Arias intensity, peak acceleration, etc.). ***(EERI Glossary of Terms)***

2. A measure of the effects of a hazard event at a particular place. ***(FEMA's Hazus)***

Inventory

1. A list of the type and quantity of hazardous materials in transport, stored or in process. ***(Australian Emergency Management Glossary)***

2. The assets identified in a study region. ***(FEMA's Hazus)***

Landslide

1. A movement of rock, debris or earth down a slope. Landslides can be a result of a natural sequence of events and/or human activities. [. . .] For the purpose of these guidelines, landslides include: rock falls, rock slumps, rock slides, rock avalanches, rock creep; debris falls, debris slides, debris flows, debris floods; earth falls, earth slumps, earth slides, earth flows, earth creep; and flow slides. Debris flows and debris floods have some characteristics of both landslides and floods. ***(APEGBC Guidelines 2010, 2012)***

2. The general term given to movement of material downslope in a mass. ***(Australian Emergency Management Glossary)***

Landslide susceptibility map

1. Depict areas that have the potential for landslides by correlating some of the principal factors that contribute to landslides, including steep slopes, geologic units that lose strength when saturated, and poorly drained rocks or soils. ***(FEMA's Hazus)***

Land use planning

1. The process undertaken by public authorities to identify, evaluate and decide on different options for the use of land, including consideration of long term economic, social and environmental objectives and the implications for different communities and interest groups, and the subsequent formulation and promulgation of plans that describe the permitted or acceptable uses. **Comment:** Land-use planning is an important contributor to sustainable development. It involves studies and mapping; analysis of economic, environmental and hazard data; formulation of alternative land-use decisions; and design of long-range plans for different geographical and administrative scales. Land-use planning can help to mitigate disasters and reduce risks by discouraging settlements and construction of key installations in hazard-prone areas, including consideration of service routes for transport, power, water, sewage and other critical facilities. ***(UN ISDR)***

Level 1 analysis

1. HAZUS-MH provided hazard and inventory data with minimal outside data collection or mapping. ***(FEMA's Hazus)***

Level 2 analysis

1. Augmenting the HAZUS-MH provided hazard and inventory data with more recent or detailed data for your study region. ***(FEMA's Hazus)***

Level 3 analysis

1. Adjusting the built-in loss estimation models used for the earthquake, flood, and hurricane loss analyses. This typically is done in concert with the use of local data (Level 2 analysis). It is only pursued by advanced users with knowledge of the hazard models developed for HAZUS-MH and when the users need more accurate results or need to solve specific problems. ***(FEMA's Hazus)***

Likelihood – See also **Frequency**

1. The chance of an event or incident happening, whether defined, measured or determined objectively or subjectively. ***(PSC EM Vocabulary)***

2. Chance of something happening.
   Note 1: This Guide uses the word "likelihood" to refer to the chance of something happening, whether defined, measured or determined objectively or subjectively, and described using general terms or mathematically (such as a probability or a frequency over a given time period).
   Note 2: The English term "likelihood" does not have a direct equivalent in some languages; instead the equivalent of the term "probability" is often used. However, in English, "probability" is often narrowly interpreted as a mathematical term. This Guide therefore uses "likelihood," with the intent that it should have the same broad interpretation as the term "probability" has in many languages other than English. ***(ISO Guide 73)***

3. A qualitative description of probability and frequency. ***(Australian Emergency Management Glossary)***

4. Estimate of the potential of an incident or event's occurrence.
   Example: The likelihood of natural hazards can be estimated through the examination of historical data.
   Annotation:
   1) Qualitative and semi-quantitative risk assessments can use qualitative estimates of likelihood such as high, medium, or low, which may be represented numerically but not mathematically. Quantitative assessments use mathematically derived values to represent likelihood.
   2) The likelihood of a successful attack occurring is typically broken into two related quantities: the likelihood that an attack occurs (which is a common mathematical representation of threat), and the likelihood that the attack succeeds, given that it is attempted (which is a common mathematical representation of vulnerability). In the context of natural hazards, likelihood of occurrence is typically informed by the frequency of past incidents or occurrences.
   3) The intelligence community typically estimates likelihood in bins or ranges such as "remote," "unlikely," "even chance," "probable/likely," or "almost certain."
   4) Probability is a specific type of likelihood. Likelihood can be communicated using numbers … or phrases …, while probabilities must meet more stringent conditions. ***(DHS Risk Lexicon)***

Liquefaction

1. A phenomenon where an earth material loses a large percentage of its shear resistance and flows in a manner resembling a liquid until the shear stresses acting on the mass are as low as the reduced shear resistance. ***(APEGBC Guidelines 2010, 2012)***

2. Process of soil and sand behaving like a dense fluid rather than a wet solid mass during an earthquake. ***(Australian Emergency Management Glossary)***

Liquefaction susceptibility map

1. Depict areas that have the potential for landslides by correlating some of the principal factors that contribute to landslides, including steep slopes, geologic units that lose strength when saturated, and poorly drained rocks or soils. These maps indicate the relative stability of slopes; however, they do not make absolute predictions. ***(FEMA's Hazus)***

