Natural Resources Canada | Ressources naturelles Canada

GEOLOGICAL SURVEY OF CANADA
OPEN FILE 8630

# Sixth generation seismic hazard model of Canada: input files to produce values proposed for the 2020 National Building Code of Canada

**M. Kolaj, S. Halchuk, J. Adams, and T.I. Allen**

**2020**

**This publication contains a preliminary release of the 6th Generation Seismic Hazard Model of Canada (CanadaSHM6) OpenQuake model files. The enclosed model will be superseded by an authoritative Open File planned for 2021 which will contain the full description of CanadaSHM6.**

Canada


**GEOLOGICAL SURVEY OF CANADA**
**OPEN FILE 8630**

# Sixth generation seismic hazard model of Canada: input files to produce values proposed for the 2020 National Building Code of Canada

**M. Kolaj[1], S. Halchuk[1], J. Adams[1], and T.I. Allen[2,3]**

[1] Canadian Hazards Information Service, Natural Resources Canada
[2] Formerly: Geological Survey of Canada, 9860 West Saanich Road, Sidney, British Columbia
[3] Present Address: Place, Space and Communities Division, Geoscience Australia, Cnr Jerrabomberra Ave and Hindmarsh Drive, Symonston, Australian Capital Territory

## 2020



Permanent link: https://doi.org/10.4095/327322

This publication is available for free download through GEOSCAN (http://geoscan.nrcan.gc.ca/).

**Recommended citation**

Kolaj, M., Halchuk, S., Adams, J., and Allen, T.I., 2020. Sixth Generation seismic hazard model of Canada: Input files to produce values proposed for the 2020 National Building Code of Canada; Geological Survey of Canada, Open File 8630, 1 .zip file. https://doi.org/10.4095/327322

# CONTENTS

# 1. ABSTRACT

The 6th Generation Seismic Hazard Model of Canada (CanadaSHM6) provides the basis for seismic design values proposed by Natural Resources Canada for the 2020 edition of the National Building Code of Canada (NBCC 2020). This Open File includes OpenQuake compatible source model files that will generate seismic hazard values as currently being proposed. Example hazard values at selected localities are included, in order to verify that the model has been implemented as intended. Once NBCC 2020 is finalized, this report will be superseded by a subsequent Open File, to document the final model used to generate seismic hazard values using CanadaSHM6 for NBCC 2020.

# 2. INTRODUCTION

This Open File is a rapid publication to release a preliminary version of the 6th Generation seismic hazard model of Canada (CanadaSHM6) implemented in OpenQuake (Pagani, et al., 2014). The CanadaSHM6 model provides the basis for design values proposed for the 2020 edition of the National Building Code of Canada (NBCC 2020). The CanadaSHM6 values were calculated with v3.3[a] of the OpenQuake engine (GEM, 2019). The enclosed model files are thus provided largely in formats consistent with those required by OpenQuake. The files included in the electronic supplement to this Open File are the trial version of the CanadaSHM6:

- source models in the 'Natural hazard' Risk Mark-up Language (NRML, GEM, 2019), a type of XML,
- summary of source models in comma separated values (CSV) file formats,
- lists of sites and a summary of selected hazard values in Excel format
- ground motion model (GMM) tables in HDF5 and text file (TXT) formats,
- logic trees for the sources and GMMs in NRML-XML format, and
- example job-description INI files consistent with OpenQuake v3.3.

An overview of the directory structure of the electronic supplement to this archive, noting relevant sections within this report, is shown in Figure 1. Files and folders in the supplement are referred to here in sans-serif font, for example, the root folder is CanadaSHM6. References to OpenQuake functions and classes use a `monospace` font.

Note that this Open File will be superseded by a subsequent Open File prior to the release of NBCC 2020; it will describe the model used to generate the final seismic hazard values for NBCC 2020. The current report does not discuss the scientific rationale for CanadaSHM6 and the NBCC 2020 hazard inputs. These details will be provided in forthcoming publications documenting the model. In the interim, interested readers are referred to Adams et al. (2019), Kolaj et al. (2019), Halchuk et al. (2019) and Kolaj et al. (2020b).

[a] Results in this Open File (and for CanadaSHM6 and NBCC 2020) were generated using v3.3.2 of OpenQuake. Hazard values generated using other versions of OpenQuake or using different hazard software may differ. In these cases, special attention should be taken to ensure that the model is both implemented correctly and produces values consistent with those included in the electronic appendix (additional sites for comparison may also be required).

