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# MEMO

**DATE:** April 1, 2015

**TO:** Portland Planning and Sustainability Commission

**FROM:** Tom Armstrong, Supervising Planner

**CC:** Susan Anderson, Director

**SUBJECT:** **Follow-up on Questions and Outstanding Issues from March 17, 2015 Hearing and Work Session on the Terminal 6 Environmental Zoning Code and Map Amendments**

## Quantitative Risk Assessment (QRA)

Akana, the City's independent reviewer of the QRA, has found the Pembina Portland Propane Terminal QRA is generally a thorough and realistic evaluation of the potential risks and consequences that can be expected due to the operation of the proposed terminal. The document conforms to industry-standard QRA techniques, guidelines and reference sources. It appears that Pembina has applied generally accepted risk mitigation procedures to the design of the terminal and plans to continue with an integrated QRA process throughout the final design of the terminal. Revision of the QRA to address the Akana general and specific comments is unlikely to significantly alter the outcome of the modeled risks.

**1. What are the risk curves from other countries? Is the UK more or less conservative?**

*From Pembina*
The FN curves represent the frequency distribution of multiple casualty events which may occur for a particular facility (Attachment 1). The figures, on surface, would suggest that other jurisdictions use as stringent or even more stringent FN criteria than the UK HSE FN criteria. However they are very similar when coupled, as they must be, with leak frequency data. The UK maintains an extensive leak frequency database, which shows a higher frequency of leaks than leak data used in other jurisdictions.

Pembina also provided a paper by their consultant, *International Comparison On The Application Of Societal Risk Criteria* (Attachment 2).

**2. What are some risk curves from other types of projects? What level of risk have other communities accepted? Refineries in Puget Sound or California? Large power plants?**

*From Pembina*
Pembina provided a diagram of acceptable risk standards compared to other types of accidents or events (Attachment 3).

| Risk | UK HSE | Rough Equivalent |
|---|---|---|
| 1:1,000 years | Workers | Travel by Air/Car |
| 1:10,000 years | Public | Accidents at Home |
| 1:1,000,000 years | New Plants | Death from CJD (prion disease) |
| 1:10,000,000 years | - | Struck by Lightning<br>Winning the Lottery |

*From Akana*
As noted in the QRA Executive Summary, because there are not requirements for individual and societal risk criteria in the US, the estimated risk levels for the terminal were evaluated against the UK HSE risk tolerability criteria for individual and societal risk. The QRA results in risk levels have been accepted for other high risk facilities in Oregon, such as the Umatilla Chemical Agent Disposal Facility that operated near Hermiston.

**3. What is the significance of the risk curve "touching" the UK benchmark?**

*From Akana*
The FN curves included in the QRA would appear to indicate that any expansion of the terminal beyond the currently proposed terminal configuration that would result in increased rail car deliveries, rail car unloading activities, additional bullet tanks or refrigerated storage, or ship loading activities, would have the resulting effect of increasing the frequency of the release scenarios sufficiently such that the United Kingdom Health & Safety Executive (UK HSE) Criteria Line would be exceeded. Although Pembina has indicated that it currently has no plans to expand the capacity of the terminal, the implication of this information in the QRA is that the City of Portland should consider limiting the current and future capacity and configuration of the terminal to the design currently proposed. If this is not the intended implication of the QRA or the impact of future expansions on the total FN risk curve, the QRA should be revised to clearly indicate what level of expansion or increased capacity might be acceptable. Alternatively, the City of Portland should consider including limitations in their Intergovernmental Agreement with the Port of Portland regarding future expansion and the need for a revised QRA before any such expansion could proceed.

**4. What are the regulations or standards of practice regarding the assessment of shrapnel? Any real world experience/examples?**

No fragment risk analysis has been provided as of March 31.

**5. What is the significance of the Potential Loss of** Lives (PLL) **rate of 1 fatality every 38 years?**

There are two measures of societal risk in the QRA Report – PLL or FN curves. Section 4.2.1 (page 27) states that the total PLL is equal to 1 statistical fatality every 38 years. The PLL is the product of the combined event frequency, likelihood of that event causing a fatality, and the number of impacted persons. 60% of the total comes from off-site fatalities; which means that the number over-estimated because over the way DNV assumed that the population in zip code 97213 is evenly distributed. That is, DNV has "placed" residents in the off-site areas affected by the thermal radiation and over-pressure events even though no one lives there. This number could be reduced by changing the way the population is distributed in the model.

**6. The probability of an accident at the loading jetty is 100 percent?**

No explanation has been provided as of March 31.

*7.* **What is the standard of practice for assessing lesser injuries and property damage? +1 pounds per square inch (psi) overpressure is essentially breaking windows, so that is the extent of property damage?**

*From Pembina*
The +1 psi overpressure is just over atmospheric pressure and windows may break at that point. The +1 psi is the "end point" of the worst case scenario, as defined by the Environmental Protection Agency (EPA). Pressures at lesser distances could cause further damage, but as per the draft QRA, almost all overpressure risk contours are fully contained within the facility site.

*From Akana*
There is no discussion of injury risk versus fatality risk in the QRA. The QRA should be revised to either include an assessment of injury risk or explain why injury risk is not included in the model.

## Worst Case Scenario

**8. What is the difference between risk and worst case scenario? How should probability be factored into the safety assessment and the ALOHA model results?**

*From Pembina*
The draft QRA includes modeling of the EPA's Worst Case Scenario. The Worst Case Scenario only looks at the potential consequence resulting from the full release of the maximum propane volume stored in the facility's single largest vessel onsite (the larger of the two refrigerated double wall tanks). The worst case scenario does not incorporate any safety mitigation measures (as are required under the EPA Risk Management Program). The worst case scenario also does not address any failure frequency and therefore does not address risk in any way (Risk Assessment = Consequence x Frequency).

The Worst Case Scenario makes a number of assumptions that are not realistic and the reasons why are included in the table below following each assumption.

| USEPA Worst Case Scenario Assumption | Reason Why the Assumption is not Realistic |
|---|---|
| The refrigerated double wall storage tank (tank within a tank) is full and the tank walls disappear, instantaneously releasing the full volume of propane to the open air. | There is no historical record of such a tank exploding or rupturing, but even if such an event occurred, the tank walls would not instantaneously and completely disappear. |
| All of the liquid propane instantaneously vaporizes. | The very large volume of propane is refrigerated to -44° F, which requires a significant amount of heat to vaporize the full volume, which is not available at regular weather conditions for instantaneous vaporization. |
| The propane vapor instantaneously expands in a perfect circle to the USEPA mandated maximum outer limit which would result in an ignition case producing a +1 psi overpressure. | The propane vapor would not expand in a perfect circle to the mandated limit because of factors like topography, weather, obstructions, trees, etc. that make this an impossibility. |

| | |
|---|---|
| There is instant and total ignition. | This doesn't consider that the propane flammable mixture range is 2.1 to 9.6 percent and therefore doesn't consider whether the propane-air mixture is at the right concentration for ignition. |

**9. If one pressure (bullet) tank blows-up, who is at risk?**

From the QRA Report (Additional Hazard Zone Models), for the instantaneous rupture of one pressure storage tank, the +1 psi hazard zone extends to a 0.64 mile radius from the tank. This radius includes adjacent industrial buildings and those across Marine Drive as well as Smith and Bybee Natural Area and West Hayden Island, but it does not include the Class Harbor Floating Home docks.


**Figure 3-2 Instantaneous Release Scenario, Pressure Storage Vessel, 1 psi Overpressure Effect Zone**

*From Akana*
Although a majority of the most likely overpressure events are confined to on-site locations at the pressurized propane bullet tanks, Figure 4-10 indicates a greater than 1-in-1,000 year possibility of a 3 psi event impacting the refrigerated storage tanks. This section indicates that a 3 psi event is sufficient to deform a steel frame building and pull it away from its foundation. However, there is no discussion in the QRA regarding the ability of the refrigerated tanks to withstand a 3 psi event. The QRA should be revised to address this issue.

**10. Explain why multiple bullet tank Boiling Liquid Expanding Vapor Explosions (BLEVEs) are not likely.**

Only the pressurized propane storage bullets were modeled for a BLEVE event in the QRA Report.

*From Pembina*
As stated on Propane 101 website (http://www.propane101.com/explodingpropanetanks.htm): "Many people mistakenly believe that propane tanks in any setting will explode if they are mishandled in some certain way.... Propane tanks do not explode. They do not implode and nor do they rupture or come apart on their own. In fact, bringing a propane tank to the point of "explosion" is a tremendously difficult and time consuming task that's not as simple as most people think.... people should understand that a propane tank, operating under normal circumstances will not explode or rupture. Safety devices and mechanisms are in place to prevent explosions, accidents and propane tank ruptures or breaches."

A BLEVE occurs when the pressure in a tank exceeds the ability of the safety relief valve to safely vent excess pressure from the tank. A propane tank BLEVE may occur when the tank is subject to extreme heat such as by fire for an extended period of time. For a BLEVE to occur, the steel wall(s) of the

vessel has to significantly weaken (steel starts to weaken at 300° C or almost 600° F), or the pressure inside the vessel has to significantly exceed the design pressure.

Some specifics of the Pembina Portland Propane Export Facility at Terminal 6 that are relevant when considering the possibility of a BLEVE or multiple BLEVEs include:

- All of the propane related facilities, tanks, piping, etc are aboveground, there are no buried propane facilities on site and therefore equipment is more easily monitored visually.
- The site will be staffed 24/7/365 with both control room operators and "boots on the ground" onsite operational personnel, so there will be constant visual attendance on site.
- The full site will be secured in accordance with the Maritime Transportation Security Act and implementing regulations as well as being part of the Port of Portland controlled security system.
- The facility has numerous strategically placed infrared fire-eyes to continuously monitor for fire and heat sources as well as gas detection devices to monitor for any vapor releases. All such sensing monitors are connected to automatic shut-off valves and equipment within the facility for quick shutdown ability.
- The offloading bullets will be equipped with full time water deluge system to keep the bullet tanks cool in case of any fire which also keeps the liquid propane within the tanks cool.
- The offloading bullets will be operating at about 160 psig and are designed to over 280 psig.
- All such bullets are tied into the onsite emergency flare system to allow for controlled burn of any propane vapors immediately or as required. This flare has continuous flame which will burn the propane as soon as it is automatically routed to the flare, similar to how a house furnace or water heater works. All bullets are also isolated from each other by automatic isolation valves.
- The bullets will have fire retardant insulation on the exterior of each bullet for the bottom third or so to both keep the propane product cooler longer and inhibit any external flame from impinging on the steel.
- The emergency flare system is designed to bring the pressure of each bullet tank down by 50 percent within 15 minutes via a safe and controlled combustion in the flare stack.
- With the design and operational considerations at the Pembina facility, therefore, to BLEVE a single tank on the Terminal 6 site will require an extremely hot fire for an extended period of time which will be extremely unlikely considering the onsite monitoring equipment, shutdown systems, continuous water deluge system, tanks insulation, ongoing visual presence of staff and emergency flare system.

To BLEVE multiple tanks is also extremely unlikely for the above reasoning and if one tank was in a BLEVE situation; the remaining tanks could be isolated and vented to the emergency flare system to relieve pressure to below 50 percent within 15 minutes.

*From Akana*
The QRA could be revised to provide calculations regarding maximum pool size and fire duration versus containment design, available fuel, and time to overpressure, to provide a clearer description of the chain of unlikely events and fire duration that would be required to result in such an event.

*Testimony from Joseph Miller, PhD*
BLEVEs have occurred in the LPG tanks at the Cosmo Oil refinery in Ichihara City following the magnitude 9.0 Tohoku Earthquake in Japan on March 11, 2011. The fires were finally extinguished 10 days later. The likelihood of a Cascadia Subduction Zone mega-earthquake in the near future in Oregon raises questions about the possibility of BLEVEs occurring at Pembina's proposed terminal. *(BPS Staff note: the supporting sources cited appear to indicate that a spherical storage tank design was involved in this case, which is different from that proposed by Pembina.)*

## Propane Facility Safety Record

**11. What is Pembina's long-term safety record? What types of incidents happen at their facility? Causes? Consequences?**

*From Pembina*
In addition to the zero recordable lost time incident record of 2014 (with 2.4 million hours worked), Pembina has been and continues to be a top performing company with respect to overall safety within our industry. Pembina has been shipping propane to Oregon, without incident, for 15 years.

The Canadian Energy Pipeline Association (CEPA) represents Canada's transmission pipeline companies. As a member of CEPA, Pembina shares its safety statistics quarterly to help the association understand trends within the industry. Pembina's injury rate is consistently less than the CEPA membership companies. Pembina's motor vehicle incident frequency rate is consistently less than CEPA's membership companies.

Pembina's safe rail handling achievements include:

BNSF – Stewardship Award – 14 years
Canadian National – Rail Safe Handling Award – 9 years
Canadian Pacific – Shipper Safety Award – 2014 Shipper Safety Award
CSX – Chemical Safety Award – 13 years

**12. There are five Liquid Petroleum Gas (LPG) export terminals and three new builds planned. What is the safety record of the five facilities? Where are they located? How close is the nearest residential area?**

*From Pembina*
The Bentek Energy report ("Executive Summary and Overview of Propane Market Demand and End Uses" dated March 13, 2015) referenced a number of existing and proposed LPG marine export terminals. In addition, several operating LPG facilities that store large volumes of LPG in aboveground refrigerated tanks (although not marine export terminals, the information is still relevant). Detailed safety records of these facilities are not available, but information on incident history is summarized in the Right-to-Know Network (www.rtknet.org) websites and has been included in the summary table (Attachment 4).

The Port reviewed the locational aspects of these propane terminals and prepared are eight maps that illustrate the proximity of these facilities to residential neighborhoods (Attachment 5). The San Pedro/Wilmington LPG facility is close to the Port of Los Angeles, but is within a half mile of densely populated areas. These site characteristics are similarly found at Marcus Hook, PA and Nederland, TX. The Ferndale, WA LPG facility is located within 1.5 miles of the Neptune Beach community. In nearly every case the Port found residential development within 1 or 1.5 miles of the LPG facility.

*From Akana*
Akana reviewed the Right to Know Network (www.rtknet.org) to evaluate the similarities between the referenced facilities and the proposed Pembina Portland terminal. Although the information available regarding these facilities indicates few significant or reportable releases, only a few of them (Petrogas Ferndale, DCP Chesapeake, Suburban Elk Grove) are comparable in size or operation to the proposed Pembina Portland terminal. Many of the other terminals include underground storage (salt domes), rather than large aboveground refrigerated tanks.

Based on public comments, Akana also reviewed the Right to Know Network RMP data for the Suburban Propane facility located in Elk Grove, California. Since construction and startup operations (in 1972), there has not been an accidental release of propane, or any other hazardous substance, at the Suburban Propane Elk Grove Terminal that has resulted in any deaths or off-site injuries, property or environmental damage, evacuations or sheltering in place. The last unplanned and/or non-routine release of Propane was on September 13, 2005, when a nonemployee driver failed to check or relieve

pressure prior to disconnecting a "live hose." The non-reportable release event was mitigated by site personnel. No action was required by off-site emergency response agencies.

**13. Characterize some examples from the real world. Recent accidents at comparable facilities. Causes, impact, lessons learned.**

*From Pembina*
Pembina has not provided information on qualitative examples of incidents at other comparable facilities, with lessons learned, etc as this information is not readily accessible. The draft QRA (Section 2) outlines the scenarios for the facility that were modeled and these scenarios are based on DNV's use of detailed information from the UK LEAK incident database, which is the most comprehensive and up-to-date database of relevant actual incidents available.

