BEFORE THE STATE OF WASHINGTON
ENERGY FACILITY SITE EVALUATION COUNCIL

IN RE APPLICATION NO. 96-1 OLYMPIC PIPE LINE COMPANY: CROSS CASCADE PIPELINE PROJECT	))))))

EXHIBIT _____ (WEH-T)

REBUTTAL TESTIMONY OF WADE E. HATHHORN, Ph.D., P.E.

ISSUE: GROUNDWATER AND ASSOCIATED RISK ASSESSMENT

SPONSOR: OLYMPIC PIPE LINE COMPANY

Q. **Please introduce yourself to the council.**

A. My name is Wade Hathhorn. I am a Senior Engineer with Economic and Engineering Services, Inc.

Q. **Please provide a summary of your qualifications and experience.**

A. I hold a Ph.D. in Civil Engineering and have 13 years experience as a specialist in groundwater, subsurface contaminant transport, and water resources. I am a former member of the faculty at the University of Illinois at Chicago and at Washington State University. After leaving academia nearly two years ago, I am now working as consulting engineer for Economic and Engineering Services, Inc. in its Portland, Oregon office. My work experience includes projects involving computer modeling; contaminant transport assessment; RI/FS investigations; site remediation; hydrogeologic and landfill performance assessment; probabilistic risk assessment; quantification of heavy metal mobility in aquatic and terrestrial environments; prioritization of clean-up options at hazardous waste sites; wellhead protection; and assessment of agricultural impacts on groundwater.

I have taught a variety of university courses ranging from basic environmental engineering and fluid mechanics to advanced topics on groundwater and subsurface transport phenomena. I am the author of numerous research articles and have given presentations on my work throughout this country and abroad. I have also presented expert testimony on matters of site restoration, hydrology, fate and transport, and water rights. I am the former chair and now prominent member of the American Society of Civil Engineers' technical committee on Probabilistic Approaches to Water Resources Engineering and am Associate Editor of the society's technical Journal of Water

Resources Planning & Management. I have also served as a technical panelist on the U.S. EPA's review of the Central Columbia Basin Sole Source Aquifer Petition, as a reviewer of the U.S. EPA's Hazardous Waste Information Rule, and as a member of the State of Washington's Science Advisory Board Fate and Transport Subcommittee. A copy of my curriculum vitae is attached to my testimony as Exhibit WEH-1.

Q. On what issues are you providing rebuttal testimony?

A. The potential impact to groundwater resources posed by Olympic Pipe Line's Cross Cascade Pipeline and the respondents' assessment of risk for that project.

Q. Please provide the council with an overview of your rebuttal testimony.

A. Various respondents to the proposed pipeline have developed a negative opinion of the project based on an inaccurate account of future risk of potential groundwater contamination. Much of the commentary depicts the pipeline as a instrument of potential long-term destruction to statewide groundwater resources. Such portrayals are not reflective of the actual hydrogeologic setting for this project or the true risks associated with the construction and operation of the proposed pipeline. In short, the risks for this pipeline are small - much smaller than many of the numbers now being reported by the various respondents. Notwithstanding, the risks are real and must be weighed against the economics of requiring an unrealistic design and operation for the project. It is my opinion that an acceptable balance can be achieved through the use of modern design and monitoring technology, while ensuring a reasonably safe and viable long-term operating strategy for the pipeline.

Q. What is your understanding of the contentions raised by respondents regarding potential impacts to groundwater?

A. The proposed pipeline is to be situated above various groundwater resources of the State, including the extensive aquifers of the mid-Columbia basin basalts and the glacio-fluvial aquifers of the Puget Sound region, along with numerous other surficial and buried subsurface water-bearing units. If constructed as planned, the question raised among others is that of the future potential of the pipeline to degrade or severely reduce the existing quality of the groundwater resources as a result of a catastrophic spill or uncontrolled slow release of fuel. Such questions are thought to be even more critical in areas where the proposed pipeline would cross environmentally sensitive regions, such as those located near streams, critical recharge areas, wellhead protection areas, or sole source aquifers.

Q. Does the Cross Cascade project pose an environmental risk and, if so, what elements are important in understanding the risk?

A. It is important to remember that no activity that alters the existing landscape or changes the native environment is without consequence. The environmental risk of any infrastructure project of this kind is real and non-zero. However, in making the decision to approve this project, it is relevant to understand what is meant by risks and the options for minimizing the potential impact to the environment. The ultimate decision comes down to a trade-off between economics and the acceptance of a reasonable measure of risk regarding the potential impacts associated with a future release of fuel from the proposed pipeline, as compared to the risks of the existing transportation system.

