GEOLOGIC HAZARDS REVIEW

TROJAN NUCLEAR POWER PLANT SITE

COLUMBIA COUNTY, OREGON

OPEN FILE REPORT O-78-1

STATE OF OREGON

DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

March 14, 1978

ERRATA

p. 12, line 12 - Change to read. . . .Coombs and Ivey reviewed all major lineaments surrounding the site.

p. 12, line 15 - Remove (1972).

Bibliography

Add - Coombs to Itschner, June 16, 1970, A geologic reconnaissance of Trojan Nuclear Plant Site.

ERRATA

p. 12, line 12 - Change to read. . . .Coombs and Ivey reviewed all major lineaments surrounding the site.

p. 12, line 15 - Remove (1972).

Bibliohraphy

Add - Coombs to Itschner, June 16, 1970, A geologic reconnaissance of Trojan Nuclear Plant Site.

ERRATA

p. 12, line 12 - Change to read. . . .Coombs and Ivey reviewed all major lineaments surrounding the site.

p. 12, line 15 - Remove (1972).

Bibliography

Add - Coombs to Itschner, June 16, 1970, A geologic reconnaissance of Trojan Nuclear Plant Site.

TABLE OF CONTENTS

INTRODUCTION

On January 18, 1978, the State of Oregon Department of Energy requested the assistance of the Oregon Department of Geology and Mineral Industries in the evaluation of geologic information relating to the Trojan nuclear power plant site. The specific purpose was to determine whether there were any new facts which reflected on the safety of temporary spent fuel storage or plant operation. A presentation of the findings of the review was requested for the Energy Facility Siting Council in late February or on March 14, 1978.

This report summarizes the conclusions, recommendations, and findings formulated by the Oregon Department of Geology and Mineral Industries in responding to these specific requests.

A concerted effort was made to collect all available information on the Trojan Site and to interpret that data dispassionately. The procedure followed in the investigation included the following elements:

(1) Data collection including solicitation of new information from a variety of persons and agencies (Attachments C and D).

(2) Identification of plausible hazards including regional and local faults, earthquakes, microearthquakes, mass movement, volanic hazards, and floods.

(3) Interpretation of data pertaining to plausible hazards and including geologic analysis and interviews with a variety of persons, both public and private.

(4) Summarization of findings and development of conclusions and recommendations.

A list of references consulted in this investigation is included at the conclusion of this report.

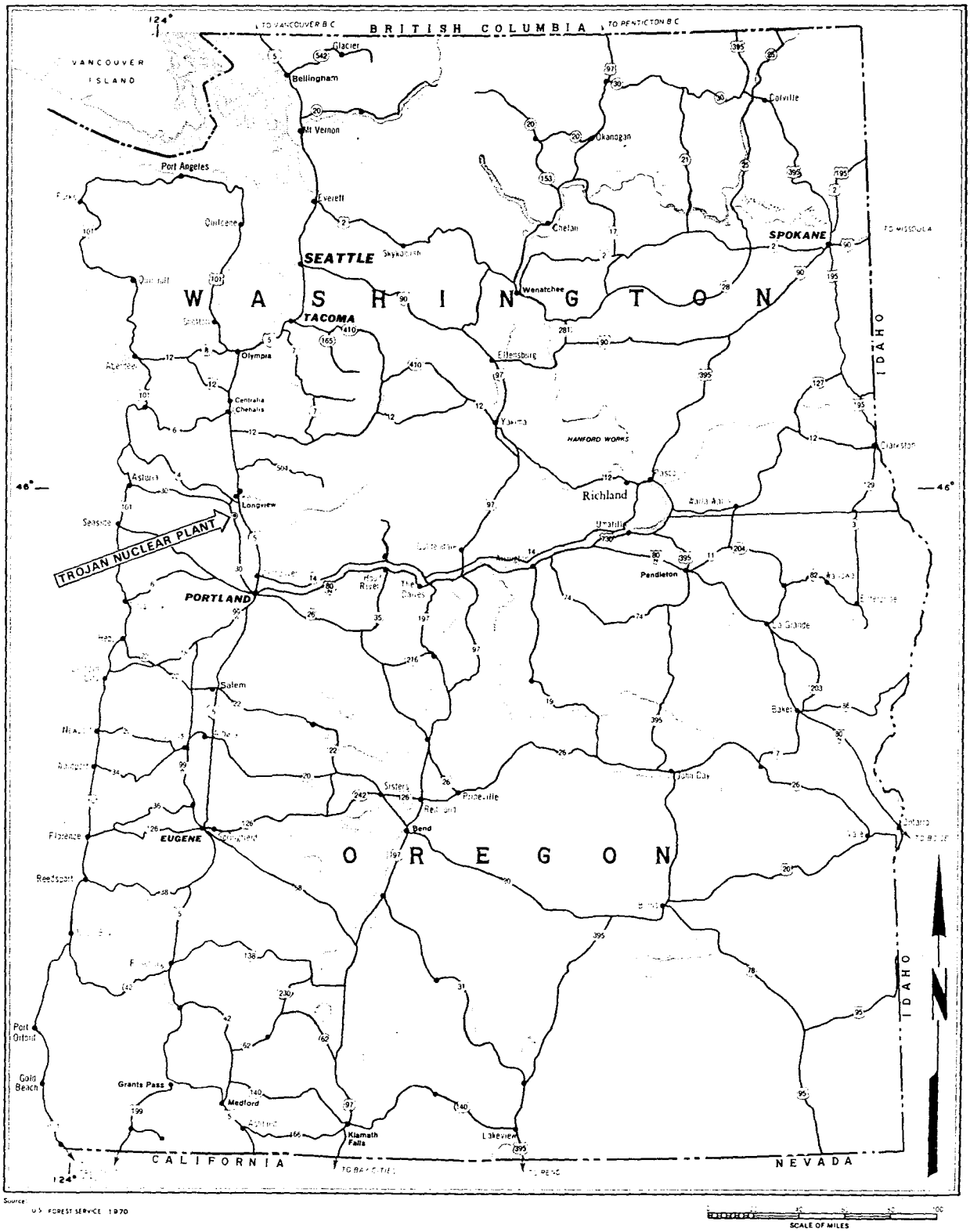
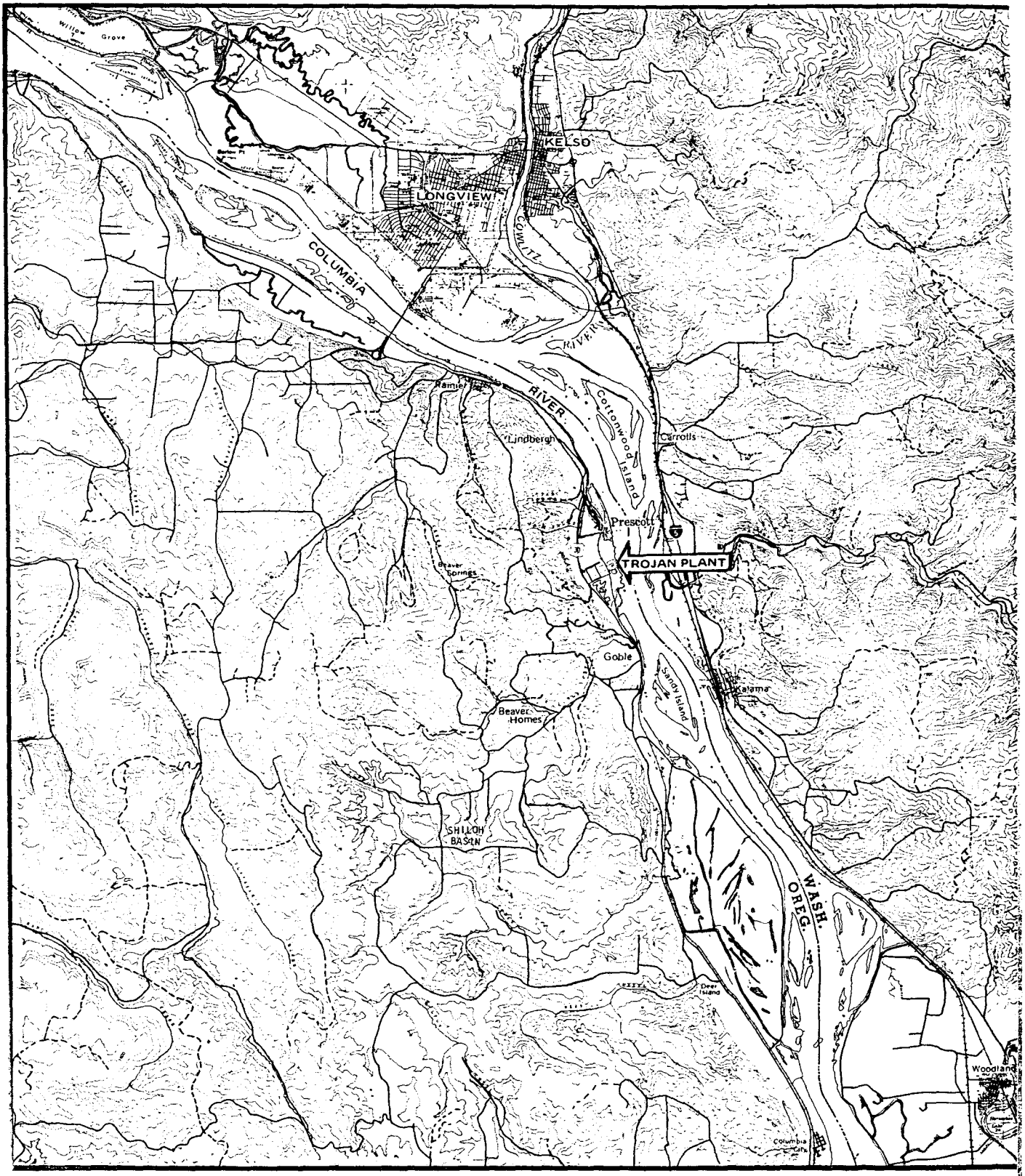


