SUBJECT: TRANS MOUNTAIN TANK FARM
TACTICAL RISK ANALYSIS

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In light of the Trans Mountain Expansion Project (TMEP) proposal by Kinder Morgan Canada (KMC) at the Trans Mountain Tank Farm (TMTF) facility, this evidentiary paper has been to analyze the fire and safety risks, hazard events and consequences associated with the project.

Each of the risks outlined have been validated as legitimate, based upon actual occurrence within the hydrocarbon industry in North America within the past decade, with the specific event occurrences being referenced. The hazard events and consequences are identified industry standard considerations with regard to emergency management of crude oil storage facilities.

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Executive Summary

On 16 December 2013, Kinder Morgan submitted an application to the National Energy Board (NEB) for the expansion of the Trans Mountain Pipeline system, which includes the expansion of the Burnaby Mountain Terminal from 13 storage tanks to 26. The findings of the fire safety and risk analysis within this paper raise concerns over KMC selection of the Burnaby Mountain Terminal for the densification of storage tank use. Based on the findings of the analysis, the Burnaby Mountain Terminal is not the appropriate location for the expansion of the Burnaby Mountain Terminal as it poses significant constraints from an emergency/fire response perspective, including but not limited to safety of firefighters and effectiveness to combat fire; containment and extinguishment of fire/spill/release; evacuation of employees within the Burnaby Mountain Terminal facility; evacuation of adjacent neighbourhoods, as well as broader areas impacted by release of sulfur based gases and toxic smoke plumes; and, protection of adjacent properties, including conservation lands.

Additionally, the TMEP lacks appropriate consideration for original facility fire protection premises and industry best practices in petroleum storage and fire protection, as the proposal only seeks to comply with minimum federal and provincial code requirements.

This paper has analyzed and identified the impacts of the TMEP with regard to the reduction in countermeasures and resulting facility susceptibility to consequences resulting from hazard event occurrence.

Countermeasures

The increased consequences arising from risk occurrence is a direct result of the facility configuration changes and additional storage tank locations which reduce the positive impact of the previously engineered fire and safety protection countermeasures. The Countermeasures which will be marginalized by the TMEP, include:

- **Tank Spacing**
  A 33% reduction in the overall facility Tank Spacing
  A 45% reduction in the proposed Tank Spacing versus existing Tank Spacing premise

- **Application Positions**
  A 70% increase in the number of Storage Tanks that do not provide safe deployment positions for fire operations in all potential wind conditions.
  100% of the proposed Storage Tanks do not provide safe deployment positions for fire operations in all wind conditions.

- **Distance to Fenceline**
  A 30% reduction in the facility average Tank to Fenceline Distance
  A 61% reduction in the average proposed Tank to Fenceline Distance
Hazard Events
The TMEP degrades the original fire protection premise of the facility and increases the likelihood of spill or fire extension exposing the community to the following hazard events.

- **Regional Seismic Event**
  The consequences of a seismic event occurrence are increased due to the location of the facility elevated immediately above residential communities and sensitive environmental areas, watercourses and eco-systems in close proximity, in the outfall downhill direction.

- **Flammable Gas Outfall**
  The lighter components of the crude oil when released form flammable outfalls with low ignition points and the significant potential to propagate explosion and fire events.

- **Release of Sulphur based Gases**
  The loss of containment of crude oil products presents the potential for poisonous Hydrogen Sulfide and Sulphur Dioxide release.

- **Watercourse Outfall of Liquid Crude Oil Release**
  The release of Crude Oil to areas outside of lined secondary containment diking creates the potential of a crude oil introduction into watercourses exiting the TMTF facility.

- **Tank Fire Burnout**
  The operations associated with protection of adjacent tanks and the Burnaby Mountain Conservation Area, as well as evacuating persons potentially impacted by a 4 day tank fire event from a facility with such tight proximity to high density residential communities would require an emergency activation of provincial scale.

- **Tank Fire Boilover**
  The potential for Boilover exists in any wide boiling range hydrocarbon, such as a crude oil storage tank full surface fire. For a proposed 200’ storage tank, a Boilover event can discharge heated and molten crude oil outwards to 2,000’, resulting in large area life hazard and the potential for propagation of additional storage tank fires.
Consequences
The Trans Mountain Expansion Project (TMEP) will create elevated risk and consequences of risk occurrence to the community by increasing the number and size of hydrocarbon storage tanks within an already geographically challenged facility. Hydrocarbon storage tanks on Burnaby Mountain present several public safety risks, which include increased potential for, include:

- **Flammable Gas Outfall against the Fenceline**
  The potential for flammable gas ignition outside the fenceline is based upon the use of the land areas in proximity to the fenceline. The highly populated areas around the TMEP present a high likelihood of ignition.

- **Release of Sulphur Based Gases against the Fenceline**
  Highly toxic Hydrogen Sulfide (H₂S) will very quickly, upon facility release, expose residential areas to conditions that are immediately dangerous to life. Smoke outfalls from fire event may contain Sulphur Dioxide (SO₂), in which KMC analysis shows a potential health concern could be felt up to 5.2 km. downwind.

- **Release of Toxic Smoke Plumes against the Fenceline**
  The potential health impacts of exposure to by-products from crude oil combustion are most notably likely to harm those with pre-existing chronic respiratory conditions, increase rates of asthma and cardiovascular illness, with potentially undetermined effects on longer term illness accumulations such as cancer.

- **Heat Discharge against the Fenceline**
  The TMEP reduces the Heat Source distance to Wildland Impact and potential Wildfire exposure of the Burnaby Mountain Conservation Area by 66%.
  The existing TMTF is designed with a set back or buffer distance of not less than 200’ from the fenceline.
Conclusions

The TMEP will increase the impacts associated with the risks of crude oil loss of containment or fire across all potential events types due to the increased proximity to residential population densities, highly susceptible conservation forest areas and downhill or downwind sensitivities. The event elapse time prior to life and environmental impact will be significantly reduced by the TMEP, as has many of the engineered in facility configuration countermeasures responsible for the minimization of event growth and corresponding impact escalation have been greatly reduced from original facility premises which fundamentally adhered to the intent of best practices, to the reduced performance of minimum code requirements.

The existing high consequence event potential of a regional seismic event will tax the TMTF facility as the tertiary containment system has not been proposed to be upgraded nor will the secondary containment provisions of existing storage tanks, creating a potential release of 40% of the volumetric crude oil from the facility or up to 2.24 Million Barrels of crude oil. The impact of this loss is not increased by frequency of event occurrence, but by the TMEP not incorporating site wide upgrades to maintain the countermeasure premises currently in place.

Fires occurring in this tank farm will have a potential to be severe in magnitude. Inherent in the layout of this tank farm is the potential of a fire event occurring in such close proximity to adjacent tanks, that subsequent ignition of additional storage tanks is a dangerous reality. A significant emergency management concern in a facility of this type is the escalation from a single tank fire to a multiple tank fire event. The resource requirements and the excessive complexity and risk to emergency responders, typically prevents the safe firefighting of a multiple tank fire event. The TMEP proposal includes the mass densification of the facility, adding many more and many larger product storage tanks. The addition of storage tanks decreases the distance between each tank. The distance between storage tanks is a key design and engineering feature provided to allow firefighters to effectively isolate an active tank fire, preventing a multiple tank fire event. The TMEP proposal effectively increases the risk associated with a multiple tank fire event due to the reduction in storage tank spacing.

The TMEP proposes the increasing of the tank farm storage tank density, by decreasing engineered tank isolation distances, which in turn increases the potential for fire event escalation through extension, in a facility that has reduced its internal fire protection capability without approval. Notable by its absence from the TMEP application to the NEB is a detailed analysis of the effect of the tank spacing reduction on the requirements of mobile and fixed fire protection countermeasures, and the subsequent changes to the fire protection premises currently utilized. Weaknesses in the design of a facility can create fire event situations that cannot be safely or effectively mitigated without allowing a storage tank or several tanks to burnout.

The TMTF was originally approved based on the provision of a 2 tank diameter spacing. In subsequent years the addition of Tank 88 marginally reduced the overall facility tank spacing to 1.86 tank diameters (average), but maintained the original premise of tank spacing to provide tank isolation and reduce escalation and extension potentials. The TMEP massively deviates from the original safety premise and approval basis of providing storage tank isolation for proposed tanks at a proximity distance of 0.5 tank diameters.
The addition of storage tanks into the existing TMTF changes the risk control premises with regard to storage tank isolation by facility design. In order to achieve the desired storage tank volume, KMC is proposing a significant replacement of designed isolation of each storage tank. In essence, the TMEP shifts the control of hazard from an engineered approach of tank isolation, to an emergency response approach. As the authority having jurisdiction for fire protection approval within the City of Burnaby, the Burnaby Fire Department has recently been advised by KMC on May 30, 2014, that the facility no longer has the emergency response ability to extinguish fire events with internal facility resources, and that additional hydrocarbon specialized firefighting resources from regional facilities are no longer available.

To complicate the emergency control activities, because of the tighter tank spacing, many heat exposure cooling operations are not possible due to insufficient firefighting deployment positions. The TMEP proposed to group many tanks with common diking separated only by small intermediate dike segregation. These larger dikes areas reduce the available access and deployment roadway positions to facilitate safe, efficient and effective firefighting stream applications.

The decreased tank spacing within the tank farm has additional significant consequences. Many of the potential tank fire scenarios within the Trans Mountain Tank Farm facility would be inextinguishable due to lack of safe firefighting positions. The general configuration proposed by Kinder Morgan provides insufficient safe access routes and operating positions from which firefighters could apply protective streams to isolate or extinguish fire events. The elevation changes within the Trans Mountain Tank Farm do not provide multiple firefighting positions or consideration for approach elevations to enable safe and effective operations for all potential wind directions. In order to extinguish a tank fire within the Tran Mountain Tank Farm emergency responders could be forced to significantly risk their personal safety in order to overcome the design inadequacies of the facility. Specifically, the configuration of the tank farm on a hillside in such a tight footprint would require firefighting personnel to operate in elevated positions above the tank, exposing them to potentially excessive heat and smoke outfalls. In these instances emergency responders would likely be forced to allow the tank fire to burn out while adjacent tanks are protected.

The TMEP presents a significantly larger fire control risk within the TMTF. The identified increase in events with potential to escalate and extend to adjacent storage tank exposures due to insufficient firefighting deployment positions increases the likelihood of a multiple tank fire (including the potential of having to allow one or several storage tanks to burnout over 2-4 days), toxic smoke plume discharge (including long term chemical exposure to adjacent communities), and heat discharge to areas outside the facility (including high probability of fire extension to the forest areas of the Burnaby Mountain Conservation Area. The risk of community impacts outside of the facility from a TMTF fire event are increased by 70%.

The reality of employing a Burnout tactic for a Tank Fire event within the proposed TMEP configuration is that success associated with preventing fire extension throughout the TMTF and the adjacent community would by no means be assured. Significant potential exists that due to the proposed configuration, density, complexity and proximity to the community impacts and fire spread potentials that would create scenarios where fire containment is not possible.
The cost of this risk potential assumed by the community is not in line with the safety and risk management premises initially utilized for original facility approval by the City of Burnaby. The specific driver of the increased risk is the reduction in the effective of the facility design to limit fire event growth and restrict hazardous impacts to an immediately controllable area of impact during a short emergency response timeframe. It is critical for public safety that design configuration utilized support the protection of life, the environment and property. The TMEP does not provide the basic engineered safety provisions standard in high-impact potential facility design.

The potential for Boilover exists in any wide boiling range hydrocarbon, such as crude oil. For a proposed 200’ storage tank, a Boilover event can discharge heated and molten crude oil outwards to 2,000’. A Boilover event occurring from a Tank Fire in the TMTF, the high hazard expected to receive the discharged heated and molten crude oil would encompass the entire TMTF, the Shellmont Tank Farm, the Forest Grove, Meadowood, and Sperling-Duthie Communities, closing Gaglardi Way and the Burnaby Mountain Parkway. It is anticipated that the consequences of Boilover exposure within the areas identified would include human injuries to emergency responders and unevaluated civilians, mass tree top based wildland fire initiation, structural fire initiation to many residential buildings, potential tank fire initiation within the TMTF and the Shellmont Tank Farm and significant isolation of the SFU and UniverCity communities.

The TMEP proposes a reduction in the tank to fenceline spacing of 30% on a facility wide comparison, and utilizes a new tank positioning premise which reduces the tank to fenceline distance by 61%. The decreased tank to fenceline distance and consequential impact potentials to the community presents the higher requirement and increased priority of evacuation operations conducted simultaneously with fire control activities. This response requirement significantly increases the emergency response resource requirements associated with identifiable emergency event potentials.

The TMEP significantly increases the urgency and expedience required to prevent community life and environmental impact outside the facility fenceline in the event of a product release or storage tank fire. The positioning of storage tanks in such close proximity creates a greater potential for citizen exposure within the adjacent communities to the hazardous effects of flammable gas outfalls and sulphur based gases. Additionally, the close proximity of storage tanks to the fenceline dramatically increases the risk of wildland fire to the Burnaby Mountain Conservation Area.

The process undertaken by KMC to seek expansion approval requires that the company, through its federal, provincial and municipal applications, accurately describes the project and its resultant operations within the proposed site. As such, the onus is on the applicant to document and commit to a project that meets the needs of the stakeholders impacted by the project and the authorities having jurisdiction.

What may not be noted by KMC is the aspect of regulatory compliance to City of Burnaby Bylaws, specifically the requirement for Emergency Response Plans and Fire Protection provision that the adequacy of which is determined, solely by the Fire Chief.
With this in mind, the Burnaby Fire Department is resolute in asking increasingly more detailed questions in order to address the increase in risk the TMEP will pose and the operation impacts the project will have on the Burnaby Fire Department and the community for which they advocate.

KMC has undertaken as part of their submission a Qualitative Risk Assessment on Facility Hazards. It is important to note in section 3.2 Facilities the KMC states that “For each valid and independent consequence reduction measure the consequence level will be reduced by one.” Presumably KMC intends to self-determine acceptable consequences, degrees of consequence reduction and levels of acceptable risk.

Following the NEB Intervener Round 1 Information Request process, in which details around the risk to safety created by the TMEP, KMC failed to answer any of the questions asked by the City of Burnaby and subsequently responded to the City of Burnaby by stating that “There is no further response required”.

No statement intent re approval of the Burnaby Fire Chief in accordance with City Bylaw NO.11860 is apparent within the submission. The point here is KMC has not provided sufficient detail for the Fire Chief to be apprised of the TMEP Facility Hazards or to comment on or approve of the adequacy of the consequence reduction measures. The key concept is that the Qualitative Risk Assessment team does not determine the adequacy of the consequence reduction measures; the Burnaby Fire Department Fire Chief has the responsibility and duty to do so.
Risk

Concepts of Risk

Both the regulatory agency and the applicant set levels of emergency preparedness based on risk. The difference is in the methodology of the risk analysis.

The hydrocarbon industry typically attempts to separate risk into two (2) categories. The first are those risks that can be shown to present no or little chance of occurring. These risks are identified as having an acceptably low level of frequency of occurrence.

The second are those risks that, due to their severity and probability of occurrence, require ‘consequence reduction measures’. This is based upon criteria that affect the company’s profitability in its broader sense (e.g. reputation, liabilities etc.). This process of risk assessment is based on an arguable premise: that sufficiently low frequency risks can remain unmanaged regardless of the severity of the consequence. This premise very often falls at odds with local government’s expectation of “necessary”.

The City of Burnaby uses a different framework for assessing risk since it has a much broader concern for the wellbeing and stewardship of its citizens and community than Kinder Morgan.

Hydrocarbon Tank Farms by the nature of the commodities received, stored and transferred out have inherent potential for emergency event occurrence. Loss of containment of hydrocarbon products and product ignition events resulting in tank fires and tank dike fire are primary emergency event potential for a Tank Farm.

The potential for a release of crude oil at the TMEP may occur by several specific means including tank overfill, the physical failure of containment provisions and human error damage associated with improperly controlled industrial work in proximity to tankage or piping. The loss of containment of crude oil is a much larger issue than the undesired exposure of the liquid product to the environment requiring collection and soil remediation operations which are very difficult to achieve 100% recovery.

A loss of containment can be provided is several means, including:

- Tank Dike Spill
- Tank Overfill to Secondary Containment
- 3D Pressurized Release
- Piping Loss Outside of a Diked Area
The TMEP proposes to utilize both External Floating Roof Tanks and Internal Floating Roof Tanks. The credible emergency event potentials for these two (2) types of tanks are (as specified by the American Petroleum Institute Recommended Practice 2021 – Management of Atmospheric Storage Tank Fires P.10 Table 1 & P.11 Table 2):

**External Floating Roof Tanks:**
1. Rim Seal Fire
2. Overfill Ground Fire
3. Obstructed Full Liquid Surface Fire
4. Unobstructed Full Surface Fire

**Internal Floating Roof Tanks:**
1. Vent Fire
2. Overfill Ground Fire
3. Obstructed Rim Seal Fire
4. Obstructed Full Liquid Surface Fire

**Special Hazards for Tanks Containing Crude Oil:**
1. Slopover
2. Frothover
3. Boilover
Tank Dike Spill

Description:
- The release of product either from the tank itself or the transfer piping inside the tank containment levee, where the product released accumulates inside the tank levee.

