GEOLOGICAL SURVEY OF CANADA

OPEN FILE 3283

Trial seismic hazard maps of Canada - 1995: final values for selected Canadian cities

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Trial seismic hazard maps of Canada - 1995: final values for selected Canadian cities

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ABSTRACT

We summarize the methods being used for new seismic hazard maps of Canada, tabulate final values of the 50th and 84th percentile ground motions for major cities, and give uniform hazard spectra, all for sites on firm soil at a 10% probability of exceedence in 50 years. The availability of strong ground motion relations for spectral parameters allows computation of spectral acceleration maps, which are being recommended as input to the seismic provisions of the National Building Code.

RÉSUMÉ

Nous résumons les méthodes utilisées pour les nouvelles cartes de péril séismique du Canada, donnons les valeurs finales de mouvement du sol au 50^{e} et 84^{e} centile pour les villes importantes et donnons les spectres de péril uniforme, tout cela pour des sites sur sol dur et une probabilité de dépassement de 10% en 50 ans. Les relations de mouvements forts du sol pour les paramètres de spectre ainsi obtenus permettent de calculer des cartes d'accélération spectrale qui sont recommandées comme base des dispositions séismiques du Code National du Bâtiment.

INTRODUCTION

The Geological Survey of Canada is producing a suite of new seismic hazard maps for Canada. These maps, to be released for trial use and public comment in 1996, are intended to be revised as appropriate and reissued in about 1997 or 1998 as the basis for seismic design provisions in the year-2000 edition of the National Building Code of Canada. Three generations of seismic hazard maps for Canada have been produced at roughly 15-year intervals (1953, 1970, 1985), and a fourth generation is now justified because there is sufficient new information available to improve the hazard estimates (Adams et al., 1995a; Basham, 1995).

The present open file is being issued to release key seismic hazard values computed using the methods that will form the basis of the "Trial Seismic Hazard Maps of Canada". A suite of Open Files will be issued in mid-1996, to be entitled:

"Trial Seismic Hazard Maps of Canada - 1995: Overview of the Method"
"Trial Seismic Hazard Maps of Canada - 1995: Eastern Earthquake Source Zones"
"Trial Seismic Hazard Maps of Canada - 1995: Western Earthquake Source Zones"
"Trial Seismic Hazard Maps of Canada - 1995: Choice of Strong Ground Motion Relations"
"Trial Seismic Hazard Maps of Canada - 1995: Computational Aspects"
"Trial Seismic Hazard Maps of Canada - 1995: Results and Maps"

For convenience, the above Open Files will be referred to as: 95-Overview, 95-East, 95-West, 95-SGM, 95-Comp, and 95-Results. The current Open File ("95-Cities") replaces a previous version "Trial Seismic Hazard Maps of Canada - 1995: Preliminary Values for Selected Canadian Cities" issued in March 1995 as GSC Open File 3029 (Adams et al. 1995b, henceforth 'GSCOF3029'). Relative to GSCOF3029, the present document updates the hazard values (Appendix A gives details of the changes), presents them in a new format, has a considerably revised text, especially regarding the choice of soil amplification factors, and contains appendices detailing the seismicity source models and their parameters that we used. The current Open File, in turn, will be superceded by the 95-Results Open File, when issued. Around 1998, the hazard model and open files will be revised and will probably be re-issued as a series: New Seismic Hazard Maps of Canada - 1998: ABCDE.

The new hazard maps will incorporate an extra 13 years of earthquake data, the most recent research on source zones and earthquake occurrence, together with complementary research on strong ground motion relations. In contrast to the 1985 maps, which gave national values for peak ground velocity (PGV) and peak ground acceleration (PGA), we can now provide spectral acceleration values ("PSA"; 5% damped) for the range of periods important for common engineered structures. We present tables of hazard values for most of the larger population centres exposed to seismic hazards, as well as Uniform Hazard Spectra (UHS), all computed for sites on firm soil at a 10% probability of exceedence in 50 years (0.0021 per annum).

METHOD

Because this Open File is being issued in advance of the Open Files containing the full documentation, a brief overview is given below.

The present method for calculating seismic hazard builds upon the work of Basham et al. (1982; 1985) which established the third generation of seismic hazard maps for Canada. We apply the same Cornell-McGuire methodology (e.g., McGuire, 1993) using the hazard code FRISK88 (a proprietary software product of Risk Engineering Inc.). This, and other new-generation codes, allow explicit inclusion, for the first time for a national hazard map of Canada, of both aleatory (randomness) and epistemic (model or professional) uncertainty (a brief account of uncertainty is given below).

Of necessity, eastern and western Canada must be treated slightly differently. In the following, the boundary between east and west is taken to slice diagonally across Canada from southeastern Alberta to the eastern Beaufort Sea.

Probability level
The probability level is 0.0021 per annum, or a 10% chance of exceedence in 50 years. This is the same as in the 1985 maps.

Cities
The "cities" in the list include most of the larger population centres exposed to seismic hazards, together with a few select localities to round-out the geographical distribution. Coordinates for the cities are given only to 0.1 degree. Final values in the 95-Results open file will be given to 0.01 degree and will represent the town hall, chief post office, or downtown core, and not the airport or weather station, as is often the case in the current NBCC.

Uncertainty
A full treatment of uncertainty will be given in 95-Overview. Suffice it to say here that the new seismic hazard maps of Canada under preparation at GSC consider both types of uncertainty:

Aleatory uncertainty arises from physical variability that is inherent in the unpredictable nature of future events. For example there is a random component of earthquake source and propagation processes which will cause a scatter of amplitudes about the median values, even if the median were known with perfect accuracy. The Cornell-McGuire approach, as implemented in the 1985 NBCC hazard maps included the aleatory uncertainty by incorporating the "sigma" of the ground motion relations into the computation. The sigma is the standard deviation of the scatter of the data about the median ground motion relations, and its incorporation through the FRISK88 code increases the median hazard (the aleatory uncertainty is also included in all the percentiles of hazard).

Epistemic uncertainty arises from the differences in expert specification of modelling assumptions, unknown or only partially known parameters, and extrapolation beyond observed range of data. Examples are: specification of seismic source zones, including judgments on stochastic behaviour of historical seismicity, or belief in future activity of seismic gaps; assumptions made in calculations of recurrence curves, such as their analytical form, and extrapolation beyond the observed data range or duration of historical record; and choice of maximum magnitude. FRISK88 uses a standard "logic tree" approach to include the epistemic uncertainty. Our 84th percentile values include the contribution of the epistemic uncertainty from all the explicitly-included parameters (strong ground motion relations, focal depth, earthquake recurrence parameters, upper bound magnitude); a further parameter — earthquake source zone configuration — is treated separately, as discussed below.

The above simple separation of aleatory and epistemic is over simplified. In fact, any uncertainty that is not explicitly identified as an epistemic uncertainty will probably be lumped together with the aleatory. For example, the amplitude of ground motions from an earthquake depends on whether its mechanism is strike-slip or thrust, or on the directivity of the source. Current estimates of the uncertainty for Canada bundle this variability into the aleatory uncertainty (as the sigma); however if factored out, as additional parameters in the ground motion relations, the new sigma would be lower than before. Hence the separation of uncertainty into aleatory and epistemic is somewhat artificial.

SEISMICITY PARAMETERS

Earthquake Catalogue

We have used the Canadian earthquake catalogue up to 1990 for the east and up to 1991 for the west. Relative to the catalog used for the 1985 maps, this adds a further 13-14 years of data. We have also made a significant number of revisions to older earthquake parameters of location and magnitude, and have supplemented the Canadian catalogue by recent U. S. catalogues. The eastern earthquakes chiefly have m_{bLg} magnitudes, so within the hazard program we converted them to moment magnitudes in order to use the Atkinson and Boore (1995) relations. The western earthquakes have a mix of magnitudes, depending on availability and quality, and are assigned in order of preference, moment magnitude for the largest, surface-wave magnitude for the next and so on; since the definition (or calibration) of these different scales are generally perceived to blend the scales smoothly into one another, we consider them equivalent to moment magnitudes in order to apply the Boore et al. (1993; 1994) relations.

Earthquake Source Zones

The last hazard maps were computed in 1982, using seismicity up to 1977 for most zones. They represented the distribution of seismicity by a single set of seismicity source zones. Since the 1982 maps, we have accumulated an additional 14 years of earthquakes, and discovered clearer epicentre patterns in some places but been surprised by 'unexpected' events in others. We have developed a better understanding of the seismotectonics behind the seismicity, but also an appreciation that much is unknown about how the future pattern of seismicity will resemble or differ from the historical pattern.

In some places, southwestern B.C. and the Queen Charlotte Fault being examples, the level of knowledge is quite high, and one would expect a single model to suffice. In most other places, the range of opinions as to the cause and distribution of the earthquakes make a single model subject to much arbitrariness, so that the hazard results would reflect the current opinion of the compiler(s) and hence add a deterministic flavour to the maps. The resultant hazard maps might change drastically if there were a change of compiler, an 'unexpected' earthquake, or a shift in the paradigm of earthquake occurrence. For these reasons we think a pair of models provides the minimal representation of the diversity of opinion as to the causes and future locations of earthquakes.

To apply the Cornell-McGuire method we purchased a license for a large commercial program (FRISK88) in 1990 that allows us to use a number of source zone models and weight them by our (subjective) assessment that they are the correct model. For eastern Canada, our philosophy over the past 6 years has been shaped by the belief that while the scale of source zones could vary from the continent-scale to very small zones around single earthquakes, there are practical reasons for not choosing these extremes. Hence we have two models, a **H** model that in general uses small source zones drawn around historical seismicity clusters, and a **R** model that establishes larger, regional zones (Fig. 1). The **H** and **R** models for the east were constructed by Adams and Halchuk (see 95-East), those for the west by Rogers and Horner (see 95-West). While some of the same philosophy is applicable in the eastern Rockies, the differences between the **H** and **R** models in western Canada are not generally interpretable in this manner, as neither expert in the west adopted a strongly historical model.

We have tried an approach proposed by A. Frankel of the USGS as part of their estimation of eastern U.S. earthquake hazard. From our perspective, the most interesting aspect of their method is the estimation of seismic hazard based on the historical occurrence rate of $M \geq 3$ earthquakes (Frankel 1995; 1996). We applied Frankel's computer code to our earthquake file (Halchuk and Adams, unpub., 1995) and found that it replicated the hazard from our **H** seismicity model very closely (our **H** model results are the appropriate ones to compare because that model in the east is designed to estimate hazard from small, historical earthquake clusters). It is reassuring that the assumptions made during the design of the **H** model, and the simplifications adopted in the Frankel code, result in similar hazard. Despite this, we have reservations about the USGS methods, particularly with respect to the estimation of seismic hazard for regions of low or negligible contemporary seismicity, such as the regions of eastern Canada where the **R** model dominates.

In eastern Canada, the **R** model often combines a number of seismicity clusters that are inferred to have a common cause into large source zones, the larger of which are the Arctic Continental Margin (ACM), the Eastern Continental Margin (ECM), and the Iapetan Rifted Margin (IRM), shown on Figure 1. For each, the **R** model zone implies that currently aseismic regions between adjacent seismicity clusters (e.g., the St. Lawrence valley near Trois Rivières) are capable of large earthquakes, and that the rate of activity at any place along the margin is constant, and not higher in the vicinity of the historical activity. Contour maps of hazard computed using the **R** model have long 'ridges' of moderate hazard and lack the 'bulls-eyes' of high hazard produced by the

H model (and exist in the current code maps). As a consequence, if the **R** model were implemented in a building code, it would reduce the protection significantly in regions of high historical seismicity while increasing protection only slightly in other places. This poses a dilemma to engineers concerned with safety. A probabilistic combination of the two models (as is possible with FRISK88) would involve their weighted-sum, but any weight given to the **R** model would reduce the protection in regions of high historical seismicity. A possible non-probabilistic solution is discussed below under "Combining diverse hazard estimates using the 'robust' approach".

In western Canada, while the tectonics are better understood, and the models are not as different, there are still differences of opinion. For example, model **R** collects crustal earthquakes around Vancouver and Seattle together with the central Vancouver Island earthquakes into one zone (CASR) to represent shallow seismicity in this region of the North American Plate above the Cascadia subduction zone; model **H** uses two smaller zones (see Fig. 1). The Queen Charlotte Fault is the only earthquake source treated as a fault; all others are area sources.

Magnitude Recurrence Parameters

We use the maximum likelihood method of Weichert (1980) to compute the magnitude recurrence parameters. To provide an estimate of epistemic uncertainty we have taken the standard errors for the calculation and combined them to give an upper and a lower curve which approximate one sigma (standard deviation) error bounds. The curves are asymptotic to an assumed upper bound magnitude, and again we have used our judgment to associate the three curves with three possible upper bound values. Examples for two eastern source zones are shown in Figure 2. The level of the recurrence curves is dominated by the number of small earthquakes, but for the hazard integration the cutoff is near the magnitude of engineering interest, i.e. 4.75.

For a few zones we have tempered the strict mathematical fit by our judgement. The only case where this has had a dramatic effect on major urban areas was in the Strait of Georgia region. Figure 3 shows the magnitude-recurrence curves we adopted for the CASR zone. The lower curve, representing a maximum likelihood fit to the earthquakes larger than magnitude 2.5, underestimates the rate of M>6.7 earthquakes from the past hundred years by an order of magnitude. In order to better match the rate of large earthquakes we neglected earthquakes smaller than the hazard cutoff, magnitude 4.75, and made a second maximum likelihood fit; the result is the upper curve. This curve, if extrapolated to smaller magnitudes, would badly underestimate the rates of small earthquakes. However, these earthquakes do not contribute to the hazard, while the upper curve, by matching the historical rate of larger earthquakes, better represents the historical hazard. In terms of the three-fold representation of the magnitude recurrence curve we use with FRISK88, we weighted the lower curve at 0.16, and took the upper curve to be both the "best" and "upper" relations, for a combined weight of 0.84.

Probabilistic seismicity models

Parameters used for the probabilistic seismicity models are given in Appendix B in the form of maps of the source zones (coordinates of the zone corners are given in Appendix C) and tables of the seismicity parameters, and in Appendix C as a full copy of the four model files used as input to the FRISK88 program.

Seismic Hazard from the Cascadia Subduction Zone

The Cascadia subduction zone has generated prehistorical great earthquakes off Vancouver Island; from their geological record, the mean recurrence interval is about 600 years, the standard deviation of the mean is about 170 years (Adams, 1990), and the last happened about 300 years ago, likely in 1700 A.D. (Satake et al., 1996). The long-term probability[1] of the next great earthquake is similar to that used for seismic zoning maps, and new U.S. and Canadian hazard mapping projects will need to accommodate its expected ground motions. We have chosen to adopt a realistic scenario for the earthquake, and so provide a deterministic, rather than probabilistic, estimate of Cascadia earthquake ground motions. Thus we tabulate the hazard separately, but intend its combination with the probabilistic results using the robust approach.

For the purpose of the Cascadia subduction earthquake scenario in this report, we have adopted a magnitude of 8.2, and determined distances to the various cities by choosing the centre of energy release at about one-third the way down from the locked zone into the transition zone (e.g., Hyndman and Wang, 1995); this is thought to be conservative, but an even more conservative choice would use the distance to the closest point on the transition zone. A combination of these and other opinions via a dendrogram (decision tree) will be used for the final maps, plus any new insights arising from ongoing research; however, at present the 84th percentile values include only the estimated epistemic uncertainty assumed for the strong ground motion relations.

STRONG GROUND MOTION RELATIONS

The different physical properties of the crust in eastern and western Canada require the use of separate strong ground motion relations.

Eastern Canada.

For eastern Canada, a source of great uncertainty in seismic hazard estimation at the moment is the correct ground-motion relations to be used. In particular, the recordings of the 1988 Saguenay earthquake have caused the ground motion modellers to revise their prior relationships to account for its unexpectedly-large short-period motions. There appears to be a consensus of experts emerging in this field (e.g., the 1994-1995 deliberations of the Senior Seismic Hazard Analysis Committee (SSHAC) of the U. S. National Academy of Sciences, see Atkinson, 1995a). Hence, we have adopted a suite of relationships[2] with their aleatory uncertainty (the base

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[1] The short-term probability is lower, since we seem to be only at about the mid-point of its occurrence interval, however the variability of the mean interval makes possible recurrence intervals as short at 300 years or as long as 900 years.

[2] Note that we obtained the relationship for PSA0.15 and PSA0.4 by interpolation, using log(period), of the Atkinson (1995a) Table 1 values. The PSA0.15 values in particular should be used with caution because for some

relations of Atkinson and Boore, 1995), and their epistemic uncertainty[3] (as proposed by Atkinson, 1995a), consistent with that consensus. While these appear to be representative of most of the available published relationships, recent modelling of the Saguenay ground motions by the GSC (e.g. Haddon, 1992; 1995), modelling of the second-largest well-recorded eastern earthquake, Mont-Laurier, 1990 (Haddon and Adams 1995; submitted 1995), and both theoretical considerations of, and empirical evidence for, the source spectrum for S-waves (Haddon, submitted, 1995) gives us strong reservations about the absolute values the SSHAC consensus has produced. We hope that this issue will be resolved before the preparation of our final, year-2000, maps for the National Building Code. In the interim, we note that the suite of relations we use gives substantially similar results, for periods of 0.5 s, to the pair being used by the USGS for the preparation of their 1996 maps which they intend to form the basis for the 1997 NEHRP provisions. One of those relationships is a single-corner-frequency model with a stress parameter of 150 bars, which gives increased ground motions at intermediate periods relative to the Atkinson-Boore two-corner-frequency model (A. Frankel, USGS, pers. comm, 1996).

The Atkinson-Boore suite of relationships was derived to fit observational data on hard-rock seismometer sites, so they need adjustment to represent the ground motions on the "firm ground"[4] reference ground condition chosen for Canada (see below under "Reference Ground Condition for Canada").

Western Canada.

For the western Canadian shallow source zones, including the subcrustal transition zones west of Vancouver Island as well as the Queen Charlotte Fault, we have adapted the ground motion relations from Boore et al. (1993, 1994 - hereafter termed 'BJF'). Our adaptation included the addition of a period-dependent anelastic attenuation term (values from Atkinson, 1995b) applied to distances larger than 100 km. We would have liked to have estimated ground motions at 4 second period, since this is of design interest. However, BJF do not give coefficients beyond 2 seconds, so this could only be done by an extrapolation of their coefficients, and we concluded that this would not be reliable.

For subcrustal source zones deeper under Puget Sound and for the Cascadia subduction zone we used Crouse's (1991) relations that were specifically developed for these areas. Crouse excluded data from hard rock and soft soil sites, and specifies "firm soil" for his relations. From contacts with Crouse and other U.S. strong motion experts, G. Atkinson (pers. comm., 1995 and submitted

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eastern cities and some percentiles (e.g., Fig. 9) they are less than both the PSA0.1 and PSA0.2 values (a physically unreasonable result), possibly due to one or more poorly interpolated coefficients (e.g. C4).

3 Note that no estimate of epistemic uncertainty is available for 2 s period, so we do not give its 84th percentiles.

4 We prefer the term "firm ground", although in foundation engineering it is common to use the term "soil" as in "California Class B soil". In that context, the term "soil" has a very different meaning than that generally understood by, say, a gardener. The "soil" classes are defined by velocity ranges; for Class B (or NEHRP Class C), this range includes very dense material and soft rock, and is not "soil" in a gardener's terms; hence our preference for "firm ground".

1995) recommends that the Crouse relations be considered to represent motions on BJF class C soil; hence we have adjusted them to class B soil by adding a period-dependent constant equivalent to the difference among the Boore et al. (1993) b7 and b6 parameters. Boore et al. (1993) differentiate between four soil classes, with most data in Class B, designated firm soil and specified as having 360 to 750 m/s average velocity in the uppermost 30 m. Our results are therefore consistent with "firm ground". As representative depths we adopted 50 km for the normal-mechanism events within the subducting slab, and 25 km for the centre of energy release of the Cascadia thrust earthquake. For the Cascadia subduction earthquake scenario we used Crouse (1991) adjusted to "firm ground", with a magnitude of 8.2 and with the centre of energy release at about one-third the way down from the locked zone into the transition zone to establish distances to the various cities.

For aleatory uncertainty for BJF we have used the smoothed standard deviations ("sigmas") about the fitted relationships, as listed by Boore et al. (1993). For Crouse, we smoothed the sigmas he tabulated, using a cubic relation, and used these smoothed values. The epistemic uncertainty (comparable to that used for the east) on each relationship we estimate by generating a pair of parallel alternative relations, factors of two higher and lower, and having weights of 0.3 each, leaving weight 0.4 for the median relation. This epistemic uncertainty is intended to capture firstly the range of opinion on western ground motions (for example, the upper curve envelopes the Idriss (1991, 1993) relations), and secondly the possibility that there may be systematic biases in the BJF relations. For example, the stress drops of the larger western Canadian earthquakes might be either higher or lower than those used in defining the BJF relations. We recognize that the assigned epistemic uncertainties represent an arbitrary and possibly conservative choice, but prefer to err on the conservative side.

Ground Motion Parameters

In contrast to the 1985 maps, which gave values for peak ground velocity (PGV) and peak ground acceleration (PGA), we present spectral acceleration values for 0.1, 0.15, 0.2, 0.3, 0.4, 0.5, 1.0, and 2.0 second periods (denoted PSA0.1, PSA0.5, PSA2, etc). We also give PGA values for both east and west but PGV values for just the east (a PGV ground motion relation is not available for the west).

Units.

We have decided to express the PGA and PSA values as (unitless) percentages of g. This avoids many entries of the form "0.072", with consequent duplicate characters "0." and "0.0", and also corresponds to the appropriate level of precision for the PSA and PGA values. However, this would lead to unacceptable rounding for some low values. Therefore we have kept 2 significant figures, with a maximum of one decimal digit, except for some small 2 s values for which one significant figure is appropriate. For PGV we have kept 2 significant figures but expressed the result in m/s, as for the 1985 maps, to reduce he chance of confusion with the PSA and PGA values.

REFERENCE GROUND CONDITION FOR CANADA

For the preparation of national hazard maps it is essential to present seismic hazard levels on the same ground condition for all of Canada. Such a "reference" ground condition ("RGC") is needed in order to make the 1995 hazard values firstly, numerically comparable between east and west, and secondly, roughly comparable in intent to the current (1985) hazard maps.

The BJF "Soil Class B" is our choice for the Canada-wide Reference Ground Condition, because:

a) it appears to be the closest to the soil conditions implied in 1985 NBCC and referred as 'rock or firm soil'. Class B is the softer part of the 'rock' classification earlier proposed by Joyner, Boore and co-workers, with the larger number of strong motion recordings.
b) "Soil Class B" is the reference ground condition for the main strong motion relationship we use in western Canada.
c) a choice near the mid-range between very hard and very soft ground is preferred because it minimises the effects of uncertainty in the amplification or deamplification factors for the extreme sites.
d) the Hasegawa et al. (1981) relations used in eastern Canada for the 1985 maps were established by setting their near-source levels equal to those for western Canada (i.e. on "firm ground") and using isoseismal (felt intensity) maps to constrain the distance dependence of the relations. The isoseismal maps relied on felt-intensities reported by Canadians living on average eastern site conditions that were certainly not "hard rock". Thus the Class B "firm ground" condition is, in our view, close to the ground conditions that were implied by the 1985 eastern relationships.

The hard-rock strong ground motion equation of Atkinson and Boore (1995) has been modified by Atkinson (1995a) to represent motions on ground conditions other than rock in a way similar to that of BJF's equation for the western U.S. — by the addition of a soil response parameter, c_5S, (S=0 for hard rock and S=1 for soil sites) whose coefficients, c_5, are a function of period. Atkinson (1995a) does not recommend values for her c_5 coefficients, but notes that for 'deep soil' the values in Atkinson and Boore (1995), adopted directly from Boore and Joyner (1991), might be applicable.

Approach used to compute the RGC factors given in GSCOF3029

For our "firm ground" reference ground condition we propose to use BJF's "B6" coefficients (as smoothed by period, see Boore et al., (1993) Table 7b and Fig. 3a, which are reproduced in Appendix D) as the seismological basis of our period-dependent values. The B6 coefficients relate BJF's California Soil Class B to the California Soil Class A, which is rock/soil with average velocity >750 m/s. Only one of the sites that contributed data to BJF's 1993 analysis was on rock with average velocity >1500 m/s. Hence the California Soil Class A is distinct from eastern Canadian hard rock seismometer sites which were the observational basis for the Atkinson-Boore eastern relations, and which have velocities of >2500 m/s.

A new "Hard Rock" class (termed 'Ao' by Martin and Dobry (1994) and adopted into the 1994 NEHRP Provisions (NEHRP, 1994), section 1.4.2, after being renamed 'A'), has been defined to have average velocity >1500 m/s, and may be appropriate for eastern hard-rock sites. Martin and Dobry (1994) reported the conclusions of a 1992 workshop on earthquake site response which represented the consensus of Borcherdt, Dobry, and Seed. Their Tables 2 and 3 (reproduced in our Appendix D) show that for both 0.3 s and 1 s periods, and for all shaking intensities, motions on Class A sites are 25% higher than on Class Ao sites. Although they specifically note that their analysis in those tables "does not address the period range between 0 and about 0.2 seconds, and thus cannot be used to amplify peak acceleration or other high frequency spectral values" we consider this caution should not apply to the A to Ao relationship. Hence, we increase the B6 coefficients by the 25% factor (0.097 log units), and consider these RGC factors (Table 1) to represent the difference in amplification between the hard-rock sites for which the Atkinson-Boore relations were derived and our reference "firm ground" condition.

An Alternative Approach

Since the issue of GSCOF3029, there has been some concern expressed that the Class Ao represented rock with velocities much lower than those of the seismometer sites in eastern Canada, and hence that the amount of amplification from rock to firm ground was being underestimated.

After discussions with Gail Atkinson it seems that an appropriate choice for the near-surface shear wave velocity is 2800 m/s for eastern hard rock. California rock (Martin and Dobry Class A) might be taken as 1050 m/s, the average of Borcherdt's shear velocity range for California SC-1b (Borcherdt, ATC 35-1) or 1130 m/s from NEHRP's class B rock. For the former, Martin and Dobry's 0.8 factor would have de-amplified Class B soil to 1640 m/s rock, and an additional factor of 0.76 would have been needed to match the extra impedance contrast of eastern hard rock. However the regression results in BJF94, and the analysis below both indicate that the data suggest ≈1750 (range 1100 to 2200) m/s for the Class A reference rock velocity (assuming that the BJF's VA parameter has physical meaning).

In the BJF94 characterization of site velocities the terms "b6*Gb +b7*Gc" in their 1993 formulation are replaced by the term:

$$BV(\log VS - \log VA)$$

where BV and VA are empirical coefficients (given in BJF94, Table 2), VS is the time-weighted average shear-wave velocity to 30 m depth for the site, and VA can be thought of as the reference rock condition (since when VS = VA the "soil" term vanishes),

Then, for example, for 5% damped 0.5 sec motions:

BV= −0.553, VA=1780 (BJF94, Table 2)
VS=2800 ("eastern hard-rock" - our assumption)
coefficient (hard rock → VA) = 0.109 log units

[This assumes that the behaviour of waves in rock with velocities above ≈1800 m/s is better obtained by extrapolation from relations in slower rock than by direct computation of impedance.]

and

BV= −0.553, VA=1780 (BJF94 Table 2)
VS=555 (average of range of velocity for definition of class B)
coefficient (VA → soil B) = 0.280 log units

Hence, hard-rock to class B = 0.109 + 0.280 = 0.389 log units
amplification factor (hard rock → class B) = 2.45
(compare to GSCOF3029 RGC factor of 2.38)

We have broken out the calculation into a two-stage process purposefully, and chosen 0.5 s deliberately as it may be a key mapping parameter. Comparison with the 0.5 s values in GSCOF3029 Table 1 suggest that in the new formulation the "hard-rock → class B" coefficient for 0.5 s replicates the B6 value (BJF93) <u>and</u> the "hard rock → VA" replicates the Martin and Dobry "0.8" value (of 0.097 log units) very well.

Note that the physical meaning of the VA parameter is rather uncertain because:
(1) together, the parameters BV and VA must include (a) density change effects, since conservation of energy involves impedance contrast, not just the seismic velocities; (b) any non-linear effects in class B soil; and (c) "skin" effects (through the 1/4 wavelength effect?), perhaps accounting for some of the decrease in VA for periods less than 0.2 sec;

(2) there may well be non-physical (statistical) trade-offs between VA and the parameter BV; and
(3) the VA parameter varies somewhat with damping.

Now, regardless of the exact meaning of VA, we could use the BJF94 formulation directly to get "Class B → 2.8 km/s rock" coefficients through:

coefficient (hard rock → class B) = BV[log (555) − log (2800)] = −0.703*BV

which depends only on the assumed average velocity of soil B and of eastern hard rock, and the coefficients BV (see Table 2).

The new values are similar to the GSCOF3029 RGC factors for periods except 1.0 s, for which the VA values are discrepant and rather smaller (1410 m/s) than for the rest of the periods we use (range 1780-2130 m/s). If we accept the above approach, it seems that the consensus of Martin and Dobry of 1/0.8 = 1.25 for hard rock indeed accommodates our eastern hard rock (for T=0.5, VA=1780 m/s, VS=2800 for hard rock, the square-root relationship, neglecting density, gives 1.254).

A Second Alternative approach

A different approach could be used, accepting the Class B → VA amplification factors directly from BJF94 and then adjusting from the BJF VA value to 2800 m/s rock. Atkinson (submitted, 1995), made the adjustment by using the square-root of the velocity ratio, 2800/VA, as an approximation, but this neglects the density contrast. In Table 2 we show RGC factors calculated by the impedance method using estimated densities.

The RGC estimates in Table 2 are quite similar among the three approaches for periods 0.15-0.5 s and 2.0 s (Fig. 4), and confirm the robustness of the simple approach taken to derive the RGC factors in GSCOF3029. The difference at 1.0 sec (the largest RGC estimate is 20% larger than smallest), is of concern, but occurs where BJF94's VA values are in a low between values of >1750 m/s at both shorter and longer periods. The major discrepancy at the 0.1 s period seems to be directly related to the very low VA (VA falls rapidly from 1720 m/s at 0.14 to 1110 m/s at 0.1 s in BJF94) used in the impedance method. The large value of RGC computed by the impedance approach may not be physically realistic, because ground motions at higher frequencies are normally considered to be weakly amplified or even attenuated on soft ground.

Conclusions Regarding RGC Factors

- The Reference Ground Condition (RGC) amplifications factors in GSCOF3029 are adequate for converting from eastern hard rock sites as used by Atkinson and Boore (1995) to "firm ground" (BJF class B soil conditions).
- Eastern hard rock is not significantly harder than was assumed by the Martin and Dobry class 'Ao' or NEHRP class 'A'.
- More complicated approaches using shear-wave velocities, as suggested by BJF 1994, produce similar amplification of hard rock strong ground motions for most periods.

Use of the RGC Factors

The Reference Ground Condition (RGC) factors in Table 1 have been used to amplify seismic hazard *spectral* values calculated for the hard-rock Atkinson-Boore relations to those to be expected for the reference ground condition. This is mathematically identical to introducing the appropriate log factors into the Atkinson-Boore strong ground motion relations (e.g. through Atkinson's 1995 soil-response parameter, S) before the hazard calculation. For consistency, a similar factor must be applied to the PGA and PGV values, but for those parameters it is necessary to assign an average period for the motions; we have chosen 0.1 s for PGA and 0.5 s for PGV, but recognize that these periods may be a function of earthquake magnitude and distance (for the 1985 NBCC maps the choice was 0.2 and 1 s.). It is important to realize that hard-rock hazard values for eastern sites can be extracted from Table 4 by dividing the tabulated values by the appropriate RGC factor from Table 1.

Not too much should be read into the 3-figure precision for the RGC factors supplied in Table 1. We considered multiplying all periods by a simple factor of two, being a crude approximation with no pretensions to either accuracy or precision, however, on balance we feel that the tabulated RGC factors better represent the period dependence. If new information on the reference ground condition arises, it can be incorporated by a revision of the RGC factors.

The effect of applying the RGC factors is to flatten the spectra of eastern sites, most particularly by the small amplification at 0.1 s. This is evident in Table 3 and Figure 5 which compare the 50th percentile hazard values for Montreal for hard-rock and firm ground.