*From Akana*
Akana reviewed the PHMSA Office of Hazardous Materials Safety Incident Reports Database Search (https://hazmatonline.phmsa.dot.gov/IncidentReportsSearch/search.aspx). Only 50 incidents are currently listed, with the largest spill totaling 100 liquid gallons. No significant injuries, deaths or environmental impact was reported for similar facilities in the United States.

## Seismic Standards

**14. Facility design to 9.0 / 2,475 year seismic event. Does it make a difference in the modeling that experts now predict that such an event is more likely to occur in the next 30-50 years? How is being "overdue" for an event get factored into the model?**

*From Pembina*
No, if the event size and population remain constant, then the risk and results are the same as modelled.

*From Akana*
The earthquake hazard contributes to a large percentage of the overall calculated risk from the terminal.

The QRA claims to be conservative due to the difference in the design basis earthquake and the QRA basis earthquake, but does not provide any information regarding the magnitude of the uncertainty. The QRA notes that the current civil/geotechnical design earthquake is a 1-in-2,495-year event, but does not identify the design standard, while noting that the current QRA design earthquake is a 1-in-475-year event but does not identify the basis for this assumption. The QRA should be revised to include a quantitative evaluation of the magnitude of the degree of conservatism introduced by this difference (that is, a sensitivity analysis).

**15. Will the safety systems (water deluge/generators) be operational after a seismic event, especially a subduction zone earthquake with a lot of vertical movement? What are the seismic standards are for the pipe rack system?**

*From Pembina*
The safety systems within Pembina's propane facility will be designed to be operational after a seismic event. This would include:

- The fire water system (water storage tank, diesel driven fire water pumps, fire water pipe and fire water hydrants and monitors).
- The emergency diesel driven electrical generator sized to provide critical safety systems with power.
- The flare system allowing safe combustion of propane.
- The site control room which would continue to function after an earthquake.

The following seismic design parameters have been incorporated into the facility:

- The majority of the upland facility foundations will be designed to exceed the International Building Code (IBC) and the Oregon Specialty Structural Code (OSSC), which refer to ASCE 7-10, Section 15 for design criteria specific to non-building structures. The warehouse and administration buildings will be designed in accordance with the IBC and OSSC. All seismic loading will account for the importance factor associated with a given component or building, based on the Risk Categories defined in Table 1604.5 of the OSSC. In fact, the facility will be built to the equivalent of an "essential facility" level as defined in the Oregon Revised Statutes (ORS 455.477(a)); this includes such facilities as hospitals, fire stations and emergency centers.
- The two refrigerated propane storage tanks will be designed in accordance with the two-level performance based seismic design approach based on the guidelines set forth in API 620 (Design and Construction of Welded, Low-pressure Storage Tanks). The two design level earthquakes defined through API 620 are an Operating Level Earthquake (OLE), sometimes referred to as OBE or Operating Basis Earthquake, and a Contingency Level Earthquake (CLE), sometimes referred to as SSE or Safe Shutdown Earthquake. The performance basis objectives and hazard levels for these API based ground motions are defined by API 620 as follows.
    a) OLE—the tank system will remain operational with only minor repair required. The tank system should be capable of withstanding multiple events with this ground motion without significant damage. Ground motions are based on an event with a 10 percent probability of exceedance in 50 years (475 year hazard level).
    b) CLE—the primary liquid container will survive and contain the liquid (with only minor leaks permitted) to protect the public but extensive damage may occur and the tank system may not be repairable after this event. Ground motions are based on the risk targeted Maximum Considered Earthquake (MCER), which is defined in ASCE 7-10 Chapter 21.
- The pipes within the facility will be designed to the seismic performance requirements of ASME B31.3 as well as NFPA 58.
- In terms of foundation performance requirements specific to this facility, it has been determined that all equipment and components critical to safe shutdown shall not exceed 2 inches of vertical settlement and 12 inches of lateral displacement at the foundation level during a CLE seismic event or Design Level Earthquake.
- ASCE 7-10 develops response spectra based on ground motions associated with the Risk-Targeted Maximum Considered Earthquake ("MCER"). The ground motions associated with the probabilistic MCER represent a targeted risk level of 1 percent in 50 year probability of building collapse in the direction of maximum horizontal response with 5 percent structural damping, and the targeted risk level is based on modifications to the US Geological Survey 2,475-year hazard level Probabilistic Seismic Hazard Assessment results. At the site, it should be noted that the MCER values and the 2,475 year hazard level values are relatively similar.

It should also be emphasized that geotechnical hazards for most of the structures will be evaluated consistent with the new 2012 IBC and ASCE7-10 discussed above which now require consideration of liquefaction hazards at a significantly higher level than in previous code cycles. The ASCE 7-10 based liquefaction hazards are now evaluated at the Maximum Considered Earthquake Geometric Mean (MCEG) hazard level, which is based on the 2,475 return period event and is roughly equivalent to the API 620 CLE event.

*From Akana*

The QRA does not indicate the location of the emergency generator or pumps used to power the fire water protection system in case of a loss of site power. It seems reasonable to assess the impact of potential fires or blasts on this building. The QRA should be revised so that the LSIR ranking points include an analysis of the structures housing the emergency generators and pumps for the fire water protection system.

## Rail Safety

**16. Address the off-site rail safety in some way. What is accident rate of BNSF or UPRR in Portland region? Do derailments happen more or less frequently?**

Minimal information on rail safety is available. BPS staff checked the Federal Railroad Administration online database and found that from January 2010 to December 2014 there were 41 reported accidents that resulted in no casualties in Multnomah County.

The QRA does not cover rail operations at the facility – but an analysis is expected. There is a worst-case release scenario that covers an instantaneous rail car rupture and BLEVE. A vapor cloud explosion involving the entire propane volume of one rail car is modelled as a detonation. A BLEVE is also modeled, the consequences of which would include a blast wave and fireball. Fragment throw of vessel pieces was not assessed. The worst-case scenario analysis found the flammable vapor dispersion (1/2LFL) distance is 245 meters or 0.15 miles and the explosion hazard zone (+1 psi) is 674 meters or 0.42 miles.

The maps in the QRA show the explosion hazard zone at the unloading facility (Figure 4.3 and 4.4). BPS has prepared a map of those zones along the two most common railroad routes through Portland to Terminal 6 (Attachment 6).

**17. Who regulates and ensures the rail system is safe? ODOT Rail or Federal Railroad Administration (FRA)?**

Railroads are subject to stringent FRA regulation regarding track and equipment inspections; employee certification; operating speeds; and signaling systems. FRA safety inspectors travel the country evaluating rail facilities and operations. In many states, FRA inspectors are supplemented by state inspectors. Railroads are also subject to safety oversight by a number of other federal agencies, including the Occupational Safety and Health Administration (OSHA), the Pipeline and Hazardous Materials Safety Administration (PHMSA), and the Department of Homeland Security (DHS).

ODOT's Rail Division (ODOT Rail) ensures the safe transport of propane and other hazardous substances in Oregon primarily by focusing on prevention. ODOT Rail acts as an agent for the Federal Railroad Administration (FRA) by inspecting track, railroad equipment and cars, hazardous materials and operating practices. As an agent of FRA, ODOT Rail is responsible for implementing FRA and other federal requirements through the Pipeline and Hazardous Materials Safety Administration (PHMSA), as well as currently applicable state law.

Over the last decade, ODOT Rail has increased its focus on prevention of incidents through inspections. Specifically, Agency inspectors regularly monitor train speeds, track conditions, train car placement and tanker car valve closure settings at individual facilities, rail yards operated by railroads and the rail system more broadly in Oregon.

While ODOT Rail focuses on prevention, local public safety agencies serve as first responders in the event of an oil spill, explosion or derailment. ODOT Rail also helps emergency response agencies be prepared in the case of a hazardous material derailment or spill by directing railroads operating in Oregon to provide information on the movement of hazardous materials to first responder agencies, as currently required by law (ORS 842.082).

More recently, ODOT Rail has coordinated with the State Fire Marshal, Oregon Office of Emergency Management, Oregon Department of Environmental Quality, other state agencies and emergency first responders on new rule making that, if adopted, would modify ORS 842.082 and other related statutes to require railroads operating in Oregon to provide information on the movement of hazardous materials directly to ODOT Rail, which would function as a clearinghouse for all first responders in the Oregon.

The Oregon Legislature has a bill introduced in this legislative session to address rail safety regarding the movement of petroleum products as well as other hazardous materials, which includes propane. Oregon House Bill 3225 has been introduced which "Directs Environmental Quality Commission to adopt rules applying certain oil spill prevention and emergency response planning requirements to railroads that own or operate high hazard train routes in this state"

**18. What upgrades or investments are Burlington Northern Santa Fe (BNSF) and Union Pacific (UP) making?**

There is very little information on specific projects in Portland, but there is some publicly available information from the Port of Portland, BNSF and UP websites.

The Port of Portland has reported on investments in the Rivergate Industrial District:

- Port of Portland – South Rivergate Rail Yard Expansion Boosts Flow of Export (August 2012): http://www.portofportland.com/publications/PortDispatch/post/South-Rivergate-Rail-Yard-Expansion-Boosts-Flow-of-Export.aspx
- Port of Portland - More Than $50 Million in Road and Rail Projects Showcased in Rivergate (April 2011): http://www.portofportland.com/publications/PortDispatch/post/More-Than-2450-Million-in-Road-and-Rail-Projects-Showcased-in-Rivergate.aspx
- Port of Portland – Transportation Projects: http://www2.portofportland.com/Properties/TransportationProjects

In addition, the two class one rail carriers servicing the Port of Portland have information on their websites about their capital investment program. BNSF's website has information about previous investment value (over $5 billion completed in 2014) and 2015 planned investment value ($1.5 billion). Links for this information are below:

- BNSF – Investing in Infrastructure/Expanding Capacity: http://www.bnsf.com/customers/service-page/index.html
- BNSF - 2013 Annual Review: http://www.bnsf.com/about-bnsf/bnsf-review/2013/bnsf-annual-review-2013.pdf

UP issued a press release that discussed their 2015 capital plan of $4.3 billion (http://www.uprr.com/newsinfo/releases/financial/2015/0205_dividend.shtml)

**19. Is the rail system is getting safer, despite recent incidents?**

Based on data collected from the Federal Rail Administration (FRA), from 1980 through 2013, the train accident rate fell 79 percent; the employee injury rate fell 84 percent; and the grade crossing collision rate fell 81 percent. Since 2000, the declines have been 42 percent, 47 percent, and 42 percent, respectively, indicating that railroads are continuing to improve their safety record.

In 2012, 99.998 percent of rail hazmat shipments reached their destination without a release caused by a train accident. Rail hazmat accident rates are down 91 percent since 1980, down 51 percent since 1990, and down 36 percent since 2000.

Within Oregon, train derailments have been reduced from 75 in 2004 to 18 in 2013, a 76 percent drop. Over the same period, rail crossing incidents have declined from 23 to 9, a reduction of 61 percent.

**20. What is the safety record, not just design, of the DOT 112 rail car?**

No additional information has been provided as of March 31.

Public testimony has noted that an accident in Alberta, Canada occurred in which pressurized DOT 112 rail cars transporting propane ruptured and exploded after becoming uncoupled during a derailment, jackknifing across a track and impacted by following cars.

## Shipping Safety

### 21. What is the safety record of Very Large Gas Carriers?

The information available addresses Liquid Natural Gas (LNG). A 2014 report from the Society of International Gas Tanker and Terminal Operators Ltd (SIGTTO) and the International Group of LNG Importers (GIIGNL) indicates that in the last 50 years, LNG carriers have safely delivered over 77,000 cargoes. These consignments all reached their destinations with no breach of a cargo containment system and with no onboard fatalities directly attributable to the cargo.

LNG carriers have been involved in three high-speed grounding incidents. Although the vessels suffered substantial bottom damage as a result of the groundings, in no case was a cargo containment system breached. There have also been other LNGC groundings in port areas when the vessels were proceeding at slower speeds. Again, containment systems have remained intact in each of these occurrences

LNG carriers have also been involved in two collision incidents in the last 24 months. In the first a LNG carrier and a container ship collided in the Singapore Straits and in the second an LPG carrier and an LNG carrier came together in Tokyo Bay. As was the case with the grounding incidents, no LNG carrier containment system was compromised as a result of the collisions.

## Security

### 22. What are the Homeland Security standards for securing this type of facility?

*From Port of Portland*
The primary framework for regulation to address terrorist threat is the Maritime Transportation Security Act (MTSA), implemented by the U.S. Coast Guard. Note that facilities regulated pursuant to the MTSA are not regulated by a different set of Department of Homeland Security standards, the Chemical Facility Anti-Terrorism Standards (CFATS).

MTSA-regulated facilities such as the Port of Portland's Terminal 6 and the proposed Pembina Terminal must submit a Facility Security Assessment (FSA) to the Coast Guard that identifies and evaluates critical assets, critical infrastructure, potential threats to critical assets and infrastructure, and general facility security vulnerabilities. Pembina must develop and submit a Facility Security Plan (FSP) to the Coast Guard that addresses these vulnerabilities. These plans must also include provisions for establishing and maintaining physical, passenger / crew and cargo security, access control, and ensuring training programs to protect a facility. The FSA and FSP are considered Sensitive Security Information and as such are not publicly releasable. The FSP, approved by the Coast Guard, is valid for five years, after which time the facility must submit an updated FSP and FSA. Vessels are likewise required to submit Vessel Security Plans (VSP).

The measures that would be implemented at Terminal 6 would include fences, gates, monitoring (by personnel and camera), remote detection systems, patrol, credentialing, collaboration with federal, state, and local law enforcement authorities, vehicle and personnel inspections, restriction of personal vehicles, emergency drills, unannounced federal inspections, etc. The measures are custom suited to the facility based on the Facility Security Assessment FSA) which requires a look at multiple aspects of the physical facility, personnel accessing the facility, the nature and handling of the cargo. The idea is that the program is risk based, in other words, we would expect additional measures for a facility handling propane than we would for a facility handling steel rail because of the nature of the cargo. Likewise, a cruise ship terminal would have more measures because of the number of people at the facility. In addition, there are additional or different measures (or frequency for example) when the federal threat level (called a Maritime Security or MARSEC) changes. The USCG approves both the FSA and the Facility Security Plan (FSP). In addition, all personnel working at the terminal undergo a

federal background check and must hold a federally issued Transportation Worker Identification Credential (TWIC).

The Coast Guard Sector Columbia River Area Maritime Security Committee (AMSC). The AMSC coordinates the activities of all port stakeholders, including other federal, local and state agencies, industry and the boating public. The AMSC also collaborates on plans to secure the port and effectively use limited resources to deter, prevent and respond to terror threats. Through the Joint Terrorism Task Force, the Port of Portland Police plays a crucial role in passing appropriate threat-based information to the Port's terminal managers as well as all tenants. This facilitates increased security activities (increased presence/monitoring) that could be critical to deterrence and/or response if something should occur.