Event Validity:
- Embridge Tank Farm, Crude Oil Tank Farm Release, Mokena Illinois, 2012 Nov 20
- Kinder Morgan, Spill Release to Levee, Abbotsford BC, 2012 Jan 24
- Kinder Morgan, Crude Oil Release to Levee, Burnaby BC, 2009 May 6
- Citgo Refinery, Crude Oil Release past Levee, Lake Charles Louisiana, 2006 July 19
- Louisiana area facilities, Product Release, Louisiana area, 2005 Aug 30

Typical Cause:
- Tank overfill and piping/valve/flange failures are the typical causes of product loss to the secondary containment of the levee. Due to the volumes within the tank and the rates of flow through the piping systems, large volume losses are reasonable prior to isolation.

Associated Hazards:
- The loss of containment of flammable products typically results in rapidly expanding and migrating areas of flammable vapor, creating fire and explosion hazards throughout the facility and potentially outside the facility fenceline.
- Crude oil loss of containment presents a lower yet still significant risk of flammable vapor generation, but often releases toxic substances immediately hazardous to life. This is most significant with sour crude oil.

Control Options:
- The early detection and isolation of the release source is critical to minimize the scope of a loss of containment event. For events that aren’t easily or remotely isolated a large amount of product can accumulate prior control being achieved. The volume of product accumulated is directly proportionate to the amount of flammables released to the levee.
- With a large flammable or toxic release present, a difficult decision is required. The application of foam solution is the best alternative to suppressing the discharge of toxic outfalls and flammables from a hydrocarbon release. However, there is risk associated with applying foam to unignited flammables.
  - The risk of foam application to due to the generation of static charge from fire streams travelling through the air from the nozzle to landing point. The discharge of this static charge in the flammable vapor could create a product ignition and subsequent levee fire. This risk however does not apply for crude oil as it is not a static electrical charge accumulator.
The risk in delaying foam application is that the areas exposed to flammable vapors and toxic outfalls will remain uncontrolled for a significant period of time, creating a risk of flammable ignition, fire, explosion and toxic exposure.

Sustained foam solution application from mobile or fixed monitors/pourers at a rate that achieves a comprehensive and maintained foam blanket, which includes:

- Positioning and operation of high volume mobile foam discharge monitors consistent with available discharge positions, wind conditions and stream reach distances, such that foam applications can be made that land the foam solution accurately and gently at desirable application points within the levee
- Positioning of connecting hose lines to and from foam proportioning equipment, water supplies, discharge devices and foam concentrate supplies
- Operation of foam proportioning equipment and foam concentrate supplies
- Water supply systems consistent with the required capacity to generate sufficient foam solution
- Water pump and foam proportioning devices capable of providing sufficient foam solution for foam blanket application and maintenance
- An emergency response team of 8 to 12 highly trained and equipped personnel supported by a highly function staff of facility operational personnel.

Semi-fixed levee foam system, including:

- Levee fixed foam pourers designed to apply foam solution comprehensively throughout the tank levee
- Fixed foam lateral and piping connections to deliver the required foam solution volume to the foam pourers
- Positioning of connecting hose lines to and from foam proportioning equipment, water supplies, discharge laterals and foam concentrate supplies
- Operation of foam proportioning equipment and foam concentrate supplies
- Water supply systems consistent with the required capacity to generate sufficient foam solution
- Water pump and foam proportioning devices capable of providing sufficient foam solution for foam blanket application and maintenance
- An emergency response team of 6 to 8 highly trained and equipped personnel supported by a highly function staff of facility operational personnel.

Fully fixed levee foam system, including:

- Levee fixed foam pourers designed to apply foam solution comprehensively throughout the tank levee
- Fixed foam lateral and piping connections to deliver the required foam solution volume to the foam pourers
- Fixed foam proportioning devices capable of producing foam solution at the required volume to achieve foam blanket application and maintenance
- Foam concentrate and water supplies sufficient to provide a sustained foam application throughout the event
- The system is pre-connected together such that the activation of the system requires control valve operation only, and can be operated by a team of two to three (2-3) operations personnel.
Consequences:

- The uncontrolled discharge of toxic and flammable vapor outfall, causing potential life hazards, fire and explosion.
- Fire and explosion against other risk areas within the facility fenceline
- Toxic and flammable outfalls outside of the facility fenceline
- Levee release ignition causing a full surface levee fire generating the toxic outfall of the products of combustion, heat exposure to the tank, and the potential for escalation to a tank fire
- The loss of containment within the levee spreading flammable products throughout the facility outfall retention system, causing potential of secondary fire areas and massively increasing the scope of the event and the subsequent resource requirements to mitigate

Tank Overfill to Secondary Containment

Tank overfill is a common loss of containment scenario for stored crude oil. Even with the continued advent of computerized monitoring and alarm systems such as High Level Alarms, and High-High Level Alarms the overfilling of tanks and the subsequent loss of containment to the secondary containment dike areas still occurs. The containment dike provisions are critical in limiting the size of the spill area.

The risk associated with loss of containment from tank overfill is typically associated with operator error or mechanical/computerized monitoring system failure. The TMEP proposes crude oil product movements to increase by three fold at completion of the project, meaning a much greater impact by human operators on the operations at the TMTF.
3 Dimensional Pressurized Release

Description:
- A loss of containment generated from a partially damaged pipe, flange or valve, can create a release under pressure that discharges a fine crude oil mist.
- Crude oil released with this means typically propagates a much larger flammable gas outfall due to the atomization and near 100% release of the light hydrocarbon components.
- Instead of a slow release of light end components from only the surface of the crude oil spill exposed to the atmosphere, the flammable components are released completely during the small droplet exposure to atmosphere.
- The flammable area, concentration and spread of a spill release of this type with a reasonable volume discharge prior to isolation, would be of much greater magnitude than is typically experienced with a tank overfill event.

Typical Cause:
- Caused by piping/valve/flange failure due to damage, over pressurization or inadvertent relief

Associated Hazards:
- Migrating exposure of flammable vapor and toxic outfalls throughout facility and against adjacent facility risks
- Increased potential to expose areas outside of the facility fenceline
- Increased likelihood to create a life hazard due to traveling flammable exposures

Control Options:
- Identification, isolation and restriction of flammable outfall to a controlled area
- Application of a dual agent stream (foam & dry chemical) to extinguish the pressurized fire.
- Sustained foam solution application from mobile monitors at a rate that achieves or exceeds the minimum application to achieve and maintain extinguishment of the accumulated product fire area, which includes:
  - Positioning and operation of highly mobile foam discharge monitors consistent with available discharge positions, wind conditions, heat exposures and stream reach distances, such that foam applications can be made that land the foam solution accurately and gently at desirable application points within product fire area
  - Positioning of connecting hose lines to and from foam proportioning equipment, water supplies, discharge devices and foam concentrate supplies
  - Operation of foam proportioning equipment and foam concentrate supplies
  - Water supply systems consistent with the required capacity to generate sufficient foam solution
  - Water pump and foam proportioning devices capable of providing sufficient foam solution for foam blanket application and maintenance
An emergency response team of 8 to 14 highly trained and equipped personnel supported by a highly function staff of facility operational personnel.

**Consequences:**
- Escalation of the levee fire to a tank fire either within the levee or in an adjacent levee
- Spread of release fire through the facility’s outfall liquid retention system
- Ignition via heat exposure to adjacent facility risks

**Piping Loss Outside of a Diked Area**

**Description:**
- A loss of containment resulting from piping failures and physical damage occurring outside of secondary containment areas creates the potential for the spread of crude oil throughout the facility area in outfall directions until retention by tertiary containment is possible.

**Event Validity:**
- Chevron Inlet Refinery, Gasoline Release, Burnaby BC, 2012 Feb 21
- Chevron Inlet Refinery, Crude Oil Loss, Burnaby BC, 2010 May 27

**Typical Cause:**
- Caused by piping/valve/flange failure due to damage, over pressurization or inadvertent relief

**Associated Hazards:**
- Migrating exposure of flammable vapor and toxic outfalls throughout facility and against adjacent facility risks
- Increased potential to expose areas outside of the facility fenceline
- Increased likelihood to create a life hazard due to traveling flammable exposures

**Control Options:**
- Identification, isolation and restriction of flammable outfall to a controlled area
- Sustained foam solution application from mobile monitors at a rate that achieves or exceeds the minimum application to achieve and maintain extinguishment, which includes:
  - Positioning and operation of highly mobile foam discharge monitors consistent with available discharge positions, wind conditions, heat exposures and stream reach distances, such that foam applications can be made that land the foam solution accurately and gently at desirable application points within product accumulation, and move stream applications quickly to overcome release travel
Positioning of connecting hose lines to and from foam proportioning equipment, water supplies, discharge devices and foam concentrate supplies
- Operation of foam proportioning equipment and foam concentrate supplies
- Water supply systems consistent with the required capacity to generate sufficient foam solution
- Water pump and foam proportioning devices capable of providing sufficient foam solution for foam blanket application and maintenance
- An emergency response team of 8 to 14 highly trained and equipped personnel supported by a highly function staff of facility operational personnel.

Consequences:
- Ignition of adjacent facility risks
- Trapping or restricting of safe exit routes to unprotected facility operations staff
- Limiting of safe access routes to emergency responders

**Tank Vent Fire**

Internal Floating Roof Tanks have potential to experience ignition and fire conditions at the vents located on the perimeter of the tank roof. Ignition of the roof’s vents typically occurs as a result of lightning strikes, static electrical accumulation or as an escalation event from a dike fire or adjacent tank fire.

Vent fire have the potential to cause ignition of the Internal Floating Roof tank’s rim seal area when the pressure-vacuum valve fails to provide high-velocity movement to the exterior of the tank vent.
Rim Seal Tank Fire

Description:
- A rim seal fire is the ignition of the periphery edge seal closing the gap between the tank wall and tank roof on an Internal or External Floating Roof Tank.
- Ignition of the roof’s rim seal typically occurs as a result of lightning strikes, static electrical accumulation or as an escalation event from a vent fire, dike fire or adjacent tank fire.
- Ignitable mixtures of light end components and air may occur at the rim seal during the initial fill of the tank and for up to 25 hours.

Event Validity:
- Teppoco, Crude Oil Rim Seal Tank Fire, Texas City Texas, 2009 July 23

Typical Cause:
- Accumulated induced charge ignition from area lightning strikes

Associated Hazards:
- A rim seal fire will discharge a reasonable amount of smoke (Reference: Consequences - Release of Toxic Smoke Plumes against the Fenceline, P. 72). Typically, rim seal fire event are extinguishable with semi-fixed or fixed fire protection system. However, an explosive ignition of the flammables at the rim seal can occur with sufficient force as to damage the rim seal foam pourers or the floating roof.
- The historical premise of working from the tank perimeter walkway or roof during a rim seal fire event, has been dismissed in recent years due to the risk of exposure and the lack of rapid escape routes for firefighters.
- If left uncontrolled, heating of proximity roof components cause warping and damage that may allow product or firefighting agents to flood the floating roof.
- Application of foam solution via ground monitors presents a real risk of being applied to the hard roof portion with the potential to partially sinking the floating roof and escalating the fire to a full surface fire event

Control Options:
- Foam application to a rim seal fire is best provided via fixed foam pourers attached to the tank wall. These foam pourers are designed to gently flow foam solution down the tank wall to the rim seal area. The multiple foam pourers are designed as a comprehensive system which will apply sufficient foam solution to the rim seal area in close enough proximity to each other that allows the foam solution to fill the rim seal area and flow together to completely suppress the rim seal fire.
- Foam delivery to the fixed foam pourers via a fixed foam lateral connection and piping
- Generation of foam solution through either fixed or semi-fixed foam system
  - A fixed foam system is a standalone automated foam generation and delivery system that includes foam pourers, foam lateral, water supply, foam
proportioning device and a foam concentrate supply. The system is pre-connected together such that the activation of the system requires control valve operation only, and can be operated by a team of two to three (2-3) operations personnel.

- Of critical importance is the maintenance and periodic testing of the fixed system to ensure proper operation during emergency events

- A semi-fixed foam system is a foam application system connected to the tank for effective delivery of foam solution that includes foam pourers and a foam lateral. The water supply, foam proportioning device and foam concentrate supply are typically mobile devices that are positioned, connected together and operated by a team of four to six (4-6) appropriately trained and equipped emergency responders. Of critical importance is:
  - The maintenance and periodic testing of the semi-fixed system to ensure proper operation during emergency events
  - The maintenance and periodic testing of the mobile equipment to ensure proper operation during emergency events
  - The ensuring the prompt availability of emergency response personnel
  - The maintenance of emergency response personnel training, skills, knowledge and abilities

Consequences:

- The greatest risk associated with a rim seal fire is the event escalation to a full surface tank fire. Event escalation to a full surface tank fire occurs when the floating roof sinks from initial explosion, warping due to long term heat exposure or from the weight of firefighting agents.

- A rim seal fire when promptly dealt with will not accumulate sufficient heat to warp the roof components. The prompt control of the rim seal fire is contingent upon a properly functioning foam pourer, foam lateral, foam proportioning and water supply systems. A partial failure to any of these systems will constitute an ineffective fire attack of the entire system causing extended heat exposure and the potential for roof warping and sinking.

- The partial blockage or the catastrophic failure of a rim seal pourer creates the opportunity for foam solution to be applied in undersigned directions. The high risk of this occurrence is the potential for foam solution to be applied directly to the floating roof, or to be applied at an excessive rate that overflows rim seal area.

- A rim seal fire escalation potential also exists if the foam pourers have been damaged and direct foam onto the floating roof inside of the foam dam. In this case, the fire may continue to burn at the rim seal indicating additional foam application, which would direct additional foam to the floating roof. If sufficient foam solution is applied inside the foam dam or where foam dam damage has occurred during ignition the floating roof may sink causing escalation to a full surface tank fire.

- Rim seal foam pourers are highly susceptible to a lack of maintenance. Foam pourers operating as designed provide a very effective fire suppression application. When
foam pourers are poorly maintained or are provided with an insufficient foam solution discharge rate, the fire attack they present ranges from ineffective to causing fire escalation. A common foam pourer system failure is the lack of consistent operation around the rim seal perimeter, causing areas of insufficient flow to lack foam solution, and other areas to have excessive foam flow which risks flooding the floating roof. Additionally, many unmaintained foam pourer systems experience an over-pressurization and resultant catastrophic failures by having the pourers break completely off. The loss or poor operation of just one (1) foam pourer significantly affects the performance of the entire foam pourer system.

- Water supply systems and foam lateral piping is highly susceptible to corrosion and scale build-up if not properly maintained. The release of metal corrosion and pipe scale during foam lateral emergency use causes an end-point accumulation of debris in the foam pourer. Rim seal foam pourers utilize a metal screen at the final discharge portion of pourer. This screen has two purposes: 1.) to keep wildlife from nesting within the pourer body, and 2.) to aerate the foam solution to create a highly engineered foam bubble. The size of the foam bubble is critical to providing the foam solution with maximum resistivity to thermal breakdown. The accumulation of metal and pipe scale debris at the foam screen will create a partial blockage of the screen surface area. Screen blockage creates the legitimate risk of providing an ineffective rim seal application or a rim seal application that has potential to discharge foam solution to the hard roof area risking roof sinking and event escalation to a full surface fire.

- A pontoon explosion during ignition has legitimate potential to damage the floating roof causing either:
  - An unobstructed full surface tank fire caused by a floating roof full submersion
  - An obstructed full surface tank fire caused by a floating roof partial submersion
Full Surface Tank Fire

Description:
- A full surface tank fire is a fire involving the entire horizontal surface area of the tank top
  - Internal floating roof tank fire occurs where the exterior roof has failed and is fully or partially displaced and the internal floating roof is partially or fully sunk.
  - External floating roof tank occurs where floating roof is partially or fully sunk.
- A full surface tank fire can occur in one of two forms; Obstructed or Unobstructed.
  - An unobstructed full surface tank fire occur to External Floating Roof tanks or to Internal Floating Roof tanks where an explosion has occurred with sufficient force to displace the frangible seam on the outer roof design to give way and expel the exterior roof.
  - An obstructed full surface tank fire occurs where ignition of the Internal Floating Roof Tank only partially dislodges the exterior roof or where the floating roof only partially sinks.