Discussion

The proposed scheme allows the uniform representation of seismic hazard across Canada. The choice of "firm ground" (Class B soil) as the reference is appropriate, because this is the ground condition with the best observational data set (from California) and is the basis for the BJF relations we are using for western Canada. However, we emphasize we are not making any judgment as to whether Class B is a typical or even a common condition in either western or eastern Canada. Adjustments will need to be made to compensate for ground conditions different from Class B, most probably through a redefined Foundation factor, F. It is entirely possible that most sites will not have F = 1.0.

The choice of "firm ground" (Class B soil), and hence the RGC factors in Table 1, places some constraints on the Foundation factors that must be used with the hazard results. In the current (1995) National Building Code of Canada, Foundation factors of 1.0, 1.3, 1.5, and 2.0 are applied to the zonal hazard values, both east and west, dependent on the type and depth of soil as described in Table 4.1.9.C of the current code. The current code considers only amplifications of the computed hazard, and gives no credit for sites on hard rock. We consider that a consistent set of foundation factors should adjust the ground motion levels on the reference soil (irrespective of whether it is sited in the east or the west) to the various typical ground conditions. For some conditions, e.g., long period motion on thick soft soils, this will be an amplification from the computed hazard (like the current code); for short period motion on thick soils the amplification may be traded off against anelastic attenuation, reducing the motions.

Hence, our choice of "firm ground" (Class B soil) requires that considerable deamplification also be allowed (i.e., $F < 1$) to give credit for better ground conditions than Class B. To be explicit, a period-dependent F factor which is the exact reciprocal of the RGC factors in Table 1, would be required in order to recover the "hard-rock" ground motions, which should be the basis for design levels if a building's foundation is set on, or blasted into, hard rock. Although these "exact" foundation factors are the correct ones, a simplified set may be more appropriate for code purposes. The same deamplification may occur in both eastern and western Canada, because some west coast rock sites have rock velocities as high as many eastern hard rock sites; though other rock sites may be equivalent to California class A rock.

A further complication is that actual soil sites differ in both thickness and average velocity from the "firm ground" (Class B soil) condition. Class B was established for California, where most soils would be considered "deep", say 60 m thick, in contrast to much of eastern Canada where many firm soils are "thin". A soil column that is similar to the Class B soil, but only half as thick, will give both a different amount of amplification, but also a different distribution of amplification with period. Another issue not fully addressed by the trend in the U.S. to use average velocity of the soil/rock column in the top 30 m, is the treatment of thin, very low velocity sediment over rock, which could have the same average 30-m velocity as a 30-m firm soil but very different amplifications.

It has been suggested that the typical eastern site has thinner and firmer soil than Class B; this will tend to cause less amplification at long periods, but more at short periods (because of competing effects involving thickness and the Kappa factor, i.e. anelastic attenuation). Hard data is sparse for eastern Canada, but five seismometer sites in southern Ontario (founded on firm till, but underlain by an unknown thickness of sediment of unknown properties) have considerable short-period amplification (G. Atkinson, pers. comm., 1995), exceeding a factor of five at 0.1 s for station WEO (Atkinson, 1989).

RESULTS

Table 4 gives probabilistic hazard values for selected Canadian cities, itemizing separately the values for the H and R models and the 50th and 84th percentiles. Table 5 is a summary of the Cascadia subduction earthquake scenario hazard, and Table 6 represents a 1-page summary of the parameters from Tables 3 and 4 likely to be used for the trial design values (see, e.g., Naumoski and Heidebrecht, 1995).

Combining diverse hazard estimates using the 'robust' approach

It is important to realize that each of the entries labelled 'H' or 'R' in the tables represents the result of a complete probabilistic hazard calculation. Combining such diverse models within a probabilistic framework inevitably requires that one or other alternative models be down-weighted, thus reducing the protection it would otherwise provide.

Adams et al. (1994; 1995c) suggest a 'quasi-probabilistic' alternative method that they term "robust". We first compute the probabilistic hazard for a 100% **H** and for a 100% **R** model using the same grid of points, and then choose the higher value for each grid point to be contoured for the "robust" map. The mapped "robust" estimates are "probabilistic" at any one place, in that for each site and every ground motion parameter being computed there is an identifiable probabilistic hazard calculation made using a particular source-zone model. Hence for design purposes (for a building or a city) the map provides a suitable probabilistic hazard value, though from a regional perspective the map as a whole is not probabilistic, because the model used may differ from site to site, or indeed from ground motion period to period at a particular site.

The chief advantage of the "robust" approach is that it preserves protection in areas of high seismicity but also provides increased protection in currently-aseismic areas that are geologicallylikely to have future large earthquakes. A further advantage is that the approach is computationally simple, and it is easy to explain what was done. Finally, the method allows a simple combination of deterministic and probabilistic hazard where this is desired. For example, the values for the seismic hazard from the Cascadia subduction earthquake scenario in Table 5 are intended to be incorporated into the national hazard maps by the 'robust' approach; that is, where the Cascadia ground motions are larger than the probabilistic calculation, the Cascadia values would be adopted.

Choice of Confidence Level

We provide values for two confidence levels, the 50th percentile and the 84th percentile; the former is the median, and the latter includes a measure of epistemic uncertainty[5]. Either might be used for engineering design. The median is often chosen because it is a robust parameter and can be expected to remain stable as the range of scientific opinion changes, while the 84th percentile must be expected to fluctuate in future (hopefully decreasing over the long term) as improved knowledge about epistemic uncertainty is incorporated into the analysis.

Measures of uncertainty are represented by the "84th percentiles" in the tables. During the preparation of GSCOF3029, it seemed likely that the 84th percentile values would form the basis for the seismic design forces based on the trial maps. These values had the perceived benefit that they included a measure of the epistemic uncertainty, so that, for regions with the same median hazard, designs would accommodate higher values in regions where the seismic hazard was less certain than where the hazard was more certain. However, several concerns have led us to consider the median to be a better measure at this time.

Firstly, the range of parameters we use to indicate the epistemic uncertainty is itself rather arbitrary. While we can defend that range for some parameters and some zones (and have some confidence that in a relative sense we have captured differences in epistemic uncertainty), we recognize that the largest part of the epistemic uncertainty arises from that contained in the ground motion relations. For example, for the western SGM relations we have taken the upper and lower values to be a factor of two above and below the adopted relations. Such a crude assignment of uncertainty serves only as an indication of the true uncertainty, and does not justify additional conservatism in design. For this reason we prefer the median values, because they are least affected by the assumptions of uncertainty.

Secondly, the amount of epistemic uncertainty contained in the input parameters (whose effect is most simply seen by taking the ratio of the 84th/50th percentile values in Table 4) does not differ greatly among sites. For example, for Montreal the ratio ranges from 1.4 for PSA0.1 to

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[5]The 84th percentile is often chosen, because of its notional association with one standard deviation of a normal distribution. The standard deviation is less meaningful in our case, since the distributions of ground motions can be quite asymmetrical, due to the fact that the epistemic distribution is or can be quite asymmetric, and may be far from lognormal. Nevertheless, the use of the 84th percentile does include a measure of the epistemic uncertainty which we wish to include.

3.1 for PSA1, i.e. the ratio is 2.1 ± 50%. In the west, the ratios are only slightly larger than a factor of 2, due mostly to our (arbitrary) choice of epistemic uncertainty for the western SGM relations. Hence, there is no large difference in the effect of epistemic uncertainty to be captured by the adoption of the 84th percentile; and use of either the median or 84th percentile values in a calibration process will give a similar range of design values; so the median values are preferred for reason 1 (it is intended to calibrate design forces such that the level of protection resulting from a design according to the "trial" results will match the NBCC (1995) code level (see, e.g., Naumoski and Heidebrecht, 1995).

Thirdly, while the mean may indeed be preferred to the median (McGuire, 1993), it contains elements of the same epistemic uncertainty estimation process; we consider the median results will probably be more stable.

Therefore we emphasize in this Open File the median values, while providing the 84th percentiles to give users a measure of the epistemic uncertainty.

Uniform Hazard Spectra

Spectral plots (Figures 6-27) show the results from Tables 4 and 5 as Uniform Hazard Spectra (UHS). Each figure shows the median (50th percentile) and 84th percentile UHS determined by the robust approach; i.e., the values plotted for each period are the higher of the H or R model values. Hence adjacent values may be taken from different models. Note that it is inappropriate to display PGA values on these plots (even though PGA is sometimes (arbitrarily) plotted at 0.03 s or 0.01 s), because its associated period differs from place to place and is generally not known.

Non-Newmark-Hall amplification

The previous code used scaled Newmark-Hall spectra (Newmark and Hall, 1969; 1982). These spectra were derived by averaging (or enveloping) the few then available spectra from magnitude 6-7 earthquakes in the 20-50 km range. The spectral shape was specified by certain corner frequencies and fixed amplification factors relative to peak ground motion. If the dominant hazard at the desired probability level comes from such earthquakes and distances in a similar tectonic environment, this spectrum is appropriate. For many sites in Canada, short period hazard comes from smaller magnitude events at near distances; longer period hazard from larger earthquakes at greater distances. This was recognized by the last code edition by giving PGA and PGV values at the same hazard level, necessarily resulting in a variable corner period, i.e. variable spectral shape. Similarly, the spectral acceleration relations now allow construction of uniform hazard spectra for given sites (e.g., Figs 6-27) which have variable shapes and amplification factors different from the deterministically-derived Newmark-Hall spectrum.

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TABLES

FIGURE CAPTIONS

Figure 1. Earthquake source zone maps of Canada showing the zones that form the **H** (top) and **R** (bottom) models for earthquake distribution. Zones referred to in the text are shaded and labelled on the bottom map; corresponding **H**-model zones are shaded on the top map.

Figure 2. Sample magnitude-recurrence data and curves, for Charlevoix and the Niagara-Attica Trend (NAT) zones. The cumulative rates of earthquakes are represented by solid circles with stochastic error bounds and the best-fit curve (bold) are flanked by upper and lower "error" curves that are more widely separated for the poorly-constrained NAT dataset. All curves are asymptotic to assumed upper-bound magnitudes.

Figure 3. Magnitude-recurrence data and curves for CASR, the shallow crustal source for the Strait of Georgia - Puget Sound region. The maximum likelihood fit including the small magnitude earthquakes (lower curve) passes through the point (0.002, 7.0), considerably below the historical rate of $M>6.8$ earthquakes. The maximum likelihood fit to only $M>4.75$ earthquakes (upper curve) matches the historical rate of larger earthquakes much better. Both curves are asymptotic to assumed upper-bound magnitudes.

Figure 4. RGC factors as a function of period, as derived by the three methods described in the text and shown in Table 2. The "Table 1" factors are the preferred ones.

Figure 5. Seismic hazard for Montreal depicted as Uniform Hazard Spectra on various ground conditions. These 50th percentile UHS from the **R** model are derived from values given in Table 4 for hard-rock and soil Class B using the RGC factors; a baseline derived from the hard-rock values using a uniform amplification of a factor of two is shown for comparison.

Figures 6-27 show the 0.0021 per annum ground motion "firm ground" results as Uniform Hazard Spectra for the named city. The 50th percentile (thick solid line) and 84th percentile (thick dashed line) UHS are derived by the robust method from the **H** and **R** model values given in Table 4. For southwestern Canadian cities, two additional curves (light lines) are shown. These are the 50th and 84th percentile spectra for the scenario M8.2 Cascadia event, as given in Table 5.

Figure 6. St. John's	Figure 7. Halifax	Figure 8. Moncton
Figure 9. Fredericton	Figure 10. La Malbaie	Figure 11. Quebec
Figure 12. Trois-Rivieres	Figure 13. Montreal	Figure 14. Ottawa
Figure 15. Niagara Falls	Figure 16. Toronto	Figure 17. Windsor
Figure 18. Calgary	Figure 19. Kelowna	Figure 20. Kamloops
Figure 21. Prince George	Figure 22. Vancouver	Figure 23. Victoria
Figure 24. Tofino	Figure 25. Prince Rupert	
Figure 26. Queen Charlotte City	Figure 27. Inuvik	

Table 1

Proposed Reference Ground Condition factors

Period (s)	B6	A-to-Ao	C_5	RGC factor
	.........$\log_{10}$ units.........			
0.1	0.046	0.097	0.143	1.39
0.15	0.140	0.097	0.237	1.73
0.2	0.190	0.097	0.287	1.94
0.3	0.239	0.097	0.336	2.17
0.4	0.264	0.097	0.361	2.30
0.5	0.279	0.097	0.376	2.38
1.0	0.314	0.097	0.411	2.58
2.0	0.360	0.097	0.457	2.86
PGA	0.046	0.097	0.143	1.39
PGV	0.279	0.097	0.376	2.38

Notes:

1. This table updates Table 1 of GSCOF3029 by the addition of values for the 2.0 s period.
2. Column B6 is taken from Boore-Joyner-Fumal (1993) Table 7b.
3. The A-to-Ao conversion is +25% from Martin and Dobry (1994), Tables 2 and 3 (site class A = 1.0, site class Ao = 0.8 for all shaking intensities and both Fa and Fv periods).
4. Column C_5 contains the proposed coefficients (in $\log_{10}$ units) to be used for Class B soil with Atkinson's (1995a) S parameter.
5. The RGC (Reference Ground Condition) factor represents the C_5 values as a multiplicative factor, and is intended to modify eastern hard rock hazard values to those expected on the reference ground condition of "firm ground".
6. RGC factors for PGA and PGV were assigned by associating them with periods of 0.1 s and 0.5 s., respectively.

Table 2

Comparison of Reference Ground Condition Factors computed by alternative approaches

Period (s)	BV log10	VA m/s	C5 log10	RGC BJF	B←VA	VA←EHR	C5	RGC Imped.	RGC Table 1
					...log10 units..				
Notes→	1	2	3	4	5	6	7	8	9
0.1	-0.212	1110	0.149	**1.41**	0.064	0.245	0.309	**2.04**	**1.39**
0.15	-0.238	1820	0.167	**1.47**	0.123	0.110	0.233	**1.71**	**1.73**
0.2	-0.292	2120	0.205	**1.60**	0.170	0.069	0.239	**1.73**	**1.94**
0.3	-0.401	2130	0.281	**1.91**	0.234	0.068	0.302	**2.00**	**2.17**
0.4	-0.487	1950	0.342	**2.20**	0.266	0.087	0.353	**2.25**	**2.30**
0.5	-0.553	1780	0.389	**2.45**	0.280	0.111	0.391	**2.46**	**2.38**
1.0	-0.698	1410	0.491	**3.09**	0.283	0.175	0.458	**2.87**	**2.58**
2.0	-0.655	1790	0.460	**2.89**	0.333	0.110	0.443	**2.77**	**2.86**
PGA	-0.212	1110	0.149	**1.41**	0.064	0.245	0.309	**2.04**	**1.39**
PGV	-0.553	1780	0.389	**2.45**	0.280	0.111	0.391	**2.46**	**2.38**

General Notes

A. Columns C5 contain the calculated coefficients (in log10 units) that might be used for Class B soil with Atkinson's (1995a) S parameter.

B. The RGC (Reference Ground Condition) factors represent the C5 values as a multiplicative factor. and might be used to modify eastern hard rock hazard values to those expected on the reference ground condition of "Class B" soil.

C. RGC factors for PGA and PGV were assigned by associating them with periods of 0.1 s and 0.5 s., respectively.

D. An excess of digits is carried in this table to show the derivation of the factors. Final factors should be represented to 2 significant figures (e.g. 2.4). The guess made for the velocity of eastern hard rock results in a ≈5% uncertainty in the multiplicative factors.

Column Head Notes:

1. Column BV is taken from Boore-Joyner-Fumal (1994) Table 2, "random 05%" column.
2. Column VA is taken from Boore-Joyner-Fumal (1994) Table 2, "random 05%" column.
3. Column C5 (in log10 units) is calculated from −0.703*BV.
4. The RGC factor represents the C5 value as a multiplicative factor.
5. B←VA calculated using VB=555 m/s.
6. VA←EHR (Eastern Hard Rock) using log10(sqrt[(2800*2.7)/(VA*densityVA)]) where densityVA is taken to be values like: 2.2 g/cm^3 for ≈1100 m/s, 2.4 for 1400, 2.6 for 2000, and 2.7 for 2800.
7. Column C5 (in log10 units) is calculated from the sum of B→VA and VA→EHR columns.
8. The RGC factor represents the C5 value as a multiplicative factor,
9. This RGC column represents the values in GSCOF3029 (see Table 1).

Table 3

Effects of Reference Ground Condition factors for a sample eastern site (Montreal)

Period (s)	Hard rock	RGC (Table 1)	Firm Ground
0.1	22	1.39	31
0.15	17	1.73	30
0.2	15	1.94	29
0.3	9.5	2.17	21
0.4	6.9	2.30	16
0.5	5.4	2.38	13
1.0	2.1	2.58	5.3
2.0	0.6	2.86	1.7

Notes:

1. Entries in the table represent the 50th percentile values of the 0.0021 p.a. seismic hazard (5% damped PSA values in %g) for the **R** model.
2. The "Hard rock" values are those computed using the Atkinson and Boore (1995) hard-rock ground motion relations; "firm ground" is the amplification of the hard rock values by the RGC factors given in Table 1).
3. The hazard values are rounded.

Table 4

Probabilistic Seismic Hazard Estimates for Selected Cities[1]

Spectral Parameter	H Model 50%ile	H Model 84%ile	R Model 50%ile	R Model 84%ile	Robust 50%ile	Robust 84%ile
St. John's (47.6 -52.7)						
PSA 0.1 sec	4.9	6.5	5.9	8.6	5.9	8.6
PSA 0.15 sec	5.9	9.5	7.3	12	7.3	12
PSA 0.2 sec	6.4	11	8.9	16	8.9	16
PSA 0.3 sec	5.6	12	8.3	17	8.3	17
PSA 0.4 sec	4.3	10	7.0	16	7.0	16
PSA 0.5 sec	3.6	9.4	5.8	15	5.8	15
PSA 1.0 sec	1.8	4.7	3.1	8.4	3.1	8.4
PSA 2.0 sec[2]	0.5	-	0.9	-	0.9	-
PGA	3.3	4.5	4.1	5.5	4.1	5.5
PGV	0.021	0.055	0.031	0.081	0.031	0.081
Halifax (44.6 -63.6)						
PSA 0.1 sec	5.0	6.9	7.4	11	7.4	11
PSA 0.15 sec	6.3	11	8.2	14	8.2	14
PSA 0.2 sec	7.4	13	9.7	17	9.7	17
PSA 0.3 sec	6.9	14	8.6	18	8.6	18
PSA 0.4 sec	5.5	13	7.2	17	7.2	17
PSA 0.5 sec	4.7	12	5.9	15	5.9	15
PSA 1.0 sec	2.3	6.7	3.0	8.3	3.0	8.3
PSA 2.0 sec	0.7	-	0.9	-	0.9	-
PGA	3.5	4.7	5.0	6.8	5.0	6.8
PGV	0.026	0.069	0.031	0.086	0.031	0.086
Moncton (46.1 -64.8)						
PSA 0.1 sec	12	17	10	15	12	17
PSA 0.15 sec	11	22	10	20	11	22
PSA 0.2 sec	14	24	13	23	14	24
PSA 0.3 sec	10	20	10	22	10	22
PSA 0.4 sec	8.5	20	8.2	20	8.5	20
PSA 0.5 sec	7.2	18	6.9	18	7.2	18
PSA 1.0 sec	3.0	9.5	3.1	9.2	3.1	9.5
PSA 2.0 sec	1.0	-	1.0	-	1.0	-
PGA	8.4	12	6.9	11	8.4	12
PGV	0.043	0.11	0.038	0.10	0.043	0.11
Fredericton (45.9 -66.6)						
PSA 0.1 sec	14	20	14	21	14	21
PSA 0.15 sec	13	26	14	27	14	27
PSA 0.2 sec	16	28	17	28	17	28
PSA 0.3 sec	13	27	13	26	13	26
PSA 0.4 sec	10	25	10	25	10	25
PSA 0.5 sec	8.5	22	8.6	22	8.6	22
PSA 1.0 sec	3.7	11	3.6	11	3.7	11
PSA 2.0 sec	1.1	-	1.1	-	1.1	-
PGA	9.5	14	9.9	15	9.9	15
PGV	0.050	0.12	0.050	0.13	0.050	0.13

Spectral Parameter	H Model 50%ile	H Model 84%ile	R Model 50%ile	R Model 84%ile	Robust 50%ile	Robust 84%ile
La Malbaie (47.6 -70.1)						
PSA 0.1 sec	90	150	27	37	90	150
PSA 0.15 sec	100	170	26	42	100	170
PSA 0.2 sec	99	170	25	43	99	170
PSA 0.3 sec	71	150	18	38	71	150
PSA 0.4 sec	56	130	14	33	56	130
PSA 0.5 sec	48	110	11	29	48	110
PSA 1.0 sec	20	60	4.4	14	20	60
PSA 2.0 sec	5.9	-	1.5	-	5.9	-
PGA	56	94	18	24	56	94
PGV	0.27	0.68	0.071	0.18	0.27	0.68
Quebec (46.8 -71.2)						
PSA 0.1 sec	21	30	24	32	24	32
PSA 0.15 sec	23	35	23	36	23	36
PSA 0.2 sec	24	40	23	38	24	40
PSA 0.3 sec	20	39	17	34	20	39
PSA 0.4 sec	15	36	13	31	15	36
PSA 0.5 sec	12	32	10	27	12	32
PSA 1.0 sec	5.7	17	4.1	13	5.7	17
PSA 2.0 sec	1.8	-	1.4	-	1.8	-
PGA	14	19	16	22	14	19
PGV	0.071	0.18	0.064	0.16	0.071	0.18
Trois-Rivieres (46.3 -72.5)						
PSA 0.1 sec	13	19	30	41	30	41
PSA 0.15 sec	14	25	29	45	29	45
PSA 0.2 sec	16	28	27	48	27	48
PSA 0.3 sec	13	28	20	41	20	41
PSA 0.4 sec	10	26	15	36	15	36
PSA 0.5 sec	9.0	24	12	32	12	32
PSA 1.0 sec	4.2	12	4.9	16	4.9	16
PSA 2.0 sec	1.3	-	1.6	-	1.6	-
PGA	8.5	13	20	27	20	27
PGV	0.050	0.13	0.076	0.20	0.076	0.20
Montreal (45.5 -73.6)						
PSA 0.1 sec	22	36	31	43	31	43
PSA 0.15 sec	24	40	30	49	30	49
PSA 0.2 sec	24	42	29	50	29	50
PSA 0.3 sec	18	35	21	44	21	44
PSA 0.4 sec	14	32	16	38	16	38
PSA 0.5 sec	11	28	13	34	13	34
PSA 1.0 sec	4.8	14	5.3	17	5.3	17
PSA 2.0 sec	1.4	-	1.7	-	1.7	-
PGA	16	24	21	27	21	27
PGV	0.074	0.18	0.079	0.20	0.079	0.20

Spectral Parameter	H Model 50%ile	H Model 84%ile	R Model 50%ile	R Model 84%ile	Robust 50%ile	Robust 84%ile
Ottawa (45.4 -75.7)						
PSA 0.1 sec	18	27	27	37	27	37
PSA 0.15 sec	18	34	27	43	27	43
PSA 0.2 sec	21	37	27	46	27	46
PSA 0.3 sec	15	32	20	40	20	40
PSA 0.4 sec	12	28	15	36	15	36
PSA 0.5 sec	9.5	25	12	31	12	31
PSA 1.0 sec	4.2	12	5.2	16	5.2	16
PSA 2.0 sec	1.2	-	1.6	-	1.6	-
PGA	12	19	18	24	18	24
PGV	0.057	0.14	0.074	0.19	0.074	0.19
Niagara Falls (43.1 -79.1)						
PSA 0.1 sec	18	25	7.6	12	18	25
PSA 0.15 sec	16	31	7.9	15	16	31
PSA 0.2 sec	15	31	9.1	16	15	31
PSA 0.3 sec	11	26	7.5	15	11	26
PSA 0.4 sec	8.3	21	5.8	14	8.3	21
PSA 0.5 sec	6.6	17	4.7	12	6.6	17
PSA 1.0 sec	2.8	8.1	2.2	6.3	2.8	8.1
PSA 2.0 sec	0.8	-	0.6	-	0.8	-
PGA	12	18	5.2	8.5	12	18
PGV	0.048	0.12	0.031	0.079	0.048	0.12
Toronto (43.7 -79.4)						
PSA 0.1 sec	10	16	6.7	9.9	10	16
PSA 0.15 sec	9.3	20	7.0	13	9.3	20
PSA 0.2 sec	11	21	8.4	15	11	21
PSA 0.3 sec	8.3	18	7.1	14	8.3	18
PSA 0.4 sec	6.3	15	5.5	13	6.3	15
PSA 0.5 sec	5.0	13	4.6	12	5.0	13
PSA 1.0 sec	1.8	6.3	2.2	6.1	2.2	6.3
PSA 2.0 sec	0.6	-	0.6	-	0.6	-
PGA	7.1	11	4.6	6.9	7.1	11
PGV	0.033	0.088	0.029	0.074	0.033	0.088
Windsor (42.3 -83.0)						
PSA 0.1 sec	4.1	6.1	5.7	9.0	5.7	9.0
PSA 0.15 sec	4.4	9.0	6.0	11	6.0	11
PSA 0.2 sec	6.0	9.8	6.8	12	6.8	12
PSA 0.3 sec	4.4	9.7	5.2	10	5.2	10
PSA 0.4 sec	3.4	8.4	4.0	9.6	4.0	9.6
PSA 0.5 sec	2.8	7.5	3.3	8.6	3.3	8.6
PSA 1.0 sec	1.0	3.4	1.4	4.2	1.4	4.2
PSA 2.0 sec	0.3	-	0.4	-	0.4	-
PGA	2.6	4.1	4.1	6.4	4.1	6.4
PGV	0.017	0.048	0.021	0.057	0.021	0.057

Spectral Parameter	H Model 50%ile	H Model 84%ile	R Model 50%ile	R Model 84%ile	Robust 50%ile	Robust 84%ile
Calgary (51.0 -114.0)						
PSA 0.1 sec	4.2	8.7	3.2	5.9	4.2	8.7
PSA 0.15 sec	6.1	13	4.4	9.6	6.1	13
PSA 0.2 sec	6.7	14	4.8	10	6.7	14
PSA 0.3 sec	5.7	12	4.4	9.4	5.7	12
PSA 0.4 sec	4.6	10	3.8	7.4	4.6	10
PSA 0.5 sec	4.1	8.1	3.3	6.1	4.1	8.1
PSA 1.0 sec	2.0	4.0	1.6	3.3	2.0	4.0
PSA 2.0 sec	1.2	2.3	1.0	1.8	1.2	2.3
PGA	4.0	7.8	3.2	5.6	4.0	7.8
Kelowna (49.9 -119.4)						
PSA 0.1 sec	11	20	7.7	15	11	20
PSA 0.15 sec	14	28	10	20	14	28
PSA 0.2 sec	15	31	12	23	15	31
PSA 0.3 sec	13	26	10	20	13	26
PSA 0.4 sec	11	22	9.4	18	11	22
PSA 0.5 sec	8.8	17	7.8	15	8.8	17
PSA 1.0 sec	4.2	8.6	4.6	9.8	4.6	9.8
PSA 2.0 sec	2.3	4.5	2.9	5.5	2.9	5.5
PGA	6.9	14	5.1	11	6.9	14
Kamloops (50.7 -120.3)						
PSA 0.1 sec	10	20	8.3	16	10	20
PSA 0.15 sec	13	28	11	22	13	28
PSA 0.2 sec	15	31	12	25	15	31
PSA 0.3 sec	13	25	11	22	13	25
PSA 0.4 sec	11	21	10	20	11	21
PSA 0.5 sec	8.7	17	8.8	17	8.8	17
PSA 1.0 sec	4.2	8.5	5.2	11	5.2	11
PSA 2.0 sec	2.3	4.5	3.2	6.1	3.2	6.1
PGA	6.9	14	5.7	12	6.9	14
Prince George (53.9 -122.7)						
PSA 0.1 sec	3.7	7.3	3.1	5.5	3.7	7.3
PSA 0.15 sec	5.2	11	4.2	8.9	5.2	11
PSA 0.2 sec	5.7	12	4.6	10	5.7	12
PSA 0.3 sec	5.1	11	4.3	9.1	5.1	11
PSA 0.4 sec	4.3	8.9	3.8	7.6	4.3	8.9
PSA 0.5 sec	3.6	7.2	3.4	6.5	3.6	7.2
PSA 1.0 sec	1.9	3.8	2.1	4.2	2.1	4.2
PSA 2.0 sec	1.2	2.4	1.4	2.9	1.4	2.9
PGA	3.5	6.7	3.1	5.4	3.5	6.7

Spectral Parameter	H Model 50%ile	H Model 84%ile	R Model 50%ile	R Model 84%ile	Robust 50%ile	Robust 84%ile
Vancouver (49.2 -123.2)						
PSA 0.1 sec	34	65	35	68	35	68
PSA 0.15 sec	38	76	42	87	42	87
PSA 0.2 sec	45	97	48	100	48	100
PSA 0.3 sec	33	63	38	76	38	76
PSA 0.4 sec	28	52	33	63	33	63
PSA 0.5 sec	22	43	28	53	28	53
PSA 1.0 sec	10	20	15	30	15	30
PSA 2.0 sec	3.9	7.8	7.6	15	7.6	15
PGA	17	34	19	38	19	38
Victoria (48.5 -123.3)						
PSA 0.1 sec	41	85	39	78	41	85
PSA 0.15 sec	47	100	45	98	47	100
PSA 0.2 sec	57	120	54	120	57	120
PSA 0.3 sec	40	82	40	83	40	83
PSA 0.4 sec	34	66	35	68	35	68
PSA 0.5 sec	28	53	30	56	30	56
PSA 1.0 sec	13	26	15	31	15	31
PSA 2.0 sec	4.7	9.6	7.6	15	7.6	15
PGA	22	44	21	41	22	44
Tofino (49.1 -125.9)						
PSA 0.1 sec	14	28	20	39	20	39
PSA 0.15 sec	18	36	28	52	28	52
PSA 0.2 sec	20	41	31	58	31	58
PSA 0.3 sec	17	35	26	50	26	50
PSA 0.4 sec	15	30	22	44	22	44
PSA 0.5 sec	12	24	19	37	19	37
PSA 1.0 sec	6.7	14	11	21	11	21
PSA 2.0 sec	3.9	7.8	6.0	12	6.0	12
PGA	9.3	18	13	26	13	26
Prince Rupert (54.3 -130.4)						
PSA 0.1 sec	6.8	14	12	23	12	23
PSA 0.15 sec	10	20	16	33	16	33
PSA 0.2 sec	11	22	18	35	18	35
PSA 0.3 sec	11	22	16	33	16	33
PSA 0.4 sec	10	20	14	29	14	29
PSA 0.5 sec	9.9	19	13	25	13	25
PSA 1.0 sec	7.2	14	8.6	17	8.6	17
PSA 2.0 sec	4.2	8.7	4.9	10	4.9	10
PGA	5.9	12	9.3	18	9.3	18

Spectral Parameter	H Model 50%ile	H Model 84%ile	R Model 50%ile	R Model 84%ile	Robust 50%ile	Robust 84%ile
Queen Charlotte City (53.3 -132.0)						
PSA 0.1 sec	26	50	28	53	28	53
PSA 0.15 sec	36	70	38	74	38	74
PSA 0.2 sec	38	76	41	82	41	82
PSA 0.3 sec	38	74	40	80	40	80
PSA 0.4 sec	36	70	37	73	37	73
PSA 0.5 sec	34	64	35	67	35	67
PSA 1.0 sec	22	43	23	46	23	46
PSA 2.0 sec	12	25	13	25	13	25
PGA	20	40	21	42	21	42
Inuvik (68.4 -133.6)						
PSA 0.1 sec	3.2	6.3	3.1	5.7	3.2	6.3
PSA 0.15 sec	4.8	10	4.5	9.6	4.8	10
PSA 0.2 sec	5.4	11	5.1	11	5.4	11
PSA 0.3 sec	5.1	11	4.9	10	5.1	11
PSA 0.4 sec	4.4	9.0	4.4	9.1	4.4	9.1
PSA 0.5 sec	3.8	7.6	3.9	7.7	3.9	7.7
PSA 1.0 sec	2.1	4.2	2.3	4.5	2.3	4.5
PSA 2.0 sec	1.3	2.7	1.5	3.0	1.5	3.0
PGA	3.3	6.5	3.2	6.0	3.3	6.5

Notes.

All values are given for a probability of 0.0021 p.a. (10% in 50 years) on firm ground.

[1]Spectral (5% damped) and peak acceleration values are in %g, peak velocity in m/s.

