Trans Mountain Expansion Project (TMEP): Evaluation of Risks to SFU

PREPARED FOR:
Simon Fraser University
8888 University Drive
Burnaby, BC V5A 1S6

Attention: Mark Lalonde, Chief Safety Officer

PREPARED BY:
PGL Environmental Consultants
#1200 – 1185 West Georgia Street
Vancouver, BC V6E 4E6
M. Shum, Ph.D., & L. Beckmann, M.A.

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Executive Summary

The Trans Mountain Expansion Project (TMEP) is a proposal by Trans Mountain Pipeline ULC (Trans Mountain) to expand petroleum export capacity to Asia. Components of the project include twinning the pipeline, expanding storage capacity at several locations along the pipeline route, and the addition of berthing capacity at the Westridge Marine Terminal.

The existing infrastructure carries and stores a wide range of grades and varieties of petroleum products. These are generally divided into four categories – heavy crude including bitumen; light crude; gasoline; and distillates – based on how refined they are.

All of these products are currently moved through Kinder Morgan's existing pipeline infrastructure. The increased capacity associated with the TMEP will be used to carry a proportionately larger volume of heavy crudes, including bitumen that has been diluted by distillates (diluted bitumen or "dilbit") so that it is fluid enough to flow through the pipeline.

Simon Fraser University (SFU) retained PGL Environmental Consultants (PGL) to evaluate the risks to SFU from the TMEP. This report contains PGL's findings.

In brief, PGL finds that there is an increased risk to SFU from the TMEP.

Specific components of the TMEP that contribute to the increased risk and safety concern for SFU are:

- The significant increase of volume of product (including dilbit, which is more flammable than other crude products) through the twinning of the pipelines;
- A greater proportion of the product is expected to be heavy crudes, including dilbit;
- The increased number and density of storage tanks at the Burnaby Tank Farm (storage capacity/volume will increase from 267,900m^3 to 894,320m^3) from 12 to 26 tanks; additionally, new tanks are closer to each other than the existing tanks; and
- The plan to locate some of the proposed tanks closer to fences and roads.

These operational characteristics (i.e., increase in product flow, increase storage, densification of tanks, and placement of new tanks close to fences/roads) increase the potential for accidents or malfunctions (like spills or ruptures) that may lead to:

- Fires near or on SFU property, leading to risks to the public and damage to property or infrastructure;
- The release of smoke or other toxic emissions to the atmosphere near or on SFU property resulting in exposure to the public; and/or
- Disruption or blockage of the single evacuation route from the SFU campus, such that students/staff/visitors on campus may be stranded on Burnaby Mountain.

In addition, a further risk stems from inadequate information; TMEP has not made public the characterization of potential accidents or malfunctions. This means that SFU cannot adequately plan for the safety of the community on Burnaby Mountain.

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The risk of community impacts outside of the tank farm increase by 70% because of the increase in likelihood of adverse events (City of Burnaby Fire Department, 2015). The body of the report provides additional detail regarding these risks. The report is structured as follows:

- Section 1.0, **Background**, contains overview information about the TMEP. This section also includes a brief ***primer on petroleum chemistry*** relevant to the discussion;
- Section 2.0, **Risk Setting**, identifies the physical characteristics of SFU that leave it susceptible to risk, as well as the potential accidents that could cause harm;
- Section 3.0, **Risk Findings Summary**, identifies the specific incidents and associated consequences of the TMEP, specific to SFU;
- Section 4.0, **Discussion**, explores each potential hazard in greater detail such that decision-makers can understand how SFU may be affected. This discussion is divided into subsections by hazard:
  - Section 4.1 – Chemical Exposure Hazards to SFU;
  - Section 4.2 – Fire/Air Quality Hazards to SFU; and
  - Section 4.3 – Incomplete Emergency Planning at SFU (due to lack of information).
- Section 5.0 contains our standard limitations; and
- Section 6.0 contains source information for references made in the report.

This Executive Summary is subject to the same standard limitations as contained in the report and must be read in conjunction with the entire report.

