BEFORE THE STATE OF WASHINGTON
ENERGY FACILITY SITE EVALUATION COUNCIL

In the Matter of: Application No. 2013-01 TESORO SAVAGE, LLC VANCOUVER ENERGY DISTRIBUTION TERMINAL	No. 15-001 PRE-FILED WRITTEN DIRECT TESTIMONY OF DR. ERIC PETERSON ON BEHALF OF CLARK COUNTY

I. INTRODUCTION AND QUALIFICATIONS

1. Please state your name, your title and employment, area of expertise and business address:

My name is Eric Peterson and I am employed as a Senior Principal Engineer in the Technical Safety and Risk Department of MMI Engineering (MMI), Inc., a subsidiary of Geosyntec Consultants, Inc. My business address is 11490 Westheimer Road, Houston, Texas 77077. I possess a broad range of knowledge and expertise on technical process safety and risk related to infrastructure projects for industrial clients worldwide, particularly those involved in oil and gas, hydrocarbon transport, and the chemical industry. A copy of my curriculum vitae is attached as Exhibit A.

2. Please describe your educational background:

I hold an MS in Geophysical Sciences from the University of Chicago and a PhD in Chemical Engineering from Lamar University, as well as undergraduate degrees in both Physics and Mathematics. I am currently on the technical steering committee for the American Institute of Chemical Engineers (AIChE) Center for Chemical Process Safety (CCPS) and on the committee responsible for producing the "Siting and Layout of Facilities" (2nd edition) to be

published by Wiley later this year. I am also a steering committee member of the Mary Kay O'Connor Process Safety Center at Texas A & M University.

3. What are your responsibilities in your current role?

In my current professional role, I lead the technical safety efforts at MMI. I have more than 30 years' experience in the fields of Physics, Mathematics, and Chemical Engineering, most recently applied to Technical Process Safety and Risk for the oil and gas industries.

4. Prior to your current role, what other positions have you held?

Prior to my employment at MMI in January 2012, I was a Principal Consultant with Scandpower, a subsidiary of Lloyds Register (2010-2012) and a Specialty Engineer at Fluor (2008-2010), performing many of the same duties.

5. What is your understanding of the proposed oil terminal project as it relates to your testimony?

I have reviewed the EFSEC Vancouver Energy Draft Environmental Impact Statement of January 22, 2016 and am familiar with Vancouver Energy's 2013 Application for Site Certification to construct the proposed rail to marine oil terminal. Based upon this review, it is my understanding that Vancouver Energy proposes to construct and operate a rail to marine oil terminal at the Port of Vancouver on property that is adjacent to the Clark County Jail Work Center (JWC). It is my understanding that this terminal will be capable of receiving an average of 360,000 barrels of Bakken crude oil per day and that this oil will be off loaded from rail cars and transferred to above ground storage tanks via above ground piping that runs along the northern boundary of the JWC property. From the storage tanks, oil would be transferred to marine vessels on the Columbia River via above ground piping that runs along the eastern boundary of the JWC property. Finally, it is my understanding that the Port of Vancouver intends

to construct an electrical substation adjacent to the JWC and in close proximity to the above ground piping bordering the JWC property.

II. MODELING OF POTENTIAL RISKS TO CLARK COUNTY JAIL WORK CENTER (JWC)

6. What work were you asked to perform in connection with reviewing the proposed oil terminal?

Geosyntec/MMI was requested by Clark County, Washington to analyze the likelihood of adverse petro-chemical events, disasters, spills, explosions or other environmental threats that could arise at the proposed Tesoro Savage LLC Vancouver Energy Distribution Terminal (terminal) that could present a risk to human health and safety for those employed, visiting [or] and incarcerated at the Clark County Jail Work Center (JWC). This evaluation included an analysis of: 1) the risks presented by transporting, transferring, and storing crude oil within the proposed facility; and 2) potential options to mitigate the risks to human health and safety at the JWC. A written report regarding these analyses is attached as Exhibit B (EFSEC Ex.2001-000000-CLA.)

7. What was the scope of this evaluation?

MMI's preliminary scope was to undertake a hazard identification and risk assessment study focused on identifying and quantifying the potential risk presented by the proposed oil terminal to the JWC. This work was executed by completing both a consequence-based screening assessment and a Quantitative Risk Assessment (QRA).

8. Please describe the scope and nature of the consequence-based screening assessment that you performed.

The screening assessment objective was to evaluate the potential for fire, toxic, and explosion events at the proposed terminal based on what is currently known regarding the planned infrastructure and operations. The methodology for the execution of this work

incorporated guidance widely accepted by the oil and gas industry and provided by the American Petroleum Institute (API) and Center for Chemical Process Safety (CCPS). The terminal is assumed to be handling Bakken crude oil for storage and transfer between rail and marine transportation services. A hazard evaluation was conducted to identify "credible worst case" release events which could result in potential consequences at the JWC.