[2]PSA2.0 s epistemic uncertainty to provide the 84th percentile is not available.

Table 5

Hazard Values for Cascadia Subduction Earthquake Scenario, ordered by distance

	Tofino		Victoria		Vancouver		Kamloops		Kelowna		Prince George		Calgary	
Distance (km)	50		120		200		450		450		600		900	
Percentile	50%	84%	50%	84%	50%	84%	50%	84%	50%	84%	50%	84%	50%	84%
Period (s)														
0.1	27	55	18	37	12	25	5.2	10	5.2	10	3.5	7.1	1.9	3.9
0.15	30	60	20	40	14	27	5.7	11	5.7	11	3.9	7.8	2.2	4.3
0.2	37	73	25	49	17	33	7.0	14	7.0	14	4.8	9.5	2.6	5.3
0.3	33	66	23	45	16	32	7.0	14	7.0	14	4.9	9.8	2.8	5.6
0.4	29	59	21	41	15	29	6.8	14	6.8	14	4.8	9.7	2.9	5.8
0.5	28	55	19	38	13	26	5.8	12	5.8	12	4.0	8.0	2.3	4.6
1.0	20	40	13	27	9.3	19	4.0	8.2	4.0	8.2	2.8	5.7	1.6	3.2
2.0	6.7	14	5.0	11	3.8	8.0	2.0	4.3	2.0	4.3	1.5	3.3	1.0	2.1
PGA	22	47	12	27	7.1	15	2.1	4.4	2.1	4.4	1.2	2.6	0.5	1.1

Notes

The scenario event has a magnitude of 8.2 and is located at a depth of 25 km at given distances from the cities.

Seismic hazard levels are given in units of %g for Peak Ground Acceleration (PGA) and spectral (5% damped) values on firm ground.

Columns labelled "50%" are the medians, which are exceeded half of the time.

Columns labelled "84%" are the 84th percentiles, which are exceeded only 16% of the time (at present the 84th percentile values include only the estimated epistemic uncertainty assumed for the strong ground motion relations).

Table 6. Selected seismic hazard values at 0.0021 per annum for "Firm Ground"

City	Coordinates °North	°West	PGV (m/s) 50% H	PGA (%g) 50% H	0.2 s PSA (%g) 50% H	0.2 s PSA 50% R	0.2 s PSA 84% H	0.2 s PSA 84% R	0.5 s PSA (%g) 50% H	0.5 s PSA 50% R	0.5 s PSA 84% H	0.5 s PSA 84% R	0.5 s PSA (%g) Cascadia 50%	Cascadia 84%
St. John's	47.6	52.7	0.021	3.3	6.4	8.9	11	16	3.6	5.8	9.4	15	see	
Halifax	44.6	63.6	0.026	3.5	7.4	9.7	13	17	4.7	5.9	12	15	note	
Moncton	46.1	64.8	0.043	8.4	14	13	24	23	7.2	6.9	18	18		
Fredericton	45.9	66.6	0.050	9.5	16	17	28	28	8.5	8.6	22	22		
La Malbaie	47.6	70.1	0.27	56	99	25	170	43	48	11	110	29		
Quebec	46.8	71.2	0.071	14	24	23	40	38	12	10	32	27		
Trois-Rivieres	46.3	72.5	0.050	8.5	16	27	28	48	9.0	12	24	32		
Montreal	45.5	73.6	0.074	16	24	29	42	50	11	13	28	34		
Ottawa	45.4	75.7	0.057	12	21	27	37	46	9.5	12	25	31		
Niagara Falls	43.1	79.1	0.048	12	15	9.1	31	16	6.6	4.7	17	12		
Toronto	43.7	79.4	0.033	7.1	11	8.4	21	15	5.0	4.6	13	12		
Windsor	42.3	83.0	0.017	2.6	6.0	6.8	9.8	12	2.8	3.3	7.5	8.6		
Calgary	51.0	114.0	see	4.0	6.7	4.8	14	10	4.1	3.3	8.1	6.1	2.3	4.6
Kelowna	49.9	119.4	note	6.9	15	12	31	23	8.8	7.8	17	15	5.8	12
Kamloops	50.7	120.3		6.9	15	12	31	25	8.7	8.8	17	17	5.8	12
Prince George	53.9	122.7		3.5	5.7	4.6	12	10	3.6	3.4	7.2	6.5	4.0	8.0
Vancouver	49.2	123.2		17	45	48	97	100	22	28	43	53	13	26
Victoria	48.5	123.3		22	57	54	120	120	28	30	53	56	19	38
Tofino	49.1	125.9		9.3	20	31	41	58	12	19	24	37	28	55
Prince Rupert	54.3	130.4		5.9	11	18	22	35	9.9	13	19	25	see	
Queen Charlotte	53.3	132.0		20	38	41	76	82	34	35	64	67	note	
Inuvik	68.4	133.6		3.3	5.4	5.1	11	11	3.8	3.9	7.6	7.7		

This summary of seismic hazard results is selected from the values in Tables 4 and 5.

Abbreviations: PGV - peak ground velocity; PGA - peak ground acceleration; 0.2 s PSA - pseudo-spectral acceleration at 0.2 seconds; 0.5 s PSA - pseudo-spectral acceleration at 0.5 seconds; RGC - reference ground condition.

This table is replaces Table 1 of Adams et al. 1995a. Eastern RGC multiplicative factors (in brackets) as follows: PGV (2.38), PGA (1.39), 0.2 s (1.94), 0.5 s (2.38). Eastern hard rock values can be found by dividing by the appropriate RGC factor; RGC factors are not applicable for the west.

The columns labelled "50%" are the medians, which are exceeded half of the time. The columns labelled "84%" are the 84th percentiles, which are exceeded only 16% of the time.

Columns labelled 'H' and 'R' are the hazard values for the probabilistic models discussed in the text; 'Cascadia' is the Cascadia scenario event.

note: PGV values are not available for the west; Cascadia values are given only where relevant.

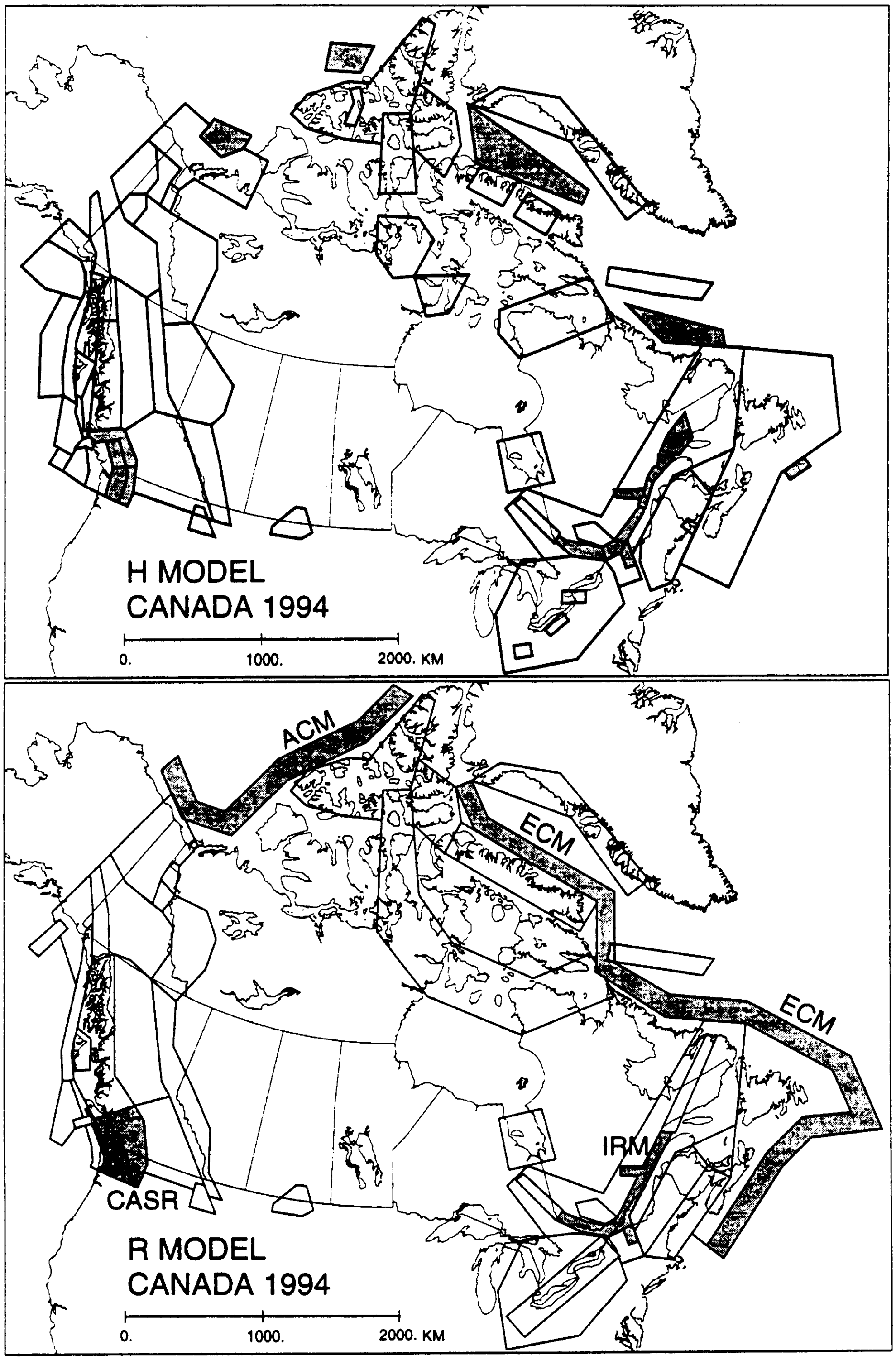


Figure 1. Earthquake source zone maps of Canada showing the zones that form the H (top) and R (bottom) models for earthquake distribution. Zones referred to in the text are shaded and labelled on the bottom map; corresponding H-model zones are shaded on the top map.

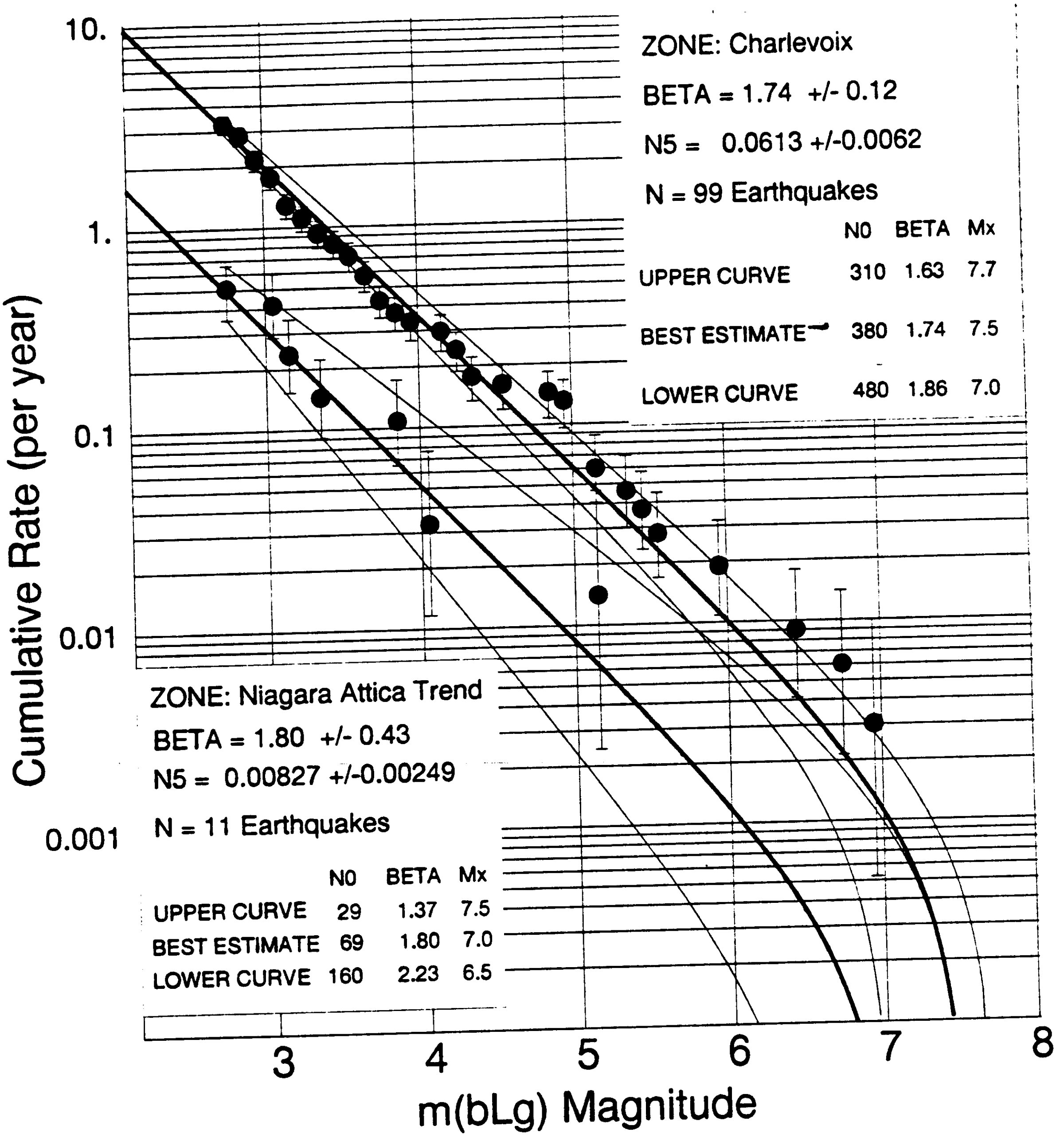


Figure 2. Sample magnitude-recurrence data and curves, for Charlevoix and the Niagara-Attica Trend (NAT) zones. The cumulative rates of earthquakes are represented by solid circles with stochastic error bounds and the best-fit curve (bold) are flanked by upper and lower "error" curves that are more widely separated for the poorly-constrained NAT dataset. All curves are asymptotic to assumed upper bound magnitudes.

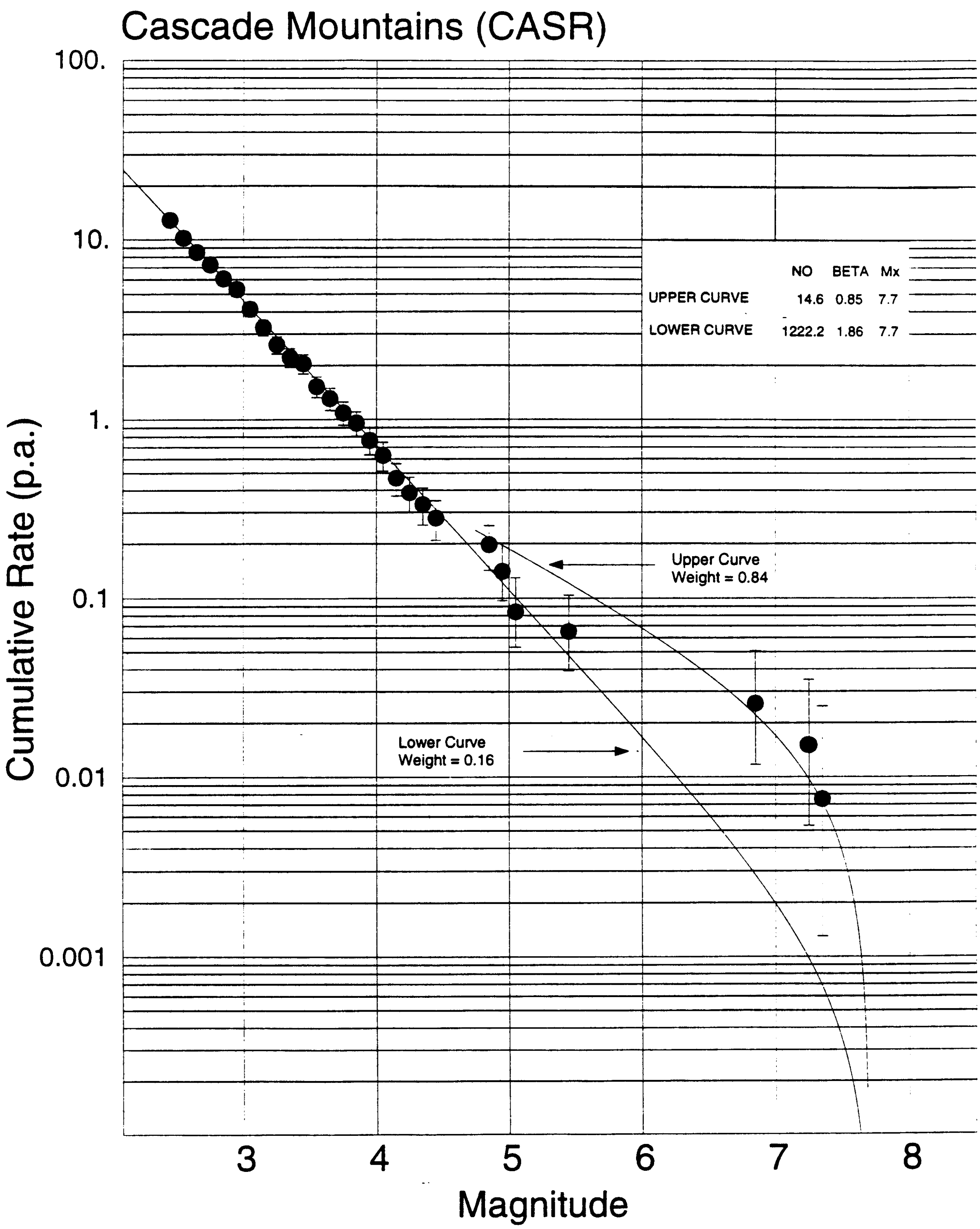


Figure 3. Magnitude-recurrence data and curves for CASR, the shallow crustal source for the Strait of Georgia - Puget Sound region. The maximum likelihood fit including the small magnitude earthquakes (lower curve) passes through the point (0.002, 7.0), considerably below the historical rate of M>6.8 earthquakes. The maximum likelihood fit to only M>4.75 earthquakes (upper curve) matches the historical rate of larger earthquakes much better. Both curves are asymptotic to assumed upper-bound magnitudes.

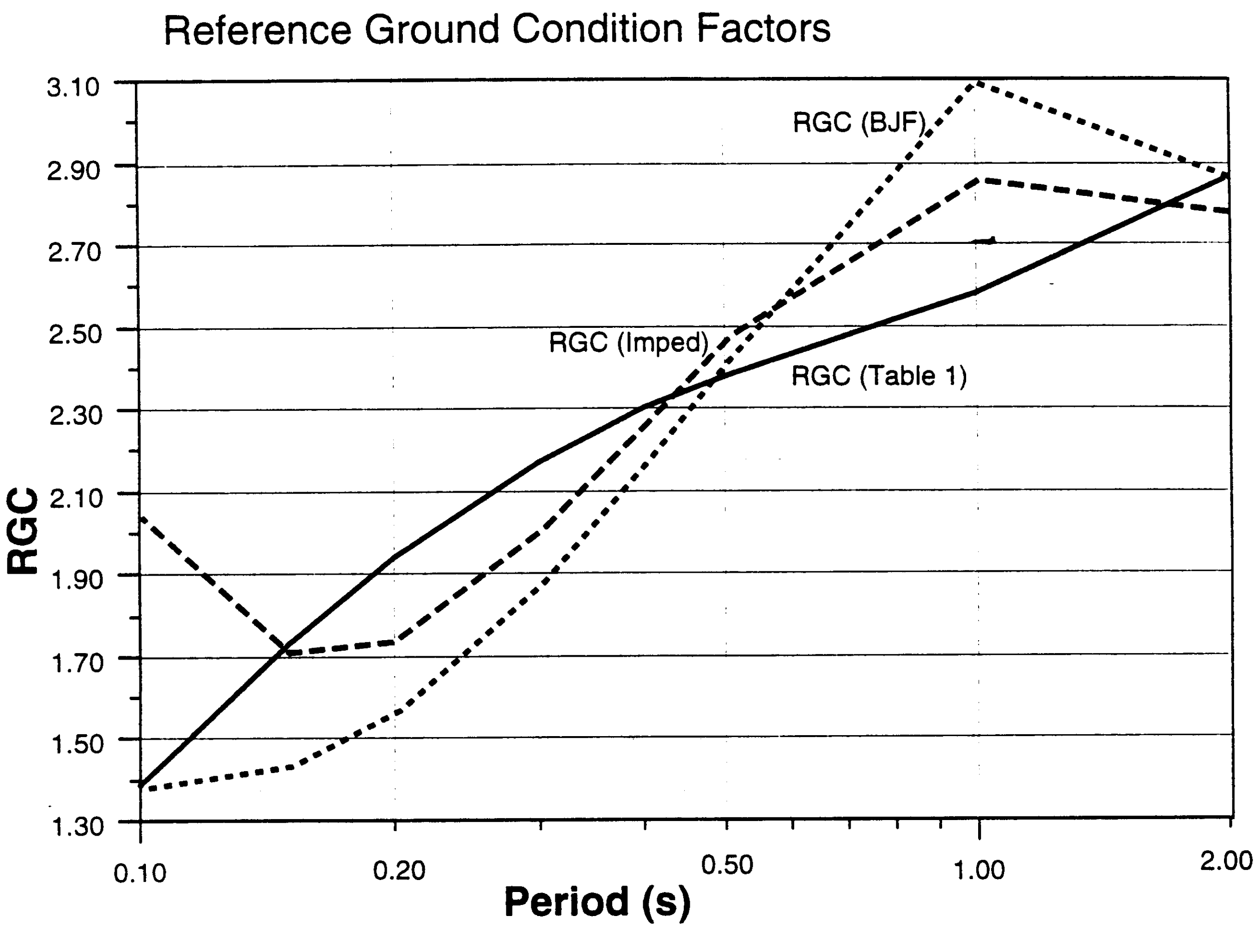


Figure 4. RGC factors as a function of period, as derived by the three methods described in the text and shown in Table 2. The "Table 1" factors are the preferred ones.

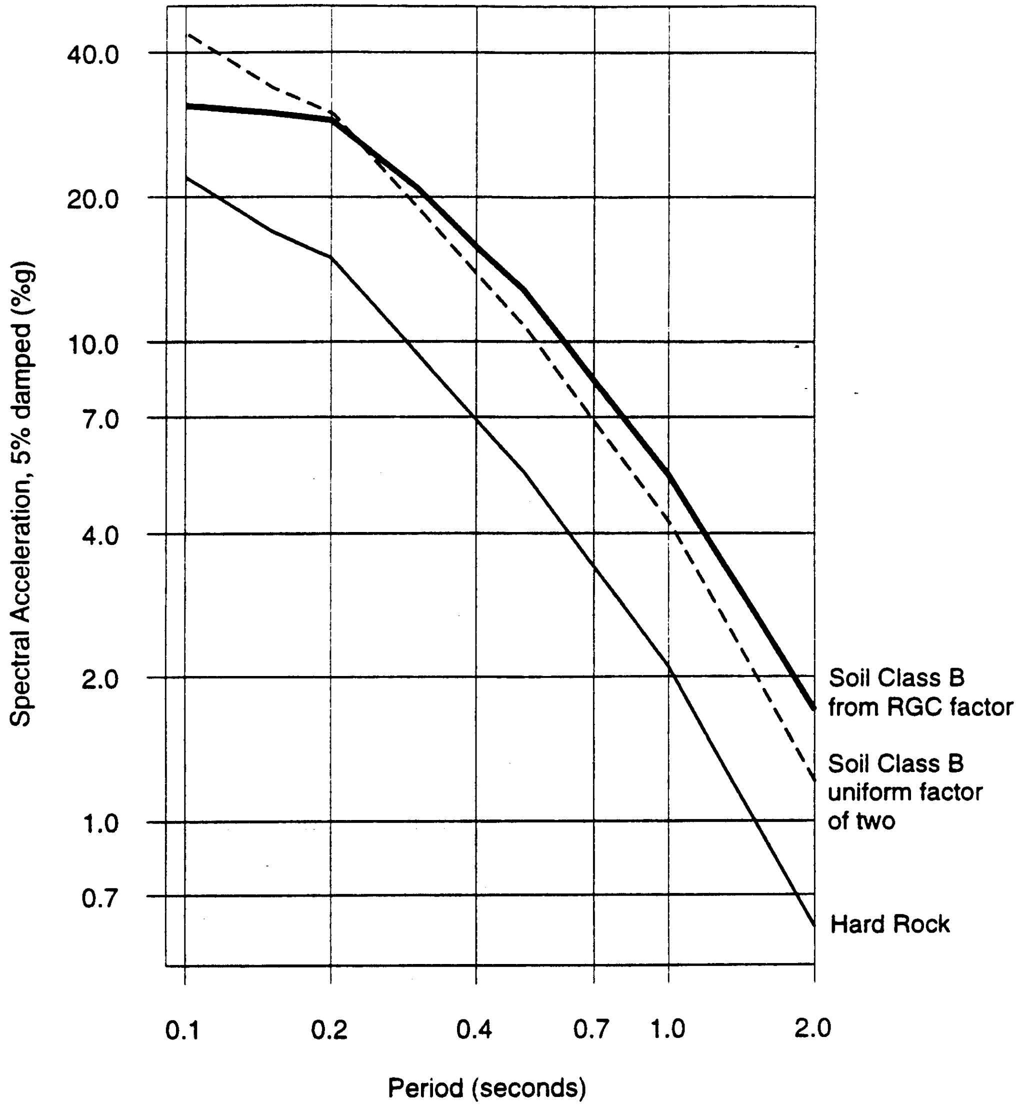


Figure 5. Seismic hazard for Montreal depicted as Uniform Hazard Spectra on various ground conditions. These 50th percentile UHS from the **R** model are derived from values given in Table 4 for hard-rock and soil Class B using the RGC factors; a baseline derived from the hard-rock values using a uniform amplification of a factor of two is shown for comparison.

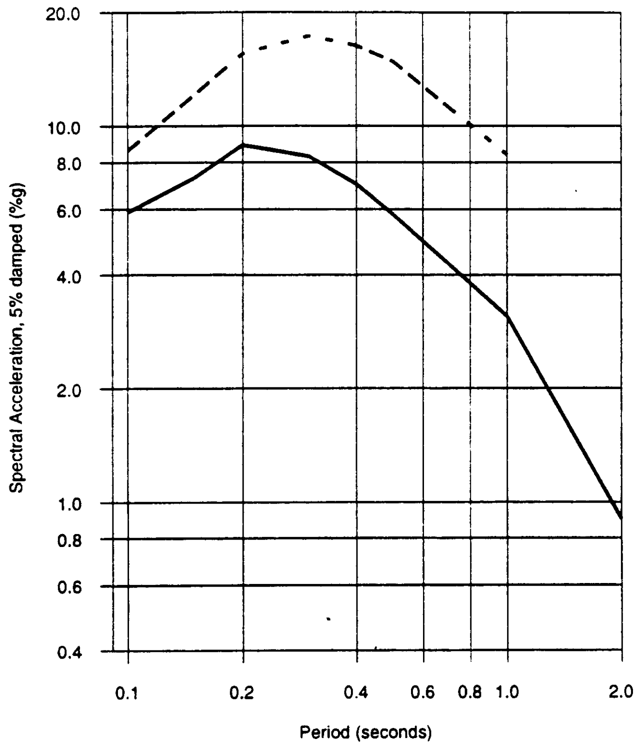


Figure 6. St. John's "Robust" Uniform Hazard Spectra

Figures 6-27 show the 0.0021 per annum ground motion "firm ground" results as Uniform Hazard Spectra for the named city. The 50th percentile (thick solid line) and 84th percentile (thick dashed line) UHS are derived by the robust method from the **H** and **R** model values given in Table 4. For southwestern Canadian cities, two additional curves (light lines) are shown. These are the 50th and 84th percentile spectra for the scenario M8.2 Cascadia event, as given in Table 5.