Table of Contents

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List of Acronyms

CLWB	-	Cold Lake Winter Blend
NEB	-	National Energy Board
PGL	-	PGL Environmental Consultants
SFU	-	Simon Fraser University
TMEP	-	Trans Mountain Expansion Project

1.0 BACKGROUND

Trans Mountain Pipeline ULC (Trans Mountain) is proposing to expand its pipeline system between Edmonton, AB and Burnaby, BC. The current system transports heavy crude (e.g., diluted bitumen, unrefined), light crude (e.g., conventional crude oil, unrefined), synthetic crude (e.g., processed bitumen, semi-refined), and refined petroleum (e.g., gasoline and diesel, refined). The Trans Mountain Expansion Project (TMEP) will transport the same petroleum products that are shipped today, but the increase in capacity is mainly allocated for unrefined products (e.g., diluted bitumen and conventional crude oil).

The proposed expansion involves:

- Completing the twinning of the pipeline in Alberta and BC with 987km of new buried pipeline;
- New and modified facilities, including pump stations and tanks;
- Additional tanker loading facilities at the Westridge Marine Terminal in Burnaby, BC; and
- Additional tanker traffic to export petroleum products to markets in Asia.

Specific infrastructure for Burnaby Mountain will include:

1. New pipelines carrying more product to the Burnaby Terminal, and an additional 14 storage tanks to hold the additional volume; and
2. New pipelines between the Burnaby Terminal and Westridge Marine Terminals.

The additional storage tanks, which will increase storage capacity from 300,000 barrels per day to 890,000 barrels per day, are proposed on the north and east sides of the site, closer to the Simon Fraser University (SFU) fence lines and the single roadway to/from campus.

In May 2015, on behalf of SFU, PGL Environmental Consultants (PGL) prepared an evidence report with our opinion of the human health risk assessment work completed for the proposed TMEP and submitted to the National Energy Board (NEB). The report identified several areas that were not clearly addressed, which meant that conclusions in the human health risk assessments may have been incomplete. The report concluded that the NEB may risk approving a project that has not fully considered the health risks associated with a realistic emergency situation, lacks appropriate response plans, and potentially exposes the SFU community to unknown health risks.

This current report builds on the previous report by identifying additional risks to SFU.

1.1 Petroleum Products Overview

To understand the potential risk to SFU, it is important to understand the petroleum products at issue. As noted in the Executive Summary, four general categories of petroleum products are currently transported through the Kinder Morgan system:

- **Heavy crude**: these are long-chain hydrocarbons that have been minimally refined. They tend to be very viscous (thick), move very slowly, and are less volatile and harder to ignite.
  - **Bitumen** is an extremely heavy crude. It is too viscous to move freely at room temperature, and cannot be moved through pipelines as extracted. The TMEP will not transport bitumen.

- **Diluted bitumen** ("dilbit") is bitumen that has been thinned by "diluents" made of very "light" petroleum products so that it can flow through pipelines. The diluents are less dense, more mobile, lighter than water, volatile, and highly flammable.

  Dilbit is frequently discussed of in terms of its "blend." Typically, dilbit is 70 to 80% bitumen, and 20 to 30% "diluent." Different blends are based on the specific proportions and diluents. Two such blends are "Wabiska Heavy" and "Cold Lake Winter."

  Dilbit is more flammable than other crude products, as measured by flash point (which is the temperature at which the product gives off sufficient vapour to ignite).

  Other heavy crudes include products like "bunker C" fuel oil which fuels many large marine vessels.

- **Light crude**: these are more refined products that flow freely at room temperature. They have fewer impurities and are valuable on the market because they can be more efficiently refined to diesel and gasoline.
- **Gasoline**: this is a still lighter (smaller hydrocarbon chain length) petroleum product used in most internal combustion machines.
- **Petroleum distillates**: these are the "lightest" hydrocarbons, many of which are volatile (vaporize) at room temperature. This group of products includes a number of solvents that can be used as feedstocks for producing a range of plastics. The diluents used to dilute bitumen are petroleum distillates.

A number of chemical compounds found in all petroleum products have been studied for their health effects. Relevant for this discussion are several of these components: **benzene**, **ethylbenzene**, **toluene**, and a class of compounds called **xylenes**; their effects are discussed in Section 4.1.