Event Validity:
- Vopak Terminal, Diesel Storage Tank Fire, Essex England, 2013 April 29
- Indian Oil Corporation, Tank Fire (4 fatalities), Surat India, 2013 Jan 5
- Chevron Refinery, Tank Fire, Richmond California, 2012 Aug 6
- Merit Energy, Tank Fire, Samford Texas, 2012 May 8
- Petro China, Diesel Tank Fire, Dalian China, 2011 Aug 30
- Chevron, Tank Fire (4 fatalities), Pembrooke Wales, 2011 June 2
- Petroleos de Venezuela, Tank Fire, Bonaire Dutch Caribbean, 2010 Sept 10
- Colonial Pipelines, Tank Fire, Greensboro North Carolina, 2010 June 13
- Sitapur, Tank Farm Fire (11 Tank Fires), Jaipur India, 2009 Oct 29
- Caribbean Petroleum, Tank Farm Fire (30 Tank Fires), San Juan Puerto Rico, 2009 Oct 9
- Magellan Midstream Partners, Gasoline Tank Fire, Fairfax California, 2008 June 7
- Hertfordshire Oil Storage, Tank Farm Fire (20 Tank Fires), England, 2005 Dec 13

Typical Cause:
- Incident escalation from a rim seal fire due to sinking of the floating roof
  - Foam solution applied and accumulating on floating roof
  - Warping and failure of floating roof due to extended heat exposure during rim seal fire event
- Explosion within an internal floating roof tank
- Floating roof pontoon explosion during ignition

Associated Hazards:
- The mass discharge of Toxic Smoke Plumes for several hours to several days
- The mass discharge of heat against adjacent storage tanks for several hours to several days
The mass discharge of heat to areas outside the fenceline for several hours to several days
The heating of all piping, storage tanks and internal contents within 1 tank diameter in all
directions (at equal elevation; with additional heat exposure to areas at greater elevations
and reduced heat exposure to areas at decreased elevations)

The heating of all piping, storage tanks and internal contents within 2 tank diameters in
the downwind direction (at equal elevation; with additional heat exposure to areas at
greater elevations and reduced heat exposure to areas at decreased elevations)

The heating of all piping, storage tanks and internal contents within 1 tank diameter in all
directions (at equal elevation; with additional heat exposure to areas at greater elevations
and reduced heat exposure to areas at decreased elevations)

The potential ignition of a Rim Seal Fire on External Floating Roof adjacent storage
tanks

The potential ignition of a Vent Fire or Rim Seal Fire on Internal Floating Roof adjacent
storage tanks

The potential for Slopover, Frothover and Boilover

Loss of tank structural integrity due to tank warping from heat exposure causing product
loss to levee

Control Options:

Tank structure cooling required to prevent warping and tank failure in order to retain the
product within the tanks and prevent exposure tank involvement

Sustained foam solution application from mobile or fixed monitors/pourers at a rate that
achieves or exceeds the rate required to extinguish, which includes:

- Positioning and operation of high volume mobile foam discharge monitors
  consistent with available discharge positions, wind conditions, heat exposures and
  stream reach distances, such that foam applications can be made that land the
  foam solution accurately and gently at desirable application points to the tank fire
  surface
- Positioning of connecting hose lines to and from foam proportioning equipment,
  water supplies, discharge devices and foam concentrate supplies
- Operation of foam proportioning equipment and foam concentrate supplies
- Water supply systems consistent with the required capacity to generate sufficient
  foam solution for fire extinguishment and fire water cooling streams simultaneously
- Water pump and foam proportioning devices capable of providing sufficient foam
  solution for fire extinguishment and fire water cooling streams simultaneously
- An emergency response team of 24 to 40 highly trained and equipped personnel
  supported by a highly function staff of facility operational personnel, an
  emergency operations centre and an incident command team.
- Fully fixed full surface tank fire system, including:
  - Tank fixed foam pourers designed to provide extinguishment to full
    surface fire at rate consistent with a delayed application of foam solution
  - Fixed foam lateral and piping connections to deliver the required foam
    solution volume to the foam pourers
Fixed foam proportioning devices capable of producing foam solution at the required volume to achieve extinguishment

- Foam concentrate supplies sufficient to provide a sustained foam application
- Water supply sufficient to provide foam solution and cooling fire streams simultaneously and consistently throughout the event
- Exterior facility operations which include proximity isolation, evacuation, security, access control and exposure heat wave fire extinguishment

Consequences:

- Burnout of the tank fire due to an inability to muster a fire extinguishing effort of sufficient affect. Burnout occurs when the entire product within the tank has burned away and what remains is insufficient to support fire. The pumping out of the tank on fire is often utilized to reduce time to burnout. The negative effects to the community are due to unsuppressed heat waves and airborne toxic outfall of the products of combustion that can continue for 2 to 4 days.
- Catastrophic heated product explosion and expulsion from a crude oil tank fire with delayed cooling and extinguishment efforts. Known as a “Boilover”, this event has a high hazard to life at a distance of 15 times the diameter of the original tank fire.
- Warping and heat breakdown of an uncooled tank exterior causing tank rupture and catastrophic loss of internal products to the dike, and likely subsequent levee fire or dike overrun and fire to adjacent areas of the facility and in outfall grade directions
- Adjacent tank fires propagated from heat wave exposures uncontrolled by tank cooling initiatives. The extinguishment of multiple fire events typically exceeds the capability of most regional industrial response cooperatives.
Regional Seismic Event

The reality of the geographical area of southeastern coastal British Columbia is the expected occurrence of a high magnitude seismic event. Depending on magnitude and duration, a significant seismic event has potential to:

- Structural damage to piping throughout facility, causing loss of primary containment
- Structural damage storage tanks, causing a loss of primary containment
- Geo-physical damage secondary containment diking, causing loss of secondary containment
- Structural damage to fire water main, causing an inability for the system to provide the specified volume and pressure
- Structural damage to the fire protection semi-fixed and fixed systems, causing potentially ineffective fire applications
- Introduction of ignition sources from facility infrastructure damage
- Structural damage to Control Room, automated control and monitoring systems
- Geo-physical damage tertiary containment provisions, causing loss of facility containment

The consequences of a seismic event occurrence are increased due to the location of the facility. The TMTF is located, elevated immediately above residential communities and sensitive environmental areas, watercourses and eco-systems in close proximity, in the outfall downhill direction. The TMTF is located, immediately below a high density treed environmental conservation area, a highly populated university and high density residential community, in direct outfall uphill direction.

The resulting damage, loss of containment and fire potentials associated with an expected regional seismic event would likely encompass the following impacts:

- Long Duration exposure of Lochdale, Sperling-Duthie, Meadowood, Forest Grove, Simon Fraser University, and UniverCity to long duration flammable gas outfalls
- Long Duration exposure of North and Central Burnaby, West Port Moody and West Coquitlam to sulphur based gas outfalls
- Extensive wildland fire event extending across the Burnaby Mountain Conservation Area
- Residential structure fires across Wildland Interface with Burnaby Mountain Conservation Area
- Long duration exposure of environmentally sensitive watercourses to crude oil, including Eagle Creek, Brunette River and Burnaby Lake
Countermeasures

Facility Design
The design of a hydrocarbon facility is a critical component of the safety of the facility. Tank spacing, topography, distance to the fenceline, access/egress routes and overall facility configuration impact the risk, hazard, consequence and complexity of emergency management operations.

Tank Spacing
The fundamental premise in reducing emergency event consequence is the designed isolation of initiating hazards from adjacent risks. Facility design must consider and attempt to configure components such that the possibility of a cascading, escalating, growth or moving/changing emergency event is reduced. Tank spacing is the primary method to which a hydrocarbon facility isolates hazards. By placing storage tank with sufficient separation, the risk associated with a multiple emergency event occurrence is reduced.

The goal of tank spacing is to provide sufficient distance between each tank that, in the event of an emergency event occurrence at one tank, the consequences of that event can be prevented from impacting other adjacent tanks. The heat outfall from a full surface tank fire will expose adjacent tanks, piping and structures within one (1) tank diameter in all directions, and two (2) tank diameters in the downwind directions. The premise of the one (1) tank diameter in all directions and two (2) tank diameters in the downwind direction is based upon a zero elevation change between tanks. The acceptance of practical tank spacing requirements has been formed with the design perspective of 2 dimensional topography, or topography without an elevation change.

Of specific concern are storage tanks located uphill. Tanks located uphill of a tank fire (at the same tank spacing) receive significantly greater heat exposure than a tank located at the same elevation. The heat discharged from a tank fire is released in an inverted triangular dispersal pattern vertically away from the tanks surface (Reference Diagram 1), impacting tanks at the same spacing distance (vertical distance) but at an increased elevation with a greater heat accumulation potential.

To achieve the same tank isolation characteristics in a facility that has elevation changes, two (2) options exist to achieve best practices, in the absence of direction from consensus standards:

1. The increasing of tank spacing to meet or exceed the one (1) diameter minimum heat outfall potential.
2. Provide heat outfall modeling against the actual tank size, spacing and topography to identify the increase in distance requirements for uphill locations.
Diagram 1
Storage Tank Heat Exposure

1 Tank Diameter

2 Tank Diameters

Wind Direction

Heat Outfall

1 Tank Diameter

2 Tank Diameters

Wind Direction

Heat Outfall
The tanks, piping and structures within these heat outfall distances can require cooling to reduce heat accumulation to facing surfaces. Without the provision of cooling measures to surfaces exposed to heat outfalls of this nature, the potential for accumulations causing a secondary fire event are dramatically increased. The criticality of cooling provisions is based upon the distance from the heat source. The need for immediate, simultaneous and/or increased cooling operations due to reduced tank spacing can significantly impact emergency response requirements in order to achieve incident isolation and prevent incident escalation, including:

- Increased fire stream discharge devices provided with all supporting equipment to provide an effective cooling stream application for all potential wind directions
- Increased firefighting personnel to position and operate cooling stream application devices
- Increased fire water and/or firefighting agents
  - Increased fire water volume, as required for all simultaneous operations conducted for the full duration of the heat exposure and fire event
  - Increased fire water pump volume and pressure capacity
  - Increased fire water main and distribution system capacity
  - Increased foam proportioning system capacity (if cooling streams and cooling streams are required simultaneously from a single firefighting water / foam solution fire main, as has been identified as a potential plan by KMC)
- Increased foam concentrate requirement (if cooling streams and cooling streams are required simultaneously from a single firefighting water / foam solution fire main, as has been identified as a potential plan by KMC), as required for all simultaneous operations conducted for the full duration of the heat exposure and fire event
- Increased need for multiple safe access routes to firefighting discharge positions
  - Access routes that allow emergency responder access and emergency egress to and from effective deployment positions, and are available free from heat exposure and negative outfalls for all wind direction potentials.
- Increased need for multiple safe deployment positions
  - Positions that allow stream application to exposed tank surfaces, and are available free from heat exposure and negative outfalls for all wind direction potentials.
- Increased levels above minimum standard requirements for semi-fixed or fixed fire protections system for tanks within the potential heat exposure area
- Increased facility operations associated with transfer out of products from heat exposed storage tanks
- Increased facility need to retain un-utilized storage capacity to accommodate transfer out volumes from heat exposed storage tanks

A negative impact of reduced tank spacing is the subsequent reduction in perimeter roadway access. Roadway access is critical for emergency responders to be capable of approaching, and escaping from hazardous conditions from all directions possible. Hydrocarbon facilities that do not provide roadway access to all sides of a storage tank within reasonable proximity, create significantly increased risk and limitations to the safe operations that can be conducted for fire events.
Potential exists, when safe access and/or safe deployment positions are not present, that emergency responders may not have the ability to position to cool adjacent tanks or attack a tank fire. In the event that an adjacent tank exposed to heat exposure can’t be provided cooling to its affect surfaces that the original tank fire event can extend to a second tank fire event. In the event that an extinguishing stream can’t be applied to the surface of a tank fire, it is likely that defensive strategy would need to be employed to protect adjacent tanks while allowing the original tank fire to burnout over several days.

The original TMTF facility utilized the following tank space premise:

- Reference Appendix A – Tank Spacing Analysis

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On significant note is that prior to addition of Tank 88 in the far North-West corner of the facility, the TMTF utilized a designed tank spacing premise of two (2) Tank diameters in all directions.
The TMTF facility tank spacing at the completion of the TMEP

- Reference *Appendix A – Tank Spacing Analysis*

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**Average**: 0.98, 1.42, 1.55
Reference Appendix A – Tank Spacing Analysis

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<td></td>
<td>1.85</td>
<td>2.14</td>
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<tr>
<td>Post TMEP</td>
<td></td>
<td>0.98</td>
<td>1.42</td>
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<tr>
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<td></td>
<td>- 0.87</td>
<td>- 0.72</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 47%</td>
<td>- 34%</td>
</tr>
<tr>
<td>Overall</td>
<td></td>
<td>- 0.81 Tank Diameters</td>
<td>- 33%</td>
</tr>
<tr>
<td>New TMEP Tanks</td>
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<td>0.50</td>
<td>1.13</td>
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<tr>
<td>Change</td>
<td></td>
<td>- 1.35</td>
<td>- 1.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 59%</td>
<td>- 39%</td>
</tr>
<tr>
<td>Overall</td>
<td></td>
<td>- 1.03 Tank Diameters</td>
<td>- 45%</td>
</tr>
</tbody>
</table>
Diagram 2
Storage Tank Heat Exposure

Current Trans Mountain Tank Spacing

No Heat Exposure

1.85 Tank Diameters Average

Downwind Critical Heat Exposure

Post TMEP Trans Mountain Tank Spacing Average

Critical Heat Exposure

0.98 Tank Diameters Average

Downwind Critical Heat Exposure

TMEP New Tank Trans Mountain Tank Spacing

Critical Heat Exposure

0.50 Tank Diameters Average

0.50 Tank Diameters Average
The new tank installation proposed by the TMEP significantly changes the conceptual design of the TMTF with respect to storage tank spacing. The existing TMTF configuration provides a separation of 1.85 tank diameters (average). The importance of the existing spacing, is that it provides sufficient spacing to ensure that only the tanks in the downwind direction will experience heat outfall exposures that may require immediate cooling in order to prevent incident escalation through fire extension. The proposed TMEP configuration of the TMTF will reduce the tank spacing by 33% (average). The spacing provided by this project places many tanks so close together that in the event of a full surface tank fire or a dike fire, several adjacent tanks many need to be immediately cooled in order to prevent incident escalation through fire extension. Therefore the tighter tank spacing will significantly increase the firefighting operations required to control a tank fire or dike fire event.

The addition of storage tanks into the existing TMTF changes the risk control premises with regard to storage tank isolation by facility design. In order to achieve the desired storage tank volume, KMC is proposing a significant replacement of designed isolation of each storage tank. In essence, the TMEP shifts the control of hazard from an engineered approach of tank isolation, to an emergency response approach. As the authority having jurisdiction for fire protection approval within the City of Burnaby, the Burnaby Fire Department has recently been advised by KMC on May 30, 2014, that the facility no longer has the emergency response ability to extinguish fire events with internal facility resources, and that additional hydrocarbon specialized firefighting resources from regional facilities are no longer available.

To complicate the emergency control activities, because of the tighter tank spacing, many heat exposure cooling operations are not possible due to insufficient firefighting deployment positions. The TMEP proposed to group many tanks with common diking separated only by small intermediate dike segregation. These larger dikes areas reduce the available access and deployment roadway positions to facilitate safe, efficient and effective firefighting stream applications.

The TMEP proposes the increasing of the tank farm storage tank density, by decreasing engineered tank isolation distances, which in turn increases the potential for fire event escalation through extension, in a facility that has reduced its internal fire protection capability without approval. Notable by its absence from the TMEP application to the NEB is a detailed analysis of the effect of the tank spacing reduction on the requirements of mobile and fixed fire protection countermeasures, and the subsequent changes to the fire protection premises currently utilized. Weaknesses in the design of a facility can create fire event situations that cannot be safely or effectively mitigated without allowing a storage tank or several tanks to burnout.

In conclusion the TMTF was originally approved based on the provision of a 2 tank diameter spacing. In subsequent years the addition of Tank 88 marginally reduced the overall facility tank spacing to 1.86 tank diameters (average), but maintained the original premise of tank spacing to provide tank isolation and reduce escalation and extension potentials. The TMEP significantly deviates from the original safety premise and approval basis of providing storage tank isolation for proposed tanks at a proximity distance of 0.5 tank diameters.
On Page 208 & 209 of 754, Question 01.13.05 (ii) of the City of Burnaby IR – Round 1:

City of Burnaby:  Will Trans Mountain provide tank spacing consistent with 1 tank diameter?

KMC – TMEP:  It is important for Trans Mountain to follow the statutory requirements for storage tank spacing at Burnaby Terminal, where the topography will allow, in order to provide the number of tanks and the capacity of the tanks required to support the proposed expanded operation at Westridge Marine Terminal.

KMC’s answer to this inquiry in the NEB approval process identifies hierarchy for design consideration that infers where topography limitations exist; the required capacity for expanded operations will be prioritized over safety needs for tank spacing.