Figure 6. St. John's	Figure 7. Halifax	Figure 8. Moncton
Figure 9. Fredericton	Figure 10. La Malbaie	Figure 11. Quebec
Figure 12. Trois-Rivieres	Figure 13. Montreal	Figure 14. Ottawa
Figure 15. Niagara Falls	Figure 16. Toronto	Figure 17. Windsor
Figure 18. Calgary	Figure 19. Kelowna	Figure 20. Kamloops
Figure 21. Prince George	Figure 22. Vancouver	Figure 23. Victoria
Figure 24. Tofino	Figure 25. Prince Rupert	
Figure 26. Queen Charlotte City	Figure 27. Inuvik	

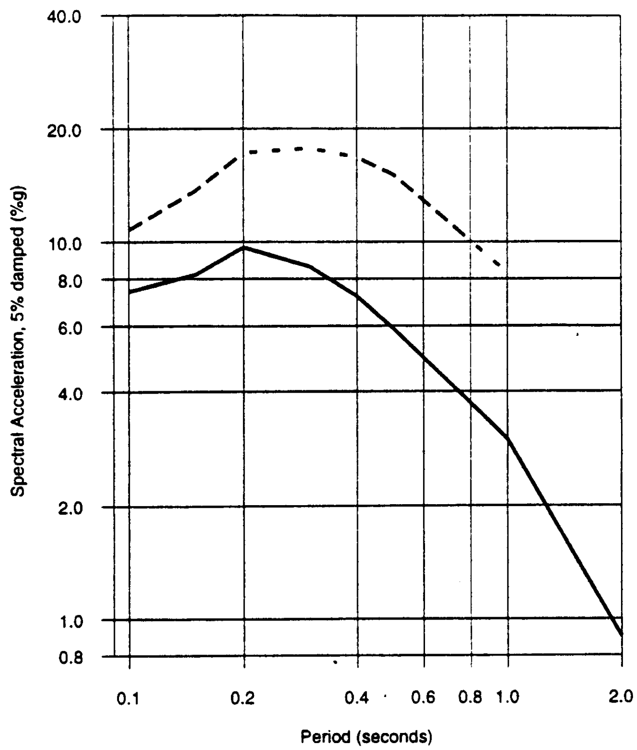


Figure 7. Halifax "Robust" Uniform Hazard Spectra

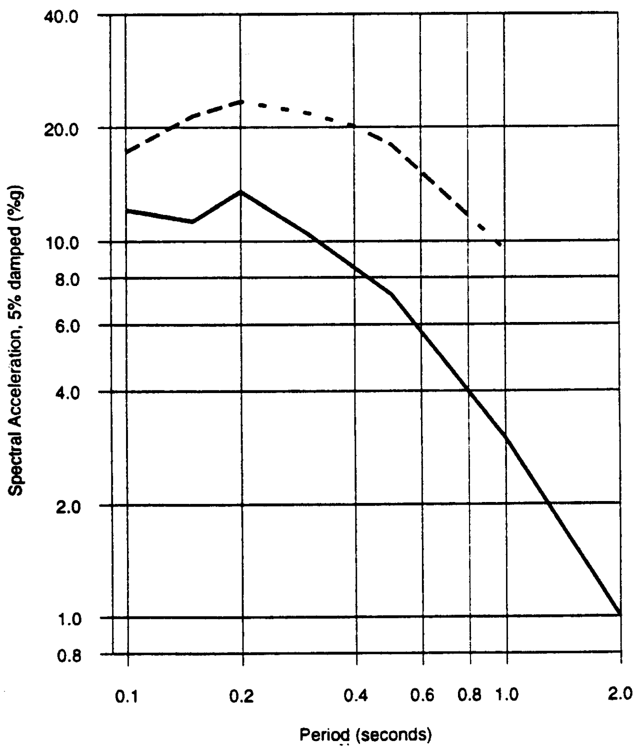


Figure 8. Moncton "Robust" Uniform Hazard Spectra

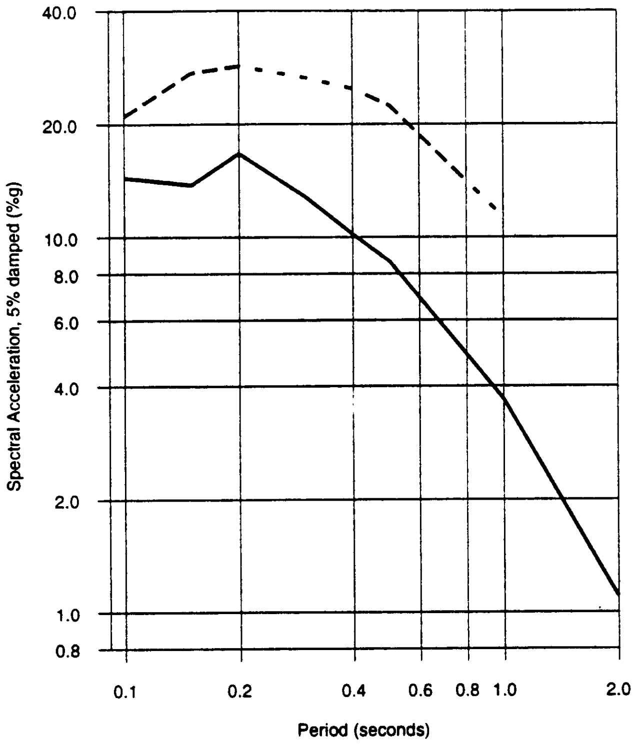


Figure 9. Fredericton "Robust" Uniform Hazard Spectra

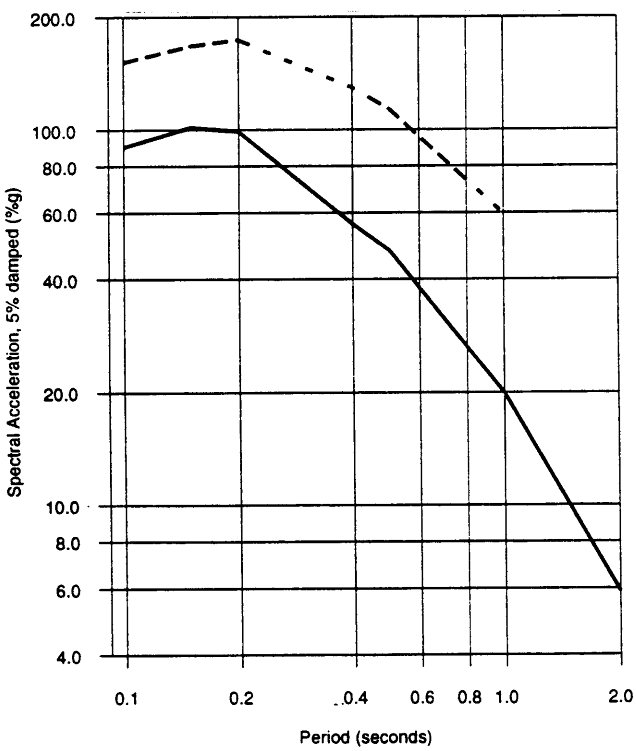


Figure 10. La Malbaie "Robust" Uniform Hazard Spectra

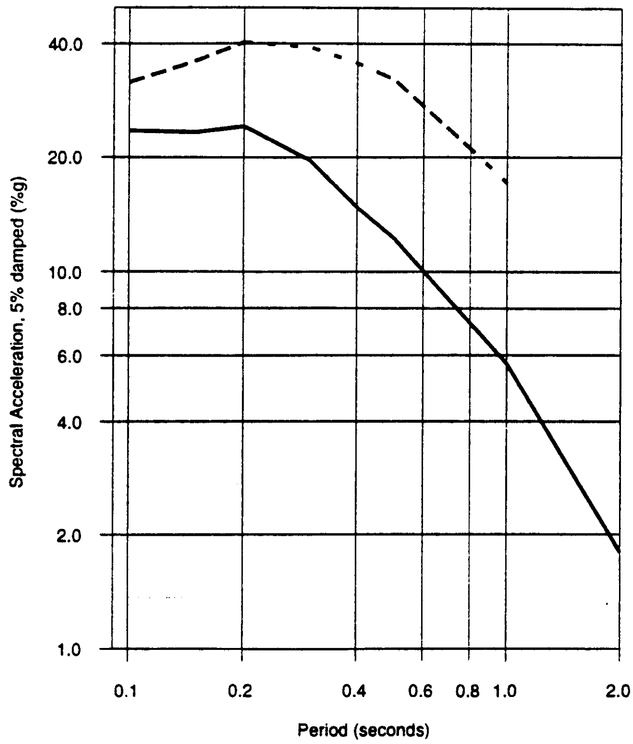


Figure 11. Quebec "Robust" Uniform Hazard Spectra

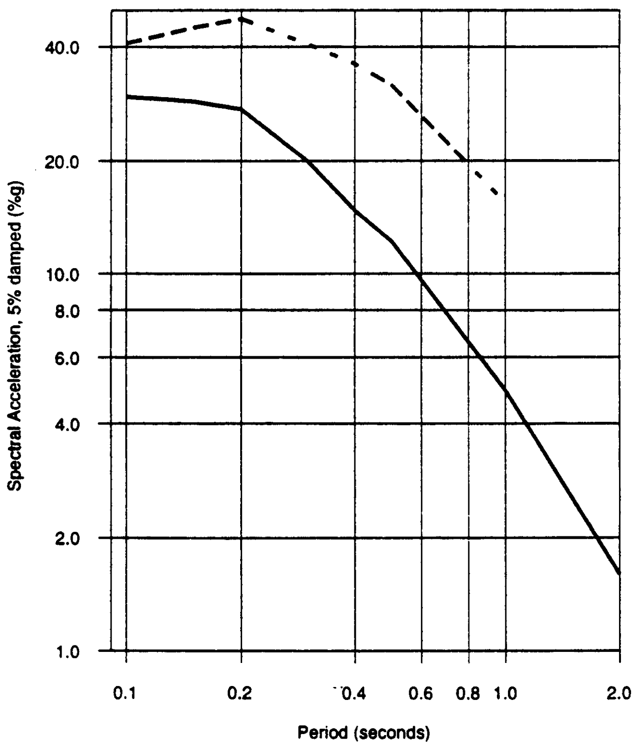


Figure 12. Trois-Rivieres "Robust" Uniform Hazard Spectra

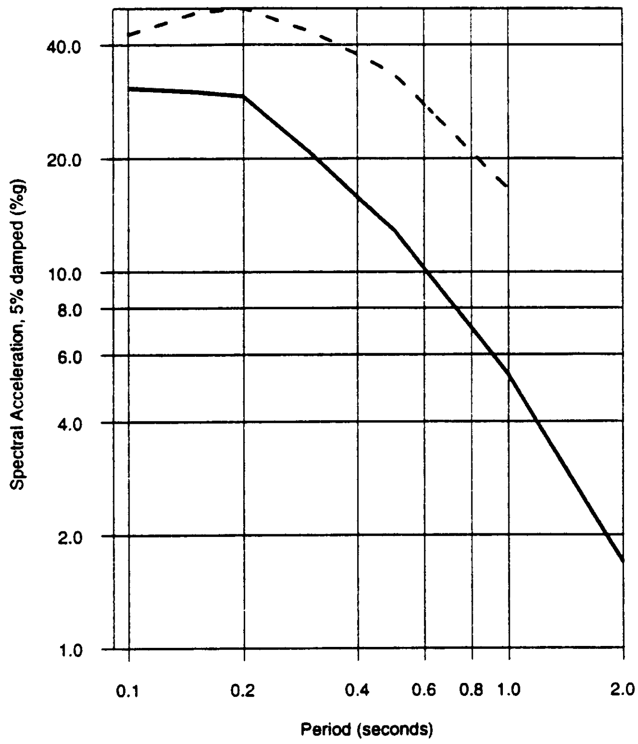


Figure 13. Montreal "Robust" Uniform Hazard Spectra

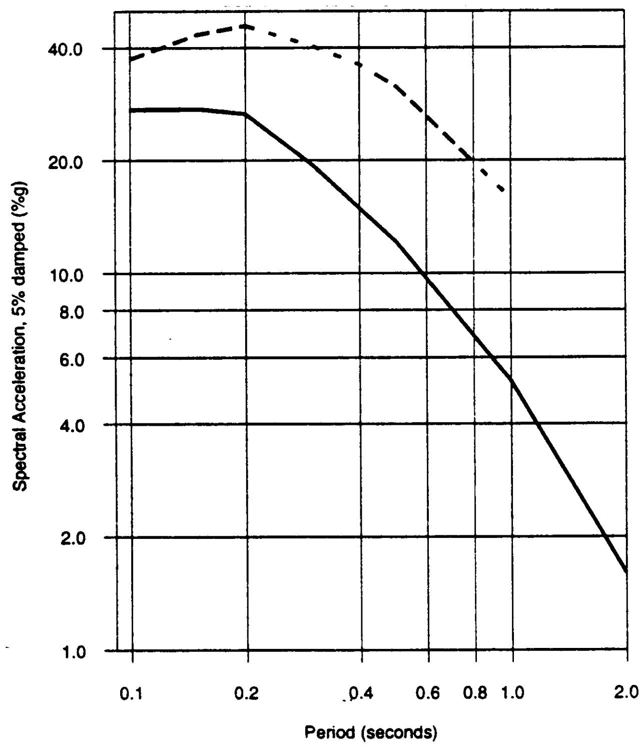


Figure 14. Ottawa "Robust" Uniform Hazard Spectra

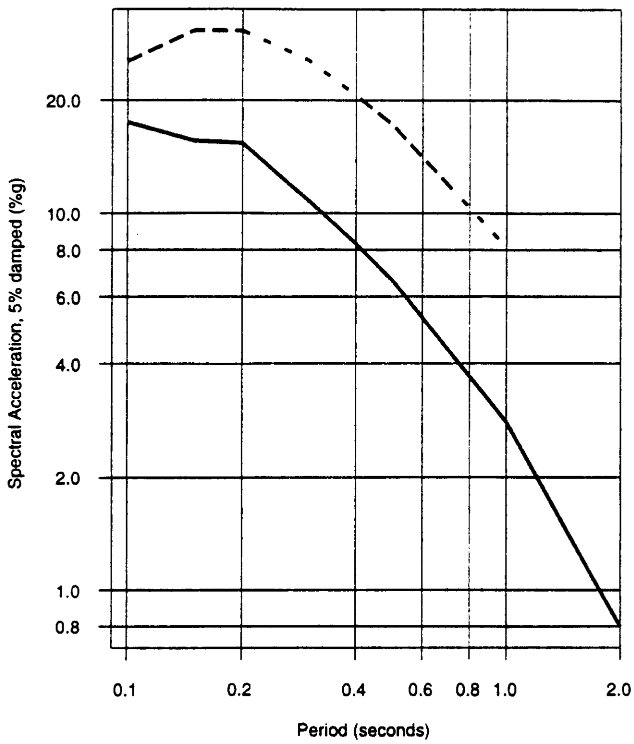


Figure 15. Niagara Falls "Robust" Uniform Hazard Spectra

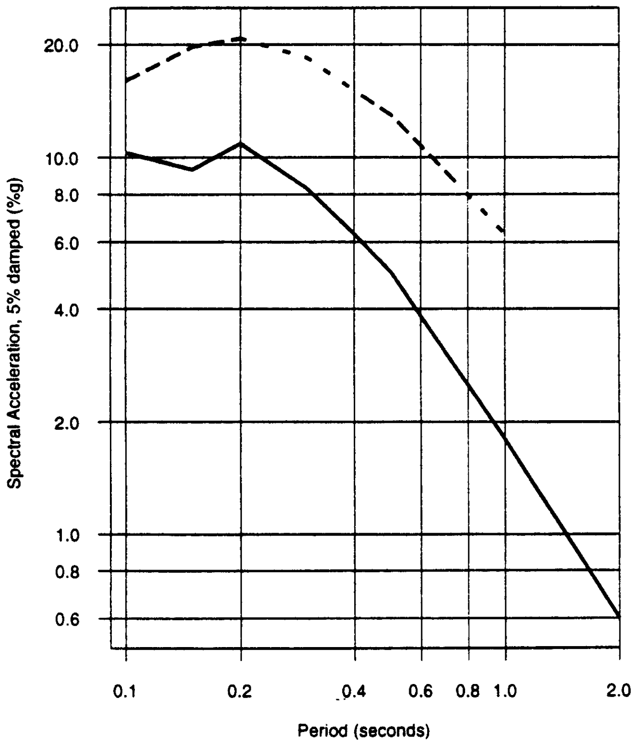


Figure 16. Toronto "Robust" Uniform Hazard Spectra

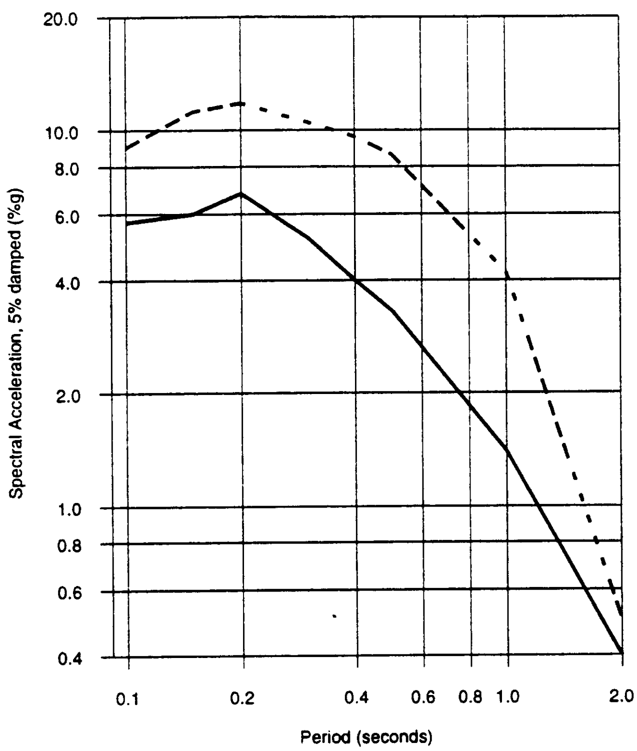


Figure 17. Windsor "Robust" Uniform Hazard Spectra

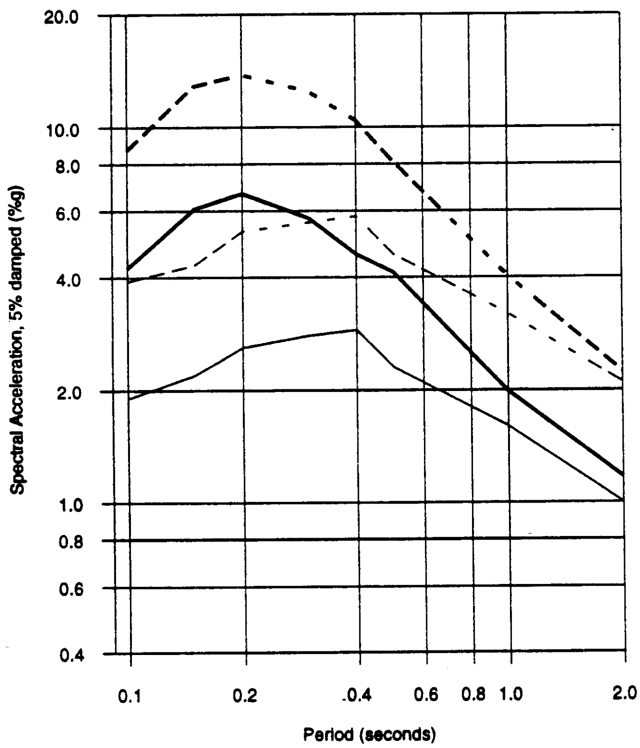


Figure 18. Calgary "Robust" Uniform Hazard Spectra

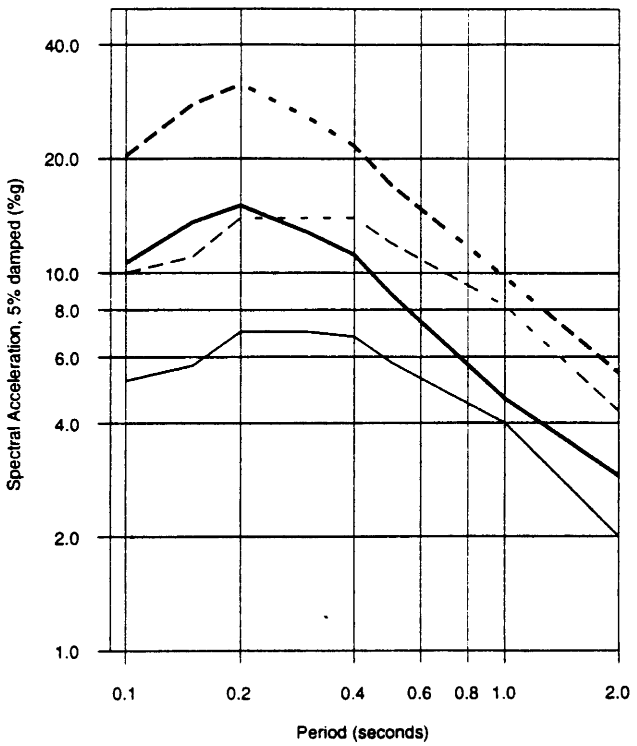


Figure 19. Kelowna "Robust" Uniform Hazard Spectra

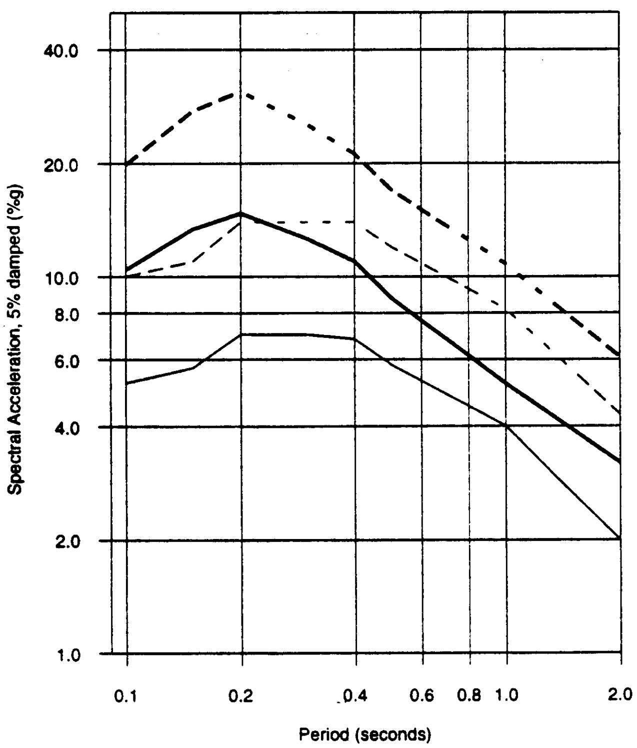


Figure 20. Kamloops "Robust" Uniform Hazard Spectra

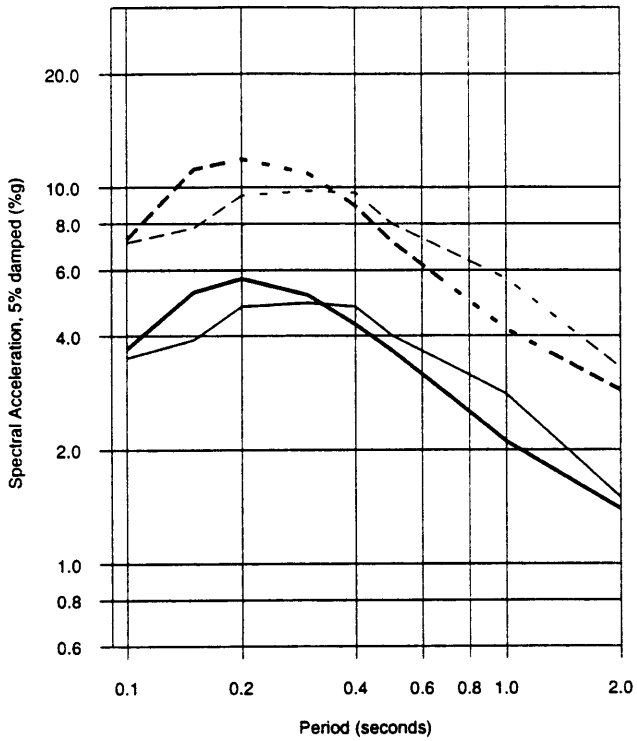


Figure 21. Prince George "Robust" Uniform Hazard Spectra

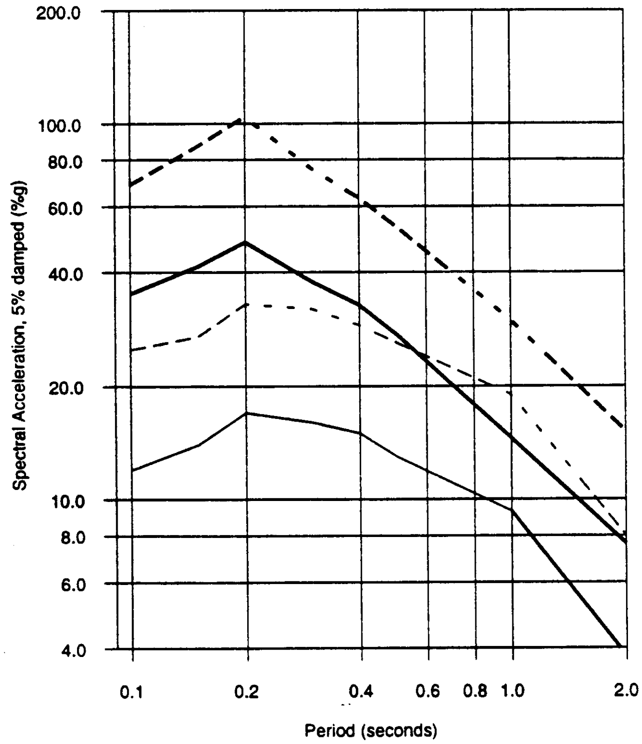


Figure 22. Vancouver "Robust" Uniform Hazard Spectra

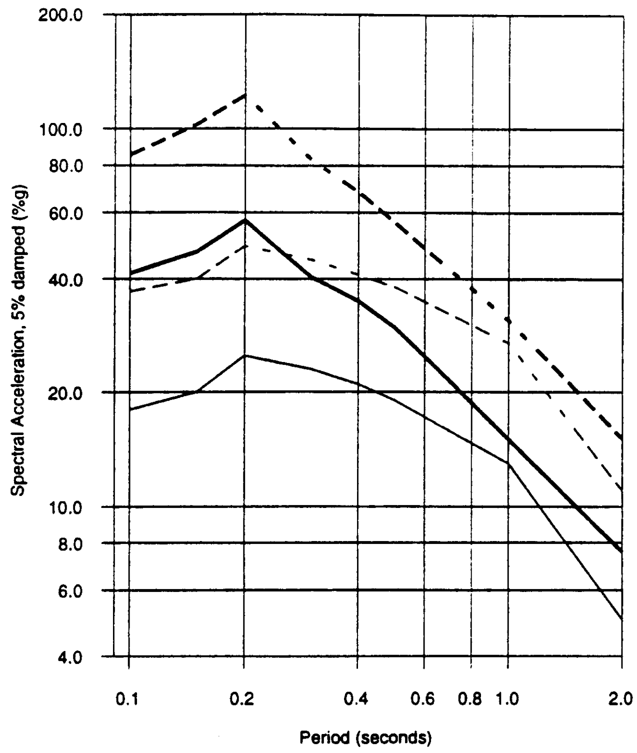


Figure 23. Victoria "Robust" Uniform Hazard Spectra

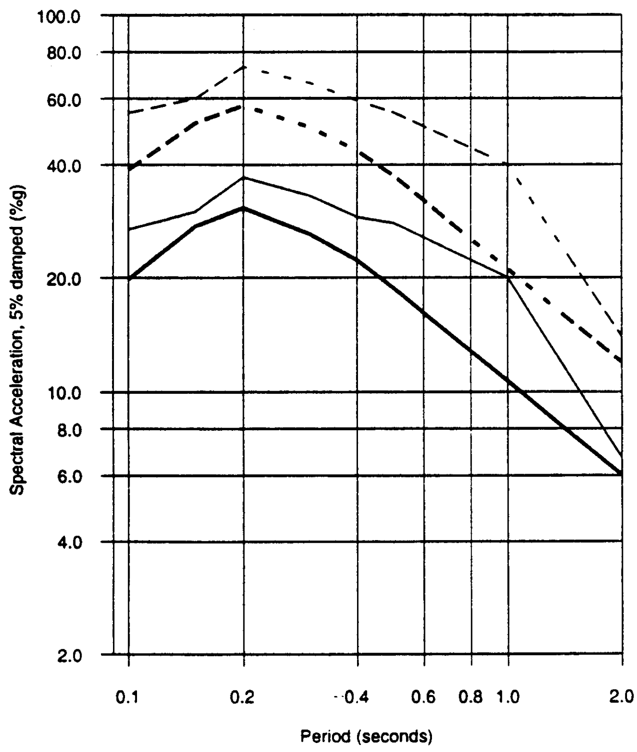


Figure 24. Tofino "Robust" Uniform Hazard Spectra

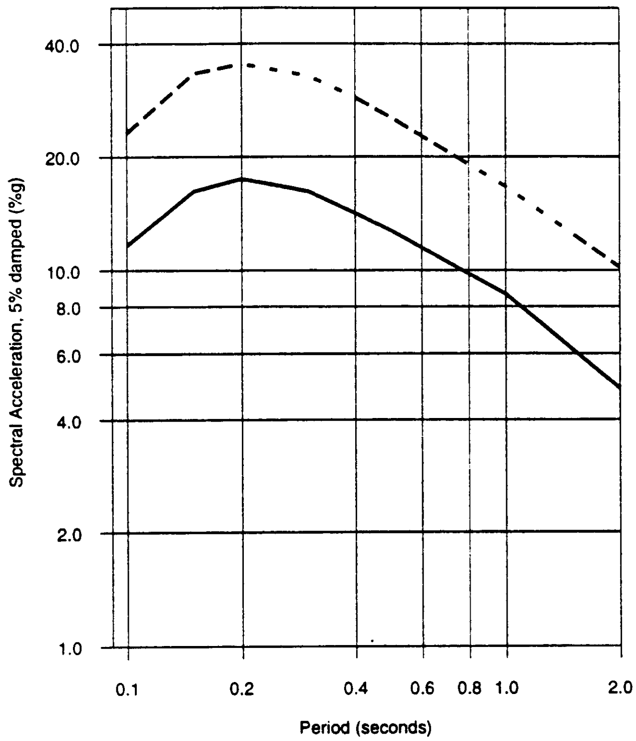


Figure 25. Prince Rupert "Robust" Uniform Hazard Spectra

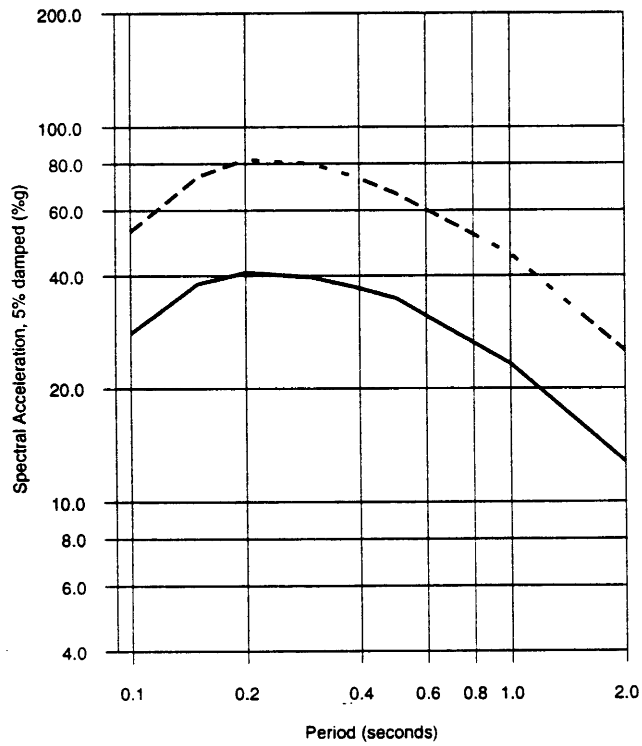


Figure 26. Queen Charlotte City "Robust" Uniform Hazard Spectra

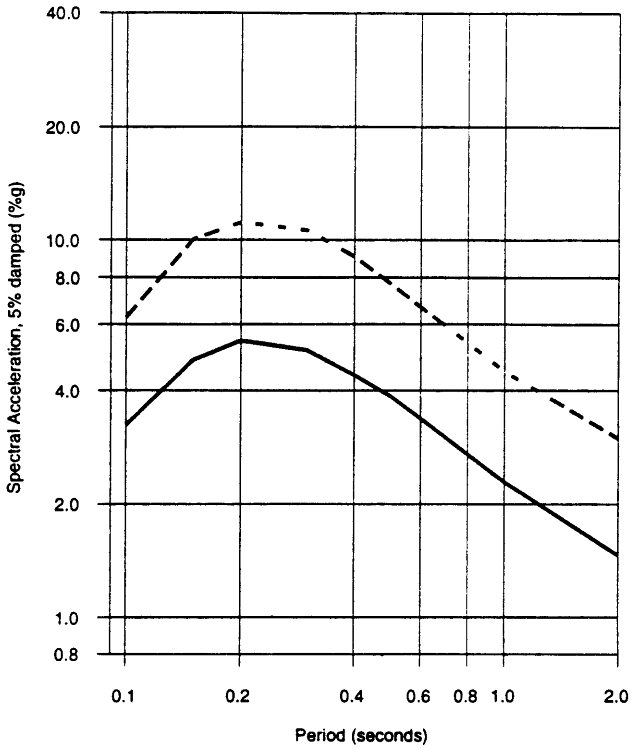


Figure 27. Inuvik "Robust" Uniform Hazard Spectra

APPENDICES

A. Summary of changes since GSC Open File 3029

B. The 1995 seismicity models for probabilistic hazard

C. Input models for FRISK88 seismic hazard code (including strong ground motion parameters).

D. Published information relevant to the derivation of RGC factors

APPENDIX A

Summary of Changes since GSC Open File 3029

Philosophy (by iteration between seismologists and engineers)
"Robust" combination approved by CANCEE.
Decision to use median (50th percentile) values adopted, so as to de-emphasize uncertainties.
Cascadia to be evaluated deterministically and combined with probabilistic values by "robust" method.

Source zones and Earthquake recurrence rates
Boothia-Ungava zone, northern Canada, replaced by 4 smaller zones in H model.
Some events in the Puget Sound / Strait of Georgia were reassigned from shallow to deep zones.
Magnitude-recurrence curve for crustal earthquakes in SW B.C. changed to accommodate history of large events (see figure 4 of the Open File).

SGM relations - East
No changes

SGM relations - West
Corrected errors in coefficients (b0+b6) for PSA0.2 for BJF relationship.
Corrected errors in PSA0.4 sigma values for Crouse relationship.
Smoothed Crouse's sigma values using a cubic relation.
Upper and lower attenuation relations for Crouse were set at a factor of 2 above and below the best relation to represent uncertainty consistent with treatment of BJF.
Crouse relations attributed to "soil", not "firm ground"; adjustments made.

Calculation program:
New subroutine to correct map projection at high latitudes.
Modified subroutine ATTEN in FRISK88 to "unbundle" the c1 ("constant") terms for western attenuations.

Blunders
Corrected values for St John's, Halifax and Moncton (PSA 0.3 and 0.5 s only) resulting from these three locations having been all shifted by one site.

APPENDIX B

The 1995 Seismicity models for Probabilistic Hazard

Contents: Background Information on the Zone Parameters in the Parameter Tables
Tables of the seismic source zone parameters
Maps of the seismic source zones for **H** and **R** models:
Canada, Eastern Canada, Western Canada, Shallow/deep zones in SW B.C.

Background Information on the Zone Parameters in the Parameter Tables

Source Models. For four models — eastern **H** and **R**, and western **H** and **R** — zone parameters are tabulated separately (zone corner coordinates are available in Appendix C). By using the code FRISKGSC (which is the front-end for a slightly custom-tailored version of the commercial hazard code FRISK88 of Risk Engineering Inc.) we can incorporate a range for some of the input parameters so as to include multiple hypotheses and compute a degree of uncertainty in the resultant hazard calculations. Some zones are common to more than one model (see table) and where practical the common parameters and ranges of parameters have been kept consistent.

Magnitude Recurrence. Three estimates, weighted 0.68, 0.16, and 0.16, are used. The heavily-weighted "best" represents the Maximum Likelihood fit using essentially the modification of the maximum likelihood method suggested by Weichert (1980), the same method as used for the last seismic hazard mapping project, as described by Basham et al. (1985).

Earthquakes with epicentres within the source zones of the two alternate models are selected from the appropriate Earthquake Epicentre File. Magnitude intervals of 0.1 magnitude units were used; for zones with events spanning only a short magnitude range this should result in a better definition of the recurrence slope, since grouping into half-magnitude intervals would irrevocably discard information. The magnitude uncertainty of a single event is nevertheless still on the order of 1/4. No explicit correction for this has been attempted.