Figure 2.1-1 Regional Map
from FSAR



Source: U. S. Geological Survey, 1953.

from FSAR

CONCLUSIONS

Geologic understanding of Oregon is continually evolving as new data, new techniques of analysis, and new models of the earth's crust are developed. Final analysis of the adequacy of any site in an absolute sense is therefore not possible. However, best conclusions in terms of given standards at given points in time are possible. Periodic review can insure that new data are considered. Available geologic data viewed collectively support the following conclusions at this time:

(1) Faults are tectonic structures along which differential slippage of earth materials has occurred parallel to the fracture plane. Lineaments, tectonic stress fields, and plate tectonic theories are commonly linked with one another to produce structural hypotheses of regional scope. Although these hypotheses guide our evaluations of a site, they do not replace the site specific data gained from traditional mapping techniques.

(2) No active faulting affecting Quaternary units in the area surrounding the site is evident, although geologic maps are available on a variety of scales. In addition, no lineaments cross Quaternary units based on presently available information. Geophysical studies, including gravity studies, reveal no large faults passing through the slough area or beneath the Columbia River. It is worth noting that similar gravity studies strongly suggest faulting in the Portland area.

(3) No new seismic data are available to change the conclusion in the Trojan FSAR that potential seismicity of the site area, as indicated in the historic record and in the regional distribution of seismic events, is adequately portrayed in site design.

(4) A microearthquake study at this time would probably produce ambiguous results in view of expected high noise levels, low historic seismicity, and poorly defined objectives in terms of defined structures or seismic event clustering.

(5) Mass movement does not pose a threat to the facility.

(6) Floods of meteorologic and dam collapse origin are adequately considered in the Trojan FSAR document.

(7) Potential volcanic activity does not pose a significant threat to the facility.

(8) Recently developed information on the possibility of landslide dam release of water upstream on the Columbia River (Portland General Electric, 1978) reasonably supports the conclusion that landslide dam release does not pose an undue threat to the facility.

(9) The most significant geologic data and information that we can foresee being developed within the earth science community in the future include: (1) more precise data on laterites and Pleistocene units, (2) improved recognition and interpretation of lineaments and better definition of northwest and northeast trending structures that may exist, (3) a more complete seismic record for the State through the operation of a statewide seismic

net, (4) more complete information on landslide dams along the Columbia River, (5) more precise province definition, and (6) more precise tectonic models. We respectfully request the opportunity to review our conclusions in the event that new information contradicts them and/or necessitates additional studies.

In summary, we know of no geologic reason, based on presently available information. to reasonably question the geologic adequacy of the site for safe plant operation or for temporary storage of spent fuel. The various findings leading to these conclusions are described below.

RECOMMENDATIONS

Due to the ever increasing volume of pertinent geologic data in Oregon, it is recommended that the Energy Facility Siting Council consider the systematic and periodic review of the geology of the Trojan Site on regular intervals of possibly ten years, or more frequently if significant new data so require, or if licensing procedures so require.

Clear definition of agency responsibility for requesting and initiating such reviews of available new data and clear definition of the means of financing of such periodic reviews is needed.

FINDINGS

Faults

A fault is a tectonic structure along which differential slippage of the adjacent earth materials has occurred parallel to the fracture plane. Faults can be speculated on the basis of linear features identified by remote sensing techniques. Although movement has not been demonstrated along these features, such movement is regarded as possible.

