Maplewood Chemical Hazard DPA
Preliminary Study

For

The District of North Vancouver

FINAL REPORT

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Prepared By:

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EXECUTIVE SUMMARY:

The "Scope of Work" included:

1. *Review the inventory of chemicals by substance type, location and maximum quantity and assess what substances pose a theoretical risk to residents/businesses in the nearby Village Centre.*
2. *Identify the geographical scope of potential risk and recommend the boundaries of the eventual Development Permit Area.*
3. *Discuss the relative merits of building, site and area-level measures to mitigate any identified theoretical risks.*

In "Step 1" the identified chemicals were assessed for potential to cause harm to the community of Maplewood. Four existing industrial operations plus a proposed new one were looked at in terms of risk and acceptability to the community using the Major Industrial Accidents Council of Canada risk based land use planning criteria. An analysis for hazards followed by calculations to determine the extent of impact outside the company property lines and the probability of such events was undertaken for this report. The result showed only those hazards and risks for the Canexus facilities are of concern. All other facilities either had no concerns or the impact could only be felt within their company property lines.

For "Step 2" of the Scope of Work, The opportunity to utilize the Canexus peer reviewed Quantitative Risk Assessment was instrumental in forming the basis for suggesting risk based planning needs for the proposed Maplewood community development. Because there are no other company risks to consider using the Canexus study provided a sound approach to determine acceptable buildings and occupancies, a clear opportunity to implement the MIACC criteria, Canada's best practice.

The MIACC Criteria is shown as a pictorial view on Figure 3 on page 16. It was developed in conjunction with a global approach to understanding just what society is willing to accept in terms of the impact from industrial operations. An industrial facility needs to control its level of risk but if it has the potential to impact beyond the property line, certain activities are allowed as one gets further away from the industrial site because the risk levels decline as one moves further from the industrial source based on the MIACC approach. The further away from the source of risk more activities for a higher concentration of people are allowed. As seen in Figure 3 a smaller graph indicates the numbers of people impacted can grow continuously the further out from the industrial facility one gets. The point is it is not a "step change" but a continuous gradual change.

The MIACC approach does not prescribe specific distances to each risk level. This is left up to individual jurisdictions to decide on based on their circumstances such as the type of industry, the type of community, and the emergency planning needs of the area, either way the company is responsible to meet the risk criteria and the most stringent criteria will dictate what they include in their facility designs.

The MIACC approach to risk based land use planning accepts that if the risk levels to the community are less than one chance in a million of a fatality (1×10^{-6}), there is no requirement

to add additional measures to the already existing building codes. This review specifically noted the impact of a Chlorine or Hydrogen Chloride release from Canexus would have offsite consequences potentially leading to fatalities. The Canexus *"Technology Conversion Project" (TCP*) - *2006* Quantitative Risk Assessment by Dr. Alp shows there can be consequences impacting the community but since the probability is so low the impacts are within acceptable limits. Further, if advance warning systems are in place to alert the community and if residents close their windows and doors (shelter in place) there is ample time to protect oneself in an emergency (*Dr. David Wilson University of Alberta*). Typically a major release will take a lot of time (many minutes and possibly up to an hour) to travel to the residential community leaving the emergency response teams time to work at implementing an effective plan to evacuate people.

A release of Chlorine will create a heavier than air cloud that will stay together and move with the wind. That cloud will stay close to the ground as it moves forward mixing with air on the cloud surface. The mixing action will eventually dilute the cloud to a lower safe concentration a certain distance down wind. Because the cloud is heavier than air it moves with the wind but slowly as the wind brushes over the body of the cloud. Further the cloud movement will be slowed by obstructions on the ground. Some of it will be absorbed by moisture in the air and vegetation. it will take time to reach the Village area. Further the cloud will have some early warning odours at very low concentrations giving time for people to take action before their safety is compromised.

For the case of a Hydrogen Chloride (HCl) vapour release the scenario is somewhat different because HCl is not as heavy as Chlorine gas and closer to air. The cloud will move forward with the wind with more mixing action. Similar to Chlorine the cloud will travel next to the ground and be impacted by obstructions as it moves forward. HCl is easily absorbed in water where Chlorine is not. And HCl also is detectable at very low concentrations giving time for people to react in a safe manner.

Applying the MIACC criteria to the proposed community layout it is recommended to designate Spicer Road as risk contour 1×10^{-5}, Front Street as risk contour 1×10^{-6} and Old Dollarton as the 0.3×10^{-6} risk contour, appropriate building developments would fit the existing plan as well as provide tools for determining acceptable future development projects. Applying the MIACC criteria to the proposed community beyond the 1×10^{-6} risk contour line (north of Front Street) would require no additional scope to the building designs. This would also mean no specific additions to building requirements would be needed to ensure acceptable risk levels, with the exception of a small area on the south side of the 1×10^{-6} risk contour (GWL holdings, north of Dollarton Highway and south of Front Street) for buildings with residential components where the following are suggested:

- HVAC systems that maintain a slight positive pressure inside the building to keep Chlorine from entering.
- Including toxic gas detectors for Chlorine on building HVAC systems to automatically shutdown air intake on high Chlorine levels.
- At least two stair wells with battery back up lighting and sealed doors at each floor level.
- Emergency phones for contact with emergency responders and building residents.
- Building PA system.
- Use local radio and TV stations for communications to residents.

- Building owners and management would need to ensure emergency plans for all residents in the building clearly defining what to do to protect themselves should they be asked to evacuate or to shelter inside.

"Step 3" of the Scope of Work basically boils down to developing a specific emergency plan for the new Maplewood community with special consideration for the zone between Front Street and Dollarton Highway. Here there is some residential development proposed. Because the design for the residential area is for multi story buildings there is a need to recognize some special design considerations as noted above.