A reliability factor for the eastern zones (# EVTS) is the total number of events above the lower completeness threshold, usually around magnitude 2.8 to 4.0. Since the FRISK88 program expects the activity rate at zero-magnitude, N0, as a parameter, this is listed, but we note that it is strongly dependent on the slope, "BETA". We have also reported it to an undue level of precision. Also listed is the activity near the damage threshold, "BEST N5". This parameter is much less dependent on the BETA estimate than N0 (which is obtained by extrapolation), and is far more representative of the rate of earthquakes which contribute significant ground motions. The value "Mag 5 Rate/Area" normalizes the activity to the source zone size to allow comparison between zones.

Conservative estimates for the "LOWER" and "UPPER" magnitude-recurrence curves are obtained by curves anchored to points one standard deviation above and below the total number of observed events at the magnitude threshold, and having slope parameters one standard deviation shallower and steeper than the central value. This corresponds to a full standard deviation for each variable (instead of the more usual root-mean-square), but the increase is small for most data sets because at the magnitude threshold the uncertainty in the cumulative rate is generally low.

An examination of recurrence slopes in adjacent source zones showed that the recurrence slope could be averaged over several zones, and the activity then fitted under the constraint of a common slope. This procedure is useful for source zones with inadequate data for independently fitting both recurrence parameters. In the east, the recurrence slope derived from a larger source zone (say IRM) was sometimes imposed on smaller zones contained therein (e.g. TIM); it is flagged by an 'F' in the parameter table.

The three corresponding activity-recurrence slope pairs and the three maximum magnitude estimates are specified for input to FRISK88; a program switch specifies that these parameters are treated as 'perfectly dependent'. This appears reasonable since they are calculated in a dependent manner.

Maximum Magnitude: Estimates of upper-bound magnitude were made for each source zone on the basis of observed largest earthquake, tectonic judgement, or simply in a conservative fashion, remembering that the Nahanni and Saguenay earthquakes both exceeded the maximum earthquake specifications for their respective source regions within 10 years of publication. For each zone, three estimates were used and fitted with a slope and recurrence. While the activity rate is dominated by the total number of events observed above the lower threshold, properly weighted according to their period of observation, the recurrence slope is more strongly affected by the chosen upper-bound magnitude. In anticipation of using these upper-bound magnitude estimates as input to FRISK88, two points of view were considered in choosing the three trial values. FRISK88 allows only one common set of weights to be applied to the alternate choices of parameter sets in a given model. This would imply that the three upper-bound magnitudes should be representative of the same percentile of the upper-bound magnitude distribution for each source zone. Often it *feels* best, to space the estimates evenly, suggestive of symmetric distributions, but this may lead to unreasonably high maximum upper-bound magnitudes, because that value is pushed up by an observed, but possibly incorrect magnitude. This scenario would justify unequal spacing of the upper-bound magnitude estimates. Similarly, some regions may have quite well-established upper-bound magnitudes, because of high activity with a sharp cutoff, supported by a knowledge of maximum fault areas in the source zone; in this case the upper two upper-bound magnitude estimates may also justifiably be set closer together. These considerations have led to slightly different weightings for the LOWER-BEST-UPPER upper-bound magnitude: 0.3-0.6-0.1 for the east and 0.16-0.68-0.16 for the west.

Depth: For the east, best depths and upper and lower bounds are intended to indicate the likely range of earthquake depths. However in order to assign appropriate weights to the various values, for some zones (e.g. SGL), the terms lower and upper refer merely to alternative values, not relative depths. The weights are 0.5, 0.25, and 0.25.

Depth values in the western zones where the BJF relations are used (shallow crustal zones) have no physical meaning in the hazard calculation, despite our knowledge of earthquake depths there. Instead the value is a parameter in the Boore et al. (1993, 1994) equations and its value depends on the period for which ground motions are being estimated. For the subcrustal zones, for which the Crouse relation is used, we decided on a single depth of 50 km near the depths of the large earthquakes that presumably occur at or near the change of subduction angle of the Juan de Fuca plate.

1994 H MODEL ZONE PARAMETERS

EASTERN CANADA

ZONE	Mag 5 Rate/Area	BEST BETA	BEST NO	LOWER BETA	LOWER NO	UPPER BETA	UPPER NO	BEST N5	MX BEST	MX LOWER	MX UPPER	DEPTH BEST	DEPTH LOWER	DEPTH UPPER	APPROX. AREA	EVTS
WEIGHTS	(x 10^-6)	0.68		0.16		0.16			0.6	0.3	0.1	0.5	0.25	0.25	(sq. km)	
Southeastern Canada																
ADR	0.454	1.84	142	2.19	291	1.50	60	0.0138	7.0	6.0	7.5	10	20	5	30400	20
AOH	1.90	2.05F	575	2.15	402	1.95	700	0.0200	7.0	6.0	7.5	5	20	5	10500	7
BSL	2.09	1.93	533	2.13	781	1.74	344	0.0335	7.5	6.0	7.7	10	20	5	16000	58
CHA	0.417	2.00F	107	2.10	92	1.90	120	0.0048	7.5	6.0	7.7	10	20	5	11500	7
CHV	13.2	1.74	374	1.85	477	1.62	310	0.0625	7.5	7.2	7.7	10	20	5	4740	100
COC	0.110	2.00F	76	2.10	74	1.90	126	0.0034	7.5	6.0	7.7	10	20	5	31000	5
GAT	1.17	2.07	1190	2.23	1580	1.91	811	0.0378	7.0	6.5	7.5	10	20	5	32300	97
GNS	0.283	2.00F	237	2.10	248	1.90	223	0.0107	7.5	6.0	7.7	10	20	5	37800	21
JMS	0.0545	2.00F	167	2.10	190	1.90	237	0.0072	6.5	6.0	6.7	10	20	5	132000	9
MNT	0.986	1.96	258	2.19	405	1.74	167	0.0140	7.5	6.5	7.7	10	20	5	14200	35
NAN	0.231	1.75	374	1.90	508	1.60	276	0.0573	7.0	6.0	7.0	5	20	5	248000	79
NAT	0.568	1.80	69	2.23	164	1.37	29	0.0083	7.0	6.0	7.5	5	20	5	14600	11
OBGH	0.0216	2.00F	273	2.20	346	1.80	176	0.0118	6.5	6.0	6.7	5	20	10	547000	23
PEM	0.293	1.95	140	2.34	271	1.57	55	0.0080	7.5	6.0	7.7	10	20	5	27300	16
PMQ	1.26	1.72	49	2.17	124	1.26	18	0.0089	7.0	6.5	7.5	10	20	5	7050	9
SAG	0.328	2.00F	89	2.10	67	1.90	84	0.0040	7.5	6.5	7.7	10	30	5	12200	9
SEB	0.0310	2.00F	649	3.33	25400	1.80	532	0.0289	7.0	6.0	7.5	10	20	5	932000	35
SLE	0.403	2.09	169	2.57	457	1.61	61	0.0048	7.0	6.0	7.5	5	20	5	11900	11
TAD	-	-	-	-	-	-	-	-		as TRR			as TRR		5780	0
TIM	0.763	2.00F	63	2.10	47	1.90	65	0.0029	7.5	6.5	7.7	10	20	5	3800	8
TRR	0.279	2.00F	113	2.10	113	1.90	122	0.0051	7.5	6.0	7.7	10	20	5	18300	11
Arctic Canada																
DIB	0.0945	2.25F	1200	2.55	2330	1.95	600	0.0154	7.0	6.0	7.5	10	20	5	163000	7
GLA94	4.25	1.54	206	1.90	597	1.18	65	0.0884	7.0	6.5	7.5	10	30	5	20800	18
QES	0.862	2.00F	1175	2.25	2310	1.75	570	0.0530	7.33	6.29	7.63	10	20	5	61500	18
									7.5	6.0	8.0[1]					
RST	0.289	2.00F	914	2.28	1920	1.72	406	0.0408	7.0	6.5	7.5	10	20	5	141000	14
SPB	0.109	2.00F	374	2.20	478	1.34	88	0.0167	7.0	6.5	7.5	10	20	5	153000	6
SVD94H	0.207	2.25F	6330	2.55	16300	1.95	2390	0.0814	7.0	6.5	7.5	10	20	5	393000	37
UNG	0.128	2.00F	849	2.28	1700	1.24	60	0.0378	7.0	6.5	7.5	10	20	5	296000	13
WGB	0.380	2.00F	737	2.28	1470	1.72	366	0.0328	7.0	6.5	7.5	10	20	5	86300	11
Eastern Continental Margin																
AOBH	0.0381	2.00F	755	2.20	1530	1.80	927	0.0340	7.5	6.0	7.5	10	20	5	893000	5
BFB	1.04	1.64	884	1.84	1570	1.45	485	0.233	7.5	7.3	8.0	10	20	5	224000	53
BIN	1.83	1.92F	1730	2.09	2440	1.75	1000	0.114	7.0	6.5	7.5	5	20	10	62200	69
BIS	0.644	1.92F	558	2.09	705	1.75	351	0.0370	7.0	6.0	7.5	5	20	10	57500	22
GLD	0.326	1.70F	500	3.11	78300	1.50	285	0.100	7.33	7.0	7.63	10	20	5	307000	23
									7.5	7.0	8.0[1]					
LBR	1.64	2.00F	3970	2.46	21900	1.90	3210	0.171	6.66	6.29	7.33	10	20	5	104000	34
									6.5	6.0	7.5[1]					
LBS	0.733	1.70F	358	2.61	11100	1.50	225	0.0718	7.33	6.66	7.63	10	20	5	98000	12
									7.5	6.5	8.0[1]					
LSP94	4.13	1.70F	278	1.90	404	1.44	140	0.0558	7.33	7.33	7.63	10	20	5	13500	18
									7.5	7.5	8.0[1]					

1994 R MODEL ZONE PARAMETERS

ZONE	Mag 5 Rate/Area (x 10^-6)	BEST BETA	BEST NO	LOWER BETA	LOWER NO	UPPER BETA	UPPER NO	BEST N5	MX BEST	MX LOWER	MX UPPER	DEPTH BEST	DEPTH LOWER	DEPTH UPPER	APPROX. AREA (sq. km)	EVTS
WEIGHTS		0.68		0.16		0.16			0.6	0.3	0.1	0.5	0.25	0.25		
Southeastern Canada																
ADR	0.454	1.84	142	2.19	291	1.50	60	0.0138	7.0	6.0	7.5	10	20	5	30400	20
CMF	0.122	2.02	425	2.27	696	1.78	247	0.0169	7.0	6.5	7.5	10	20	5	138000	40
COC	0.111	2.00F	76	2.10	74	1.90	126	0.00345	7.5	6.0	7.7	10	20	5	31000	5
GAT	1.17	2.07	1190	2.23	1580	1.91	811	0.0378	7.0	6.5	7.5	10	20	5	32300	97
IRB	0.0301	2.00F	630	2.10	844	1.90	688	0.0281	7.0	6.0	7.5	10	20	5	932000	34
IRM	0.942	1.98	2220	2.07	2720	1.88	1810	0.113	7.5	7.2	7.7	10	20	5	120000	215
JMS	0.0545	2.00F	167	2.10	190	1.90	237	0.00720	6.5	6.0	6.7	10	20	5	132000	9
LAB	0.101	2.00F	155	2.10	131	1.90	164	0.00699	7.5	6.0	7.7	10	20	5	69300	9
NAI	0.366	1.51	111	1.68	152	1.33	79	0.0567	7.0	6.0	7.0	5	20	5	155000	49
OBGR	0.0114	2.00F	144	2.20	156	1.80	100	0.00621	6.5	6.0	6.7	5	20	10	547000	10
SGL	0.121	1.99	454	2.23	724	1.75	262	0.0212	7.0	6.0	7.5	5	20	10	175000	40
Arctic Canada																
ACM	0.461	2.08	5100	2.34	11600	1.83	2250	0.152	7.33	7.0	7.63	10	20	5	330000	57
									7.5	7.0	8.0[1]					
BOU94	0.129	2.02	3150	2.30	7730	1.74	1250	0.128	7.0	6.5	7.5	10	20	5	989000	45
DIB	0.0945	2.25F	1200	2.55	2330	1.95	600	0.0154	7.0	6.0	7.5	10	20	5	163000	7
SVD94R	0.303	2.25	9170	2.53	23000	1.96	3590	0.119	7.0	6.5	7.5	10	20	5	393000	55
Eastern Contineta1 Margin																
AOBR	0.0472	2.00	587	2.20	873	1.80	514	0.0261	7.0	6.0	7.5	10	20	5	553000	9
BFI	0.540	1.92	2390	2.09	3490	1.74	1380	0.160	7.0	6.5	7.5	5	20	10	300000	96
ECM	0.434	1.70F	1840	1.90	3460	1.50	956	0.368	7.33	7.20	7.63	10	20	5	848000	89
									7.5	7.3	8.0[1]					
GLD	0.326	1.70F	500	3.11	78300	1.50	285	0.100	7.33	7.0	7.63	10	20	5	307000	23
									7.5	7.0	8.0[1]					
LBR	1.63	2.00F	3970	2.46	21900	1.90	3210	0.171	6.66	6.29	7.33	10	20	5	105000	34
									6.5	6.0	7.5[1]					

1994 R MODEL ZONE PARAMETERS

REGION: WESTERN CANADA

ZONE	Mag 5 Rate/Area	BEST BETA	BEST NO	LOWER BETA	LOWER NO	UPPER BETA	UPPER NO	BEST N5	MX BEST	MX LOWER	MX UPPER	DEPTH BEST	DEPTH LOWER	DEPTH UPPER	APPROX. AREA
WEIGHTS	(x 10^-6)	0.68		0.16		0.16			0.68	0.16	0.16	1.0	0.0	0.0	(sq. km)
ALC	21.4	1.43	3848	1.51	5731	1.35	2585	3.00	8.5	8.2	8.7	2.9-7.2	0	0	140000
ALI	29.0	1.73	57235	1.84	99129	1.62	33058	10.0	8.5	8.2	8.5	2.9-7.2	0	0	344000
BFT	1.90	1.69	622	1.86	853	1.52	393	0.126	7.0	6.7	7.3	2.9-7.2	0	0	66300
BRO	36.2	1.06	8	1.26	8	0.86	6	0.0347	7.0	6.7	7.3	2.9-7.2	0	0	66300
CAS	1.12	0.85	14	1.86	1222	0.85	14	0.188	7.7	7.7	7.7	2.9-7.2	0	0	166000
CST	0.481	1.55	317	1.76	563	1.34	177	0.133	7.5	7.4	7.6	2.9-7.2	0	0	275000
DEN	4.50	1.87	3903	1.96	4836	1.78	3182	0.334	7.0	6.7	7.3	2.9-7.2	0	0	74200
EXP	11.4	1.30	103	1.45	160	1.15	85	0.143	7.0	6.7	7.3	2.9-7.2	0	0	12500
FHL	2.33	2.49	14016	2.93	63130	2.06	3021	0.0546	7.3	7.1	7.5	2.9-7.2	0	0	23400
GOA	15.7	2.31	49696	2.47	86255	2.15	28865	0.472	7.8	7.6	8.0	2.9-7.2	0	0	30100
GSP	2.70	1.12	29	1.25	35	0.99	25	0.0974	7.1	6.9	7.3	50	0	0	36000
HEC	1.76	1.97	1187	2.06	1358	1.87	1088	0.0626	7.0	6.7	7.3	2.9-7.2	0	0	35500
JDFF	0.368	1.87	91	2.26	175	1.48	42	0.0079	7.0	6.7	7.3	2.9-7.2	0	0	21300
JDFN	0.219	2.07	109	2.58	264	1.56	39	0.0035	7.1	6.7	7.3	2.9-7.2	0	0	15900
MMB	1.42	2.43	58008	2.50	72700	2.35	49997	0.307	7.1	6.9	7.3	2.9-7.2	0	0	216000
NBC	0.008	3.20	22787	3.73	67166	2.67	4205	0.0025	6.0	5.7	6.3	2.9-7.2	0	0	314000
NOF	8.53	1.73	458	1.82	522	1.64	428	0.0778	7.0	6.7	7.3	2.9-7.2	0	0	9110
NYK	0.193	3.75	7080982	4.35	70270912	3.15	697501	0.0508	7.0	6.7	7.3	2.9-7.2	0	0	262000
OFS	20.5	2.10	46683	2.22	73246	1.98	30343	1.26	7.1	6.9	7.3	2.9-7.2	0	0	61700
QCF	10.9	1.55	1529	1.61	1829	1.48	1387	0.671	8.5	8.2	8.5	2.9-7.2	0	0	61700
RMN	6.72	2.00	2918	2.14	3948	1.86	2016	0.131	7.0	6.7	7.3	2.9-7.2	0	0	19400
RMS	13.6	1.67	1248	1.78	1540	1.56	945	0.287	7.0	6.7	7.3	2.9-7.2	0	0	21000
ROC	0.251	2.04	1560	2.25	2557	1.82	883	0.0582	7.0	6.7	7.3	2.9-7.2	0	0	232000
SBC	0.117	2.21	1384	2.49	2787	1.92	673	0.0219	7.0	6.7	7.3	2.9-7.2	0	0	186000
SOY	0.134	2.15	1690	2.42	3157	1.87	853	0.0362	7.0	6.7	7.3	2.9-7.2	0	0	270000
YAK	5.93	2.01	16307	2.07	18689	1.95	14305	0.705	8.5	8.2	8.7	2.9-7.2	0	0	118000

1994 H MODEL ZONE PARAMETERS

REGION: WESTERN CANADA

ZONE	Mag 5	BEST		LOWER		UPPER		BEST	MX			DEPTH			APPROX.
	Rate/Area	BETA	NO	BETA	NO	BETA	NO	N5	BEST	LOWER	UPPER	BEST	LOWER	UPPER	AREA
WEIGHTS	(x 10^-6)	0.68		0.16		0.16			0.68	0.16	0.16	1.0	0.0	0.0	(sq. km)
ALC	21.4	1.43	3848	1.51	5731	1.35	2585	3.00	8.5	8.2	8.7	2.9-7.2	0	0	140000
ALI	29.0	1.73	57235	1.84	99129	1.62	33058	10.0	8.5	8.2	8.5	2.9-7.2	0	0	344000
BFC	0.089	3.35	507980	3.98	4858170	2.72	50890	0.0271	7.0	6.7	7.3	2.9-7.2	0	0	305000
BFS	2.13	1.67	577	1.82	766	1.51	381	0.133	7.0	6.7	7.3	2.9-7.2	0	0	62300
BRP	19.2	1.21	22	1.39	31	1.03	20	0.0486	7.0	6.7	7.3	2.9-7.2	0	0	2530
CAS	1.30	2.01	1402	2.12	1704	1.90	1137	0.0600	7.3	7.1	7.5	2.9-7.2	0	0	46200
CCM	0.074	1.76	81	2.41	400	1.11	18	0.0118	7.0	6.5	7.3	2.9-7.2	0	0	158000
DEN	3.74	1.85	2424	1.94	2982	1.75	2030	0.232	7.0	6.7	7.3	2.9-7.2	0	0	62000
EGA	5.99	2.04	20316	2.12	25399	1.96	16518	0.756	7.9	7.6	8.2	2.9-7.2	0	0	126000
FHL	3.56	2.24	6064	2.66	26533	3.08	111693	0.0834	7.1	7.3	7.5	2.9-7.2	0	0	23400
GEO	0.040	2.27	66	2.79	117	1.76	28	0.0008	7.0	6.5	7.3	50	0	0	19500
GLB	13.7	1.75	896	1.88	1153	1.62	682	0.135	7.0	6.7	7.3	2.9-7.2	0	0	9830
HEC	1.19	2.06	1132	2.17	1323	1.94	1009	0.0383	7.0	6.7	7.3	2.9-7.2	0	0	32000
JDF	0.387	1.97	423	2.10	503	1.84	364	0.0220	7.3	7.2	7.4	2.9-7.2	0	0	56900
MCK	1.76	2.21	35815	2.28	44670	2.13	30775	0.578	7.2	6.9	7.5	2.9-7.2	0	0	328000
NCM	1.07	1.79	333	2.25	1142	1.33	78	0.0420	7.0	6.7	7.3	2.9-7.2	0	0	39100
NEA	0.435	2.20	2555	2.46	4567	1.93	1262	0.0424	7.0	6.7	7.3	2.9-7.2	0	0	97500
NFT	0.009	2.79	2757	3.43	13842	2.15	619	0.0024	7.0	6.7	7.3	2.9-7.2	0	0	275000
NJFP	1.21	1.25	22	1.56	48	0.94	13	0.0394	6.8	6.6	7.0	2.9-7.2	0	0	32400
NJFR	4.77	2.67	47690	3.32	560310	2.01	3856	0.0714	6.0	5.5	6.5	2.9-7.2	0	0	14900
NOF	7.72	1.73	368	1.82	433	1.64	347	0.0624	7.0	6.7	7.3	2.9-7.2	0	0	8090
NRMT	0.074	2.09	278	2.44	558	1.74	156	0.0079	7.0	6.7	7.3	2.9-7.2	0	0	106000
OGL	2.01	1.69	318	1.96	646	1.43	193	0.0651	7.0	6.7	7.3	2.9-7.2	0	0	32300
PUG	3.90	1.01	18	1.12	19	0.90	16	0.105	7.3	7.1	7.6	50	0	0	26800
QCB	0.149	1.96	363	2.39	1101	1.53	140	0.0196	7.0	6.7	7.3	2.9-7.2	0	0	131000
QCF	4.88	1.43	829	1.51	977	1.59	1146	0.641	8.2	8.5	8.7	2.9-7.2	0	0	131000
QCS	5.19	1.43	72	1.67	131	1.19	47	0.0540	7.0	6.7	7.3	2.9-7.2	0	0	10400
RDS	28.1	1.46	2443	1.51	2824	1.41	2226	1.56	7.0	6.8	7.2	2.9-7.2	0	0	55600
RIC	7.14	2.06	3519	2.21	4797	1.92	2392	0.115	7.0	6.7	7.3	2.9-7.2	0	0	16000
SCM	0.441	1.70	129	1.85	153	1.55	108	0.0254	7.0	6.5	7.3	2.9-7.2	0	0	57700
SEBC	0.323	1.81	854	1.95	1168	1.68	634	0.0965	7.0	6.7	7.3	2.9-7.2	0	0	298000
SFT	0.146	2.48	4878	2.74	9370	2.22	2514	0.0186	6.0	5.0	7.0	2.9-7.2	0	0	127000
SYT	0.185	1.93	529	2.25	1050	1.61	239	0.0337	7.0	6.7	7.3	2.9-7.2	0	0	181000
YFF	8.88	2.13	27728	2.21	35213	2.05	22338	0.661	8.5	8.2	8.7	2.9-7.2	0	0	74400

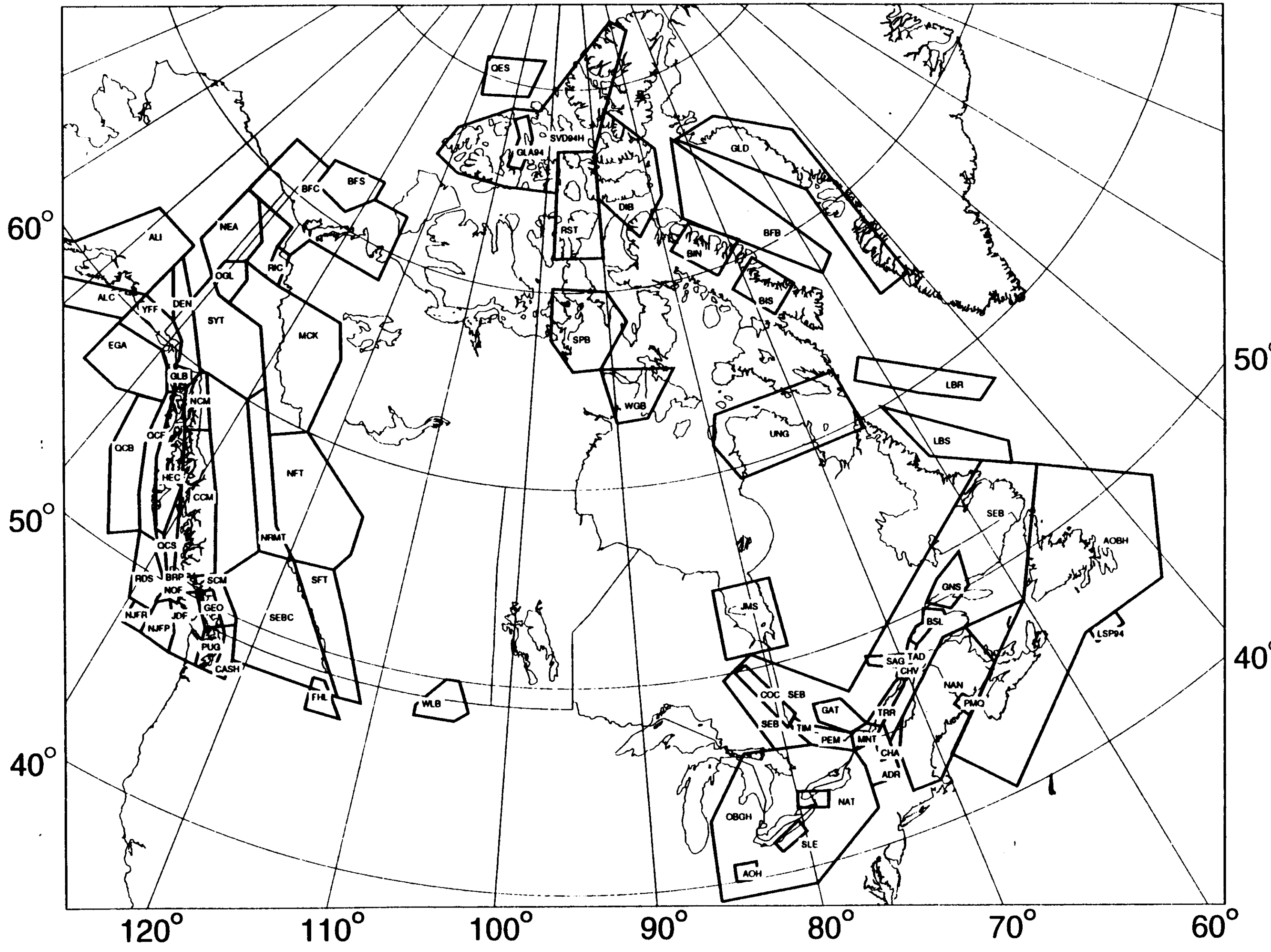
Notes

[1]moment magnitude - see note on MX below.

MX - The represents the upper-bound magnitude and is taken to be m_{bLg} for the eastern (with exceptions below) and moment magnitude for the western zones. For eastern and arctic offshore zones, the upper-bound magnitude is defined in terms of moment magnitude and given on the second line; equivalent m_{bLg} magnitudes are given on the first line. These are the values input into the FRISK88 code, where they are reconverted to moment magnitudes (using the inverse relation) for calculation of the hazard.

F - Zones with BETA flagged with F have has a slope imposed rather than derived from a maximum likelihood fit to the data.

CANADA 1994 - MODEL H SEISMIC ZONES



GEOLOGICAL SURVEY OF CANADA
COMMISSION GÉOLOGIQUE DU CANADA

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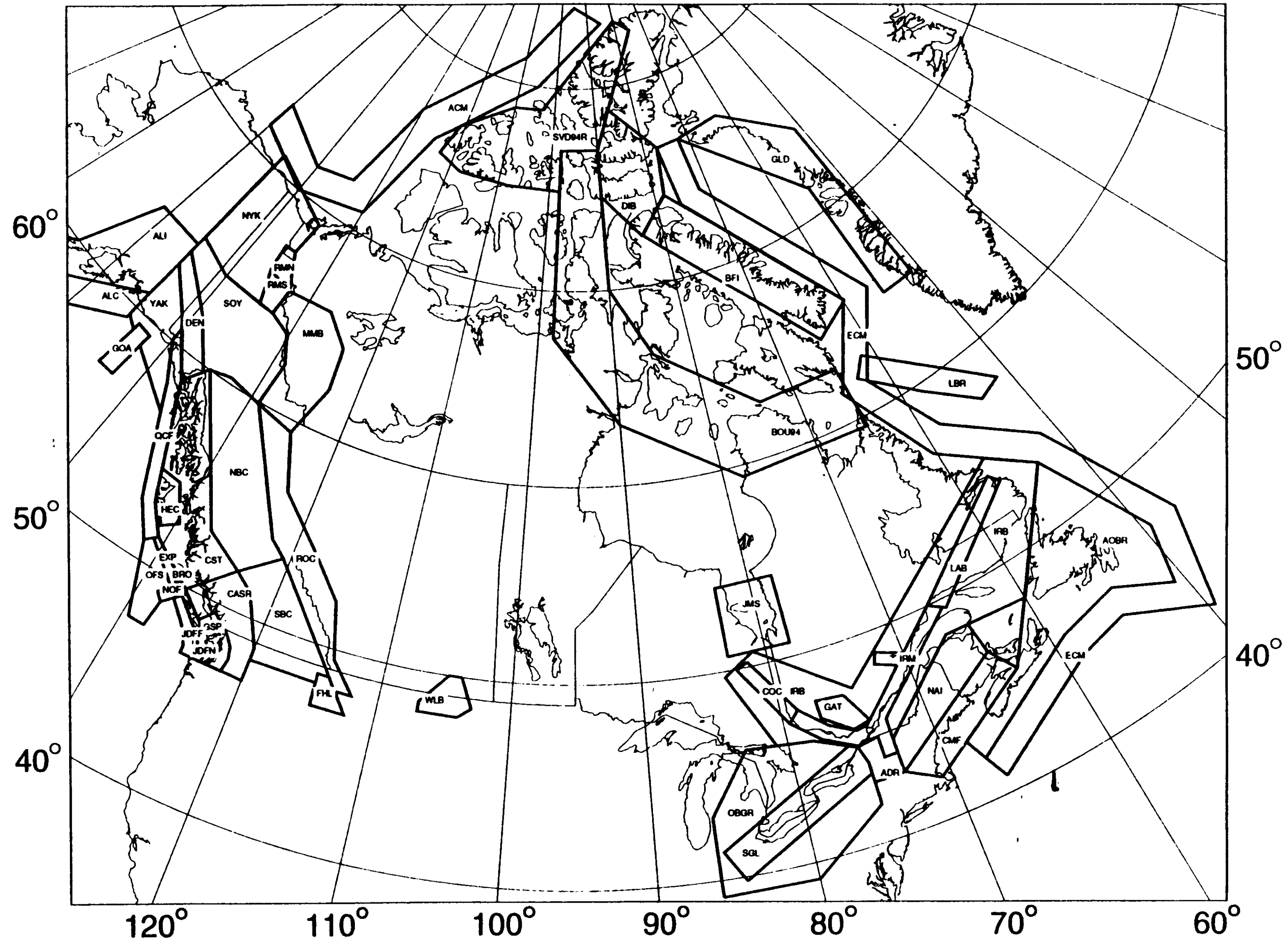
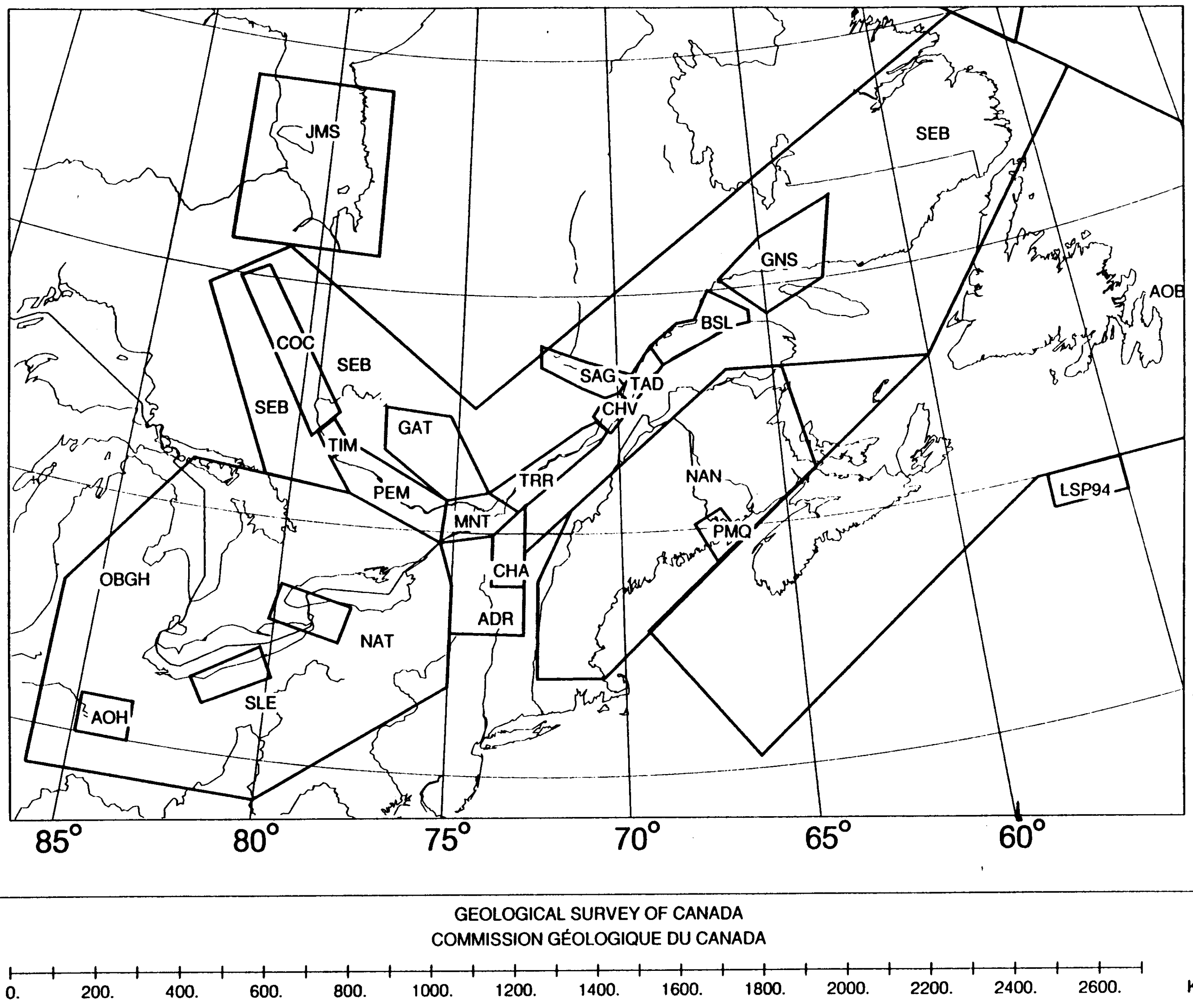
CANADA 1994 - MODEL R SEISMIC ZONES