Q. What is your overall opinion of the reasonableness of the respondents' claimed risks for the project?

A. The respondents have written volumes about the potential risks to the State's groundwater resources resulting from the construction and operation of the proposed Cross Cascade Pipeline. Much of the commentary paints a picture of eventual doom and environmental destruction. In my opinion, such portrayals are based on inaccurate science and the development of overly conservative (i.e. excessive) predictions of associated risk.

Q. What is unique about "sole source" aquifers?

A. There is nothing physically special about a sole source aquifer. The designation, by definition, has nothing to do with the potential for contamination. Rather, such designation is generally granted based on the utilization of the resource by 50% percent or more of area residents as the only viable source of drinking water. In theory, sole source aquifers are no more susceptible or vulnerable to contamination than any other aquifer of similar physical constructs. In short, the risk to sole source aquifers is a function of their use, not of the physical properties of the aquifers themselves.

Q. Is it your understanding that the respondents' concern regarding risk to groundwater resources is based on a "risk assessment"?

A. Yes. The respondents' concerns are largely premised on an assessment of the potential risk of a spill and the associated impact to groundwater resources.

Q. Did any of the respondents attempt to actually quantify the risk of a spill impacting groundwater resources?

A. Yes. Dr. Roberds of Golder Associates submitted testimony sponsored by the Cross Valley Water District. Attached to that testimony as Exhibit WJR-1 was the description of a risk assessment model and resulting calculations that attempt to quantify the risk to groundwater resources. Other witnesses appear to rely on the Golder risk assessment in their own testimony.

Q. Generally speaking, what is a risk assessment model and how does one work?

A. A risk assessment model is an analytical tool, often times a collection of computer models, used to assess the likelihood of exposing a receptor to contamination along a given environmental pathway. In this case, the pathway is that of a spill into the subsurface and resulting exposure to humans in a groundwater well used as a potable drinking water source. In assessing this risk, a conceptual model is usually constructed of the pathway, wherein analytical equations are derived for quantifying the associated transport of contaminants and resulting computation of risk. The model is then assigned quantitative input parameters, allowing numerical estimates to be derived of the noted risk outcome.

Q. Before turning to the specifics of the respondents' risk assessments, please briefly describe the factors that control potential impact to groundwater?

A. The nature and extent of a spill is controlled by a number of factors, including the volume and type of fuel released, the timing of the release, the depth to groundwater, the proximity to wells, streams and other discharge points, and the regional movement of underlying groundwaters. However, no one factor is generally more important in the evolution of a spill than the physical composition of the subsurface domain itself. The type of soil or rock and the overall physical make up of the subsurface environment are the dominant factors in determining the area of coverage and travel velocity of a spill.

Q. How does the complexity of the subsurface environment affect a risk assessment model?

A. In quantifying the risks, there are no absolutes - especially not within the confines of the subsurface environment. Unlike the common textbook portrayal, the movement of subsurface water and contaminants is very complex. This complexity is linked to the natural variability of the geologic environment and the inherent inability to accurately observe the physical and chemical processes that control water and contaminant movement in this setting. It is difficult for any risk assessment model to account for the variability and complexity of the subsurface environment. Recognizing this uncertainty is the key to understanding and interpreting all predictions of risks or outcomes within this environment.

Q. What role does that uncertainty play in the assessment of risk to groundwater resources?

A. The decision making process generally demands specificity. Without exact numbers and figures upon which to base a decision, choice often becomes mired in dispute of fact. The key to finding an appropriate answer often relies on experience, a proper understanding of the physical and biochemical processes, and an reasonable approach to quantifying potential outcomes. In short, risk assessment modeling can provide order of magnitude estimates if sufficient data and modeling are employed. It does not, however, provide absolute answers.

Q. Risk assessment modeling aside, what would need to actually occur in order for a spill to result in groundwater contamination?

A. The most relevant setting would be that of an unconfined aquifer. Here, the subsurface profile contains an unsaturated zone, capillary fringe, and phreatic aquifer. The released non-aqueous phase liquid (NAPL) would invade (e.g. flood) the unsaturated zone, moving downward under the forces of gravity in and among the pore space not already filled with water. The principal driving mechanism would be the volume and timing of the release above. Lateral spreading would occur under local capillary forces and the tensions exerted by the finer grained sediments. The fuel would fill the remaining void space in sufficient volume so as to satisfy local capillary pressures. Once cut-off from its source, the spilled NAPL would ultimately reach a volumetric content referred to as residual saturation.

