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January 22, 2016

Mr. Brendan Wright
Director of Performance Solutions
Savage Services
901 W Legacy Center Way
Midvale, UT 84047

Re: **Review of Tesoro-Savage DEIS, Final Report**
BakerRisk Project No. 01-05692-001-16

Dear Mr. Wright:

Baker Engineering and Risk Consultants, Inc. (BakerRisk®) has completed a review of the Draft Environmental Impact Study (DEIS). The DEIS pertains to Tesoro Savage Petroleum Terminal LLC, a Delaware limited liability company doing business as Vancouver Energy (Vancouver Energy) and the proposed terminal located in Port of Vancouver, Washington (Terminal). The objective of the work was to provide information regarding typical crude terminal hazards and risks as part of the response to claims made in the DEIS.

1.0 INTRODUCTION

BakerRisk® was retained to prepare information for a response to the DEIS for Vancouver Energy, located in Port of Vancouver, Washington. The Terminal includes a 360,000 barrel-per-day (bpd) crude-by-rail uploading and marine loading facility that will provide North American crude oil to U.S. refineries. This evaluation qualitatively assessed hazards and risks at a crude transfer terminal. The resulting comments provide a qualitative assessment of risk posed by the Terminal operations and are based on engineering judgment and experience with similar facilities.

2.0 SCOPE OF WORK

The objective of this work is to provide information for a response to the sections of the DEIS describing risks to public health and safety. In order to meet the objective, BakerRisk completed two tasks:

1. Identified and qualitatively assessed the risk of the operation of the facility (as distinguished from the risks of vessel transportation and rail transportation related to the facility).

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2. Provided comments and analysis to supply context and a framework for understanding and evaluating the various risks identified in the DEIS from the Terminal operations.

The scope of the analysis is limited to the typical operation of the facility and does not include the transportation of crude to or from the facility. The analysis is qualitative in nature and based on engineering judgment and experience with similar facilities. It is noted that specific facility layout, design conditions, and operational procedures are important to any risk analysis.

3.0 REVIEW OF COMMENTS

After a review of the DEIS, BakerRisk has comments on the following:

1. General overview comments
2. Comments related to the qualitative risk assessment
3. Comments on specific sections

Each of these areas is addressed separately below.

3.1 General Comments

The DEIS makes many statements about the frequency and consequence of events associated with the Terminal without a rigorous treatment of the associated credible hazards and risks. In general, the DEIS takes a consequence-based approach to looking at potential hazards from the facility. Although the DEIS occasionally mentions the relative frequency of events, most conclusions center around the maximum identified consequence, as opposed to the maximum credible scenario or the likely outcome. Consequence analyses performed without regard for the associated frequencies or feasibility of the scenarios are not typically good decision making tools, since it is almost always possible to think of factors that could be applied to a scenario to make it worse.

Risk studies combine the consequence of particular events with the likelihood of such events actually occurring. Risk studies allow common and rare events to be compared and assist in decision making such as risk mitigation prioritization and risk tolerance.

3.2 Qualitative Risk Assessment Comments

Risk is typically defined as the frequency of an event occurring multiplied by the consequence of that event should it happen. The DEIS states that there is insufficient data to obtain a range of release volumes for crude storage tanks. BakerRisk holds that this is not the case, but agrees with the quoted statement from the EPA given in the DEIS (Section 4.4.1) that properly designed, constructed, and maintained aboveground storage tanks are highly unlikely to fail.

While there are multiple methods of calculating failure rates for events, BakerRisk typically implements a parts count approach. Common equipment types are grouped together (e.g., pumps, tanks, etc.) and standard failure rates are determined for each group. The standard failure rates are developed by determining the number of failures in a given time period and normalizing by the total number of that type of equipment in the given service over the same period. The expected pieces of equipment for this type of facility include pumps, atmospheric storage tanks, and piping. Pumps and storage tanks both have a predicted failure rate of about 3E-3 failures per year per pump or tank for small releases[1-11] (i.e., leak area equivalent to a circular hole with a diameter of approximately 0.5 inches). Catastrophic failures are predicted to occur at a much lower frequency, between 2E-5 and 8E-5 failures per year per tank[1-11]. It should be noted that these failure rates are conservative estimates (i.e., tend to overstate release frequency) based on older tanks in a variety of services. New tanks that are installed and maintained according to RAGAGEP (Recognized and Generally Accepted Good Engineering Practices) should show significantly lower failure rates, resulting in a lower predicted frequency for loss of containment.