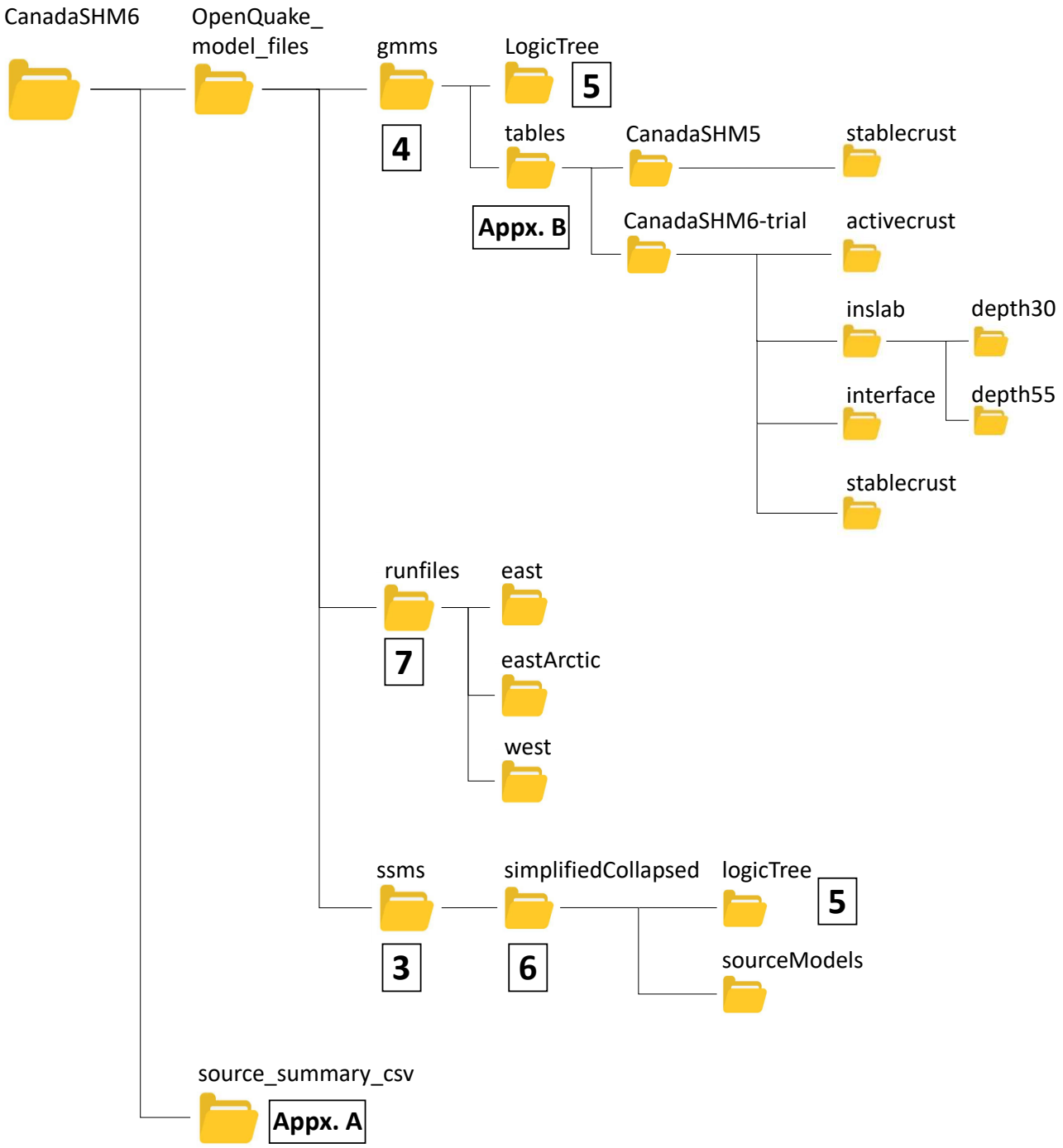


*Figure 1. Directory structure of enclosed files. Numbers and letters refer to relevant sections in this Open File.*

# 3. SOURCE MODELS

The CanadaSHM6 model is comprised of three separate regional models (Figure 2). The subdivision of the national model into three components was necessary to account for different numbers of weighted sub-models in each region. Sub-models within each regional model are used to represent the epistemic uncertainty in the characterization of the sources. The three regional models and their individual sub-models are (see also Adams et al., 2019, Kolaj et al., 2020c):

- The western model comprised of a single sub-model, weighted at 1.0;
- The east arctic model comprised of two sub-models: Historical (H2) weighted at 0.6 and Regional (R2) weighted at 0.4;
- The eastern model comprised of three sub-models: H2 weighted at 0.4, Hybrid (HY) weighted at 0.4 and R2 weighted at 0.2.

In CanadaSHM6, the hazard for a site in the boundary region of the sub-models is taken as the larger hazard calculated from each of the two adjacent sub-models (overlap regions in Figure 2). For most sites, the boundaries have been placed in low-hazard regions and the difference in hazard values between the adjacent sub-models are not significant. A national version of the model without regional partitioning will be released in a subsequent publication on CanadaSHM6.

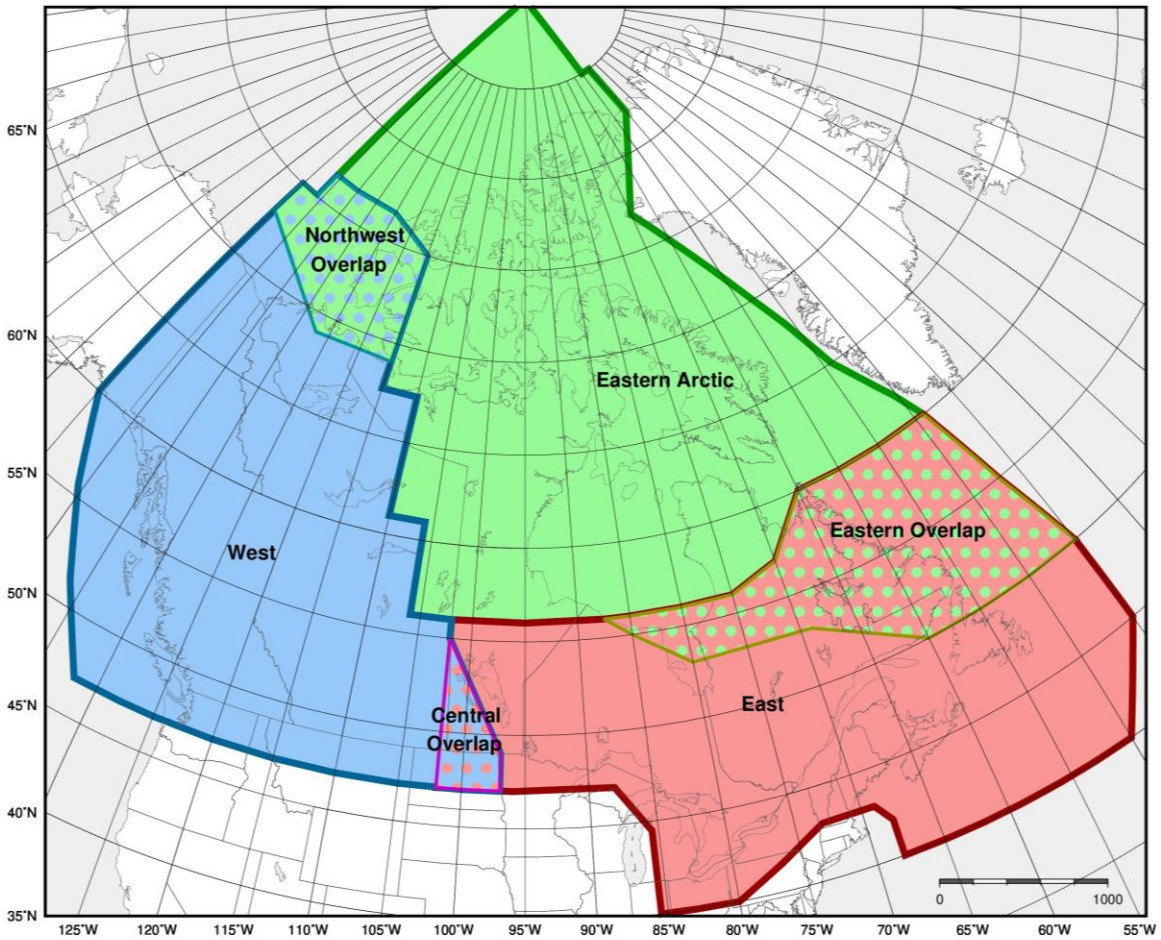


*Figure 2. Three regional models used to calculate hazard in the trial version of CanadaSHM6. In the central, eastern and northwest overlap zones, the larger hazard of the adjacent models is used.*