Provided sufficient volume is released, the spill would eventually reach the capillary fringe and water table, forming a floating lens of free-product material. This lens would tend to depress the surrounding water table and act as source of local contamination within the phreatic aquifer. From this lens, various compounds of the NAPL are dissolved and carried away by the regional movement of water within the aquifer. The central primary mechanisms controlling transport within the aquifer are those associated with the movement of water itself and the hydrophobicity of the dissolved compounds. The dissolved hydrocarbons would sorb onto the soil or rock, creating an effect known as retardation wherein the contaminant moves slower than the water. This retardation can easily slow the movement of a plume by an order of magnitude or more. The principal elements of a gasoline spill (i.e. BTEX) may experience retardation effects on the order of 2 to 10 times the movement of the water, depending on the BTEX components involved.

For example, the typical retardation of benzene is around 2 or 3. This means that the benzene is traveling at a rate 2 to 3 times slower than the surrounding groundwater.

Q. Are NAPL spills readily mobile in groundwater ?

A. Although mobile to a certain extent, it is important to note that NAPLs do not move as readily as the groundwater itself. Owing to the effects of retardation and other attenuating factors, there is a tendency for the NAPL and its aqueous dissolution products to remain near the origin of the spill. Moreover, light NAPLs such as gasoline and diesel fuels are less dense than water and float near the surface of an unconfined aquifer. Once released, the relative slow movement of the water and the hydrophobicity of the compounds often times results in a stable, very slowly moving plume. The more dominant transport pathway for benzene, toluene, xylene and to a lesser extent ethylbenzene (BTEX) is commonly that of volatilization and movement as a gas in the vadose zone. Moreover, under certain geochemical conditions (especially an aerobic setting), BTEX compounds are readily biodegraded, resulting in further natural mass reduction within the aquifer. In combination, these effects tend to limit the lateral migration of these contaminants within an aquifer and greatly reduce the risk of large downgradient contaminant migration.

Q. Are you familiar with the terms "natural bioremediation" or "natural attenuation"?

A. Yes. The terms are related to one another. Natural attenuation is a term used to describe the inherent processes within the subsurface which tend to reduce the mass, toxicity, mobility, volume or concentration of contaminants in soil or groundwater. Natural bioremediation, on the other hand, is one of the processes that lead to natural attenuation, wherein pollutant mass reduction is achieved through the metabolic activity of microbes within the subsurface.

Q. **Based on your review of their testimonies, did the respondents consider the effects of these "natural" factors in assessing the risk posed by pipeline release?**

A. In my opinion, natural bioremediation and associated natural attenuation were not given just review by some of the respondents. Throughout the 1980's and 1990's, there have been extensive studies conducted to assess the occurrence and effects associated with natural attenuation on petroleum spills throughout the United States. Citing a recently published review article by Chapelle (1999), the author writes:

"…. Perhaps the best-documented example of this behavior was a crude oil spill in northern Minnesota near the town of Bemidji. In 1979, an oil pipeline ruptured and spilled 1670 cubic meters (approx. 441,000 gallons) onto the land surface. Over the next year, oil migrated downward and formed a lens floating on the water table. The site was instrumented with observation wells and monitored throughout the 1980's and 1990's. A plume of dissolved hydrocarbon, principally BTEX compounds, was observed to develop downgradient of the oil lens. However, by 1985, the BTEX plume had stopped spreading, extending only about 150 m downgradient of the oil lens."

Q. **What effect does natural attenuation have on groundwater transport?**

A. As noted above, it is a widely observed fact that petroleum-based groundwater contamination tends not to form large, extensive plumes and often degrades on its own under the influence of naturally occurring bacteria. As a result, BTEX plumes generally tend be very slow moving and isolated near the origin of their release. Citing Chapelle (1999) once again:

"Perhaps the most unanticipated technology has been the development, widespread use, and regulatory acceptance of intrinsic bioremediation. Intrinsic bioremediation, the use of natural attenuation processes combined with environmental monitoring as a remedial strategy, is most effective when applied to plumes of dissolved BTEX compounds."

These effects are also commonly observed for many of the heavier hydrocarbon fractions found in diesel. Although less biodegradable, these heavier organic compounds are highly immiscible and largely retarded in typical aquifer settings. These results further highlight the growing body of evidence that spills, even large ones do not necessarily pose a long-term threat to groundwater resources. Moreover, plumes from hydrocarbon spills tend not to grow over time in magnitude (once the source is removed), but rather tend to stabilize and degrade under a variety of natural attenuation processes.