Emergency planning and notification systems complement building designs and for the Maplewood area should also be considered as a means to protect residents and at least provide comfort and quality of life. Although risk assessments do not take into consideration existing emergency response planning the outcome of risk assessments is the basis for developing emergency plans, based on understanding the risks involved. In fact this is exactly the premise for emergency planning in Canada as described in Canadian Standards Association guideline *"CAN/CSA-Z731-03 - Emergency Preparedness and Response"*. Such emergency plans when promptly initiated and followed through will reduce the consequences of major incidents.

Recommendations include:

- Ensure there is a special emergency planning recognition of the residents living in the zone between 1 X 10^{-5} and 1 X 10^{-6} risk contours (New Dollarton and Front Street).
- For any residences between the 1 X 10^{-5} and 1 X 10^{-6} risk contours provide for at least two roads in and out of the areas and no dead end roads where there is only one exit. Where possible this may not be practical to do for example Seymour River Place), the emergency plan should note these as a special case within the emergency plan for alternative action such as alternate evacuation pathways.
- Recommend including an automated phone calling system to alert citizens downwind of a Chlorine release in the area between the 1 X 10^{-5} and 1 X 10^{-6} risk contours. These systems do have challenges but are a reliable tool to use in emergency communications. It is recommended the District strongly encourage residents in the area to register annually and make it a requirement for strata's and rental buildings.
- Consider including emergency sirens activated specifically for Chlorine releases for notification of people within the 1 X 10^{-5} and 1 X 10^{-6} risk contours. They have a simple way of communicating serious emergencies and if their installation and use are communicated well with the community they can be a very useful tool. They need to be routinely and regularly tested which is something that can be incorporated into regular emergency planning communications activities already conducted. The sirens are costly and do require regular maintenance though. It is recommended that these be a requirement for Strata and rental buildings.
- All the recommendations need to be done in consultation with the Emergency Services department.

The intention of this report is to assess the proposed development and make recommendations for defining the "Development Permit Area" (DPA) from a risk based land use planning approach. Maintaining a positive relationship between the industrial activities and the residential life style is at the basis of the risk based approach and the MIACC criteria. Through recognizing the global involvement towards determining acceptability of risk and applying that

outcome into developments like this that positive relationship can be successful. The community can be satisfied they meet the global and Canadian standards and industry can be successful into the future knowing what they need to do to manage their operations to meet that standard., and not fear future encroachment on their operations.

I believe this analysis is appropriate for the study area. Please let me know of any questions. Thank you for asking me to develop this review.

Doug McCutcheon, P. Eng.

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GENERAL REPORT:

INTRODUCTION TO RISK (Specifically Industrial Risk):

Risk = (Consequence) X (Probability)

Industrial Risk is the potential (probability) to cause a fatality (consequence) to an individual and is expressed as a number for example; one chance in a million ($1 X 10^{-6}$) or one chance in ten thousand ($1 X 10^{-4}$), etc.

As a society we have various needs and demands in order to enjoy our quality of life. Industry depends on these demands and supports our needs but included in their industrial activities is a certain amount of potential (probability) for something unwanted (consequence) to happen. It turns out that there is always a probability for that unwanted consequence to happen, it is never zero. Recent examples of such events include the Costa Concordia cruise ship disaster or the recent BC sawmill explosions and fires where the public may have been put in situations where there may be fatalities.

In 1984 a major industrial accident happened in Bhopal India where a very large release of a toxic chemical killed approximately 2,500 people within hours and well over 20,000 deaths have resulted from that event to date. That incident impacted the world in general. The unacceptability of that event initiated a global response resulting in standards and guidelines to be used to proactively determine:

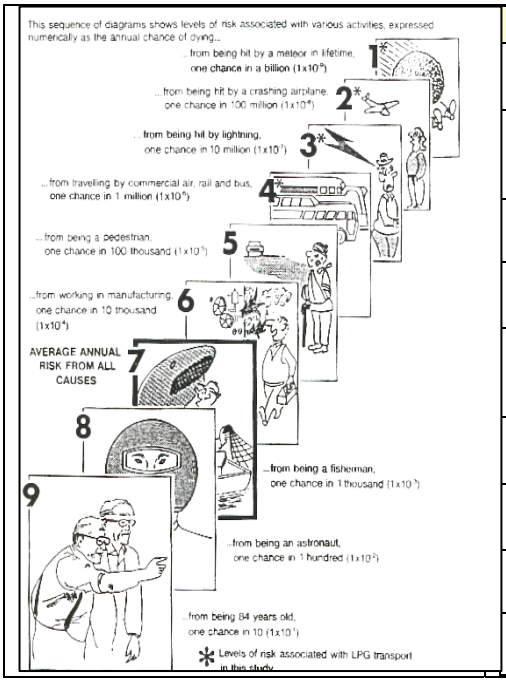
- What the consequence would be in terms of fatalities from such an event.
- What the probability (likelihood) of such an event happening would be, and
- What would be considered to be an acceptable level of risk we can measure our activities against, and finally
- How to manage any of that risk to prevent the unwanted event from happening.

A very key part of the development of these standards and guidelines was to determine what society considers an "Acceptable Level of Risk". To this end a global dialogue ensued resulting in:

- ***If the annual probability of a fatality imposed on an individual located in one location for an entire year is less than one chance in a million ($1 X 10^{-6}$) the risk is considered to be acceptable.***

Note this is based on an individual being exposed involuntarily to an industrial operation for an entire year. This allows for calculating risk numbers for comparison purposes. To put this in context, below is Figure 3 describing the probability of a fatality that may give a basis to help understand what society is willing to accept in terms of that probability of a fatality in order to enjoy the quality of life we demand as a society today.

Figure 1: Annual Risk of Dying – Individual Risk *(Institute of Risk Research University of Waterloo)*
* Taken from a study on transporting hazardous materials.