The model parameters for all sources are provided in OpenQuake NRML-XML format in CanadaSHM6\OpenQuake_model_files\ssms\simplifiedCollapsed\ (note that these are the simplified models, see Section 6), and summarized as tables in CanadaSHM6\source_summary_csv (Appendix A). The NRML-XML file should be taken as the authoritative document for the source information.

Earthquake rates are described in terms of a truncated Gutenberg-Richter (GR) magnitude-frequency distribution. Prior to CanadaSHM6, the rates were described as cumulative rates according to Weichert (1980):

$$N(m) = N_0 e^{-\beta m}\left[1 - e^{-\beta(M_{max}-m)}\right] \quad (1)$$

where $N$ is the cumulative number of earthquakes greater than magnitude $m$, $N_0$ is the number of earthquakes per year with magnitude greater than or equal to 0, $M_{max}$ is the maximum magnitude considered, and $\beta$ is a constant that describes the relative number of small to large earthquakes. Herein, the magnitude values for $m$ and $M_{max}$ are measured on the moment magnitude scale, $M_W$.

In the enclosed OpenQuake files and for CanadaSHM6, the rates are implemented as discretized incremental frequency distributions. This is largely done in order to collapse the magnitude recurrence logic tree (see Section 6.1). The incremental rates were calculated using the `TruncatedGRMFD` OpenQuake class (effectively equivalent to equation 1 but defined in terms of incremental instead of cumulative rates, and using the Gutenberg-Richter *a*- and *b*-values where $N_0 = 10^a$, and $\beta = b \ln(10)$).

There are several exceptions to the implementation of `TruncatedGRMFD` in CanadaSHM6, namely:

- Cascadia interface source: incremental rates were derived directly from the paleoseismic record (see Kolaj et al., 2020b),
- Western faults: pseudo-characteristic rates were estimated using a combination of $b = 0.8$ and $b \approx 0$ following Note that the zero *b*-value rate model uses a modification of equation 1 which normalizes the rates by the implied cumulative rate for $m \geq 0$ Allen et al., (2015).
- Leech River Valley and Devil's Mountain Faults as described in Halchuk et al. (2019).

Additional source parameters (e.g., adopted magnitude scaling relations) are available in the NRML-XML and associated summary csv files (Appendix A).

# 4. GROUND MOTION MODELS (GMMs)

A description of the GMMs used in CanadaSHM6 are provided in Kolaj et al. (2019) with further modifications as described in Kolaj et al. (2020a). The model includes GMMs for subduction interface, subduction inslab, active crust, and stable crust earthquakes.

The GMMs are implemented in OpenQuake using the `GMPETable` OpenQuake GSIM class and associated HDF5 tables. As CanadaSHM6 provides seismic hazard values for a range of $V_{S30}$ values, GMM tables are provided for fifteen $V_{S30}$ values in CanadaSHM6\OpenQuake_model_files\gmms\tables\. Text versions of the tables are also provided in the same directory for convenience (the HDF5 tables are the authoritative version) and a description of the format is provided in Appendix B. These tables are considered interim versions; the CanadaSHM6 GMMs will be implemented as native OpenQuake GSIM classes and documented in subsequent publications relating to CandaSHM6 (note: included GMM tables were generated from trial versions of these classes). It is expected that the final NBCC 2020 values will use the OpenQuake GSIM class implementation in lieu of the table-based implementation included in this Open File. As a result, minor differences may be introduced in the final model results, but they are expected to be inconsequential.

GMM tables are not available for the active crust GMMs because they require additional parameters and because they are already implemented using native OpenQuake GSIM classes. The classes are: `AbrahamsonEtAl2014`, `BooreEtAl2014`, `CampbellBozorgnia2014` and `ChiouYoungs2014`. Additionally,

these GMMs also require the definition of basin Z1.0 and Z2.5 terms. For CanadaSHM6, we use default (GMM-developer recommended) values which result in zero basin amplification relative to the central estimate of the GMM. As the default values for each GMM vary slightly, we use a single representative average value. Note that the zero-amplification Z1.0 value is $V_{S30}$ dependent. The standard values are given in the OpenQuake INI files (Section 7).

Peak ground velocity (PGV) and spectral accelerations below 0.1 s are not supported by the trial CanadaSHM6 model, as the GMM tables have not yet been properly calculated for these spectral intensity measures. These parameters will be available in the final CanadaSHM6 model.

To obtain the hazard for an arbitrary $V_{S30}$, linear interpolation of the hazard calculated at the adjacent $V_{S30}$ values must be used (Kolaj et al., 2020a). It will be possible to regenerate the GMM tables at a specified $V_{S30}$ in the final CanadaSHM6 model, but this is not currently supported. To obtain the hazard for Site Classes A-E as proposed for NBCC 2020, one must calculate the hazard for each of the $V_{S30}$ values within the $V_{S30}$ bounds of the Site Class and take the largest hazard value for each ground motion parameter (Figure 3; Kolaj et al., 2020a; Kolaj et al., 2020b).