Application Positions

The proposed TMEP storage tank configuration significantly limits the access/egress routes to and from the hazard areas of the tank farm. The proposed use of significantly greater storage tank density has impacts on the availability of appropriate application positions to control major fire events. The primary concerns created by the TMEP related to deployment positions are:

- Insufficient deployment positions to cool adjacent tanks to prevent event heat exposures from escalating into fire extension
- Insufficient roadway option to allow for safe access and egress of deployment positions to provide all necessary fire stream applications in all potential wind conditions

The design factors presented in the TMEP that limit deployment positions include:

- Reduced tank spacing that requires significantly more heat exposure cooling operations, creating the simultaneous use of more operating positions
- Reduced tank spacing that creates physical impediments to the application of extinguishment and cooling streams from safe, effective and efficient operating positions
- Large multiple tank diking areas that limit the roadway access, and don’t provide access around the tank fire event from all directions and in all wind conditions
- Access roadways provided at or above the elevation of the potential tank fire roof level, creating increased outfall heat exposures and hazards of use
- Access roadways with insufficient proximity or elevation to provide suitable operating positions to utilize for applying firefighting streams at appropriate distances

To ensure the safety, effectiveness and efficiency of firefighting stream deployment positions to apply suitable firefighting streams, consider the following fire protection requirements of application positions:
- Provide unimpeded road access around the perimeter of each individual tank
- Provide position option other than those from downwind
- Provide deployment positions without exposing personnel and equipment to significant heat outfall
- Provide unrestricted emergency egress routes
- Do not utilize positions above tank level
- Do not positioned below dike wall in the liquid product outfall direction
- Provide sufficient roadway setbacks from heat event discharge to allow for firefighting positioning or direct emergency evacuation routes

Wind direction has massive effect on how responder will access and position at hydrocarbon emergency events. The downwind and uphill directions affected by a tank fire will receive twice the heat outfall that the other directions experience, creating significant hazards to operating personnel. Wind has an extremely high impact on firefighting streams applied from Type 2 mobile monitors. The reach of firefighting streams is reduced up to 50% when applied from the downwind direction for both water and foam solution streams applied from mobile devices, thus requiring firefighting personnel to position in higher heat exposure areas in order to apply their stream effectively.

When both water or foam solution streams are applied from greater distances due to the avoidance of heat outfalls created by operating at elevations above the tank floor, or due to a lack of proximity roadway access, fire stream losses attributed to fall out can range from 20 – 50% for water, and 30 – 60% for foam solution. This requires a typical doubling of the discharge firefighting stream volume to achieve the necessary application rate.

On Page 299 of 754, Question 01.13.05 (bb) of the City of Burnaby IR – Round 1:

**City of Burnaby:** Will the containment provisions from each Trans Mountain storage tank be provided with outfall and accumulation areas away from adjacent assets and risks?

**KMC – TMEP:** General design considerations for the proposed new secondary containment areas will include appropriate outfall routes and setbacks from other infrastructure and property lines, safe access routes and locations for positioning emergency response personnel and equipment, and fire-fighting agent application, including drop-out loss potential during windy conditions.

On Page 210 & 216 of 754, Question 01.08.05 (r) of the City of Burnaby IR – Round 1:

**City of Burnaby:** Please confirm that Trans Mountain will construct an all-weather road to the tanks to handle use by heavy trucks and emergency equipment?

**KMC – TMEP:** Two classes of access roads will serve the proposed new storage tanks at Burnaby Terminal. The main roads will provide access
above the various terraces on which the tanks are located. These roads will be the primary routes for emergency response and will also provide access to the electrical service buildings, the radial walkways and stairways, the vapour recovery and treatment systems, the fire-water systems, and any other centralized equipment or systems. The secondary roads will provide access into and within the storage tank secondary containment areas. These roads will be primarily intended for routine inspection and maintenance activities, but may also be used for emergency response, if appropriate. All of the roads will be “all-weather” and designed and constructed in accordance with the applicable codes, standards, and practices for the intended services, vehicle types and loads, and travel frequencies, to the extent that the topography of the site will allow. The existing access roads at the Burnaby Terminal site are shown in Figure 3.4.6, Section 3.4.3.1, Volume 4A of the Facilities Application. Trans Mountain anticipates that the proposed new access road layout will be similar in concept.

On Page 293 & of 754, Question 01.13.05 (ii) of the City of Burnaby IR – Round 1:

City of Burnaby: With consideration for industry standards of firefighting agent drop-out, including the drop-out loss potential of high wind operations with firefighting foam, will the containment levees for each Trans Mountain storage tank provide safe operating distances for the deployment, positioning and operation of portable fire suppression equipment for all tank fire and levee release/fire event potentials, in all wind direction and strength conditions, such that the required application rate of firefighting agents can be achieved to combat advanced pre-burn time tank fires?
KMC – TMEP: General design considerations for the proposed new secondary containment areas will include appropriate outfall routes and setbacks from other infrastructure and property lines, safe access routes and locations for positioning emergency response personnel and equipment, and fire-fighting agent application, including drop-out loss potential during windy conditions.

Weaknesses in the design of a facility can create fire event situations that cannot be safely or effectively mitigated without allowing a storage tank or several tanks to burnout. Reference Appendix B - Deployment Position Analysis, for detailed Tactical Analysis of tank fire event scenarios related to safe, effective and efficient firefighting deployment positions.

The original TMTF facility utilized the following tank space premise:
- Reference Appendix B – Deployment Position Analysis

<table>
<thead>
<tr>
<th>Tank</th>
<th>Wind Direction</th>
<th>Location</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>71</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>72</td>
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</tr>
<tr>
<td>73</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>74</td>
<td>North</td>
<td>Northeast of Tank 74</td>
<td>Potential Heat Exposure</td>
</tr>
<tr>
<td>81</td>
<td>Southeast</td>
<td>East of Tank 81</td>
<td>Potential Heat Exposure</td>
</tr>
<tr>
<td>82</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>83</td>
<td>Northwest</td>
<td>Northwest of Tank 83</td>
<td>Potential Heat Exposure</td>
</tr>
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<td>84</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>85</td>
<td>Northwest</td>
<td>West of Tank 85</td>
<td>Potential Heat Exposure</td>
</tr>
<tr>
<td>86</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>North</td>
<td>Northwest of Tank 87</td>
<td>Potential Heat Exposure</td>
</tr>
<tr>
<td>88</td>
<td>East</td>
<td>East of Tank 88</td>
<td>Dangerous Heat Exposure</td>
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<tr>
<td>90</td>
<td>Northwest</td>
<td>North of Tank 90</td>
<td>Potential Heat Exposure</td>
</tr>
</tbody>
</table>
The TMTF facility tank spacing at the completion of the TMEP

- Reference Appendix B – Deployment Position Analysis

<table>
<thead>
<tr>
<th>Tank</th>
<th>Wind Direction</th>
<th>Location</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>71</td>
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<td></td>
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<tr>
<td>72</td>
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</tr>
<tr>
<td>73</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>74</td>
<td>West</td>
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<td>Dangerous Heat Exposure</td>
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<td>North of Tank 76</td>
<td>Dangerous Heat Exposure</td>
</tr>
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<td>Northwest of Tank 77</td>
<td>Dangerous Heat Exposure</td>
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<td>North of Tank 78</td>
<td>Dangerous Heat Exposure</td>
</tr>
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<td>Dangerous Heat Exposure</td>
</tr>
<tr>
<td>80</td>
<td>North</td>
<td>North of Tank 80</td>
<td>Dangerous Heat Exposure</td>
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<tr>
<td>81</td>
<td>Southeast</td>
<td>East of Tank 81</td>
<td>Potential Heat Exposure</td>
</tr>
<tr>
<td>82</td>
<td>Northeast</td>
<td>North of Tank 82</td>
<td>Dangerous Heat Exposure</td>
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<tr>
<td>83</td>
<td>Northwest</td>
<td>Northwest of Tank 83</td>
<td>Potential Heat Exposure</td>
</tr>
<tr>
<td>84</td>
<td>Northeast</td>
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<td>Dangerous Heat Exposure</td>
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<td>Dangerous Heat Exposure</td>
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<td>Dangerous Heat Exposure</td>
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<td>Dangerous Heat Exposure</td>
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<tr>
<td>90</td>
<td>Northwest</td>
<td>North of Tank 90</td>
<td>Dangerous Heat Exposure</td>
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<tr>
<td>91</td>
<td>South</td>
<td>South and East of Tank 90</td>
<td>Dangerous Heat Exposure</td>
</tr>
<tr>
<td>93</td>
<td>Northeast</td>
<td>North of Tank 93</td>
<td>Dangerous Heat Exposure</td>
</tr>
<tr>
<td>95</td>
<td>Northeast</td>
<td>North of Tank 95</td>
<td>Dangerous Heat Exposure</td>
</tr>
<tr>
<td>96</td>
<td>Southeast</td>
<td>North &amp; South of Tank 96</td>
<td>Dangerous Heat Exposure</td>
</tr>
<tr>
<td>97</td>
<td>Northeast</td>
<td>North of Tank 97</td>
<td>Dangerous Heat Exposure</td>
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<tr>
<td>98</td>
<td>East</td>
<td>North &amp; East of Tank 98</td>
<td>Dangerous Heat Exposure</td>
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<td>Configuration</td>
<td>Total Storage Tanks</td>
<td>Tanks without Issue</td>
<td>Tanks with Limited Deployment Positions</td>
</tr>
<tr>
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<tr>
<td><strong>Current TMTF</strong></td>
<td>13</td>
<td>6</td>
<td>7</td>
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<tr>
<td><strong>Post TMEP</strong></td>
<td>26</td>
<td>3</td>
<td>23</td>
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<tr>
<td><strong>Change</strong></td>
<td>+ 100%</td>
<td>- 3</td>
<td>+ 16</td>
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<td><strong>Overall</strong></td>
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<td>14</td>
</tr>
<tr>
<td><strong>Change</strong></td>
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<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
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<td></td>
<td>100% of the proposed Storage Tanks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>will not provide safe deployment positions to control potential fire events</td>
</tr>
</tbody>
</table>

The TMEP presents a significantly larger fire control risk within the TMTF. The identified increase in events with potential to escalate and extend to adjacent storage tank exposures due to insufficient firefighting deployment positions increases the likelihood of a multiple tank fire, and toxic smoke plume, and heat discharge to areas outside the facility. The risk of community impacts outside of the facility from a TMTF fire event are increased by 70%.

The cost of this risk potential assumed by the community is not in line with the safety and risk management premises initially utilized for original facility approval by the City of Burnaby. The specific driver of the increased risk is the reduction in the effective of the facility design to limit fire event growth and restrict hazardous impacts to an immediately controllable area of impact during a short emergency response timeframe. It is critical for public safety that design
configuration utilized support the protection of life, the environment and property. The TMEP does not provide the basic engineered safety provisions standard in high-impact potential facility design.

**Distance to Fenceline**

The TMEP expands the existing TMTF with high density storage tank configurations into the northern and eastern corners of the existing facility property. The proposed configuration changes the tank to fenceline distances of the facility. The tank to fenceline distance is critical as it directly impacts time elapse to hazard impacts to the community life, environmental health and property outside the TMTF facility.

Directly adjacent to the TMTF facility are the residential neighborhoods of Forest Grove, Meadowood, Sperling Duthie and Lochdale. Of specific and notable proximity is Forest Grove Elementary school in immediate danger of exposure to hazardous event exposures due to it close proximity on the southern outfall of the facility.

The TMEP proposed TMTF configuration presents the following increased potentials for community impact outside the facility fenceline:

- Reduced response, set-up and firefighting suppression time prior to harmful community impact
- Increased depth of hazard impact past the fenceline prior to preventive or corrective action
- Increased preventive or corrective operations required to inhibit fire event escalation and extension

The reduction in the distance and elapse time to exterior fenceline community impact creates a greater magnitude of exposure impact and directly

The TMEP creates emergency control scenarios risking the residential areas in proximity, Simon Fraser University, UniverCity village and the Burnaby Mountain Conservation Area, related to:

- Fenceline exposure to heat, including subsequent fire extension to the proximity treeline and high potential for treetop driven wildfire
- Smoke exposure to the community
- Sulphur based gas exposure to the community
- Ignition of flammable gas releases within community
The original TMTF facility utilized the following tank distance to fenceline premise:

- Reference Appendix C – Tank Distance to Fenceline Analysis

<table>
<thead>
<tr>
<th>Tank</th>
<th>Distance to Fenceline in Tank Diameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>71</td>
<td>4.5</td>
</tr>
<tr>
<td>72</td>
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<tr>
<td>90</td>
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Average 3.65 Tank Diameters
The TMTF facility tank distance to fenceline at the completion of the TMEP

- Reference *Appendix C – Tank Distance to Fenceline Analysis*

<table>
<thead>
<tr>
<th>Tank</th>
<th>Distance to Fenceline in Tank Diameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>71</td>
<td>4.5</td>
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<td>1.5</td>
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<td>77</td>
<td>1.5</td>
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<td>2</td>
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<tr>
<td>98</td>
<td>0.5</td>
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</table>

| Average | 2.56 Tank Diameters |
### Reference Appendix C – Tank Distance to Fenceline Analysis

<table>
<thead>
<tr>
<th>Tank</th>
<th>Table 10 Distance to Fenceline in Tank Diameters</th>
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<td>75</td>
<td>2</td>
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<tr>
<td>98</td>
<td>0.5</td>
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</tbody>
</table>

**Average**: 1.43 Tank Diameters
The TMEP proposes a reduction in the tank to fenceline spacing of 30% on a facility wide comparison, and utilizes a new tank positioning premise which reduces the tank to fenceline distance by 61%. The decreased tank to fenceline distance and consequential impact potentials to the community presents the higher requirement and increased priority of evacuation operations conducted simultaneously with fire control activities. This response requirement significantly increases the emergency response resource requirements associated with identifiable emergency event potentials.

The TMEP significantly increases the urgency and expedience required to prevent community life and environmental impact outside the facility fenceline in the event of a product release or storage tank fire. The positioning of storage tanks in such close proximity creates a greater potential for citizen exposure within the adjacent communities to the hazardous effects of flammable gas outfalls and sulphur based gases. Additionally, the close proximity of storage tanks to the fenceline dramatically increases the risk of wildland fire to the Burnaby Mountain Conservation Area.

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Table 11 Average Tank Distance to Fenceline in Tank Diameters</th>
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</thead>
<tbody>
<tr>
<td>Current TMTF</td>
<td>3.65</td>
</tr>
<tr>
<td>Post TMEP</td>
<td>2.56</td>
</tr>
<tr>
<td>Change</td>
<td>- 30%</td>
</tr>
<tr>
<td>New TMEP Tanks</td>
<td>1.43</td>
</tr>
<tr>
<td>Change</td>
<td>- 61%</td>
</tr>
</tbody>
</table>
Emergency Response

The onus remains on Kinder Morgan to produce an acceptable business case and, through a formal review, obtain the Fire Chief’s approval of the TMEP consequence reduction measures at the Burnaby Trans Mountain Tank Farm facility (TMTF). Once approved, the consequence reduction measures set forth are to become part of the facility’s operating permit requirements.

Issues Critical Interest of:

1. Trans Mountain Site Densification
2. Risk of Products Present
3. Emergency Management Scope
4. Management of Security Potentials

The Burnaby Fire Department’s focus in reviewing the Kinder Morgan Volume 7 application to the NEB Act Section 52 is keyed upon the three (3) general sensitivities of; transferring primary fire/release responsibility, the level of preparation commitment by Kinder Morgan and the scale of Kinder Morgan emergency response resources.

The underlying premise within this document of utilizing the Burnaby Fire Department to replace or take-on Kinder Morgan’s responsibility to provide primary specialized hydrocarbon emergency response is a critical issue. This potential increase in the Department’s responsibility would also include potentially significant liability for the health, environmental & economic outfalls generated from Kinder Morgan emergency event control operations. The operational impacts of this increase service request constitute a large escalation in response capability both from staffing consideration and from the requirement to acquire, maintain, inspect & train to, very specialized hydrocarbon equipment. Current shift staffing levels are marginally sufficient to protect & manage a hydrocarbon facility event with only current responsibility to protect the Citizens of Burnaby through notification, high & low risk evacuation, area isolation & rescue, while maintaining only a minimum service need elsewhere within the city. In essence, the Burnaby Fire Department can manage larger scale hydrocarbon events with current staffing & resources, but would require a significant resource increase to simultaneously manage interior fence line & exterior fence line operations.

An additional impact of the changes in the emergency response capabilities of, most notably, the TMTF facility, is the significant gap presented by the required management of major scale hydrocarbon events within the Burnaby – Port Moody area. The Upper Burrard Inlet Petrochemical Mutual Aid Group (UBIPMAG) was predicated upon the cumulative emergency response resources of all the partner companies. With the loss of the fire brigades & mobile resources from the Kinder Morgan & Shell Burnaby facilities, these companies no longer present any value for partnership with Suncor Burrard Products Terminal & Chevron Burnaby. Because of this inequality in resource commitment the UBIPMAG agreement has been dissolved; with Suncor & Chevron increasing their internal capabilities to achieve the ability to stand alone manage all of their event potentials, including the low frequency major impact events. For Kinder Morgan, the dissolution of the UBIPMAG and no agreement on change in the roll of the
Burnaby Fire Department, leaves the TMTF facility without the requisite fire protection capability for any of their fire/release risks.

Within this application many requirements for emergency response preparation & resource allocation are vaguely stated & present without a concrete plan or commitment. From the City’s perspective the interpretation of this application should be in one of three (3) forms.

Option 1
This option would have the City table decision (or primarily oppose the application pending adjustment) on the application until a comprehensive plan complete with commitments to the specific detail & content of the facility resource allocation & emergency response preparedness responsibilities are provided. This option is challenged in the inherent lack of detail present within these global project documents, where commitments can be vague, clouded, hidden or subject to differing interpretation.

Options 2
This option would have the City, post-approval, utilize the fire bylaw to enforce the provision of appropriate emergency response resources & preparedness. This option is challenged by the difficulty & burden of enforcement, created by undocumented expectations at project approval & the lack of pre-project notification to applicant.