A release of crude oil may remain unignited, may ignite and result in a pool fire, or may ignite and result in a vapor cloud explosion (VCE). Each of these potential consequences is considered separately in the subsections below, followed by a summary of the expected consequence of a crude release.

3.2.1 Unignited Release

An unignited release of crude oil will typically constitute a negligible health hazard to offsite populations. Sumps and berms would be used to contain the spill and decrease the amount of hydrogen sulfide (H_2S) given off. Monitoring should be in place to assess long term exposure to facility personnel, but that is a different concern than acute toxic exposure due to a crude release. It is recognized that a release of crude oil alone (i.e., without ignition) may have unwanted environmental impacts.

The majority of tank failure risk is for small releases. These releases would likely result in small pools of liquids that could be easily held by the secondary containment within the facility but could escalate to a larger event if mitigation efforts are unsuccessful. Larger releases would still likely be contained by secondary containment.

[1] Guidelines for Process Equipment Reliability Data, CCPS, 1995
[2] Methods for Determining and Processing Probabilities, CPR12E-TNO, 2nd Ed., 1997
[3] F. P. Lees, Loss Prevention in the Process Industries, Butterworth (publishers), 1980
[4] OREDA 1984
[5] IEEE Standard 500-1984, IEEE Guide to the Collection and Presentation of Electrical, Electronic, Sensing Component, and Mechanical Reliability Data for the Nuclear Power Generating Stations, IEEE, 1984
[6] Technica, Risk Assessment Equipment Failure Data Handbook
[7] Roodbol, Risk Analysis of Six Potentially Hazardous Industrial Objects in the Rijnmond Area, A Pilot Study, 1982
[8] HSE FRED Database
[9] GICRA “Recueil de données de fiabilité d’appareils de l’industrie chimique” (actualisation 1999)
[10] Smith and Warwick, A Survey of Effects in Pressure Vessels in the UK for the Period 1962-1978 and its Relevance to Nuclear Primary Circuits, UKAEA, 1981
[11] ANIMAL (Handbook Probability Figures, vs. 1), Belgium Ministry of Physical Planning and the Environment

3.2.2 Release Leading to Fire

As noted above, severe injuries to personnel would not typically result from an unignited release of crude oil. Personnel injuries likely require that the released material be ignited. This means that the conditional probability of ignition must also be accounted for, in addition to the release frequency, in order to express the corresponding risk. Crude oil is stored at ambient temperatures and atmospheric conditions. Under these conditions, crude oil is relatively inert and much more difficult to ignite than typical hydrocarbons (hence the need for the refining processes to create usable fuels). As such, a conservative value for the conditional probability of ignition for crude oil would be about 0.1 for releases in a typical industrial setting[12]. This gives a frequency of ignited small releases of approximately 3E-4 per year per tank for a typical crude oil storage tank. It should be noted that the DEIS report indicates that Vancouver Energy will be following RAGAGEP with regard to permitting and ignition controls within their facility, so the conditional probability of an ignition value of 0.1 invoked above is likely very conservative (i.e., the actual value should be much lower).

In the unlikely event of a release of crude followed by ignition, the most likely outcome would be a pool fire. Pool fires normally form slowly enough that onsite populations have time to evacuate away from the event. Typically, industry standard spacing tables require that crude tanks be sited away from occupied buildings. A pool fire would therefore be unlikely to impact occupied buildings. Clouds of dense smoke may form depending on the fire and meteorological conditions; however, proper emergency response plans should mitigate this hazard such that it would have a negligible impact on populations in and near the facility.