Risk Level	What it Means	
1 X 10^{-9} One in a billion	From being hit by a meteor in a lifetime	
1 X 10^{-8} One in a hundred million	From being hit by a crashing airplane	
1 X 10^{-7} One in ten million	From being hit by lightening	
1 X 10^{-6} One in a million	**From traveling by commercial air, rail or bus**	
1 X 10^{-5} One in a hundred thousand	From being a pedestrian	
1 X 10^{-4} One in ten thousand	From working in a manufacturing facility	
1 X 10^{-3} One in a thousand	Average annual risk from all causes. From being a fisherman	
1 X 10^{-2} One in a hundred	From being an astronaut	
1 X 10^{-1} One in ten	From being 84 years old	

Globally the acceptable level of risk for an industrial operation is similar to that risk that we as individuals are willing to accept when we travel by commercial air, rail or bus transportation systems where the pilot or train engineer or bus driver are in control. In fact industry is expected to design and operate facilities to not exceed this acceptable risk level ceiling.

In order to test this global opinion the courts of the United Kingdom were asked to participate and concluded this to be reasonable for society today to expect from industrial developments. The result is many of these standards have found there way into regulation and law in various countries. Also it is considered to be best practice meaning professional judgement around industrial projects needs to include this type of analysis.

Finally, Canada has been actively involved and through the work of the Major Industrial Accidents Council of Canada (MIACC) produced the accepted technical guidance needed and is recognized as Canada's best practice here and abroad. Some jurisdictions have included the MIACC approach in land use bylaws and some standard setting organizations have referenced the MIACC approach. This risk assessment uses the MIACC approach.

PROCESS USED TO COMPLETE THE STUDY:

SCOPE OF WORK

Description of Work

The objective of this study is to facilitate the responsible (re)development of the Maplewood Village Centre by identifying the area and relative risk of chemical hazards and evaluating a range of planning/design measures that would reasonably mitigate developments from the potential risk (if any) of proximate chemical industries. This has three main and sequential aspects are noted in the following steps:

1. ***Review the inventory of chemicals by substance type, location and maximum quantity and assess what substances pose a theoretical risk to residents/businesses in the nearby Village Centre***. *This study should assess the levels of risk posed by different substances and articulate which risks can be reasonably addressed through site planning and building design measures and which by can only be addressed by other means (e.g. emergency response).*
2. ***Identify the geographical scope of potential risk and recommend the boundaries of the eventual Development Permit Area***. *If appropriate, this mapping should indicate the varying degrees of risk associated with different areas if alternative design measures should apply in these sub-areas.*
3. ***Discuss the relative merits of building, site and area-level measures to mitigate any identified theoretical risks***. *The consultant is expected to provide judgement on the relative efficacy (the capacity to produce an effect.) of different design tools for managing the built environment, including for example: site planning, building orientation and design; fenestration (Openings in a building) and ventilation controls; notification measures (e.g. sirens, sensors); shelter in place provisions. If appropriate, these recommendations should indicate the relative suitability or necessity of recommended measures as they may apply to different land uses, building forms and/or densities.*

In a subsequent phase of this project, the findings and recommendations of this study will inform the establishment of a development permit area where specific design guidelines apply.

PROCESS USED FOR STEP 1:

Review the inventory of chemicals by substance type, location and maximum quantity and assess what substances pose a theoretical risk to residents/businesses in the nearby Village Centre.

A risk assessment consists of first identifying hazards that may have an adverse impact outside the company property lines, refer to Appendix 3 *"Risk Management Process"*. Once the hazards are known consequences and probabilities can be determined for each hazard. Step 1 of the Scope of Work followed the risk assessment process for hazard identification, consequence analysis and a probability study to determine first if there is a "risk" concern to be aware of. In Canada the process defined through the Major Industrial Accidents Council of Canada (MIACC) follows the steps identified above as best practice.

1. Hazard Identification:

The MIACC process for risk assessments identifies six group characteristics to consider;

Table 1: MIACC Hazard Identification Groups and Characteristics

Group	Group Characteristics
A	Flammable liquids (pool fire hazard)
B	Flammable liquids (flash fire hazards)
C	Liquefied flammable gases (flash fire hazard)
D	Toxic gases liquefied by compression (toxic cloud hazard)
E	Toxic gases liquefied by cooling (toxic cloud hazard)
F	Toxic liquid (toxic cloud hazard due to evaporation)

NOTE: One additional concern was added to consider the impact of a shockwave (overpressure) from an explosion.

Hazards identified for this project included:

- Impact due to a fire (UNIVAR and NEWALTA have identified concerns)
- Impact as a result of a toxic release to the community (Hydrogen Sulphide at NEWALTA, Chlorine and Hydrogen Chloride at Canexus concerns were identified)
- Damage as a result of an explosion (the new *"Hydrogen Technology and Energy Corporation"* (HTEC) project concern was identified)

Chemical inventories for four neighbouring companies were provided and compared to the MIACC lists of hazardous substances (reference; *"MIACC Hazardous Substances Risk Assessment: a Mini-Guide for Municipalities and Industry – 1994"*). This guide is a listing of hazardous substances which are frequently encountered in Canada which, if released, could cause fatalities off company sites. A "threshold quantity" is listed for each substance where a risk assessment is recommended if the company exceeds those quantities.

Of the chemicals considered there were two at Canexus identified, Chlorine and Hydrogen Chloride gas (both group "D" characteristics) as the major risk issue that could impact the Maplewood community. Other chemicals having the possibility of creating offsite fatalities include:

- Ethanol is stored in large quantities in two large tanks at UNIVAR Canada and is highly flammable (group "A" characteristics). Although not on the MIACC Hazardous

Chemicals list should a fire develop the impact of the radiant heat will extend beyond the company property line.