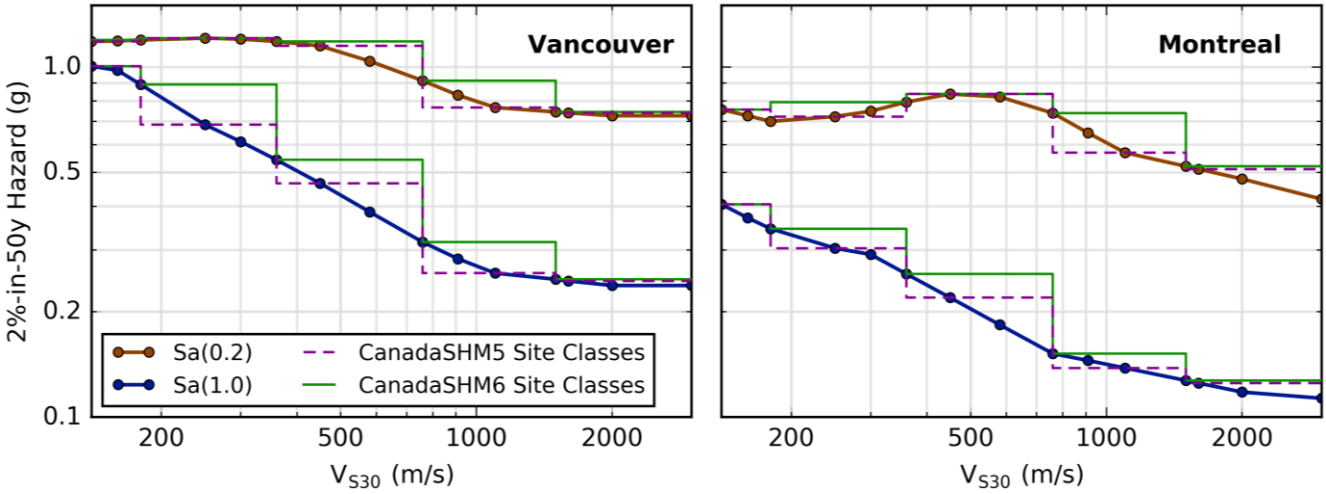


*Figure 3. Hazard as a function of $V_{S30}$ for Vancouver (left) and Montreal (right) for Sa(0.2) and Sa(1.0). Site Class definitions using the CanadaSHM5 and CanadaSHM6 approaches shown with dashed-purple and solid-green lines, respectively. From Kolaj et al., (2020a).*

# 5. LOGIC TREES

Epistemic uncertainty in model parameters is incorporated using a logic tree. An example of the logic tree for the southeastern regional model is in Figure 4. Each source region has preferred values (central, *c*) for maximum magnitude and the recurrence parameters ($N_0$ and *b* pairs), and these are given the largest weights in the logic tree. Each of these parameters has an "upper" (*u*) and a "lower" (*l*) value, which are given lesser weights. The regional source models for eastern Arctic and western Canada are the same, with the exception of the number of source sub-models (Section 3) and the GMMs (Section 4).

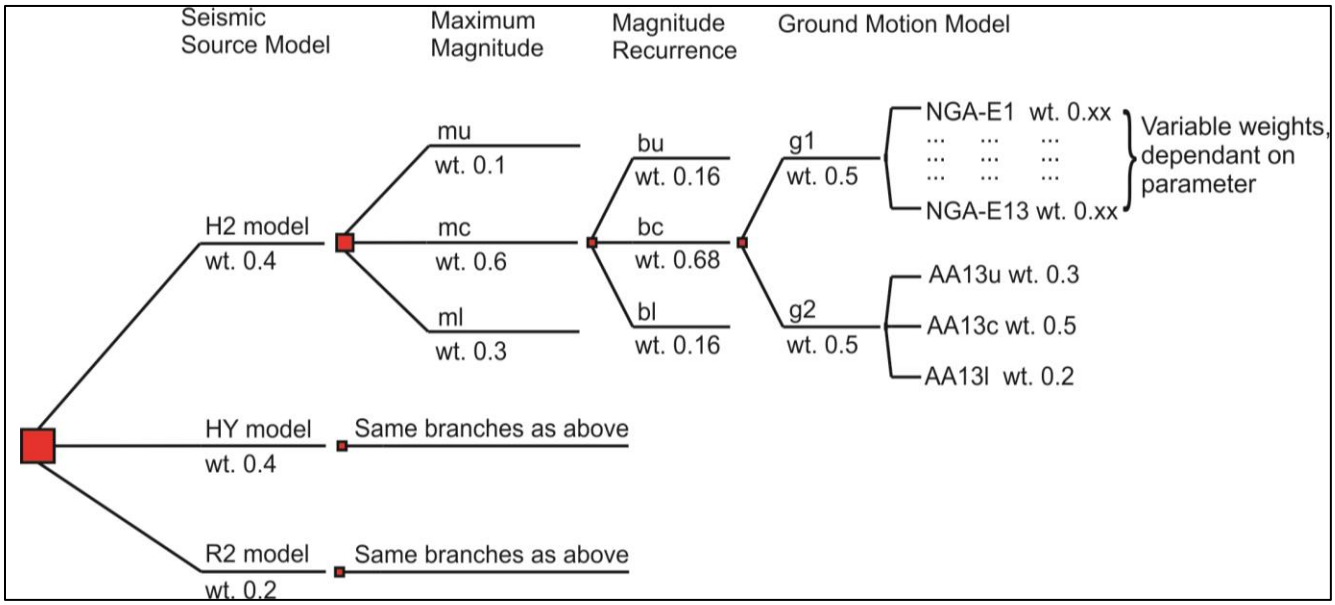


*Figure 4. Source logic tree for southeastern Canada (from Kolaj et al. 2020c). Mu, mc, ml and bu, bc and bl refer to the upper, central (preferred) and lower values for Mmax and magnitude recurrence parameters, respectively. Note that the b-branches are composed of $N_0$ and b value pairs (e.g., "bc" refers to $N_0$c and bc).*

With OpenQuake, the logic trees for sources and ground motion models are encoded in two sets of NRML-XML files. The source-model logic trees for each region are located in CanadaSHM6\OpenQuake_model_files\ssms\simplifiedCollapsed\logicTree\. As the GMM implementation is table-driven, separate GMM logic trees are required for each $V_{S30}$. The GMM logic trees for the fifteen $V_{S30}$ values (140 – 3000 m/s) calculated for CanadaSHM6 (and NBCC 2020) are located in CanadaSHM6\OpenQuake_model_files\gmms\logicTree\. Details on the file format are provided in the OpenQuake manual (GEM, 2019).