Loss

1. An injury or damage to health, property, the environment, or something else of value. ***(CSA Q850-97)***

2. Any adverse economic value attained by a variable during a specified exposure time. ***(EERI Glossary of Terms)***

3. Any negative consequence, financial or otherwise. ***(Australian Emergency Management Glossary)***

4. Structural loss, content loss, and function loss. ***(FEMA's Hazus)***

Loss estimation

1. Estimation of potential losses by assigning hazard-related costs and losses to inventory data such as data for populations, building stocks, transportation and utility lines, regulated facilities, and more). HAZUS-MH can estimate economic and social losses based on a specific hazard event. Loss estimation is essential to decision-making at all levels of government and provides a basis for developing mitigation plans and policies. Loss estimation also supports planning for emergency preparedness, response, and recovery. ***(FEMA's Hazus)***

Magnitude / Magnitude (Earthquake magnitude – M)

1. A general term for the measure of the strength of an earthquake or the strain energy released by an earthquake, as determined by a seismographic observations. In BCBC 2006, magnitude is referred to as moment magnitude. Modal magnitude is the moment magnitude providing the largest contribution to the ground motion. ***(APEGBC Guidelines 2010, 2012)***

2. A measure of the strength of a hazard event. The magnitude (also referred to as the severity) of a given hazard event is usually determined using technical measures specific to the hazard. ***(FEMA's Hazus)***

Mitigation – See also **Prevention**

1. The lessening or limitation of the adverse impacts of hazards and related disasters.
2. Comment: The adverse impacts of hazards often cannot be prevented fully, but their scale or severity can be substantially lessened by various strategies and actions. Mitigation measures encompass engineering techniques and hazard-resistant construction as well as improved environmental policies and public awareness. It should be noted that in climate change policy, "mitigation" is defined differently, being the term used for the reduction of greenhouse gas emissions that are the source of climate change. ***(UN ISDR)***

3. Actions taken to reduce the impact of disasters in order to protect lives, property and the environment, and to reduce economic disruption.
   Note: Mitigation includes structural mitigative measures (e.g. construction of floodways and dykes) and non-structural mitigative measures (e.g. building codes, land-use planning and insurance incentives). Prevention and mitigation may be considered independently or one may include the other. ***(PSC EM Vocabulary)***

4. Measures taken in advance of a disaster aimed at decreasing or eliminating its impact on society and environment. ***(Australian Emergency Management Glossary)***

<u>Natural hazard</u> – See also **<u>Geohazard</u>**

1. Natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.
   Comment: Natural hazards are a sub-set of all hazards. The term is used to describe actual hazard events as well as the latent hazard conditions that may give rise to future events. Natural hazard events can be characterized by their magnitude or intensity, speed of onset, duration, and area of extent. For example, earthquakes have short durations and usually affect a relatively small region, whereas droughts are slow to develop and fade away and often affect large regions. In some cases hazards may be coupled, as in the flood caused by a hurricane or the tsunami that is created by an earthquake. ***(UN ISDR)***

2. A source of potential harm originating from a meteorological, environmental, geological or biological event.
   Note: Examples of natural hazards include tornadoes, floods, glacial melt, extreme weather, forest and urban fires, earthquakes, insect infestations and infectious diseases. ***(PSC EM Vocabulary)***

3. Geologic, meteorological, or biological hazard. Source of harm or difficulty created by a meteorological, environmental, or geological phenomenon or combination of phenomena.
   Example: A natural hazard, such as an earthquake, can occur without warning. ***(Australian Emergency Management Glossary)***

<u>Non-structural element</u>

1. Those parts of a building (eg. partitions, ceilings, etc.) which do not belong to the load-bearing system. ***(Australian Emergency Management Glossary)***

2. Architectural components such as exterior cladding, parapets, glazing, cornices, and corbels, as well as interior partitions, suspended ceilings, and lighting fixtures. ***(FEMA's Hazus)***

<u>Planning / Planning process</u>

1. The collective and collaborative efforts by which agreements are reached and documented between people and organisations to meet their communities' emergency management needs. It is a sequence of steps which allows emergency management planning to take place. ***(Australian Emergency Management Glossary)***

2. The act or process of making plans and establishing goals, policies, and procedures for a social or economic unit. ***(FEMA's Hazus)***

Preparedness

1. The knowledge and capacities developed by governments, professional response and recovery organizations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or current hazard events or conditions.
   Comment: Preparedness action is carried out within the context of disaster management and aims to build the capacities needed to efficiently manage all types of emergencies and achieve orderly transitions from response through to sustained recovery. Preparedness is based on a sound analysis of disaster risks and good linkages with early warning systems, and includes such activities as contingency planning, stockpiling of equipment and supplies, the development of arrangements for coordination, evacuation and public information, and associated training and field exercises. These must be supported by formal institutional, legal and budgetary capacities. The related term "readiness" describes the ability to quickly and appropriately respond when required. ***(UN ISDR)***

2. Actions taken prior to a disaster to be ready to respond to it and manage its consequences.
   Note: Preparedness actions include emergency response plans, mutual assistance agreements, resource inventories and training, equipment and exercise programs. ***(PSC EM Vocabulary)***

3. Arrangements to ensure that, should an emergency occur, all those resources and services which are needed to cope with the effects can be efficiently mobilised and deployed. Measures to ensure that, should an emergency occur, communities, resources and services are capable of coping with the effects. ***(Australian Emergency Management Glossary)***