- H_2S is generated at the NEWALTA facility and a release of small amounts could be harmful to the public.
- Sodium Chlorate was noted as a product manufactured and stored at ERCO Worldwide but is not considered directly harmful. Sodium Chlorate will though, act as an oxidizing agent and accelerate a fire scenario in the case of a warehouse fire liberating small concentrations of Chlorine to the atmosphere.
- Hydrogen Peroxide is used by NEWALTA and ERCO Worldwide which is also an oxidizing agent in a fire situation.
- A lubricating oil fire contained within the NEWALTA site can create radiant heat sufficient to cause fatalities if heated.
- Other chemicals listed are of very small quantities and not harmful off site.
- Or in the case of Caustic Soda, Ethylene Glycol, and Hydrochloric Acid which are in large quantities, there are no offsite impacts.

2. Consequence Analysis:

For each hazard identified there is one or more consequence to consider. When evaluating possible consequences the concern is how far outwards from the company facility can fatalities be expected. There is a distance that can be calculated and the objective is to determine where that will be for a realistic worst case scenario. Once defined, for the worst case, all other possible scenarios will be of less impact. Tables 2 & 3 below describe for different events how to measure what the consequence of a fatality will look like. The consequences listed in the middle column (irreversible effects) are used to measure that distance.

Table 2: Some Types of Measurable Consequences

TYPE OF INCIDENT	**CONSEQUENCE Odour/Irritation Threshold**	**CONSEQUENCE Irreversible Effects Threshold**	**CONSEQUENCE Life Threatening Effects Threshold**
Toxic Release (concentration - 1 hour exposure)	ERPG-1	ERPG-2	ERPG-3
Fireball - Immediate Ignition (radiation intensity - 60 second exposure)	1st Degree Burns 2 Kw/m^2 600 BTU/hr/ft^2	2nd Degree Burns 5 Kw/m^2 1600 BTU/hr/ft^2	3rd Degree Burns 8 Kw/m^2 2500 BTU/hr/ft^2
Flash Fire – Delayed Ignition (flammable gas dispersion)	NOTE there is no lower level consequence	1/2 of Lower Flammability Limit	1/2 of Lower Flammability Limit
Pool / Jet Fire (radiation intensity - 90 second exposure)	1st Degree Burns 1 Kw/m^2 400 BTU/hr/ft^2	2nd Degree Burns 4 Kw/m^2 1200 BTU/hr/ft^2	3rd Degree Burns 6 Kw/m^2 1900 BTU/hr/ft^2
Unconfined Vapor Cloud Explosion (overpressure)	Window Breakage 0.3 psig 0.02 bar	Partial Demolition of Houses 1.0 psig 0.07 bar	Threshold of Ear drum rupture. Lower limit of serious structural damage 2.3 psig 0.16 bar

Definitions:

Kw/m^2: are kilowatts per meter squared. A measure of heat energy over a surface area.

Psig & bar: are measures of pressure

ERPG-1: is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for one hour without experiencing other than mild transient adverse health effects or perceiving a clearly objectionable odour.

ERPG-2: is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing any irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.

ERPG-3: is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.

Table 3: Consequences Specific to Thermal Radiation Incidents

(CCPS – "Guidelines for Chemical Process Quantitative Risk Analysis, second edition – 2000")

Intensity Kw/m^2	Consequential Exposure Damage to People	Consequential Damage to Equipment
37.5	• Significant injury after 10 seconds exposure. • 1% lethality after 10 seconds exposure • 100% lethality after 100 seconds exposure	Sufficient to cause damage to process equipment.
25	• Significant injury after 10 seconds exposure. • 1% lethality after 30 seconds exposure • 100% lethality beyond 100 seconds exposure	Minimum energy to ignite wood at indefinitely long exposures & "unpiloted".
12.5	• Significant injury after 60 seconds exposure. • 1% lethality after 80 seconds exposure	Minimum energy required for "piloted" ignition of wood, melting of plastic tubing
9.5	• Significant injury after 60 seconds exposure. • 1% lethality after 80 seconds exposure	No significant damage
4 **	• Significant injury after 90 seconds exposure.	No significant damage
1.6	• Pain threshold met after 60 seconds	No significant damage

***** Any intensity level that is greater than 4 kw/m^2 can lead to fatalities.***

Once the main hazardous chemical (Chlorine and Hydrogen Chloride) were identified along with Ethanol, Hydrogen Sulphide, Hydrogen and lubricating oil as there were large quantities of these noted, a consequence analysis was conducted and shown of the individual plants in Table 4 below. Calculations included toxic cloud impacts for Chlorine and Hydrogen Sulphide and radiant heat impacts from fires involving Ethanol and lubricating oil. The consequence results are noted here and shown in Appendix 2:

Table 4: Consequences Having the Potential to Impact Maplewood

Company	Chemical	Impact
Canexus	Chlorine	As described in the Alp Risk Assessment report the risk of a fatality will be one in a million ($1 X 10^{-6}$) just north of Front Street.
	Hydrogen Chloride gas	A release will impact beyond the Canexus property line but within the impact distances for Chlorine.
	Hydrogen Explosion	An impact of up to 28 metres from inside the site with no impact beyond the property line.
NEWALTA	Hydrogen Sulphide gas	A release from the Hydro-treater unit will not be impactful beyond the property line.
	Lubricating Oil	A lubricating oil spill and possible fire will not impact beyond the property line.
UNIVAR	Ethanol	A major tanks spill to the diked area will have a radiant heat impact about 155 metres from the tanks but will not impact the Maplewood Village area.
HTEC	Hydrogen Explosion	Can impact up to 200 metres from the site location and will not impact beyond the property line.
	Hydrogen fire	An impact of up to 100 metres with no impact beyond the property line.
ERCO Worldwide	None of note	None to note

Of the chemicals two at Canexus were identified, (*Chlorine and Hydrogen Chloride (HCl) gas both group "D" characteristics*) as the major risk issue that could impact the Maplewood community. Both have a strong odour at low safe concentrations which act as early warning properties and an emergency can be responded to effectively. However they are different, of note is a release of HCl gas is more easily handled as water spray will absorb the gas, where only small amounts will be absorbed in water for a Chlorine gas release. An emergency plan for a Chlorine release will be very similar to that for a Hydrogen Chloride release.