Plate tectonic theory, as it is applied to the northwestern part of the United States, is suggestive of many zones of large scale displacement or otherwise structural significance. Included are a variety of tectonic models for the northwest trending Brothers Fault Zone (historically not active) in central Oregon and its possible extension to the northwest or the southeast. Also included are the possibility of major north-south structures which truncate the Brothers Fault Zone at its presently mapped extremities, and the possibility of northeast trending displacements or structural zones. Plate tectonic models of these sorts guide our inquiry into the seismicity of given regions, but do not supplant more rigorous data with regard to given sites.

Lineaments are features at the earth's surface with a variety of plausible interpretations and explanations as to their origin and structural geologic significance. Lineaments of regional extent commonly are linked with plate tectonic theories to produce hypotheses of regional displacement for later checking in the field. Regional lineaments of structural significance may represent primary structures, secondary

structures, active structures, inactive structures, or assemblages of structures, each of which is subject to a wide variety of interpretive models available for more critical analysis.

With regard to plate tectonic theory and the identification of lineaments, it is noteworthy that northwest trending lineaments have been identified in northwest Oregon and may represent a zone of one or more faults including the Portland Hills Fault. Recent interpretations also suggest that the fault zone in the Portland area may consist of a series of en echelon faults of 10 to 15 kilometers length. The existence of a Portland Hills Fault has been fairly well established by personnel of the Department of Earth Sciences at Portland State University. The significance of linear features of northwest trend outside the Portland metropolitan area generally has not been established as well in terms of structural origin or possible fault activity.

Other linear trends of undetermined significance are also noted. Researchers at Oregon State University have noted the presence of northeast trending lineaments of undetermined significance in the northwestern part of Oregon and southwestern Washington. They state that the lineaments at present pose no serious questions as to the geologic suitability of the Trojan Site.

Corcoran (October 16, 1970) speculated that the Queen Charlotte Island Fault may extend south of its present mapped distribution as does Groh (March 21, 1970) in an earlier memo to Corcoran. Recent progress in the definition and interpretation of seismo-tectonic provinces indicates that this particular speculation is not now supported by the facts.

Regional Faults

The tectonic map of North America (King, 1969) indicates a hypothetical fault along the Columbia River in its north trending segment which passes by the Trojan Site. A later version of the map by the same author produced in 1974 does not show such a fault. The State geologic maps of Oregon and Washington show no fault at this location. Present information on the lineament trend in question is better explained in terms of a southwest dipping monocline. The State Bouguer gravity anomaly maps do not indicate a large scale fault in the vicinity of the site along the river. Deflections in the gravity field are indicated in the Portland Hills area where the Portland Hills Fault is mapped, but not nearer the Trojan Site.

A Portland Hills fault at Portland is fairly well documented with a variety of geomorphological, geological and geophysical and geochemical evidence. Seismicity of the fault or of the Portland area is adequately described in the literature. Seismicity of the Portland area, however, has not been directly linked to the probable Portland Hills Fault. Recent data on buried volcanic ash suggests that near-surface disruption of earth materials is not occurring, but the evidence is in need of further refinement. Historic seismicity of the Portland area is localized and does not extend to the Trojan Site. The extensions of the Portland Hills Fault, if projected to the northwest, pass 15 to 18 miles southwest of the Trojan Site, although there is no geologic evidence available at the present time to support these extensions.

In the Camas area of Washington, a northwest trending fault is indicated by Mundorff (1959) to cut Pliocene sediments. There is no evidence of great extent for this feature, although it does parallel other lineaments and structures which may have a regional extent according to some interpretations. Regional evidence from other areas to the east indicates that northwest trending faulting of materials now at the surface in Oregon and Washington ceased 3.5 - 4.5 million years ago.

Northwest trending lineaments of possible structural significance to the Trojan Site were noted by Corcoran in March 3, 1970, and were mapped by Corcoran in a memo of May 21, 1970. Coombs (1972) inventories all faults within 50 miles of the site. The Trojan FSAR reviews all known faults within 200 miles of the site. Coombs and Ivey (1972) review all major lineaments within 150 miles of the site. Corcoran (July 27 and October 16, 1970) acknowledged the inventory of linears conducted by Coombs and Ivey (1972). Lineaments are subjectively identified and they will continue to be identified as the resolution of remote sensing techniques continues to improve. The significance of lineaments must be carefully evaluated in view of the many possible explanations of their origin. Studies are presently proposed to assist in the objective interpretation of the significance of lineaments in Oregon.

The fault at the Kelso interchange is reviewed in the Trojan PSAR and the FSAR; displacement is restricted to Eocene units and the distribution of the fault is local according to presently available information. Similar structures noted elsewhere in the Coast Range of Washington are considered

to be of diapiric origin. Secondary shears in the fault zone trend toward Pliocene sediments which are not affected by faulting. Corcoran (March 3, 1970 and May 21, 1970) interpreted a northwest trend in the faulting at the interchange. Cowlitz River terraces of Pleistocene age on trend with the structure are undeformed indicating a pre-Pleistocene age of faulting at that locality if substantial movement occurred. Sense of displacement on the fault at the interchange is normal (PSAR appendix G) rather than strike-slip.

A hypothetical fault along the segment of the Columbia River adjacent to the Trojan Site has been postulated. Geophysical studies designed to detect large scale faulting included gravity studies, aeromagnetic studies, seismic refraction studies and resistivity studies. Evidence was not indicative of a fault in the area suggested. A fault conceivably could still exist at this location but remain undetected by the geophysical studies owing hypothetically to peculiarities of local geologic units. It is noted, however, that smaller scale gravity maps and aeromagnetic maps of the area also do not indicate faulting. Also, a gravity study of similar design in the Portland area did detect faulting in the latter area, although additional kinds of geophysical studies (aeromagnetic studies, resistivity studies, or seismic refraction) were not employed. Studies of these types were performed in the Trojan Site area with negative results.

Possible faulting in the slough west of the Trojan plant is not supported by gravity, seismic refraction, resistivity, or aeromagnetic studies, nor is it supported by examination of the geology of the cliffs

on trend with the slough fault postulated by workers. Groh (August 21, 1970) and the FSAR note that faults are not evident in the cliffs overlooking the slough area.