Option 3
This option would be a combination of both Option 1 & 2, with a requirement to receive greater detail in the application prior to approval with the City retaining the opportunity to adjust or require additional emergency management resources & preparedness provisions based on the bylaw strength in the post-approval phase.

In Kinder Morgan Canada Risk Assessment Trans Mountain Expansion Project – Burnaby Terminal Project, October 1st, 2013 Doug McCutcheon and Associates, Consulting

- P. 31 “Risk is the combination of consequence and probability. It is often referred to as: "Risk = Consequence X Probability"
- The consequences of concern for the realistic worst case scenario (a fire with heavy smoke) are:
  - Radiant heat exposure to workers and anyone within 224m of the dike walls represents an exposure of 4kW/m2 from a dike fire. For a tank top fire that distance shrinks to 71m from the dike wall.
  - It seems impossible but at a distance of 536 m from a dike fire and 184m for a tank top fire the public will feel the heat and could be exposed to 1 kW/m2 which is are for 1st degree type burns (sunburn level).
  - The impact of a SO2 cloud can be felt 5.2km downwind from a crude oil fire.
  - The impact of a large volume of smoke as a result of a fire could extend outwards for approximately 43 km. causing possible public outrage.”
• P. 32 “Nearby workers will be exposed to the effects of a major tank or tank area fire. Although workers can seek protection indoors from the radiant heat evacuation requirements will be needed for beyond the 86 - 224 meter distance in the event of a fire.”
• P. 33 “Toxic SO₂ is a concern. The analysis shows SO₂ levels can extend outwards 5.2km for a dike fire and 2.2km for a tank top fire should a crude tank catch fire.’, “Appropriate emergency planning involving foam addition and shelter-in-place or evacuation plans is needed.”

Relevant Local Changes in Industry Fire Protection

Historically, the Hydrocarbon Industry within the Burnaby – Port Moody area have provided frontline emergency response capabilities in the form of management personnel, field fire suppression resources & trained industrial fire brigades. Whether, these emergency management provisions were mandated by the bylaws, the inspectors, the Fire Chiefs, the City Councils of the day, or were put in place out of due diligence, these resources have become the basis for city fire prevention approvals.

As the Hydrocarbon Industry in the area, started the strategic move away from operating refineries and toward bulk commodity storage terminals during the 1980’s, trained personnel & fire resources became more difficult to fund. As a result, in order to maximize the investment dollars of each facility & retain the emergency protection that each facility required, the Hydrocarbon Industry within the area formed the UBIPMAG. This group included Chevron Burnaby, Petro-Canada Burrard Products Terminal, Shell Burnaby & Terasen Trans Mountain & Westridge.

The premise of the UBIPMAG was the following:


- Each facility retained the operational firefighting ability to mitigate higher frequency minor to moderate scale events as the primary control agency. Additional support in non-hydrocarbon specialized fire service operations, where required, was provided by the Burnaby Fire Department (for facilities geographically located within Burnaby). Additional hydrocarbon specialized fire service operations were provided by the other partner companies of the UBIPMAG.

- Each facility would provide the primary fire response to major scale events as the primary agency, supported by the industrial fire brigade & resources from partner companies for additional hydrocarbon specialized fire service operations & by the Burnaby Fire Department (for events geographically located within Burnaby) to provide non-hydrocarbon specialized fire
Each facility would maintain the ability to manage an emergency event through the application of trained company management personnel to form the events Incident Command Team.

Each facility would maintain their company’s emergency response resources & fire brigade capabilities.

The value of the UBIPMAG was that participating companies no longer bore the full cost of providing a response capability to lower frequency - high resource requiring event potentials. The cost in essence was shared between each of the partner companies, with each dependant on the other to fulfill their fire protection requirements.

Through the 1980’s & 1990’s as the hydrocarbon industry in Canada massively downsized & restructured. Emergency response capabilities at many area facilities began to be significantly underfunded, especially for facilities deemed as non-profit bearing (Bulk Commodity Terminals). This hit the certain facilities hard than others.

Petro-Canada, now Suncor Burrard Products Terminal, funded by Canadian dollars, was able to maintain their full response capability. With the exception of a short period where the facility struggled to staff their Emergency Response Team due to a two (2) year soft-labour dispute, Suncor has fully maintained, & most recently actively expand their emergency response capabilities. Chevron Burnaby experienced a minor decrease in their capabilities during the 1990’s, but has been holding steady for the last decade. During this period, these two partners of the UBIPMAG were able to maintain some semblance of frontline emergency response capabilities, including; management personnel, field fire suppression resources & trained industrial fire brigades.

Shell Burnaby facilities (including the Shellburn Products Terminal, Burmount Truck Loading Facility, & Shellmont Tank Farm) experienced a dramatic reduction in personnel & funding. For a significant period of time, the Shell Burnaby facilities attempted to prop up their emergency response capability through the use of a small number of facility personnel coordinated & managed by a contract emergency response provider. As the Shellburn Products Terminal continued to lose personnel, the operation of an industrial fire brigade under this model became less feasible. In order to maintain a fire protection capability for the higher frequency small & moderate scale events, Shell Burnaby invested in fully automatic Fixed Fire Protection Systems. These systems replaced the more traditional fire brigade operations with fire protection systems that allowed a single facility operator to initiate the automated application of fire streams to higher frequency minor & moderate scale event potentials. The traditional mobile equipment & technically trained personnel were replaced completed by automated fixed fire protection systems. In this change, a gap was allowed to develop. Fixed fire protection systems are typically very expense, and useful for only a single event potential. Also, the use of a fixed fire protection systems is typically not feasible (by effectiveness or by Cost-Benefit analysis – Company) for the lower frequency large scale event potentials. The emergency response gap.
that has occurred is this; the Shell Burnaby facilities no longer retain the ability to provide an industrial fire brigade. While they are capable of controlling many of their fire/release risks with automated systems, the facilities have no resource ability to initiate a response to several higher frequency minor & moderate event potentials, & all of the lower frequency major event potentials.

The Trans Mountain & Westridge facilities, previously operated by Terasen, and now by Kinder Morgan, faced a similar challenge. The Trans Mountain & Westridge facilities have always struggled to provide sufficient personnel to staff a fire brigade. Unlike Shell Burnaby that had a large number of employees when the Shellburn Refinery operated, the Trans Mountain & Westridge facilities have always had significantly less personnel available. During the 1990’s, the Trans Mountain & Westridge facilities, faced the same challenge as Shell Burnaby, in that it was deemed either unachievable or unsustainable (economically or logistically) to maintain a fire brigade with mobile fire protection equipment. However, unlike Shell Burnaby, Terasen – Kinder Morgan, made no notable attempt to replace the loss of their fire brigade & mobile response resources with any other fire protection provisions. Recently Kinder Morgan’s strategy for fire protection was to gain the agreement of the Burnaby Fire Department to change the Department’s responsibilities with regard to hydrocarbon facility events. Kinder Morgan has requested that the Burnaby Fire Department take-on the Hydrocarbon Company’s previous (& bylaw specific) responsibilities to provide hydrocarbon specialized fire operations as the primary response agency.

The Imperial Oil facility, although a smaller scale operation, also presents similar unmanaged risk potentials. The Burnaby based Imperial Oil truck loading rack & tank farm is protected by an aging fixed fire protection system. Other than the single fixed fire protection system, this facility maintains no other emergency response capability to manage or control any other fire/release risk potential.
Burnaby Fire Department Level of Service

The application for hydrocarbon facility expansion or operational change often develops into active discussion on the level of emergency preparedness required to be provided by the applicant. The construction, purchase, maintenance & training costs of these emergency response systems can be significant. The difficulty in determining the appropriate level of emergency preparedness is due to the fundamental premise of how levels of emergency prevention and response resources are established. The City of Burnaby Fire Bylaw is based upon a simple principle in order to protect the community as a whole: if a risk is present, it must be addressed.

This is very relevant for the hydrocarbon industry as their inherent business plan is to handle high risk commodities for profit. The costs associated with the handling of these commodities, including emergency preparedness and protection should reside firmly as a business expense to the operator, having a bearing on the profitability of the operations but not downloaded to the City of Burnaby’s existing tax base.

While the tax base provides for City services to the applicant, it does not extend to extraordinary risks posed by the Oil and Gas industry in Burnaby. These services as provided by the industry in Burnaby have historically included:

- Standard emergency response services
- Participation in Drills and Exercise
- Use of BFD resources at industry incidents within the scope and training of the department.
- Regulatory activities associated with being the “Authority Having Jurisdiction”

The Fire Department has historically never owned or operated any industry specific fire suppression equipment or agreed to manage or operate non-BFD equipment.

On Page 336 & 209 of 754, Question 01.13.05 (ii) of the City of Burnaby IR – Round 1:

City of Burnaby: Will existing municipal and third party services to Westridge Marine Terminal require upgrading?

KMC – TMEP: As discussed in Section 3.4.4.10, Volume 4A of the Facilities Application, Trans Mountain will seek additional power supply capacity from BC Hydro. Trans Mountain may also seek a natural gas connection from Fortis BC to supply support gas for the proposed new vapour combustion unit.
This question was provided to identify the scope of City service increase required by the TMEP. The answer clearly identifies the service upgrades, and does not include the identification of an upgrade in the fire service response required by the TMEP. The Burnaby Fire Department provides municipal structural, incipient wildland fire protection, public education, fire prevention, investigation, technical rescue and medical interventions. The Burnaby Fire Department does not provide technical hydrocarbon firefighting, but will support and assist companies within Burnaby with Fenceline operations and basic structural firefighting activities such as augmenting remote water supply and low hazard exposure protection. The NEB IR Response identifies no additional service of the Fire Department above existing established levels.
Hazard Events
Crude oil loss of containment events can propagate many secondary event impacts as the flammability of the product disperses from the facility or in the event of spill ignition and subsequent fire:

- Flammable Gas Outfall of Fenceline
- Release of Sulphur Based Gases
- Liquid Product Release to Watercourse Outfall to Fenceline
- Dike Spill Ignition
- Release of Toxic Smoke Plumes
- Heat Discharge against Fenceline
- Tank Rim Seal Ignition
- Flammable or Ignited Product Loss from Secondary Containment

Flammable Gas Outfall
Reference: Consequences – Flammable Gas Outfall against the Fenceline, P. 66

Release of Sulphur based Gases
Reference: Consequences – Release of Sulphur Based Gases against the Fenceline, P. 69

Watercourse Outfall of Liquid Crude Oil Release
The release to areas outside of lined secondary containment diking creates the potential of a crude oil introduction into watercourses exiting the TMTF facility. The release of crude oil to earthen surfaces outside secondary containment provisions, presents the expansion of the release to the subterranean water shed system of Burnaby Mountain. The natural water shed system off Burnaby Mountain would route collected crude oil to areas of downstream impact to Eagle Creek.

Dike Spill Ignition
Description:
- Fire of an accumulated flammable release retained fully or partially within the secondary containment of the tank levee
  - The contained release of crude oil to the dike area presents the risk of ignition and subsequent dike fire.
  - The unignited spill of crude oil presents the risk of delayed flammable gas ignition.
  - The ignition of these spills can be sudden and explosive in nature when the flammable gases are confined and maintained in higher concentrations by atmospheric conditions or physical barriers.
Typical Cause:
- The ignition of migrating flammable release vapors back to flammable liquid accumulation within or partially within a tank levee

Associated Hazards:
- Significant toxic airborne outfall products of combustion
- Heat wave requiring immediate extinguishment in order to prevent levee tank ignition at rim seal or full surface
- Loss of tank structural integrity due to tank warping from heat exposure
- Heat exposure to adjacent tanks, piping and areas of risk within the facility

Control Options:
- The early detection and isolation of the release source is critical to minimize the volume of the product release. For events that aren’t easily or remotely isolated, a large amount of product can accumulate prior to control being achieved. The volume of product accumulated is directly proportionate to the amount of product available to fuel the burning fire.
- Sustained foam solution application from mobile or fixed monitors/pourers at a rate that achieves or exceeds the minimum application to achieve and maintain extinguishment, which includes:
  - Positioning and operation of high volume mobile foam discharge monitors consistent with available discharge positions, wind conditions, heat exposures and stream reach distances, such that foam applications can be made that land the foam solution accurately and gently at desirable application points within the levee
  - Positioning of connecting hose lines to and from foam proportioning equipment, water supplies, discharge devices and foam concentrate supplies
  - Operation of foam proportioning equipment and foam concentrate supplies
  - Water supply systems consistent with the required capacity to generate sufficient foam solution
- Water pump and foam proportioning devices capable of providing sufficient foam solution for foam blanket application and maintenance
- An emergency response team of 14 to 20 highly trained and equipped personnel supported by a highly function staff of facility operational personnel.

Semi-fixed levee foam system, including:
- Levee fixed foam pourers designed to apply foam solution comprehensively throughout the tank levee to achieve and maintain an extinguishing foam blanket
- Fixed foam lateral and piping connections to deliver the required foam solution volume to the foam pourers
- Positioning of connecting hose lines to and from foam proportioning equipment, water supplies, discharge laterals and foam concentrate supplies
- Operation of foam proportioning equipment and foam concentrate supplies
- Water supply systems consistent with the required capacity to generate sufficient foam solution
- Water pump and foam proportioning devices capable of providing sufficient foam solution and cooling fire water streams to provide tank cooling, foam blanket application and maintenance
- An emergency response team of 6 to 8 highly trained and equipped personnel supported by a highly function staff of facility operational personnel.

Fully fixed levee foam system, including:
- Levee fixed foam pourers designed to apply foam solution comprehensively throughout the tank levee to extinguish a full surface levee fire
- Fixed foam lateral and piping connections to deliver the required foam solution volume to the foam pourers
- Fixed foam proportioning devices capable of producing foam solution at the required volume to achieve foam blanket application and maintenance to achieve extinguishment
- Foam concentrate and water supplies sufficient to provide a sustained foam application throughout the event
- The system is pre-connected together such that the activation of the system requires control valve operation only, and can be operated by a team of two to three (2-3) operations personnel.

Consequences:
- The Release of Toxic Smoke Plumes
- The discharge of heat against adjacent storage tanks
- The discharge of heat to areas outside the fenceline
- The potential ignition of a Rim Seal Fire on External Floating Roof adjacent storage tanks
- The potential ignition of a Vent Fire on Internal Floating Roof adjacent storage tanks
The potential release of flammable or ignited product from the secondary containment provisions spreading to outfall retention systems throughout the facility prior to arrival at the tertiary containment system.

Tank Fire Burnout

The risk of Tank Fire Burnout exists whenever extinguishment of a hydrocarbon tank fire event cannot be fully managed to extinguishment. The terms refer to the utilization of a Defensive or Passive Strategy for managing a tank fire event (refer to Appendix D – Burnaby Fire Department General Tank Fire Protocol – General Strategy Type). Tank Fire Burnout is utilized as a tactic of ending a Tank Fire by allowing it to completely burn off all of the crude oil present with the tank. Once the crude oil has burned off, the fire self-extinguishes.

Tank Fire Burnout, as a contingency tactic, has historically been utilized as an option for fire extinguishment when adverse environmental conditions exist, a lack of firefighting resources are present or when the facility design precludes safe offensive firefighting operations. Tank Fire Burnout can be utilized as a passive tactic when the more aggressive tactics of direct fire extinguishment and firefighting may significantly endanger responders, due to conditions like insufficient firefighting resources, uncontrolled safety concerns due to imminent event escalation from boilover, or tank failure. Tank Fire Burnout can also be utilized as a defensive tactic when current resources are required for the protection of exposed tanks / facility components as a means of minimizing the escalation of the incident, for instance as an initial action while resources are mustered, a command structure is formed, during size-up and actions plan development or when sufficient resources are just not available. As a defensive tactic the response priorities focus on the safety of responders, the protection of exposed components, the protection of the environment.

Typically the operation of “pumping out the tank”, or transferring as much of the product from the burning tank to an alternate safe storage tank, is utilized in concert with the strategy of allowing a tank to burnout. By reducing the volume of product available to the fire, the total length of time required for the tank to self-extinguish is reduced. However, for crude oil, pumping out the tank is not recommended (American Petroleum Institute 2021 Recommended Practice – Management of Atmospheric Storage Tank Fires – June 2006 – 8.3.2 Assessing the Tank Fire Situation).

- P. 28-29 “The time to reach boilover depends on the amount of material in the tank. Tanks holding wide boiling range materials (such as crude oil) should not be pumped out since pumping removes the buffer between the water layer and hot heavy ends.”

Therefore the use of a Tank Burnout tactic exposes the community to the full potential impact and duration of toxic smoke and heat discharge based upon the volume of crude oil present at the time of ignition.
The use of Tank Fire Burnout as a tactic will require the simultaneous evacuation of personnel from areas exposed to potential incident escalations and hazardous outfalls. The operations associated with evacuating persons potentially impacted by a 4 day tank fire event from a facility with such tight proximity to high density residential communities would constitute an emergency activation of provincial scale.