GEOLOGICAL SURVEY OF CANADA
COMMISSION GÉOLOGIQUE DU CANADA

0. 2000. 4000. 6000. KM

SOUTHEASTERN CANADIAN - 1994 MODEL H ZONES



GEOLOGICAL SURVEY OF CANADA
COMMISSION GÉOLOGIQUE DU CANADA

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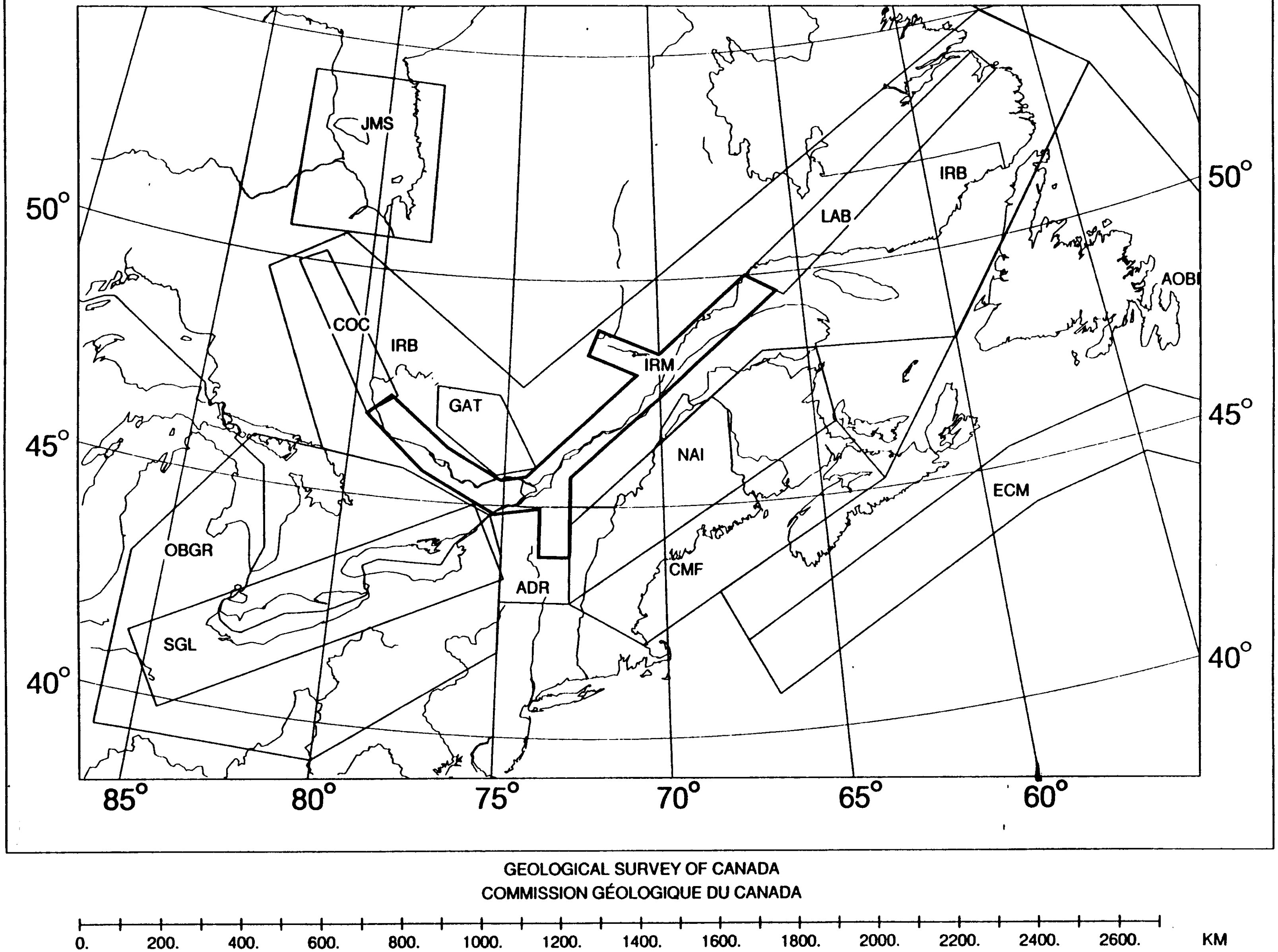
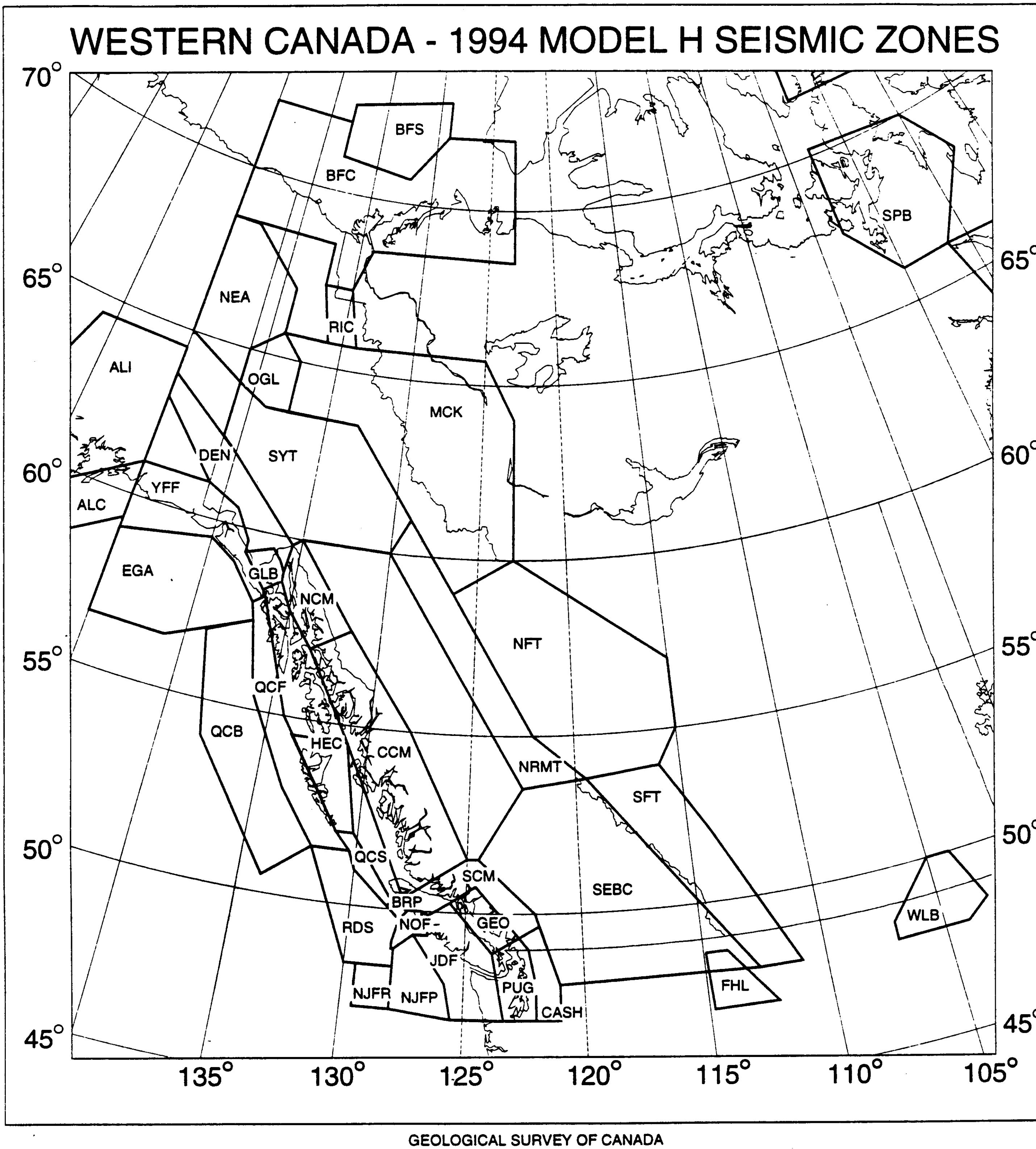


GEOLOGICAL SURVEY OF CANADA
COMMISSION GÉOLOGIQUE DU CANADA



GEOLOGICAL SURVEY OF CANADA
COMMISSION GÉOLOGIQUE DU CANADA

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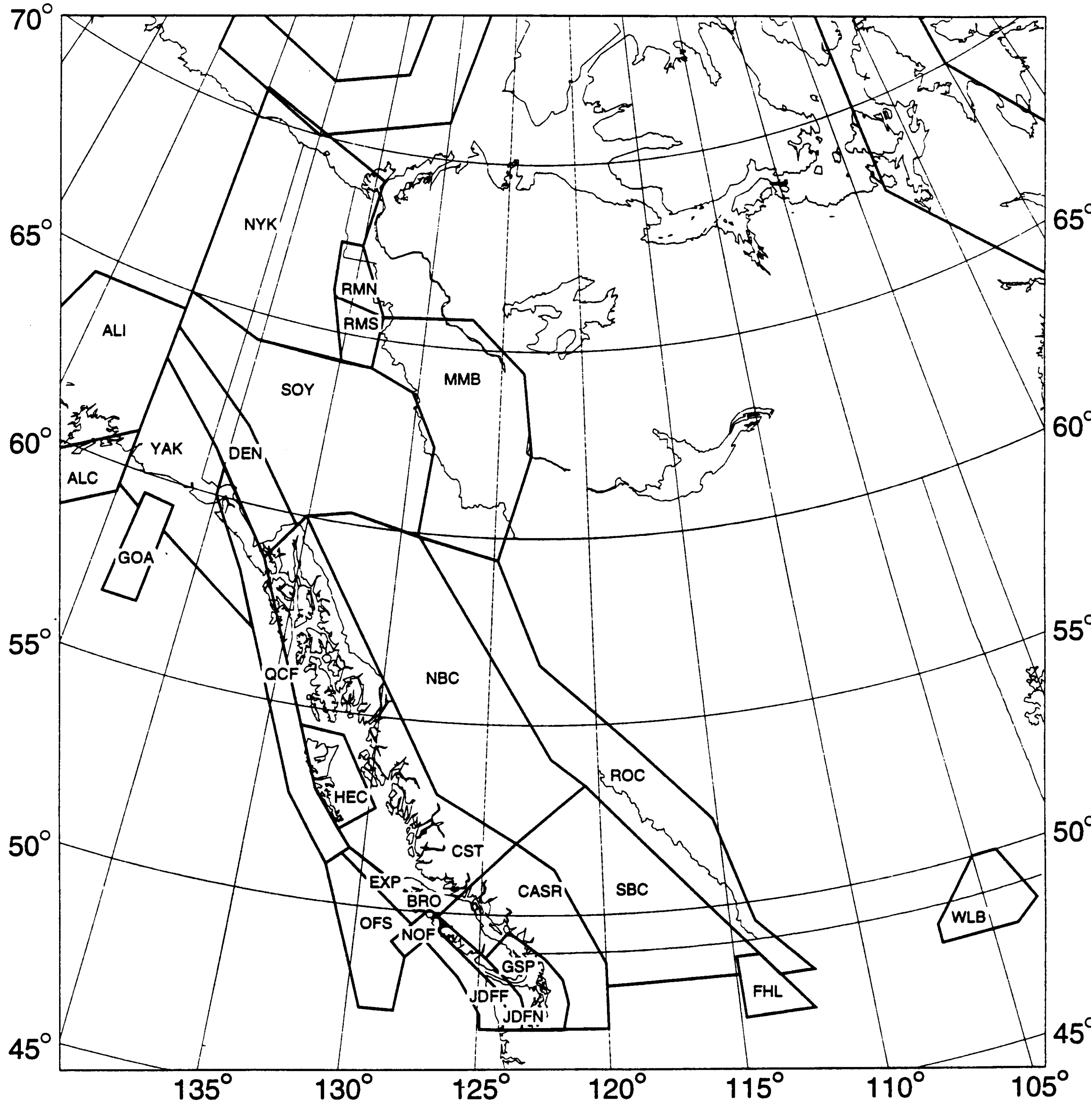
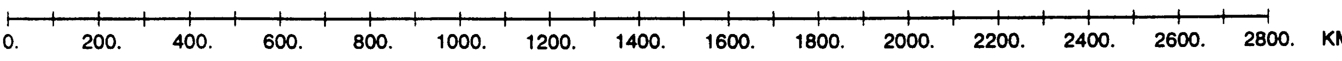
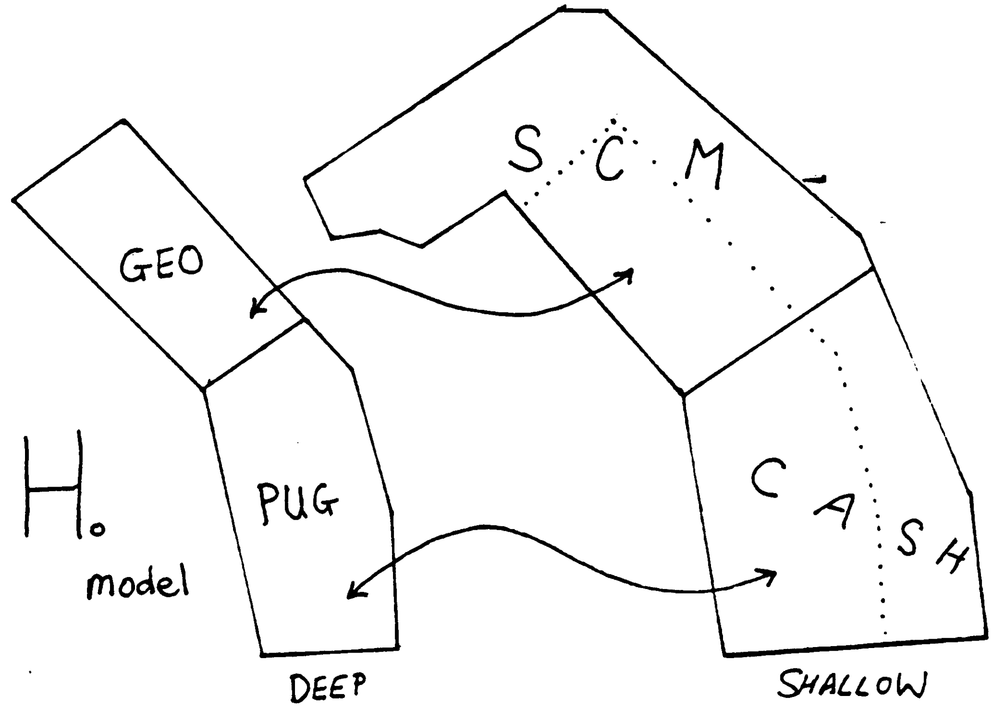
WESTERN CANADA - 1994 MODEL R SEISMIC ZONES

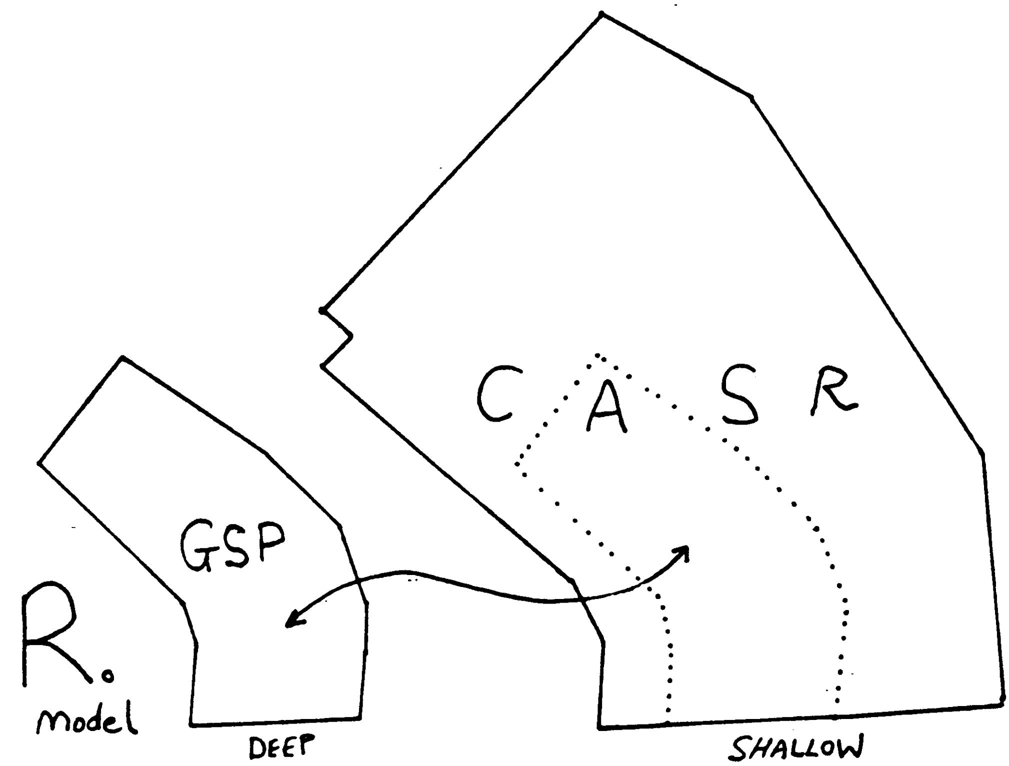


GEOLOGICAL SURVEY OF CANADA
COMMISSION GÉOLOGIQUE DU CANADA



Deep and Shallow zones, SW B.C.





APPENDIX C

Input models for FRISK88 seismic hazard code (including strong ground motion parameters).