Determination of recency of movement on mapped faults can be pursued in several ways including laterite study, volcanic ash analysis, Pleistocene stratigraphic unit analysis, and seismic history correlation. Because laterites are faulted in the region surrounding the site, the age of the laterites provides us with a crude estimate of the time after which faulting was still occurring. An early Pliocene to late Miocene age is at present generally accepted for the age of the laterites. This age determination is most consistent with the geologic and topographic distribution of the laterite but is subject to on-going reinterpretation. Pliocene faulting is indicated. The distribution of subsurface ash deposits recovered in drill cores provides us with time datum with which to bracket the upper ages of possible faulting, provided adequate data on the age of the ash is available. Presently the ash data are not complete. The ash layer resulting from the eruption of Mt. Mazama is 6600 years old and is not displaced in the Portland area. This can be explained either by lack of faulting on the Portland Hills Fault or parallel faults, by exclusive strike-slip faulting, or by diffusion of fault displacement in the unconsolidated deposits in which the ash occurs. Presently recognized differences in elevation and the distribution of the ash relative to mean sea level can be explained in terms of pre-existing topography, or environment of deposition within a large fluvial system, or structure. Evidence of offset of Quaternary units was

actively sought along faults and lineaments in the investigations for the site. No such offset was discovered. No lineaments noted either by the operator or by others are indicated as passing through Quaternary units. Quaternary units, as they are presently understood, offer no evidence of Quaternary faulting in the region surrounding the site. Many of the Quaternary deposits are less than 13,500 years old.

Historic earthquakes in the Portland area are consistent with northwest or northeast trending faulting, and are not definitely linked with the postulated Portland Hills Fault. Distribution of the earthquakes is consistent with a variety of possible fault distributions and uniquely supportive of none. The historic earthquake record of the area surrounding the Trojan Site suggests minimal seismic activity in contrast to that of the Portland area.

Site Faults

Excavations for construction at the Trojan Site revealed surfaces of small scale displacement of probable pre-Quaternary age as noted by Corcoran (October 16, 1970). No offsets of Pleistocene units are evident. Data from cores and trenches incorporated into the interpretation of the shear zones are noted in a report by PGE (July 2, 1972). The shears average one inch in width and required no dental excavation and filling during the construction phase. Although lineations in Quaternary units were specifically sought with aerial photographs and helicopter reconnaissance, none were found (PSAR Appendix 2D). It should be noted laterites are not present at the site and ash deposits are not noted in the core records.

The shears at the site are mapped and photographed by Content (August 25, 1970) and are interpreted by Coombs (August 31, 1970) to be of probable Miocene age and to be sympathetic to regional folding at that time.

Earthquakes

The Trojan Site is located in the Coast Range Province near the eastern boundary and in a region of historic low seismicity. A map of isoseismals prepared by Coombs and others (1976) indicated that no intensities greater than VII have affected the site. Preliminary work by Jones (July 8, 1970) assigned an intensity in the range of VII to VIII to the site for the Olympia quake but he did not consider the favorable effect of local geology. Woodward and Clyde (1970) interpret a maximum possible intensity of VII for the site. Byerly (February 5, 1969) interpreted a maximum intensity of VII for the site based on local geology and historic seismicity. The 1872 earthquake in the north Cascades region in Washington State was probably felt at the site with an intensity of IV. Had the earthquake occurred nearer the site at the closest point within the north Cascades Province, it would have affected the site with a Mercalli intensity of VI or VII. The complete earthquake history of the site is adequately summarized in supporting documents of the PSAR and the FSAR.

Future projections for seismic activity are based on the historic record. Seismically the area is separate and distinct from the Olympia, Washington, area in terms of seismic activity and also is distinct from the Portland area. The largest historic quake of the Portland area could conceivably impact the site with a maximum intensity of VII if it occurred along a speculative northwestern projection of the Portland Hills Fault at a point southwest of the site, although a projection of the Portland Hills Fault to this point

is not supported by present geologic evidence. The competent bedrock nature of the material upon which the site is constructed is favorable in the context of seismic ground response. Studies have shown that bedrock response to given earthquakes is generally less severe than the response of unconsolidated materials by a factor of I or II Mercalli Intensities.

Historic acceleration at the site is 0.05 according to Adair (May 21, 1970) and future projected maximum g for the site is 0.11 according to Woodward and Clyde (1970). A local quake of intensity VI could produce an acceleration of 0.15 g according to Jones (July 8, 1970) and a distant quake producing intensity VII-VIII at the site would yield an acceleration of 0.25 g (Jones, July 8, 1970). The site is designed for an OBE of 0.15 g and a SBE of 0.25 g.

Microearthquakes

Microearthquakes are small earthquakes in an area which can be detected with special seismic instrument arrays. Analysis of microearthquakes ideally can assist in the interpretation of known structures of special interest or in the interpretation of areas of above average seismic activity. Corcoran (July 27 and October 16, 1970) requests a microearthquake survey for the site.

Design of microearthquake studies must specifically address the objective being sought and extenuating circumstances at the site in question. To identify an active structure, arrays of several kilometers size and capability to monitor events at several kilometers depth are generally

required even in areas where specific surface structures or historic or instrumentally detected seismic clusters have been identified. Additionally, the regional duration of the study is determined in part by the frequency of seismic events and background noise levels.

To reasonably identify an active structure results must include a population of seismic events which spatially define a planar surface and for which first motion results are reasonably consistent. With these constraints in mind, it is probable that a microearthquake study at the site would produce ambiguous results in a reasonable time frame. The historic seismicity surrounding the site is very low and specific objectives in terms of known structures or seismic event clusters have not been identified. Noise levels are expected to be generally high.

Completion of a statewide seismic network and operation over a reasonable period of time may identify seismic clusters in Oregon. If such a cluster is located in northwestern Oregon near the Trojan facility, microearthquake analysis would possibly be justified.

Mass Movement

Mass movement potential to be considered in the evaluation of the site is the possibility that the bedrock underlying the plant may be a large bedrock slide block of regional proportions. This issue is raised in general terms by Corcoran (May 21, 1970).

Available geophysical data and geologic information collectively indicate that the site area is underlain by continuous bedrock and that deep mass movement is not a factor. The site geology differs from large slide blocks

elsewhere along the Columbia River in general topography and in that the site bedrock is stratigraphically in place. The slough area west of the plant is one of a possible set of meanders along this segment of the Columbia River. Drays Mound across the river is an erosional remnant of the Goble Formation similar to that at Trojan Ridge and obviously is not a slide block. Gravity modelling for the site did not produce ambiguous results as would be expected if a slide plane were present at depth.

Volcanic Hazard

Potential volcanic hazards to be considered include ash falls, mudflows, and the release of floodwaters from behind temporary dams of volcanic mudflow origin. Floodwater release is adequately handled in the FSAR for events on the Lewis River. Mudflows are not a factor at the site due to distance of active or semi-active volcanoes. Ash falls are very improbable owing to the distance from active centers of volcanism and the direction relative to statistically favored wind directions. Volcanic hazards are under active long-range investigation in the Cascade Range and no new evidence has come to light to require modification of conclusions regarding volcanic hazards as they are presented in the FSAR.