2.0 RISK SETTING – BURNABY MOUNTAIN

SFU's main campus is on Burnaby Mountain overlooking Burrard Inlet to the north. It includes a complex of interconnected buildings spanning 1.7km across Burnaby Mountain. On any given day, there are thousands of students, faculty members, staff, and visitors on campus.

The area between SFU and the Burnaby Terminal is predominately forest with only two access routes, which cross at a single junction, to the campus. The nearest new storage tank is proposed to be approximately 150m from the junction of Burnaby Mountain Parkway and Gaglardi Way, or 700m from SFU campus.

Spilled or leaked product will flow downhill, and/or be absorbed into the ground, and will not have a direct effect on SFU which is at a higher elevation than the pipeline or tank farm. However, SFU could be affected by fires or explosions, or airborne emissions resulting from a leak or spill. The increased potential for these events will increase risk for SFU.

Dilbit is already transported through the Kinder Morgan system along with other petroleum products. The increased risk from the TMEP stems from:

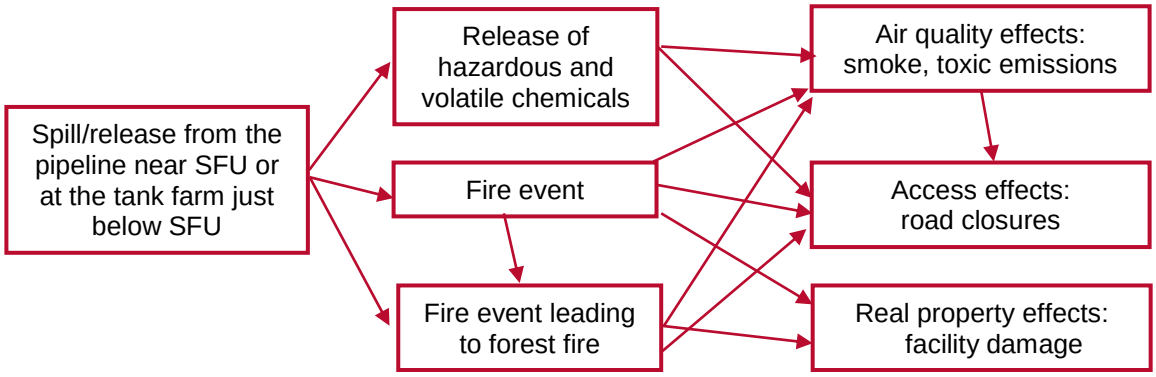
- Movement of a greater volume of product through the pipelines for storage at the Burnaby Tank Farm (storage capacity will increase from 267,900m^3 to 894,320m^3, from 12 to 26 tanks). A greater proportion of the product is expected to be heavy crudes, including dilbit;

- The increased number and density of storage tanks at the tank farm (new tanks are closer to each other than the existing tanks); and
- Proposed tanks that are in closer proximity to fences and roads.\

In simple terms, the chains of events that increase risk could include any of the following:

- A spill/release from the pipeline near SFU or at the tank farm just below SFU could lead to an immediate release of hazardous and volatile chemicals, impacting air quality;
- A fire event, which would lead to smoke and toxic air emissions; and/or
- Air-borne emissions (chemical or fire related) could migrate from the tank farm to areas that could potentially include the Burnaby Mountain Parkway (~100m to the nearest tank), and/or Gaglardi Way (~60m to the nearest tank).

If a fire spread to the adjacent forest, access routes to/from SFU and infrastructure at the UniverCity and on campus could be compromised. This is summarized graphically below.



3.0 REVIEW FINDINGS SUMMARY

PGL has reviewed and summarized available information filed with the NEB to identify the key issues/risks to SFU and its campus.

The scope of our review work was not expected to be exhaustive; rather it was intended to identify and present some of the issues of key concern. Much of the information is from Etkin et al. (2015), City of Burnaby Fire Department (2015), and PGL (2015).

The summary of the key issues and their potential effects are listed in the table below, followed by a detailed discussion of the issues.