Other chemicals having the possibility of creating offsite fatalities include:

- Ethanol stored in large quantities in two large tanks at UNIVAR Canada and is highly flammable (group "A" characteristics). Although not on the list should a fire develop the impact of the radiant heat will extend beyond the company property line but will not impact the Maplewood Village Centre area.

There were other concerns evaluated:

- H_2S is generated at the NEWALTA facility but not enough to escape the property that would be harmful to the public.
- Sodium Chlorate was noted as a product manufactured and stored at ERCO Worldwide but is not considered directly harmful to the Maplewood Village Centre. Sodium Chlorate will act as an oxidizing agent and accelerate a fire scenario in the case of a warehouse fire liberating small concentrations of Chlorine to the atmosphere.
- Hydrogen Peroxide is used by NEWALTA and ERCO Worldwide which is also an oxidizing agent in a fire situation and not considered to be harmful to the Maplewood Village Centre.
- A lubricating oil fire contained within the NEWALTA site can create radiant heat sufficient to cause fatalities but only on site and not beyond the property line.

- Other chemicals listed are of very small quantities and not harmful off site.
- Or in the case of Caustic Soda, Ethylene Glycol, and Hydrochloric Acid which are in large quantities, there are no offsite impacts.

3. The Probability Study:

As noted at the beginning, risk is a combination of consequences and probabilities. Using the tools and methods we have today consequences can be accurately determined. As far as the probability side of the risk equation they too can be accurate and reasonable. Generally company data is the more accurate data but there have been peer reviewed research data made available too which can give an accurate value as well, usually a conservative value.

The probability data used is described as a number between 0 and 1 on an annual basis. 0 meaning it will never happen and 1 being it always is happening. As one will see these risk assessments are using numbers that are very low like 0.000001 (1×10^{-6}) and almost zero. The public is not very willing to accept risk but if they want to have a certain standard of living they must take some risk but not very much. This puts a lot of emphasis on companies to build, operate and manage their business with care. It also puts emphasis on building codes and standards to be strong.

Probability values were assumed from the Canexus TCP Project - Alp QRA for Chlorine and as shown on Figure 19 as the annual probability of a fatality to the Maplewood area. The result is a probability of a fatality just north of Front Street of 1×10^{-6} (one chance in a million on an annual basis).

For the other consequences accepted and conservative peer reviewed academic probabilities were used as shown in Tables 5, 6 & 7 below.

- For the Hydrogen Chloride gas release the probability chosen was 1×10^{-4} to 6×10^{-6} on an annual basis, based on a tank leak.

- For the UNIVAR flammable Ethanol case the probability is 1×10^{-5} to 6×10^{-7}, a tank leak that catches fire. (*Note only 10% of these types of flammable liquid releases catch fire*).

- The probability for the release of Hydrogen Sulphide from the NEWALTA site is 1×10^{-8} to 1×10^{-10}, based on a piping leak on site.

- And the probability of a pressure tank release of Hydrogen at HTEC is 1×10^{-5} causing an explosion and fire.

Failure Data for several situations have been identified through various analyses around the world. Below are a few databases, which would be appropriate for these circumstances. These databases have been developed as research projects and have undergone rigorous peer review to ensure their validity. Normally, company databases will provide a more accurate probability, however few companies collect this data. The probability data shown in Tables 5 & 7 are used for this analysis.

Table 5: Probability Data from the Canvey and Rijmond Reports

Type of failure	Canvey Report # Incidents / year	Rijnmond Report # Incidents / year
○ Pipe leak	3×10^{-4} /km	1×10^{-8} to 1×10^{-10}
○ Tank leak		1×10^{-4} to 6×10^{-6}
○ Railcar derail & spill	1×10^{-6} /km traveled	
○ Pump failure	1×10^{-4}	1×10^{-4}
○ Hose failure		4×10^{-5} to 4×10^{-6}
○ Valve opening (relief valve)		1.4×10^{-5} to 3.6×10^{-5}
○ Truck road spill incident	1×10^{-8}/km traveled	

Data from the UK HSE analysis of incidents 1978 and from the Netherlands review 1982 For a Rotterdam link to the North Sea.

Table 6: Probability Data from the Center for Chemical Process Safety

Type of failure	Center for Chemical Process Safety Mean Time Between Failures (MTBF)
○ Operator error (serious incident)	252,000 hours or once per 28 years
○ Detection system failure	220,000 hours or once every 25 years
○ Truck loading or unloading failure	1,156,000 hours or once every 131 years
○ Spills and leaks	148,000 hours or once every 17 years
○ Process control system failure	167,000 hours or once every 19 years

Data from an analysis of LNG plants by CCPS (1 year = 8,760 hours)
Data is also per person, per system, per truck operation, per tank.

Table 7: Probability Data from the Center for Chemical Process Safety

Type of Failure	Probability	Source(s)
○ Atmospheric storage tank release	1×10^{-4}	Rijnmond Report
○ Pressure storage tank release	1×10^{-5}	Canvey Report
○ In-plant piping release	1×10^{-9}	Rijnmond Report
○ Pipelines	6.2×10^{-4}/Km	ERCB
○ Pumps	1×10^{-4}	Rijnmond & Canvey Reports
○ Truck transport incident	1.6×10^{-8}/Km	Transport Canada
○ Rail transport Dangerous Goods release	3.8×10^{-8}/Km	Transport Canada
○ Hose failure and full bore release	4×10^{-5}	Rijnmond Report
○ BLEVE's	1×10^{-10}	Lees

PROCESS USED FOR STEP 2:

Identify the geographical scope of potential risk and recommend the boundaries of the eventual Development Permit Area.