Flood Hazard

Floods rigorously and adequately analyzed by the FSAR include the following:

Standard Project Flood (1000 year frequency)
Ten thousand year flood
Probable maximum meteorologic flood
Dam failure (Grand Coulee collapse as worst case)
Maximum surge flood
Tsunami
Ocean and river surge flood
Ice flooding
Volcanic dam release of Lewis River

Triem (April 11, 1972) discounts the possibility of a large landslide dam blocking the Columbia River at Bonneville on the basis of large scale topographic modifications resulting from prior movement on the slide.

In order to complete the public record on potential flooding, on February 24, 1978, a request was placed with Portland General Electric Company to more thoroughly investigate the potential of landslide damming in the Columbia River Gorge regarding the magnitude of future potential slides, if any, and the size of floods that could be generated from such slides if actual damming of the river did, in fact, occur.

Results of the study indicate that "pre-historic landslide movement has essentially removed the cliff forming Columbia River Basalt and Eagle Creek Formations and degraded slopes to a condition which rules out any possibility of a reoccurrance of a quick catastrophic landslide similar to the Bonneville (or Cascade) landslide. On the Oregon side of the Columbia River Gorge all studies indicate that none of the known landslide areas could cause a significant restriction in flow of the river."

GEOLOGIC REFERENCES
FOR THE TROJAN NUCLEAR POWER SITE

Adair, M.J. (n.d.), Geology, seismology, and foundation conditions: PGE pres. to ONPSTF on May 21, 1970.

Albee, A.L., and Smith, J.L., 1966, Earthquake characteristics and fault activity in southern California: in Engineering geology in southern California, special pub. of AEC.

Algermissen, S.T., 1977, Appendix A to U.SGS/NOAA, 1977.

Beeson, M., and others, 1975, Chapter IX, Environmental implications, earthquake hazards and suggestions for further study.

Bechtel Corporation, Oct. 1967, revised Jan. 1968, Trojan Powder Company property, Evaluation of foundation, ground water, and seismic conditions.

Benson, G.T., July 2, 1970, Statement.

_____, July 15, 1970, Letter to R.E. Corcoran.

Brazee, R.J., 1977, Appendix B to USGS/NOAA, 1977.

Bromery, R.W., and Snavely, P.D., Jr., 1964, Geologic interpretation of reconnaissance gravity and aeromagnetic surveys in northwestern Oregon: U.S. Geol. Survey Bull. 1181-N, scale 1:500,000.

Content, C.S. (n.d.), Progress report on foundation evaluation for the Trojan nuclear power plant site.

Coombs, H.A., 1953, A summary of Washington earthquakes: Bull. Seis. Soc. America, vol. 43, no. 1, p. 1-5.

_____, Aug. 31, 1970, Letter to L. E. Hodel.

_____, 1972, Faulting in northwestern Oregon and southwestern Washington, with letter of submittal to Kelly Woods by J.L. Williams, dated April 28, 1972.

_____, Milne, W.G., Nuttli, O.W., and Slemmons, D.B., 1976, Report of the review panel on the December 14, 1872, earthquake, Appendix A.B.C.

Corcoran, R.E., Mar. 3, 1970, Letter to Governor Tom McCall.

_____, May 11, 1970, Letter to USGS.

_____, May 21, 1970, Memo to F. Bristol, H. Banta, and R.W. de Weese.

Corcoran, R.E., May 21, 1970, Letter to Cardonne.

_____, June 8, 1970, Letter to Wes Bruer.

_____, June 11, 1970, Letter to V. E. Livingston.

_____, June 16, 1970, Letter to V. E. Livingston.

_____, July 21, 1970, Letter of transmittal to General Itschner.

_____, July 21, 1970, Letter to L.F. Williams.

_____, July 27, 1970, Letter to General E.C. Itschner.

_____, Oct. 14, 1970, Letter to Lawrence Wilkinson.

_____, Oct. 16, 1970, Statement of Department of Geology and Mineral Industries regarding proposed PGE nuclear power plant at Trojan.

_____, Mar. 9, 1971, Letter to Don Willner.

_____, April 3, 1971, Letter to Ted Hallock.

Couch, R., and Heinrichs, D., July 1972, Gravity survey of Trojan site.

_____, Keeling, K., and Thrasher, G., 1976, Investigation of the Deschutes Valley, Oregon, earthquake of 12 April, 1976.

Dehlinger, P., Bowen, R.G., Chiburis, E.F., and Westphal, W.H., 1963, Investigations of the earthquake of November 5, 1962, north of Portland: Oregon Dept. Geology and Min. Ind. Ore Bin, vol. 25, no. 4, scale 1:334,000.

Docket 50-344

Applicant response to McCoy motion

Attachment 2: Excerpts from Trojan Safety Evaluation Report (SER), issued by the Atomic Energy Commission, dated October 19, 1970.

Attachment 3: U.S. Coast and Geodetic Survey letter on Trojan seismicity, attached as Appendix D to the above SER.

Attachment 4: U.S. Geological Survey letter on Trojan geology and hydrology, attached as Appendix E to the above SER.

Attachment 5: Excerpts from Trojan Safety Evaluation Report (SER), issued by the Atomic Energy Commission, dated October 7, 1974.

Attachment 6: Excerpts from "Brief for Petitioners" filed by Portland attorney, John J. Haugh, Case 71-1230, in the United States Court of Appeals for the District of Columbia Circuit (In the Matter of Oregon Environmental Council,

Docket 50-344 (cont.)

Northwest Environmental Defense Center, Friends of the Earth, and Northwest Steelheaders Chapter of Trout Unlimited, Inc., Petitioners vs. U.S. Atomic Energy Commission and the United States of America).

Attachment 7. "Memorandum of Agreement" relating to a settlement reached in ASLB proceedings of May 2, 1972 regarding ongoing Trojan construction during detailed NEPA review (Docket 50-344 and Case 71-1230 between Applicants and the Oregon Environmental Council, et al, mentioned above).

Atomic Energy Commission

Agendas: November 4, 1970
November 19, 1970

McCoy, David B., January 8, 1974, Motion for admission of new contention.

McKeel, Sharon, Paper filed in support of McCoy motion; cites Lawrence, 1976; Benson and Balsillie, 1971; and Mundorff, 1959

_____, Paper filed in support of McCoy motion; discussion of possible strike-slip right lateral fault structures in northwestern Oregon and southwestern Washington.

_____, Paper filed in support of McCoy motion; discussion of the controversy of the geological siting of the Trojan Nuclear Power Plant in northwestern Oregon.

Energy Facility Siting Council, 1977, Minutes of meeting of Nov. 8, 1977, Blue Cross Auditorium, Portland, Oregon.

Exploration Data Consultants, Inc., 1972, Aeromagnetic interpretation for the Trojan Geophysical Advisory Board.

Groh, E.A., 1970, Letter to R. E. Corcoran dated Aug. 21, 1970.

Halicki, R., Jan. 17, 1978, Letter to Donald A. Hull.