# 6. MODEL SIMPLIFICATIONS FOR NATIONAL MAPS

The complexity of the model was reduced in order to reduce the time required to compute hazard values for CanadaSHM6 on a national grid. The two simplifications were:

a) collapsing of magnitude recurrence branches (see 6.1), and
b) reduction in the number of rupture planes and hypocentral depths (see 6.2).

For the trial version of CanadaSHM6, only this simplified model is available. The simplified models produce mean hazard values very close to those from the full model, but cannot accurately produce quantile (e.g. median, 84$^{th}$ percentile) values. It is recommended that for site-specific hazard studies, the model simplifications should not be used. The non-simplified model will be released in a subsequent CanadaSHM6 publication.

## 6.1 Collapsing of magnitude recurrence branches

CanadaSHM6 includes nine branches for the epistemic uncertainty in magnitude recurrence statistics (three *Mmax* and three activity rate ($N_0$) / *b*-value pairs). For mean hazard, the recurrence statistics can be collapsed by finding the mean of the nine incremental rates weighted by the probabilities assigned in

the logic tree. This reduces the logic tree by a factor of nine. This simplified version of the model is referred to as the "collapsed" model. An example of the nine branches and the collapsed equivalent magnitude recurrence for the OBGH source is provided in Figure 5.

While the collapsed magnitude recurrence accurately represents the mean, it is not appropriate for any other quantile/percentile (e.g., median) or for the computation of hazard uncertainty (e.g., Kolaj et al., 2020c).

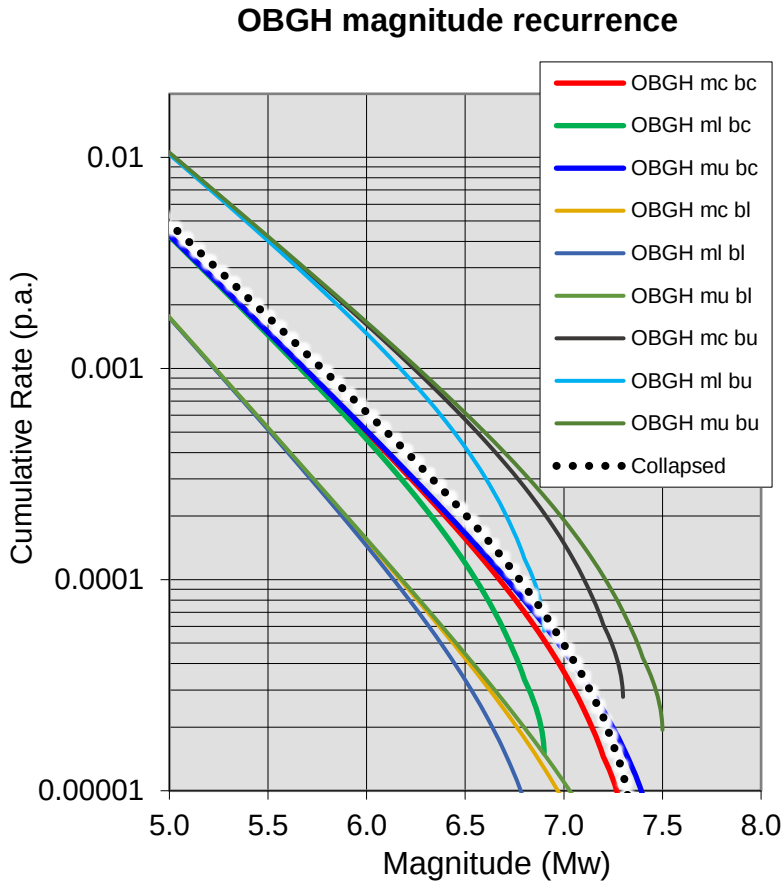


*Figure 5. Example of the nine-branch and collapsed magnitude recurrence rates for the Ontario Background Source (OBGH). mu, mc, ml and bu, bc and bl refer to the upper, central and lower values for Mmax and magnitude recurrence parameters (N0 and b value pairs), respectively.*

## 6.2 Further simplifications

Further simplifications were made to reduce the runtime of the national model. The model simplifications include:

- East and east-arctic regional models:
  - Reduction in the number of rupture planes from twelve to two.
  - Reduction in the number of hypocentral depths from three to one.
- Western regional model:
  - Reduction in the number of rupture planes from twelve to six.
- Stable cratonic core (SCC) sources:
  - Reduction in the number of rupture planes from twelve to one.

Testing with an early version of CanadaSHM6 model indicated that these simplifications resulted in mean hazard values that were within a few percent of the base model (i.e., well within the inherent epistemic uncertainty in mean hazard which is on the order of a factor of 2; Kolaj et al. 2020c). The non-simplified model will be released in subsequent CanadaSHM6 publications.

# 7. OPENQUAKE JOB DESCRIPTION FILES

Example OpenQuake job description INI files are located in the CanadaSHM6\OpenQuake_model_files\runfiles directory for each of the three regional models at each $V_{S30}$. File names follow the convention: CanadaSHM6-trial_[*RegionalModel*]CollapsedSimple_[Vs30].mps.ini. Please see the OpenQuake manual (GEM, 2019) for more information on the required fields within the INI file.

The example INI files reference the collapsed simplified model (Section 6) and the CanadaSHM6 GMM tables (Section 4). The INI files use relative file paths (as shown in the Figure 1) such that if the file structure in the electronic supplement is maintained, the files should not need any modification.

Coordinates for 680 Canadian localities have been included as files in the appropriate directories. Example hazard outputs for a selection of these locations are included in the electronic supplement and described in Appendix C. New implementations should verify that those hazard values are adequately reproduced. Minor discrepancies of less than 1% may occur, and will likely be considered acceptable (note the special treatment for the overlap zones, as discussed in Section 3).

# 8. MODEL LIMITATIONS

The enclosed trial version of CanadaSHM6 has the following limitations:

- The western regional model should not be run for $V_{S30} > 1100$ m/s.
- The current GMM tables are not valid for PGV or Sa with T < 0.1 s (but will be available when the final model is released).
- The chosen Mmin (minimum magnitude of earthquakes contributing to hazard) of 4.8 can have a significant effect on the calculated hazard values, especially for high return probabilities and in regions of low-seismicity (Halchuk and Adams, 2010).
- The model is of unknown reliability at probabilities below 2%-in-50 years (0.000404 p.a.).