The Code of Federal Regulations site provide a basic outline of expectations for facilities.
http://www.gpo.gov/fdsys/granule/CFR-2010-title33-vol1/CFR-2010-title33-vol1-part105/content-detail.html

There is additional detail in the Navigation and Vessel Inspection Circular (NVIC) guidance document.
https://www.uscg.mil/hq/cg5/nvic/pdf/2003/NVIC_03-03_CHANGE_2.pdf

## Other Issues

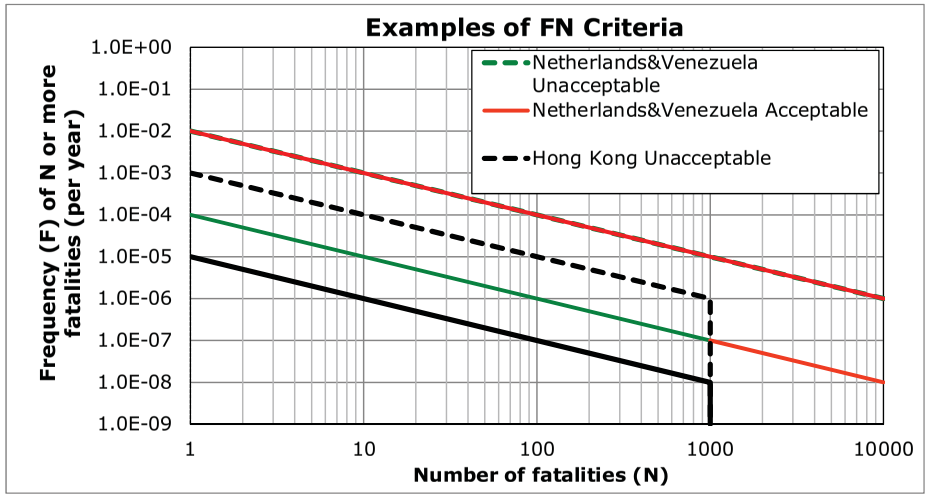
### 23. Pacific Northwest Energy Projects

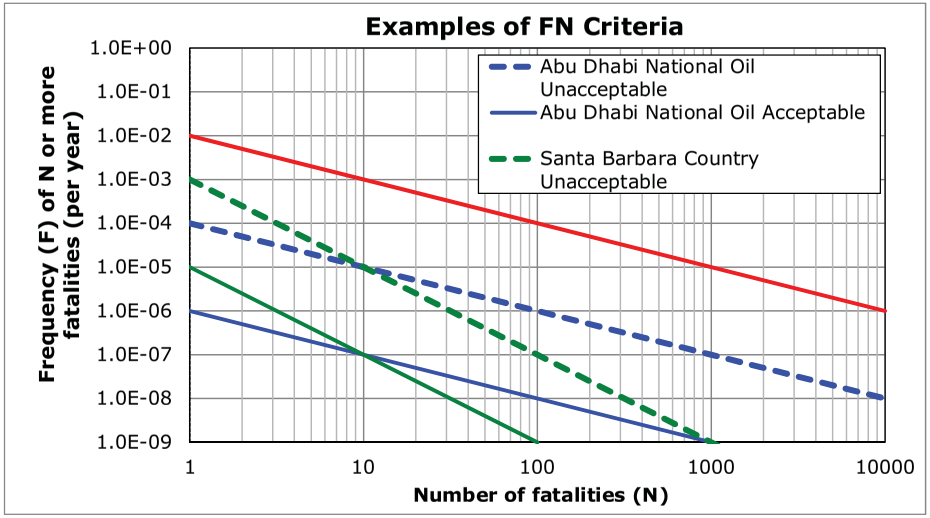
Vancouver Oil Terminal
The City of Vancouver has passed a resolution opposing the proposed oil terminal at the Port of Vancouver. The project is currently waiting for a recommendation from the Energy Facility Site Evaluation Council — expected in March 2015. The final decision point is the Washington Governor must approve the site certification agreement — expected September 2015.

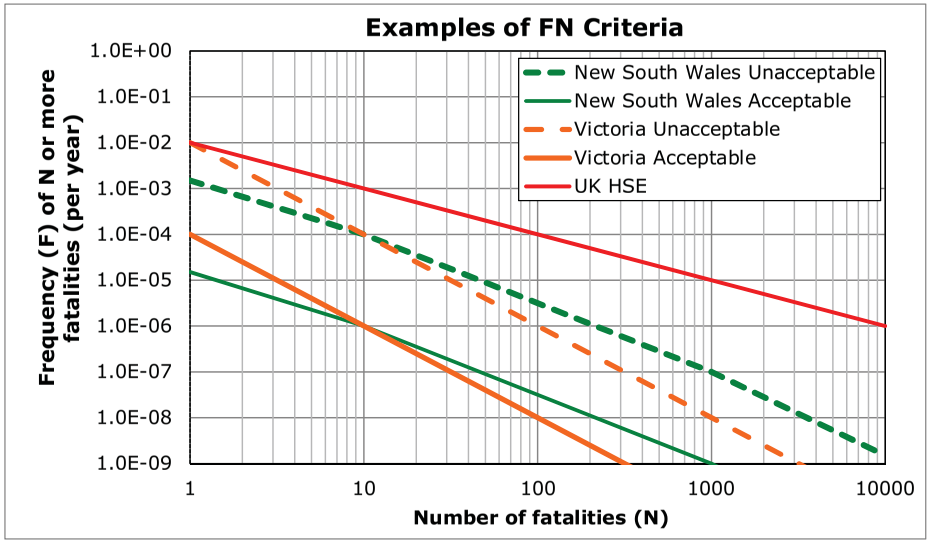
Longview Propane Terminal
In March 2015, the Port of Longview rejected plans to lease a 24-acre site for a proposed $300 million propane terminal. Commissioners expressed concern that the site rather than the nature of the project wouldn't work. It is not clear if the vote ends the project. Two commissioners said they would support the project, but not at the proposed 24-acre site near Berth 4. The other commissioner raised several concerns about the project.
http://tdn.com/news/local/port-of-longview-commissioners-reject-haven-energy-lease-on-/article_f7e284cc-c73f-11e4-bc68-5f5ac32ce6b8.html

Data

| National Authorities | | Frequency of fa | Number of fatalities |
|---|---|---|---|
| Netherlands & Petroleum of Venezuela | Unacceptable | 1.00E-02 | 1 |
| | | 1.00E-05 | 1000 |
| | | 1.00E-06 | 10000 |
| | Acceptable | 1.00E-04 | 1 |
| | | 1.00E-07 | 1000 |
| | | 1.00E-08 | 10000 |
| UK | Unacceptable | 1.00E-02 | 1 |
| **Slope - 1.0** | | 2.00E-04 | 50 |
| | | 1.00E-06 | 10000 |
| Hong Kong | Unacceptable | 1.00E-03 | 1 |
| | | 1.00E-06 | 1000 |
| | | 1.00E-09 | 1000 |
| | Acceptable | 1.00E-05 | 1 |
| | | 1.00E-08 | 1000 |
| | | 1.00E-09 | 1000 |
| Abu Dhabi National Oil Company | Unacceptable | 1.00E-04 | 1 |
| | | 1.00E-07 | 1000 |
| | | 1.00E-08 | 10000 |
| | Acceptable | 1.00E-06 | 1 |
| | | 1.00E-09 | 1000 |
| | | | 10000 |
| County of Santa Barbara US California | Unacceptable | 1.00E-03 | 1 |
| | | 1.00E-07 | 100 |
| | | 1.00E-11 | 10000 |
| | Acceptable | 1.00E-05 | 1 |
| | | 1.00E-09 | 100 |
| | | 1.00E-13 | 10000 |
| Australia - New South Wales | Unacceptable | 1.50E-03 | 1 |
| **Slope -1.5** | | 1.00E-04 | 10 |
| | | 1.00E-07 | 1000 |
| | | 1.50E-09 | 10000 |
| | Acceptable | 1.50E-05 | 1 |
| | | 1.00E-06 | 10 |
| | | 1.00E-09 | 1000 |
| | | 1.50E-11 | 10000 |
| Australia - Victoria | Unacceptable | 1.00E-02 | 1 |
| **Slope - 2** | | 1.00E-04 | 10 |
| | | 1.00E-08 | 1000 |
| | | 1.00E-10 | 10000 |
| | Acceptable | 1.00E-04 | 1 |
| | | 1.00E-06 | 10 |
| | | 1.00E-10 | 1000 |
| | | 1.00E-12 | 10000 |




Examples of FN Criteria
Frequency (F) of N or more fatalities (per year)
1.0E+00
1.0E-01
1.0E-02
1.0E-03
1.0E-04
1.0E-05
1.0E-06
1.0E-07
1.0E-08
1.0E-09
1
10
100
1000
10000
Number of fatalities (N)
New South Wales Unacceptable
New South Wales Acceptable
Victoria Unacceptable
Victoria Acceptable
UK HSE

# INTERNATIONAL COMPARISON ON THE APPLICATION OF SOCIETAL RISK CRITERIA

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*Det Norske Veritas*
*1-DNV Houston TX, 2-DNV Brazil, 3-DNV UK, 4-DNV Abu Dhabi, 5-DNV Belgium*

## Introduction

Quantitative risk assessment is now a common tool used for planning and approval of high risk process facilities globally. The initial focus was towards individual risk contours as these were easier to apply and communicate, but a number of regulators and companies also wish to see societal risk results. This is particularly true for offsite risk predictions. Also some transportation risks only make sense for assessment by societal risk methods as the individual risk can be too low for standard criteria as the total risk is distributed over a long distance over many different populations. There are quite significant differences in the global application and this paper will review experiences the authors have found in application examples in Europe, North and South America, the Middle East, and the Far East. The differences are not just to criteria lines on F-N graphs, but also the definition of what populations are included and excluded and this can have significant impact on societal risk results. Finally, offshore oil and gas facilities use a variant of the societal risk concept, the Potential Loss of Life (PLL) statistic, which is the integrated form of the FN curve. This is mainly used for comparative purposes rather than for absolute assessments.

## Risk Criteria

There are some summaries of risk criteria. Trbojevic [1] provided a useful survey with a focus on EU risk criteria, and later Frank and Farquharson [2] set out in a CCPS Guideline an extensive review of published risk criteria with a global scope. These publications do not always bring out the subtleties in applying Societal Risk criteria and this paper seeks to compare several examples from around the world. However, the paper does not aim to repeat the extensive list as covered in Frank and Farquharson.

A few general points at first are useful, but more detailed definitions on risk criteria can be found in Frank and Farquharson [ibid] or the CPQRA guideline [3].

**Individual Risk**: The risk to a person in the vicinity of a hazard. This includes the nature of the injury to the individual, the likelihood of the injury occurring, and the time period over which the injury might occur.

**Societal Risk**: A measure of risk to a group of people. It is most often expressed in terms of the frequency distribution of multiple casualty events.

**ALARP**: As Low As Reasonably Practicable – a widely used UK concept that divides a risk criterion into 3 bands – Intolerable, ALARP and Broadly Acceptable. In the ALARP zone a risk may be tolerable if it can be demonstrated that the effort to reduce that risk is grossly disproportionate to the benefit obtained, if not then the measure should be implemented.

The best known early use of societal risk measures was in the Rasmussen Nuclear Regulatory study for 100 nuclear power stations [4]. This proposed for a societal risk measure what is now termed an F-N curve, but then was known as a CCDF – Continuous Cumulative Distribution Function. No

criteria were available in 1975, but Rasmussen compared predicted risks from 100 nuclear power stations against a range of natural and man-made risks. As these were all significantly greater than predicted from 100 nuclear power stations or were so trivial (e.g. meteor strikes), then the conclusion was that the imposed incremental risk was acceptable vs the benefit obtained. While F-N curves are a common means to display SR, there are other numerical metrics including PLL (Potential Loss of Life fatalities/year - the sum of F*N), EV (Expectation Value, applies a weighting power to N but may be 1), Risk Integral (a weighted measure applying a power to N when summing $F*N^a$).

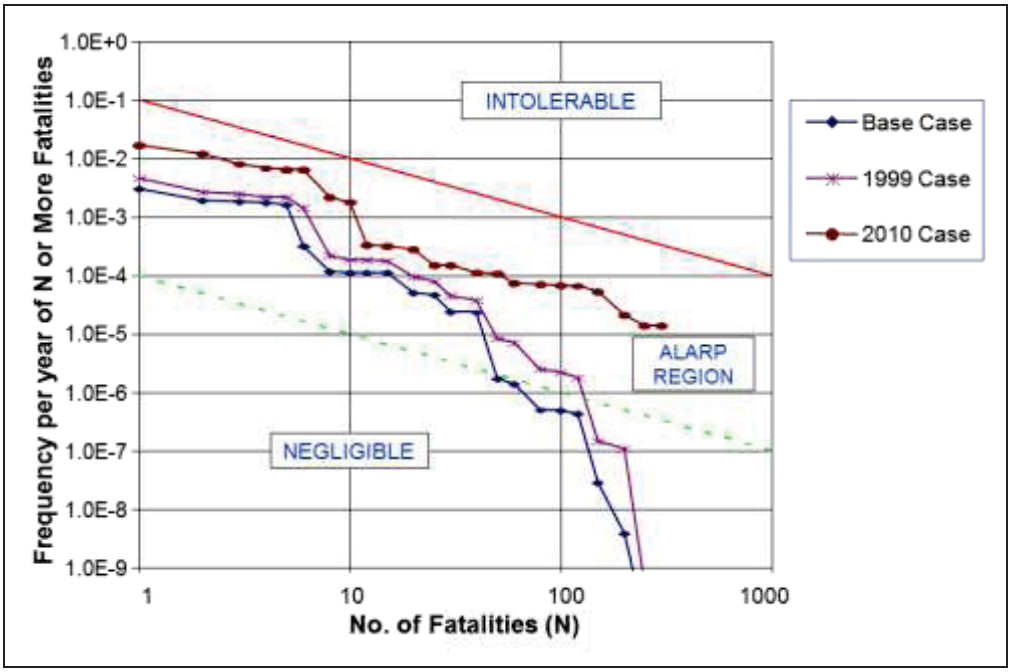
The focus of this paper is on the application of SR Criteria. However some comments on IR vs SR are useful. IR and SR are calculated from the same result set but the risks are assembled in a quite different manner and it is not possible to move directly from an IR result to an SR result by any simple manipulation. It is possible to have low IR but high SR and vice versa. Understanding both provides a richer understanding of risks.

Table 1. Comparison of Individual and Societal Risk Features

| Individual Risk (sometimes called Location Risk) | Societal Risk |
|---|---|
| Individual Risk does:<br>• Focus is on a specific individual<br>• Normally calculated at a specific place with no protection, evacuation or shelter basis (Location Risk)<br>• For public assume continuous occupation at a location<br>• Join locations of equal IR to get Iso-Risk contours<br>• For employees can do the same, but frequently with multiple work locations take account of time in each job location and protections afforded<br>• The aim is to demonstrate that individuals should not accept excessive risk<br><br>Individual risk does not:<br>• Explicitly show the maximum event possible, major accidents can contribute only a little to IR<br>• Allow sensible calculation of cost-benefit of risk reduction measures<br>• Well represent installations with large numbers of personnel on board (e.g. offshore) and benefits of reducing these | Societal Risk does:<br>• Focus on all the population exposed to the risk<br>• The aim is to assess the total risk from the whole range of accidents on numbers of people affected, not on specific individuals<br>• It allows major accident risks affecting many people to be identified explicitly even if the frequency is very low<br>• It can be produced for the public only or for employees only or for both combined<br>• It allows sensible cost benefit analysis of risk reduction measures as it calculates total risk exposure<br>• It can allow for aversion to multi-fatality accidents<br><br>Societal Risk does not:<br>• Lend itself to easy communication to non-specialists<br>• Provide a measure of maximum risk to any individual |

The Societal Risk graph is often called an F-N graph, but strictly CCDF is more accurate. Simply plotting F and N pairs from a risk assessment would give hundreds or thousands of points on a graph but no meaningful way to interpret these. Thus the cumulative approach is used where what is actually plotted is the Frequency of causing "N or more" casualties vs N. Since accumulation can be upwards or downwards, one might think that it might be better to plot "N or less" but in practice as F-N curves often cover several orders of magnitude in both dimensions – the frequency of major accidents (large N) will in fact be dominated by the frequency of small accidents (1 fatality) and the risk line for the "N or less" form of F-N graph would be almost horizontal providing no valuable information. This is why F-N graphs are always produced as F (N or more) vs N.