The consequences of utilizing Tank Fire Burnout as an extinguishment tactic are several. In a defensive strategy, as would be required in the TMEP configuration due to the density of the tank farm (close tank proximity), extensive fire operations would be necessary to simultaneously cool multiple adjacent fire spread risks, such as other storage tanks and the wildland exposure at the fenceline (Reference Diagram 3 & Diagram 4). The operations of providing these cooling streams in close proximity to the extensive and continuing heat output of a tank fire presents significant responder risk and high potential for secondary fire occurrence. By nature allowing the tank to burnout over a period of 3 – 4 days would expose the community to longer term and higher concentrations of toxic smoke exposure. The total water volume requirement to operate cooling streams for 3 – 4 days would be in the range of 5 million USgal. This volume of water is not present within the fire water reservoir system utilized by the TMTF, nor is the ability for the runoff water to be retained and fully treated prior to discharge to sensitive watercourses within the City of Burnaby.

Additionally, note that within the Diagram 3 & Diagram 4, both examples require multiple large caliber cooling streams to be operated against heat exposed areas impacted from the tank fire. Even in the event that a tank is only being permitted to burn without extinguishment operations for short timeframes prior to mounting an offensive fire attack to extinguish, the emergency response will be forced to take immediate action in order to prevent incident escalation including fire spread to adjacent storage tanks and wildland areas. For tank fire event that are not able to mount a safe offensive attack for extinguishment, the cooling activities, like those identified in the diagrams provided will be required continually for 3 - 4 days.

In Diagram 3 which represents the Burnout tactic applied to Tank 77 in a wind to the North aptitude, fire water stream volume required to cool the heat impact adjacent storage tanks and wildland area would be in the magnitude of 6,000 USgal/min for 3 – 4 days, or 3,500,000 USgal.
Diagram 3
Example Tank 77
Operations required for Burnout Tactic utilization

Wind Direction: to North
Elevation Change: to North
Fire Risk:
- Tank 76 within 2D
- Tank 75 within 1D
- Tank 74 within 2D
- Tank 79 within 1D
- Wildland within 2D

Note: Extreme Hazard of Firefighting operations identified inside the RED heat exposed area
The reality of employing a Burnout tactic for a Tank Fire event within the proposed TMEP configuration is that success associated with preventing fire extension throughout the TMTF and the adjacent community would by no means be assured. Significant potential exists that due to the proposed configuration, density, complexity and proximity to the community impacts and fire spread potentials that would create scenarios where fire containment is not possible.
Tank Fire Boilover

The potential for Boilover exists in any wide boiling range hydrocarbon, such as crude oil. Boilover occurs when the heat created at the top portion of a full surface tank fire causes the heavy components of the crude oil to form a solid crust like plate at or near the surface. As the fire continues to burn, this developing crust increases in depth and therefore total weight. When the weight of the developing crust can no longer be suspended by the less dense liquid crude oil underneath, the crust formation beings to slowly sink toward the bottom of the tank. As the crust formation moves toward the bottom of the tank, the water content present within the crude oil is restricted from moving upward through the crude oil and released from the surface of the tank. This trapped water formation is heated along with the contents of the tank. When the water content trapped below the crust formation is heat sufficient to change the physical state of the liquid water to steam, a volumetric expansion occurs, which converts 1 usgal of water to greater than 1,700 usgal of steam. As many gallons of water are potentially present within storage tanks the size currently present in the TMTF and proposed by the TMEP, a mass and sudden increase in the volume of the tank content occurs. The steam rapidly expanding in the bottom portion of the tank, will suddenly force the heated crude oil contents above out the top of the tank, discharging heated and molten crude oil over the area 10 times the tanks diameter. For a proposed 200’ storage tank, a Boilover event can discharge heated and molten crude oil outwards to 2,000’.

A Boilover event occurring from a Tank Fire in the TMTF, the high hazard expected to receive the discharged heated and molten crude oil would encompass:

- The entire TMTF
- The Shellmont Tank Farm
- Forest Grove Community
- Meadowood Community
- Sperling-Duthie Community
- Closing Gaglardi Way
- Burnaby Mountain Parkway

In Kinder Morgan Canada Risk Assessment Trans Mountain Expansion Project – Burnaby Terminal Project, October 1st, 2013 Doug McCutcheon and Associates, Consulting

- P. 3 Executive Summary “Should such a scenario develop ample time will be available for emergency procedures to implement appropriate action”

The statement made in the NEB Submission for the TMEP with regard to ample time being available to implement appropriate control options to prevent a Boilover event is questionable.

P. 28-29 “The time to reach boilover depends on the amount of material in the tank. Tanks holding wide boiling range materials (such as crude oil) should not be pumped out since pumping removes the buffer between the water layer and hot heavy ends. While the rate of descent of the hot layer varies, as a first approximation it can be estimated to travel down from the burning fuel surface at the same rate at which fuel burns. Thus, the hot layer will be as far below the surface as the burning surface is below the original liquid level in the tank. From the original tank level, the descent of the heat wave is twice the rate of burning. In general, if foam cannot be applied successfully within 4 hours of the fire starting in a relatively full crude oil tank, then the incident commander should begin clearing the area within 10–15 tank diameters.”

KMC application to the NEB for the TMEP seems to directly contradict the recommendation of the American Petroleum Institute (API) and their recommendation for the management of storage tank fires. API is largest US oil & natural gas industry trade organization and represents 400 corporations with regard to governmental, legal and regulatory agencies. Of note Kinder Morgan Energy Partnership, L.P. is an active API Member Company.

The scope of the area potential impacted by a Boilover scenario is illustrated in Diagram 5. It is anticipated that the consequences of Boilover exposure within the areas identified would include:

- Human Injuries to Emergency Responders and unevaluated civilians
- Mass Tree Top Based Wildland Fire initiation
- Structural Fire initiation to many residential buildings
- Potential Tank Fire initiation within the TMTF and the Shellmont Tank Farm
- Significant isolation of the SFU and UniverCity communities
Diagram 5
Storage Tank Boilover
Impact Areas
Consequences

The Kinder Morgan application for expansion at the Trans Mountain Tank Farm facility presents many uncontrollable and unacceptable safety risks to the City of Burnaby. The Trans Mountain Expansion Project (TMEP) will create elevated risk to the community by increasing the number and size of hydrocarbon storage tanks within an already geographically challenged facility. Hydrocarbon storage tanks on Burnaby Mountain present several public safety risks, which include the release of liquid hydrocarbon products, flammable vapors, toxic smoke and heat. In its application to the National Energy Board (NEB), Kinder Morgan has specifically identified the release of sulfur based gases, toxic smoke plumes and tank fire boilover as facility safety risks. Tactical firefighting analysis, presents the additional risks of wildland fire initiation due to the close proximity of fire hazards to the forested fenceline, the isolation of SFU communities by endangering travel on both Gaglardi Way and Burnaby Mountain Parkway during fire events and the potentials for tank fire burnout or a multiple tank fire event.

The location of the Trans Mountain Tank Farm presents risks of downhill liquid product release to the Forest Hills residential area solely because of its uphill elevation. The immediate impact to lives during a liquid product release is associated to exposure of gaseous sulphur compounds and the potential ignition of flammable vapors. The most significant liquid release scenario, is also the most difficult to prevent from occurring. The potential liquid product release scenario stemming from an expected regional area seismic event would be catastrophic in nature, and has potential to release the contents of several if not all of the storage tanks simultaneously, overwhelming the facilities retention provisions and flowing unrestricted to highly populated residential areas and sensitive environmental habitats.

The risk of fire is always present when flammable commodities are stored, handled or transported. Extensive engineering, control systems and design provisions have been unable to completely prevent fires from occurring in hydrocarbon storage facilities. Ignited hydrocarbon products present serious health impacts due to the very toxic nature of the smoke released. Operations at emergency events are prioritized by the protection of life, the protection of the environment, followed by the protection of property. An emergency event at the proposed Trans Mountain Tank Farm would likely require the Burnaby Fire Department to operate in the following manner. The primary operations would focus on the rescue of workers from the facility, followed by the protection of lives at high risk in the adjacent communities. The secondary operations would include the prevention of environmental impact and the continuity of basic emergency service throughout the City of Burnaby. Because of magnitude of the resource requirements for primary and secondary operations, the Burnaby Fire Department would have to choose to risk exposing life and the environment in order to commit department personnel to assist Kinder Morgan with any active firefighting operations inside the Trans Mountain facility to control the fire event itself.

With the exception of immediate evacuation, it is extremely difficult to control or prevent the harmful exposures created by discharging smoke from a fire event to lives within the community. In order to protect the citizens in proximity to the facility, evacuation of from areas exposed to smoke outfalls may be required. Hydrocarbon storage tanks are susceptible to fires
that can grow quickly into events that would expose the citizens of Burnaby in large numbers requiring emergency services to focus the bulk of available resources on executing the safe removal of lives from the areas of smoke exposure while extinguishing wildland and building fires outside the fenceline in immediate proximity to the heat outfall. The emergency services within the city of Burnaby would be challenged to maintain basic services elsewhere within the city during an event of this nature. The operations required to isolate and restrict access to areas of hazard, evacuate areas immediately or potentially impacted by toxic smoke outfalls, and prevent fire extension outside the fenceline would create a major demand and overwhelm the resources currently present. The location of proposed new storage tanks massively decreases the buffer zone currently in place at the facility, moving facility hazards significantly closer to the public, reducing the time to negative impact on the community, as well as providing many increased event risks previously not present.

Fires occurring in this tank farm will have the potential to be more severe in magnitude. Inherent in the layout of this tank farm is the potential of a fire event occurring in such close proximity to adjacent tanks, that subsequent ignition of additional storage tanks is a dangerous reality. A significant emergency management concern in a facility of this type is the escalation from a single tank fire to a multiple tank fire event. The resource requirements and the excessive complexity and risk to emergency responders, typically prevents the safe firefighting of a multiple tank fire event. The TMEP proposal includes the mass densification of the facility, adding many more and many larger product storage tanks. The addition of storage tanks decreases the distance between each tank. The distance between storage tanks is a key design and engineering feature provided to allow firefighters to effectively isolate an active tank fire, preventing a multiple tank fire event. The TMEP proposal effectively increases the risk associated with a multiple tank fire event due to the reduction in storage tank spacing.

The decreased tank spacing within the tank farm has additional significant consequences. Many of the potential tank fire scenarios within the Trans Mountain Tank Farm facility would be inextinguishable due to lack of safe firefighting positions. The general configuration proposed by Kinder Morgan provides insufficient safe access routes and operating positions from which firefighters could apply protective streams to isolate or extinguish fire events. The elevation changes within the Trans Mountain Tank Farm do not provide multiple firefighting positions or consideration for approach elevations to enable safe and effective operations for all potential wind directions. In order to extinguish a tank fire within the Tran Mountain Tank Farm emergency responders could be forced to significantly risk their personal safety in order to overcome the design inadequacies of the facility. Specifically, the configuration of the tank farm on a hillside in such a tight footprint would require firefighting personnel to operate in elevated positions above the tank, exposing them to potentially excessive heat and smoke outfalls. In these instances emergency responders would likely be forced to allow the tank fire to burn out while adjacent tanks are protected.

Many of the new proposed storage tanks in the TMEP will share containment diking. Because of the tight facility footprint, in order to provide containment diking as many as four (4) storage tanks will share a common containment dike. These large dike areas also prevent firefighting
crews from positioning effectively. Many wind directions may require firefighting personnel to operate from locations immediate downhill from the containment dike, or operate excessively close to the fire/spill area. In the event of a sudden wind shift or foam blanket burn through, the operating positions dictated by these large dike sizes, could cause firefighting personnel to be exposed to extending fire, flammable atmospheres and/or be cut off from their safe escape routes.

Many scenarios exist with the proposed configuration of the Trans Mountain facility that would likely present an unacceptable risk, or an inability to effect access to protect adjacent tanks, during a tank fire burnout, thus risking escalation of a single tank fire to a multiple tank fire event. The outfall toxic smoke plumes would have significant impacts within the community, its people, their environment and their property. Historically the hydrocarbon industry has accepted the strategic option of allowing a tank fire to burnout over several days as a method of tank fire extinguishment for fires that cannot be combatted safely. The TMEP proposal presents many conditions that provide no legitimate and safe strategies for extinguishment, other than allowing tank fire burnout.

The TMEP presents many tank fire scenarios that do not permit immediate containment, control and extinguishment. If allowed to burnout over several days, crude oil storage tanks may experience an explosion known as Boilover. Boilover is an explosive discharge of molten crude oil from the tank to all potential areas inside of 10 - 15 times the diameter of the storage tank (example: for a 200’ Tank diameter, the area immediately hazardous to life is 2,000’ – 3,000’). Within this hazard area should boilover occur, it is expected that unprotected lives and property would be significantly impacted. Post boilover event operations would include the medical aid to impacted life, and extensive fire suppression requirements for many residential and commercial structures, as well as wildland areas impacted within the hazard zone. The potential for a secondary hydrocarbon tank fires within the Trans Mountain facility or the adjacent Shellmont Tank Farm is an anticipated result of a boilover event.

Due to its geographical location, tank farm density, proximity of hazards to the fenceline and the potential hazardous release and fire events, the Kinder Morgan TMEP proposal and the emergency event scenarios identified within the proposal present an unacceptable magnitude risk and consequence to the city of Burnaby.

In the TMEP NEB Application Volume 7 Risk Assessment & Management of Pipeline & Facility Spills, Section 3.2.2 - Secondary Containment and Tank Fire Risk Assessment, states:

“The risk assessment begins with identification of hazards or concerns. This step relies on regulations and company direction to determine what is considered a hazard. Possible scenarios are fire and explosion risks from flammable materials, boil over from an internal tank fire, and toxic smoke plumes. Since a product release is the most likely event to occur, the Trans Mountain Pipeline (ULC) Trans Mountain Expansion Project Volume 7 Volume 7 - Risk Assessment and Management of Pipeline and Facility Spills Page 7–20 realistic worst case scenario is a fire and/or explosion of flammable material. Even
though a boilover scenario is not considered likely, this hazard is considered for emergency planning purposes. In addition, because the product in the storage tanks may contain trace amounts of sulphur, the hazard of human exposure is also considered for emergency planning purposes.”

This portion of the application clearly identifies the hazards that require emergency planning as potential incidents:

- Fire and Explosion of flammable materials
- Boilover from an Internal Tank Fire
  (therefore a full surface Internal Floating Roof Tank Fire)
- Toxic Smoke Plume release
- Sulphur based gas release

**Flammable Gas Outfall against the Fenceline**

The release of crude oil products from primary containment within the TMTF can present the potential for flammable gas outfall to areas outside the fenceline. Crude oil contains components that when released from the containment provided by piping and storage tanks causes the release of high volatile “Light Ends”. The lighter components of the crude oil when released form flammable outfalls with low ignition points.

Regardless of the preventative measures undertaken by a facility, the nature of the commodity, risks of emergency events associated with product release are legitimate.

In Kinder Morgan Canada Risk Assessment Trans Mountain Expansion Project – Burnaby Terminal Project, October 1st, 2013 Doug McCutcheon and Associates, Consulting

- P. 29 “From an operational view there is a higher than accepted probability for releases caused through the handling of materials during transfers as well as through tank leaks and spills.”

The risk to the community exists when a pipe or storage tank loss of containment results in a flammable gaseous release. The proximity of the release to the fenceline is of significant issue. Typically the hazard of a flammable gas release is reduced by the “weathering” of the flammables prior to their engagement with an ignition source. Weathering is the dispersal of the flammable gaseous hydrocarbon light ends. Weathering includes the dispersal to elevation of the atmosphere by flammable products lighter than air, and dispersal due to loss of concentration at ground level due to dilution with common air atmosphere during travel away from the propagating source.

Ignition sources within the facility are mostly controlled by electrical classification save the potential for ignition by a passenger or industrial motor vehicle, or hot work. Outside the fenceline any manner of ignition source is possible. The positive effects of weathering are significantly reduced with the movement of storage tanks, diked area and piping significantly closer to the fenceline. The TMEP proposes a significantly reduced buffer zone to the
community, reducing the positive effects of weathering prior to community infiltration and presenting flammable gas exposure risks to the community much sooner upon release.

The potential for flammable gas ignition outside the fenceline is based upon the use of the land areas in proximity to the fenceline. The highly populated areas around the TMEP present a high likelihood of ignition by the natural community activities. The TMEP has planned not to provide a notification mechanism to initiate community protection from a flammable gas release. The first emergency based actions to prevent flammable gas ignition will be provided by City of Burnaby emergency responders.

Of significant interest is the TMEP states that it will take full responsibility for an emergency event occurring, it also states that the TMEP takes no responsibility to provide immediate community notifications for this type of public safety hazard.

On Page 436 of 754, question 25.07 (c.) of the City of Burnaby IR – Round 1:

City of Burnaby: Will Trans Mountain personnel have the skills, knowledge, training and ability to deploy, move, adjust and augment spill containment booms immediately at spill occurrence, and simultaneously with:
   i) initial site emergency management actions, notifications, isolation provisions, activation of both internal and external resources?
   ii) the discontinuing of transfer operations, field access, assessment, intervention and mitigation operations in a safe, effective and efficient manner for all emergency event potentials?

KMC – TMEP: Kinder Morgan Canada (KMC) takes full responsibility for any emergency that results from the Trans Mountain Pipeline system.