The pages which follow this page contain (in 2-column format) the input files for the four models used to generate the 1 s spectral acceleration values in Table 4, followed by a listing of the strong ground motion parameters used for each period. This page annotates the beginning of the first file.

```
1995 Eastern Canada model H Atkinson 95 attenuation PSA 1.0 s
Data for INTERP subroutine
4  0.01       0.005      0.0021      0.001                           ! Probability levels
Main data set for FRISKGSC program
3  10  5.0  5.0  0.10  4  1                                          ! Array sizes, integration increments
10   0.01 0.1 1.0 3.0 10.0 30.0 100.0 300.0 1000.0  3000.0           ! Ground motion interpolation points
0.44 0.14 0.42                                                       ! weights for attenuation relations
A
AB95R PSA 1s Mlg Median grd motion for PSA1.0s ATKINSON BOORE 1995   ! Best attenuation relation
2.77 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0         !       Attenuation parameters
AB95R PSA 1s Mlg L grd motion for PSA1.0s ATKINSON BOORE 1995 L limit ! Lower attenuation relation
2.59 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0         !       Attenuation parameters
AB95R PSA 1s Mlg U grd motion for PSA1.0s ATKINSON BOORE 1995 U limit ! Upper attenuation relation
3.31 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0         !       Attenuation parameters
1  1.0
H - MODEL 1995  37 ZONES  HISTORICAL ZONES
37  3  3  3  37  20                                                  !
0.6 0.3 0.1                                                          ! weights for Maximum magnitudes
0.68 0.16 0.16                                                       ! weights for magnitude recurrence
0.5 0.25 0.25                                                        ! weights for depths
1  1  1  1
ADR    - NORTHERN ADIRONDACKS                                        ! Zone name
1
ONLY ALTERNATIVE
1.
area                                                                 ! type of zone (area/fault)
10.0  20.0  5.0                                                      ! depth to hypocentres/JB pseudo-depth
7                                                                    ! number of zone corner coordinates
-75.39  44.77                                                        ! longitude/latitude pairs
-73.85  44.95
-73.85  43.90
-72.90  43.90
-72.90  42.90
-75.00  42.90
-75.00  43.90
4.75 7.0 6.0 7.5                                                     ! minimum and maximum magnitudes
1
142. 1.84  291. 2.19  60. 1.50                                       ! No/β pairs (best, lower, upper)
```

```
1995 Eastern Canada model H Atkinson 95 attenuation PSA 1.0 s
Data for INTERP subroutine
4  0.01      0.005      0.0021      0.001
Main data set for FRISKGSC program
3  10  5.0  5.0  0.10  4  1
10   0.01 0.1 1.0 3.0 10.0 30.0 100.0 300.0 1000.0  3000.0
0.44 0.14 0.42
A
AB95R PSA 1s Mlg Median grd motion for PSA1.0s ATKINSON BOORE 1995 Mlg
2.77 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 1s Mlg L grd motion for PSA1.0s ATKINSON BOORE 1995 L limit
2.59 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 1s Mlg U grd motion for PSA1.0s ATKINSON BOORE 1995 U limit
3.31 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
1  1.0
H - MODEL 1995  37 ZONES  HISTORICAL ZONES
37  3  3  3  37  20
0.6 0.3 0.1
0.68 0.16 0.16
0.5 0.25 0.25
1  1  1  1
ADR     - NORTHERN ADIRONDACKS
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
7
-75.39  44.77
-73.85  44.95
-73.85  43.90
-72.90  43.90
-72.90  42.90
-75.00  42.90
-75.00  43.90
4.75 7.0 6.0 7.5
1
142. 1.84  291. 2.19  60. 1.50
AOBH    - ATLANTIC OFFSHORE BACKGROUND (H model)
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
7
-53.10  53.20
-46.70  49.00
-51.00  44.90
-57.50  45.00
-66.40  40.25
-69.30  42.95
-60.00  48.00
4.75  7.5 6.0 7.5
1
755. 2.00  1530. 2.20  927. 1.80
AOH     - ANNA OHIO
1
ONLY ALTERNATIVE
1.
area
5.0 20.0 5.0
4
-84.90  40.00
-83.50  40.00
-83.50  40.80
-84.90  40.80
4.75  7.0 6.0 7.5
1
575. 2.05  402. 2.15  700. 1.95
BFB     - BAFFIN BAY
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
6
-60.00  67.40
-57.70  68.00
-64.30  73.00
-73.10  76.80
-75.80  72.90
-71.00  71.60
4.75 7.5 7.3 8.0
1
884. 1.64  1570. 1.84  485. 1.45
BIN      - BAFFIN ISLAND NORTH
1
ONLY ALTERNATIVE
1.
area
5.0 20.0 10.0
4
-73.40  69.60
-68.50  70.90
-75.10  72.60
-79.20  71.50
4.75  7.0 6.5 7.5
1
1730. 1.92  2440. 2.09  1000. 1.75
BIS      - BAFFIN ISLAND SOUTH
1
ONLY ALTERNATIVE
1.
area
5.0 20.0 10.0
4
-67.80  69.80
-64.10  67.70
-68.10  66.70
-72.10  68.70
4.75 7.0 6.0 7.5
1
```

```
558. 1.92  705. 2.09  351. 1.75
BSL    - BAS SAINT LAURENT
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
8
-68.90  48.90
-68.00  49.35
-67.40  49.40
-66.90  50.00
-65.60  49.50
-65.60  49.25
-66.20  49.20
-68.50  48.50
4.75  7.5 6.0 7.7
1
533. 1.93  781. 2.13  344. 1.74
CHA    - CHAMPLAIN
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
4
-73.85  44.95
-72.90  45.60
-72.90  43.90
-73.85  43.90
4.75  7.5 6.0 7.7
1
107. 2.00  92. 2.10  120. 1.90
CHV    - CHARLEVOIX
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
5
-70.25  47.10
-69.53  47.69
-69.95  47.95
-70.40  47.85
-70.79  47.46
4.75  7.5 7.2 7.7
1
374. 1.74  477. 1.85  310 1.62
COC    - COCHRANE
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
4
-81.60  50.25
-82.50  49.95
-79.55  46.80
-78.75  47.35
4.75 7.5 6.0 7.7
1
76. 2.00  74. 2.10  126. 1.90
DIB    -  DEVON ISLAND BACKGROUND
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
6
-83.60  72.50
-78.20  74.30
-77.10  76.60
-86.50  78.90
-90.00  77.00
-90.00  74.70
4.75  7.0 6.0 7.5
1
1200. 2.25  2330. 2.55  600. 1.95
GAT    - GATINEAU
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
5
-75.26  47.43
-74.00  45.85
-75.26  45.66
-77.26  46.66
-77.32  47.55
4.75 7.0 6.5 7.5
1
1190. 2.07  1580. 2.23  811. 1.91
GLA94  - GUSTAF LOUGHEED ARCH
1
ONLY ALTERNATIVE
1.
area
10.0 30.0 5.0
6
-108.50  76.00
-105.50  76.00
-104.00  77.50
-106.00  78.60
-109.00  78.30
-107.00  77.50
4.75 7.0 6.5 7.5
1
206. 1.54  597. 1.90  65. 1.18
GLD     - GREENLAND        Original magnitudes  7.5 7.0 8.0
1
ONLY ALTERNATIVE
```

```
1.
area
10.0 20.0 5.0
6
-55.30  64.85
-51.10  64.85
-51.10  74.15
-62.60  76.95
-72.20  76.70
-55.30  71.35
4.75  7.33 7.0 7.63
1
500. 1.70  78300. 3.11  285. 1.50
GNS    - GULF OF ST. LAWRENCE - NORTH SHORE
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
5
-65.00  49.40
-63.00  50.00
-62.40  51.70
-65.00  51.00
-66.50  50.20
4.75  7.5 6.0 7.7
1
237. 2.00  248. 2.10  223. 1.90
JMS    - JAMES BAY
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
4
-83.00  50.70
-78.00  50.70
-78.00  54.20
-83.00  54.20
4.75 6.5 6.0 6.7
1
167. 2.00  190. 2.10  237. 1.90
LBR    - LABRADOR RIDGE              Original magnitudes 6.5 6.0 7.5
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
6
-61.50  62.80
-63.10  61.85
-58.00  59.60
-53.60  57.50
-51.20  57.90
-55.00  60.00
4.75  6.66 6.29 7.33
1
3970. 2.00  21900. 2.46  3210. 1.90
LBS    - LABRADOR SHELF              Original magnitudes 7.5 6.5 8.0
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
4
-54.70  54.00
-53.80  55.00
-62.00  60.00
-60.40  56.60
4.75  7.33 6.66 7.63
1
358. 1.70  11100. 2.61  225. 1.50
LSP94  - LAURENTIAN SLOPE            Original magnitudes 7.5 7.5 8.0
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
4
-57.20  44.30
-55.00  44.30
-55.00  45.00
-57.20  45.00
4.75 7.33 7.33 7.63
1
278. 1.70  404. 1.90  140. 1.44
MNT    - MONTREAL
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
5
-74.00  45.85
-73.10  45.46
-73.85  44.95
-75.39  44.77
-75.26  45.66
4.75  7.5 6.5 7.7
1
258. 1.96  405. 2.19  167. 1.74
NAN   - NORTHERN APPALACHIANS
1
ONLY ALTERNATIVE
1.
area
5.0 20.0 5.0
7
-70.60  42.00
-64.00  46.05
-64.70  48.25
-66.50  48.30
```

```
-71.50  45.50
-72.50  44.00
-72.50  42.00
4.75  7.0 6.0 7.0
1
374. 1.75  508. 1.90  276. 1.60
NAT   - NIAGARA ATTICA TREND  (1994)
1
ONLY ALTERNATIVE
1.
area
5.0  20.0  5.0
4
-77.85  43.30
-79.90  43.65
-80.15  42.90
-78.15  42.55
4.75  7.0 6.0 7.5
1
69. 1.80  164. 2.23  29. 1.37
OBGH   - ONTARIO BACKGROUND (H model)
1
ONLY ALTERNATIVE
1.
area
5.0  20.0  10.0
8
-86.00  39.20
-80.00  39.20
-75.00  41.80
-75.00  43.90
-75.39  44.77
-78.21  45.68
-83.00  46.00
-86.00  43.00
4.75  6.5 6.0 6.7
1
273. 2.00  346. 2.20  176 1.80
PEM    - PEMBROKE
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
5
-78.20  46.70
-75.26  45.66
-75.39  44.77
-78.21  45.68
-78.89  46.36
4.75  7.5 6.0 7.7
1
140. 1.95  271 2.34  55. 1.57
PMQ    - PASSAMAQUODDY BAY
1
ONLY ALTERNATIVE
```

```
1.
area
10.0 20.0 5.0
4
-67.00  45.40
-66.40  44.75
-67.20  44.30
-67.80  45.10
4.75 7.0 6.5 7.5
1
49. 1.72  124. 2.17  18. 1.26
QES    - QUEEN ELIZABETH SHELF  original magnitudes  7.5 6.0 8.0
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
4
-118.70  79.00
-106.60  79.50
-103.20  81.30
-120.70  80.80
4.75 7.33 6.29  7.63
1
1175. 2.00  2310. 2.25  570. 1.75
RST    - RESOLUTE
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
4
-90.00 77.00
-98.00 77.00
-98.00 71.70
-90.00 71.70
4.75  7.0 6.5 7.5
1
914. 2.00 1920. 2.28  406. 1.72
SAG    - SAGUENAY
1
ONLY ALTERNATIVE
1.
area
10.0 30.0 5.0
7
-71.00  48.62
-69.54  48.32
-69.95  47.95
-70.40  47.85
-71.10  48.05
-72.45  48.50
-72.45  48.95
4.75 7.5 6.5 7.7
1
89. 2.00  67. 2.10   84. 1.90
```

```
SEB    - SOUTHEAST CANADA BACKGROUND
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
14
-72.90  44.60
-66.50  48.30
-60.00  48.00
-53.10  53.20
-56.70  55.00
-74.50  47.62
-81.00  50.70
-83.50  49.70
-80.80  45.90
-78.21  45.68
-75.39  44.77
-75.00  43.90
-75.00  42.90
-72.90  42.90
4.75  7.0 6.0 7.5
1
649.  2.00  25400 3.33  532  1.80
SLE    - SOUTH SHORE LAKE ERIE
1
ONLY ALTERNATIVE
1.
area
5.0 20.0 5.0
4
-81.70  41.00
-79.90  41.70
-80.30  42.30
-82.10  41.50
4.75  7.0 6.0 7.5
1
169. 2.09  457. 2.57  61. 1.61
SPB    - SPENCE BAY
1
ONLY ALTERNATIVE
1.
area
10.D 20.0 5.0
6
-91.50 66.10
-87.50 68.40
-90.00 70.00
-98.00 70.20
-98.00 67.60
-95.00 66.00
4.75  7.0 6.5 7.5
1
374. 2.00 478. 2.20  88. 1.34
SVD94H - SVERDRUP BASIN  - No GLA events (H model)
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
11
-117.80  75.00
-108.00  75.00
 -98.00  75.00
 -98.00  77.00
 -90.00  77.00
 -75.00  82.40
 -80.00  83.00
-103.20  78.90
-110.00  78.80
-121.00  77.10
-122.90  75.50
4.75  7.0 6.5 7.5
1
6330. 2.25  16300. 2.55  2390. 1.95
TIM    - TIMISKAMING
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
4
-78.30  46.65
-78.89  46.36
-79.37  46.89
-78.90  47.20
4.75  7.5 6.5 7.7
1
63. 2.00  47. 2.10  65. 1.90
TRR    - TROIS-RIVIERES
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
6
-71.14  47.22
-70.70  47.35
-70.35  47.15
-70.60  46.90
-73.10  45.46
-74.00  45.85
4.75 7.5 6.0 7.7
1
113. 2.00  113. 2.10  122. 1.90
UNG    - UNGAVA
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
5
```

```
-78.00  59.40
-64.50  59.50
-64.80  62.80
-79.00  62.90
-80.00  61.40
4.75  7.0 6.5 7.5
1
849. 2.00 1700. 2.28  60. 1.24
WGB    - WEGER BAY
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
4
-90.00  63.30
-86.50  63.40
-82.50  65.70
-91.50  66.10
4.75  7.0 6.5 7.5
1
737. 2.00 1470. 2.28  336. 1.72
WLB    - WILLISTON BASIN
1
WLB
1.0
area
10.0  20.0  5.0
6
-104.00  50.00
-103.00  48.50
-104.00  48.00
-107.00  48.00
-107.00  48.50
-105.00  50.00
4.75 6.0 5.5 6.5
1
28.28 1.6590   16.74 2.2590   39.83 1.0590
```

```
1995 seismic hazard for E Canada model R A95 PSA 1.0
Data for INTERP subroutine
4  0.01      0.005      0.0021      0.001
Main data set for FRISKGSC program
3  10  5.0  5.0  0.10  4  1
10   0.01 0.1 1.0 3.0 10.0 30.0 100.0 300.0 1000.0  3000.0
0.44 0.14 0.42
A
AB95R PSA 1s Mlg Median grd motion for PSA1.0s ATKINSON BOORE 1995 Mlg
2.77 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 1s Mlg L grd motion for PSA1.0s ATKINSON BOORE 1995 L limit
2.59 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 1s Mlg U grd motion for PSA1.0s ATKINSON BOORE 1995 U limit
3.31 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
1  1.0
R - MODEL 1995  21 ZONES REGIONAL ZONES
21  3  3  3  21  22
0.6 0.3 0.1
0.68 0.16 0.16
0.5 0.25 0.25
1  1  1  1
ACM     - ARCTIC CONTINENTAL MARGIN   Original magnitudes 7.5 7.0 8.0
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
13
-150.00  71.30
-140.00  70.00
-130.00  71.00
-125.00  76.00
-121.00  77.10
-105.00  80.00
 -85.00  83.00
 -95.00  83.80
-110.00  81.25
-130.00  77.00
-134.00  72.10
-140.00  71.50
-150.00  72.80
4.75  7.33 7.0 7.63
1
5100. 2.08  11600. 2.34  2250. 1.83
ADR    - NORTHERN ADIRONDACKS
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
7
-75.39  44.77
-73.85  44.95
-73.85  43.90
-72.90  43.90
-72.90  42.90
-75.00  42.90
-75.00  43.90
4.75 7.0 6.0 7.5
1
142. 1.84  291. 2.19  60. 1.50
AOBR   - ATLANTIC OFFSHORE BACKGROUND (R model)
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
8
-53.10  53.20
-49.40  47.20
-50.70  44.30
-54.40  46.00
-59.00  45.40
-67.60  42.00
-68.35  43.10
-63.00  45.20
4.75  7.0 6.0 7.5
1
587. 2.00  873. 2.20  514. 1.80
BFI    - BAFFIN ISLAND
1
ONLY ALTERNATIVE
1.
area
5.0 20.0 10.0
8
-59.85  65.65
-65.00  69.00
-71.25  72.00
-78.20  74.25
-83.60  72.55
-75.20  69.90
-70.05  67.70
-64.70  64.50
4.75  7.0 6.5 7.5
1
2390. 1.92  3490. 2.09  1380. 1.74
BOU94  - BOOTHIA UNGAVA
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
10
-64.50  59.50
-64.80  62.80
-74.00  62.80
-85.00  66.50
-90.00  70.00
-90.00  77.00
-98.00  77.00
-98.00  67.60
```

```
-90.00  63.10
-78.00  59.40
4.75 7.0 6.5 7.5
1
3150. 2.02  7730. 2.30  1250. 1.74
CMF    - COASTAL MAINE FUNDY
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
5
-72.90  42.90
-70.70  42.00
-63.00  45.20
-64.30  46.60
-68.40  45.00
4.75  7.0 6.5 7.5
1
425. 2.02  696. 2.27  247. 1.78
COC    - COCHRANE
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
4
-81.60  50.25
-82.50  49.95
-79.55  46.80
-78.75  47.35
4.75 7.5 6.0 7.7
1
76. 2.00  74. 2.10  126. 1.90
DIB    -  DEVON ISLAND BACKGROUND
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
6
-83.60  72.50
-78.20  74.30
-77.10  76.60
-86.50  78.90
-90.00  77.00
-90.00  74.70
4.75  7.0 6.0 7.5
1
1200. 2.25  2330. 2.55  600. 1.95
ECM    - EASTERN CONTINENTAL MARGIN     Original magnitudes 7.5 7.3 8.0
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
22
-66.80  40.80
-58.50  44.10
-54.90  44.60
-49.60  42.20
-47.20  47.10
-51.40  54.30
-58.30  57.70
-62.30  61.50
-56.60  65.60
-71.70  74.00
-72.20  76.70
-77.15  76.60
-75.70  73.60
-59.90  65.70
-65.30  61.50
-60.30  56.60
-53.10  53.20
-49.40  47.20
-50.70  44.30
-54.40  46.00
-59.00  45.40
-67.60  42.00
4.75 7.33 7.20 7.63
1
1840. 1.70  3460. 1.90  956. 1.50
GAT    - GATINEAU
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
5
-75.26  47.43
-74.00  45.85
-75.26  45.66
-77.26  46.66
-77.32  47.55
4.75 7.0 6.5 7.5
1
1190. 2.07  1580. 2.23  811. 1.91
GLD     - GREENLAND         Original magnitudes  7.5 7.0 8.0
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
6
-55.30  64.85
-51.10  64.85
-51.10  74.15
-62.60  76.95
-72.20  76.70
-55.30  71.35
4.75  7.33 7.0 7.63
1
```

```
500. 1.70  78300. 3.11  285. 1.50
IRB    - Iapetan Rift Background
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
14
-72.90  44.60
-66.50  48.30
-60.00  48.00
-53.10  53.20
-56.70  55.00
-74.50  47.62
-81.00  50.70
-83.50  49.70
-80.80  45.90
-78.21  45.68
-75.39  44.77
-75.00  43.90
-75.00  42.90
-72.90  42.90
4.75  7.0 6.0 7.5
1
630. 2.00  844. 2.10  688. 1.90
IRM    - Iapetan Rift Margin
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
18
-72.90  43.90
-72.90  45.65
-70.00  47.40
-65.85  49.60
-66.90  50.00
-70.00  48.35
-72.00  48.90
-72.35  48.35
-70.75  47.90
-74.30  45.65
-75.10  45.55
-76.85  46.20
-78.75  47.35
-79.55  46.80
-77.60  45.65
-75.25  44.80
-73.85  44.95
-73.85  43.90
4.75  7.5 7.2 7.7
1
2220. 1.98  2720. 2.07  1810. 1.88
JMS    - JAMES BAY
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
4
-83.00  50.70
-78.00  50.70
-78.00  54.20
-83.00  54.20
4.75 6.5 6.0 6.7
1
167. 2.00  190. 2.10  237. 1.90
LAB    - SOUTHERN LABRADOR
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
4
-66.90  50.00
-65.60  49.50
-56.60  53.61
-57.29  54.15
4.75 7.5 6.0 7.7
1
155. 2.00  131. 2.10  164. 1.90
LBR    - LABRADOR RIDGE                Original magnitudes 6.5 6.0 7.5
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
6
-61.50  62.80
-63.10  61.85
-58.00  59.60
-53.60  57.50
-51.20  57.90
-55.00  60.00
4.75  6.66 6.29 7.33
1
3970. 2.00  21900. 2.46  3210. 1.90
NAI    - NORTHERN APPALACHIANS INTERIOR
1
ONLY ALTERNATIVE
1.
area
5.0 20.0 5.0
7
-72.90  42.90
-68.40  45.00
-64.30  46.60
-64.70  48.25
-66.50  48.30
-69.00  47.00
-72.90  44.60
4.75  7.0 6.0 7.0
```

```
1
111. 1.51  152. 1.68  79. 1.33
OBGR   - ONTARIO BACKGROUND (R MODEL)
1
ONLY ALTERNATIVE
1.
area
5.0  20.0  10.0
8
-86.00  39.20
-80.00  39.20
-75.00  41.80
-75.00  43.90
-75.39  44.77
-78.21  45.68
-83.00  46.00
-86.00  43.00
4.75  6.5 6.0 6.7
1
144. 2.00  156. 2.20  100. 1.80
SGL    - SOUTHERN GREAT LAKES
1
ONLY ALTERNATIVE
1.
area
5.0 20.0 10.0
6
-84.40  39.80
-75.00  43.35
-75.00  43.90
-75.39  44.77
-76.00  44.95
-85.60  41.30
4.75  7.0 6.0 7.5
1
454. 1.99  724. 2.23  262. 1.75
SVD94R - SVERDRUP BASIN ALL EVENTS (R model)
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
11
-117.80  75.00
-108.00  75.00
 -98.00  75.00
 -98.00  77.00
 -90.00  77.00
 -75.00  82.40
 -80.00  83.00
-103.20  78.90
-110.00  78.80
-121.00  77.10
-122.90  75.50
4.75  7.0 6.5 7.5
1
```

```
9170. 2.25  23000. 2.53  3590. 1.96
WLB    - WILLISTON BASIN
1
WLB
1.0
area
10.0  20.0  5.0
6
-104.000  50.000
-103.000  48.500
-104.000  48.000
-107.000  48.000
-107.000  48.500
-105.000  50.000
4.75 6.0 5.5 6.5
1
28.28 1.6590   16.74 2.2590   39.83 1.0590
```

```
WEST H model (zones by Meaney 04/95) PSA1.0 sec (Dec95 modified)
Probilities of Exceedence for INTERP Subroutine in GSCFRISK.
4  0.01 0.005 0.0021 0.001
Data Set for Integrations in GSCFRISK.
6 10 5.0 5.0 0.10 4 2
10 0.1 1.0 3.0 10.0 30.0 100.0 300.0 1000.0 2000.0 5000.0
3 1 0.3 2 0.4 3 0.3
B
Boore/Joyner/Fumal(1993) Attenuation; PSA1.0s + 0.7 natlog or 0.3 declog
2.822 0.450 -0.014 -0.00097 -0.798 0.314 2.90 0.0 0.0 11 0.622 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA1.0s
2.522 0.450 -0.014 -0.00097 -0.798 0.314 2.90 0.0 0.0 11 0.622 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA1.0s - 0.7 natlog or 0.3 declog
2.222 0.450 -0.014 -0.00097 -0.798 0.314 2.90 0.0 0.0 11 0.622 0 0.0
Crouse EERI(1993); PSA (1.0s) + 0.7 nat log
3.500 1.56 0.0 1.83 1.58 0.608 0.0570 0.0 0.0 10 0.706 0 0.0
Crouse EERI(1993); PSA (1.0s)
2.800 1.56 0.0 1.83 1.58 0.608 0.0570 0.0 0.0 10 0.706 0 0.0
Crouse EERI(1993); PSA (1.0s) - 0.7 nat log
2.100 1.56 0.0 1.83 1.58 0.608 0.0570 0.0 0.0 10 0.706 0 0.0
1 1.0
HORNER'S 1992 SOURCE ZONES (RBH92)
34  3  3  1  34  12
0.68  0.16  0.16
0.68  0.16  0.16
1.0
1  1  1  1
ALASKA COASTAL
1
ALC
1.0
area
******************************************
Borrowed from USGS; No Completeness Data.
******************************************
2.90  !JB-pseudo_depth
4
-145.000  61.000
-145.000  59.300
-156.000  54.700
-157.500  55.800
4.75  8.5 8.2 8.7
1
3848.1 1.43  5731.25 1.51 2585.08 1.35
ALASKA INLAND
1
ALI
1.0
area
******************************************
Borrowed from USGS; No Completeness Data.
******************************************
2.90  !JB-pseudo_depth
7
-145.000  64.500
-145.000  61.000
-157.500  55.800
-160.000  54.300
-160.000  57.000
-154.000  60.000
-151.000  64.500
4.75  8.5 8.2 8.5
1
57235.7 1.73  99129.5 1.84 33058.6 1.62
BEAUFORT COAST
1
BFC
1.0
area
6
4.0   4.8   5.3   5.8   6.3   7.2
1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
  12
-123.00 72.00
-123.00 68.50
-134.00 68.50
-135.00 67.30
-137.00 67.30
-137.00 68.50
-145.00 68.50
-145.00 72.00
-138.00 72.00
-138.00 71.00
-132.00 70.70
-129.00 72.00
4.75  7.0 6.7 7.3
1
507980.34  3.3488  4858170.0  3.9772  50890.54  2.7205   !created 20/09/95
BEAUFORT SEA
1
BFS
1.0
area
8
3.0   3.3   3.8   4.8   5.3   5.8   6.3   7.2
1982  1969  1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
   5
-129.00 73.00
-129.00 72.00
-132.00 70.70
-138.00 71.00
-138.00 72.50
4.75  7.0 6.7 7.3
1
577.51  1.6683  766.80  1.8244  381.16  1.5123   !created 20/09/95
BROOKS PENINSULA
1
BRP
1.0
area
```

```
7
2.0   2.8   3.3   3.8   4.8   5.3   6.8
1982  1962  1965  1956  1940  1917  1899
2.90  !JB-pseudo_depth
   5
-128.00 50.33
-127.75 50.33
-127.50 50.00
-127.85 49.72
-128.43 50.08
4.75  7.0 6.7 7.3
1
22.86  1.2120  31.11  1.3908  20.40  1.0332   !created 20/09/95
CASCADE MOUNTAINS ! Modified
1
CAS              (shallow)
1.0
area
7
2.5   2.8   3.8   4.8   5.3   5.8   6.8
1976  1970  1956  1940  1917  1899  1860
2.90  !JB-pseudo_depth
   5
-121.83 49.65
-121.00 48.00
-121.00 47.00
-123.35 47.00
-123.84 48.88
4.75  7.3 7.1 7.5
1
1402.9 2.01  1704.1 2.12 1137.9 1.90 ! Modified 15/12/95 984.93  1.8647  1164.[illegible]826.08  1.7668   !created 20/09/95
CENTRAL COAST MOUNTAINS
1
CCM
1.0
area
6
3.0   3.3   3.8   5.3   5.8   6.8
1985  1971  1965  1940  1917  1899
2.90  !JB-pseudo_depth
   6
-131.55 57.67
-128.00 55.00
-125.00 51.50
-127.75 50.33
-131.00 54.50
-133.55 57.00
4.75  7.0 6.5 7.3
1
81.39  1.7624  400.87  2.4103  18.83  1.1146   !created 20/09/95
DENALI FAULT
1
DEN
1.0
area
8
2.8   3.8   4.3   4.8   5.3   5.8   6.3   7.2
1979  1972  1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
  11
-145.00 63.70
-140.00 62.00
-135.50 59.80
-135.70 59.00
-136.00 59.30
-136.50 59.60
-138.00 59.33
-138.00 59.67
-139.00 60.50
-141.00 61.00
-145.00 63.00
4.75  7.0 6.7 7.3
1
2424.71  1.8459  2982.22  1.9401 2030.76  1.7517   !created 20/09/95
EASTERN GULF OF ALASKA
1
EGA
1.0
area
8
3.4   3.8   4.3   4.8   5.3   5.8   6.3   7.2
1979  1972  1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
   7
-145.00 59.00
-140.00 59.50
-138.[illegible]
-137.00 58.00
-136.75 57.50
-141.00 56.50
-145.00 56.50
4.75  7.9 7.6 8.2
1
20316.14  2.0392  25399.62  2.1186  16518.40  1.9599   !created 20/09/95
FLATHEAD LAKE
1
FHL
1.0
area
4
4.0   4.8   5.3   5.8
1960  1940  1917  1899
2.90  !JB-pseudo_depth
   4
-114.900  48.600
-114.000  48.600
-112.200  47.000
-114.800  47.000
4.75  7.1 7.3 7.5
1
6064.676000 2.237000  26533.883000 2.656000  111693.594000 3.075000 !created 20/09/95
GEORGIA STRAIT
```

```
1
GEO               (deep)
1.0
area
7
2.0    2.3    2.8    4.8    5.3    5.8    6.8
1982  1976  1956  1940  1917  1899  1860
50.0  !Depth
   4
-124.60 50.75
-122.70 49.33
-123.84 48.88
-125.70 50.27
4.75   7.0 6.5 7.3
1 3 4 0.3 5 0.4 6 0.3
66.91  2.2711  117.93  2.7856  28.03  1.7566   !created 20/09/95
GLACIER BAY
1
GLB
1.0
area
8
2.8    3.8    4.3    4.8    5.3    5.8    6.3    7.2
1979  1972  1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
   6
-136.50 59.60
-136.00 59.30
-135.70 59.00
-135.70 58.75
-136.60 58.40
-138.00 59.33
4.75   7.0 6.7 7.3
1
896.47  1.7544  1153.34  1.8849  682.50  1.6239   !created 20/09/95
HECATE STRAIT
1
HEC
1.0
area
7
2.0    2.8    3.3    3.8    5.3    5.8    6.8
1986  1985  1971  1965  1940  1917  1899
2.90  !JB-pseudo_depth
   4
-131.00 54.50
-130.20 52.00
-131.00 52.00
-133.72 54.51
4.75   7.0 6.7 7.3
1
1132.47  2.0558  1323.60  2.1672  1009.03  1.9444   !created 20/09/95
JUAN DE FUCA BENDING
1
JDF
1.0
area
7
2.0    2.8    3.8    4.8    5.3    5.8    6.8
1982  1970  1956  1940  1917  1899  1860
2.90  !JB-pseudo_depth
   8
-127.20 49.33
-126.60 49.33
-126.60 49.90
-125.70 50.27
-123.84 48.88
-123.35 47.00
-125.50 47.00
-125.80 48.00
4.75   7.3 7.2 7.4
1
423.86  1.9707  503.34  2.1010  364.22  1.8404   !created 20/09/95
McKENZIE MOUNTAINS
1
MCK
1.0
area
8
3.2    3.3    3.8    4.8    5.3    5.8    6.3    7.2
1982  1969  1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
   11
-136.00 65.70
-134.00 65.70
-125.00 65.70
-123.00 64.00
-123.00 60.00
-126.30 59.00
-129.00 61.00
-133.00 63.50
-137.50 63.50
-137.50 65.00
-139.00 65.70
4.75   7.2 6.9 7.5
1
35815.17  2.2054  44670.69  2.2762  30775.68  2.1347   !created 20/09/95
NORTHERN COAST MOUNTAINS
1
NCM
1.0
area
8
3.6    3.8    4.3    4.8    5.3    5.8    6.3    7.2
1979  1972  1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
   7
-135.00 60.00
-131.55 57.67
-133.55 57.00
-135.00 58.00
-135.70 58.75
```

```
-135.70 59.00
-135.50 59.80
4.75  7.0 6.7 7.3
1
333.94  1.7908  1142.79  2.2519  78.41  1.3298   !created 20/09/95
NORTHEASTERN ALASKA
1
NEA
1.0
area
8
3.0   3.3   4.3   4.8   5.3   5.8   6.3   7.2
1985  1972  1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
   7
-143.00 68.50
-139.00 67.00
-139.00 65.70
-141.00 65.00
-141.00 64.00
-145.00 65.00
-145.00 68.50
4.75  7.0 6.7 7.3
1
2555.64  2.1988  4567.81  2.4627  1262.61  1.9349   !created 20/09/95
NORTHERN FOOTHILLS
1
NFT
1.0
area
5
2.9   3.3   5.3   5.8   6.8
1982  1965  1940  1917  1899
2.90  !JB-pseudo_depth
   7
-123.00 60.00
-115.00 57.00
-115.00 55.00
-116.00 54.00
-119.50 53.75
-122.00 55.00
-126.30 59.00
4.75  7.0 6.7 7.3
1
2757.76  2.7926  13842.16  3.4304  619.38  2.1549   !created 20/09/95
NORTHERN JUAN DE FUCA PLATE
1
NJFP
1.0
area
4
3.0   3.3   5.3   6.8
1982  1965  1917  1899
2.90  !JB-pseudo_depth
   5
-127.20 49.33
-125.80 48.00
-125.50 47.00
-128.00 47.20
-128.00 48.90
4.75  6.8 6.6 7.0
1
22.56  1.2477  48.75  1.5574  13.03  0.9380   !created 20/09/95
NORTHERN JUAN DE FUCA RIDGE
1
NJFR
1.0
area
3
4.1   5.3   6.8
1965  1917  1899
2.90  !JB-pseudo_depth
   4
-128.00 48.40
-128.00 47.20
-129.50 47.20
-129.50 48.40
4.75  6.0 5.5 6.5
1
47690.44  2.6681  560310.19  3.3228  3856.19  2.0134   !created 20/09/95
NOOTKA FAULT
1
NOF
1.0
area
7
2.0   2.8   3.3   3.8   4.8   5.3   6.8
1982  1962  1965  1956  1940  1917  1899
2.90  !JB-pseudo_depth
   9
-127.85 49.72
-127.50 50.00
-126.90 50.00
-126.60 49.90
-126.60 49.33
-127.20 49.33
-128.00 48.90
-128.10 48.90
-128.10 49.10
4.75  7.0 6.7 7.3
1
368.53  1.7302  433.60  1.8238  347.70  1.6366   !created 20/09/95
NORTHERN ROCKY MOUNTAIN TRENCH
1
NRMT
1.0
area
5
2.5   3.3   5.3   5.8   6.8
1982  1965  1940  1917  1899
2.90  !JB-pseudo_depth
   6
```

```
-129.00 61.00
-126.30 59.00
-122.00 55.00
-119.50 53.75
-122.50 53.50
-130.00 60.00
4.75  7.0 6.7 7.3
1
278.62  2.0912  558.80  2.4389  156.85  1.7436   !created 20/09/95
OGILVIE MOUTAINS
1
OGL
1.0
area
8
3.0   3.3   4.3   4.8   5.3   5.8   6.3   7.2
1985  1972  1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
   6
-139.00 65.70
-137.50 65.00
-137.50 63.50
-139.00 63.50
-141.00 64.00
-141.00 65.00
4.75  7.0 6.7 7.3
1
318.14  1.6921  646.53  1.9550  193.82  1.4292   !created 20/09/95
PUGET SOUND         ! MODIFIED
1
PUG              (deep)
1.0
area
7
2.2   2.8   3.8   4.8   5.3   5.8   6.8
1976  1970  1956  1940  1917  1899  1860
50.0  !Depth
   6
-122.70 49.33
-122.30 49.00
-122.00 48.00
-122.00 47.00
-123.35 47.00
-123.84 48.88
4.75  7.3 7.1 7.6
1 3 4 0.3 5 0.4 6 0.3
18.1  1.01 19.9 1.12  16.4 0.90 !modified 15/12/95
QUEEN CHARLOTTE FAULT BORDER
1
QCB
1.0
area
6
3.0   3.3   4.3   5.3   5.8   6.8
1985  1971  1965  1940  1917  1899
2.90  !JB-pseudo_depth
   7
-136.75 57.50
-136.00 55.50
-133.75 53.00
-132.00 51.50
-134.00 50.50
-138.00 54.00
-139.00 56.95
4.75  7.0 6.7 7.3
1
363.97  1.9619  1101.62  2.3947  140.58  1.5291 !created 20/09/95
QUEEN CHARLOTTE FAULT
1
QCF
1.0
fault
90.0 90.0 3 10.0 25.0
-1.085  0.389  0.01
3
-136.80  58.70
-132.40  52.90
-130.60  51.50
4.75  8.2 8.5 8.7
1
829.029000 1.431000  977.199000 1.510000  1146.396000 1.589000 !created 20/09/95
QUEEN CHARLOTTE SOUND
1
QCS
1.0
area
4
3.0   3.3   5.3   6.8
1983  1965  1917  1899
2.90  !JB-pseudo_depth
   6
-130.20 52.00
-128.21 50.21
-128.43 50.08
-130.00 51.00
-130.30 51.50
-131.00 52.00
4.75  7.0 6.7 7.3
1
72.73  1.4292  131.09  1.6718  47.41  1.1867   !created 20/09/95
REVERE-DELLWOOD, SOVANCO
1
RDS
1.0
area
3
3.3   5.3   6.8
1965  1917  1899
2.90  !JB-pseudo_depth
   10
-130.30 51.50
-130.00 51.00
```

```
-128.43 50.08
-127.85 49.72
-128.10 49.10
-128.10 48.90
-128.00 48.90
-128.00 48.40
-130.00 48.40
-132.00 51.50
4.75  7.0 6.8 7.2
1
2443.76  1.4599  2824.63  1.5088  2226.72  1.4110   !created 20/09/95
RICHARDSON MOUNTAINS
1
RIC
1.0
area
8
3.0   3.3   3.8   4.8   5.3   5.8   6.3   7.2
1982  1969  1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
   4
-135.00 67.30
-134.00 65.70
-136.00 65.70
-137.00 67.30
4.75  7.0 6.7 7.3
1
3519.08  2.0631  4797.84  2.2094  2392.91  1.9169   !created 20/09/95
SOUTHERN COAST MOUNTAINS
1
SCM            (shallow)
1.0
area
8
2.0   2.3   2.8   3.3   4.8   5.3   5.8   7.2
1982  1976  1962  1956  1940  1917  1899  1860
2.90  !JB-pseudo_depth
   10
-126.60 49.90
-126.90 50.00
-127.50 50.00
-127.75 50.33
-125.00 51.50
-124.50 51.50
-122.00 50.00
-121.83 49.65
-123.84 48.88
-125.70 50.27
4.75  7.0 6.5 7.3
1
129.59  1.7003  153.52  1.8461  108.12  1.5546 !created 20/09/95
SOUTHEASTERN BRITISH COLUMBIA
1
SEBC
1.0
area
6
3.0   3.3   4.3   4.8   5.3   5.8
1966  1965  1960  1940  1917  1899
2.90  !JB-pseudo_depth
   6
-119.50 53.75
-112.75 48.00
-121.00 48.00
-122.00 50.00
-124.50 51.50
-122.50 53.50
4.75  7.0 6.7 7.3
1
854.77  1.8125  1168.50  1.9479  634.06  1.6772   !created 20/09/95
SOUTHERN FOOTHILLS
1
SFT
1.0
area
6
3.0   3.3   4.3   4.8   5.3   5.8
1966  1965  1960  1940  1917  1899
2.90  !JB-pseudo_depth
   5
-116.00 54.00
-114.00 52.00
-111.00 48.00
-112.75 48.00
-119.50 53.75
4.75  6.0 5.0 7.0
1
4878.34  2.4781  9370.34  2.7375  2514.87  2.2186   !created 20/09/95
SOUTHERN YUKON TERRITORY
1
SYT
1.0
area
8
3.0   3.8   4.3   4.8   5.3   5.8   6.3   7.2
1979  1972  1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
   9
-141.00 64.00
-139.00 63.50
-133.00 63.50
-129.00 61.00
-130.00 60.00
-135.00 60.00
-135.50 59.80
-140.00 62.00
-141.00 62.40
4.75  7.0 6.7 7.3
1
529.50  1.9283  1050.45  2.2452 239.13  1.6114   !created 20/09/95
YAKUTAT FAIRWEATHER FAULT
1
```

```
YFF
1.0
area
8
3.4   3.8   4.3   4.8   5.3   5.8   6.3   7.2
1979  1972  1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
   11
-145.00 61.00
-141.00 61.00
-139.00 60.50
-138.00 59.67
-138.00 59.33
-136.60 58.40
-136.40 58.24
-137.00 58.00
-138.50 59.00
-140.00 59.50
-145.00 59.00
4.75  8.5 8.2 8.7
1
27728.38  2.1288  35213.07  2.2119 22338.68  2.0457 !created 20/09/95
```

```
WEST R model (zones by Meaney 04/95) PSA1.0 sec (Dec95 modified)
Probilities of Exceedence for INTERP Subroutine in GSCFRISK.
4  0.01 0.005 0.0021 0.001
Data Set for Integrations in GSCFRISK.
6 10 5.0 5.0 0.10 4 2
10 0.1 1.0 3.0 10.0 30.0 100.0 300.0 1000.0 2000.0 5000.0
3 1 0.3 2 0.4 3 0.3
B
Boore/Joyner/Fumal(1993) Attenuation; PSA1.0s + 0.7 natlog or 0.3 declog
2.822 0.450 -0.014 -0.00097 -0.798 0.314 2.90 0.0 0.0 11 0.622 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA1.0s
2.522 0.450 -0.014 -0.00097 -0.798 0.314 2.90 0.0 0.0 11 0.622 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA1.0s - 0.7 natlog or 0.3 declog
2.222 0.450 -0.014 -0.00097 -0.798 0.314 2.90 0.0 0.0 11 0.622 0 0.0
Crouse EERI(1993); PSA (1.0s) + 0.7 nat log
3.500 1.56 0.0 1.83 1.58 0.608 0.0570 0.0 0.0 10 0.706 0 0.0
Crouse EERI(1993); PSA (1.0s)
2.800 1.56 0.0 1.83 1.58 0.608 0.0570 0.0 0.0 10 0.706 0 0.0
Crouse EERI(1993); PSA (1.0s) - 0.7 nat log
2.100 1.56 0.0 1.83 1.58 0.608 0.0570 0.0 0.0 10 0.706 0 0.0
1 1.0
ROGERS' 1991 SOURCE ZONES - GR91
26   3   3   1   26   11
0.68   0.16   0.16
0.68   0.16   0.16
1.0
1   1   1   1
ALASKA COASTAL
1
ALC
1.0
area
*****************************************
Borrowed from USGS; No Completeness Data.
*****************************************
2.90   !JB-pseudo_depth
4
-145.000  61.000
-145.000  59.300
-156.000  54.700
-157.500  55.800
4.75   8.5 8.2 8.7
1
3848.1 1.43  5731.25 1.51 2585.08 1.35
ALASKA INLAND
1
ALI
1.0
area
*****************************************
Borrowed from USGS; No Completeness Data.
*****************************************
2.90   !JB-pseudo_depth
7
-145.000  64.500
-145.000  61.000
-157.500  55.800
-160.000  54.300
-160.000  57.000
-154.000  60.000
-151.000  64.500
4.75  8.5 8.2 8.5
1
57235.7 1.73  99129.5 1.84 33058.6 1.62
BEAUFORT SEA
1
BFT
1.0
area
7
3.0    3.3    3.8    4.8    5.3    5.8    6.8
1982   1969   1965   1961   1951   1935   1917
2.90  !JB-pseudo_depth
   4
-137.800  72.800
-128.700  72.800
-130.900  70.600
-138.600  71.100
4.75  7.0 6.7 7.3
1
622.72  1.6935  853.62  1.8624  393.90  1.5246   !created 25/09/95
BROOKS PENINSULA
1
BRO
1.0
area
6
2.0    3.3    3.8    4.8    5.3    6.8
1982   1965   1956   1940   1917   1899
2.90  !JB-pseudo_depth
   4
-127.740  50.330
-127.300  50.150
-127.630  49.980
-128.000  50.180
4.75  7.0 6.7 7.3
1
8.03  1.0635  8.75  1.2636  6.58  0.8634 !created 25/09/95
CASCADE MOUNTAINS - MODIFIED!
1
CAS             (shallow)
1.0
area
7
2.5    2.8    3.8    4.8    5.3    5.8    7.3
1976   1970   1956   1940   1917   1899   1860
2.90  !JB-pseudo_depth
   10
-123.600  51.900
-122.000  51.200
-120.000  48.700
-120.000  47.000
```