# 9. NATIONAL BUILDING CODE OF CANADA

CanadaSHM6 is currently proposed as the basis for seismic hazard values in NBCC 2020. NBCC 2020 is expected to be released in 2021. Seismic hazard values generated using a trial version of CanadaSHM6 were released for 679 localities in Kolaj et al. (2020a). The model contained in this Open File is an update to the model which was used to generate those values. In general, the values are similar but there are some small changes in hazard in western Canada. Seismic hazard values produced by the model and contained in Appendix C are considered to supersede the values given in Kolaj et al. (2020a).

# 10. SUMMARY

This Open File contains the model files required to calculate hazard using the CanadaSHM6 model which is the basis for the seismic hazard values proposed for NBCC 2020. A subsequent Open File will be released prior to NBCC 2020 to reflect the final seismic hazard values calculated using CanadaSHM6. Further details on the required input files and on the definition of model parameters in OpenQuake can be found in GEM (2019).

Questions and comments can be directed to Michal Kolaj, Michal.Kolaj@Canada.ca.

# 11. ACKNOWLEDGEMENTS

We thank Dylan Young for his extensive work to ensure consistency in the models and in the development of the OpenQuake compatible source model files. We thank Nicholas Ackerley for his internal review.

# 12. REFERENCES

Note that the references published by the authors of this Open File are available in the hazard section of the Earthquakes Canada website https://earthquakescanada.nrcan.gc.ca/hazard-alea/recpubs-en.php (website address correct as of October 2020)

Adams J, Allen T, Halchuk S, Kolaj M (2019): Canada's 6th Generation Seismic Hazard Model as Prepared for the 2020 National Building Code of Canada. *12th Canadian Conference on Earthquake Engineering*, Quebec City, Canada.

Allen T, Adams J, Rogers G, Halchuk S (2015): New seismic hazard model for north-western Canada. *11th Canadian Conference on Earthquake Engineering*, Victoria, Canada.

Global Earthquake Model OpenQuake Manual (2019): Openquake Engine User Instruction Manual v 3.3. Available at https://docs.openquake.org/manuals/OpenQuake%20Manual%203.3.pdf. Last accessed February 27 2020.

Halchuk S, Allen T, Adams J, and Onur T (2019): Contribution of the Leech River Valley - Devil's Mountain fault system to seismic hazard for Victoria B.C. *12th Canadian Conference on Earthquake Engineering*, Quebec City, Canada.

Kolaj M, Allen T, Mayfield R, Adams J, Halchuk S (2019): Ground-motion models for the 6th Generation Seismic Hazard Model of Canada. *12th Canadian Conference on Earthquake Engineering*, Quebec City, Canada.

Kolaj, M, Halchuk S, Adams J, Allen TI, (2020a): Trial Sixth Generation seismic hazard model of Canada: seismic hazard values for selected localities; Geological Survey of Canada, Open File 8629, 1 .zip file. https://doi.org/10.4095/321473

Kolaj M, Adams J, Halchuk S (2020b): The 6th Generation seismic hazard model of Canada. *17th World Conference on Earthquake Engineering*, Sendai, Japan. Paper 1c-0028

Kolaj M, Adams J, Halchuk S (2020c): Seismic hazard in southeastern Canada: uncertainty and controls on seismic hazard in a region of low-to-moderate seismicity. *17th World Conference on Earthquake Engineering*, Sendai, Japan. Paper 1c-0029.

Pagani M, Monelli D, Weatherill G, Danciu L, Crowley H, Silva V, Henshaw P, Butler L, Nastasi M, Panzeri L, Simionato M, Vigano D (2014): OpenQuake Engine: An Open Hazard (and Risk) Software for the Global Earthquake Model. Seismological Research Letters, 85 (3), 692-702.

Weichert DH (1980): Estimation of the earthquake recurrence parameters for unequal observation periods for different magnitudes. *Bulletin of the Seismological Society of America*, **70**, 1337-1346.

# Appendix A: Description of source model summary csv files

The NRML-XML version of the files should be considered the authoritative source. However, source summaries are also providing in individual CSV files for each regional model in CanadaSHM6\source_summary_csv\. A description of the fields for the csv file is available below. Note that the Leech River Valley and Devil's Mountain Faults and Cascadia Interface sources, have separate csv files because their rates are calculated differently (characteristic rates and directly estimated incremental rates, respectively). See also the OpenQuake manual (GEM, 2019) for a description of the required source fields.

### Area and simple faults:

| | |
|---|---|
| srcCode | Unique source identifier/acronym |
| srcName | Name of source following convention of: "full source name (comments)" |
| srcType | OpenQuake source type (typically `areaSource`, `simpleFaultSource` or `complexFaultSource`) |
| tectReg | Tectonic region (determines which branch of the GMM logic tree is used) |
| minMag | Minimum magnitude of truncated GR distribution (MFD) |
| maxMagCentral | Preferred maximum magnitude of truncated GR distribution (see Figure 4) |
| maxMagUpper | Upper maximum magnitude of truncated GR distribution (see Figure 4) |
| maxMagLower | Lower maximum magnitude of truncated GR distribution (see Figure 4) |
| N0Central | Preferred activity rate of truncated GR distribution (see Figure 4) |
| N0Upper | Upper activity rate of truncated GR distribution (see Figure 4) |
| N0Lower | Lower activity rate of truncated GR distribution (see Figure 4) |
| bCentral | Preferred b-value of truncated GR distribution (see Figure 4) |
| bUpper | Upper b-value of truncated GR distribution (see Figure 4) |
| bLower | Lower b-value of truncated GR distribution (see Figure 4) |
| seismogenicDepth (upper, lower) | Minimum and maximum seismogenic depths |
| hypoCentralDist (weight, depth) | List of hypocentral depths and associated weights |
| magScaleRel | Scaling relation between magnitude and the area of the rupture (e.g. `WC1994`, `CEUS2011`, `GSCOffshore`, etc.). See OpenQuake class descriptions for additional details. |
| ruptAspectRatio | Aspect ratio of the rupture (length / width) |
| NodalPlaneDistribution (weight, strike, dip, rake) | List of rupture orientations and associated weights |
| rake | Rake of fault (`complexFaultSource` only) |
| faultDip | Dip of fault (`simpleFaultSource` only) |
| shape | Well-known text (WKT) format string describing geometry |
| areaGeometry discretization | Spacing (km) of mesh used to determine contributions from area sources |