Q. What factors influence the potential impacts to aquifers that supply drinking water?

A. The potential impacts to groundwater, especially drinking water supplies, of a sizable petroleum spill are greater near a well or wellfield. In producing water at a well, a pump is utilized in capturing water from the surrounding aquifer. It is important to note, however, that the resulting capture zone is three-dimensional and greatly influenced by the physical composition of the surrounding aquifer, the pumping rate, and the regional component of groundwater flow. Aside from proximity, the depth of the well also plays a very important factor in determining if it will be impacted by a spill. Gasoline and diesel are less dense than water and float on a local water table. Hence, deeper wells are less likely to be impacted by such a release. Moreover, many of the wells noted by respondents as being vulnerable to a potential spill (e.g. Wells #1 and #9 of the Cross Valley Water District) are partially confined, that is, they are naturally protected from contamination from above by local layers of low hydraulic conductivity within the subsurface.

Q. What is a "capture zone"?

A. A capture zone defines the hydraulic boundaries within an aquifer which act to serve a well during its operation. Capture zones are typically quantified in terms of the time required for water to reach a well during pumping. As an example, the 5-year capture zone refers to the collection of subsurface hydraulic pathways for which the representative travel time of water to a well will be less than or equal to five years. The size of capture zones are largely a function of the rate of pumping, the physical properties of the aquifer, and the rate of regional groundwater flow within the aquifer.

Q. Did you find the respondents' characterization of capture zones accurate?

A. To the extent the characterizations purport to reflect reality, they are not accurate. Capture zones are normally predicted (or delineated) using very simplified models of the actual aquifer system to which they are applied. In particular, predictions of this kind are based on limited two-dimensional perspectives of a much more complex, three dimensional hydrogeologic environment. Moreover, these models are executed using homogeneous (or nearly so) representations of aquifer properties and improper assignment of important boundary conditions. The resulting predictions of capture are fraught with error and represent nothing more than planning level of estimates of upgradient areas which may be hydraulically connected to the well. The extrapolation is that any spill which might occur within such a zone would eventually produce a contamination event at the well. Such broad conclusions are simply not true. The impact from a spill depends greatly on the depth of the well, the presence or absence of confining or semi-confining layers, and the overall heterogeneity of the aquifer. In short, most capture zones are defined for simplified models of the subsurface, neglecting the true complex, three-dimensional character of most aquifers. Such models can be a useful tool so long as their inherent limitations are recognized.

Q. With regard to spill migration, what is the difference between lateral and vertical migration?

A. Like the aquifer itself, the spill environment is three-dimensional. As noted earlier, the typical gasoline or diesel spill will produce contamination that will tend to float on top of an unconfined aquifer and migrate laterally in the direction of local groundwater movement. Wells on the other hand tend to be placed at depth. Their capture zones are more lateral than vertical in radial dimension. As a result, vertical separation provides an important buffer between the intake of a well and any contamination that may be generated in a potential fuel release from above.

Q. Did the respondents take vertical migration into account in their risk assessment?

A. Generally, no. The noted quantification of contaminant risk and capture zone analysis employ only a limited, two-dimensional aquifer model. The vertical element has been ignored. As a result, the reported risks reflect a very conservative (i.e. overly pessimistic) estimate of real hydrogeologic response.

Q. What is your opinion of the respondents' calculated groundwater risk assessment ?

A. Much is made in the Golder Associates pre-filed testimony of the computed risks associated with a release from the proposed Cross Cascade Pipeline on the supply wells of the Cross Valley Water District (CVWD). In an approach which incorporates a mix of complexity and over simplification, an elaborate string of calculations were performed to derive an expected annual probability of exceeding State action levels (i.e. one-half of the MCL) in at least one of CVWD's wells. The resulting number is reported as a 0.08% chance every year, which translates to an approximate 4% chance over 50 years. Mr. Anderson of Golder further opined: "It is therefore reasonable for CVWD to assume ... that they will experience water quality problems in one of the wells over its planning period . . .." It is very unclear as to the justification of this finding as a whole and as to the degree of uncertainty in Golder's risk calculation outlined by the 4% chance over 50 years. Even if the reported number were true, one can question whether or not the reported risk justifies the conclusion that a problem will occur. Moreover, this result is solely based on the contaminant MTBE which will not be present in the pipeline. For benzene and the other BTEX compounds, Golder's own calculations have shown the risk to be small, in fact, zero.

Q. How accurate is the Golder calculation of risk?

A. Regardless of what the actual number might be, it is important note that the approach used in calculating such a number is in itself the source of a great deal of uncertainty. The methods employed by Golder Associates are based on a simplistic representation of the subsurface and conservative model input data. Depending on such selection, one can get a wide variety of results. The question then becomes which number is correct? An absolute answer is not clear and may not be predicted with any degree of certainty. What can be concluded, however, is that the real risk of potential groundwater contamination for the reported hydrogeologic setting is small - likely much smaller than the reported 4% chance in 50-years.

