

APPENDIX

APPENDIX D NRCAN SEISMICITY MEMO

Comments from NRCan on Seismicity
(Extracted from Jericho Final EIS Review, dated 12 May 2003)

The project is in a region of very low seismicity, but two magnitude 4+ earthquake recently happened in a similar part of the shield (Magnitude 4.5 and 4.2; November 28th 2001; 64.95N 113.5W; about 140 km SW of the site). These demonstrate that all the seismic hazard does not come from distant earthquakes. Indeed events exceeding magnitude 6.5 are thought possible anywhere in the Canadian Shield, albeit rarely.

The seismic hazard calculation from PGC used to conclude that the overall impact is negligible is what the GSC calculates as being equivalent to the 1995 (and 1985) National Building Code of Canada and is based on GSC's 1982 seismic source zones. It indicates less than 2% g and 0.05 m/s for the 1/1000 year event, from Attachment 3.3. However these results are rather inappropriate (see below). A specific point is that the seismic sources used in 1982 totally neglect all earthquakes within about 400 km of the Jericho site, and so the seismic hazard is computed only from distant sources in Boothia-Ungava and the Nahanni and Mackenzie mountains. Furthermore, the Nahanni earthquakes - earthquakes far larger than any considered by the 1982 model that are relevant to the site - were not included since they happened after the calculations were finalized.

Our "4th generation" seismic hazard calculations for the 2005 edition of the National Building Code of Canada (details available on the WWW at www.seismo.nrcan.gc.ca) uses two probabilistic models that include the consequences of the Nahanni earthquakes and updates other seismicity parameters. NRCan ran a computation for the site at the 0.0001 p.a. probability level and found the hazard from these two models to be negligible.

A better representation of seismic hazard at the site considers instead the occurrence of large earthquakes in the Canadian Shield as a whole, and in worldwide shields of similar age. NRCan has concluded that:

- the maximum earthquake credible would have magnitude 6 3/4;
- current knowledge does not permit the screening out of shield areas that could have earthquakes of this size, so they should be considered as low probability events anywhere on the Canadian Shield;
- a reasonable design earthquake for the shield would be magnitude 6.0; and
- the rate of magnitude 6.0 or greater is estimated to be 0.004 p.a. per 1,000,000 square kilometres.

For the probability level of 0.001 p.a., the M6 earthquake could be expected to occur within an area of 250,000 km*km, equivalent to a circle of radius 280 km about the site. For the probability level of 0.0001 p.a., the earthquake could be expected to occur within an area of 25,000 km*km, equivalent to a circle of radius 90 km about the site. Thus by this analysis, the mine should cope with a magnitude 6 earthquake at a distance of 280 km (estimated Peak Ground Acceleration of about 1% g and PGV of 0.004 m/s, on a rock site) or possibly 90 km (Peak Ground Acceleration of about 5% g and PGV of 0.01 m/s, on a rock site). For comparison, NRCan computed the largest Nahanni earthquake (M6.9 at about 600 km distance) might have produced a little less than 0.3% g.

NRCan has incorporated a comparable probabilistic analysis into our NBCC 2005 work as a third model representing the shield earthquakes. The probabilistic hazard values for NBCC will be 6% g for a probability of 0.000404 per annum (2% in 50 years).

NRCan concludes that a safety check against the shaking from these rare large shield earthquakes which may occur close to the site would be prudent.

Seismic Hazard Analysis for Contwoyto Lake, Nunavut

prepared by Alison Bird, Seismologist

What follows is a detailed hazard assessment of the site near Contwoyto Lake, Nunavut (65.997°N, 111.475°W). The approach for this site is somewhat different to that of sites addressed in the past as it does not lie in the vicinity of any large active faults for which a maximum possible earthquake could be determined. This site instead lies within the 'stable craton' of central Canada, with a 'floor' level of potential seismic activity.

It should be noted that neither site conditions nor structural engineering are considered in this analysis.

RECORDED EARTHQUAKES

All seismicity which has been located in the region since 1898 (when the first seismographs were installed in western North America) is shown on the map in Figure 1. The Contwoyto Lake site is indicated with a red triangle. Note that although the level of recording in this region has, until recent years, been minimal, any earthquake which could be expected to cause damage would have been recorded during the past century. There have been few events, all less than magnitude 5; seismic activity in this region is generally thought to be caused by post-glacial rebound:

Date yyyy mm dd	Time hhmm ss.s	Lat	Lon	Depth km	Mag
1963 06 05	0131 37.0	66.500	-110.000		3.10
1966 01 10	0428 20.0	66.250	-111.830		4.60
1966 01 19	0710 20.0	67.830	-107.670		3.70
1966 04 19	0520 59.0	66.750	-111.000		2.50
1976 10 21	1750 56.0	68.060	-109.930	18.00F	2.90
1983 03 23	1147 23.0	65.690	-111.560	18.00F	3.30
2001 11 28	0411 14.2	64.914	-113.666	20.00F	3.90
2001 11 28	0418 39.6	64.957	-113.660	20.00F	4.50

PROBABILISTIC ANALYSIS

The current standard probabilistic analysis of the Contwoyto Lake site was sent to Mr. Robertson on September 3rd. The results are also presented below:

Return Period (years)	100	200	475	1,000
Probability of Exceedence per annum	0.010	0.005	0.0021	0.001
Probability of Exceedence in 50 years	40%	22%	10%	5%
Peak Horizontal Ground Acceleration (g)	0.009	0.011	0.013	0.016
Peak Horizontal Ground Velocity (m/s)	0.027	0.032	0.040	0.047

The zoning for this site, using the 1990 NBCC/CNBC, is Acceleration Zone 0, corresponding to 0.00-0.04 g; Velocity Zone 0, corresponding to 0.00-0.04 m/s. These figures are for a probability level of 10% in 50 years.

Extrapolated Values

If the above data is presented in a log-log plot, it can be extrapolated to determine a peak ground acceleration (PGA) of 0.030 g and peak ground velocity (PGV) of 0.090 m/s, for a return period of 10,000 years (Figure 2). It should be noted that extrapolation to this return period is outside the realm of the NBCC and should be taken only as a rough approximation.

Proposed values for new National Building Code

As mentioned above, the site near Contwoyto Lake lies within the 'stable craton' of central North America, which has too few earthquakes to define reliable source zones. Previous hazard maps (as used in the current probabilistic analysis presented above) considered only ground motions generated from distant sources. Understanding of seismicity in the stable shield or core regions of continents, using global examples, has lead to revised values and the development of a 'floor' level of seismic hazard which has been incorporated into proposed models which will form the basis of the 2005 edition of the National Building Code of Canada (Adams *et al.* 2003). This assumes large earthquakes could occur anywhere in Canada.

What follows are the proposed NBCC 2005 median values for Site Class C (firm ground) 2%/50 year (equivalent to 1/2475 years or 0.000404 per annum probability) values for your region of interest. Peak acceleration (PGA) and 5% damped spectral acceleration values are expressed in terms of g.

Location	Sa(0.2)	Sa(0.5)	Sa(1.0)	Sa(2.0)	PGA
Contwoyto Lake, NU	0.12	0.056	0.023	0.006	0.059

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