BEFORE THE STATE OF WASHINGTON
ENERGY FACILITY SITE EVALUATION COUNCIL

IN RE APPLICATION NO. 2002-01 BP WEST COAST PRODUCTS, LLC BP CHERRY POINT COGENERATION PROJECT	**EXHIBIT 32R.0 (SRM-RT)**

APPLICANT'S PREFILED REBUTTAL TESTIMONY

SANJEEV R. MALUSHTE, Ph.D., SE, PE (CIVIL), PE (MECHANICAL), CEng, F.ASCE

Q. Please introduce yourself to the Council

A. My name is Sanjeev R. Malushte. My business address is 5275 Westview Drive Frederick, MD 21703.

Q. What testimony are you addressing?

A. I am responding to the prefiled testimony of Mr. Douglas Goldthorp submitted by Whatcom County.

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Q. What are your occupation and title?

A. I am an active structural engineering professional with broad experience as a researcher, educator, practicing engineer, technical specialist, engineering supervisor, and active member of the code/standard community. I am currently employed as a Senior Engineering Specialist in the Civil/Structural department at Bechtel Power Corporation in Frederick, MD. Among other things, I am responsible for evaluating the seismic design criteria for Bechtel's domestic and international power projects (both fossil and nuclear). For the past five years, I have also been teaching graduate structural engineering courses on a part-time basis at The Johns Hopkins University in Baltimore, MD (I have been responsible for graduate courses in Design of Structural Systems for Lateral and Gravity Forces, Structural Dynamics, and Advanced Steel Design). I am also a registered Professional Engineer in Civil, Structural, and Mechanical disciplines in various US states and the United Kingdom.

I am an active member of many code/standard, technical, and administrative committees and professional organizations. Following is the list of my affiliations with various committees/organizations and my professional registrations.

- Fellow, American Society of Civil Engineers (ASCE)
- Fellow, Institution of Civil Engineers in UK (inducted by direct entry)
- Member, American Society of Mechanical Engineers (ASME)
- Licensed Civil Engineer (MD, CA); licensed Mechanical Engineer (VA, CA); licensed Structural Engineer (IL); Chartered Engineer (UK)

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- Member, Main Voting Committee of the ASCE 7 Standard “Minimum Design Loads for Buildings and Other Structures” (this is the model load standard adopted by current building codes).
- At-Large Member, Seismic Load Task Committee for the ASCE 7 Standard
- Member, General Provisions Task Committee for the ASCE 7 Standard (this task committee is responsible for stipulating occupancy categories for structural design, among other things)
- Member, Strength Task Committee for the ASCE 7 Standard
- Corresponding Member, AISC Standard Committee for Seismic Design of Steel Structures (term as a full member will begin on 1/1/04)
- Charter Member, AISC Adhoc Committee for Nonbuilding Structures (such as power generation facilities)
- Corresponding Member, FEMA National Earthquake Hazard Reduction Program (NEHRP) Committee for Nonbuilding Structures (the NEHRP recommendations serve as a pre-standard for seismic codes in the US)
- Control Group Member, ASCE Seismic Effects Technical Committee
- Associate Editor, ASCE Journal of Structural Engineering (<u>invited</u> to serve; responsible for research papers that can influence seismic code development)
- Past Member, ASCE Shock & Vibratory Effects Technical Committee
- Panelist, National Science Foundation (NSF) Review Panel for Research Program in Structural Systems and Hazard Mitigation (<u>invited</u> to serve)
- Panelist/Independent Peer Reviewer, NIST/DOE/FEMA sponsored Electric Power Expert Panel for evaluation of seismic safety in design/construction of power generation/distribution/transmission facilities (<u>invited</u> to serve)

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- Member, Bechtel Corporate Seismic Committee; participant in several technical advisory forums
- Chair of Structures Track for 2004 ASCE Annual Convention in Baltimore
- Steering Committee Member for 2001 Structures Conference in Washington, DC
- Control Group Member, ASCE Administrative Oversight Committee for Structures Conferences
- Chair/Organizer of two technical sessions on seismic code practice at ASCE Structures conferences and one technical session on impact/blast at an ASCE Engineering Mechanics conference
- Author/Presenter of numerous journal papers, research reports, conference papers, and invited seminars in the field of Earthquake Structural Engineering, Impact, and Structural Design/Analysis
- Nominated to the advisory panel for the Government of India on Seismological and Earthquake Engineering issues (committee inactive)