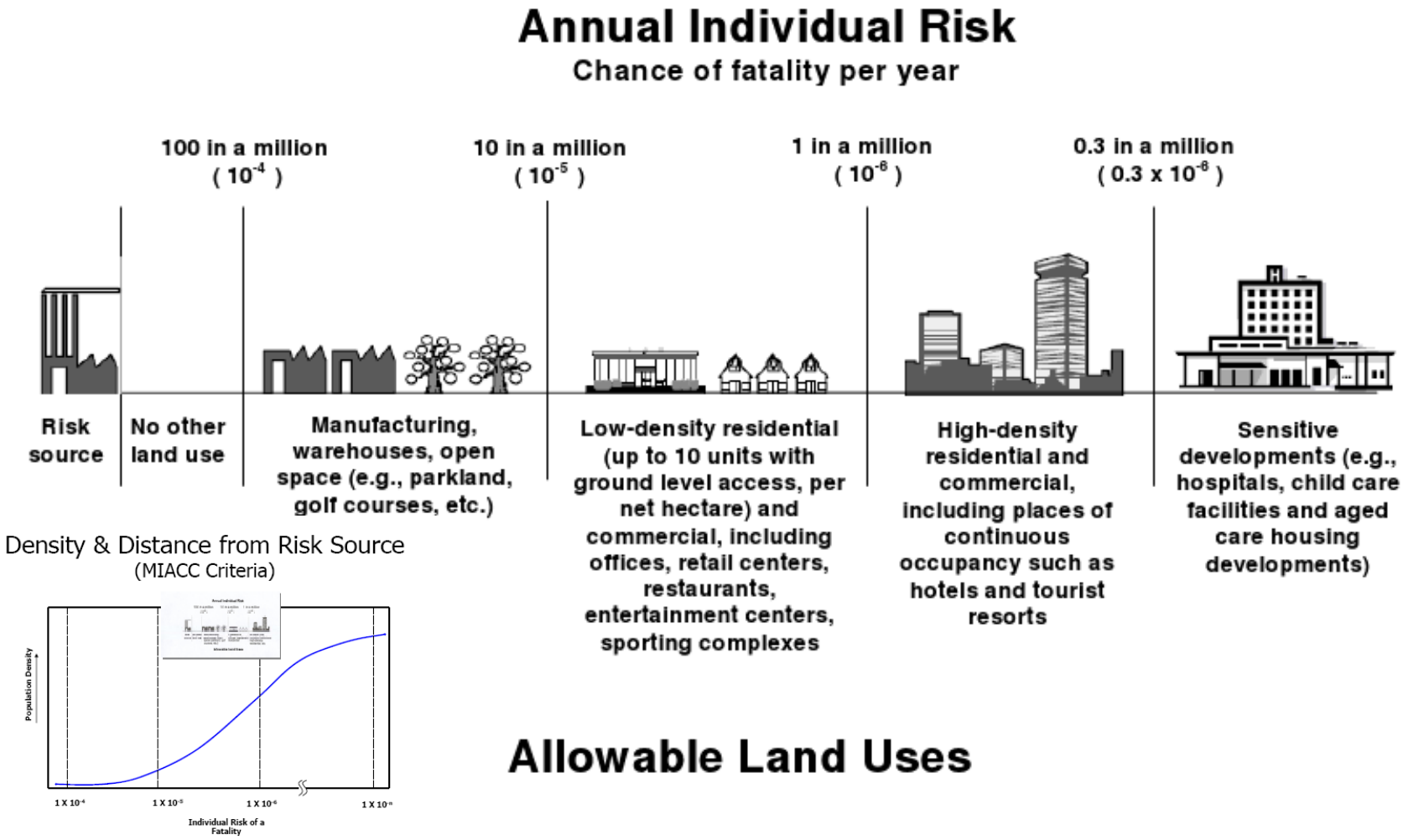
Step 2 asks to identify the geographical scope of potential risk and recommend the boundaries of the eventual Development Permit Area. The main concern being the Canexus TCP Quantitative Risk Assessment risk contours as shown in Figure 2. Here previous work has been conducted by this author with respect to recommending a decision to designate the centerline of Front Street as the location of a 1 X 10^{-6} (one chance in a million) acceptable level of risk for the purposes of land use planning. Here there are two areas to look at:

- Where the risk contours as described by MIACC should be placed.
- What should the allowable residential density be for the region between the 1 X 10^{-5} and 1 X 10^{-6} risk contours?

The approach is to accept the Canexus risk contour for 1 X 10^{-6} as a starting point. The contour line is approximately 50 metres north of Front Street (as shown in Figure 2 below and Figure 19). The recommendation is to locate that contour along Front Street for land use planning purposes.