**Figure 1. Example F-N Curve**




What is included in Individual Risk

The full calculation procedure for IR is documented with some detailed sample calculations in CCPS (2000). In most cases for offsite risks no discounts are applied for presence factors or escape – the risk is to a hypothetical person as if they were always standing at that place unprotected and without escape. This is necessary as if people in houses were given a lower risk (which would actually be the case) compared to a person outdoors, then there would "islands" of apparent safety in a "sea" of higher risks. This would make decision making confused and very difficult, so by convention individual risk offsite is always plotted on an outdoors – no protection – no escape basis. Individual risk inside facilities conversely is often calculated taking account of presence factors and other realistic discounts – but these are not plotted as IR Contours, just reported as an individual risk value at different locations.

What is included in Societal Risk?

Societal risk is usually more complicated than IR in its calculation. Rather than determining what risk exists at a particular place from every event on its own and then summing these, SR determines how many casualties occur from every event and collects these as F-N pairs. Once all are calculated these are sorted in order of N and the cumulative frequency is calculated starting at the largest N and working downwards.

Unlike IR, multiple risk discount factors are usually applied. These include:

- Indoors or outdoors, and if indoors amount of protection and duration
- Escape or Shelter in Place – yes or no and % surviving
- Presence factor (% time at that location)
- Group events to consider or not – e.g. sporting events, bus queues and traffic jams (although this can significantly increase the complexity of the calculations)

Some of these factors will differ depending on the type of consequence – explosion, fire (and for different fire types), or toxic dispersion. If these are not well controlled in a risk study then very

different results can be obtained by different analysts and the specification of a criterion line may be less meaningful.

## Societal Risk in the UK

The UK approach to SR is the most complex and nuanced and extra detail is provided here in its explanation and because there appear to have been some changes since Frank and Farquharson (2009). The regulatory body for major hazard industries in the UK is the Health & Safety Executive. They have both a statutory role for enforcement with major hazard industries and an advisory role in respect of land use planning. They apply different criteria for individual and societal risk in each case [1].

***Criteria for Regulatory Enforcement/Intervention***

The HSE's publication *Reducing Risks, Protecting People – R2P2* [6] sets out the societal risk criterion thus:

> "The risk of an accident causing the death of 50 or more people in a single event should be regarded as intolerable if the frequency is estimated to be more than one in five thousand per annum".

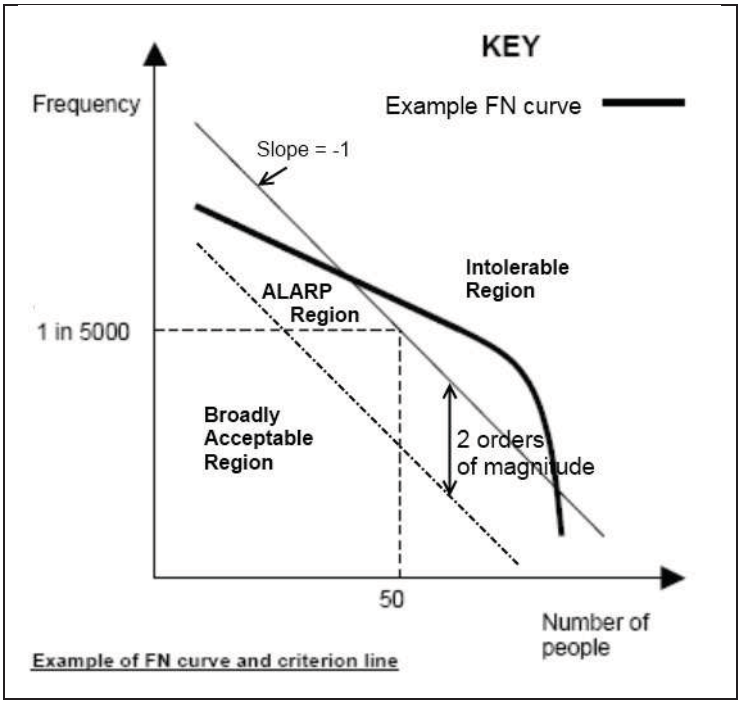
This is interpreted to be a point on an FN graph (the reference to "50 *or more* people implies this). HSE has also stated [7]:

> "'Criterion lines' on FN plots have been suggested as a means to define risk zones/ categories. R2P2 defines one point, (N=50, F(N)=1/5000 per year), and if this point is placed on an FN curve, and a line drawn through it, with a slope of -1, it can provide a criterion comparison line."

The HSE does not, in R2P2 [6], state that the slope *should be* -1. The Hazardous Installations Directorate of HSE has adopted the above criterion point for addressing concerns for societal risk when there is a risk of multiple fatalities occurring in a single event [18] (and subsequently [19]) with a slope of -1. This enables criteria for societal risk to be defined as shown in Figure 2.

At first sight this gives a straightforward means of assessing risk acceptability: if the FN curve crosses the criterion line to lie partly above it, the risk is unacceptable; if it lies everywhere below the criterion line, the risk is tolerable if ALARP (As Low As Reasonably Practicable). Although in [7] it is questioned whether the whole societal risk curve must be below the criterion line at all points if these are balanced by points where the curve is below the criterion line, as illustrated also in Figure 2. There is no universal agreement on this [7] but it is common practice for HID to interpret the criterion line as a line which the curve should be completely below. This allows some flexibility and this is similar to the Dutch FN approach which is not necessarily a rigid pass-fail test (see later).

**Figure 2 Example of an F-N curve and the R2P2 criterion point**




F-N curves can only be generated accurately by a QRA, which is time-consuming. The HSE has therefore developed a number of alternative approaches to QRA-produced F-N curves [10], [20] which can give predictions quickly and with limited information. These were primarily to enable HSE to include the concept of societal risk more explicitly in land use planning decisions. One, QuickFN [9], uses detailed QRAs carried out for a number of representative installations to generate an approximate F-N curve. Other approaches are based on calculating a single-value measure, the risk integral (*RI*). This can be expressed as:

$$RI = \sum f_i N_i^a$$

where: f = frequency of outcome *i*

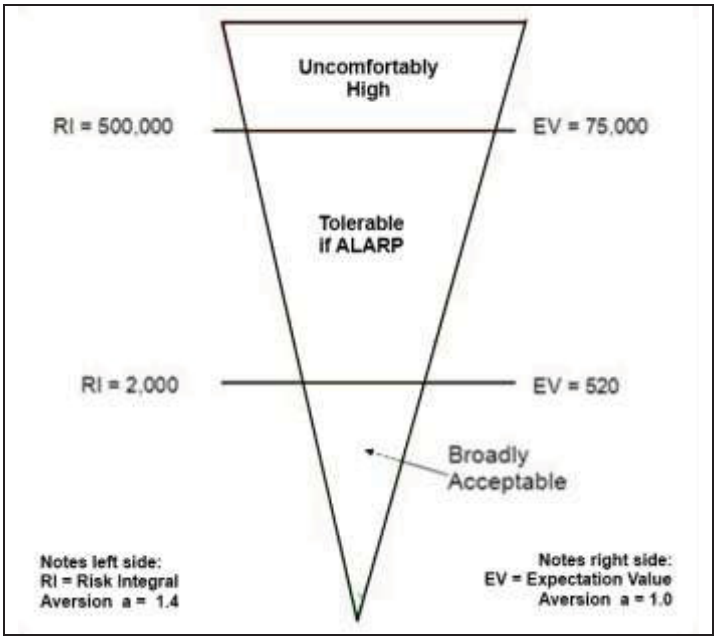
N = number of fatalities resulting from outcome *i*

a is the "scale aversion factor" and depends on the measure being computed, as follows:

- Expectation Value (EV) or Potential Loss of Life (PLL): a = 1 (no scale aversion)
- COMAH Risk Integral ($RI_{COMAH}$ ) [10]: a = 1.4
- Land Use Planning Risk Integral ($RI_{LUP}$) [5]: a = 2

However, recent research [11],[12] has questioned the use of a scale aversion factor greater than 1 and the HSE's preferred metric is now EV (rather than RI) for the judgment of ALARP [13], although the HSE has established criteria for both as shown in Figure 3.

**Figure 3 UK Societal Risk Criteria (reproduced from [13])**




Note that Figure 3 describes the highest-risk region as "Uncomfortably High" rather than "Intolerable" as is used for individual risk and in R2P2. However, HID clearly use the term Intolerable in this context. The HSE's position is stated [13] as follows:

> "It should be noted that the current policy is not to enforce risk reduction for risks which are purely societally based."

However, in a land use planning context HSE would take action if the RI was above 750,000 [25].

Indeed, although Figure 3 shows a solid boundary between the "Uncomfortably High" and "Tolerable if ALARP" regions, elsewhere in the source document [13] the boundary is shown as a broken line, whereas the equivalent figure for individual risk is shown as a solid line: the broken line can therefore, from the statement quoted above, be understood not to be a "pass-fail" criterion. Elsewhere [5] they have stated:

> "The Government's view … is that informed public opinion, and not solely professional judgment, should guide decisions on societal risk …".

In 2007 HSE launched a consultation on societal risk [14] with reference both to decisions by operators about investment in additional on-site safety measures (i.e. meeting ALARP criteria) and by planning authorities about land use around such sites. In 2010 the HSE published a status summary [15] regarding 23 areas of technical and policy matters, setting out the HSE's adopted positions on these areas. Those pertinent to the regulatory regime are as follows:

> No. 4. On-site and industrial populations. Occupied buildings located at major hazard installations will be subject to Occupied Building controls. Any worked located on a major hazard installation not subject to occupied building controls, and workers on sites adjacent to a major hazard installation, will be included in societal risk assessments.
>
> No. 10. Should more vulnerable (or less vulnerable) populations be given a different weighting? Population sensitivity should be a factor in any decision making process, but not on a mathematical basis in the risk estimates.
>
> No. 20. Should the assessment be updated for every decision or only occasionally and on what basis? Societal risk estimates will be reviewed where establishment risks may be significantly affected by

changes that significantly increase risk. Significant incremental PLL additions will be monitored otherwise a periodic review will be undertaken.

***Pipelines***

The R2P2 criteria are considered appropriate for cross country pipelines and transport routes in addition to major hazard installations. Pipeline codes require separation from occupied buildings but because of the type of hazard associated with pipelines, societal risk is generally more appropriate than individual risk to assess the acceptability of the risk. Societal risk criteria have been published for gas pipelines [21], [22] and for pipelines conveying other materials [23]. These just define the boundary between Broadly Acceptable and Tolerable if ALARP, they do not define an Intolerable zone.

A feature of the F-N curve in the PD 8010 line is that it is straight whereas the IGEM line is a curve (although it is generally similar to the straight line), both apply to a specified length of pipeline and the x axis is number of casualties (rather than fatalities which is normally used for F-N criteria). The basis for the IGEM criterion is a line which was constructed around the F-N lines from a range of generic cases (which gave a series of rectangular shaped lines) which are acceptable in accordance with the code [21]. The PD 8010 line is the same as the lower HSE line. The method of calculation of the risks is given in [22] and [23] and, as with all criteria, as different methods of calculation give different risk predictions it is recommended that predictions are compared with at least one benchmark case in order to align with the methodology and recommendations in the publications, and therefore it is appropriate to compare them with the criterion line.

***Criteria for Land Use Planning***

Where a site near to a major hazard chemical installation or pipeline is proposed for development the planning authority will have a statutory duty to refer the planning application to the HSE [16] but will weigh HSE's advice on risks with other socio-economic issues and benefits.

The HSE's advice is determined by the use of their LUP (Land Use Planning) methodology, PADHI (Planning Advice for Developments near Hazardous Installations) [16]. The PADHI Tool can be run by Local Authorities without direct involvement of the HSE. This tool does not *explicitly* apply societal risk criteria. The criteria include an *implicit* societal risk consideration for each individual development, in that the number of people likely to be at the development is taken into account in determining 'sensitivity level' (see below) and so in arriving at HSE's advice [5].

PADHI uses two inputs to a decision matrix to generate the advice, developed below:

- Which of 3 zones that HSE sets around major hazard sites where the development is located;
- The 'sensitivity level' of the proposed development.

For a major hazard site, the HSE determines a Consultation Distance (CD) boundary and within this 3 zones (termed Inner, Middle, Outer based on 10, 1 and 0.3 chances in a million of receiving a dangerous dose – less than a fatality but severe distress to all and easier to justify to the public [17]).

A single consultation may consist of a number of different development types (e.g. homes, schools, shopping) and may lie within more than one zone. In this case, each combination of zone and sensitivity level needs to be considered. If any combination of zone and sensitivity level leads to an Advise Against decision, then the overall decision for the whole proposal will be Advise Against [16]. Having determined which zone the development falls in to and the sensitivity level of the development, the decision matrix shown in Table 2 is used to decide the type of advice.

**Table 2 HSE's LUP Decision Matrix**

| Level of Sensitivity | Development in Inner Zone | Development in Middle Zone | Development in Outer Zone |
|---|---|---|---|
| 1 | DAA | DAA | DAA |
| 2 | AA | DAA | DAA |
| 3 | AA | AA | DAA |
| 4 | AA | AA | AA |

DAA = Don't Advise Against development; AA = Advise Against development

## Societal Risk in Ireland

The Eire Health and Safety Authority (HSA) is the central competent authority for the purposes of the Major Accident Hazards Regulations 2000 (which implement the Seveso Directive in Ireland). The approach to land use planning was indicated in 2003 [24]. The intention was that it should provide a high level of protection but was not intended to guarantee the absence of risk. The criteria were based on those used in the UK at that time, i.e. hazard levels or risk of receiving a dangerous dose. The policy has now been updated [25] and this now explicitly includes societal risk and advises when the HSA will consider it. The HSA give criteria for the risk integral approach (above), and when assessing a proposed establishment that would come under the Seveso Directive would use a scale aversion factor of 1.4. A value of 2000 would be considered to be broadly acceptable and a value of 500,000 would be regarded as significant. A proposal for a new installation could include an F-N curve and this would be used by the HSA as part of their consideration regarding the suitability of the proposed development. Two points are specified which are on the lines presented in **Error! Reference source not found.**, but it is not explicitly stated that these points lie on lines with a slope of -1. The HSA would not determine a F/N curve (so would use the integral approach if one was not presented).

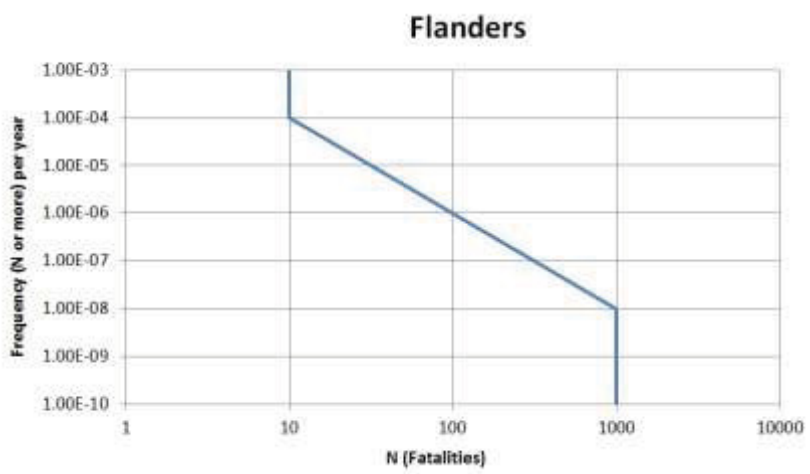
## Societal Risk Belgium (Flanders)

Belgium has not historically been quoted much with regard to QRA risk criteria, but they did suffer a major pipeline event at Ath near Brussels in 2004 that led to 24 fatalities and 122 injured and the Belgian Government after that time developed detailed guidance. They issued for example guidance documents on specific frequencies to use in QRA Seveso studies in 2009 [26]. Most of this data in this guidance was obtained from older DNV publications.