3.2.3 Release Leading to VCE

A VCE requires that a flammable vapor cloud first be formed, and then ignited. For a VCE capable of generating damaging blast loads, the release must therefore be able to form a sizable flammable gas cloud. In addition, the ignition source must not immediately ignite the released material, but rather must be delayed in time, such that the flammable gas cloud can form before it is ignited (e.g., a delayed ignition source). As noted above, crude oil is stored at ambient temperature and atmospheric pressure, so that only a very small fraction of the released crude will vaporize or aerosolize. A small portion of lighter hydrocarbons would come out of suspension, but this is unlikely to be sufficient to form a sizable flammable gas cloud. It is therefore very difficult to form a sizable flammable vapor cloud due to a crude release. The frequency of VCEs would be further reduced due the conditional probability of a delayed ignition source. VCE scenarios capable of generating damaging blast loads due to a crude oil release are therefore extremely unlikely.

3.2.4 Expected Crude Release Injuries and Risk

Assuming a typical layout and occupancy distribution for the facility, it would be unlikely that onsite populations would be injured by any of the events described here. Moreover, the number of people located at most crude terminals and tank farms is minimal. All of the above factors contribute to the consequence being relatively negligible for many scenarios.

[12] AW Cox, Lees, and Ang, Estimates of Probability of Ignition for Leaks of Flammable Fluids, 1990.

The low consequences and low frequencies expected result in a very low risk predicted for the facility. There are a variety of mitigation measures that may further reduce the associated risks at the facility. In general, the DEIS does not consider the prevention and mitigation measures that would be in place to lower the frequency of hazardous events and mitigate their severity.

3.3 Specific DEIS Section Comments

BakerRisk was asked to comment on specific sections of the DEIS. Comments on each of these specific sections are provided below.

3.3.1 Response to Section 4.7.1

Table 4-13 claims that a large explosion at the facility could project debris beyond the proposed facility boundaries. As explained in Section 3.2 above, there is little chance of experiencing a severe explosion due to the characteristics of the crude and the design of atmospheric storage tanks. One hazard that could cause debris would be an internal tank explosion; however, it is expected that an internal tank explosion would not throw debris beyond the proposed facility boundaries. Furthermore, tanks properly designed, constructed, and maintained would be very unlikely to experience an internal explosion event.

3.3.2 Response to Section 4.7.2

Section 4.7.2 claims that the crude oil explosions from the facility could form craters and impact local topography. Given the low likelihood of an explosion event occurring as discussed in Section 3.2.3, and that the vast majority of releases at the site would be contained by dikes, it is extremely unlikely that the craters could be formed or the local topography impacted by a crude oil explosion at the facility. As such, these statements appear to be overly conservative.

3.3.3 Response to Section 4.7.4

Section 4.7.4.1 confirms that "the largest potential spill identified at the proposed Facility would be located within the bermed and lined secondary containment area surrounding the storage tanks." The likelihood of such a release is low, as discussed in Section 3.2. The likelihood of such a release escaping a berm or happening to be near the water is even more remote. Proper design, construction, and maintenance of tanks, berms, and sumps should result in a very low probability of a facility release impacting the Columbia River.

With regard to fires and explosions, the already low predicted failure rate would be further reduced by the need for an ignition source. Fires would likely be contained by secondary containment within the facility. Explosions are extremely unlikely due to the nature of crude oil and the requirement for a delayed ignition source. In the unlikely event of an accidental release and ignition, proper firefighting techniques coupled with adequate facility layout design as well as fire protection designed into the system consistent with industry standards would likely be able to control a pool fire and prevent it from spreading. It would be important to monitor any sparks caught by the breeze to prevent a fire from spreading to other areas.

3.3.4 Response to Section 4.7.5

Section 4.7.5 uses the same arguments made in previous statements to indicate that facility operations will pose a significant impact to vegetation near the plant. The DEIS has indicated that there is minimal vegetation in close proximity to the facility. As such, these claims are likely overstated. As noted previously, the majority of spills (already a low frequency occurrence) should be contained by berms and sumps.