Hallock, Ted, March 29, 1971, Letter to R. E. Corcoran.

_____, June 8, 1972, Letter to Kelly Woods.

Heider, Douglas, March 7, 1972, Statement before the Nuclear and Thermal Energy Council.

_____, April 4, 1972, Letter to Dr. Kelly Woods.

Hendrie, Joseph M., July 17, 1970, Letter to Hon. Glenn T. Seaborg - Report on Trojan Nuclear Plant Unit 1 from Hendrie of Advisory Committee on Reactor Safeguards.

Herron, Robert F., July 3, 1967, Letter to Cole R. McClure.

_____, July 21, 1967, Letter to Cole R. McClure.

_____, 1967, Letter to Cole R. McClure, Bechtel Corporation.

Itschner, E.C., Sept. 2, 1970, Letter and foundation report to R. E. Corcoran, with photos.

Jackson, Ronald L., 1971, Description of the ferruginous bauxite ore profile in Columbia County, Oregon: Oregon Dept. Geology and Min. Ind. Ore Bin, vol. 33, no. 12, p. 223-229.

Lawrence, R., and Carter, J., 1974, Preliminary lineament map of Oregon from ERTS imagery at 1:1,000,000: Oregon Dept. Geology and Min. Ind. map.

Livingston, May 8, 1970, Letter to R. E. Corcoran re Kelso Fault.

_____, V.E., June 12, 1970, Letter to R. E. Corcoran.

Lockwood, Kessler, and Bartlett, Inc., July 26, 1972, Operational report - Aeromagnetic survey at the Trojan Power Plant site, Oregon-Washington.

Mann, Irwin, March 18, 1971, Letter to R. E. Corcoran.

McKean, John W., Sept. 1, 1970, Memo to Larry E. Wilkinson.

_____, Sept. 21, 1970, Letter to Larry Wilkinson.

Morris, Peter, July 27, 1970, Letter to General Itschner re ACRS.

Newmann, F., 1958, Provisional map of earthquake zones in the State of Washington.

Newton, V.C., 1972, Review of geophysical survey report - Trojan Nuclear Power Plant site.

_____, 1976, Prospects for natural gas production or underground storage of pipeline gas in the upper Nehalem River basin, Columbia and Clatsop Counties, Oregon: Oregon Dept. Geology and Min. Ind. Oil and Gas Invest. 5.

_____, 1977, Conference on the 1872 Northwest earthquake, Portland, Oregon, October 28, 1977; personal notes.

Nuclear Plant Siting Task Force, May 21, 1970, Minutes.

_____, July 2, 1970, Notice public hearing.

_____, Oct. 20, 1970, A review of the Trojan Nuclear Power Plant site evaluation.

Oregon Environmental Council, April 4, 1972, Statement presented to the Oregon Nuclear and Thermal Energy Council by the Oregon Environmental Council, at Salem, Oregon

Oregon, State of

Agriculture, Department of, Oct. 8, 1970, Letter to Larry F. Wilkinson from Walter Leth.

Energy, Department of, 1976, Site certificate application rules for thermal power plants (draft, revised).

Executive Department, Oct. 9, 1970, Memo to NTEC from L.E. Wilkinson.

_____, Oct. 9, 1970, Memo to Nuclear Plant Siting Task Force by L.W. Wilkinson.

Fish Commission, Aug. 11, 1970, Memo to files by James B. Haas re Meulweld letter to NTEC.

Game Commission, Oct. 16, 1970, Statement of Oregon State Game Commission relating to Trojan Nuclear Power Plant.

Geology and Mineral Industries, Department of, Governing Board minutes, April 2, 1970; July 10, 1970.

_____, Oct. 16, 1970, Statement of Department of Geology and Mineral Industries regarding proposed PGE nuclear power plant site at Trojan.

Palmer, Leonard, March 6, 1972, Memorandum to Dr. W. Kelly Woods.

_____, Portland State University, Jan. 8, 1978, Affidavit of Leonard Palmer Attachment 5 of McCoy motion.

Peterson, R.A., White, J.E., and Dodds, R., Aug. 1972, Geophysical survey report Trojan Nuclear Power Plant Site.

Portland General Electric Company

Preliminary Safety Analysis Report, 1969.

Preliminary Safety Analysis Report, vol. 1, April 6, 1970.

Appendix 2D, Supplemental geologic study, 1970.

Trojan Nuclear Plant progress report, PGE activities, Oct. 1970.

Trojan Juclear Plant environmental report, vol. 1, 1971; also amended sections, 1972.

Environmental statement related to operation of Trojan Nuclear Plant, Docket 50-344, Aug. 1973.

Final safety analysis report, vol. 1, June 1976.

Portland General Electric Company (cont.)

Pebble Springs seismic network annual report, Nov. 1, 1975 to November 20, 1976.

Pebble Springs Nuclear Plant - additional information on the seismicity and tectonics of the Columbia Plateau Attachment 5, n.d.

Press, Edward, M.D., Oct. 7, 1970, Memo to L.E. Wilkinson.

Shannon & Wilson, Inc., Aug. 7, 1972, Report of electrical resistivity investigation, Trojan Nuclear Power Plant site.

_____, Aug. 7, 1972, Report of seismic refraction investigation, Trojan Nuclear Plant site.

Smith, Stewart, Oct. 13, 1970, Letter to PGE re microseismic.

Spies, Kenneth H., Oct. 16, 1970, Statement of Department of Environmental Quality to the Nuclear Development Coordinating Committee regarding the proposed PGE Nuclear Power Plant at Trojan.

Stanford Research Institute, 1962, Seismic aftershock investigations - Project VELA, Portland, Oregon earthquake of 6 November 1962.

Stover, C.W., 1977, Appendix C to USGS/NOAA, 1977.

U.S. Atomic Energy Commission, Division of Reactor Licensing, Nov. 2, 1970, Docket 50-344, Summary statement re Trojan Nuclear Power Plant.

_____, 1971, Title 10, Chapter 1, Part 100, Seismic and geologic siting criteria for nuclear power plants; draft by W.B.McCool.

_____, Dec. 5, 1973, Title 10, Chapter 1, Part 100, Reactor site criteria.

_____, 1973, Rules and regulations, Title 10, Atomic energy, Part 100, Reactor site criteria.

U.S. Geological Survey/NOAA, Ad hoc working group on intensities of historic earthquakes, 1977, Maximum intensity of the Washington earthquake of Dec. 14, 1872.

U.S. Nuclear Regulatory Commission, 1977, Affidavit of J. Carl Stepp, Docket Nos. 50-514, 50-515.

Wall Street Journal, Jan. 26, 1972, Nuclear power plant in Oregon generates dispute over safety; Critics of power plant get an electric response.