Q. Please describe your education and work history.

A. I have attached a current copy of my resume as Exhibit 32R.1. Highlights are as follows:

- Doctorate in Engineering Mechanics from Virginia Tech, with thesis work in seismic isolation
- Master's degree in Civil Engineering from Virginia Tech, with thesis work in development of site-specific seismic design spectra
- Master's degree in Engineering Mechanics from Virginia Tech, with thesis work in structural dynamics and random vibrations

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- Master's degree in Engineering Management from The George Washington University
- Bachelor's degree (with Honors) in Civil Engineering from University of Bombay
- Fourteen-plus years at Bechtel Corporation as Technical Specialist, Engineering Supervisor, Resident Engineer, Acting Assistant Chief Civil/Structural Engineer, and Assistant Project Engineer; served in nuclear/fossil power projects and civil/structural technical staff
- Advanced design/analysis experience at Bechtel for nuclear/fossil power plant structures made of concrete/steel/masonry/prestressed concrete (using domestic and international codes/standards for dynamic/time-history analysis, seismic design, response spectrum analysis, finite element analysis)
- Five years part-time teaching experience at Johns Hopkins University, responsible for graduate courses in Advanced Steel Design, Design of Structural Systems for Lateral/Gravity Forces, and Structural Dynamics
- Six years experience as a Research Assistant/Associate and Post-Doctoral Research Scientist in Department of Engineering Science & Mechanics at Virginia Tech, Blacksburg, VA; carried out National Science Foundation (NSF) funded research on three topics in the field of earthquake structural engineering
- One year experience as a civil/structural design engineer at M. N. Dastur Company, designing industrial facilities (steel mills and chemical plants)
- Reviewed numerous research papers and proposals in earthquake structural engineering in capacity as an Associate Editor/Reviewer for ASCE Journal of Structural Engineering and Panelist for NSF Research Panel on Hazard Mitigation
- Authored/reviewed many seismic code change proposals as a committee member

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Q. What information about the BP Cogeneration project have you reviewed?

A. I have reviewed the following documents concerning the BP Cogeneration Project:

- APPLICATION FOR SITE CERTIFICATION (Section 3.1 and Appendix G),
- DEIS (Section 3.1),
- URS GEOTECHNICAL REPORT
- BECHTEL GEOTECHNICAL REPORT

Q. Mr. Goldthorp prefaces his testimony and "concerns" about the geology of the site with the statement that he thinks that "it is imperative that the Energy Facility Site Evaluation Council (EFSEC) take all reasonable steps to ensure that the facility is appropriately designed for seismic events." In your opinion, is the Applicant taking all reasonable steps to ensure that the facility is designed to withstand significant seismic events?

A. Yes. In my opinion, the Applicant is taking all reasonable steps to ensure that the BP Cogeneration facility is designed to withstand an appropriately significant seismic event that is commensurate with the nature of the subject facility. There are two issues to address to ensure appropriate seismic design of a facility of this nature. First, the design level seismic hazard and facility occupancy category are determined using the applicable building code (in this case, the Uniform Building Code – 1997 Edition, also referred to as UBC-97). Second, the geotechnical and soil conditions at the site are assessed to determine the design ground motion at grade level and to ascertain that the local soil is not subject to liquefaction, slope instability, ground

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rupture, and fault offset when subjected to the design seismic event. Here, the Applicant has completed both assessments thoroughly and adequately for design of the plant.

Q. Let's discuss each of those assessments in turn. Have appropriate data been considered to safely address seismic hazards in the facility design?

A. Yes. The design level seismic hazard for this type of project is determined by using "design seismic event" stipulated by the governing building code. The applicable code for the BP Cogeneration site is UBC-97. The cogeneration site is located within a large region on/near the west coast of the US that the UBC-97 treats as "Seismic Zone 3." Under UBC-97, the design peak ground acceleration (PGA) to be used for the cogeneration facility site is 0.30 g. This reference acceleration value is based on a seismic hazard associated with at least a 475-year return period (corresponds to a probability of exceedance of 10% or less in 50-years); it is then modified to reflect the local soil conditions. However, based on the latest available Probabilistic Seismic Hazard Assessment (PSHA) data from United States Geological Survey (USGS) (October 29, 2003, see http://geohazards.cr.usgs.gov/eq/html/data2002.html), the actual PGA associated with a 475-year return period at the BP Cogeneration facility site is only 0.23 g. This is less severe than the design value stipulated for the whole Zone 3 region. In fact, the 0.23 g value is closer to the 0.20 g design value stipulated for Seismic Zone 2B.