Flanders (a region in Belgium) requires an External Safety Report (ESR) for every new demand of environmental permit for high tier Seveso companies. The External Safety Report (ESR), provided by the duty holder (plant owner) requires quantification of risk. Risks are evaluated against two criteria: location specific risk and societal risk. The risk criteria for Flanders have been defined and entered into law in 2006, however risk based assessments have been used for over 15 years..

Criteria for individual risk are: Maximum location specific risk on plants boundary line is 1E-5 per year, at residential areas (isolated buildings are not counted) is 1E-6 per year, and at vulnerable areas (schools, hospitals and elderly houses – not included child care centers) is 1E-7 per year.

Figure 4. Flanders Criterion for societal risk




Note: Risks above and to the right of this line are unacceptable, risk below and to the left are acceptable.

source www.lne.be website

Flanders uses quantitative risk criteria which are the same for both new and existing establishments. The criteria are based on three values for location-based risk and a curve for societal risk. Note that independent of the terminology the criteria (no legally bound limit value) are used as limit values. If establishments fail to comply with the criteria, a clear description of technical and organizational measures linked to the most important accident scenarios is required. In addition, additional safety measures will be required, their environmental permit may not be issued, or the government may prohibit operation of (parts of) the establishment.

In case an Individual Risk curve exceeding $10^{-5}$ intrudes into neighboring facilities, a so called safety information plan needs to be drafted. This plan is a formal agreement between the major hazard establishment and other establishments in the surrounding area where they commit to exchange information about risks arising from dangerous substances.

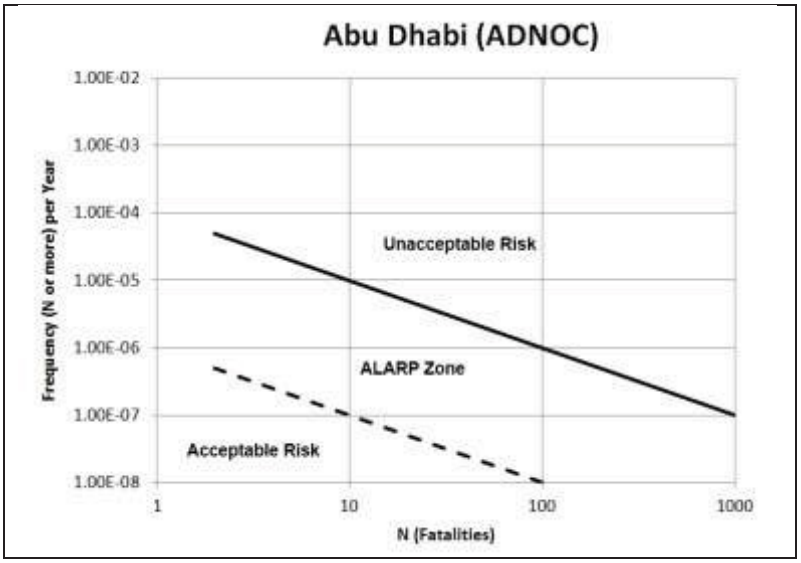
When assessing societal risk, employees and contractors at the major hazard establishment are not considered. People present in neighboring establishments, residents, persons in traffic are taken into account (including fractional occupation).

Risk calculations shall be updated every 5 years or at any important change.

## Societal Risk in Abu Dhabi

The regulator in Abu Dhabi is ADNOC – where it acts as both the national oil company and the regulator. They apply the rules to their own companies and to other companies. They have a Societal Risk criterion in their HSE Management code of practice – ADNOC-CoP-V5-06. This shows a SR FN curve which employs the three band approach. This is shown in Figure 5. They also have an Individual Risk criterion.

Figure 5. ADNOC Societal Risk Criterion for a Single Fixed Installation




Both IR and SR results are required by ADNOC as part of its approval process. Societal risk is evaluated for new developments as well as for existing facilities/installation (every 5 years for normal operating plant during revision of safety case/HSEIA study).

Currently no societal risk criteria is specified for offshore facilities. However ADNOC has requested that developments use IRPA and PLL values as risk indicators. ADNOC has not specified acceptance criteria for IRPA and PLL values. ADNOC has mentioned that for offshore installation HSE UK guidelines should be used as guidance only and not as absolute criteria.

The ADNOC code of practice societal risk refers to the public only ( i.e. offsite persons and excluding ADNOC Group companies and contractor personnel).

If any ADNOC Group company has impact on another group company then it is not considered as offsite risk. Societal risk is risk to any person or group of persons who are not connected to ADNOC group companies business and are outside the facilities/plants/Premises of ADNOC Group companies.

Societal risk is evaluated for new developments as well as for existing facilities/installation (every 5 years for normal operating plant during revision of safety case/HSEIA study).

## Societal Risk in Netherlands

The Dutch situation is the most formal globally for risk assessment of major hazard facilities and is codified in the Bevi manual [27]. There are hard criteria for individual risk and these may not be exceeded. The SR criteria are a little more flexible in that projects can exceed the maximum line if they are in the national interest (an example of this was Schiphol airport expansion that passed IR but failed SR and was approved after significant debate).

The following extracts from the Bevi document define their approach. “In order to be able to use the results of a QRA for decisions, they must be verifiable, reproducible and comparable. The QRA calculation method was more or less defined in full with the publication of the colored books [TNO Yellow, Green and Purple Books]. The combination of the SAFETI-NL calculation package and the present Reference Manual currently represent the calculation method for carrying out a QRA as part of the Bevi, and is referred to hereinafter as the ‘Bevi calculation method’. In the Bevi calculation method, risk is understood to be: the probability of (acute) death as a result of an accident involving

hazardous substances. Effects are understood to be: acute death as a result of exposure to toxic substances, heat radiation or overpressure."

These ESR requires quantification of the risk and evaluation against quantitative risk criteria formulated as location-based risk and societal risk. Risk Evaluation Decisions are taken by the authorities in the processes of environmental permitting for establishments and urban planning close to existing establishments. Distinction is made between 'vulnerable objects' and 'objects with limited vulnerability'. The latter category includes scattered residences (less than two per ha), small shops and hotels, business areas, recreational objects, and objects which serve as infrastructure (electricity supply, telephone exchanges, air traffic control towers, etc.). Vulnerable objects are residences, areas for children, the aged, the sick, or the disabled (schools, preschools, nursing homes, hospitals, etc.) large (centers containing) stores and hotels (defined as more than 1500 m2 of floor space) and campgrounds for over 50 people.

***Individual Risk***

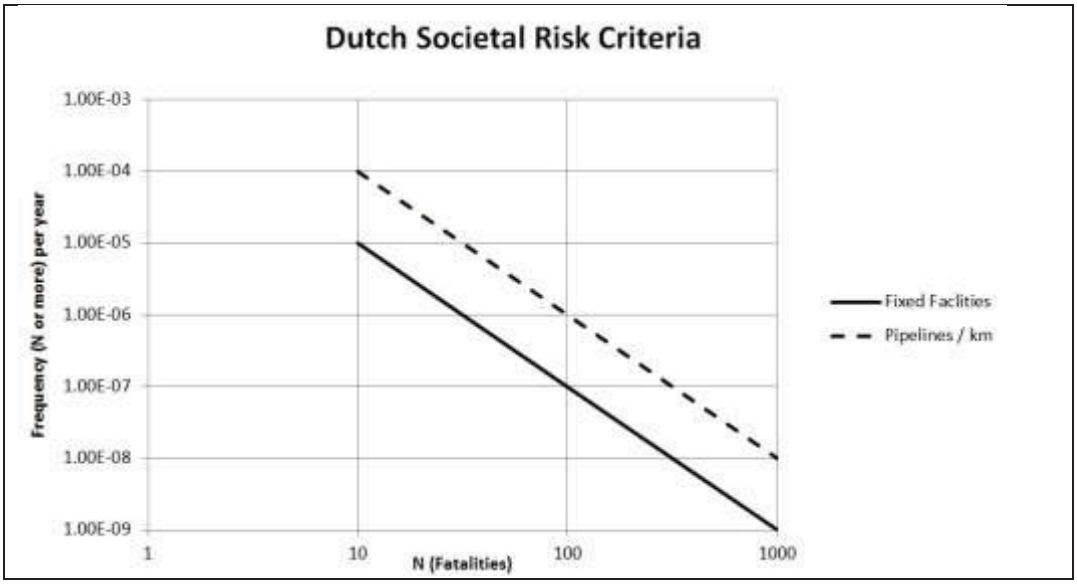
For vulnerable objects, a limit value for location-based risk of $10^{-6}$ per year must not be exceeded. For objects with limited vulnerability, the same value applies as a *target*, but may be exceeded under certain conditions. For existing environmentally approved establishments, an interim acceptance criteria of $10^{-5}$ per year applied, but the general limit value of $10^{-6}$ per year applies since 2010.

***Societal risk***

QRA's are normally required, but there is a separation distance look-up table that allows less complex and well separated facilities to avoid the requirement to carry out a QRA. The SAFETI-NL package is supplied by DNV and is virtually identical to PHAST-Risk, but with specific parameters agreed for the Dutch application and fixed, and not variable by the user. Default meteorology for several Dutch locations is built into the tool. As the tool is mandated by the Dutch Government, they arranged a license for all of the Netherlands, and users need only pay a modest fee for training and updates. Among the fixed parameters are impact parameters which determine probability of death given various consequence intensities and durations. IR assumes no protections and no escape, whereas SR allows for the protection of clothing and housing against fire, explosion and toxic events. Ignition probabilities are also standardized. Failure events and frequencies are mandated and are included in Module C of the Bevi Manual. All this together is believed necessary to achieve the previously identified goal for risk studies of "verifiable, reproducible, and comparable".

Societal risk must address offsite people, whether of neighboring companies or local residential populations, but can exclude own staff, contractors and visitors. Non-continuous populations must be considered (e.g. schools and major events), but not transients populations such as traffic or pedestrians. This is a non-trivial exclusion as during rush hours there can be large numbers of people in these classes directly outside a facility.

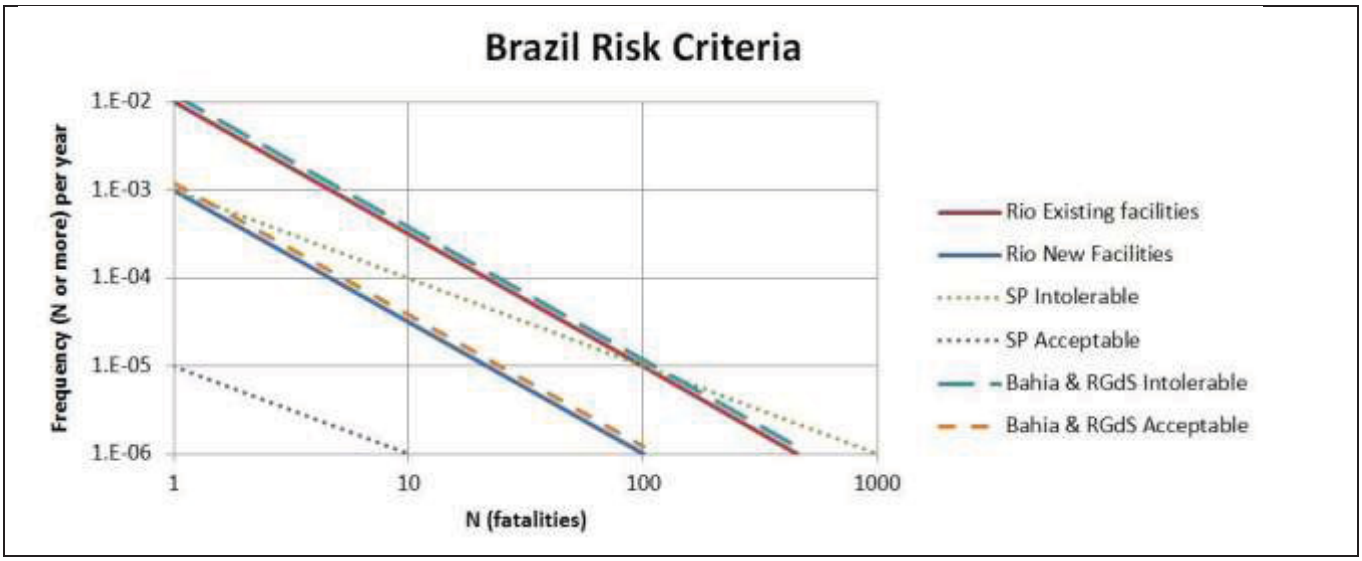
**Figure 6. Netherlands Societal Risk Criterion**




## Societal Risk in Brazil

Brazil regulates societal risk on both a federal and state level. National environmental regulations require a risk assessment for certain types of installations (Resolution No 1, 23rd October 1986, of the National Environmental Council – CONAMA). However, each state in Brazil has autonomy to methodology and criteria to be applied in their risk assessment. Up to 2012, four states (Rio de Janeiro, São Paulo, Rio Grande do Sul and Bahia State) have formally established guidelines for risk assessment. The risk criteria are different in each state. Other states have not established their own methodology and mainly follow what is established in São Paulo, for situations where the Environmental Agency requires a risk assessment. A comparison of the 4 state criteria is shown in Figure 7 – for Rio de Janeiro, São Paulo, Bahia, and Rio Grande do Sul. In this figure, where overlap occurs the values have been slightly displaced to allow overlapping lines to be visible.

**Figure 7. Comparison Societal Risk Criteria in Brazil**




Note States shown: Rio de Janeiro (RdJ), São Paulo (SP), Bahia, Rio Grande do Sul (RGdS)

***Rio de Janeiro State and Rio Grande do Sul***

Institute of Environment (INEA) has Guidance for Risk Analysis Studies [28] which establishes a method to develop a Risk Analysis Study. The need to develop a quantitative risk assessment, with both societal and individual risk criteria, is based relation between the inventory of hazardous materials (flammable, toxic or explosive) and distance to residential area or public street address. This study is developed in three main phases:

- Qualitative analysis, using a PHA technique and classifying scenarios using a risk matrix;
- Consequence analysis for scenarios classified on PHA with possibility of fatalities;
- Quantitative risk assessment in case of scenarios that have the level of 1% of fatalities or the lower limit of flammability (for flash fires) reaching fixed people outside boundary limits of the company (either residential or industrial area).

Projects must pass both IR and SR, and if either fails then risk mitigation measures must be proposed.

Note that Rio Grande do Sul State [29] applied in its methodology definitions as Rio de Janeiro and the societal risk criteria is equal to Bahia State.

***São Paulo State***

Resolution from Environmental Agency CETESB - P4.261, published in May, 2003 [30], establishes a guideline to develop a Risk Analysis Study, if required to Environmental Licensing.

As established by Rio de Janeiro State, the definition of the need of development of risk assessment is based on inventory. For each inventory of each hazardous material, there is threshold distance to the installation boundary limits and in the case where the limit is beyond the threshold, the risk assessment has to be performed. The study is developed in the same three phases, also considering that quantitative risk has to be calculated if the consequence effects can reach outside the company, within the 1% of fatality or lower flammability limit level. Again, criteria for Individual Risk and Social Risk should be complied with together for the enterprise approval, in other words and risk has to be re-evaluated. In the case of not acceptable level, the risk has to be re-evaluated.

***Bahia State***

Established by Resolution 3965 from CEPRAM – Conselho Estadual do Meio Ambiente, in June 2009 [31]. As with Rio de Janeiro, the definition on whether an installation must perform risk assessment is based on the relation between inventory and distance to installation limit. The same steps of the other states are followed for the development of the study.

***Parameters used within QRA***

The States do not specify any parameters to use in the QRA study – e.g. ignition probabilities, indoor/outdoor fractions, protection afforded by clothing or buildings or escape probabilities, against various impacts. Populations to be considered for SR are always the public and external neighbors, but not own staff. Temporary gatherings of people must be considered at parks or sporting events, but not transient populations as might exist in traffic jams and pedestrian traffic.