### Additional fields for fitted incremental rates (Cascadia Interface sources):

| | |
|---|---|
| rates | List of lists of incremental magnitude frequency distributions (MFD, annual rates), one for each branch of the logic tree |
| binWidth | Width of the bin used for all MFDs |
| uncertaintyWeight | List of logic tree weights for each MFD |

## Additional fields for characteristic rate faults (Leech River and Devil's Mountain Faults):

| | |
|---|---|
| maxMag | List of characteristic magnitudes (Mmax is 0.25 units larger) branches of the logic tree |
| N0 | List of activity rates values for each branch of the logic tree |
| b_val | List of b-values for each branch of the logic tree |
| char_rate | List of characteristic rates of each of the characteristic magnitudes |
| uncertaintyWeight | List of logic tree weights for each characteristic rates |

# Appendix B: Description of Ground Motion Model (GMM) tables

Ground motion model (GMM) tables (TXT and HDF5) for CanadaSHM6 are located in: CanadaSHM6\OpenQuake_model_files\gmms\tables\. File names follow the format: CanadaSHM6-trial_[*GMM name*].vs[*Vs30*].h[*depth*].txt, where the field within the brackets is variable depending on the GMM name, the $V_{S30}$ and the hypocentral depth. Both HDF5 and the TXT tables were generated simultaneously by iterating rupture and site parameters using the trial version of the CanadaSHM6 GMMs implemented as OpenQuake GSIM classes. These OpenQuake classes will be released in subsequent CanadaSHM6 publications. For now, the HDF5 files are the authoritative source.

Text files are formatted as:

| | |
|---|---|
| Line 1 | Header: free-form string typically listing the GMM name (and whether the OpenQuake class is used directly or with modifications), distance measure, and disclaimer. |
| Line 2 | Number of magnitudes, distances, intensity measures (e.g., SA, PGV, PGA) and free-form comments. |
| Line 3 | Period of spectral acceleration, or PGA or PGV |
| Line 4 | Aleatory uncertainty (sigma) in natural log units |
| Line 5+ | Magnitude ($M_W$), distance (km), log10(hazard value) for each period. Spectral and peak acceleration value units are cm/s/s. |

**Examples:**

OpenQuake_model_files\gmms\tables\inslab\depth30\CanadaSHM6-trial_AtkinsonBoore2003SSlabCascadia.vs450.h55.txt

```
AtkinsonBoore2003SSlabCascadia_CanadaSHM6-trial modified from OpenQuake implementation, distance is rrup. Log10 ground motion values in cgs units, PGV and Sa(T<0.1s) not valid
        14 31 11 : nmag, ndist, nperiod
        10.000 5.000 3.000 2.000 1.000 0.400 0.200 0.100 0.040 PGA PGV
        0.691 0.691 0.691 0.691 0.668 0.645 0.645 0.645 0.576 0.622 0.000
4.750 1.000 0.266 0.924 1.523 2.201 2.783 3.172 3.417 3.337 3.352 3.069 0.000
4.750 1.260 0.222 0.877 1.474 2.152 2.734 3.123 3.369 3.288 3.303 3.021 0.000
4.750 1.580 0.160 0.813 1.408 2.086 2.668 3.057 3.302 3.222 3.237 2.954 0.000
4.750 2.000 0.079 0.729 1.322 2.000 2.582 2.971 3.216 3.135 3.150 2.868 0.000
4.750 2.510 -0.021 0.625 1.216 1.893 2.475 2.864 3.109 3.028 3.043 2.761 0.000
4.750 3.160 -0.138 0.503 1.091 1.767 2.349 2.760 3.008 2.928 2.943 2.667 0.000
4.750 3.980 -0.270 0.366 0.950 1.626 2.207 2.657 2.911 2.830 2.845 2.582 0.000
4.750 5.010 -0.413 0.217 0.796 1.472 2.052 2.533 2.792 2.710 2.725 2.472 0.000
4.750 6.310 -0.564 0.060 0.634 1.309 1.889 2.391 2.654 2.572 2.587 2.340 0.000
4.750 7.940 -0.719 -0.103 0.466 1.139 1.718 2.237 2.501 2.419 2.433 2.192 0.000
4.750 10.000 -0.878 -0.270 0.293 0.965 1.543 2.062 2.326 2.243 2.257 2.017 0.000
4.750 12.590 -1.038 -0.439 0.118 0.788 1.364 1.883 2.146 2.063 2.077 1.837 0.000
4.750 15.850 -1.199 -0.610 -0.060 0.608 1.182 1.701 1.964 1.880 1.893 1.655 0.000
4.750 19.950 -1.360 -0.782 -0.239 0.426 0.998 1.516 1.779 1.693 1.706 1.469 0.000
4.750 25.120 -1.522 -0.954 -0.420 0.242 0.811 1.329 1.591 1.504 1.516 1.281 0.000
4.750 31.620 -1.683 -1.127 -0.601 0.055 0.621 1.139 1.400 1.311 1.322 1.089 0.000
4.750 39.810 -1.845 -1.301 -0.784 -0.133 0.428 0.945 1.205 1.115 1.124 0.894 0.000
4.750 50.120 -2.008 -1.476 -0.967 -0.324 0.231 0.748 1.007 0.913 0.921 0.694 0.000
4.750 63.100 -2.171 -1.652 -1.152 -0.519 0.030 0.546 0.803 0.706 0.712 0.489 0.000
4.750 79.430 -2.335 -1.829 -1.339 -0.717 -0.177 0.338 0.592 0.491 0.495 0.276 0.000
4.750 100.000 -2.501 -2.008 -1.527 -0.920 -0.392 0.122 0.373 0.267 0.267 0.056 0.000
```