Incident/Issue	Consequence/Effect
Liquid release: Release of petroleum products under transport or storage, from spill, accident, or natural disaster	Exposure to volatile substances at levels that potentially lead to health issues.
Fire or explosions along the pipeline or at the tank farm	Hazardous/toxic emissions from fire events include soot and particulate matter, SO_2, carbon monoxide, sulphur and nitrogen oxides, volatile organic compounds such as benzene, and semi-volatile compounds such as polycyclic aromatic hydrocarbons.
Fire spreading from tank farm to surrounding forest	Fire could envelop the university, and block access to and from SFU, thus making an evacuation difficult or impossible.
	Hazardous/toxic emissions from fire events include soot and particulate matter, SO_2, carbon monoxide, sulphur and nitrogen oxides, volatile organic compounds such as benzene, and semi-volatile compounds such as polycyclic aromatic hydrocarbons.
	Loss of natural terrestrial habitat, adverse impacts to watercourses and to downgradient surface water features, and potential contamination with fire-fighting chemicals.
Boil-over and fire	Discharge of heated, molten crude oil to a height of up to 1km above ground and a range of up to 0.76 km, potentially impacting the adjacent roadway's to SFU, or SFU directly.
Configuration and densification of storage tanks at the Burnaby Mountain facility	Increased risk of a multiple tank fire by decreasing the ability of firefighters to isolate an active tank fire.
	Insufficient safe access routes and operating positions from which firefighters could apply protective streams to isolate or extinguish fire events
Inability of SFU to design sufficient emergency plans	If an uncontrolled event (fire, smoke, etc.) occurs at the tank farm, access to and from SFU may be compromised. This would lead to potentially greater exposure and risk to SFU from smoke and emissions, and potential isolation of the campus by blockage of egress routes. If egress routes are compromised, escape will not be a viable emergency response option and the population on Burnaby Mountain will be confined to SFU until the emergency is resolved.

4.0 REVIEW FINDINGS DISCUSSION

The proposed pipeline and tank farm expansion on Burnaby Mountain increases risk to SFU, in part because of the greater volume of product that will be flowing through the pipelines and stored in an enlarged tank farm.

The following section provides a more detailed discussion of our review findings in the context of chemical exposure, fire, and air quality and emergency planning. Although the discussion below has been grouped under these headings, the reality is that they are all related and any particular incident has multiple consequences.

4.1 Chemical Exposure Hazards to SFU

Incident/Issue 1 – There are a variety of hazards that can result in spills or product leaks from pipelines as a result of cracking, fractures, or corrosion. Natural causes include earthquakes and landslides; technological causes include corrosion and equipment failure; and human causes include incorrect operation and construction errors.

Consequence/Effect 1 – Uncontrolled product releases can lead to unacceptable human exposure to chemicals. For SFU, exposure would occur through inhalation of volatile substances.

Diluted bitumen is currently the major product that will be transported through the TMEP (Intrinsik, 2013, 2014). Since the greater pipeline capacity will move proportionately more heavy crude, the likelihood is that any spilled product will be dilbit.

One dilbit blend – Cold Lake Winter Blend (CLWB) – has been tested for health effects and has been shown to contain chemicals sufficiently volatile to be a potential acute hazard to human health from inhalation exposure (Intrinsik, 2014. Table 4-4, Table 4-6). These compounds and their effects are identified in the table below.

While CLWB is the most common dilbit to pass through the pipeline, other dilbit will also be shipped. Most of these other blends have not yet been tested for their specific content or health effects, so the potential health effects of a spill of these other blends is unknown.

Chemical Groups	CLWB Chemical Components	Potential Effects
Aliphatic C1-C4 group	iso-Butane, n-Butane, Propane	Neurological effects
Aliphatic C5-C8 group	iso-Pentane, n-Pentane, Aliphatics C6-C8	Unspecified
Aliphatic C9-C12 group	Aliphatics >C8-C10, Aliphatics >C10-C12	Unspecified
Aromatic C9-C12 group	Aromatics >C8-C10[2], Aromatics >C10-C12	Eye irritation
Benzene	Benzene	Immunological effects, known carcinogen
Dibenzothiophene	Dibenzothiophene	Unspecified
Dimethyl sulphide group	Dimethyl sulphide, Methyl ethyl sulphide	Unspecified
Ethanethiol group	Ethanethiol, iso-Propanethiol, Thiophene/sec-Butanethiol, n-Butanethiol, n-Hexanethiol	Respiratory irritation
Ethylbenzene	Ethylbenzene	Neurological effects
Toluene	Toluene	Eye and nasal irritation, neurological effects
Trimethylbenzenes	1,2,4-Trimethylbenzene	Neurological effects
Xylenes	Xylenes	Respiratory irritation, neurological effects