***Transportation***

For all the above states, for pipeline transportation, the same methodology is to be followed, but there is no definition whether the societal risk is to be calculated for the whole pipeline, per defined extension or per community that is crossed by the pipeline. For Rio de Janeiro, the societal risk criterion for pipelines is the same as the one for fixed units. In the case of São Paulo, the societal

criteria is not to be applied for defining the acceptability of the risk (only individual risk is used) and for Bahia there is a criteria established, that has the unacceptable limit 1000 times higher than the one applied for fixed installation.

It is important to note that if a pipeline crosses more than one state in Brazil, there will be a need to develop one study for each part of the pipeline crossing each state and different criteria might be applied. Also, a study for the National Environmental Agency [5] has to be prepared and presented, for the whole pipeline, using criteria similar to São Paulo State. There is not established need to develop quantitative risk studies for road and railway transportation.

In Brazil, offshore operation is regulated by the National Environmental Agency, and in that case in order to obtain a permit to perform activities, societal criteria is not a criteria used. The focus of the Environmental Agency is accidents with possibility of environmental damage and risk related to people is not under their legislation. For the international companies operating in Brazil, the same methodology and criteria applied worldwide.

Finally it is important to note that all studies developed for installation shall be reviewed every 5 years. Also, in the case of major changes, mainly adding new units or increasing inventories, the study shall be reviewed.

## Societal Risk used by Private Companies

***BP***

Some private companies carry out risk assessments for their own decision making purposes, whether or not required by local regulations. Considine and Hall [33] describe the process for BP. While the exact risk criteria used are not published they are based on an SR F-N graph format. Like the Bevi process a very prescriptive modeling approach is employed to allow for a consistent view on risk to be obtained. This includes a standardized BP model, standardized parameters, and predefined release cases. Where individual sites may prefer different modeling or parameters, this is permitted but only after the standardized model approach has been run.

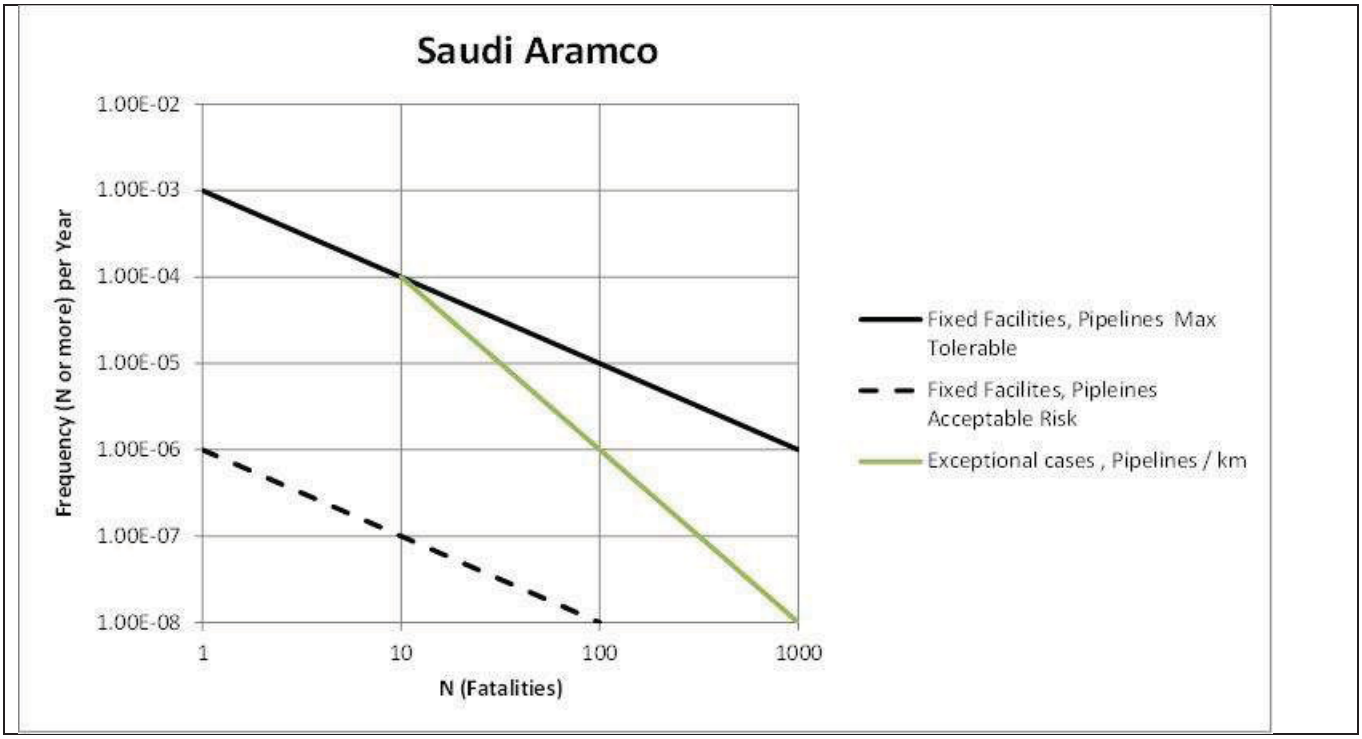
An interesting feature of the approach is that the risk criteria line on the F-N curve is not a pass-fail test. It is termed a Group Reporting Line and facilities which exceed this line must report the risk to a higher level in the organization for decision making on acceptability. The process does not have an ALARP zone beneath the line either. Instead, a process of Continuous Risk Reduction (CRR) is used which addresses the top risks and drives improvement investments in these regardless of whether an argument of ALARP could have been made. This addresses an issue of ALARP improvements – once a risk has been shown to be ALARP then there is no driving mechanism to reduce that risk. It has been noted in the UK for example that the largest societal risk on many process sites is due to the site administration building – and that was identified in the first round of CIMAH studies in the 1980's. Now 30 years on it may often still be the largest risk as it has always been ALARP. It is argued that the largest risk should not remain the largest risk for 30 years, and the CCR process should ensure this does not occur.

An interesting feature of the BP approach is that the Group Reporting Line has different positions depending on the scale of activity under review. That is every facility small or large is not granted the same "share" of the company risk profile. It is obvious that an isolated gasoline station should not be permitted the same risk target as a complex $5 billion refinery. However many national SR criteria embody that principle.

***Saudi Aramco***

The main operator in Saudi Arabia is Saudi Aramco and their Loss Prevention Department has significant input to all safety requirements issued by government. Most of the Safety Engineering standards for fixed facilities and pipelines issued by Saudi Aramco use separation distances based on Rupture Exposure Radii (RER) as the main criterion for onsite and offsite safety. These RER distances can be very stringent or less conservative in some cases and hence the standards recommend risk assessment to estimate the risk to offsite population and hence justify the necessity for increasing or decreasing the separation zones between offsite population and hydrocarbon facilities. There is no established risk criterion (Individual or Societal) by Saudi Aramco. For Individual Risk, Saudi Aramco uses U.K. HSE's Published criteria (Intolerable limit of 1E-4 /year for workers and 1E-3 /year for public and a negligible risk of 1E-6 /year). For Societal Risk, risk criteria to be applied for fixed facilities, pipeline corridors have been based on a DNV review of worldwide data (see Figure 8). The same criterion has already been applied for numerous QRA studies conducted for Saudi Aramco. However for a recent pipeline risk assessment study, where there were numerous encroachments along different sections of the pipeline, applying the fixed facility criteria was not meaningful, hence the pipeline risk criteria recommended by the Dutch Ministry of Transport per kilometer of the pipeline was used (see also Figure 6). Both IR and SR results are used by Saudi Aramco as part of its risk assessment process. PLL is used in cost benefit analysis while demonstrating ALARP.

Figure 8. Saudi Aramco Risk Criteria




Societal risk will include offsite people, whether of neighboring companies or local residential populations. For onsite situations staff are treated separately to public and offsite industry, but for pipelines staff located in offices along the route would be included like any other population. Temporary populations such as schools, mosques, hospitals must be considered but not transient populations such as traffic or pedestrians. This part is expected to be covered by using indoor/outdoor presence factors for fixed population.

## Overall Comparisons

The discussions in prior sections are compiled and displayed in Table 3.

Table 3.Comparison – Application of Societal Risk Criteria

| Country | IR | SR | FN Curve | Pop types covered | Temporary Pop | Model mandated | Parameters Mandated |
|---|---|---|---|---|---|---|---|
| Abu Dhabi | Yes | Yes | Yes ALARP Zone Start at 2 | Public Industry | ? | No | No |
| Brazil – Rio de Janeiro(RdJ) | Yes, Inventory distance based | Yes, as per IR | Yes, Pass-fail, New + existing Start at 1 | Public + neighbor industry | Yes: Parks + Sports No: transient | No | No |
| Brazil – Sao Paulo (SP) | Yes, Inventory distance based | Yes, as per IR | Yes, ALARP zone Start at 1 | Public + neighbor industry | As for RdJ | No | No |
| Brazil – Bahia | Yes, Inventory distance based | Yes, as per IR | Yes ALARP zone Start at 1 | Public + neighbor industry | As for RdJ | No | No |
| Brazil – Rio Grande do Sul (RGdS) | As per RdJ | As per RdJ | As per Bahia | Public + neighbor industry | As for RdJ | No | No |
| Belgium – Flanders | Yes | Yes | Yes Pass-fail Start at 10 | Public + neighbor industry | Yes: Parks + Sports Yes: transient | No | Yes: Frequency only |
| Ireland | Yes | Yes | Yes - if provided by an applicant | Offsite | Not stated | No | No |
| Netherlands | Yes | Yes Some flexibility | Yes Pass-fail Start at 10 | Public + neighbor industry | Yes: Parks + Sports, Camps | Yes | Yes: Frequency + Parameters |
| Saudi Arabia | Normally use UK approach | Normally use compilation of world practice | Yes, fixed facilities, use ALARP zone, start at 1. Pipelines pass-fail, start at 10 for exceptional pipeline cases | Public + neighbor industry | Yes: Parks + Sports No: transient | No | Yes |
| UK | Yes | Yes – but not mandatory | SR Point formal, FN implied | Public + neighbor industry | In principle, yes (see [15]) | No But HSE own model | No But HSE own model |
| USA | No | No | n/a | n/a | n/a | n/a | n/a |

**Conclusions**

Societal risk shows facets of risk not visible using individual risk. In particular it makes major accidents easily visible. These often are only a small contributor to total risk and may be hidden in IR results as lesser scale events dominate risk. Given Macondo and Texas City, and other very large scale incidents, regulators now ask more detailed questions around the largest accidents. Societal risk is one means to clearly make these visible and to allow this more detailed examination.

The authors, in our work globally, have encountered multiple versions of societal risk criteria – sometimes national, sometimes state based. The issue is not as simple as different criteria lines on an F-N log-log plot. It is also which type of people are included, whether temporary and transient populations are included, and whether the risk model, failure cases, likelihoods and modeling parameters are defined. These additional factors can make very large differences to predictions. Although risk criteria are very different globally, often by some orders of magnitude, DNV do not see dramatically different designs as there is a convergence in safety technologies – inherent safety ideas, gas detection, ESD, depressurization etc., the impact is more on locations where facilities may be built.

In DNV's own work we have firm controls over the model (Phast Risk), while the modeling cases, likelihoods and parameters are defined on our RiskNet work procedures system, and this must contribute to consistency. However different models and values from different analysts would change results. This is not well recognized in international societal risk criteria. DNV believe that there would be value in a more standardized set of recommendations for failure cases to be employed, failure frequencies, and modeling parameters. The Netherlands has done this fully for its implementation of the Seveso Directive; Belgium has addressed some of these issues; and BP has done this fully for its internal risk reviews. The USA has made some steps for formal validation of consequence models used for LNG facility land use planning applications (see another paper in this conference: Witlox et al, 2012). Frequency issues were the subject of a special conference in Canada in 2010, and substantial work remains to be done to standardize this area. Finally, risk criteria should better reflect the value added of facilities and not assign the same risk "allowance" to every facility – whether small or large.

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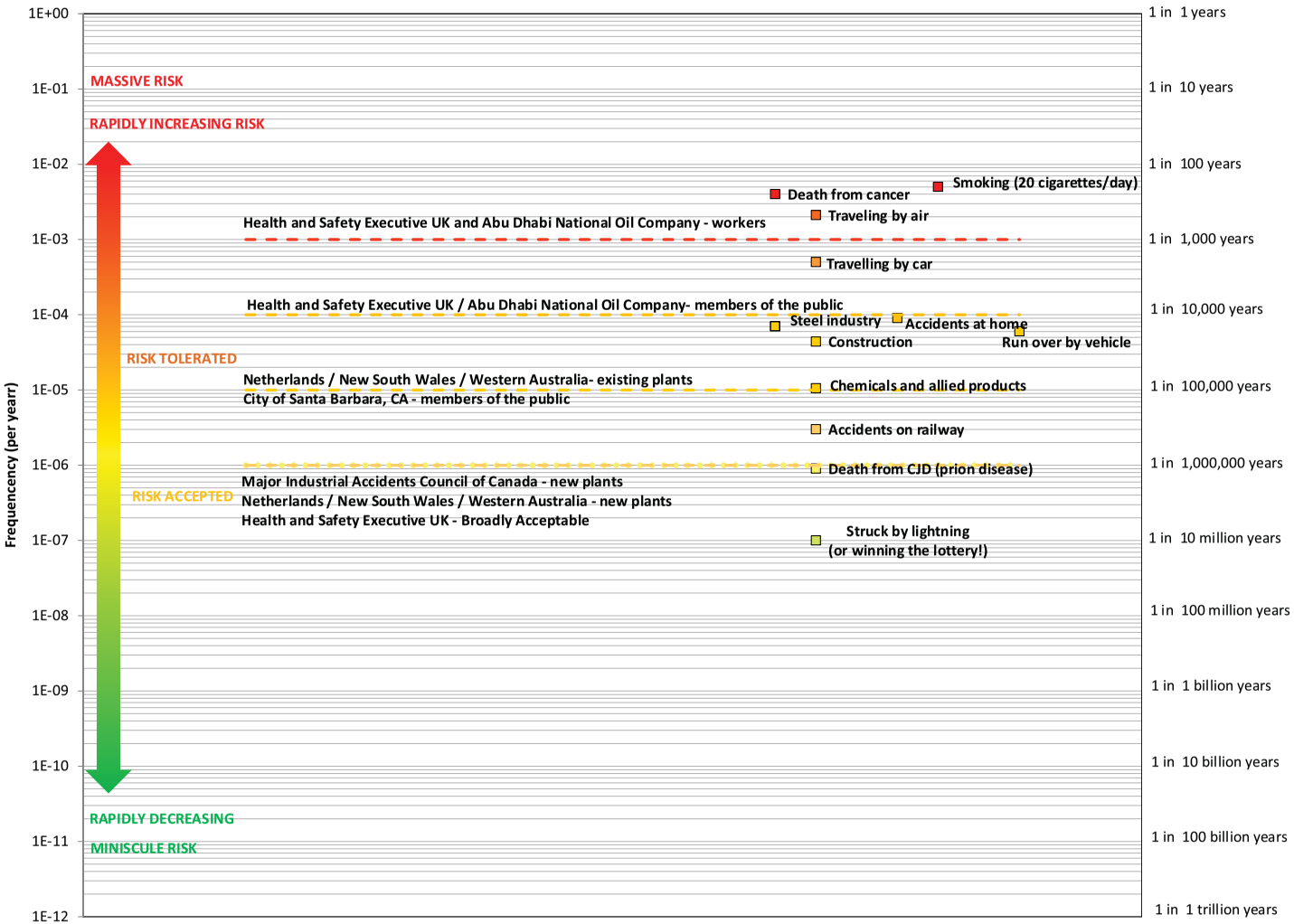


adapted from Chemical Process Safety: Fundamentals with Applications (2nd Edition) 2001 by Daniel A. Crowl and Joseph F. Louvar