This means that the facility will be designed using a more conservative hazard level than the minimum target of UBC-97. The reason for this conservatism stems from

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the fact that UBC-97 treats a large region on/near the west coast of the US as Seismic Zone 3; as such, the design ground motion for all locations within this region is conservatively stipulated on the basis of seismic hazard of more active location(s) within this region.

It is also noteworthy that power plants and similar industrial facilities are frequently built in areas with significantly greater seismic hazards, including in UBC Seismic Zone 4 – the designation throughout much of California. That is, the UBC-97 stipulated design ground motion, which considers a seismic event with 475-years return period, has been deemed appropriate for regions with frequent/intense seismic activity. Bechtel has designed and constructed a number of similar combined cycle power plants in California in the Seismic Zone 4 region.

Q. Can you explain what a PGA of 0.30 g means in terms of seismic hazard?

A. Yes. Again, relying on the October 29, 2003 PSHA data from USGS, for the BP Cogeneration facility site, the 0.30 g ground motion corresponds to a return period of approximately 1,000-years (which translates into slightly less than 5% probability that the design ground motion will be exceeded in 50-years). This is a significant seismic event considering that UBC-97, which has been used to design major power facilities nationwide (including California), targets 475-years as the minimum return period for the design seismic event (which corresponds to 10% probability of exceedance in 50-years). Per the latest PSHA information from USGS, the PGA for a 475-year event is only 0.23 g. Therefore, the latest PSHA indicates that 0.30 g will

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result in over 30% conservatism in design seismic acceleration value compared to the corresponding value associated with UBC's minimum target for a 475-year event.

Q. What assurance is there that the UBC-97 establishes adequate levels of protection to avoid significant damage during a seismic event?

A. Design of the facility per UBC-97 code provisions is expected to provide a "life safety" performance level at minimum. This means that, when subjected to the design earthquake ground motion, the facility will pose very little risk to the lives of its occupants while retaining a significant margin against collapse (the structure would be expected to have an additional factor of safety of 1.50 against collapse). It is also important to note that power plant structures and equipment are inherently robust and have consistently exhibited good performance during past earthquakes.

Q. Can you describe what work has been done to date to analyze the geotechnical and soil conditions at the Cogeneration site?

A. Certainly. The Technical Report on Earth prepared by Golder Associates, Inc. is set out in Appendix G and summarized in Section 3.1 of the Application for Site Certification. This report provides the basic geotechnical and soil data for the preliminary design phase of a project to determine whether the site is suitable for development of this sort. If a site is deemed suitable, further soil analysis is conducted to evaluate more detailed design features that should be incorporated into a project, including features to ensure its stability during a seismic event. In this case, two detailed geotechnical reports have already been prepared. URS Group Inc. completed a Geotechnical Data Report for the Cogeneration project on July 3, 2003.

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This report presents the results of a site-specific investigation, and includes all of the data from surveying, drilling and sampling, temporary observation wells, field permeability testing, static and seismic cone penetrometer testing, field electrical resistivity testing, seismic cross-hole testing, geophysical seismic refraction survey, and laboratory testing. Based on this report, in August 2003, Bechtel completed a Subsurface Investigation and Foundation Report for the Cogeneration project to support design and construction of the project on this specific site. This report considered the URS data, and from that data assessed the site geotechnical conditions and seismic risks relevant to soil liquefaction. It was concluded that the subsurface profile throughout the site consists predominantly of clay soils that are not considered susceptible to liquefaction.

Q. In your opinion, does the soil assessment to date provide adequate and appropriate data to design the facility for seismic events?

A. Yes, it does. The geotechnical studies were very thorough. As I indicated previously, they included field explorations, field testing, and laboratory testing, and yielded detailed reports. I have been designing facilities such as this for over 10 years, and the soil assessment for this site is sufficiently thorough to ensure that it can be safely designed.

Q. How then would you address Mr. Goldthorp's suggestion that the seismicity and geology of the site should be defined using "all available data"?

