EARTHQUAKE RISK FACTORS AT THE COLUMBIA GENERATING STATION (formerly known as WPPSS WNP-2)

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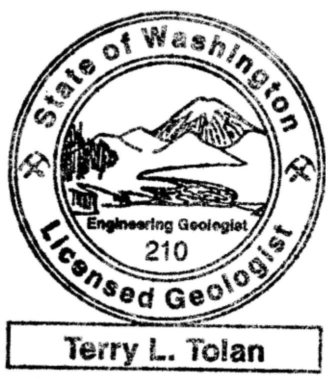

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ORIGINAL EARTHQUAKE HAZARDS/RISK ASSESSMENT

The original earthquake risk assessment for the Columbia Generating Station (then known as "Washington Nuclear Power unit number 2" or "WNP-2") was done more than 30 years ago over a period from about 1974 to 1981. The primary goal of this work was to develop a quantitative estimate of the maximum vibratory ground motion expected at this site from the maximum credible earthquake. This estimate of maximum vibratory ground motion would be used to design the Columbia Generating Station.

Their analysis of historical "felt" and instrumentally recorded earthquakes for the Columbia Generating Station (CGS) was used to determine magnitude and location of the largest historical earthquakes to hit this region. From historical accounts the December 14, 1872 earthquake was the largest earthquake to occur in the Pacific Northwest. Few seismographs existed in the Pacific Northwest region to record the "1872 earthquake", but based on historical accounts of the earthquake duration and damage patterns, it has been estimated to have been a M 6.5 to 7.4 (WPPSS, 1981; Bakun et al., 2002). The exact location of the epicenter for the 1872 earthquake was unknown, but based on the 1981 Washington Public Power Supply System analysis (accepted by the Nuclear Regulatory Commission, 1982) it was assumed to be in the North Cascades likely at least 180 miles from the Columbia Generating Station (WPPSS,1981). Given the distance of the 1872 earthquake epicenter from the Columbia Generating Station, its potential importance to seismic risk was greatly reduced with respect to smaller magnitude earthquakes that had epicenters closer to the Columbia Generating Station.

The earthquake that was selected for the Columbia Generating Station design (would have created the maximum vibratory ground motion at the site) was the M5.7 to 6.1 July 16, 1936 Milton-Freewater earthquake. The epicenter for this earthquake was located approximately 55 miles southeast of the Hanford Site within the Walla Walla Valley, but no faults were known to exist at this location. The estimated maximum vibratory ground motion from the 1936 Milton-Freewater earthquake at the Columbia Generating Station site would have been **0.015 g** (WPPSS, 1981, p 2.5-139).

To capture the potential seismic risk from earthquakes on unknown faults, their assessment assumed that a 1936 Milton-Freewater earthquake might potentially occur anywhere within a 16 mile radius of the Columbia Generating Station site (WPPSS, 1981). A peak vibratory ground motion of **0.25 g** for Columbia Generating Station site was derived from their analysis and was assigned as the "Safe Shutdown Earthquake" to be consistent with "*conservatism previously adopted for design criteria at the Hanford Reservation"* (WPPSS, 1981, p 2.5-139). The peak vibratory ground motion of **0.125g** was assigned as the "Operating Basis Earthquake" which is one-half that of the Safe Shutdown Earthquake.

Mapping and analysis of geologic structures (faults and folds) was conducted and their potential to generate earthquakes was also assessed. Based on the state of geologic knowledge at that time, it was determined that no **capable faults**[1] existed within a 5 mile radius of the Columbia Generating Station (WPPSS, 1981) and "… *surface faulting is not a factor in the design of the plant.*"(WPPSS, 1981, p 2.5-143). Their seismic risk assessment also included a panel of experts who evaluated all known geologic structures (faults) that might potentially generate earthquakes which could impact the Columbia Generating Station. Based on their review, six Yakima Fold and Thrust Belt geologic structures were identified as potential seismic (earthquake) sources (WPPSS, 1981). These six Yakima Fold and Thrust Belt structures were (highlighted in brown on Figure 1) :

1. Umtanum Ridge-Gable Mountain
2. Rattlesnake Ridge-Wallula Alignment
3. Horse Heaven Hills
4. Rattlesnake Hills
5. Yakima Ridge
6. Saddle Mountains

Their evaluation of these six geologic structures concluded that potential earthquakes generated by these sources would most likely fall within a less than M4 to M6 range with a low likelihood of potentially larger magnitude earthquakes (M6 to greater than M7; WPPSS, 1981, Appendix 2.5K). Given the *apparent* low probabilities of earthquakes of significantly large magnitude (greater than M6), relative distance of the earthquake-source structures from the Columbia Generating Station (assumed attenuation of vibratory ground motions), and probable frequency of recurrence of earthquakes of various magnitudes on these geologic structures it was concluded that there was a very low annual probability of exceedance (0.00011) of the **0.25** g vibratory ground motion threshold of the Safe Shutdown Earthquake for the Columbia Generating Station.