A total of six (6) hazardous scenarios were evaluated using Recognized and Generally Accepted Good Engineering Practices (RAGAGEP) principals and MMI's experience with similar facilities. Scenario descriptions from the more detailed Table 2-3 of Exhibit B (EFSEC Ex.2001-000000-CLA) are:

- Rail Terminal – release during rail car transfer operations.
- Rail Terminal – single car catastrophic failure.
- Rail Terminal – multiple rail car catastrophic failure resulting from escalation event.
- Pipeline – release during transfer from rail car to tank storage.
- Pipeline – release during transfer from tank storage to marine terminal.
- Storage Tanks – loss of containment from tank or connected equipment.

For purposes of the screening assessment, we selected assumed locations of each hazardous scenario. The assumed location of each hazardous scenario are depicted on Figure 2-2 of Exhibit B (EFSEC Ex.2001-000000-CLA.) The locations specified are approximate and were chosen based on closest proximity to the JWC. In the case of transfer pipeline events, these could occur anywhere along the pipeline. For the purposes of the consequence representations, several points along the pipeline were chosen, including several in the vicinity of the JWC. Meteorological data consisted of annual average conditions for Vancouver, WA.

9. How did you calculate what the likely consequences of these adverse events would be?

To determine event consequences, this study utilized industry-recognized criteria set by the following end points: 1) maximum downwind distance to lower flammable limit (LFL) and ½ LFL levels for flash fire scenarios at or near ground level; 2) maximum thermal radiation levels with impact to personnel and buildings/structures for fire scenarios; and 3) maximum overpressure loads with impact to personnel and buildings/structures for explosion (blast) scenarios. The end point criteria are summarized as Table 2-4 in Exhibit B (EFSEC Ex.2001-000000-CLA.) Computer modeling was performed using Process Hazards Analysis Software Tools (PHAST), a widely-used industry standard by Norwegian software manufacturer DNV GL. PHAST calculates release rates, plume dispersion, thermal limits of pools and jets, and overpressure results based on supplied inputs. In this study, as is typical in consequence based screening assessments, the calculations represent open field; meaning, neither geometric or topography effects are taken into account.

10. What assumptions were made regarding the potential hazardous release scenarios you evaluated?

All releases were assumed to be oriented in a horizontal direction and assumed to be continuous with no mitigation measures. In the case of directional events such as jet fire and downwind distance from pool fires, the maximum extent is rotated and assumed possible in all directions. A summary of consequence modeling results for the different hazards are provided in Section 2 of Exhibit B (EFSEC Ex.2001-000000-CLA.)

III. POTENTIAL RISKS TO CLARK COUNTY JAIL WORK CENTER ASSOCIATED WITH PROXIMITY OF PROPOSED ELECTRICAL SUBSTATION TO PROPOSED OIL PIPELINE INFRASTRUCTURE

11. What were the results of this screening assessment?

Potential scenarios leading to impact(s) to the JWC are discussed in Table 2-5 of Exhibit B (EFSEC Ex.2001-000000-CLA.) for each hazard type, from each of the six hazardous scenarios. Since the study attempted to be realistically conservative, in each case the end points which have the potential to reach the boundary of the JWC are identified. Based on the results of the consequence based screening assessment; the most likely hazard to the JWC is presented by releases from the planned 24-30″ oil pipelines on the northern and eastern boundaries of the JWC property.

12. **Based upon the results of the screening assessment showing credible hazards to the JWC, what additional did analysis did you perform?**

Since the screening assessment determined that some of the "credible worst case" release events have the ability to adversely impact occupants of the JWC, MMI conducted a preliminary QRA. The objectives of the preliminary QRA was to quantitatively evaluate the level of risk posed to occupants of the JWC as a result of the operation of the terminal, compare this risk to relevant risk acceptance criteria, and to aid Clark County and EFSEC in its understanding of health and safety risk for the incarcerated, jail employees, and visitors at the JWC.

The scope of the QRA consisted of the following tasks:

- Develop isolatable sections of process equipment based on supplied data and operational understanding.
- Conduct a release frequency evaluation of transfer pipelines based on identified hazardous events.
- Calculate consequences to the JWC based from hazardous releases from the transfer pipelines. Consequences were calculated for a selection of potential hole

sizes, intended to represent a number of incidents/failures resulting in a loss of containment.