Acute/short-term exposure to the substances listed in the table is known to cause neurological and immunological effects, and they are irritants to the eye, nasal, and respiratory systems. Depending on the extent of the release event, the location, and weather patterns, there would be potentially greater exposure and risk to the SFU population. There might also be restrictions on egress routes, preventing escape from exposure.

Additionally, benzene (shown above) is a known carcinogen (i.e., cancer-causing agent) in humans (Health Canada, 2013; US EPA, 2016; WHO, 2010).

4.2 Fire/Air Quality Hazards to SFU

The TMEP changes to the tank farm will alter the "risk environment" associated with fires on Burnaby Mountain in several ways.

The Burnaby Fire Department, in their analysis of the changes to fire safety and risk, indicate the Burnaby Mountain Terminal is not the appropriate location for the expansion for a number of reasons:

- The slopes and general topography are not appropriate;
- Limited site area and access; and
- Close proximity to a number of neighbourhoods including SFU and sensitive conservation areas.

Some of these factors/issues pose significant challenges for:

- Ensuring firefighter safety;
- Combatting, containing, and extinguishing fires;
- Evacuating Burnaby Mountain Terminal employees and adjacent neighbourhoods; and
- Protecting adjacent properties, including conservation areas.

Components of this risk are discussed below.

Incident/Issue 2 – Changes in the Burnaby tank farm will alter the "risk environment" in the area.

Consequence/Effect 2 – The risk of community impacts outside of the tank farm increase by 70% because of the increase in likelihood of adverse events (City of Burnaby Fire Department, 2015).

Incident/Issue 3 – The TMEP proposal includes densification of the facility, adding more and larger product storage tanks. The addition of storage tanks decreases the distance between each tank.

Consequence/Effect 3 – There is increased hazard because the original fire protection premise of the facility degrades or deteriorates in the TMEP scenario based on a greater potential for multiple tank fires (fire spreading from tank to tank) and increased complexity in a fire-fighting scenario.

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.

Additionally, the general configuration proposed does not provide sufficient safe access routes and operating positions from which firefighters could apply protective streams to isolate or extinguish fire events. The elevation changes (i.e., slopes) within the 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 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.

Incident/Issue 4 – Petroleum products are flammable by nature; dilbit is more flammable than other crude products. Spill or release may be more likely to result in fires or explosions.

Consequence/Effect 4 – Fire/explosion events are extremely dangerous. Increased heavy crude storage (including dilbit) results in increased risk to SFU by virtue of increased risk of fire. McCutcheon and Associates (2013) discussed various fire scenarios and their effects. The three specific scenarios considered were:

- A tank fire caused by a major oil-tank release;
- A toxic cloud release from a fire (includes smoke and SO_2); and
- A boil-over (specific type of fire scenario).

Two effects – **radiant heat** and **smoke** – were considered most significant. The potential impact extent was estimated for radiant heat, the smoke plume, and sulphur (SO_2). The immediate impact of radiant heat from fire at the facility is estimated to be up to 224m from the dike walls and as far as 536m[1]. The modelled concentrations for smoke and SO_2 were compared to Emergency Response Planning Guidelines and Immediately Dangerous to Life and Health levels. Smoke is estimated to drift downgradient up to 43km. SO_2 is modelled to extend as far as 5.2km. The SFU campus is less than 1km northeast of the Burnaby Terminal component of the TMEP.

In the case of one type of fire known as a **boil-over event**, which is extremely rare, heated, molten crude oil can be discharged to a height of 1km and a range of 0.76km. These distances would affect the SFU campus. The consequences of boil-over exposure would include human injuries to emergency responders and un-evacuated civilians, mass tree-top based wildland fire initiation, structural fire initiation to many residential buildings, potential tank fire initiation within the tank farm and the Shellmont Tank Farm, and significant isolation of the SFU and UniverCity communities.

