SUPPLEMENTAL TESTIMONY CF JOHN KELLEHER
RELATING TO ESTIMATES OF STRONG GROUND MOTION

This supplemental testimony is to respond to the request of the Board for additional information on methods of determining ground motion parameters. Initially the staff would note that no technique for estimating strong ground motion is clearly superior to other methods under all conditions. The choice of method is usually determined by the type of information available for the specific seismic hazard or by site specific considerations. However, to help the Board in its understanding of the different techniques to estimate ground motion, we provide some site specific remarks on the Skagit site and some general remarks describing the position of the staff on techniques of estimating ground motion.

1. Large earthquakes occurring within the near surface environment ($H \leq 15KM$) are typically accompanied by surface rupture or surface faulting. For the specific evaluation of the SKAGIT site for potential sources of strong motion an important consideration is the virtual absence of evidence inferring surface faulting. Indeed with the possible exception of a location on the Olympic Peninsula there is no evidence that surface rupture has ever accompanied a large shock during Quaternary time throughout the entire province in which the site is location.[1] Thus while surface faulting cannot be categorically precluded the evidence indicates that it is minor or absent throughout most of the province and that there is no reason to anticipate major release of seismic energy in a near-surface environment.

[1] The staff considers the Skagit site to be in the tectonic province formed by the overriding continental lithosphere and bounded on the north by an extension through Vancouver Island of the zone of decoupling between the Explorer and Juan de Fuca plates, on the south by the zone of transition associated with the Mendocino triple junction, on the east by the volcanic chain and on the west by oceanic lithosphere of the Pacific plate. The bounds are not included in the province.

1258 345

7911020/05

By way of contrast, major earthquakes in central or southern California commonly are accompanied by surface faulting; major energy release has typically occurred at depths of 10 km or less.

The significance of this tectonic feature is that earthquakes of given magnitudes which have caused the most serious destruction have been extremely shallow earthquakes usually accompanied by surface faulting. For example the Tangshan, China earthquake of 1976 (M=7.6) and the Managua, Nicaragua earthquake of 1972 (M=6.4) caused great devastation. These earthquakes had major seismic energy release at extremely shallow depths as evidenced by the surface rupturing in the central part of the respective cities. By contrast the largest earthquakes of the tectonic provinces of the northwest have consistently occurred at the base of the crust or below. Even for the largest earthquakes of the northwest no single observation of intensity has ever exceeded MM VIII. A key consideration, therefore, in the site specific evaluation of the proposed Skagit facility is the absence of any evidence suggesting the likelihood that large earthquakes would be accompanied by surface faulting and by inference by major seismic energy release in the near surface environment.

2. Some studies have estimated relationships among earthquake magnitude, distance and peak horizontal ground acceleration. Such studies include Schnabel and Seed (1973), Trifunac and Brady (1976), and U.S. Geological Survey Circular 795. Other studies have provided correlations between peak ground accelerations and seismic intensity. These include Trifunac and Brady (1975) and Murphy and O'Brien (1977).

1258 346

These latter sources are used if only intensity information is available, while the other studies are useful if estimates can be made of source parameters such as magnitude, focal depth and distance to generating structure.

If instrumental determinations of magnitude exist, then estimates of strong ground motion relationships should be used such as Schnabel and Seed (1973), Trifunac and Brady (1976) or U.S. Geological Survey Circular 795. If no instrumental determination of magnitude exists for earlier earthquakes, then intensity estimates are the most direct kind of information. In such cases intensity-ground motion relationships such as Trifunac and Brady (1975) or Murphy and O'Brien (1977) should be used.

No instrumental determination of magnitude is available for the 1872 earthquake of the Pacific Northwest. Only intensity estimates are available and these are generally sparse. The staff concluded that the maximum intensity associated with the 1872 earthquake was intensity VIII MM. For reasons discussed below, the estimate of Trifunac and Brady (1975) of .25 g for intensity VIII MM would provide a conservative reference for the specific purpose of bounding the ground motion associated with the 1872 earthquake in accordance with Reg. Guide 1.60.

In the original Safety Evaluation Report (SER) the staff compared the 1872 earthquake to a series of attenuation curves for an earthquake of magnitude 7.5. This was done because at that time the series of attenuation curves (PSAR for WPPSS No. 3 Figure 2-5-57b) was the most complete set available. The set of curves was compiled for earthquakes of magnitude 7.5. Thus even though the magnitude of 7.5 was larger than any estimated for the 1872 earthquake, the completeness of the set of curves justified some comparison. At no time, however, did the staff make a determination that the 1872 earthquake was of magnitude 7.5 and this fact was so stated in the SER.

The study by Murphy and O'Brien (1977) probably provides better estimates of actual peak acceleration at various intensities than does the study by Trifunac and Brady (1975). The reason is that Murphy and O'Brien (1977) had a larger data set and improved statistical techniques. Nevertheless, the more conservative relationship of Trifunac and Brady (1975) is considered more appropriate for setting reference accelerations because at intensities V, VI and VII the Reg. Guide 1.60 spectra determined by the mean of the peaks (i.e., the method of Trifunac and Brady) falls between the mean and 84th percentile spectrum for the frequencies of interest (Agbabian Associates, 1977). For intensity VIII, Trifunac and Brady (1975) appears to be conservative for their cited data set, in that the mean of observed peak accelerations is .167 g whereas their relationship predicts .256 g.

3. For near field location of earthquakes (within about 10 km for M=6 and within about 20 km for M=7), there is no generally accepted method for estimating strong ground motion. Each such situation requires an extensive and specific examination. For earthquake locations between approximately 20 or 30 km to 100 km there is reasonable agreement on estimates of strong ground motion among many recent studies including Schnabel and Seed (1973), Trifunac and Brady (1976) and the U.S. Geological Survey Circular 795.

1258 348