Prevention

1. The outright avoidance of adverse impacts of hazards and related disasters.
   Comment: Prevention (i.e., disaster prevention) expresses the concept and intention to completely avoid potential adverse impacts through action taken in advance. Examples include dams or embankments that eliminate flood risks, land-use regulations that do not permit any settlement in high risk zones, and seismic engineering designs that ensure the survival and function of a critical building in any likely earthquake. Very often the complete avoidance of losses is not feasible and the task transforms to that of mitigation. Partly for this reason, the terms prevention and mitigation are sometimes used interchangeably in casual use. ***(UN ISDR)***

2. Actions taken to eliminate the impact of disasters in order to protect lives, property and the environment, and to avoid economic disruption.
   Note: Prevention and mitigation may be considered independently or one may include the other. Prevention and mitigation include structural mitigative measures (e.g. construction of floodways and dykes) and non-structural mitigative measures (e.g. building codes, land-use planning and insurance incentives). ***(PSC EM Vocabulary)***

3. Regulatory and physical measures to ensure that emergencies are prevented, or their effects mitigated. Measures to eliminate or reduce the incidence or severity of emergencies. ***(Australian Emergency Management Glossary)***

Probabilistic analysis

1. Evaluates the statistical likelihood that a specific event will occur and what losses and consequences will result. ***(FEMA's Hazus)***

Probabilistic risk assessment

1. Type of quantitative risk assessment that considers possible combinations of occurrences with associated consequences, each with an associated probability or probability distribution.
   Example: The engineers conducted a probabilistic risk assessment to determine the risk of a meltdown resulting from a series of compounding failures.
   Annotation: Probabilistic risk assessments are typically performed on complex technological systems with tools such as fault and event trees, and Monte Carlo simulations to evaluate security risks and/or accidental failures. ***(DHS Risk Lexicon)***

Probability – See also **Frequency**

1. In statistics, a measure of the chance of an event or incident happening. ***(PSC EM Vocabulary)***

2. Measure of the chance of occurrence expressed as a number between 0 and 1, where 0 is impossibility and 1 is absolute certainty. ***(ISO Guide 73)***

3. The likelihood of a specific outcome, measured by the ratio of specific outcomes to the total number of possible outcomes. Probability is expressed as a number between 0 and 1, with 0 indicating an impossible outcome and 1 indicating an outcome is certain. See also Frequency; Likelihood; Conditional probability ***(Australian Emergency Management Glossary)***

4. Likelihood that is expressed as a number between 0 and 1, where 0 indicates that the occurrence is impossible and 1 indicates definite knowledge that the occurrence has happened or will happen, where the ratios between numbers reflect and maintain quantitative relationships.
   Example: The probability of a coin landing on "heads" is 1/2.
   Annotation:
   1) Probability (mathematical) is a specific type of likelihood estimate that obeys the laws of probability theory.
   2) Probability is used colloquially as a synonym for likelihood. ***(DHS Risk Lexicon)***

5. A statistical measure of the likelihood that a hazard event will occur. ***(FEMA's Hazus)***

Quantitative assessment

1. A risk assessment method that assigns statistical values to risks. ***(PSC EM Vocabulary)***

Quantified/Quantitative risk assessment (QRA) – See also **Risk assessment**

1. A risk assessment that is based essentially on quantified inputs. ***(Australian Emergency Management Glossary)***

Quantitative risk assessment methodology

1. Set of methods, principles, or rules for assessing risks based on the use of numbers where the meanings and proportionality of values are maintained inside and outside the context of the assessment.
   Example: Engineers at the nuclear power plant used a quantitative risk assessment methodology to assess the risk of reactor failure.
   Annotation: While a semi-quantitative methodology also involves the use of numbers, only a purely quantitative methodology uses numbers in a way that allows for the consistent use of values outside the context of the assessment. ***(DHS Risk Lexicon)***

Recovery

1. The restoration, and improvement where appropriate, of facilities, livelihoods and living conditions of disaster-affected communities, including efforts to reduce disaster risk factors.
   Comment: The recovery task of rehabilitation and reconstruction begins soon after the emergency phase has ended, and should be based on pre-existing strategies and policies that facilitate clear institutional responsibilities for recovery action and enable public participation. Recovery programmes, coupled with the heightened public awareness and engagement after a disaster, afford a valuable opportunity to develop and implement disaster risk reduction measures and to apply the "build back better" principle. ***(UN ISDR)***

2. Actions taken to repair or restore conditions to an acceptable level after a disaster.
   Note: Recovery actions include the return of evacuees, trauma counselling, reconstruction, economic impact studies and financial assistance. There is a strong relationship between long-term sustainable recovery and prevention and mitigation of future disasters. Recovery efforts should be conducted with a view towards disaster risk reduction. ***(PSC EM Vocabulary)***

3. The coordinated process of supporting emergency-affected communities in reconstruction of the physical infrastructure and restoration of emotional, social, economic and physical wellbeing. Measures which support emergency-affected individuals and communities in the reconstruction of the physical infrastructure and restoration of emotional, economic and physical well-being. In oil spills, the entire process of the physical removal of spilled oil from land, water or shoreline environments. General methods of oil recovery from water use mechanical skimmers, sorbents and manual recovery by the clean-up work force; the main method of recovering oil spilled on land or shorelines is excavation of contaminated materials. ***(Australian Emergency Management Glossary)***