3.3.5 Response to Section 4.7.9

Section 4.7.9.1 states:

> "A crude oil spill at the proposed Facility could potentially expose onsite personnel, nearby Port facility personnel, and residents/workers at the Clark County Jail Work Center (JWC) and Fruit Valley neighborhood to released oil and its vapors. Health effects could result from direct exposure to crude oil or crude oil vapor compounds. Workers and spill responders would be at risk for exposure in the event of a crude oil spill."

In the experience of BakerRisk, studies of similar terminals have not shown significant offsite impacts from crude oil. The only effects likely to be experienced are a "smell nuisance" in the unlikely event of a loss of containment or, in the more unlikely event of a fire, clouds of smoke. It is unlikely that a loss of containment would produce high enough H_2S concentrations to cause acute toxic exposure to typical offsite populations. Emergency response plans, spill containment, and firefighting techniques should be in place to reduce the likelihood of these events and consequences.

In the last paragraph of section 4.7.9.3, the DEIS acknowledges that there is a wide variety of consequences associated with a potential fire or explosion. As such, looking at only the consequences of severe events cannot provide a complete decision-making framework. Looking at the frequency of these events would likely show a very low risk of significant injury to onsite populations or to the public.

3.3.6 Response to Section 4.10

Section 4.10 states:

> "The potential for major unanticipated events resulting from factors occurring alone or in combination as described in Section 4.1 cannot be totally eliminated. Although extremely unlikely, an unprecedented event could potentially cause one or more crude oil storage tanks and the secondary containment berm to be significantly damaged, which could result in a very large crude oil spill at the proposed Facility. Such a spill could spread inland to other Port facilities, nearby wetlands and neighborhoods and could reach the Columbia River. Impacts from such an event could result in significant adverse impacts to environmental resources and would require a major response effort."

It is acknowledged that an event could be conceived that could have these effects; however, such an event strains the limits of credibility. OSHA and EPA both ask operators to consider credible release scenarios. The types of events described as highly consequential throughout the DEIS are normally predicted to be very low frequency events at the similar facilities studied by BakerRisk. Consequence analyses done without regard for the associated scenario feasibility or frequency are typically of little merit in decision making, as it is almost always possible to think of factors that could be applied to the scenario to increase the consequences.

4.0 CONCLUSION

The DEIS makes many statements about the frequencies and consequences of events associated with the crude Terminal without a rigorous treatment of the credible hazards and risks. Moreover, the DEIS often uses the concepts of consequence, frequency, and risk interchangeably, without regard to their inherent differences and proper use. The findings from the DEIS are therefore of questionable worth as a decision-making tool.

Crude oil handling is a well understood process with relatively low safety consequences due to loss of containment events. In BakerRisk's experience, terminals handling crude oil tend to pose negligible risks to offsite populations due to fire, explosion, and toxic hazards. Fire, explosion, and toxic exposure scenarios that impact onsite personnel can be postulated; however, both the frequency of such events and the likelihood of a person being in the given area at the time the event takes place tend to be low.

Although the predicted risk to onsite and offsite populations from terminal operations should be low, the DEIS primarily articulates worst case scenarios and neglects the highly infrequent nature of their occurrence. It is difficult to determine what would constitute an acceptable level of risk for a facility evaluated in this manner, as it is almost always possible to conceive ever more unlikely scenarios that could result in ever more severe consequences. In addition, this type of consequence modeling ignores the full range of prevention and mitigation options available to a facility to reduce the both the likelihood and consequence of an event.

The analysis performed by the DEIS does not support a claim that the Terminal would be unsafe, only that it is possible to devise scenarios where populations could be adversely impacted. A more thorough analysis would likely remove many of the conservative assumptions made in the DEIS and provide a more realistic view of the risk posed by the Terminal.

5.0 CLOSURE

We appreciate the opportunity to perform this study, and look forward to working with you in the future. If you have any questions or comments, please do not hesitate to contact me at PHodge@BakerRisk.com or to call me at (281) 822-3100.

Sincerely,

Phillip R. Hodge
Senior Consultant

Approval:

J. Kelly Thomas, Ph.D.
Vice-President and Blast Section Manager

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