APPENDIX 2: BOLIDE FREQUENCY AND MAGNITUDE

The flux of small near-Earth objects colliding with the Earth follows a power-law distribution (Brown et al., 2002). The cumulative number N of objects colliding with the Earth each year with diameters exceeding D is given by:

logN = 1.57(±0.03) – 2.70(±0.08)•logD **Equation A 2.1**

or in terms of energy, E (in kilotons):

logN = 0.568(±0.015) – 0.90(±0.03)•logE **Equation A 2.2**

(One kiloton TNT equivalent is 4.185 x 1012 Joules).

The flux is more-or-less uniformly distributed over Earth's surface, and so the proportion falling on any smaller area is approximately in direct proportion to the ratio of areas. The area within a 1000 km radius of Wellington is ~0.62% of the Earth's surface, and the area within a 3000 km radius is ~5.54% (we choose these two distances arbitrarily for the purpose of illustration). A larger bolide could cause a dangerous tsunami from a more distant ocean impact than a smaller bolide.

To estimate the potential of these bolides to generate tsunami, we use the relationship between kinetic energy, mass and velocity (E=½mv2), and assume that they transfer 50% of their energy to create a water wave (much water is heated and some is vaporised). Hence the mass of water (M kg) displaced is given by:

M= 4.185 x 1012V-2•100.63(±0.04)-1.11(±0.04)logN **Equation A 2.3**

In deep water, the wave speed (V) is ~200 m/s. It is unlikely that the efficiency of transfer of kinetic energy on impact with water is as great as 50%. A portion of the energy of the bolide is lost in its passage through the atmosphere; this is 100% for smaller than fist-sized bolides. Above a few tens of metres in diameter, energy is also consumed in forming a crater in the sea floor. Hence the estimation of the probability of displacement of a given volume of water is conservative with respect of public safety. Again to be conservative, we ignore the salt content of sea water to estimate the volume of displaced sea water (Figure A 2.1).

Within the probability horizon of our calculation of risk, out to a probability of once in a few thousand years, bolide-impact tsunami do not feature as a significant risk; they are lost in the background noise below other large and more probable events. But at longer event horizons, bolide tsunami are the largest tsunami waves that can hit large areas of the New Zealand coast. There is, however, a bolide size at which a tsunami is not the most significant effect of the collision. Such large events are not only conceivable, they are known to have occurred a number of times in Earth's history.

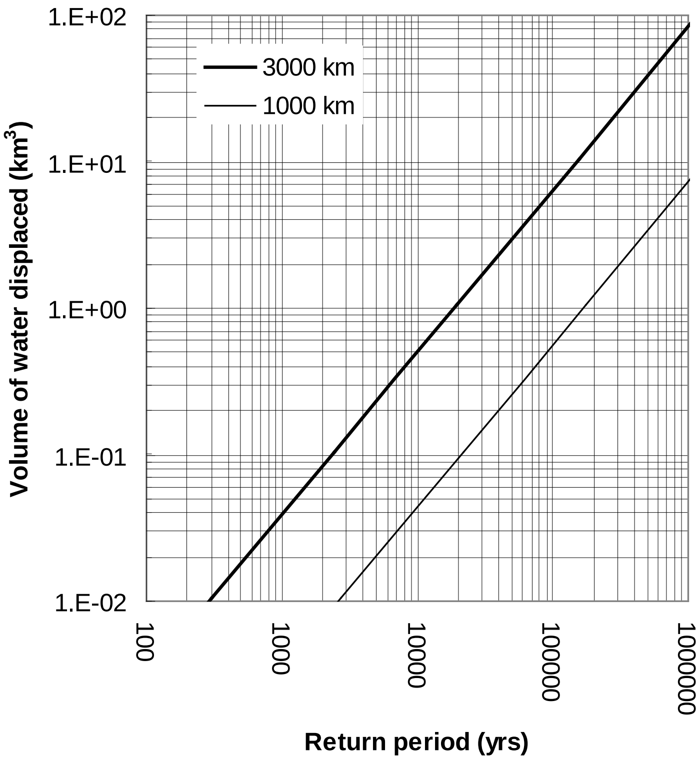

Figure A 2.1 Estimated volume of water displaced by a bolide hitting ocean within 1000 and within 3000 km of Wellington for various return periods. A displaced volume of less than 0.1 cubic kilometres is not likely to produce a damaging tsunami, and hence bolides are not a factor warranting concern in New Zealand's tsunami risk. In the rare event of a large Near Earth Object colliding with the Earth, a warning time of weeks to months is available with current technology.

Because all larger Near Earth Objects are identified and tracked, warnings can be issued. Hence, unlike any other tsunami, the possibility exists to know of the likelihood of generation of a specific bolide tsunami weeks or months in advance of the event.