On Page 188 of 754, Question 07.23 (e.) of the City of Burnaby IR – Round 1:

City of Burnaby: Is Trans Mountain going to provide an Emergency Notification System or an early warning system to communicate risk to the public?

KMC – TMEP: Kinder Morgan Canada does not currently have an early warning system to communicate risk to the public. Application Volume 7, Section 4.8 outlines the process to enhance Kinder Morgan Canada’s (KMC) existing emergency management programs as they relate to the Trans Mountain Pipeline system to address the needs of TMEP. The final programs will be developed in a manner consistent with the NEB’s draft conditions related to emergency management.
Of note, during the TMTF 2009 storage tank overfill event, KM failed to notify the community in any manner during the release of flammable gas from a crude oil loss of containment. The Burnaby Fire Department received many emergency calls for assistance from citizens residing in proximity to the TMTF complaining of foul odours. Upon investigation, the Burnaby Fire Department identified that the odours had originated from the TMTF and a spill occurrence several hours earlier. The lack of community notification likely presented risk of flammable gas ignition outside the facility fenceline. The ability or unwillingness to either inform the community or inform City of Burnaby emergency responders does not characterize event management focused on public safety interests as a priority.

A similar event occurring from a storage tank in much closer proximity to the fenceline, such as presented by the proposed TMEP configuration, would present a much higher likelihood of ignition and severe life hazard. Specifically, proposed Tanks 91, 93, 95, 96, 97 and 98 all present significant risk of flammable release ignition by motor vehicles utilizing Burnaby Mountain Parkway or Gaglardi Way (The risk likelihood is increased due to the elevated location of the roadway. The elevated topography will provide significantly less dispersal.). Tanks 75, 77 and 79 present a significantly higher risk of flammable risk potential to the Forest Grove community area directly South from the tank dike edges (although the elevation change in this area favors increased dispersal, higher density residential areas and an Elementary School are present to the South extremely close to the proposed tank dike edges.)

Storage tank diked areas and product piping situated close to the fenceline creates a significant increase in the fire risk to the adjacent community and the facility itself. The control of such close proximity releases may not be possible by the application of firefighting foam agents to the spill surface in a timeframe that could reduce the risk of flammable gas exposure prior to ignition.
Release of Sulphur Based Gases against the Fenceline

The loss of containment of crude oil products presents the potential for formation and release of sulphur based gases. Most significant of the potential sulphur based gases that could be released is Hydrogen Sulfide. Hydrogen Sulfide is a poisonous, colorless, and heavier than air, highly flammable gas that has potential to create explosive mixtures with Oxygen. In lower concentrations, this gas is detectable by human smell, but its irritant and asphyxiating properties quickly kills the sense of smell making it falsely seem as if the gas concentration has dissipated.
Sulphur Dioxide is another compound generated from the combustion of crude oil with sulphur content.

In Kinder Morgan Canada Risk Assessment Trans Mountain Expansion Project – Burnaby Terminal Project, October 1st, 2013 Doug McCutcheon and Associates, Consulting

- P. 3 “However as there is a possibility some of the oil will contain small amounts of Sulphur which will be converted to Sulphur Dioxide (SO2) in a fire, the analysis shows a potential health concern could be felt up to 5.2 km downwind”

The design basis of the TMEP that moves crude oil storage tanks closer to the fenceline, creates close proximity potential release or spill of crude oil into secondary containment dikes and the potential for the release of Sulphur based gases to areas outside the fenceline. These gases that dissipate very slowly because of their molecular weight, present legitimate health hazard to populated areas.
In Kinder Morgan Canada Risk Assessment Trans Mountain Expansion Project – Burnaby Terminal Project, October 1st, 2013 Doug McCutcheon and Associates, Consulting

- P. 3 “Included are the analysis of the smoke plume from the and a consideration of the Sulphur component in the oil, which has been recognized as a health concern”

The potential health effects of Hydrogen Sulfide are:

*Low Concentrations:*
- Irritation of eyes, nose, throat and respiratory system
- Breathing difficulties in Asthmatics

*Moderate Concentrations:*
- Coughing, difficulty breathing, headache, dizziness, nausea, vomiting, staggering and excitability

*High Concentrations*
- Shock, convulsions, inability to breathe, extremely rapid unconsciousness, coma and death

In considering the likelihood of the life impact to the community members from a potential release that includes Hydrogen Sulfide, distance from the facility to adjacent residential living is critical. At its greatest impact the TMEP facility will be 20 meters from residential property. This proximity would provide very little opportunity to notify adjacent residential community members prior to harmful impact.

Of significant interest is the TMEP takes no responsibility to provide immediate community notifications for this type of public safety hazard. While KMC states on ……. It takes full responsibility…….

On Page 188 of 754, Question 07.23 (e.) of the City of Burnaby IR – Round 1:

*City of Burnaby:* Is Trans Mountain going to provide an Emergency Notification System or an early warning system to communicate risk to the public?

*KMC – TMEP:* Kinder Morgan Canada does not currently have an early warning system to communicate risk to the public. Application Volume 7, Section 4.8 outlines the process to enhance Kinder Morgan Canada’s (KMC) existing emergency management programs as they relate to the Trans Mountain Pipeline system to address the needs of TMEP. The final programs will be developed in a manner consistent with the NEB’s draft conditions related to emergency management.

The detail not present in KMC’s answer to the above 07.23 question, is that within the existing emergency management programs at TMTF, KMC has no immediate emergency communication plans, protocols or procedures to notify the community at the first identification of hazard to the community.
The reduction magnitude of distances from the proposed crude oil storage tanks to the exterior facility exposures are as follows (approximate values based on KMC TMEP NEB Application devoid of accurate technical plans):

- Distance to Life Impact via Primary routes of travel from SFU and UniverCity
  - 20% Reduction Magnitude
  - 250’ Distance
  - 1 ½ Tank Diameters
  - Expected impact from a Full Surface Tank Fire, Dike Fire or Spill to require abandonment of all routes leaving Burnaby Mountain as unsafe

**Release of Toxic Smoke Plumes against the Fenceline**

The risk to human life and the environment of release toxic smoke plumes for crude oil fires which includes exposures to soot clouds, liquids, aerosols and gases, particulate matter, metals, sulfur compounds and nitrogen oxides, specifically:

- Carbon Dioxide
- Carbon Monoxide
- Sulfur Dioxide
- Nitrogen Oxides
- Volatile Organic Compounds
- Polycyclic Aromatic Hydrocarbons
- Hydrogen Sulfide
- Acidic Aerosols
- Solid Carbon
- Nickel
- Vanadium
- Arsenic

The potential health impacts of exposure to these products of crude oil combustion are most notably likely to harm those with pre-existing chronic respiratory conditions, increase rates of asthma and cardiovascular illness, with undetermined effects on longer term illness accumulations such as cancer.

The depositing of solid soot containing amounts of the metals, aerosols and liquids identified above can create imbalances and may harmfully affects to the delicate environmental balance associated with wildland and watercourse habitats in direct impact from the outfall smoke.

The smoke discharge associated with an uncontrolled full surface tank fire would significantly impact the health of all lives in the outfall region of smoke as the extent of long term illness occurrence is currently unestablished. As of June 2014, KMC’s plan for the control of a full surface tank fire was based on the utilization of resources mobilized from Alberta and the state of
Texas, with an expected arrival time of within 24 hours. Considering that the required equipment mustering, organizational and planning work associated with mitigating an full surface tank fire can take several hours and the direct fire attack is likely to take nearly 2 hours if initially effective, KMC has stated it is expecting of a timeframe of toxic smoke discharge prior to possible extinguishment of 1 – 2 days.

It is expected that the 1 – 2 day burn time would generate sufficient toxic smoke plume discharge to significantly affect the entire Greater Vancouver Regional District, with specifically high concentration of exposure and respiratory health hazards to all Burnaby, Port Moody, Coquitlam and New Westminster residents at risk with pre-existing respiratory conditions.

In Kinder Morgan Canada Risk Assessment Trans Mountain Expansion Project – Burnaby Terminal Project, October 1\textsuperscript{st}, 2013 Doug McCutcheon and Associates, Consulting
- P. 6 “A toxic impact up to 5.2 km downwind due to SO\textsubscript{2} created in a fire, and smoke impacts as far out as 43 km.”
- INSERT area ENCOMPASSED
- P. 25 “Toxic concerns were identified for smoke (soot) and for SO\textsubscript{2} downwind of the site. These are both issues that should be included in the site emergency plan. From a risk exposure point of view the impacts are very hard to define due to weather conditions and just the turbulence created by the heat from a fire. The likely result will be significant mixing of any SO\textsubscript{2} in the air to reduce the impact at ground level. However it cannot be ignored that the emergency plan needs to extend outwards to 5.2km for SO\textsubscript{2} concerns assuming 70% combustion efficiency. The Buncefield UK experience in terms of smoke impacts as shown in the above photographs gives a vivid picture of what a similar fire could look like.”
The reduction magnitude of distances from the proposed crude oil storage tanks and the exterior facility exposures are as follows (approximate values based on KMC TMEP NEB Application devoid of accurate technical plans):

- Distance to Life Impact via Primary routes of travel from SFU and Univercity
  - 20% Reduction Magnitude
  - 250’ Distance
  - 1 ½ Tank Diameters
  - Expected impact from a Full Surface Tank Fire or Dike Fire to require abandonment of all routes leaving Burnaby Mountain

**Heat Discharge against the Fenceline**
The existing TMTF is designed with a set back or buffer distance of not less than 200’ from the fenceline. The proposed TMEP massively decreases the distance The TMTF sits directly adjacent to the Burnaby residential communities of Lochdale, Sperling-Duthie, Meadowood, Forest Grove (the nearest residential property being 20 m away), as well as in proximity to Simon Fraser University and UniverCity.

In Kinder Morgan Canada Risk Assessment Trans Mountain Expansion Project – Burnaby Terminal Project, October 1st, 2013 Doug McCutcheon and Associates, Consulting

- P. 6 “Evaluating the consequences of the release scenarios indicated a low level radiant heat impact radius of up to 205 - 536m from a pool fire. Serious impact is felt up to 86 - 224m from the dike walls.”

INSERT area ENCOMPASSED
• P.21 “For a fully involved dike fire, the type of fire will undoubtedly be a heavy smoke type. With this in mind the major damage is up to 17 meters from the dike wall similar to the Dow calculation of 24 meters. The damage quickly reduces as the radiant heat energy is dissipated outwards. Applying the MIACC Criteria for 4 kW/m², the acceptable level of risk radius is approximately 86 - 224 m from the dike wall. The radiant heat energy eventually declines to 1.0 kW/m² (sunburn) at a distance of 205-536 meters from the dike wall. Of note are the specific tanks close to the northern and eastern boundaries where the impacts can be felt beyond the company property lines.”

• P. 21 “For a tank top fire, the type of fire will undoubtedly generate heavy smoke. With this in mind the major damage is up to 19 – 24 meters from the source of the fire. The damage quickly reduces as the radiant heat energy is dissipated outwards. Applying the MIACC Criteria, for 4 kW/m², the acceptable level of risk radius is approximately 56 - 71 m from the source. The radiant heat energy eventually declines to a “safe level” equivalent to a sunburn at about 144 - 184 meters.”

KMC in their NEB application for the TMEP that low level heat will be present at up to 1,750’, and high radiant heat at up to 730’.

The potential of heat exposure from a fire event initiated inside the TMTF facility is of critical issue with the TMEP. KMC stated in their Round 1 response to the City of Burnaby’s Intervener questions that, the reduction in inter-tank spacing within the facility is a product of the number of tank the TMEP requires and the square footage available within the TMTF site. The TMEP has proposed a new facility configuration that places many more storage tanks much closer to the fenceline creating new and significant fire spread risks to adjacent wildland areas.

The heat from a tank fire or dike fire will create heat accumulation on adjacent tanks and flammable exposures dependant on wind direction and elevation difference. Areas of potential fire spread in the downwind direction or at higher elevations from a tank fire or dike fire, are particularly susceptible to heat accumulation and fire spread. Based on a full surface tank fire, all potential fire spread areas within 1 tank diameter will experience heat exposure, except for fire spread areas in the downwind direction and areas of increased elevation, which will experience heat exposure to a distance of 2 times the tank diameter (Reference Table 12).
Table 12
Trans Mountain Storage Tank Configuration
Proximity Risk of Wildland Fire

<table>
<thead>
<tr>
<th>Current TMTF</th>
<th>TMEP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Distance to Fenceline</strong></td>
<td><strong>Distance to Fenceline</strong></td>
</tr>
<tr>
<td><strong>Linear Distance</strong></td>
<td><strong>Tank Diameters</strong></td>
</tr>
<tr>
<td>Tank 88</td>
<td>1500’</td>
</tr>
<tr>
<td>Tank 72</td>
<td>200’</td>
</tr>
<tr>
<td>Tank 91</td>
<td>100’</td>
</tr>
<tr>
<td>Tank 76</td>
<td>150’</td>
</tr>
<tr>
<td>Tank 72</td>
<td>200’</td>
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<tr>
<td>Tank 75</td>
<td>300’</td>
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<tr>
<td>Tank 77</td>
<td>250’</td>
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<tr>
<td>Tank 72</td>
<td>200’</td>
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<tr>
<td>Tank 75</td>
<td>300’</td>
</tr>
<tr>
<td>Tank 73</td>
<td>300’</td>
</tr>
<tr>
<td>Tank 96</td>
<td>300’</td>
</tr>
<tr>
<td>Tank 95</td>
<td>400’</td>
</tr>
</tbody>
</table>

The TMEP increases the potential of exterior fenceline heat impact scenarios by a magnitude of 7.5 times. The current TMTF has potential heat impacts to exterior fenceline areas from only 2 tanks. The TMEP will create potential heat impacts to exterior fenceline sensitivities from 15 tanks. Additionally, as illustrated in Diagrams 8 & Diagram 9, the depth at which the heat impacts from a tank fire event in the proposed TMEP Configuration will penetrate the forested area is extensive. In many cases the depth of heat impact is expected to increase from 100’ on a single event potential, to 300’ on up to 6 event potentials, and 100’ on 5 event potentials.

KMC NEB Application included a Risk for the Trans Mountain Expansion Project – Burnaby Terminal Project, provided on October 1st, 2013 by Doug McCutcheon and Associates, Consulting. Within this document a visual representation is provided titles Figure 5: Summary of Risk Distances for Radiant Energy from a Tank Top Fire. Of note, is that both Burnaby Mountain Parkway and Gaglardi Way are fully encompassed, as well as a great portion of the Burnaby Mountain Conservation Area, in the 4 kW/m² heat intensity, which described as:

- “Consequential Exposure Damage to People: Significant injury after 100 seconds exposure”
Diagram 8
Trans Mountain Tank Farm
Current Configuration
The heavily treed forest area of the Burnaby Mountain Conservation Area, surrounding the TMTF would be highly sensitive to heat exposure from a TMTF tank or dike fire. An uncooled heat exposure to the trees surrounding the TMTF, would create conditions consistent with ignition and development of a rapidly advancing “High Tree Top” Wildfire event. Uncontrolled fire growth of this nature would generate loss potentials that include:

- Significant forest loss on Burnaby Mountain prior to extinguishment
- Significant risk of heat wave impact back on the TMTF and potential ignition of additional Crude Oil Storage Tanks
- Significant interface property loss adjacent to the Burnaby Mountain Conservation Area
- Isolation of the access/egress routes from SFU and UniverCity until extinguishment is achieved
- Potential impacts to the Suncor Burrard Products Refined Hydrocarbon Storage Tanks in the Glenayre neighborhood of Port Moody
- Long duration loss of the parks and recreation usage and quality of the Burnaby Mountain Conservation Area
The reduction magnitude of distances from the proposed crude oil storage tanks and the exterior facility exposures are as follows (approximate values based on KMC TMEP NEB Application devoid of accurate technical plans):

- Distance to Wildland Impact of the heavily treed Burnaby Mountain Conservation Area
  66% Reduction Magnitude
  50’ Distance
  ¼ Tank Diameter
  Expected heat impact from a Full Surface Tank Fire or Dike Fire to ignite treed area

- Distance to Life Impact via Primary routes of travel from SFU and University
  20% Reduction Magnitude
  250’ Distance
  1 ½ Tank Diameters
  Expected impact from a Full Surface Tank Fire or Dike Fire to require abandonment of all routes leaving Burnaby Mountain

- Distance to Event Escalation Potential of adjacent Hydrocarbon Storage Tank Farm
  11% Reduction Magnitude
  900’ Distance
  4.5 Tank Diameters
Conclusions

On 16 December 2013, Kinder Morgan submitted an application to the National Energy Board (NEB) for the expansion of the Trans Mountain Pipeline system, which includes the expansion of the Burnaby Mountain Terminal. The expansion involves the densification of storage tanks within the existing footprint of the site from 13 tanks to 26 tanks – a tripling of the subject terminal’s storage capacity from 1.7 million barrels to 5.6 million barrels. The findings of the fire safety and risk analysis within this paper, raises concerns over KMC selection of the Burnaby Mountain Terminal for the densification of storage tank use.