Data

Common Nonindustrial Activities

| Label | Fatality rate (deaths per person per y | |
|---|---|---|
| Death from cancer | 4.00E-03 | 9 |
| Accidents at home | 9.00E-05 | 10.5 |
| All accidents | 6.00E-04 | 9.5 |
| Accidents on railway | 3.00E-06 | 9.5 |
| Run over by vehicle | 6.00E-05 | 12 |
| Struck by lightning (or winning the lottery!) | 1.00E-07 | 9.5 |
| Death from CJD (prion | 9.00E-07 | 9.5 |
| Traveling by air | 2.10E-03 | 9.5 |
| Smoking (20 cigarette | 5.00E-03 | 11 |
| Steel industry | 7.01E-05 | 9 |
| Construction | 4.38E-05 | 9.5 |
| Travelling by car | 4.99E-04 | 9.5 |
| Chemicals and allied p | 1.05E-05 | 9.5 |
| Health and Safety Exe | 1.00E-04 | 2.5 |
| | 1.00E-04 | 12 |
| Health and Safety Exe | 1.00E-03 | 2.5 |
| | 1.00E-03 | 12 |
| Netherlands / New Sou | 1.00E-05 | 2.5 |
| | 1.00E-05 | 12 |
| Netherlands / New Sou | 1.00E-06 | 2.5 |
| | 1.00E-06 | 12 |
| Major Industrial Accide | 1.00E-06 | 2.5 |
| | 1.00E-06 | 12 |

ear)

**Pembina Supplemental Information**
**Provided to City Planning and Sustainability Bureau Staff (March 26, 2015)**

**Attachment 1 – LPG Facility Information**

**Existing and Expanding Marine LPG Export Terminals referenced in the Bentek Report**

| Company | **Targa Midstream Services LP (Existing)** | **Enterprise Products (Existing and Expanding)** | **Petrogas Energy (Existing)** | **DCP Midstream Partners (Existing)** | **Sunoco (Existing and Expanding)** | **Sunoco (Existing)** |
|---|---|---|---|---|---|---|
| Facility Name | **Galena Park Marine Terminal** | **EPOLP Marine Loading Facility** | **Ferndale Terminal (LPG Marine Export)** | **Chesapeake Terminal** | **Marcus Hook** | **Mariner South** |
| Port Map Name | Galena Park LPG Facility | Not mapped | Ferndale LPG Facility | Not mapped | Marcus Hook LPG Facility | Nederland LPG Facility |
| Estimated Throughput[5] | 217,000 barrels/day | 533,000 barrels/day | 30,000 barrels/day | 8,000 barrels/day | 217,000 barrels/day | 200,000 barrels/day |
| Facility Description[2,3] (from RMP and press releases) | The Galena Park Terminal is a facility which receives and delivers liquefied petroleum gases (both mixed and pure), olefins, and chemical feedstocks by ships, barges, trucks, rail, and pipelines.<br>Import/ Export Marine Terminal for propane and butane and handles Very Large Gas Carriers and Medium Gas Carriers for propane.<br><br>Expansions completed 2013 and 2014 for increased capacity of propane to an overall capacity of 6.5 million barrels per month of propane | Enterprise's Marine Loading Facility is used to offload and load various LPG streams. Off loaded products include propane and butanes. These LPG products are imported from ships and barges. The products are then pumped into pipelines for distribution. Loaded products at the marine facility include propane and butanes.<br><br>Expansion announced January 2014 to increase capacity to load 16 million barrels per month of propane or butane (planned to be in service at the end of 2015) | The Terminal serves as a storage facility for Liquefied Petroleum Gas (propane and butane) receiving and sending these products via railcar, truck, pipeline and ship.<br><br>Purchased from Chevron in 2014.<br><br>Can import or export up to 30,000 barrels per day of LPG. | Chesapeake Terminal imports, exports and stores fully refrigerated liquid propane.<br><br>The terminal also heats the propane to +40 deg F for shipment to its customers by truck and rail.<br><br>Ethyl mercaptan is added to the LPG being distributed from the terminal.<br><br>An expansion to store and export butane is underway and exports were expected to begin late 2014. | The Marcus Hook Facility, located in Marcus Hook, Pennsylvania and Claymont, Delaware, is a terminal facility with LPG storage and transfer capabilities. It also handles crude oil. It has processing, storage, dock facilities, truck racks, pipeline access and rail access. | Mariner South is an LPG export/import project at Sunoco's existing Nederland Marine Terminal. They rcently built a pipeline to transport propane and butane from Lone Star's fractionation and storage complex in Mont Belvieu, Texas to Sunoco's Nederland Terminal for export. |
| Address[2] | 12510 American Petroleum Road | 15602 JacintoPort Blvd, Site C | 4100 Unick Road | 2901 South Military Highway | 100 Green Street | Unknown |
| City, State[2] | Galena Park, Texas | Jacinto City[4], Texas | Ferndale, Washington | Chesapeake, Virginia | Marcus Hook, Pennsylvannia (the facility is also located in Delaware) | Nederland, Texas |
| County[2] | Harris County | Harris County | Whatcom County | Chesapeake City | Delaware County | Jefferson County |
| Most recent RMP[1] | 2009 | 2012 | 2008 (by Chevron) | 2010 | 2013 | Not found |
| Link to most recent RMP[2] | http://www.rtknet.org/db/rmp/rmp.php?reptype=a&database=rmp&facility_name=galena&combined_name=&parent=targa&all_naics=&execsum=&city=&county=&state=TX&zip=&chemical_id=&detail=4&datatype=T | http://www.rtknet.org/db/rmp/rmp.php?reptype=f&database=rmp&facility_name=epolp&parent=&combined_name=enterprise&city=&county=&state=TX&zip=&district=&execsum=&all_naics=&chemical_id=98&detail=4&datatype=T&sortp=F | http://www.rtknet.org/db/rmp/rmp.php?reptype=a&database=rmp&facility_name=&combined_name=&parent=&all_naics=&execsum=&city=ferndale&county=&state=WA&zip=&chemical_id=&detail=4&datatype=T | http://data.rtknet.org/rmp/rmp.php?database=rmp&detail=3&datype=T&facility_id=100000168301 | http://www.rtknet.org/db/rmp/rmp.php?city=marcus+hook&state=PA&parent=sunoco&datype=T&reptype=a&database=rmp&detail=4&submit=GO | Not found |
| 5-Year Accident History | There have been no releases of listed Hazardous Substances which resulted in offsite effects and there have been no OSHA recordable injuries over the last fifteen (15) years. | Over the past five years there have been no large or small releases which resulted in any injuries, property damage or offsite consequences. | There were no incidents that occurred during the past 5 years. | There has been no accidental release over the last 5 years. | During the past five years, there were two accidents resulting chemical releases. No offsite consequences occurred due to either incident. (6) | Not found |

Footnotes:
1 An RMP is a Risk Management Plan that is required for operational facilities with a capacity to store hazardous products over certain thresholds. The RMPs are published on-line through the Right to Know Network (www. rtknet.org)
2 This information is pulled from the most recently available RMP for the facility on the Right to Know Network. Some of the information may be out of date and may not fully reflect the facility's current capacities.
3 Relevant information is pulled from recent relevant press releases or company website.
4 The most recent RMP references Houston as the city. Jacinto City is part of the Houston-Sugar Land-Baytown metropolitan area and is bordered by the Cities of Houston and Galena Park.
5 Numbers are from the Bentek report and include predicted capacity from proposed expansions, where applicable
6 On May 17, 2009, there was a hydrocarbon release and fire on the ethylene unit. The incident investigation determined the root cause to be crevice corrosion at a pipe support sleeve. After the initial release, the heat from the fire caused several secondary line failures. While the effective and timely efforts by emergency responders prevented escalation or injury, the greater part of the unit was not restarted after the fire. On June 20, 2009, a release of propane/propylene mix occurred when a loading hose separated from the connection on a contract carrier truck during offloading. This incident caused an OSHA-recordable injury. The incident investigation determined that significant degradation of the threads on the truck fitting allowed the initial release.

**Pembina Supplemental Information**
**Provided to City Planning and Sustainability Bureau Staff (March 26, 2015)**

**Marine Terminals being Repurposed for LPG Export or Proposed as New Builds referenced in the Bentek Report[1]**

| Company | **Kinder Morgan** | **Phillips 66** | **Targa** | **EnLink Midstream** | **Occidental Chemical** | **Pembina Marine Terminals Inc.** |
|---|---|---|---|---|---|---|
| Facility Name | **Fairless Hills (Repurpose)** | **Freeport LPG (Repurpose)** | **Patriot (Repurpose)** | **EnLink (Proposed)** | **Ingleside (Proposed)** | **Pembina Portland Propane Export Terminal (Proposed)[3]** |
| Port Map Name | Not mapped | Freeport LPG Facility | Not mapped | Not mapped | Not mapped | Pembina LPG Facility |
| Estimated Throughput[4] | To be determined | 147,000 barrels/day | To be determined | To be determined | 100,000 barrels/day | 37,500 barrels/day |
| Facility Description[2] | Current facility used for steel products with storage, rail service, and 3 marine-access berths on Delaware River.<br><br>Proposed LPG repurposing in two phases beginning with 200,000 barrels (approximately 8.4 million gallons) butane storage (estimated in service 2015) followed by 200,000 barrels (approximately 8.4 million gallons) of refrigerated propane storage. | LPG Export terminal will be located at their current marine terminal for crude oil and petroleum products.<br><br>The Facility's planned initial capacity will be 4.4 million barrels of LPG a month (both propane and butane), shipped by approximately 8 VLGCs per month. The project will include NGL storage and additional pipelines for connectivity.<br><br>Construction started in late 2014. | Existing dock with rail access on the Houston Ship Channel in close proximity to Targa's Galena Park Marine Terminal. This facility is proposed for LPG exports (both propane and butane).<br><br>Additional publicly available information on scope and timing was not readily found. | Publicly available information was not readily available | Plans to build a propane export terminal at the site of the former Naval Base in Ingleside, Texas with existing dock. | Proposed facility for marine export of liquid propane received by rail. The facility would refrigerate and store propane in 2 large refrigerated propane storage tanks with a total capacity of up to approximately 33.6 million gallons, and would also have approximately 1.2 million gallons of short term storage in pressurized rail unload tanks. |
| Address[2] | 1 Sinter Road[2] | Quintana Road | Unknown | Unknown | Unknown | ~5600 to 6399 N Marine Drive |
| City, State[2] | Fairless Hills, Pennsylvania | Freeport, Texas | Houston Ship Channel, Texas | Eunice, Louisiana | Ingleside, Texas | Portland, Oregon |
| County[2] | Bucks County | Brazoria County | Harris County | Unknown | Unknown | Multnomah County |

Footnotes:
1 As these facilities are proposed and not yet constructed, relevant Risk Management Plans were not available on the Right to Know Network (www. rtknet.org) and readily available public information varied greatly between projects
2 Relevant information is pulled from recent relevant press releases or company website.
3 Pembina's proposed propane terminal for consistency as it was referenced in the Bentek report filed on March 16, 2015
4 Estimated capacities are from the Bentek report and include predicted capacity from proposed expansions, where applicable

**Pembina Supplemental Information**
**Provided to City Planning and Sustainability Bureau Staff (March 26, 2015)**

**Other Operational Large LPG Terminals with Aboveground Storage**

| Company | **Enterprise Propane Terminals and Storage LLC** | **Plains All American** | **Plains All American** | **Crestwood West Coast LLC** |
|---|---|---|---|---|
| Facility Name | **Apex Terminal** | **Shafter Facility** | **San Pedro Terminal** | **North Coles Levee** |
| Port Map Name | Apex LPG Facility | Not mapped | Wilmington/ San Pedro LPG Facility | Not mapped |
| Estimated Capacity[3] | Unknown | 7.3 million gallons of storage | 25.3 million gallons of storage | 24 million gallons of storage |
| Facility Description[2,3] (from RMP , company website and press releases) | The Apex terminal receives and stores ethyl mercaptan and liquefied propane, and loads propane onto trucks. The facility consists of one refrigerated propane storage tank, ten propane pressure storage tanks, a six-station truck loading rack, mercaptan storage and injection equipment, a propane refrigeration system and associated piping, valves and other miscellaneous equipment. | Plains' Shafter Facility processes liquefied petroleum gas (LPG) into a mixture of normal butane, propane, natural gasoline, and isobutane and has approximately (or 7.3 million gallons) of Natural Gas Liquid (NGL) storage, as well as truck and rail loading/ unloading operations. | Plains' San Pedro facility stores and distributes butane and propane, receives and ships product by pipelines, and has rail and truck unloading and loading. The LPG storage consists of two 12.5 million-gallon refrigerated tanks as well as five 60,000-gallon horizontal storage tanks. | The facility processes, stores, and transfers natural gas, natural gasoline, propane, and butane. There are 32 tanks with capacities ranging from 4,000 to 44,000 gallons, two tanks with a capacity of 1.3 million gallons, two tanks with a capacity of 1.7 million, one refrigerated tank with a capacity of 5 million gallons (for butane), and one 15 million gallon refrigerated storage tank (for propane). |
| Address[2, 3] | 1521 East Williams Street | 19430 Beech Avenue | 2110 North Gaffey Street | 9224 Tupman Road |
| City, State[2, 3] | Apex, North Carolina | Shafter, California | San Pedro, California | Tupman, California |
| County[2, 3] | Wake County | Kern County | Los Angeles County | Kern County |
| Most recent RMP[1] | 2011 | 2014 | 2011 | 2014 |
| Link to most recent RMP[2] | http://www.rtknet.org/db/rmp/rmp.php?reptype=f&database=rmp&facility_name=apex&parent=&combined_name=propane&city=&county=&state=&zip=&district=&execsum=&all_naics=&chemical_id=&detail=4&datype=T&sortp=F | http://www.rtknet.org/db/rmp/rmp.php?facility_id=100000082858&database=rmp&detail=3&datype=T | http://www.rtknet.org/db/rmp/rmp.php?facility_id=100000170389&database=rmp&detail=3&datype=T | http://www.rtknet.org/db/rmp/rmp.php?facility_id=100000143141&database=rmp&detail=3&datype=T |
| Local Response Agency (Contact #)[2] | Apex Fire Department (919-362-4001) | Kern County Fire Department (661-746-3933) | Los Angeles Fire Department (310-548-2836) | Kern County Fire Department (661-831-3467) |
| Five-Year Accident History | Over the past five years there have been no large or small releases, with no injuries or offsite consequences. | No reportable accidents over the last five years (June 2004 to June 2009) that resulted in an injury, environmental damage, or off-site impact. | This facility has not had an accident or release meeting RMP criteria within the last five years. | This facility has not had an accidental release. |

Footnotes:
1 An RMP is a Risk Management Plan that is required for operational facilities with a capacity to store hazardous products over certain thresholds. The RMPs are published on-line through the Right to Know Network (www. rtknet.org)
2 This information is pulled from the most recently available RMP for the facility on the Right to Know Network. Some of the information may be out of date and may not fully reflect the facility's current capacities.
3 Relevant information is pulled from recent relevant press releases or company website.
4 The most recent RMP references Houston as the city. Jacinto City is part of the Houston-Sugar Land-Baytown metropolitan area and is bordered by the Cities of Houston and Galena Park.