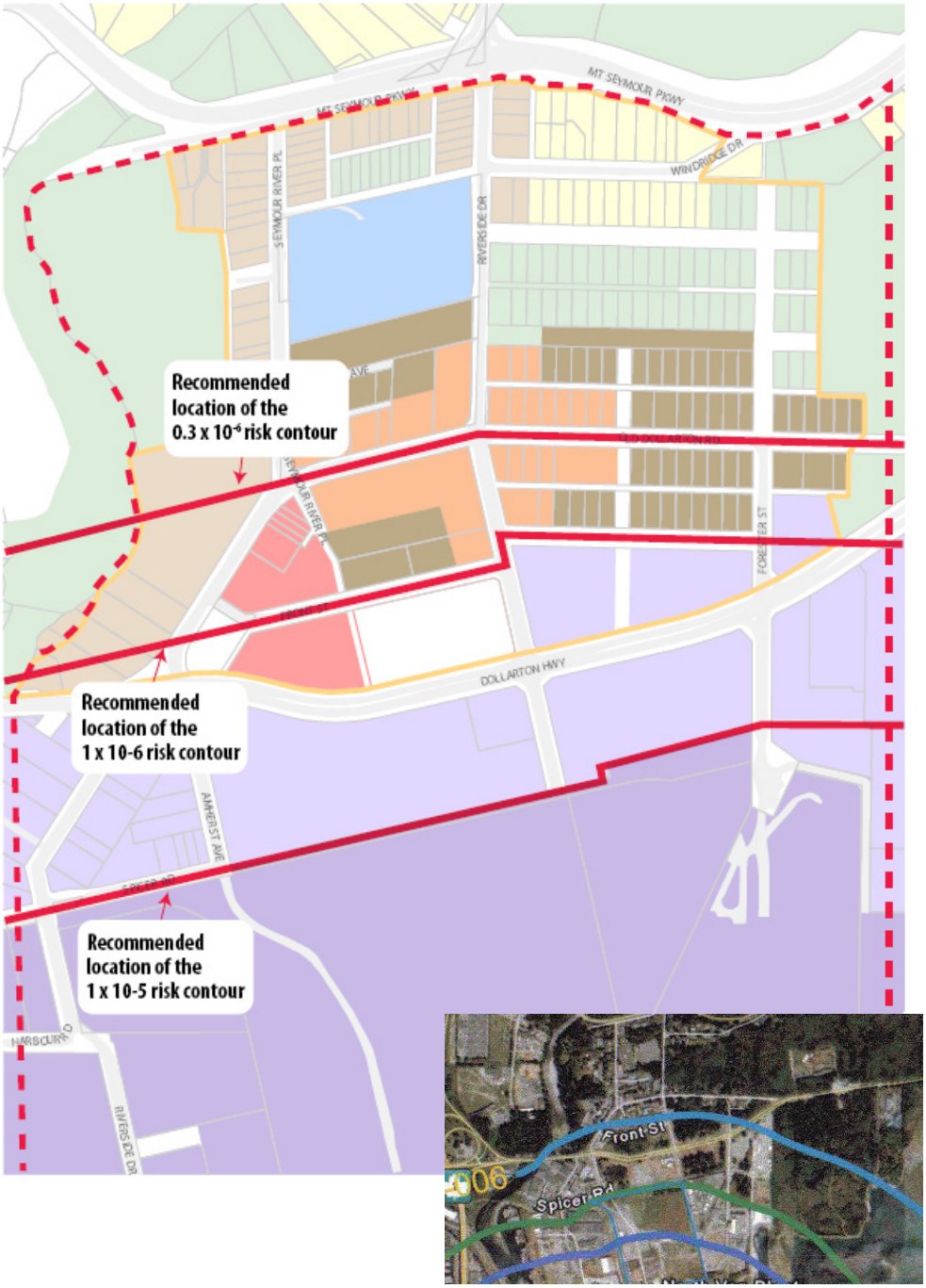
Figure 2: Approximate Location of the Canexus 1 X 10^{-6} Risk Contour North of Front Street

Figure 3: MIACC Land Use Planning Criteria



With the establishment of the 1 X 10^{-6} risk contour through Front Street and adjusting it accordingly to the west and east extremities as shown in Figure 4 below, the 1 X 10^{-5} risk contour can be drawn through Spicer Road. This allows for light to medium industry as shown by MIACC to be located south of Spicer Road with commercial and some residential between Spicer Road and Front street. As well a similar contour line through the "Old Dollarton Hwy." is recommended to define the 0.3 X 10^{-6} risk level and satisfy the need for sensitive institutions such as the existing Maplewood school.

Figure 4: Maplewood Centre Recommended Risk Contours for Land Use Planning



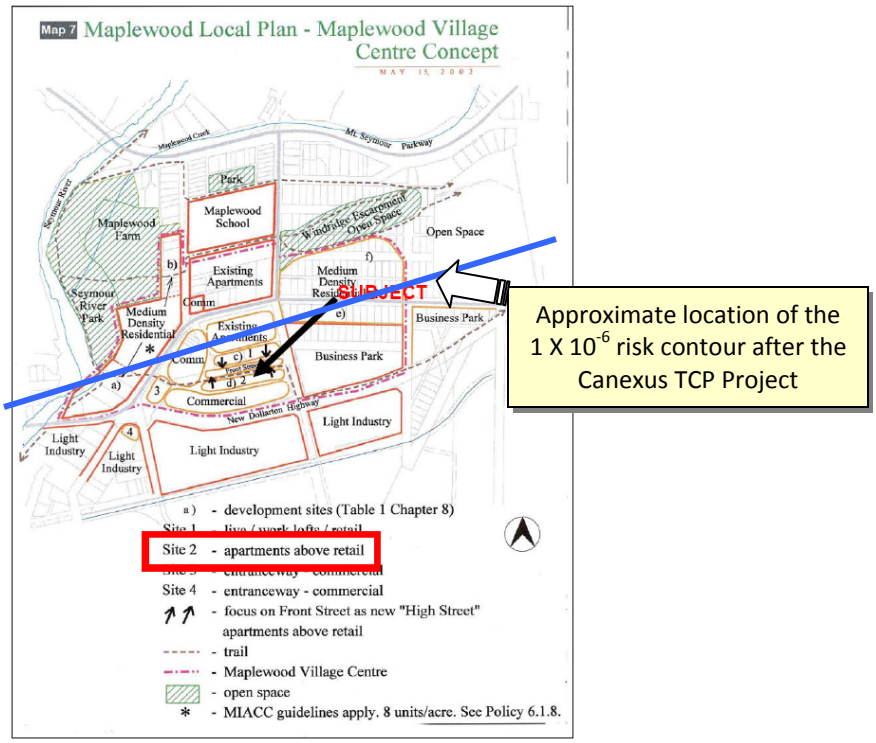
These distances are relatively short in comparison to other jurisdictions where there is a much larger heavy industrial component involved, but in my view appropriate. With just the Canexus operation having a risk impact on the existing and planned community of Maplewood, setting into play these risk criteria will ensure risks that have already been accepted will fit into the development plan and future proposed industrial developments will need to design to meet the same criteria. The result is the District of North Vancouver will be meeting Canada's best practices as outlined in the MIACC criteria as shown. The criteria for sensitive developments (0.3×10^{-6}) will most likely be the key risk focus for any future proposed projects as meeting that criteria will most likely mean the other risk criteria will be easily met.