Resilience/ Resiliency

1. The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.
   Comment: Resilience means the ability to "resile from" or "spring back from" a shock. The resilience of a community in respect to potential hazard events is determined by the degree to which the community has the necessary resources and is capable of organizing itself both prior to and during times of need. ***(UN ISDR)***

2. The capacity of a system, community or society to adapt to disruptions resulting from hazards by persevering, recuperating or changing to reach and maintain an acceptable level of functioning.
   Note: Resilience is built through a process of empowering citizens, responders, organizations, communities, governments, systems and society to share the responsibility of keeping hazards from becoming disasters. ***(PSC EM Vocabulary)***

3. Capacity to resist being affected by an event. ***(ISO Guide 73)***

4. A measure of how quickly a system recovers from failures. ***(Australian Emergency Management Glossary)***

5. Ability to resist, absorb, recover from or successfully adapt to adversity or a change in conditions.
   Example: The county was able to recover quickly from the disaster because of the resilience of governmental support systems.
   Extended Definition:
   1) ability of systems, infrastructures, government, business, and citizenry to resist, absorb recover from, or adapt to an adverse occurrence that may cause harm, destruction, or loss of national significance.

2) capacity of an organization to recognize threats and hazards and make adjustments that will improve future protection efforts and risk reduction measures.

Annotation: Resilience can be factored into vulnerability and consequence estimates when measuring risk. ***(DHS Risk Lexicon)***

Response

1. The provision of emergency services and public assistance during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected.
   Comment: Disaster response is predominantly focused on immediate and short-term needs and is sometimes called “disaster relief”. The division between this response stage and the subsequent recovery stage is not clear-cut. Some response actions, such as the supply of temporary housing and water supplies, may extend well into the recovery stage. ***(UN ISDR)***

2. Actions taken during or immediately before or after a disaster to manage its consequences and minimize suffering and loss.
   Note: Response actions include emergency public communication, search and rescue, emergency medical assistance, evacuation, etc. ***(PSC EM Vocabulary)***

3. Actions taken in anticipation of, during, and immediately after an emergency to ensure that its effects are minimised, and that people affected are given immediate relief and support. Measures taken in anticipation of, during and immediately after an emergency to ensure its effects are minimised. ***(Australian Emergency Management Glossary)***

Risk

1. The combination of the probability of an event and its negative consequences.
   Comment: This definition closely follows the definition of the ISO/IEC Guide 73. The word “risk” has two distinctive connotations: in popular usage the emphasis is usually placed on the concept of chance or possibility, such as in “the risk of an accident”; whereas in technical settings the emphasis is usually placed on the consequences, in terms of “potential losses” for some particular cause, place and period. It can be noted that people do not necessarily share the same perceptions of the significance and underlying causes of different risks. ***(UN ISDR)***

2. The combination of the likelihood and the consequence of a specified hazard being realized; refers to the vulnerability, proximity or exposure to hazards, which affects the likelihood of adverse impact. ***(PSC EM Vocabulary)***

3. Effect of uncertainty on objectives.
   Note 1: An effect is a deviation from the expected - positive and/or negative.
   Note 2: Objectives can have different aspects such as financial, health and safety, and environmental goals and can apply at different levels such as strategic, organization-wide, project, product, and process.
   Note 3: Risk is often characterized by reference to potential events, consequences, or a combination of these and how they can affect the achievement of objectives.
   Note 4: Risk is often expressed in terms of a combination of the consequences of an event or a change in circumstances, and the associated likelihood of occurrence. ***(ISO Guide 73)***

4. The chance of injury or loss as defined as a measure of the probability and severity of an adverse effect to health, property, the environment, or other things of value. ***(CSA Q850-97)***

5. A measure of the probability and severity of an adverse effect to health, property or the environment. Risk is often estimated by the product of probability and consequence. A more general interpretation of risk involves a comparison of the probability and consequences in a non-product form. ***(APEGBC Guidelines 2010, 2012)***

6. A concept used to describe the likelihood of harmful consequences arising from the interaction of hazards, communities and the environment. The chance of something happening that will have an impact upon objectives. It is measured in terms of consequences and likelihood. A measure of harm, taking into account the consequences of an event and its likelihood. For example, it may be expressed as the likelihood of death to an exposed individual over a given period. Expected losses (of lives, persons injured, property damaged, and economic activity disrupted) due to a particular hazard for a given area and reference period. Based on mathematical calculations, risk is the product of hazard and vulnerability. ***(Australian Emergency Management Glossary)***

7. Potential for an unwanted outcome resulting from an incident, event, or occurrence, as determined by its likelihood and the associated consequences.
   Example: The team calculated the risk of a terrorist attack after analyzing intelligence reports, vulnerability assessments, and consequence models.
   Extended Definition: potential for an adverse outcome assessed as a function of threats, vulnerabilities, and consequences associated with an incident, event, or occurrence.
   Annotation:
   1) Risk is defined as the potential for an unwanted outcome. This potential is often measured and used to compare different future situations.
   2) Risk may manifest at the strategic, operational, and tactical levels. ***(DHS Risk Lexicon)***