Q. **Is the Golder calculation of risk based on specific fuel compounds?**

A. Yes. The risk analysis is based on releases of benzene and methyl tertiary-butyl ether (or MTBE). Benzene is one of the components of BTEX and a principal constituent of gasoline. Benzene is a known carcinogen and, under regulations, may not exceed 5 parts per billion in drinking water. MTBE, on the other hand, is a fuel oxygenate added to enhance combustion and reduce air pollutants. The health effects of MTBE are not well-defined. At present, there is no regulatory standard for MTBE.

Q. According to the Golder analysis and spill scenario, is there a risk that benzene will exceed the regulatory standards?

A. No. The Golder analysis showed zero chance of benzene exceeding even one-half of the regulated groundwater action levels under the spill scenarios they considered.

Q. How might other BTEX compounds fair under similar analysis?

A. Benzene is generally the more mobile of the BTEX compounds in groundwater. One would expect greater retardation and less mobility from the other compounds. Hence, one would assume that the other BTEX components, ethylbenzene, toluene, and xylene, would also not exceed their target limits and would therefore yield a similar computed risk of zero.

Q. What role does MTBE play in the Golder risk assessment?

A. A substantial one. In fact, it is fair to say that Golder's risk calculation is driven solely by the inclusion of MTBE in its spill scenario and resulting risk assessment calculation.

Q. Is Golder's use of MTBE in its risk assessment appropriate?

A. No. For the simple reason that the petroleum products to be carried by the pipeline will not contain MTBE. MTBE is normally added just prior to distribution at tank farms or in tanker trucks, after the petroleum products has been transported through the pipeline. Thus, if MTBE is not expected to be present in the pipeline, including it for purposes of assessing the risk of an associated spill is not appropriate.

Q. Would the exclusion of MTBE affect the Golder risk assessment calculation?

A. Yes, it would change the reported risks dramatically. Removing MTBE from the Golder calculation would change the calculation from the claimed 4% chance of regulatory exceedance over 50 years to a zero percent chance during that same time period.

Q. Are you saying that there is a zero chance of impact to groundwater from a spill?

A. Not at all. There is no such thing as a zero risk of impact. What I am saying is that, under the Golder analysis, the computed risk of exceedance would be zero for the remaining BTEX compounds. Again, the point is that the Golder risk assessment is nothing more than an estimate of potential outcomes within a complex hydrogeologic setting. It is no better or no worse than the numbers and assumptions plugged into it. Accordingly, I do not believe that all numbers and assumptions used are appropriate or result in an accurate number.

Q. What is the risk of an impact to groundwater resources and how can it be minimized?

A Citing the respondents' own calculations, the risk of groundwater contamination occurring from the proposed pipeline is small, namely a number much less than the reported 4% risk over 50 years. This conclusion is derived using Golder's own numbers, wherein eliminating MTBE from the noted calculations results in a zero risk of regulatory exceedance. Notwithstanding, it seems reasonable to accept that fact that some risk of a release from the pipeline is real. Such risk, however, can be greatly minimized through the use of modern design and monitoring technology. Hence, the focus of discussion should not center on the actual estimate of risk, but rather on the means for reducing that risk through improved modern construction and maintenance for the pipeline. In recognizing this fact, OPL has agreed to incorporate a number of important design changes and operational provisions which will greatly reduce the potential for releases and their impacts within the reported areas of interest.

Q. If the precise risk to groundwater cannot be ascertained, how can the Council consider and evaluate the potential risk?

A. The decision to accept the proposed pipeline must consider a basic tradeoff between economics and risks. There is no amount of money that will reasonably reduce the risk for a project of this kind to zero, regardless of its design, placement and/or operation. Hence, the decision must be made in light of a reasonable acceptance of risk, focusing on the need for minimizing potential future impacts through the use of state-of-the-art design and monitoring of pipeline operations. In short, it is my expert opinion that the noted risks for the proposed Cross Cascade Pipeline are acceptably small and that the project can proceed under minimal threat to the State's groundwater resources, while at the same time achieving reasonable, long-term economic expectations for the construction, operation, and maintenance of the facility.

I declare under penalty of perjury under the laws of the State of Washington that the above testimony is true and correct to the best of my knowledge and belief.

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Wade E. Hathhorn, Ph.D., P.E.

References

Chapelle, F. H. (1999). Bioremediation of Petroleum Hydrocarbon-Contaminated Groundwater: The Perspectives of History and Hydrology, Groundwater, 37(1), pp. 122-132.