Warren, Frank M., March 1, 1972, Letter to Frederick Taylor.

Warren, W.C., and others, 1945, Geology of northwestern Oregon west of the Willamette River and north of latitude 45°15': U.S. Geol. Survey Map OM-42.

Warwick, H.C., n.d., Data Portland to Oregon.

Wells, F.G., and Peck, D., 1961, Geologic map of Oregon west of the 121st Meridian, 1:500,000.

Wheeler, Chris L., Oct. 16, 1970, Statement relating to Trojan Nuclear Power Plant site.

Wilkinson, L.E., July 2, 1970, Memo to Nuclear Development Coordinating Committee - Summation of the public hearing on Trojan Plant, St. Helens, draft.

_____, July 22, 1970, Memo to Dr. Edward Press.

_____(?), Jan. 12, 1970, Trojan Nuclear Plant progress report, PGE activities - Dec. 1969.

Wilkinson, W.D., Lowry, W.D., and Baldwin, E.M., 1946, Geology of the St. Helens quadrangle, Oregon: Oregon Dept. Geology and Min. Ind. Bull. 31, 1:62,500.

Williams, J.L., Nov. 16, 1970, Letter to General Itschner.

_____, Aug. 17, 1972, Letter to Dr. Kelly Woods.

Williams, L.F., July 17, 1970, Letter to R.E. Corcoran.

Willingham, Jan. 9, 1978, Memo to Bill Young re WQ-PGE Trojan spent fuel pool modification.

Willner, D., Mar. 5, 1971, Letter to R.E. Corcoran.

Woods, W. Kelly, Feb. 14, 1972, Letter to Douglas E. Heider.

_____, Mar. 27, 1972, Letter to Prof. Leonard Palmer.

_____, Mar. 27, 1972, Letter to Paul D. Triem.

_____, Mar. 29, 1972, Letter to Douglas Heider.

_____, April 14, 1972, Letter to Nuclear and Thermal Energy Council members.

_____, April 24, 1972, Letter to Leonard Palmer.

_____, April 25, 1972, Draft - Trojan geology - Meeting with State Geologist.

_____, Junw 9, 1972, Letter to Ted Hallock.

_____, 1972, Memo to NTEC regarding "Trojan geology - meeting with State Geologist."

Woodward, Clyde and Associates, Nov. 16, 1970, Ground motions, Trojan Nuclear Plant, Oregon.

Unsigned, April 1964, Notes re unlocated boring.

Unsigned, April 22, ____, Handwritten letter to General Itschner.

n.a., n.d., Answer to question propounded at pre-hearing conference.

n.d., Washington State - Intensity earthquakes from 1865-1951

n.a., n.d., Washington and Oregon, Resumé, List of earthquakes 1941-1963.

n.a., n.d., Notes.

Allen, V.T., 1948, Formation of bauxite from basaltic rocks of Oregon: Econ. Geol. vol. 43, p. 619-626.

Beeson, M.H., Johnson, A.G., and Moran, M.R., 1975, Portland environmental geology - Fault identification: U.S. Geol. Survey Contract 14-08-0001-14832.

Corcoran, R.E., 1956, Ferruginous bauxite deposits in the Salem Hills, Marion County, Oregon: Oregon Dept. Geology and Min. Ind. Bull. 46.

_____, June 24, 1970, Letter to Debbs Potts, with attachments: Executive Department approval; re: Authorization to reinstate an eliminated position, p. g-1.

_____, July 3, 1970, Memo to Dan Simmons re: Emergency Board request.

_____, Sept. 24, 1970, Letter to Debbs Potts - Emergency Board.

_____, Oct. 14, 1970, Letter to L.E. Wilkinson.

_____, Dec. 10, 1971, Letter to Emergency Board.

_____, May 1, 1972, Letter to John D. Burns.

_____, and Elfstrom R.L., June 7, 1972, Letter to Emergency Board.

_____, July 7, 1942, Letter to Emergency Board.

_____, March 15, 1973, Letter to Emergency Board.

_____, March 15, 1973, Letter to Emergency Board.

Couch, R., Johnson S., and Gallagher, J., 1968, The Portland Earthquake of May 13, 1968, an earthquake energy release in the Portland area: Oregon Dept. Geology and Min. Ind. Ore Bin, vol. 30, no. 10, p. 185-190.

Couch, R.W., and Lowell, R.P., 1971, Earthquakes and seismic energy release in Oregon: Oregon Dept. Geology and Min. Ind. Ore Bin, vol. 33, no. 4, p. 61-83.

Couch, R.W., Victor, L., and Kelling, K., 1974, Coastal and offshore earthquakes of the Pacific Northwest between 39° and 49°10' N. Latitude and 123° and 131° W. Longitude: Oregon State Univ. Dept. Oceanography and Oregon Dept. Geology and Min. Ind.

Dehlinger, P., Couch, R.W., and Gemperle, M., 1968, Continental and oceanic structure from the Oregon coast westward across the Juan de Fuca Ridge: Canadian Jour. of Earth Sciences 5, 1079 (1968), p. 1079-1090.

Dehlinger, P., Couch, R.W., McManus, D.A., and Gemperle, M., 1971, 4. Northeast Pacific structure: in The Sea, vol. 4, part II, ed. by Maxwell, pub. by John Wiley and Sons, p. 133-189.

Hammond, P.E., Benson, G.T., Cash, D.J., Palmer, L.A., Donovan, J., and Gannon, B., 1974, A preliminary geologic investigation of the ground effects of earthquakes in the Portland metropolitan area, Oregon: unpub. rept. to U.S. Geol. Survey.

Heider, Douglas, March 7, 1972, Statement before the Nuclear and Thermal Energy Council.

Hook, John W., 1976, Ferruginous bauxites of the Pacific Northwest: Oregon Dept. Geology and Min. Ind. Open File Report O-76-3, 26 p.

Libbey, F.W., et al, 1945, Ferruginous bauxites in northwest Oregon: Oregon Dept. Geology and Min. Ind. Bull. 29, 97 p.

Livingston, V.E., Jr., 1966, Geology and mineral resources of the Kelso-Cathlamet area, Cowlitz and Wahkiakum Counties, Washington: Wash. Div. Mines and Geology Bull. No. 54.

Nuclear Plant Siting Task Force, July 2, 1970, In the matter of site application for Trojan Nuclear Plant by Portland General Electric Company; Hearings officer: C.E. Leierer - includes written testimony.

Oregon Department of Energy, 1976, Site certificate application rules for thermal power plants (draft, revised).

Peterson, R.A., White, J.E., and Dodds, R.K., Aug. 1972, Geophysical Survey report of Trojan Nuclear Power Plant site.

Reiche, P., 1950, A survey of weathering processes and products: Univ. New Mexico Pubs. in Geol. no. 3, rev. ed., 95 p.