8. The estimated impact that a hazard event would have on people, services, facilities, and structures in a community, or the likelihood of a hazard event resulting in an adverse condition that causes injury or damage. Risk is often expressed in relative terms such as a high, moderate, or low likelihood of damage being sustained above a particular threshold as a result of a specific type of hazard event. Risk also can be expressed in terms of potential monetary losses associated with the intensity of the hazard event. ***(FEMA's Hazus)***

Risk analysis

1. A process to comprehend the nature of a risk and to determine its level.
   Note: Risk analysis provides the basis for risk evaluation and decisions about risk treatment. ***(PSC EM Vocabulary)***

2. Process to comprehend the nature of risk and to determine the level of risk. ***(ISO Guide 73)***

3. The systematic use of information to identify hazards and to estimate the chance for, and severity of, injury or loss to individuals or populations, property, the environment, or other things of value. ***(CSA Q850-97)***

4. The use of available information to estimate the risk to individuals, or populations, property, or the environment, from hazards. Risk analyses contain scope definition, hazard identification, and risk estimation. ***(APEGBC Guidelines 2010, 2012)***

5. A systematic use of available information to determine how often specified events may occur and the magnitude of their likely consequences. The systematic use of available information to study risk. ***(Australian Emergency Management Glossary)***

6. Systematic examination of the components and characteristics of risk.
   Example: Using risk analysis, the community identified the potential consequences from flooding.
   Annotation: In practice, risk analysis is generally conducted to produce a risk assessment. Risk analysis can also involve aggregation of the results of risk assessments to produce a valuation of risks for the purpose of informing decisions. In addition, risk analysis can be done on proposed alternative risk management strategies to determine the likely impact of the strategies on the overall risk. ***(DHS Risk Lexicon)***

Risk assessment

1. A methodology to determine the nature and extent of risk by analyzing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, likelihoods and the environment on which they depend.
   Comment: Risk assessments (and associated risk mapping) include: a review of the technical characteristics of hazards such as their location, intensity, frequency and probability; the analysis of exposure and vulnerability including the physical social, health, economic and environmental dimensions; and the evaluation of the effectiveness of prevailing and alternative coping capacities in respect to likely risk scenarios. This series of activities is sometimes known as a risk analysis process. ***(UN ISDR)***

2. The overall process of risk identification, risk analysis and risk evaluation. ***(PSC EM Vocabulary)***

3. Overall processes of risk identification, risk analysis and risk evaluation. ***(ISO Guide 73)***

4. The overall process of risk analysis and risk evaluation. ***(CSA Q850-97)***

5. The process of risk analysis and risk evaluation. ***(APEGBC Guidelines 2010, 2012)***

6. The process used to determine risk management priorities by evaluating and comparing the level of risk against predetermined standards, target risk levels or other criteria. ***(Australian Emergency Management Glossary)***

7. Product or process which collects information and assigns values to risks for the purpose of informing priorities, developing or comparing courses of action, and informing decision-making.
   Example: The analysts produced a risk assessment outlining risks to the aviation industry.
   Extended Definition: appraisal of the risks facing an entity, asset, system, network, geographic area or other grouping Annotation: A risk assessment can be the resulting product created through analysis of the component parts of risk. ***(DHS Risk Lexicon)***

8. A methodology used to assess potential exposures and estimated losses associated with likely hazard events. The HAZUS-MH risk assessment process includes four steps: identifying hazards, profiling hazard events, inventorying assets, and estimating losses. ***(FEMA's Hazus)***

Risk assessment tool (RAT)

1. Activity, item, or program that contributes to determining and evaluating risks.
   Example: A checklist is a common risk assessment tool that allows users to easily execute risk assessments in a consistent way.
   Annotation: Tools can include computer software and hardware or standard forms or checklists for recording and displaying risk assessment data. ***(DHS Risk Lexicon)***

2. A companion software tool to HAZUS-MH that will help you to expedite the preparation of your risk assessment outputs. ***(FEMA's Hazus)***

Risk-based

1. Referring to the concept that sound emergency management decision-making will be based on an understanding and evaluation of hazards, risks and vulnerabilities. ***(PSC EM Vocabulary)***

Risk-based decision-making

1. Determination of a course of action predicated primarily on the assessment of risk and the expected impact of that course of action on that risk.
   Example: After reading about threats and vulnerabilities associated with vehicle explosives downtown, the Mayor practiced risk-based decision-making by authorizing the installation of vehicle barriers.
   Annotation: Risk-based decision-making uses the assessment of risk as the primary decision driver, while risk-informed decision-making may account for multiple sources of information not included in the assessment of risk as significant inputs to the decision process in addition to risk information. Risk-based decision-making has often been used interchangeably with risk-informed decision-making. ***(DHS Risk Lexicon)***

Risk estimation

1. The activity of estimating the frequency or probability and consequence of risk scenarios, including a consideration of the uncertainty of the estimates. ***(CSA Q850-97)***

2. The process used to produce a measure of the level of risks being analysed. Risk estimation consists of the following steps: frequency analysis, consequence analysis and their integration. ***(Australian Emergency Management Glossary)***

Risk evaluation

1. The process of comparing the results of risk analysis with risk criteria to determine whether a risk and/or its magnitude is acceptable or tolerable.
   Note: Risk evaluation assists in the decision about risk treatment. ***(PSC EM Vocabulary)***