[1] At 536m, the radiant heat energy is equivalent to a sunburn (1.0 kWfm2) (McCutcheon and Associates, 2013).

Incident/Issue 5 – There is no evidence of the extent of verification completed of the modelling system for the Burnaby-SFU region.

Consequence/Effect 5 – The air quality modelling completed by Trans Mountain may not adequately represent the exposure/risk from plumes impacting air quality since there was no specific modelling completed for the unique environment of Burnaby Mountain.

Trans Mountain mainly used the CALPUFF[2] modelling system to comply with the regulatory requirements of the British Columbia air quality standards. Etkin et al. (2015) noted these potential errors in the application of the methodology, as follows:

1. The model has been completed using baseline weather data from YVR and without corrections for topography, suggesting that the model may not accurately represent baseline conditions at SFU;
2. There is a lack of site-specific verification of the model's applicability to the site; and
3. There is no evidence to show that Trans Mountain conducted adequate and a sufficient number of air dispersion simulations of toxic chemical compounds resulting from a catastrophic release of these chemicals.

Taken together, these flaws reduce the confidence in the risk assessment as it applies specifically to SFU.

4.3 Emergency Planning Impact for SFU

As above, this section is divided into several discrete incidents.

4.3.1 Information for Evacuation Planning

Incident/Issue 6 – Trans Mountain's intention to address evacuation planning in conjunction with the City of Burnaby, SFU, RCMP, BC Ambulance, and Burnaby Fire has been referenced in multiple Information Requests. However, SFU is not identified as a stakeholder in the existing plans, nor is this addressed in the available documents (Etkin et al., 2015).

Consequence/Effect 6 – Responsibility for evacuation of the campus lies with SFU. In order for effective evacuation plans, SFU requires solid information regarding risks. Trans Mountain is responsible for providing this information (i.e., they are responsible for determining recommendations relating to evacuation, such as identifying potential at-risk communities). This is not clearly identified in the facilities application, site-specific plans, or the Information Request responses. As a result, SFU does not have adequate information to develop provisions for evacuation or emergency response.

[2] CALPUFF is an advanced modelling system for the simulation of atmospheric pollution dispersion. It simulates the effects of time- and space-varying meteorological conditions on pollution transport, transformation, and removal. CALPUFF can be applied for long-range transport and for complex terrain.

4.3.2 Poor Design for Emergency Response

Incident/Issue 7 – Worst-case scenarios of fires or explosions, and exposure to resulting plumes, have the potential to impact, or even envelop the university.

Consequence/Effect 7 – Because of the decreased distance between the new storage tank locations and the junction of Burnaby Mountain Parkway and Gaglardi Way, SFU becomes more vulnerable to isolation; if the sole access/egress point is blocked, escape ceases to be a viable emergency response option.

4.3.3 Insufficient Modelling for Response Planning

Incident/Issue 8 – There is no evidence to show that Trans Mountain conducted adequate and a sufficient number of air dispersion simulations of toxic chemical compounds resulting from a catastrophic release.

Consequence/Effect 8 – There is no scientifically sound basis for SFU to develop an emergency response management plan because of the insufficient information.

5.0 STANDARD LIMITATIONS

PGL prepared this letter report for our client and its agents exclusively. PGL accepts no responsibility for any damages that may be suffered by third parties as a result of decisions or actions based on this letter report.

PGL relied on the listed documents for site information to prepare this opinion and as such, the limitations of our review are at least as great as those documents.

The findings and conclusions are site-specific and were developed in a manner consistent with that level of care and skill normally exercised by environmental professionals currently practising under similar conditions in the area. Changing assessment techniques, regulations, and site conditions means that environmental investigations and their conclusions can quickly become dated, so this report is for use now. The report should not be used after that without PGL review/approval.

The project has been conducted according to our instructions and work program. Additional conditions, and limitations on our liability are set forth in our work program/contract. No warranty, expressed or implied, is made.

Respectfully submitted,

Michael Shum, Ph.D., P.Ag., R.P.Bio.
Senior Environmental Consultant

Leslie M. Beckmann, M.A.
Senior Environmental Consultant

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