86

```
-124.030  47.000
-123.900  47.560
-124.230  48.030
-126.710  49.540
-126.400  49.740
-126.710  49.910
4.75  7.7 7.7 7.7
1
14.6 0.85 1222. 1.86 14.6 0.85 ! updated 05/12/95
COASTAL
1
CST
1.0
area
5
3.6   4.3   5.3   5.8   6.8
1972  1965  1940  1917  1899
2.90  !JB-pseudo_depth
   10
-136.800  58.700
-135.100  60.000
-127.100  53.100
-123.600  51.900
-126.710  49.910
-130.600  51.500
-131.180  51.950
-129.700  52.600
-131.500  54.400
-133.480  54.500
4.75  7.5 7.4 7.6
1
317.50  1.5519  563.97  1.7649  177.69  1.3389 !created 25/09/95
DENALI
1
DEN
1.0
area
7
3.0   3.8   4.3   4.8   5.3   5.8   6.3
1979  1972  1965  1961  1951  1935  1917
2.90  !JB-pseudo_depth
   6
-145.000  63.100
-145.000  64.000
-139.300  62.000
-135.500  59.700
-136.800  58.700
-140.700  61.200
4.75  7.0 6.7 7.3
1
3903.02  1.8681  4836.25  1.9607  3182.29  1.7755   !created 25/09/95
EXPLORER PLATE BENDING
1
EXP
1.0
area
4
3.0   3.3   5.3   6.8
1983  1965  1917  1899
2.90  !JB-pseudo_depth
   8
-130.600  51.500
-127.740  50.330
-128.000  50.180
-127.630  49.980
-127.300  50.150
-127.090  50.070
-127.750  49.640
-130.900  51.330
4.75  7.0 6.7 7.3
1
103.32  1.3007  160.40  1.4544  85.62  1.1469 !created 25/09/95
FLATHEAD LAKE
1
FHL
1.0
area
4
4.0   4.8   5.3   5.8
1960  1940  1917  1899
2.90  !JB-pseudo_depth
   4
-114.900  48.600
-114.000  48.600
-112.200  47.000
-114.800  47.000
4.75  7.3 7.1 7.5
1
14016.75  2.4905  63130.85  2.9255  3021.55  2.0554 !created 25/09/95
GULF OF ALASKA
1
GOA
1.0
area
7
4.0   4.3   4.8   5.3   5.8   6.3   7.3
1972  1965  1961  1951  1935  1917  1850
2.90  !JB-pseudo_depth
   4
-143.600  59.500
-142.000  59.400
-142.300  56.700
-144.000  56.700
4.75  7.8 7.6 8.0
1
49696.31  2.3124  86255.05  2.4729  28865.38  2.1519 !created 25/09/95
GEORGIA STRAIT/PUGET SOUND MODIFIED!
1
GSP            (deep)
1.0
area
7
```

```
2.5   2.8   3.8   4.8   5.3   5.8   6.8
1976  1970  1956  1940  1917  1899  1860
50.0  !Depth
   10
-123.850  49.550
-122.400  48.840
-121.720  48.300
-121.500  47.680
-121.700  47.000
-123.300  47.000
-123.220  47.530
-123.350  47.870
-123.830  48.250
-124.750  48.850
4.75  7.1 6.9 7.3
1 3 4 0.3 5 0.4 6 0.3
29.1 1.12 35.4 1.25 25.0 0.99  ! update 05/12/95
HECATE STRAIT
1
HEC
1.0
area
7
2.0   2.8   3.3   3.8   5.3   5.8   6.8
1986  1985  1971  1965  1940  1917  1899
2.90  !JB-pseudo_depth
   5
-133.480  54.500
-131.500  54.400
-129.700  52.600
-131.180  51.950
-132.400  52.900
4.75  7.0 6.7 7.3
1
1187.04  1.9660  1358.58  2.0597  1088.72  1.8722 !created 25/09/95
JUAN DE FUCA PLATE BENDING, OFFSHORE
1
JDFF
1.0
area
7
2.5   2.8   3.8   4.8   5.3   5.8   6.8
1982  1970  1956  1940  1917  1899  1860
2.90  !JB-pseudo_depth
   8
-126.710  49.540
-124.230  48.030
-123.900  47.560
-124.030  47.000
-124.900  47.000
-124.920  47.380
-125.800  48.320
-127.180  49.240
4.75  7.0 6.7 7.3
1
91.00  1.8665  175.26  2.2560  42.63  1.4770 !created 25/09/95
JUAN DE FUCA PLATE BENDING, ONSHORE
1
JDFN            (deep)
1.0
area
7
2.5   2.8   3.8   4.8   5.3   5.8   6.8
1982  1970  1956  1940  1917  1899  1860
2.90  !JB-pseudo_depth
   10
-126.400  49.740
-124.750  48.850
-123.830  48.250
-123.350  47.870
-123.220  47.530
-123.300  47.000
-124.030  47.000
-123.900  47.560
-124.230  48.030
-126.710  49.540
4.75  7.1 6.7 7.3
1
109.71  2.0692  264.78  2.5773  39.77  1.5610 !created 25/09/95
MACKENZIE MOUNTAINS
1
MMB
1.0
area
7
3.0   3.3   3.8   4.8   5.3   5.8   6.8
1982  1969  1965  1961  1951  1935  1917
2.90  !JB-pseudo_depth
   9
-132.800  65.600
-127.000  65.800
-123.600  64.400
-123.100  62.200
-124.800  59.400
-129.100  59.900
-128.700  62.300
-130.300  63.700
-133.000  64.200
4.75  7.1 6.9 7.3
1
58008.89  2.4285  72700.01  2.5043  49997.28  2.3528 !created 25/09/95
NORTHERN BC
1
NBC
1.0
area
4
3.0   3.3   5.3   5.8
1982  1965  1940  1917
2.90  !JB-pseudo_depth
   7
-135.100  60.000
```

```
-132.800  60.300
-129.000  59.900
-122.100  54.100
-120.600  53.400
-123.600  51.900
-127.100  53.100
4.75  6.0 5.7 6.3
1
22787.46  3.1989  67166.48  3.7311  4205.13  2.6667 !created 25/09/95
NOOTKA FAULT
1
NOF
1.0
area
6
2.0   3.3   3.8   4.8   5.3   6.8
1982  1965  1956  1940  1917  1899
2.90  !JB-pseudo_depth
   5
-127.090  50.070
-126.710  49.910
-126.400  49.740
-127.930  48.760
-128.500  49.150
4.75  7.0 6.7 7.3
1
458.64  1.7300  522.08  1.8177  428.11  1.6424 !created 25/09/95
NORTHERN YUKON
1
NYK
1.0
area
5
4.2   4.8   5.3   5.8   6.8
1965  1961  1951  1935  1917
2.90  !JB-pseudo_depth
   8
-145.000  70.800
-134.400  69.200
-135.000  67.400
-136.500  67.400
-136.300  66.100
-134.900  64.230
-140.200  64.300
-145.000  65.000
4.75  7.0 6.7 7.3
1
7080982.50 3.7503  70270912.0 4.3478  697501.56  3.1528 !created 25/09/95
OFFSHORE
1
OFS
1.0
area
3
4.3   5.3   6.8
1965  1917  1899
2.90  !JB-pseudo_depth
   7
-130.900  51.330
-127.750  49.640
-128.500  49.150
-127.930  48.760
-128.200  47.350
-129.500  47.350
-131.500  51.000
4.75  7.1 6.9 7.3
1
46683.91  2.1010  73246.15  2.2212  30343.13  1.9808 !created 25/09/95
QUEEN CHARLOTTE FAULT
1
QCF
1.0
fault
90.0 90.0 3 10.0 25.0
-1.085  0.389  0.01
3
-136.80  58.70
-132.40  52.90
-130.60  51.50
4.75  8.5 8.2 8.5
1
1529.57  1.5454  1829.25  1.6122  1387.51  1.4787 !created 25/09/95
RICHARDSON MTNS-NORTH
1
RMN
1.0
area
7
3.0   3.3   3.8   4.8   5.3   5.8   6.8
1982  1969  1965  1961  1951  1935  1917
2.90  !JB-pseudo_depth
   5
-136.500  67.400
-135.000  67.400
-132.800  65.600
-136.170  65.930
-136.300  66.100
4.75  7.0 6.7 7.3
1
2918.86  1.9990  3948.71  2.1410  2016.90  1.8570 !created 25/09/95
RICHARDSON MTNS-SOUTH
1
RMS
1.0
area
7
3.0   3.3   3.8   4.8   5.3   5.8   6.8
1982  1969  1965  1961  1951  1935  1917
2.90  !JB-pseudo_depth
   4
-132.800  65.600
-133.000  64.200
```

```
-134.900  64.230
-136.170  65.930
4.75  7.0 6.7 7.3
1
1248.33  1.6684  1540.54  1.7767  945.32  1.5601 !created 25/09/95
ROCKY MOUNTAIN F and T BELT
1
ROC
1.0
area
5
3.0   3.3   5.3   5.8   6.8
1982  1965  1940  1917  1899
2.90  !JB-pseudo_depth
   11
-129.000  59.900
-124.800  59.400
-122.600  56.600
-118.400  54.400
-115.200  52.300
-114.000  49.500
-112.000  48.000
-113.330  48.000
-114.000  48.600
-120.600  53.400
-122.100  54.100
4.75  7.0 6.7 7.3
1
1560.44  2.0359  2557.10  2.2501  883.21  1.8217 !created 25/09/95
SOUTHERN BC
1
SBC
1.0
area
6
3.0   3.3   4.3   4.8   5.3   5.8
1966  1965  1960  1940  1917  1899
2.90  !JB-pseudo_depth
   8
-123.600  51.900
-120.600  53.400
-114.000  48.600
-114.900  48.600
-114.870  48.130
-120.000  48.100
-120.000  48.700
-122.000  51.200
4.75  7.0 6.7 7.3
1
1384.70  2.2082  2787.43  2.4950  673.48  1.9215 !created 25/09/95
SOUTHERN YUKON
1
SOY
1.0
area
7
3.0   3.8   4.3   4.8   5.3   5.8   6.3
1979  1972  1965  1961  1951  1935  1917
2.90  !JB-pseudo_depth
   11
-145.000  65.000
-140.200  64.300
-133.000  64.200
-130.300  63.700
-128.700  62.300
-129.100  59.900
-132.800  60.300
-135.100  60.000
-135.500  59.700
-139.300  62.000
-145.000  64.000
4.75  7.0 6.7 7.3
1
1690.75  2.1476  3157.32  2.4208  853.36  1.8744 !created 25/09/95
YAKATAT COLLISION
1
YAK
1.0
area
8
3.0   3.8   4.3   4.8   5.3   5.8   6.3   7.3
1979  1972  1965  1961  1957  1935  1917  1850
2.90  !JB-pseudo_depth
   11
-145.000  59.500
-145.000  63.100
-140.700  61.200
-140.000  60.750
-140.000  60.000
-137.800  58.200
-136.600  56.800
-142.100  58.700
-142.000  59.400
-143.600  59.500
-143.700  59.100
4.75  8.5 8.2 8.7
1
16307.38  2.0096  18689.91  2.0681  14305.26  1.9511 !created 25/09/95
```

Strong Ground Motion Parameters used for each period for which hazard has been calculated

```
A95 PSA 0.1s Mlg Median grd motion for Pseudo Acc 0.1s ATKINSON BOORE 1995
3.99 0.360 -0.0527 -0.00121 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
A95 PSA 0.1s Mlg L grd motion for PSA 0.1s ATKINSON BOORE 1995 L limit
3.61 0.360 -0.0527 -0.00121 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
A95 PSA 0.1s Mlg U grd motion for PSA 0.1s ATKINSON BOORE 1995 U limit
4.12 0.360 -0.0527 -0.00121 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0

AB95R PSA 0.15s Mlg Median grd motion for Pseudo Acc 0.15s ATKINSON BOORE 1995
3.85 0.394 -0.0595 -0.000769 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 0.15s Mlg L grd motion for PSA 0.15s ATKINSON BOORE 1995 Lower lim
3.50 0.394 -0.0595 -0.000769 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 0.15s Mlg U grd motion for PSA 0.15s ATKINSON BOORE 1995 Upper lim
4.05 0.394 -0.0595 -0.000769 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0

AB95R PSA 0.2s Mlg Median grd motion for Pseudo Acc 0.2s ATKINSON BOORE 1995
3.75 0.418 -0.0644 -0.000457 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 0.2s Mlg L grd motion for PSA 0.2s ATKINSON BOORE 1995 Lower limit
3.43 0.418 -0.0644 -0.000457 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 0.2s Mlg U grd motion for PSA 0.2s ATKINSON BOORE 1995 Upper limit
4.00 0.418 -0.0644 -0.000457 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0

AB95R PSA 0.3s Mlg Median grd motion for Pseudo Acc 0.3s ATKINSON BOORE 1995
3.54 0.475 -0.0717 -0.000106 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 0.3s Mlg L grd motion for PSA 0.3s ATKINSON BOORE 1995 Lower limit
3.26 0.475 -0.0717 -0.000106 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 0.3s Mlg U grd motion for PSA 0.3s ATKINSON BOORE 1995 Upper limit
3.88 0.475 -0.0717 -0.000106 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0

AB95R PSA 0.4s Mlg Median grd motion for Pseudo Acc 0.4s ATKINSON BOORE 1995
3.38 0.517 -0.0674 -0.000046 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 0.4s Mlg L grd motion for PSA 0.4s ATKINSON BOORE 1995 Lower limit
3.12 0.517 -0.0674 -0.000046 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 0.4s Mlg U grd motion for PSA 0.4s ATKINSON BOORE 1995 Upper limit
3.77 0.517 -0.0674 -0.000046 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0

AB95R PSA 0.5s Mlg Median grd motion for Pseudo Acc 0.5s ATKINSON BOORE 1995
3.26 0.550 -0.0640  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 0.5s Mlg L grd motion for PSA 0.5s ATKINSON BOORE 1995 Lower limit
3.02 0.550 -0.0640  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 0.5s Mlg U grd motion for PSA 0.5s ATKINSON BOORE 1995 Upper limit
3.68 0.550 -0.0640  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0

AB95R PSA 1s Mlg Median grd motion for PSA1.0s ATKINSON BOORE 1995 Mlg
2.77 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 1s Mlg L grd motion for PSA1.0s ATKINSON BOORE 1995 L limit
2.59 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 1s Mlg U grd motion for PSA1.0s ATKINSON BOORE 1995 U limit
```

```
3.31 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0

AB95R PSA 2s Mlg Median grd motion for Pseudo Acc 2 sec ATKINSON BOORE 1995
2.27 0.634 -0.0170  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0


Boore/Joyner/Fumal(1993) Attenuation; PSA (0.1s) + 0.7 log nat or 0.3 dec log
3.751 0.327 -0.098 -0.00395 -0.934 0.046 6.27 0.0 0.0 11 0.479 0.0 0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.1s)
3.451 0.327 -0.098 -0.00395 -0.934 0.046 6.27 0.0 0.0 11 0.479 0.0 0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.1s) - 0.7 log nat or 0.3 dec log
3.151 0.327 -0.098 -0.00395 -0.934 0.046 6.27 0.0 0.0 11 0.479 0.0 0
Crouse EERI(1993); PSA(0.1s) + 0.7 nat log
7.893 1.12 0.0 1.93 1.58 0.608 0.283 0.0 0.0 10 0.694 0 0.0
Crouse EERI(1993); PSA(0.1s)
7.193 1.12 0.0 1.93 1.58 0.608 0.283 0.0 0.0 10 0.694 0 0.0
Crouse EERI(1993); PSA(0.1s) - 0.7 nat log
6.493 1.12 0.0 1.93 1.58 0.608 0.283 0.0 0.0 10 0.694 0 0.0

Boore/Joyner/Fumal(1993) Attenuation; PSA (0.15s) + 0.7 log nat or 0.3 dec log
3.814 0.305 -0.099 -0.00309 -0.937 0.140 7.23 0.0 0.0 11 0.486 0.0 0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.15s)
3.514 0.305 -0.099 -0.00309 -0.937 0.140 7.23 0.0 0.0 11 0.486 0.0 0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.15s) - 0.7 log nat or 0.3 dec log
3.214 0.305 -0.099 -0.00309 -0.937 0.140 7.23 0.0 0.0 11 0.486 0.0 0
Crouse EERI(1993); PSA(0.15s) + 0.7 nat log
8.098 1.10 0.0 1.92 1.58 0.608 0.274 0.0 0.0 10 0.694 0 0.0
Crouse EERI(1993); PSA(0.15s)
7.398 1.10 0.0 1.92 1.58 0.608 0.274 0.0 0.0 10 0.694 0 0.0
Crouse EERI(1993); PSA(0.15s) - 0.7 nat log
6.698 1.10 0.0 1.92 1.58 0.608 0.274 0.0 0.0 10 0.694 0 0.0

Boore/Joyner/Fumal(1993) Attenuation; PSA (0.2s) + 0.7 log nat or 0.3 dec log
3.764 0.309 -0.090 -0.00259 -0.924 0.190 7.02 0.0 0.0 11 0.495 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.2s)
3.464 0.309 -0.090 -0.00259 -0.924 0.190 7.02 0.0 0.0 11 0.495 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.2s) - 0.7 log nat or 0.3 dec log
3.164 0.309 -0.090 -0.00259 -0.924 0.190 7.02 0.0 0.0 11 0.495 0 0.0
Crouse EERI(1993); PSA (0.2s) + 0.7 nat log
8.382 1.09 0.0 1.92 1.58 0.608 0.2655 0.0 0.0 10 0.693 0 0.0
Crouse EERI(1993); PSA (0.2s)
7.682 1.09 0.0 1.92 1.58 0.608 0.2655 0.0 0.0 10 0.693 0 0.0
Crouse EERI(1993); PSA (0.2s) - 0.7 nat log
6.982 1.09 0.0 1.92 1.58 0.608 0.2655 0.0 0.0 10 0.693 0 0.0

Boore/Joyner/Fumal(1993) Attenuation; PSA (0.3s) + 0.7 log nat or 0.3 dec log
3.595 0.334 -0.070 -0.00202 -0.893 0.239 5.94 0.0 0.0 11 0.520 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.3s)
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3.295 0.334 -0.070 -0.00202 -0.893 0.239 5.94 0.0 0.0 11 0.520 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.3s) - 0.7 log nat or 0.3 dec log
2.995 0.334 -0.070 -0.00202 -0.893 0.239 5.94 0.0 0.0 11 0.520 0 0.0
Crouse EERI(1993); PSA (0.3s) + 0.7 nat log
7.212 1.14 0.0 1.82 1.58 0.608 0.222 0.0 0.0 10 0.693 0 0.0
Crouse EERI(1993); PSA (0.3s)
6.512 1.14 0.0 1.82 1.58 0.608 0.222 0.0 0.0 10 0.693 0 0.0
Crouse EERI(1993); PSA (0.3s) - 0.7 nat log
5.812 1.14 0.0 1.82 1.58 0.608 0.222 0.0 0.0 10 0.693 0 0.0

Boore/Joyner/Fumal(1993) Attenuation; PSA (0.4s) + 0.7 log nat or 0.3 dec log
3.426 0.361 -0.052 -0.00170 -0.867 0.264 4.91 0.0 0.0 11 0.543 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.4s)
3.126 0.361 -0.052 -0.00170 -0.867 0.264 4.91 0.0 0.0 11 0.543 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.4s) - 0.7 log nat or 0.3 dec log
2.826 0.361 -0.052 -0.00170 -0.867 0.264 4.91 0.0 0.0 11 0.543 0 0.0
Crouse EERI(1993); PSA (0.4s) + 0.7 nat log
6.160 1.18 0.0 1.69 1.58 0.608 0.1785 0.0 0.0 10 0.693 0 0.0
Crouse EERI(1993); PSA (0.4s)
5.460 1.18 0.0 1.69 1.58 0.608 0.1785 0.0 0.0 10 0.693 0 0.0
Crouse EERI(1993); PSA (0.4s) - 0.7 nat log
4.760 1.18 0.0 1.69 1.58 0.608 0.1785 0.0 0.0 10 0.693 0 0.0

Boore/Joyner/Fumal(1993) Attenuation; PSA (0.5s) + 0.7 log nat or 0.3 dec log
3.280 0.384 -0.039 -0.00148 -0.846 0.279 4.13 0.0 0.0 11 0.562 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.5s)
2.980 0.384 -0.039 -0.00148 -0.846 0.279 4.13 0.0 0.0 11 0.562 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.5s) - 0.7 log nat or 0.3 dec log
2.680 0.384 -0.039 -0.00148 -0.846 0.279 4.13 0.0 0.0 11 0.562 0 0.0
Crouse EERI(1993); PSA (0.5s) + 0.7 nat log
5.808 1.30 0.0 1.81 1.58 0.608 0.1535 0.0 0.0 10 0.694 0 0.0
Crouse EERI(1993); PSA (0.5s)
5.108 1.30 0.0 1.81 1.58 0.608 0.1535 0.0 0.0 10 0.694 0 0.0
Crouse EERI(1993); PSA (0.5s) - 0.7 nat log
4.408 1.30 0.0 1.81 1.58 0.608 0.1535 0.0 0.0 10 0.694 0 0.0

Boore/Joyner/Fumal(1993) Attenuation; PSA1.0s + 0.7 natlog or 0.3 declog
2.822 0.450 -0.014 -0.00097 -0.798 0.314 2.90 0.0 0.0 11 0.622 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA1.0s
2.522 0.450 -0.014 -0.00097 -0.798 0.314 2.90 0.0 0.0 11 0.622 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA1.0s - 0.7 natlog or 0.3 declog
2.222 0.450 -0.014 -0.00097 -0.798 0.314 2.90 0.0 0.0 11 0.622 0 0.0
Crouse EERI(1993); PSA (1.0s) + 0.7 nat log
3.500 1.56 0.0 1.83 1.58 0.608 0.0570 0.0 0.0 10 0.706 0 0.0
Crouse EERI(1993); PSA (1.0s)
2.800 1.56 0.0 1.83 1.58 0.608 0.0570 0.0 0.0 10 0.706 0 0.0
Crouse EERI(1993); PSA (1.0s) - 0.7 nat log
2.100 1.56 0.0 1.83 1.58 0.608 0.0570 0.0 0.0 10 0.706 0 0.0

Boore/Joyner/Fumal(1993) Attenuation; PSA (2.0s) + 0.7 log nat or 0.3 dec log
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2.534 0.471 -0.037 -0.00064 -0.812 0.360 5.85 0.0 0.0 11 0.675 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA (2.0s)
2.234 0.471 -0.037 -0.00064 -0.812 0.360 5.85 0.0 0.0 11 0.675 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA (2.0s) - 0.7 log nat or 0.3 dec log
1.934 0.471 -0.037 -0.00064 -0.812 0.360 5.85 0.0 0.0 11 0.675 0 0.0
Crouse EERI(1993); PSA (2.0s)  + 0.7 nat log
0.450 1.50 0.0 1.38 1.58 0.608 -0.110 0.0 0.0 10 0.749 0 0.0
Crouse EERI(1993); PSA (2.0s)
-0.250 1.50 0.0 1.38 1.58 0.608 -0.110 0.0 0.0 10 0.749 0 0.0
Crouse EERI(1993); PSA (2.0s) - 0.7 nat log
-0.950 1.50 0.0 1.38 1.58 0.608 -0.110 0.0 0.0 10 0.749 0 0.0
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APPENDIX D

Published information relevant to the derivation of RGC factors

This Appendix includes Figure 3a and Table 7b from Boore et al., (1993) and Tables 2 and 3 from Martin and Dobry (1994) referenced in the section on "Reference Ground Condition for Canada".

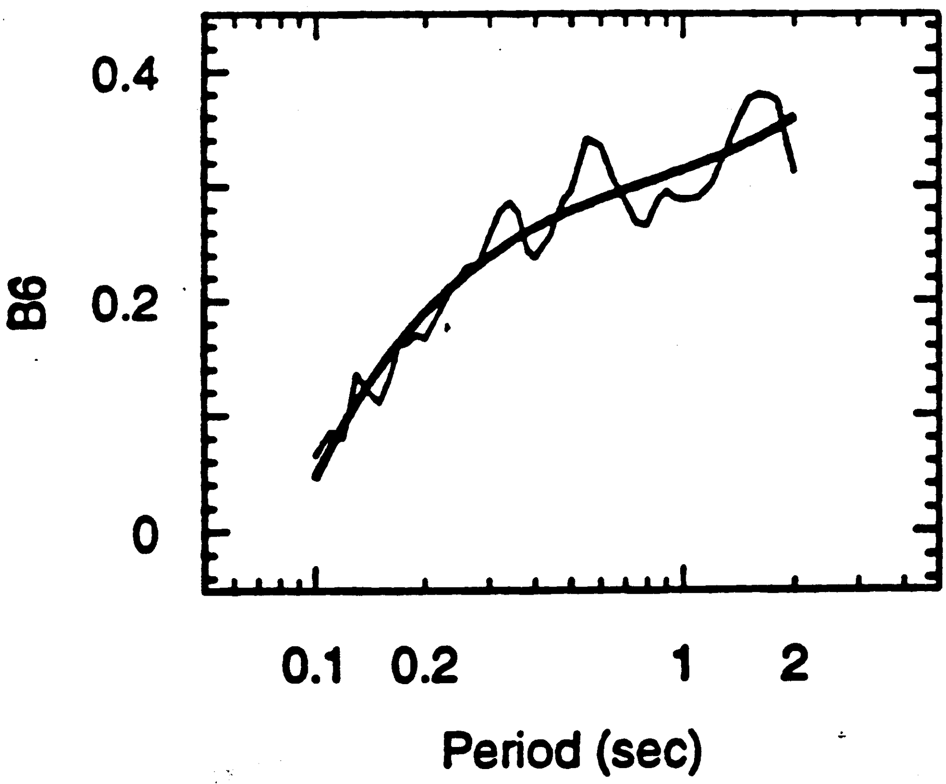

Figure 3a. The unsmoothed and smoothed coefficients (light and heavy lines, respectively) for the 5 percent damped response spectra of the random horizontal component.

Table 7b. Smoothed coefficients of equations for the random horizontal component of 5 percent damped PSV (cm/s; distance in km).

T(s)	B1	B2	B3	B4	B5	B6	B7	M	S1	SC	SR	SE	SLOGY
.10	1.653	.327	-.098	.00000	-.934	.046	.136	6.27	.191	.083	.208	.003	.208
.11	1.725	.318	-.100	.00000	-.937	.071	.156	6.65	.189	.087	.208	.005	.208
.12	1.782	.313	-.101	.00000	-.939	.093	.174	6.91	.187	.091	.208	.008	.208
.13	1.828	.309	-.101	.00000	-.939	.111	.191	7.08	.186	.094	.208	.010	.209
.14	1.864	.307	-.100	.00000	-.938	.127	.206	7.18	.185	.097	.209	.012	.209
.15	1.892	.305	-.099	.00000	-.937	.140	.221	7.23	.185	.100	.210	.015	.211
.16	1.915	.305	-.098	.00000	-.935	.153	.234	7.24	.184	.102	.210	.017	.211
.17	1.933	.305	-.096	.00000	-.933	.163	.246	7.21	.184	.104	.211	.019	.212
.18	1.948	.306	-.094	.00000	-.930	.173	.258	7.16	.184	.106	.212	.021	.213
.19	1.959	.308	-.092	.00000	-.927	.182	.269	7.10	.184	.108	.213	.023	.215
.20	1.967	.309	-.090	.00000	-.924	.190	.279	7.02	.184	.109	.214	.025	.215
.22	1.978	.313	-.086	.00000	-.918	.203	.297	6.83	.185	.112	.216	.029	.218
.24	1.982	.318	-.082	.00000	-.912	.214	.314	6.62	.185	.114	.217	.033	.220
.26	1.982	.323	-.078	.00000	-.906	.224	.329	6.39	.186	.116	.219	.036	.222
.28	1.979	.329	-.073	.00000	-.899	.232	.343	6.17	.187	.118	.221	.040	.225
.30	1.974	.334	-.070	.00000	-.893	.239	.356	5.94	.187	.120	.222	.043	.226
.32	1.967	.340	-.066	.00000	-.888	.245	.367	5.72	.188	.121	.224	.046	.228
.34	1.959	.345	-.062	.00000	-.882	.251	.378	5.50	.189	.122	.225	.048	.230
.36	1.950	.350	-.059	.00000	-.877	.256	.387	5.30	.190	.123	.226	.051	.232
.38	1.940	.356	-.055	.00000	-.872	.260	.396	5.10	.191	.125	.228	.054	.235
.40	1.930	.361	-.052	.00000	-.867	.264	.405	4.91	.192	.125	.229	.056	.236
.42	1.920	.365	-.049	.00000	-.862	.267	.413	4.74	.193	.126	.230	.058	.238
.44	1.910	.370	-.047	.00000	-.858	.271	.420	4.57	.193	.127	.231	.061	.239
.46	1.900	.375	-.044	.00000	-.854	.273	.427	4.41	.194	.128	.232	.063	.241
.48	1.890	.379	-.042	.00000	-.850	.276	.433	4.26	.195	.129	.234	.065	.243
.50	1.881	.384	-.039	.00000	-.846	.279	.439	4.13	.196	.129	.235	.067	.244
.55	1.857	.394	-.034	.00000	-.837	.284	.452	3.82	.198	.131	.237	.071	.248
.60	1.835	.403	-.030	.00000	-.830	.289	.464	3.57	.199	.133	.239	.076	.251
.65	1.815	.411	-.026	.00000	-.823	.293	.474	3.36	.201	.134	.242	.079	.254
.70	1.797	.418	-.023	.00000	-.818	.297	.483	3.20	.202	.135	.243	.083	.257
.75	1.781	.425	-.020	.00000	-.813	.300	.490	3.07	.203	.136	.244	.086	.259
.80	1.766	.431	-.018	.00000	-.809	.303	.497	2.98	.204	.137	.246	.089	.261
.85	1.753	.437	-.016	.00000	-.805	.306	.503	2.92	.205	.138	.247	.092	.264
.90	1.742	.442	-.015	.00000	-.802	.309	.508	2.89	.206	.139	.249	.095	.266
.95	1.732	.446	-.014	.00000	-.800	.312	.513	2.88	.207	.140	.250	.097	.268
1.00	1.724	.450	-.014	.00000	-.798	.314	.517	2.90	.208	.141	.251	.100	.270
1.10	1.710	.457	-.013	.00000	-.795	.319	.523	2.99	.209	.143	.253	.104	.274
1.20	1.701	.462	-.014	.00000	-.794	.324	.528	3.14	.210	.145	.255	.108	.277
1.30	1.696	.466	-.015	.00000	-.793	.328	.532	3.36	.211	.146	.257	.111	.280
1.40	1.695	.469	-.017	.00000	-.794	.333	.535	3.62	.212	.148	.259	.114	.283
1.50	1.696	.471	-.019	.00000	-.796	.338	.537	3.92	.212	.150	.260	.117	.285
1.60	1.700	.472	-.022	.00000	-.798	.342	.538	4.26	.212	.151	.260	.119	.286
1.70	1.706	.473	-.025	.00000	-.801	.347	.539	4.62	.212	.153	.261	.122	.289
1.80	1.715	.472	-.029	.00000	-.804	.351	.539	5.01	.212	.154	.262	.124	.290
1.90	1.725	.472	-.032	.00000	-.808	.356	.538	5.42	.212	.156	.263	.126	.292
2.00	1.737	.471	-.037	.00000	-.812	.360	.537	5.85	.212	.157	.264	.128	.293

The equations are to be used for 5.0 <= M <= 7.7 and d <= 100.0 km.

Table 2: Values of F_a as a function of site conditions and shaking intensity.

Shaking Intensity ⇒ Site Class ⇓	A_a = 0.1 g	A_a = 0.2 g	A_a = 0.3 g	A_a = 0.4 g	A_a = 0.5 g
(A_0)	0.8	0.8	0.8	0.8	0.8
A	1.0	1.0	1.0	1.0	1.0
B	1.2	1.2	1.1	1.0	1.0
C	1.6	1.4	1.2	1.1	1.0
D_1	2.5	1.7	1.2	0.9	(–)[1]
D_2	2.0	1.6	1.2	0.9	(–)[1]
(E)	(–)[1]	(–)[1]	(–)[1]	(–)[1]	(–)[1]

[1] Site-specific geotechnical investigations and dynamic site response analyses should be performed.

Table 3: Values of F_v as a function of site conditions and shaking intensity.

Shaking Intensity ⇒ Site Class ⇓	A_v = 0.1 g	A_v = 0.2 g	A_v = 0.3 g	A_v = 0.4 g	A_v = 0.5 g
(A_0)	0.8	0.8	0.8	0.8	0.8
A	1.0	1.0	1.0	1.0	1.0
B	1.7	1.6	1.5	1.4	1.3
C	2.4	2.0	1.8	1.6	1.5
D_1	3.5	3.2	2.8	2.4	(–)[2]
D_2	3.5	3.2	2.8	2.4	(–)[2]
(E)	(–)[2]	(–)[2]	(–)[2]	(–)[2]	(–)[2]

Site-specific geotechnical investigations and dynamic site response analyses should be performed.