2. Process of comparing the results of risk analysis against risk criteria to determine whether the level of risk is acceptable or tolerable.
   Note: Risk evaluation assists in the decision about risk treatment. ***(ISO Guide 73)***

3. The process by which risks are examined in terms of costs and benefits, and evaluated in terms of acceptability of risk considering the needs, issues, and concerns of stakeholders. ***(CSA Q850-97)***

4. The stage at which values and judgments enter the decision process, explicitly or implicitly, by including consideration of the importance of the estimated risks and the associated social, environmental, and economic consequences, in order to identify a range of alternatives for managing the risks. ***(APEGBC Guidelines 2010, 2012)***

5. The process in which judgments are made on the tolerability of the risk on the basis of risk analysis and taking into account factors such as socioeconomic and environmental aspects. The process used to prioritise risks. ***(Australian Emergency Management Glossary)***

Risk-informed decision-making

1. Determination of a course of action predicated on the assessment of risk, the expected impact of that course of action on that risk, as well as other relevant factors.
   Example: The Mayor practiced risk-informed decision-making in planning event security by considering both the results of the risk assessment and logistical constraints.
   Annotation: Risk-informed decision-making may take into account multiple sources of information not included specifically in the assessment of risk as inputs to the decision process in addition to risk information, while risk-based decision-making uses the assessment of risk as the primary decision driver. ***(DHS Risk Lexicon)***

Risk management

1. The systematic approach and practice of managing uncertainty to minimize potential harm and loss.
   Comment: Risk management comprises risk assessment and analysis, and the implementation of strategies and specific actions to control, reduce and transfer risks. It is widely practiced by organizations to minimise risk in investment decisions and to address operational risks such as those of business disruption, production failure, environmental damage, social impacts and damage from fire and natural hazards. Risk management is a core issue for sectors such as water supply, energy and agriculture whose production is directly affected by extremes of weather and climate. ***(UN ISDR)***

2. The use of policies, practices and resources to analyze, assess and control risks to health, safety, the environment and the economy. ***(PSC EM Vocabulary)***

3. Coordinated activities to direct and control an organization with regard to risk. ***(ISO Guide 73)***

4. The systematic application of management policies, procedures, and practices to the tasks of analyzing, evaluating, controlling, and communicating about risk issues. ***(CSA Q850-97)***

5. The systematic application of management policies, procedures and practices to the tasks of identifying, analysing, evaluating, treating and monitoring risk. ***(Australian Emergency Management Glossary)***

6. Process of identifying, analyzing, assessing, and communicating risk and accepting, avoiding, transferring or controlling it to an acceptable level at an acceptable cost.
   Annotation: The primary goal of risk management is to reduce or eliminate risk through mitigation measures (avoiding the risk or reducing the negative effect of the risk), but also includes the concepts of acceptance and/or transfer of responsibility for the risk as appropriate. Risk management principles acknowledge that, while risk often cannot be eliminated, actions can usually be taken to reduce risk. ***(DHS Risk Lexicon)***

Risk management framework

1. Set of components that provide the foundations and organizational arrangements for designing, implementing, monitoring, reviewing and continually improving risk management processes throughout the organization.
   Note 1: The foundations include the policy, objectives, mandate and commitment to manage risk.
   Note 2: The organizational arrangements include plans, relationships, accountabilities, resources, processes and activities.
   Note 3: The risk management framework is embedded within the organization's overall strategic and operational policies and practices. ***(ISO Guide 73)***

Risk management plan

1. Document within the risk management framework specifying the approach, the management components and resources to be applied to the management of risk.
   Note 1: Management components typically include procedures, practices, assignment of responsibilities and sequence of activities.
   Note 2: The risk management plan can be applied to a particular product, process and project, and part or whole of the organization. ***(ISO Guide 73)***

2. Document that identifies risks and specifies the actions that have been chosen to manage those risks.
   Example: Businesses often have a risk management plan to address the potential risks that they might encounter. ***(DHS Risk Lexicon)***

Risk management policy

1. Overall intentions and direction of an organization related to risk management. ***(ISO Guide 73)***

Risk management process

1. Systematic application of management policies, procedures and practices to the tasks of communicating, consulting, establishing the context, identifying, analyzing, evaluating, treating, monitoring and reviewing risk. ***(ISO Guide 73)***

Risk perception

1. A stakeholder's view on a risk.
   Note: Risk perception reflects the stakeholder's needs, issues, knowledge, beliefs and values. ***(PSC EM Vocabulary)***

2. Stakeholder's view on a risk.
   Note 1: Risk perception reflects the stakeholder's needs, issues and knowledge.
   Note 2: Risk perception can differ from objective data. The significance assigned to risks by stakeholders. This perception is derived from the stakeholders' expressed needs, issues, and concerns. ***(ISO Guide 73)***

3. Subjective judgment about the characteristics and/or severity of risk.
   Example: The fear of terrorist attacks may create a skewed risk perception.
   Annotation: Risk perception may be driven by sense, emotion, or personal experience. ***(DHS Risk Lexicon)***

Risk profile

1. A description of an entity's existing management practices, common vulnerabilities, tolerance and key interdependencies concerning its particular risks, as well as an assessment of their relative likelihood, consequences and priority. ***(PSC EM Vocabulary)***