A. I think this suggestion lacks merit and practicality. Data are only as useful as they are reliable. In the US, the most recognized source for seismic hazard information comes

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from the USGS (as noted before, we have looked at the latest available hazard data from USGS). By collaborating with renowned seismologists nationwide, USGS has been conducting major studies for the purpose of seismic hazard mapping. The USGS work is therefore considered the primary resource for obtaining PSHA information (see report: **http://geopubs.wr.usgs.gov/fact-sheet/fs017-03/fs017-03.pdf**). This credibility is rooted in the caliber of USGS' own scientists and their drive to forge a consensus with locally/nationally renowned seismologists through collaboration and an expert peer-review process. On the code development front, USGS has further solidified its role by taking an active role in FEMA's National Earthquake Hazard Reduction Program (NEHRP) initiative and through involvement in the development of the ASCE 7 Standard (*Minimum Design Loads for Buildings and Other Structures*). Thus, as far as seismic hazard data are concerned, USGS is the undisputed reliable source. Relying upon data that have not undergone similarly rigorous scrutiny would not only be unnecessary, it would be inappropriate.

Q. Mr. Goldthorp specifically suggests that the research hypotheses of Dr. Easterbrook should be incorporated into the seismic assessment of the Cogeneration facility. Do you agree?

A. No. I strongly disagree. This is my point about reliability of data. Identification and acknowledgement of a new fault must meet the rigorous "standard of care" followed in the USGS process. Review of USGS' most recently published PSHA studies (Reference: USGS Open-File Report 02-467; also, visit **http://geohazards.cr.usgs.gov/eq/2002faults/flt-speadsheet-2002.html** for the list of recognized faults and their parameters) shows that Sumas and Vedder Mt. faults

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have not been recognized by USGS. This is despite the fact that the USGS has been conducting focused research in the Pacific Northwest region; yet, the USGS' current research plans (**http://geology.wr.usgs.gov/wgmt/pacnw/pp02.html** and **http://earthquake.usgs.gov/docs/5yrplan.html**) and future research plans for the area (**http://www.usgs.gov/contracts/nehrp/attach-a.doc**) do not include the hypothetical Sumas and Vedder Mt. faults as potential faults that warrant studies. Indeed, to my knowledge, Dr. Easterbrook's findings have not been published in any peer-reviewed journal, and are available only in a very cursory form in a brief report and affidavit submitted in another permitting proceeding. By the measure of "standard of care" exercised in the field of seismology, Dr. Easterbrook's hypothesized Sumas/Vedder Mt. faults remain unrecognized and unacknowledged by the body of seismological experts. Dr. Easterbrook's hypotheses cannot therefore be deemed reliable and should not be used in seismic assessments until they have been subjected to and passed appropriate professional scrutiny.

Q. Mr. Goldthorp also specifically suggests that information developed during petroleum explorations in the area should be incorporated into the seismic assessment of the Cogeneration facility. Do you agree with that suggestion?

A. No. Again, I disagree. First, it is obviously difficult to respond to this suggestion without more information than that somewhere there exists "depth-to-bedrock, bedrock, and seismic information" developed during petroleum explorations over the past decade. I have no knowledge regarding the availability, reliability or relevance of these data from Mr. Goldthorp's description. To the extent the information described addresses soil conditions, as I explained previously, detailed site-specific

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geotechnical analyses have already been performed for the Cogeneration site. Other soil information from somewhere in the "area" will not supersede the data developed in these specific geotechnical investigations because geotechnical properties can vary significantly within a distance of mere few hundred feet, let alone miles. If there is any belief that such data may have some significance in terms regional seismic activity, I would reiterate that USGS is the most recognized and accepted source for seismic sources (i.e., faults) and hazards. It is unlikely that information from the petroleum exploration studies will provide any relevant and reliable data to improve the design safety of the BP Cogeneration facility.

Q. Mr. Goldthorp also states that a "Probabilistic Seismic Hazard Assessment (PSHA) that would define the level of construction design necessary for this specific site" should be required in the post-approval facility design criteria. Do you agree that this would be an appropriate and useful condition to impose on the Cogeneration facility?

A. I disagree that an additional site-specific PSHA would be an appropriate and useful condition to impose on the BP Cogeneration facility. The USGS has already performed a detailed PSHA. The most recent PSHA from the USGS was just published a few weeks ago, October 29, 2003. It shows that the BP Cogeneration facility site has significantly less seismic hazard potential than the default design ground motion prescribed in UBC-97. While site-specific PSHAs are required for facilities that pose greater safety hazards, like nuclear power plants, they are neither commonly used nor required to design most types of industrial facilities, like the BP

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Cogeneration plant. Design per UBC-97 will be completely appropriate and will provide a conservative design for the cogeneration facility.