[1] As defined by Nuclear Regulatory Commission (NRC) Regulations (10 CFR, Appendix A, Part 100, III (g) 1, 2, 3) "A ***capable fault*** is a fault which has exhibited one or more of the following characteristics: (1) Movement at or near the ground surface at least once within the past 35,000 years or movement of a recurring nature within the past 500,000 years; (2) Macro-seismicity instrumentally determined with records of sufficient precision to demonstrate a direct relationship with the fault; (3) A structural relationship to a capable fault according to characteristics (1) or (2) of this paragraph such that movement on one could be reasonably expected to be accompanied by movement on the other. In some cases, the geologic evidence of past activity at or near the ground surface along a particular fault may be obscured at a particular site. This might occur, for example, at a site having a deep overburden. For these cases, evidence may exist elsewhere along the fault from which an evaluation of its characteristics in the vicinity of the site can be reasonably based. Such evidence shall be used in determining whether the fault is a capable fault within this definition. Notwithstanding the foregoing paragraphs III(g) (1), (2), and (3), structural association of a fault with geologic structural features which are geologically old (at least pre-Quaternary) such as many of those found in the Eastern Region of the United States shall, in the absence of conflicting evidence, demonstrate that the fault is not a capable fault within this definition."

THIRTY YEARS OF NEW GEOLOGIC KNOWLEDGE ON SEISMIC HAZARDS AND RISK

Since the Columbia Generating Station's seismic risk assessment was completed in 1981, numerous geologic investigations of the Hanford Reservation and surrounding region have been conducted by U.S. Geological Survey, Federal government contractors, Battelle Pacific Northwest National Laboratory, State of Washington, and Universities. The outcomes of these studies conducted over the past thirty years have piled up the geologic evidence that indicates the original Columbia Generating Station's seismic risk assessment significantly under estimated the potential risks to the reactor and associated structures. This evidence includes:

- More detailed geologic mapping of the folds and faults in the region surrounding the Columbia Generating Station site. This work has shown that the folds and faults considered in the seismic risk assessment by WPPSS (1981) have significantly longer lengths (highlighted in red in Figure 1) and evidence of geologically " young" (Quaternary age) displacement on associated faults (e.g., see USDOE, 1988; Kienle, 1980; Campbell, 1989; Campbell and Bentley, 1981; Campbell et al., 1995; Geomatrix, 1990, 1996; Reidel, 1984, 1988; Reidel and Fecht, 1994a,b; Mann and Meyers, 1993; Reidel et al., 1994; Caggiano and Duncan, 1983; Watters, 1989; Schuster et al., 1997; Stoffel et al., 1991; West et al. 1995, 1996; West and Shaffer, 1989; Wood-Clyde Consultants, 1989; Blakely et al., 2011). Geologically "young" faults are indicators of relatively recent "earthquakes". Longer fault lengths also indicate that these longer faults may be capable of producing much larger magnitude earthquakes.

- Additional Yakima Fold and Thrust Belt structures were identified that could potentially generate earthquakes that could pose a risk to the Hanford Site and the Columbia Generating Station facilities (USDOE, 1988; Geomatrix, 1990, 1996). These additional "faults" included (highlighted in purple and red on Figure 1):

    - Frenchman Hills
    - Manastash Ridge
    - Toppenish Ridge
    - Columbia Hills
    - Hog Ranch-Naneum Ridge
    - Hite Fault

- The potential significance and importance of the M6.5 to 7.4 "1872 Earthquake", the largest historical earthquake to hit this region, to seismic risk analysis at the Columbia Generating Station was greatly reduced because the assumed location of the epicenter for this event was more than 180 miles away (WPPSS, 1981). Investigation of the "1872 Earthquake" by Bakun et al. (2002) determined that the epicenter for this event was located too far north by WPPSS (1981) and that the likely epicenter location for this earthquake is at the southern end of Lake

Chelan just north of Entiat, Washington. The revised location for the epicenter of the "1872 Earthquake" places it approximately 99 miles from the Columbia Generating Station.