2. Description of a set of risks. ***(ISO Guide 73)***

3. Description and/or depiction of risks to an asset, system, network, geographic area or other entity.
   Example: A risk profile for a hydroelectric plant may address risks such as structural failure, mechanical malfunction, sabotage, and terrorism.
   Annotation: A risk profile can be derived from a risk assessment; it is often used as a presentation tool to show how risks vary across comparable entities. ***(DHS Risk Lexicon)***

Risk reduction

1. A selective application of appropriate techniques and management principles to reduce either likelihood of an occurrence or its consequences, or both. ***(Australian Emergency Management Glossary)***

2. Decrease in risk through risk avoidance, risk control or risk transfer.
   Example: By placing vehicle barriers outside the facility, the security team achieved a significant risk reduction.
   Annotation: Risk reduction may be estimated both during the decision and evaluation phases of the risk management cycle. ***(DHS Risk Lexicon)***

Risk scenario

1. A defined sequence of events with an associated frequency and consequences. ***(CSA Q850-97)***

Risk source

1. Anything which alone or in combination has the intrinsic potential to give rise to risk.
   Note 1: There is no risk when another object, person or organization does not have an interaction with a risk source.
   Note 2: A risk source can be tangible or intangible. ***(ISO Guide 73)***

Risk tolerance

1. The willingness of an organization to accept or reject a given level of residual risk.
   Note: Risk tolerance may differ across an organization, but must be clearly understood by those making risk-related decisions. ***(PSC EM Vocabulary)***

2. Organization's readiness to bear the risk after risk treatments in order to achieve its objectives.
   Note: Risk tolerance can be limited by legal or regulatory requirements. ***(ISO Guide 73)***

3. Degree to which an entity is willing to accept risk.
   Example: After a major disaster, a community's risk tolerance may decrease significantly. ***(DHS Risk Lexicon)***

Scenario

1. A hypothetical situation or chain of events that depicts an incident, emergency or crisis and that is delivered to exercise players through a narrative to guide simulation during an exercise. ***(PSC EM Vocabulary)***

2. Hypothetical situation comprised of a hazard, an entity impacted by that hazard, and associated conditions including consequences when appropriate.
   Example: The team designed a scenario involving a car bomb at the power plant to help assess the risk of vehicle-borne improvised explosive devices.
   Annotation: A scenario can be created and used for the purposes of training, exercise, analysis, or modeling as well as for other purposes. A scenario that has occurred or is occurring is an incident. ***(DHS Risk Lexicon)***

Seismic event

1. The abrupt release of energy in the earth's lithosphere, causing an earthquake. ***(EERI Glossary of Terms)***

Seismic hazard

1. Any physical phenomenon (e.g. ground shaking, ground failure) associated with an earthquake that may produce adverse effects on human activities. ***(EERI Glossary of Terms)***

Seismic risk

1. The probability that social or economic consequences of earthquakes will equal or exceed specified values at a site, at several sites, or in an area, during a specified exposure time. ***(EERI Glossary of Terms)***

2. The probability of earthquakes of given magnitude occurring in a region. ***(APEGBC Guidelines 2010, 2012)***

Societal risk

1. The risk of a number of fatalities occurring. The societal risk concept is based on the premise that society is more concerned with incidents which kill a larger number of people than incidents which kill fewer numbers. ***(Australian Emergency Management Glossary)***

Structural element

1. Walls, columns, beams, and girders that support a building or structure. ***(FEMA's Hazus)***

Study region

1. The specific geographic area that your risk assessment will address. Your study region may encompass a single jurisdiction or a multi-jurisdictional geographic area. ***(FEMA's Hazus)***

Subject matter expert (SME)

1. A person who provides expertise in a specific scientific or technological area or on a particular aspect of a response. ***(PSC EM Vocabulary)***

2. Individual with in-depth knowledge in a specific area or field.
   Example: A subject matter expert was consulted to inform team members on improvised nuclear devices.
   Annotation: Structured techniques for the elicitation of expert judgment are key tools for risk assessment. Subject matter experts are also used to supplement empirical data when needed, or to provide input on specialized subject areas for the purposes of designing and executing risk assessments. ***(DHS Risk Lexicon)***

Threat – See **Hazard**

1. The presence of a hazard and an exposure pathway. A threat may be natural or human-induced, accidental or intentional.
   Note: A threat may be natural or human-induced, accidental or intentional. ***(PSC EM Vocabulary)***

2. Natural or man-made occurrence, individual, entity, or action that has or indicates the potential to harm life, information, operations, the environment and/or property.
   Example: Intelligence suggested that the greatest threat to the building was from explosives concealed in a vehicle.
   Annotation: Threat as defined refers to an individual, entity, action, or occurrence; however, for the purpose of calculating risk, the threat of an intentional hazard is generally estimated as the likelihood of an attack (that accounts for both the intent and capability of the adversary) being attempted by an adversary; for other hazards, threat is generally estimated as the likelihood that a hazard will manifest. ***(DHS Risk Lexicon)***