- Conduct a preliminary ignition probability analysis. An additional sensitivity calculation was conducted to include the potential increased ignition probability from a planned substation to be located between the transfer pipelines and the JWC.
- Determine consequences to occupants of JWC site based on fatality probits and occupied building impairment criteria.
- Conduct risk calculations and determine LSIR for personnel located on the facility ground and within buildings on the JWC site.
- Compare risk against relevant risk acceptance criteria.

Details of the QRA are found in Section 3 of Exhibit B (EFSEC Ex.2001-000000-CLA.)

13. Please briefly describe the protocol used to conduct the Quantitative Risk Assessment.

Hazardous release cases for use in the QRA were based on the hazard identification screening assessment and consequence modeling. For each hazardous release, the frequencies of jet fires, flash fires, pool fires, explosions and unignited gas clouds were evaluated using an event tree approach. Event tree analysis is a forward, bottom up, logical modeling technique for both success and failure that explores responses through a single initiating event while laying a path for assessing probabilities and frequencies of the outcomes and overall system analysis. These event trees include: initiating event frequency; and nodal success/failure probabilities.

Event trees include a number of nodal probabilities ranging from ignition through detection, isolation and blowdown. Each node represents a certain event and therefore has probability. Ignition and failure probabilities are based on information provided in appropriate

industry data sources recommended and provided in Exhibit B (EFSEC Ex.2001-000000-CLA.) Consequence analyses were conducted to assess the outcome of each identified loss of containment scenario. The consequence modeling typically included evaluation of gas dispersion (distance to flammability levels, toxic levels), heat radiation levels from fires (flash, jet and pool fires) and explosion overpressures as appropriate to the identified hazards. Immediate fatality probabilities used appropriate referenced data found in Exhibit B (EFSEC Ex.2001-000000-CLA.)

15. What standards or criteria govern whether the risk presented by a proposed oil terminal is acceptable to an adjacent residential jail facility like the JWC?

The U.S. has not adopted explicit land use planning risk criteria relating to oil terminals such as the one being proposed, but rather typically relies on development and evaluation of criteria on an individual project and location basis. It is common to use metrics from other countries as a reference; such as the UK Health and Safety Executive and the Netherlands External Safety Decree. In these references, risk is typically addressed as a function of Societal Risk (F-N curve). This evaluation requires detailed information about population distributions in both time and location and categorization of population types. In concept level evaluations, if this information is not readily available (as in this case), the metric of Individual Risk per Annum (IRPA) and Location Specific Individual Risk (LSIR) are used for evaluation.

16. What do these sources and your experience tell us about the minimum acceptable risk for the JWC?

In terms of the UK HSE societal risk guidance, a risk level of 1 in a million ($1x10^{-6}$/yr.) would generally be considered "broadly acceptable". This risk threshold is consistent with risk tolerance standards in projects that I have been involved with and, in my opinion, is the appropriate minimum risk threshold for co-locating an oil-terminal of this nature with a 200 bed

residential jail facility like the JWC. Greater risk levels in excess of 1 in one hundred thousand ($1x10^{-5}$/yr.) or one in ten thousand ($1x10^{-4}$/yr.) represent notably higher and, in my view, generally unacceptable risks that are incompatible with a residential jail facility.

17. What were the results of the Initial Quantitative Risk Assessment Study?

The QRA results are reported in terms of Location Specific Individual Risk (LSIR) to any individual located within the JWC, LSIR is the expected frequency of a fatality if an individual is located in a particular area for 24 hours a day, 365 days a year. LSIR was calculated for each hazard event using the event trees shown in Figure 3-2 of Ex. B (EFSEC Ex.2001-000000-CLA.) The value of LSIR, multiplied by the number people on average in the area provides the Potential Loss of Life (PLL) in the area. Areas of high LSIR and high PLL represent high risk to occupants of the JWC.

Using the frequency and consequence data derived for each loss of containment event, MMI built a risk picture for personnel located within the JWC. Key risk drivers were identified, thereby allowing an assessment of potential risk mitigation measures to be conducted.

The base case LSIR results for the JWC were estimated as $2.35x10^{-5}$/yr. (1 in 42,553) for people outside and $1.62x10^{-5}$/yr. (1 in 61,728) for people within the site buildings. As referenced above, this is risk range is notably higher than the "broadly acceptable" risk of 1 in a million ($1x10^{-6}$/yr.). Additionally, this risk range is in excess of 1 in one hundred thousand ($1x10^{-5}$/yr.), which I consider to be generally unacceptable for off-site facilities such as the JWC. Given the residential off site nature of the JWC, risk levels above this 1 in a million level are not appropriate and, in my view, should be reduced through required mitigation. Tables 3-1 and 3-2 in Exhibit B (EFSEC Ex.2001-000000-CLA) provide LSIR breakdown by event type. The majority of the risk is for jet (spray) fires from the pipeline. Spray fire implies that the jet is a

combination of liquid and vapor. Should the pipeline be buried, the liquid and vapor from a release will be substantially reduced as well as the risk.