# EXHIBIT 2


# Galena Park LPG Facility

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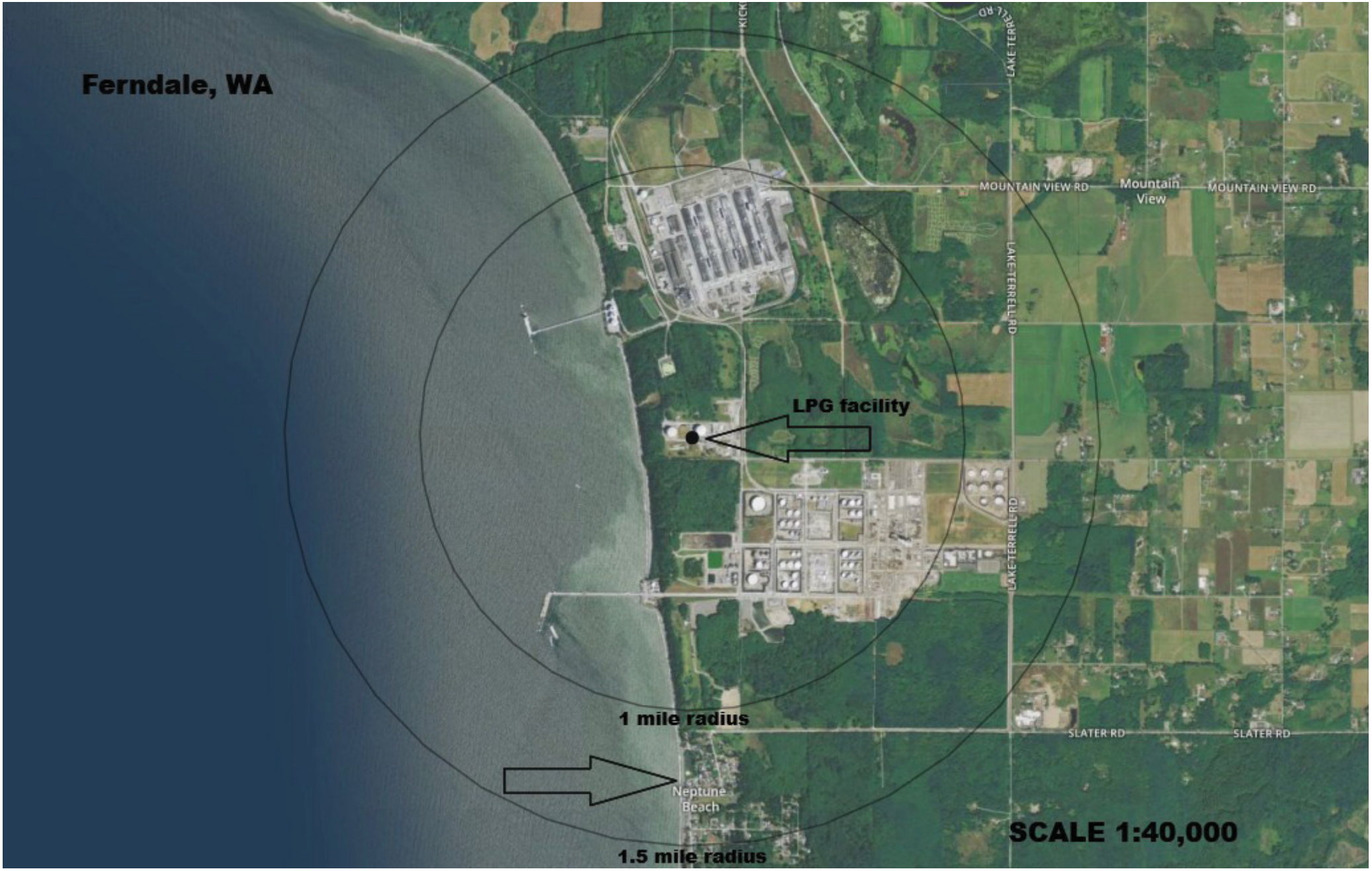


# Ferndale LPG Facility

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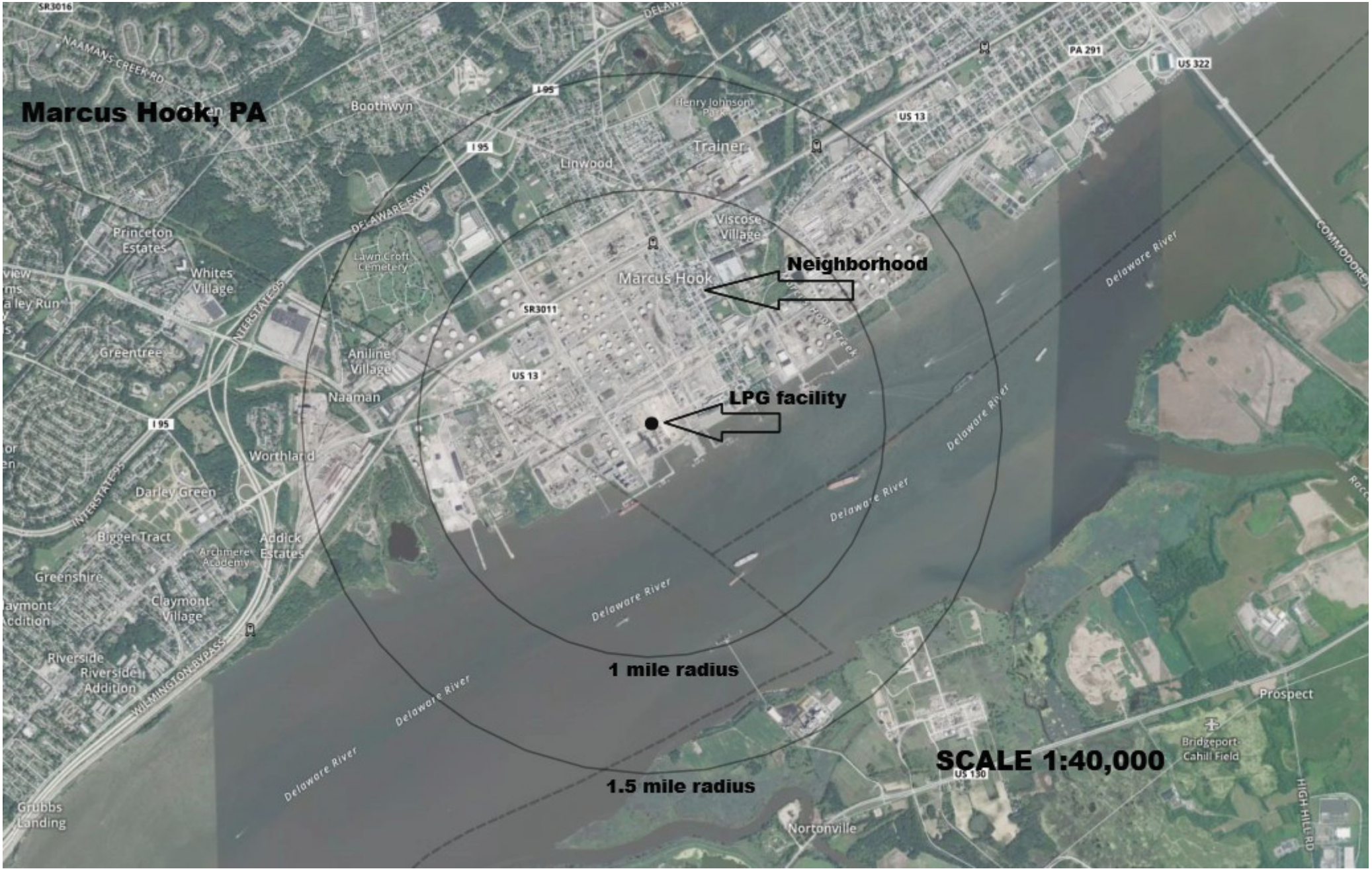


# Marcus Hook LPG Facility

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# Freeport LPG Facility

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# Pembina LPG Facility


# Nederland LPG Facility

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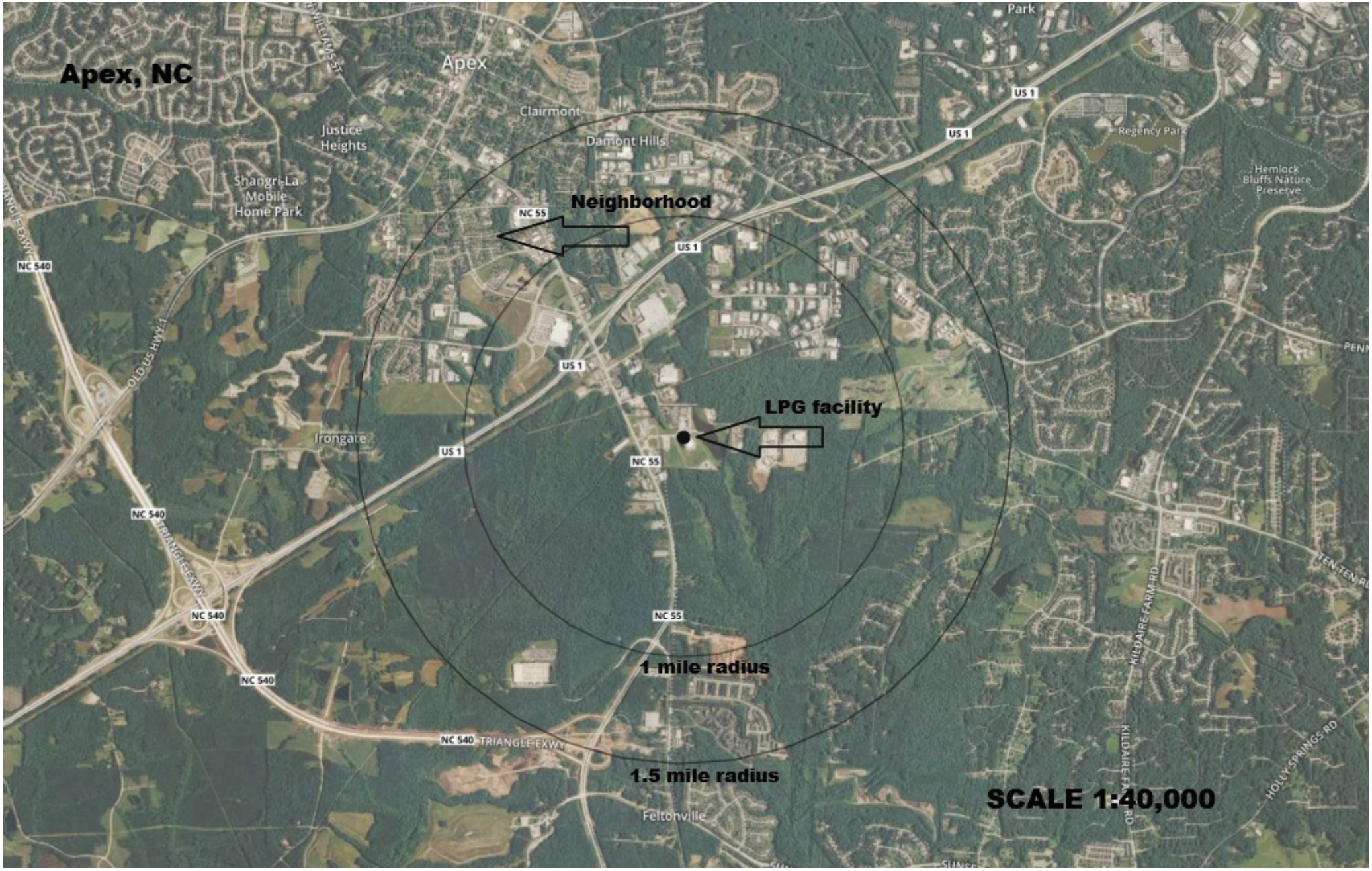


# Apex LPG Facility

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# San Pedro/Wilmington LPG Facility

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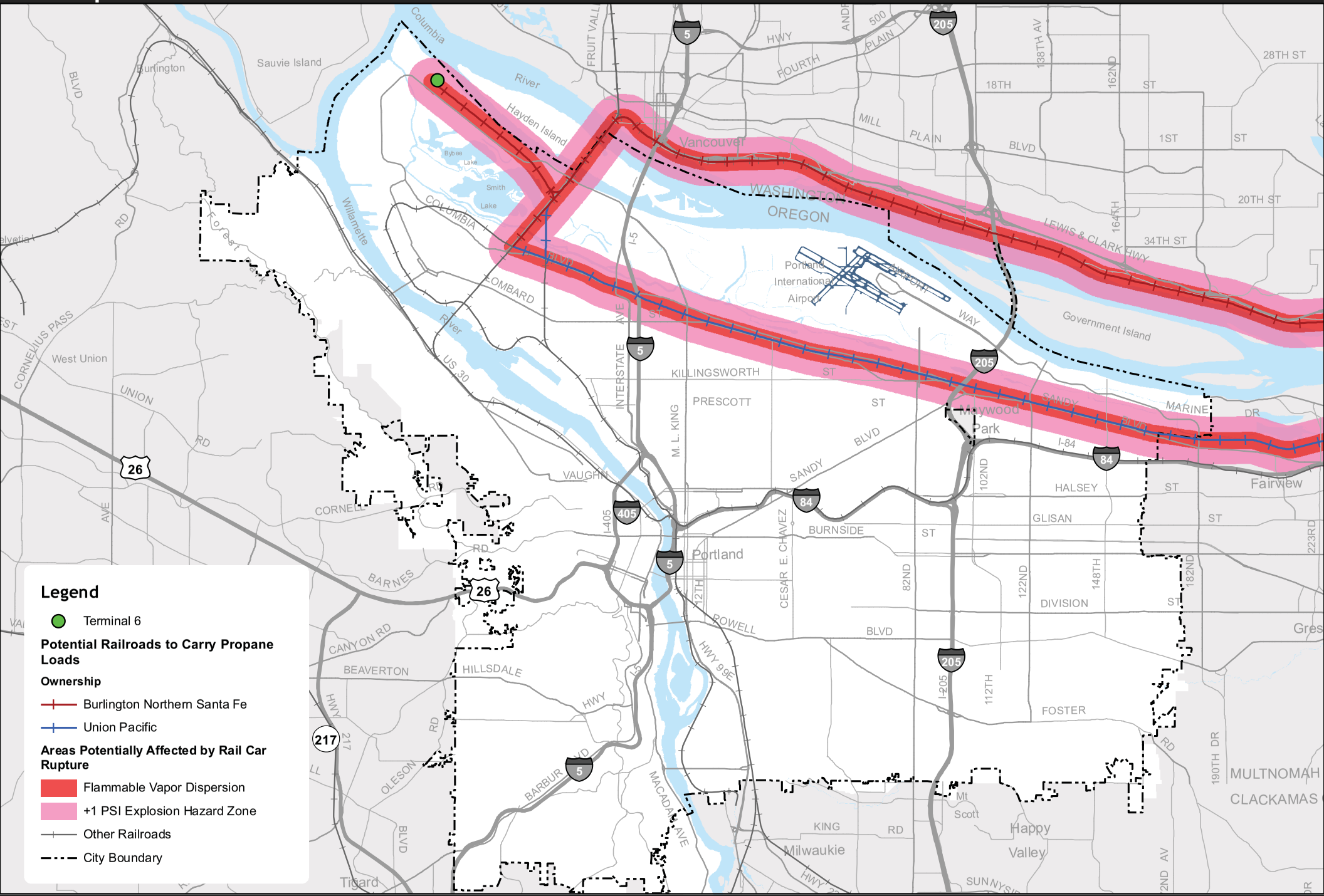
# T6 Propane Terminal

## Worst Case Scenario: Rail Car Rupture




March 31, 2015

**City of Portland, Oregon // Bureau of Planning & Sustainability // Geographic Information System**

The information on this map was derived from City of Portland GIS databases. Care was taken in the creation of this map but it is provided "as is". The City of Portland cannot accept any responsibility for error, omissions or positional accuracy.

NORTH

0 5,000 10,000 Feet

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