OpenQuake_model_files\gmms\tables\interface\CanadaSHM6-trial_AbrahamsonEtAl2015SInter.vs300.h30.txt

```
AbrahamsonEtAl2015SInter as implemented in OpenQuake, distance is rrup. Log10 ground motion values in cgs units, PGV and Sa(T<0.1s) not valid
        10 31 24 : nmag, ndist, nperiod
        10.000 7.500 6.000 5.000 4.000 3.000 2.500 2.000 1.500 1.000 0.750 0.600 0.500 0.400 0.300 0.250 0.200 0.150 0.100 0.075 0.050 0.020 PGA PGV
        0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.740 0.000
7.000 1.000 0.783 1.014 1.241 1.421 1.624 1.863 2.020 2.185 2.398 2.664 2.785 2.857 2.922 2.985 2.979 2.984 2.988 2.962 2.859 2.760 2.654 2.709 2.709 0.000
7.000 1.260 0.779 1.010 1.236 1.416 1.619 1.857 2.014 2.179 2.392 2.658 2.779 2.851 2.916 2.979 2.973 2.978 2.983 2.957 2.854 2.754 2.648 2.702 2.702 0.000
7.000 1.580 0.774 1.004 1.230 1.410 1.612 1.850 2.007 2.171 2.385 2.651 2.772 2.843 2.908 2.972 2.966 2.971 2.976 2.950 2.847 2.747 2.641 2.693 2.693 0.000
7.000 2.000 0.768 0.997 1.223 1.402 1.604 1.841 1.998 2.162 2.375 2.642 2.763 2.834 2.899 2.963 2.957 2.963 2.968 2.942 2.838 2.738 2.632 2.683 2.683 0.000
7.000 2.510 0.760 0.989 1.214 1.393 1.594 1.830 1.987 2.151 2.364 2.630 2.751 2.823 2.888 2.951 2.946 2.952 2.957 2.931 2.828 2.727 2.621 2.670 2.670 0.000
7.000 3.160 0.750 0.978 1.203 1.381 1.582 1.817 1.973 2.137 2.350 2.616 2.738 2.809 2.873 2.937 2.933 2.939 2.944 2.918 2.815 2.714 2.607 2.654 2.654 0.000
7.000 3.980 0.739 0.966 1.189 1.367 1.567 1.801 1.956 2.120 2.333 2.599 2.721 2.792 2.856 2.920 2.916 2.922 2.928 2.902 2.799 2.697 2.589 2.634 2.634 0.000
7.000 5.010 0.725 0.950 1.173 1.350 1.549 1.781 1.936 2.099 2.312 2.579 2.700 2.771 2.835 2.899 2.896 2.902 2.909 2.883 2.780 2.677 2.569 2.611 2.611 0.000
7.000 6.310 0.708 0.932 1.153 1.329 1.527 1.758 1.912 2.074 2.288 2.554 2.675 2.746 2.809 2.873 2.871 2.877 2.885 2.859 2.756 2.652 2.543 2.582 2.582 0.000
7.000 7.940 0.688 0.910 1.130 1.305 1.501 1.730 1.883 2.045 2.258 2.524 2.645 2.715 2.778 2.841 2.840 2.847 2.855 2.830 2.727 2.623 2.513 2.548 2.548 0.000
7.000 10.000 0.664 0.884 1.103 1.276 1.471 1.698 1.849 2.011 2.223 2.488 2.609 2.679 2.740 2.804 2.804 2.810 2.820 2.795 2.693 2.587 2.476 2.508 2.508 0.000
7.000 12.590 0.637 0.854 1.071 1.242 1.435 1.659 1.810 1.970 2.182 2.446 2.567 2.636 2.696 2.759 2.760 2.766 2.777 2.753 2.651 2.544 2.433 2.460 2.460 0.000
7.000 15.850 0.604 0.819 1.033 1.203 1.394 1.615 1.764 1.924 2.134 2.397 2.517 2.586 2.644 2.707 2.708 2.714 2.726 2.702 2.601 2.493 2.382 2.404 2.404 0.000
7.000 19.950 0.567 0.778 0.990 1.158 1.347 1.565 1.712 1.870 2.079 2.341 2.460 2.527 2.584 2.645 2.647 2.653 2.666 2.642 2.543 2.434 2.322 2.340 2.340 0.000
7.000 25.120 0.524 0.731 0.941 1.106 1.293 1.507 1.653 1.809 2.016 2.276 2.394 2.460 2.514 2.575 2.576 2.582 2.595 2.573 2.475 2.365 2.253 2.267 2.267 0.000
7.000 31.620 0.474 0.678 0.885 1.047 1.232 1.442 1.586 1.740 1.945 2.202 2.319 2.383 2.435 2.494 2.495 2.500 2.515 2.492 2.396 2.285 2.174 2.184 2.184 0.000
7.000 39.810 0.418 0.617 0.822 0.981 1.162 1.369 1.510 1.662 1.864 2.118 2.234 2.297 2.346 2.404 2.404 2.407 2.423 2.401 2.307 2.195 2.085 2.092 2.092 0.000
7.000 50.120 0.353 0.548 0.750 0.906 1.084 1.286 1.425 1.575 1.774 2.024 2.138 2.200 2.246 2.303 2.302 2.304 2.321 2.299 2.207 2.094 1.985 1.991 1.991 0.000
7.000 63.100 0.279 0.469 0.668 0.821 0.996 1.193 1.330 1.477 1.672 1.918 2.031 2.092 2.136 2.191 2.190 2.190 2.208 2.186 2.096 1.983 1.876 1.881 1.881 0.000
7.000 79.430 0.194 0.379 0.574 0.724 0.896 1.088 1.223 1.366 1.557 1.800 1.911 1.972 2.013 2.068 2.067 2.066 2.084 2.063 1.975 1.862 1.757 1.762 1.762 0.000
7.000 100.000 0.096 0.276 0.468 0.614 0.782 0.969 1.101 1.242 1.428 1.666 1.776 1.839 1.879 1.934 1.933 1.930 1.950 1.930 1.845 1.731 1.629 1.635 1.635 0.000
```

# Appendix C: Example Hazard Values

Example hazard outputs of CanadaSHM6 are provided in:
CanadaSHM6\OF8630_CanadaSHM6_SampleHazardValues.xlsx.

The spreadsheet provides a selection of seismic hazard values derived from the 6$^{th}$ Generation Seismic Hazard Model of Canada (CanadaSHM6). Mean, 2%/50 year probability peak and spectral acceleration values are provided for three $V_{S30}$ values: 140, 450 and 1100 m/s. Seismic hazard values should be reported to two significant figures (in our view, an appropriate level of precision). However, we have provided three significant figures to aid with verification of future implementations of CanadaSHM6.