18. What other relevant information were you able to take into account in the Quantitative Risk Assessment?

After the initial QRA was performed, it was noted that an electrical substation is planned to be installed in the north-east corner of the JWC parcel. The location of this substation is reflected in the Port of Vancouver's Petition for Condemnation (EFSEC Ex. 2002-000000-CLA). Oil terminal drawings also indicate that this substation will be located between the JWC and the proposed 24-30″ oil piping that would run along the northern and eastern edge of the JWC. Drawings indicate that the substation will be located only about 10 feet from the proposed 30″ piping to the north. The inclusion of this type of electrical equipment significantly increases the probability of ignition of flammable releases. To account for this additional proposed electrical substation infrastructure, a sensitivity of the risk assessment was conducted in which ignition probabilities were modified to account for the location of an electric substation between the proposed transfer pipelines and the JWC.

The base case LSIR results for JWC without the electric substation were estimated as 2.35×10^{-5}/yr. (1 in 42,553) for people outside and 1.62×10^{-5}/yr. (1 in 61,728) for people within the site buildings. As referenced above, this pre-electrical substation is risk range is already significantly higher than the "broadly acceptable" risk of 1×10^{-6}/yr. and, in my view, is represents an unacceptable risk to the JWC that requires mitigation. Tables 3-1 and 3-2 in Exhibit B (EFSEC Ex.2001-000000-CLA) provide LSIR breakdown by event type.

Following the QRA modification to include the electrical substation, the sensitivity case LSIR results for JWC notably increased to 3.64×10^{-5}/yr. (1 in 27,473) for people outside and 2.45×10^{-5}/yr. (1 in 40,816) for people within the building. Put simply, the presence of the

electrical substation ignition source increased the risk to the JWC population by approximately 50%. This increase in risk is driven by the increase in probability of ignition due to the proximity of the electrical substation. This heightened level of risk is well above what is considered broadly or even generally acceptable in the industry and, in my opinion, requires necessary mitigation (described below) as a condition of approval. Tables 3-3 and 3-4 in Exhibit B (EFSEC Ex.2001-000000-CLA) provide LSIR breakdown by event type updated to include the electric substation.

19. Are there any industry authorities or guidelines that relate to the co-location of oil terminal infrastructure and electrical substations?

In addition to the above referenced risk attributable to the proximity of the oil terminal infrastructure, the proposed electrical substation and the JWC, there are industry authorities that advise against co-locating such facilities in proximity to each other. For instance, the CCPS book, "Guidelines for Facility Siting and Layout", Wiley, 2003 recommends minimum separation distances of 250 feet between petrochemical infrastructure, such as the subject oil piping, and electrical substation equipment.

20. Based upon these authorities and/or your experience, what mitigation, if any, do you believe would reduce the risks to the JWC population to an acceptable level?

Based upon the above referenced heightened modeled risk associated with the co-location of oil terminal infrastructure and an electrical substation and industry guidelines recommending 250 feet of separation, I believe that it would be unwise and unreasonable to locate these facilities unless there is a minimum separation of 250 feet between the oil piping and the substation if the pipeline is not buried. Put simply, in order to reduce the risk to the JWC population, the construction of the proposed oil terminal should be conditioned upon the re-location of *either* the proposed oil piping (increased distance to 250 feet &/or burial) or the

proposed electrical substation. Alternatively, the risk to the JWC posed by the proximity of the planned oil and electrical infrastructure could be eliminated entirely by relocating the JWC facility to a suitable location that is not adjacent to these proposed facilities.

IV. CONCLUSION

Geosyntec/MMI's and my review of the EFSEC Vancouver Energy Project Draft Environmental Impact Statement (DEIS) dated January 22, 2016 and the completion of the Qualitative Risk Assessment (QRA) report attached as Exhibit B (EFSEC Ex.2001-000000-CLA) indicates that there are unnecessary potential risks to the Clark County Jail Work Center (JWC). As set forth above, the risks posed to the JWC population by the proposed oil terminal are not insignificant and should be mitigated by, at least, allowing for 250 feet of separation between the planned oil piping and electrical substation adjacent to the JWC property. Additionally, the risk to the JWC population from the proposed terminal could be reduced to nearly zero if it were re-located to another suitable location that is not adjacent to the proposed terminal and electrical substation.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge. Executed this 13th day of May, 2016, at Houston, Texas.

Dr. Eric Peterson, PhD