Based on the findings of the analysis, Burnaby Mountain Terminal is not the appropriate location for the expansion of the Burnaby Mountain Terminal and densification of petroleum storage, given the subject terminal topography, limited site area, limited site access, its close proximity to the Lochdale, Sperling-Duthie, Meadowood, Forest Grove neighbourhoods (the nearest residential property being 20 m away), Simon Fraser University, UniverCity as well as the immediate proximity to the highly sensitive and susceptible Burnaby Mountain Conservation Area. These factors pose significant constraints from an emergency/fire response perspective, including but not limited to safety of firefighters and effectiveness to combat fire; containment and extinguishment of fire/spill/release; evacuation of employees within the Burnaby Mountain Terminal facility; evacuation of adjacent neighbourhoods, as well as broader areas impacted by release of sulfur based gases and toxic smoke plumes; and, protection of adjacent properties, including conservation lands.

Additionally, the TMEP lacks appropriate consideration for original facility fire protection premises and industry best practices in petroleum storage and fire protection, as the proposal only seeks to comply with minimum federal and provincial code requirements.

These factors pose significant risks to lives and property arising from the densification of petroleum products on a sub-standard, ill-configured and under sized property located in proximity to urban residential and other populations.

This paper has analyzed and identified the impacts of the TMEP with regard to the reduction in countermeasures and resulting facility susceptibility to consequences resulting from hazard event occurrence.
Countermeasures

The increased consequences arising from risk occurrence is a direct result of the facility configuration changes and additional storage tank locations which reduce the positive impact of the previously engineered fire and safety protection counter-measures. The Counter-measures which will be marginalized by the TMEP, include:

- **Tank Spacing**
  A 33% reduction in the overall facility Tank Spacing
  A 45% reduction in the proposed Tank Spacing versus existing Tank Spacing premise
  Tank spacing is the fundamental premise in reducing fire event extension potential through designed isolation distances of hazards from adjacent risks.

- **Application Positions**
  A 70% increase in the number of Storage Tanks that do not provide safe deployment positions for fire operations in all potential wind conditions, limiting the ability for fire events to be prevented from extending to adjacent Storage Tanks or Wildland areas.
  100% of the proposed Storage Tanks do not provide safe deployment positions for fire operations in all wind conditions, limiting the ability for fire events to be prevented from extending to adjacent Storage Tanks or Wildland areas.
  The proposed use of significantly greater storage tank density has impacts on the availability of appropriate application positions to control major fire events. The primary concerns created by the TMEP related to deployment positions are:
  - Insufficient deployment positions to cool adjacent tanks to prevent event heat exposures from escalating into fire extension
  - Insufficient roadway option to allow for safe access and egress of deployment positions to provide all necessary fire stream applications in all potential wind conditions

- **Distance to Fenceline**
  A 30% reduction in the facility average Tank to Fenceline Distance
  A 61% reduction in the average proposed Tank to Fenceline Distance
  The TMEP expands the existing TMTF with high density storage tank configurations into the northern and eastern corners of the existing facility property. The proposed configuration changes the tank to fenceline distances of the facility. The tank to fenceline distance is critical as it directly impacts time elapse to hazard impacts to the community life, environmental health and property outside the TMTF facility.
Hazard Events
The risk of spill and fire occurrence is well established within the hydrocarbon industry. Engineering initiatives and best practices have reduced the occurrence frequency, but the real potential of a fire event occurring has not been removed. Spill and fires that do occur can be prevented from spreading and growing into unmanageable public health and environmental disasters, only if the configuration of the tank farm facility supports the isolation of the spill or fire risk from the adjacent facility susceptibilities. The TMEP degrades the original fire protection premise of the facility and increases the likelihood of spill or fire extension exposing the community to the following hazard events.

- **Regional Seismic Event**
  The consequences of a seismic event occurrence are increased due to the location of the facility. The TMTF is located, elevated immediately above residential communities and sensitive environmental areas, watercourses and eco-systems in close proximity, in the outfall downhill direction. The TMTF is located, immediately below a high density treed environmental conservation area, a highly populated university and high density residential community, in direct outfall uphill direction.

- **Flammable Gas Outfall**
  Crude oil contains components that when released from the containment provided by piping and storage tanks causes the release of high volatile “Light Ends”. The lighter components of the crude oil when released form flammable outfalls with low ignition points and the significant potential to propagate explosion and fire events.

- **Release of Sulphur based Gases**
  The loss of containment of crude oil products presents the potential for Hydrogen Sulfide and Sulphur Dioxide release. Hydrogen Sulfide is a poisonous, colorless, and heavier than air, highly flammable gas that has potential to create explosive mixtures with Oxygen. Exposure to 100 ppm of Sulfur Dioxide in air is considered immediately dangerous to life.

- **Watercourse Outfall of Liquid Crude Oil Release**
  The release of Crude Oil to areas outside of lined secondary containment diking creates the potential of a crude oil introduction into watercourses exiting the TMTF facility. The release of crude oil to earthen surfaces outside secondary containment provisions, presents the expansion of the release to the subterranean water shed system of Burnaby Mountain. The natural water shed system off Burnaby Mountain would route collected crude oil to areas of downstream impact to Eagles Creek.

- **Tank Fire Burnout**
  Tank Fire Burnout has historically been utilized as a contingency option for fire extinguishment when adverse environmental conditions exist, a lack of firefighting resources are present or when the facility design precludes safe offensive firefighting operations. Therefore the use of a Tank Burnout tactic exposes the community to the full
potential impact and duration of toxic smoke and heat discharge based upon the volume of crude oil present at the time of ignition. The operations associated with evacuating persons potentially impacted by a 4 day tank fire event from a facility with such tight proximity to high density residential communities would constitute an emergency activation of provincial scale. Even in the event that a tank is only being permitted to burn without extinguishment operations for short timeframes prior to mounting an offensive fire attack to extinguish, the emergency response will be forced to take immediate action in order to prevent incident escalation including fire spread to adjacent storage tanks and wildland areas such as the highly susceptible Burnaby Mountain Conservation Area.

- **Tank Fire Boilover**
  The potential for Boilover exists in any wide boiling range hydrocarbon, such as a crude oil storage tank full surface fire. For a proposed 200’ storage tank, a Boilover event can discharge heated and molten crude oil outwards to 2,000’. A Boilover event occurring from a Tank Fire in the TMTF, would result in large area life hazard and the potential for propagation of additional storage tank fires due to the mass discharge of molten crude oil over areas encompassing:
  - The entire TMTF
  - The Shellmont Tank Farm
  - Forest Grove Community
  - Meadowood Community
  - Sperling-Duthie Community
  - Closing Gaglardi Way
  - Burnaby Mountain Parkway
Consequences

The Kinder Morgan application for expansion at the Trans Mountain Tank Farm facility presents many uncontrollable and unacceptable safety risks to the City of Burnaby. The Trans Mountain Expansion Project (TMEP) will create elevated risk and consequences of risk occurrence to the community by increasing the number and size of hydrocarbon storage tanks within an already geographically challenged facility. Hydrocarbon storage tanks on Burnaby Mountain present several public safety risks, which include increased potential for, include:

- **Flammable Gas Outfall against the Fenceline**
  The potential for flammable gas ignition outside the fenceline is based upon the use of the land areas in proximity to the fenceline. The highly populated areas around the TMEP present a high likelihood of ignition by the natural community activities.

- **Release of Sulphur Based Gases against the Fenceline**
  Highly toxic Hydrogen Sulfide (H2S) will very quickly, upon facility release, expose residential areas to conditions that are immediately dangerous to life. Smoke outfalls from fire event may contain Sulphur Dioxide (SO2), in which KMC analysis shows a potential health concern could be felt up to 5.2 km. downwind.

- **Release of Toxic Smoke Plumes against the Fenceline**
  The risk to human life and the environment resulting from the release toxic smoke plumes from crude oil fires includes exposures to soot clouds, liquids, aerosols and gases, particulate matter, metals, sulfur compounds and nitrogen oxides. The potential health impacts of exposure to products of combustion from crude oil combustion are most notably likely to harm those with pre-existing chronic respiratory conditions, increase rates of asthma and cardiovascular illness, with potentially undetermined effects on longer term illness accumulations such as cancer. Considering that the required equipment mustering, organizational and planning work associated with mitigating an full surface tank fire can take several hours and the direct fire attack is likely to take nearly 2 hours if initially effective, KMC has stated it is expecting of a timeframe of toxic smoke discharge prior to possible extinguishment of 1 – 2 days. It is expected that the 1 – 2 day burn time would generate a sufficient toxic smoke plume discharge to significantly affect the entire Greater Vancouver Regional District, with specifically high concentration of exposure and respiratory health hazards to all Burnaby, Port Moody, Coquitlam and New Westminster residents at risk with pre-existing respiratory conditions.

- **Heat Discharge against the Fenceline**
  The TMEP reduces the Heat Source distance to Wildland Impact and potential Wildfire exposure of the Burnaby Mountain Conservation Area by 66%. The existing TMTF is designed with a set back or buffer distance of not less than 200’ from the fenceline. The proposed TMEP massively decreases the distance The TMTF sits directly adjacent to the Burnaby residential communities of Lochdale, Sperling-
Duthie, Meadowood, Forest Grove (the nearest residential property being 20 m away), as well as in proximity to Simon Fraser University and UniverCity.

Conclusions

The TMEP will increase the impacts associated with the risks of crude oil loss of containment or fire across all potential events types due to the increased proximity to residential population densities, highly susceptible conservation forest areas and downhill or downwind sensitivities. The time prior to life and environmental impact will be significantly reduced by the TMEP, as has many of the engineered in facility configuration countermeasures responsible for the minimization of event growth and corresponding impact escalation have been greatly reduced from original facility premises which fundamentally adhered to the intent of best practices, to the reduced performance of minimum code requirements.

The existing high consequence event potential of a regional seismic event will tax the TMTF facility as the tertiary containment system has not been proposed to be upgrade nor will the secondary containment provisions of existing storage tanks, creating a potential release of 40% of the volumetric crude oil from the facility or up to 2.24 Million Barrels of crude oil. The impact of this loss is not increased by frequency of event occurrence, but by the TMEP not incorporating site wide upgrades to maintain the countermeasure premises currently in place.

Fires occurring in this tank farm will have a potential to be severe in magnitude. Inherent in the layout of this tank farm is the potential of a fire event occurring in such close proximity to adjacent tanks, that subsequent ignition of additional storage tanks is a dangerous reality. A significant emergency management concern in a facility of this type is the escalation from a single tank fire to a multiple tank fire event. The resource requirements and the excessive complexity and risk to emergency responders, typically prevents the safe firefighting of a multiple tank fire event. The TMEP proposal includes the mass densification of the facility, adding many more and many larger product storage tanks. The addition of storage tanks decreases the distance between each tank. The distance between storage tanks is a key design and engineering feature provided to allow firefighters to effectively isolate an active tank fire, preventing a multiple tank fire event. The TMEP proposal effectively increases the risk associated with a multiple tank fire event due to the reduction in storage tank spacing.

The TMEP proposes the increasing of the tank farm storage tank density, by decreasing engineered tank isolation distances, which in turn increases the potential for fire event escalation through extension, in a facility that has reduced its internal fire protection capability without approval. Notable by its absence from the TMEP application to the NEB is a detailed analysis of the effect of the tank spacing reduction on the requirements of mobile and fixed fire protection countermeasures, and the subsequent changes to the fire protection premises currently utilized. Weaknesses in the design of a facility can create fire event situations that cannot be safely or effectively mitigated without allowing a storage tank or several tanks to burnout.

The TMTF was originally approved based on the provision of a 2 tank diameter spacing. In subsequent years the addition of Tank 88 marginally reduced the overall facility tank spacing to 1.86 tank diameters (average), but maintained the original premise of tank spacing to provide tank isolation and reduce escalation and extension potentials. The TMEP massively deviates
from the original safety premise and approval basis of providing storage tank isolation for proposed tanks at a proximity distance of 0.5 tank diameters.

The addition of storage tanks into the existing TMTF changes the risk control premises with regard to storage tank isolation by facility design. In order to achieve the desired storage tank volume, KMC is proposing a significant replacement of designed isolation of each storage tank. In essence, the TMEP shifts the control of hazard from an engineered approach of tank isolation, to an emergency response approach. As the authority having jurisdiction for fire protection approval within the City of Burnaby, the Burnaby Fire Department has recently been advised by KMC on May 30, 2014, that the facility no longer has the emergency response ability to extinguish fire events with internal facility resources, and that additional hydrocarbon specialized firefighting resources from regional facilities are no longer available.

To complicate the emergency control activities, because of the tighter tank spacing, many heat exposure cooling operations are not possible due to insufficient firefighting deployment positions. The TMEP proposed to group many tanks with common diking separated only by small intermediate dike segregation. These larger dikes areas reduce the available access and deployment roadway positions to facilitate safe, efficient and effective firefighting stream applications.

The decreased tank spacing within the tank farm has additional significant consequences. Many of the potential tank fire scenarios within the Trans Mountain Tank Farm facility would be inextinguishable due to lack of safe firefighting positions. The general configuration proposed by Kinder Morgan provides insufficient safe access routes and operating positions from which firefighters could apply protective streams to isolate or extinguish fire events. The elevation changes within the Trans Mountain Tank Farm do not provide multiple firefighting positions or consideration for approach elevations to enable safe and effective operations for all potential wind directions. In order to extinguish a tank fire within the Tran Mountain Tank Farm emergency responders could be forced to significantly risk their personal safety in order to overcome the design inadequacies of the facility. Specifically, the configuration of the tank farm on a hillside in such a tight footprint would require firefighting personnel to operate in elevated positions above the tank, exposing them to potentially excessive heat and smoke outfalls. In these instances emergency responders would likely be forced to allow the tank fire to burn out while adjacent tanks are protected.

The TMEP presents a significantly larger fire control risk within the TMTF. The identified increase in events with potential to escalate and extend to adjacent storage tank exposures due to insufficient firefighting deployment positions increases the likelihood of a multiple tank fire (including the potential of having to allow one or several storage tanks to burnout over 2-4 days), toxic smoke plume discharge (including long term chemical exposure to adjacent communities), and heat discharge to areas outside the facility (including high probability of fire extension to the forest areas of the Burnaby Mountain Conservation Area. The risk of community impacts outside of the facility from a TMTF fire event are increased by 70%.

The reality of employing a Burnout tactic for a Tank Fire event within the proposed TMEP configuration is that success associated with preventing fire extension throughout the TMTF and the adjacent community would by no means be assured. Significant potential exists that due to
the proposed configuration, density, complexity and proximity to the community impacts and fire spread potentials that would create scenarios where fire containment is not possible.

The cost of this risk potential assumed by the community is not in line with the safety and risk management premises initially utilized for original facility approval by the City of Burnaby. The specific driver of the increased risk is the reduction in the effective of the facility design to limit fire event growth and restrict hazardous impacts to an immediately controllable area of impact during a short emergency response timeframe. It is critical for public safety that design configuration utilized support the protection of life, the environment and property. The TMEP does not provide the basic engineered safety provisions standard in high-impact potential facility design.

The potential for Boilover exists in any wide boiling range hydrocarbon, such as crude oil. For a proposed 200’ storage tank, a Boilover event can discharge heated and molten crude oil outwards to 2,000’. A Boilover event occurring from a Tank Fire in the TMTF, the high hazard expected to receive the discharged heated and molten crude oil would encompass the entire TMTF, the Shellmont Tank Farm, the Forest Grove, Meadowood, and Sperling-Duthie Communities, closing Gaglardi Way and the Burnaby Mountain Parkway. It is anticipated that the consequences of Boilover exposure within the areas identified would include human injuries to emergency responders and unevaluated civilians, mass tree top based wildland fire initiation, structural fire initiation to many residential buildings, potential tank fire initiation within the TMTF and the Shellmont Tank Farm and significant isolation of the SFU and UniverCity communities.

The TMEP proposes a reduction in the tank to fenceline spacing of 30% on a facility wide comparison, and utilizes a new tank positioning premise which reduces the tank to fenceline distance by 61%. The decreased tank to fenceline distance and consequential impact potentials to the community presents the higher requirement and increased priority of evacuation operations conducted simultaneously with fire control activities. This response requirement significantly increases the emergency response resource requirements associated with identifiable emergency event potentials.

The TMEP significantly increases the urgency and expedience required to prevent community life and environmental impact outside the facility fenceline in the event of a product release or storage tank fire. The positioning of storage tanks in such close proximity creates a greater potential for citizen exposure within the adjacent communities to the hazardous effects of flammable gas outfalls and sulphur based gases. Additionally, the close proximity of storage tanks to the fenceline dramatically increases the risk of wildland fire to the Burnaby Mountain Conservation Area.
Appendix A
Tank Spacing Analysis
Appendix B
Deployment Position Analysis
Appendix C
Tank Distance to Fenceline Analysis
Appendix D
Burnaby Fire Department General Tank Fire Protocol
Appendix E
Emergency Management Evaluation
Appendix F
Industry Related Emergency Incident Occurrence - Timeline
Appendix G
Information Request Round 1 – NEB Application
Appendix H
Trans Mountain Tank Farm Fire Protection Meeting
2014.05.30
Appendix I
Fire & Safety Risks Associated with TMEP
Burnaby City Council Memo