Threat assessment – See **Hazard assessment**

1. A process consisting of the identification, analysis and evaluation of threats. ***(PSC EM Vocabulary)***

2. Process of identifying or evaluating entities, actions, or occurrences, whether natural or man-made, that have or indicate the potential to harm life, information, operations and/or property.
   Example: Analysts produced a threat assessment detailing the capabilities of domestic and foreign terrorist organizations to threaten particular infrastructure sectors. ***(DHS Risk Lexicon)***

Transportation system

1. The lifeline systems that include airways (airports and heliports), highways (bridges, tunnels, roadbeds, overpasses, and transfer centers); railways (trucks, tunnels, bridges, rail yards, and depots), and waterways (canals, locks, seaports, ferries, harbors, drydocks, and piers). ***(FEMA's Hazus)***

Uncertainty

1. State, even partial, of deficiency of information related to or understanding or knowledge of an event, its consequences, or likelihood. ***(ISO Guide 73)***

2. Degree to which a calculated, estimated, or observed value may deviate from the true value. **Example:** The uncertainty in the fatality estimate for the chemical attack was due to the unpredictable wind direction in the affected area.
   Annotation:
   1) Uncertainty may stem from many causes, including the lack of information.
   2) The concept of uncertainty is useful in understanding that likelihoods and consequences can oftentimes not be predicted with a high degree of precision or accuracy. ***(DHS Risk Lexicon)***

Uncertainty analysis

1. An analysis intended to identify key sources of uncertainties in the predictions of a model, assess the potential impacts of these uncertainties on the predictions and assess the likelihood of these impacts. ***(PSC EM Vocabulary)***

Utility system

1. The lifeline systems that include potable water, wastewater, oil, natural gas, electric power, and communication systems. ***(FEMA's Hazus)***

Vulnerability

1. The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard.
   Comment: There are many aspects of vulnerability, arising from various physical, social, economic, and environmental factors. Examples may include poor design and construction of buildings, inadequate protection of assets, lack of public information and awareness, limited official recognition of risks and preparedness measures, and disregard for wise environmental management. Vulnerability varies significantly within a community and over time. This definition identifies vulnerability as a characteristic of the element of interest (community, system or asset) which is independent of its exposure. However, in common use the word is often used more broadly to include the element's exposure. ***(UN ISDR)***

2. A condition or set of conditions determined by physical, social, economic and environmental factors or processes that increases the susceptibility of a community to the impact of hazards.
3. Note: Vulnerability is a measure of how well-prepared and well-equipped a community is to minimize the impact of or cope with hazards. ***(PSC EM Vocabulary)***

4. Intrinsic properties of something that create susceptibility to a source of risk that can lead to a consequence. ***(ISO Guide 73)***

5. The degree of loss to a given element at risk, or set of such elements, resulting from an earthquake of a given magnitude or intensity, which is usually expressed on a scale from 0 (no damage) to 10 (total loss). ***(EERI Glossary of Terms)***

6. The degree of loss to a given element or set of elements within the area affected by the flood hazard. It is expressed on a scale of 0 (no loss) to 1 (total loss). For property, the loss will be the value of the damage relative to the value of the property; for persons it will be the probability that a particular life will be lost given that the person is subject to the flood, debris flood or debris flow. ***(APEGBC Guidelines 2010, 2012)***

7. The degree of susceptibility and resilience of the community and environment to hazards. The degree of loss to a given element at risk or set of such elements resulting from the occurrence of a phenomenon of a given magnitude and expressed on a scale of 0 (no damage) to 1 (total loss). ***(Australian Emergency Management Glossary)***

8. Physical feature or operational attribute that renders an entity open to exploitation or susceptible to a given hazard.
   Example: Installation of vehicle barriers may remove a vulnerability related to attacks using vehicle-borne improvised explosive devices.
   Extended Definition: characteristic of design, location, security posture, operation, or any combination thereof, that renders an asset, system, network, or entity susceptible to disruption, destruction, or exploitation.
   Annotation: In calculating risk of an intentional hazard, the common measurement of vulnerability is the likelihood that an attack is successful, given that it is attempted. ***(DHS Risk Lexicon)***

9. How exposed or susceptible to damage an asset is. Vulnerability depends on an asset's construction, its contents, and the economic value of its functions. Like indirect damages, the vulnerability of one element of a community is often related to the vulnerability of another. For example, many businesses depend on uninterrupted electrical power; if an electrical substation is flooded, not only will the substation itself be affected, but a number of businesses as well. Indirect effects can often be much more widespread and damaging than direct ones. ***(FEMA's Hazus)***

Vulnerability assessment – See **Hazard analysis**

1. The process of identifying and evaluating vulnerabilities, describing all protective measures in place to reduce them and estimating the likelihood of consequences. ***(PSC EM Vocabulary)***

2. Process for identifying physical features or operational attributes that render an entity, asset, system, network, or geographic area susceptible or exposed to hazards.
   Example: The team conducted a vulnerability assessment on the ship to determine how it might be exploited or attacked by an adversary.
   Annotation: Vulnerability assessments can produce comparable estimates of vulnerabilities across a variety of hazards or assets, systems, or networks. ***(DHS Risk Lexicon)***

3. An assessment of the extent of injury and damage that may result from a hazard event of a given intensity in a given area. The vulnerability assessment should address the impacts of hazard events on both existing and future conditions. ***(FEMA's Hazus)***