Shannon & Wilson, 1972, Seismic regionalization studies, Bonneville Power Administration service area, Washington, Oregon, Idaho, and western Montana: report to Agbabian and Assoc., El Segundo, California.

Sims, John D., Determining earthquake recurrence intervals from deformational features in young lacustrine sediments.

Thiruvathukal, J.V., Berg, J.W., Jr., and Heinrichs, D.F., 1970, Regional gravity of Oregon: Geol. Soc. America Bull, vol. 81, p. 725-738.

U.S. Nuclear Regulatory Commission, 1975, Standard format and content of safety analysis reports for nuclear power plants: NUREG-75/094, Regulatory Guide 1.70, Revision 2.

Rockwell International, February 14-16, 1978, Tectonics and seismicity of the Columbia Plateau

Vance, J.A., The pre-Yakima basement of the Washington Cascades;

Swanson, D.A., and Wright, T.L., Some important facts and inferences concerning the Columbia River Basalt Group;

Waitt, R.B., Jr., Post-Miocene stratigraphy and tectonism of parts of the Great Columbia Plain and adjacent Cascades, Washington;

Malone, S.D., A review of eastern Washington seismicity;

Beck, M.E., Jr., Summary of tectonic models for the origin of the Columbia River Plateau;

Keinle, C.F., Jr., and others, Western Columbia Plateau tectonic structures and their age of deformation.

Washington Public Power Supply System, 1977, Preliminary safety analysis report; Volume 2A

Subappendix 2rC, Davis, G.A., 1977, Tectonic evolution of the Pacific Northwest pre-Cambrian to present.

Shannon & Wilson, March 6, 1978, Columbia River Gorge slide studies, Oregon and Washington: Rept. to Portland General Electric Company, 23 p.

Palmer, L., 1977, Large landslides of the Columbia River Gorge, Oregon and Washington: Geol. Soc. America Reviews in Engineering Geology, vol. III, p. 69-83.

ROBERT W. STRAUB
GOVERNOR

Department of Energy

Room 111, Labor & Industries Building,
528 CHURCH STREET, SALEM, OREGON 97310 PHONE 378-4128

January 18, 1978

Mr. Don Hull
State Geologist
Department of Geology
and Mineral Industries
1069 State Office Building
Portland, Oregon 97201

Dear Don,

As we discussed yesterday, there is considerable renewed public interest in the seismic character of the Trojan Nuclear Plant site. And, as you know, the Board has rejected an intervenor's contention relating to geological issues at the current Nuclear Regulatory Commission hearing.

The issues that have been raised relate to (1) whether the record is clear on the development of the state's conclusions regarding the suitability of the site in the early 1970s, and (2) the substantive issue of geological considerations relating to the safe operation of the plant and on-site storage of spent fuel.

I want the Department of Energy and the Energy Facility Siting Council to have the benefit of your expert analysis. I would appreciate your comment on the available studies and your review of any new information related to the geology of the site. I am interested in determining whether there are any new facts which reflect on the safety of spent fuel storage or plant operation or which indicate that additional research is required. A presentation of your findings to the Council in either late February or at the regular Council meeting on March 14, 1978 would be appropriate.

Sincerely,

Fred

Fred D. Miller
Director

FDM:bj

cc: Bud Kramer
Janet McLennan
Bill Young
Charlie Davis
EFSC Members

ROBERT W. STRAUB
GOVERNOR

Department of Geology and Mineral Industries
ADMINISTRATIVE OFFICE
1069 STATE OFFICE BLDG., PORTLAND, OREGON 97201 PHONE (503) 229-5580

January 26, 1978

Dr. Fred D. Miller, Director
State Department of Energy
111 Labor & Industries Bldg.
Salem, Oregon 97310

Dear Fred:

Thank you for your letter of January 18, 1978, requesting a review of the geology of the Trojan nuclear plant site near Rainier in Columbia County. I brought your request to the attention of the Governing Board of the Department of Geology and Mineral Industries at its regular quarterly meeting on January 19, and the Board agrees that we should undertake such a review.

We have begun a compilation of existing data and would appreciate your help in securing copies of all relevant materials. In this regard, would you please send us copies of all the maps and reports in your files which contain pertinent information. We will also be requesting similar assistance from the operator.

In addition to the existing data, we will review any geologic facts which have become available since the latest reports were written. After integrating all of the information, we will report our findings to you in late February or early March 1978.

Perhaps we can meet with you and your staff in the near future to answer the following questions: (1) what geologic hazards are to be evaluated, and (2) what standards are to be used in evaluating the geologic adequacy of the plant vis-a-vis on-site storage of spent fuel and plant operation. The issue of the adequacy of present data in addressing geologic hazards is not easily resolved and may be answered only with clear definitions of the intended use and the standards against which available information is to be measured.

In order to clarify the record on development of the State's conclusions in the early 1970's regarding the suitability of the site prior to the existence of the Energy Facilities Siting Council and prior to vesting of review authority for geological matters in the Department of Geology and Mineral Industries, we have enclosed a chronological tabulation of correspondence in 1970 and 1972. These letters and memoranda summarized concerns of

Mr. R. E. Corcoran, State Geologist, regarding the adequacy of site investigation.

We look forward to working with you and your staff and the Council to insure that a comprehensive and unbiased review of the geology of the site is completed in a timely manner.

Sincerely yours,

Donald A. Hull
State Geologist

DAH:jr
Encl.
cc Janet McLennan
cc Governing Board Members

CHRONOLOGICAL RECORD
OF CORRESPONDENCE RE TROJAN GEOLOGY

March 3, 1970 - Letter from R.E. Corcoran to Governor McCall regarding the need to consider earthquake risk in siting Trojan.

May 21, 1970 - Letter from R.E. Corcoran to Governing Board commenting on linears near the site and also to possibility of landsliding as a hazard for consideration.

July 21, 1970 - Letter from R.E. Corcoran to L. Williams commenting on a concurrent study of earthquake potential being conducted by the consultants of the operator.

July 27, 1970 - Letter from R.E. Corcoran to General Itschner commenting on linears near the site and requesting that a microseismic study be conducted.

October 14, 1970 - Narrative by R.E. Corcoran summarizing the regional geology of the Northwest and speculating on possible earthquake risk for the Trojan site. Includes cover letter to L. Wilkinson dated October 14, stating that the Governing Board had not reviewed the document.

October 16, 1970 - Press release stating Department of Geology and Mineral Industries accepts conclusions of U.S. Geological Survey regarding adequacy of Trojan site owing to limited staff and facilities.

October 27, 1972 - Concurrence with NTEC memo authored by Kelly Woods and stating that R.E. Corcoran has no reservations on the safety of the site, although a microseismic study had not been conducted.