- Subsequent seismic risk assessments performed for the U.S. Department of Energy for the Hanford Site that factored in newly available structural geology data (e.g., Geomatrix, 1996) and generated estimates of peak vibratory ground motions were significantly higher than those used by WPPSS (1981) for the Columbia Generating Station site. The Geomatrix (1996) estimates of peak vibratory ground motion of 0.50 g was initially used in the design of the Waste Treatment Plant (WTP or "vit plant") facility which is located approximately 10 miles east of the Columbia Generating Station site. New information about earthquake hazards developed since the Geomatrix (1996) study forced the U.S. Department of Energy to suspend work on the WTP facility to allow for new data collection and an updated seismic hazard/risk assessment to be performed. The new WTP seismic assessment (Youngs, 2007; Rohay and Brouns, 2007; Rohay and Reidel, 2005) determined that the previous vibratory ground motion estimate of **0.50 g** needed to be increased to **0.80 g.** Based on this new seismic hazard/risk analysis the U.S. Department of Energy ordered significant modifications to be made to the WTP facility in 2007.

- In July 2010, a letter from the Nuclear Regulatory Commission to Energy Northwest (Letter dated July 13, 2010, NRC to W.S. Oxenford (Energy Northwest", Request for Additional Information for the Renewal Application – SAMA Review (ADAMS Accession No. ML 101760421) requested that Energy Northwest address the NRC concerns that the most recent seismic risk study for the Columbia Generating Station (from 15 years ago) had failed to address more recent geologic findings and increased seismic risk as determined for the WTP facility (Youngs, 2007). Energy Northwest responded to this issue in a September 2010 letter (Letter dated September 17, 2010, S.K. Gambhir (Energy Northwest) to U.S. Nuclear Energy Commission; p.39-42) and indicated that there were distinct geologic differences between the WTP Site and the Columbia Generating Station site that includes the Columbia Generating Station site's "increased distance from nearby seismic sources" and different subsurface geology conditions. The fact is that the WTP facility and the Columbia Generating Station sites are geographically and geologically linked and similar, being separated by only 10 miles, and yet no modifications have been made to the Columbia Generating Station to address the increased risk from strong seismic vibratory ground motion.

- In 2011 the U.S. Geological Survey published a paper that will likely fundamentally change several of the key assumptions that past seismic risk assessments were based upon. These "game changers" include:

  1. The maximum length of some of the Yakima fold and thrust belt structures have been previously under estimated. Generally longer faults are considered to be capable of generating larger earthquakes than shorter faults. Their

paper focused on Umtanum Ridge (Gable Mountain) which they were able to trace through the Cascade Range to where it merges with Quaternary ("active") faults (e.g., Southern Whidbey Island and Seattle faults) in the Puget Sound area. Based on their work the Umtanum Ridge structure increased from about 77 miles to more than 124 miles in length.

2. Their data indicated that the Umtanum Ridge fault is not just confined to the Columbia River basalt as assumed by some previous models ("thin-skin fault model), but extends below the Columbia River basalt into the "basement rock" (thick-skin fault model). This indicates that the Umtanum fault plane potential rupture area is far greater than expected and could produce larger magnitude earthquakes than previously assumed.

3. At several locations along the Umtanum Ridge trenching of surface scarps revealed evidence of geologically recent faulting indicating that this structural feature may be more seismically active than previously believed.

None of the more recent findings of Blakely et al. (2011) have been factored into any of the present Hanford Site seismic assessments or the U.S. Geological Survey (2008) seismic hazards maps. However, this new information will be factored into the new probabilistic seismic hazards analysis being conducted by the U.S. Department of Energy for the Hanford Site that is scheduled to be completed in 2014.

SUMMARY

When the Columbia Generating Station (WPPSS WNP-2) was designed and constructed thirty years ago, WPPSS (now Energy Northwest) assured the Nuclear Regulatory Commission that their facility could safely survive the worst potential earthquake that could impact this site.

Geologic studies conducted over the past thirty years have piled up a large volume of geologic evidence that indicates that the original design basis for the Columbia Generating Station's seismic risk assessment significantly under estimated the potential earthquake risks. Recent U.S. Department of Energy earthquake risk assessments for the Hanford Site completed in 2007 that use this new geologic evidence has significantly *raised the estimates of peak vibratory ground motion from large magnitude earthquakes to more than triple the 0.25 g peak vibratory ground motion for Columbia Generating Station site*. Recent U.S. Geological Survey study (Blakely et al., 2011) presented geologic and paleoseismic evidence that the potential for large magnitude earthquakes (greater than M 7) could be much greater for eastern Washington (and the Columbia Generation Station site) than previously assumed.

No seismic structural upgrades have been made at the Columbia Generating Station despite all of the geologic evidence that has been assembled over the past thirty years which has dramatically increased the seismic risk at this site.

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