In my opinion, the seismic provisions in US building codes have done and continue to do a good job of protecting public life/property. This has been especially true in the case of power generation facilities. The reason for this good record is that our codes are backed by exhaustive research by seismologists and structural engineering professionals, cumulative design experience, good construction practices, and frequent post-earthquake observations. Based on the latest and thoroughly researched data from USGS, the design ground motion at the BP Cogeneration facility will correspond to a 1,000-year seismic event. This is more than twice the 475-years minimum acceptable return period that has been used to design similar facilities in more seismically active regions such as California.

Additional assurance also stems from the fact that most power generation facilities are designed using a conservative approach, called the Equivalent Lateral Force Method, and without considering the beneficial damping effects of soil-structure interaction. Considering these built-in conservatisms in terms of the design ground motion, past performance history, and conservative design methods, the use of a site-specific PSHA is unlikely to produce any additional benefit in terms of the performance/reliability of the BP Cogeneration facility.

Q. Mr. Goldthorp further suggests that the Council should consider information relating to the Sumas Energy 2 project with respect to the Cogeneration

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facility's application because "the geology of the two sites may exhibit commonalities." In your opinion, would the Council's analysis of seismic conditions for the Cogeneration project be enhanced by information relating to the Sumas Energy 2 project?

A. No. Again, Mr. Goldthorp fails to identify the information he thinks should be considered. Moreover, I understand that the two sites are approximately 23 miles apart. Soil and seismic hazard conditions can vary significantly over such distances (for instance, UBC-97 does not require any amplification of the 0.40 g reference PGA value for Seismic Zone 4 if a site is located more than 15-kilometers (9.3 miles) from a major fault). The likelihood of commonalties of any significance between the geology of these sites is thus minimal. Reference to analyses related to an entirely separate and distant site, like Sumas Energy 2 location, would provide no useful information for the Cogeneration plant and is more likely to confuse than clarify understanding of conditions at the BP Cogeneration site.

Q. Finally, Mr. Goldthorp proposes that the project should include an ongoing post-construction seismic monitoring program, such as installation of an accelerometer. Do you agree with this suggestion?

A. It is neither customary nor required to install seismic accelerometers for a power generation facility of this nature. For Seismic Zones 3 and 4, UBC-97 requires placement of accelerographs in every building over six stories with an aggregate floor areas of 60,000 square feet or more, and in every building over ten stories regardless of the floor area. Clearly, this recommendation would not apply to the BP Cogeneration facility. The purpose of this recommendation is to help monitor ground

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motion rather than to analyze/verify structural performance. Recently, per USGS' recommendation, the US General Services Administration (GSA) has mandated seismic instrumentation as a requirement for federal buildings in high seismic areas and over six stories with an aggregate floor areas of 60,000 square feet, and in every building over ten stories regardless of the floor area. Seismic instrumentation of these facilities is intended to serve as a tool for earthquake researchers and practitioners to learn from post-earthquake data collection and field observations.

Among power generation facilities, only nuclear power plants, where protection of public is a paramount consideration due to concerns about radiation exposure, are required to have a seismic monitoring program. The design, construction, and monitoring requirements for nuclear power plants are dictated by the US Nuclear Regulatory Commission (NRC), rather than by building codes. From this perspective, the need for a monitoring program at the BP Cogeneration facility should be assessed on the basis of risks associated with the potential failure of the facility. In contrast to the consequences of a failure of a nuclear power plant, any potential failure of the BP Cogeneration facility would result in minimal risk to life because:

- The facility is not a place of public occupancy, and
- The facility will employ a small number of employees who would generally work from the Control Building or Administration/Maintenance/Warehouse Building.
- Life/health threat to the public is minimal in the event of any failure of the facility.

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It is noted that the Pacific Northwest Seismic Network [PNSN], located at the University of Washington [http://spike.geophys.washington.edu/SEIS/PNSN/SMO/], and the Pacific Geoscience Centre of the Geological Survey of Canada [http://www.pgc.nrcan.gc.ca/seismo/seismos/sgm-net.htm] have several strong-motion stations currently in operation within about 20 to 25 miles of the project site. The presence of these stations in the nearby vicinity affords a good means for monitoring the seismic activity in the surrounding region.

END OF TESTIMONY

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