The previous work conducted for the Maplewood Development Proposal Assessment (Figure 5 below) recommended that the risk contour for 1×10^{-6} be placed along Front Street as it was close to the calculated risk level for the Canexus TCP Project. The reason being, having a reasonable and clear differentiation like a street makes it easy to plan and eliminates many questions when it comes to development proposals. It also gives development officers clear guidance for making decisions particularly when approved and discretionary uses are defined for the risk zones.

Figure 5: Maplewood Development Proposal Assessment

Excerpt from the Maplewood Development Proposal Assessment Report for the GWL Project (Appendix 4):

As there is no specific distances designated by the MIACC criteria but the criterion does put low density housing within the 1×10^{-5} and the 1×10^{-6} risk zones and close to the 1×10^{-6} risk contour, and the GWL proposal is to develop the northern edge of their property for low density residential, I look at this as meeting the MIACC criterion. Further with the choice to develop based on a "low density residential" density of 8 units/acre (average). I would conclude the GWL proposal which includes the two vacant parcels in the calculation does meet the MIACC criteria.



Residential density determination:
The second point to consider is the allowable residential densities for the area between 1 X 10^{-5} and 1 X 10^{-6} risk contours. The Maplewood Development Proposal Assessment, specifically for the GWL project, provided rationale to allow residential development for the lands of 8 units/net acre (19.8 Units/net hectare). The new MIACC criterion suggests just 10 units/net hectare, which is less than the numbers for the GWL development. This may impact the number of apartments planned for the west extremity of the GWL lands (see Figure 8: *Potential Building Heights*).

Also, the MIACC criteria is specific to having "ground level access". Several story residential buildings would not be suggested as appropriate. This preference is from emergency responder input for aiding evacuation during emergencies.

But the current plan would be acceptable with the following suggested design requirements. As the GWL project moves forward the acceptance of this difference along with building design requirements and recognition in emergency planning are acceptable solutions, in my opinion. There are many such discrepancies in all communities, the MIACC criteria is a guideline not a requirement. The fact they are recognized and appropriately dealt with is indeed sound due-diligence.

This focus is on residential buildings but the following consideration for building design requirements should be given to all buildings within the 1 X 10^{-5} and 1 X 10^{-6} risk contours. It is recommended to make it a requirement for a professional to review building designs for these considerations. Consideration to building design features includes:

- HVAC systems that maintain a slight positive pressure inside the building to keep Chlorine from entering.
- Including toxic gas detectors for Chlorine on building HVAC systems to automatically shutdown air intake on high Chlorine levels.
- At least two stair wells with battery back up lighting and sealed doors at each floor level.
- Emergency phones for contact with emergency responders and building residents.
- Building PA system.
- Use local radio and TV stations for communications to residents.
- Emergency plans for all residents in the building clearly defining what to do to protect themselves should they be asked to evacuate or to shelter inside.

If protective design action is included as described there is no need to require specially designed "*sheltering in place rooms*" within the buildings.

The Canadian Building code sets standards for the construction of buildings in Canada and Provinces generally follow those requirements and will be adequate for buildings where the risk levels are lower than 1 X 10^{-6}. Research (*Dr. David Wilson – University of Alberta*) has shown building constructed to the Canadian code standards are tight because of our winters in comparison to those in warmer climates and in fact can offer several hours (typically 2 – 3hours in Canada)of protection (sheltering in place) should a toxic gas release impact the building. Following the building code for development north of Front Street (the 1 X 10^{-6} risk contour) would be sufficient protection. For buildings south of Front Street, adding some if not all the suggested additions noted above provide a safe haven as well as time for emergency responders to provide safe rescue.

PROCESS USED FOR STEP THREE:

Discuss the relative merits of building, site and area-level measures to mitigate any identified theoretical risks.

Step three asked to provide judgement on the relative efficacy *(the capacity to produce an effect)* of different design tools for managing the built environment, including for example: site planning, building orientation and design; fenestration *(openings in a building)* and ventilation controls; notification measures (e.g. sirens, sensors); shelter in place provisions. If appropriate, these recommendations should indicate the relative suitability or necessity of recommended measures as they may apply to different land use.

The work conducted through the MIACC process as well as globally considered unwanted impact on people. To this end the acceptability of one chance in a million (1×10^{-6}) on an annual basis of a fatality created by an unwanted industrial accident was considered to be the key. The MIACC criteria states that residential development need not consider any further features as long as the risk is lower than one in a million *i.e. north of Front Street*. As long as this criteria is met there is no need for further building design features.

However, as noted in Step 2, there are some multi story buildings already proposed for the GWL project between New Dollarton and Front Street which are within the 1×10^{-5} and 1×10^{-6} risk contours with the following suggested additional features:

- HVAC systems that maintain a slight positive pressure inside the building to keep Chlorine from entering.
- Including toxic gas detectors for Chlorine on building HVAC systems to automatically shutdown air intake on high Chlorine levels.
- At least two stair wells with battery back up lighting and sealed doors at each floor level.
- Emergency phones for contact with emergency responders.
- Building PA systems for emergency plan activation needs.
- Use of local radio and TV stations for communications to residents.
- Building owners and management would need to ensure emergency plans for all residents in the building clearly defining what to do to protect themselves should they be asked to evacuate or to shelter inside.

Emergency planning for the Maplewood area should also be considered as a means to protect residents and at least provide comfort and quality of life in the form of peace of mind. Recommendations include:

- Ensure there is a special emergency planning recognition of the residents living in the zone between 1×10^{-5} and 1×10^{-6} risk contours (New Dollarton and Front Street).
- For the above mentioned zone for any residences between the 1×10^{-5} and 1×10^{-6} risk contours provide for at least two roads in and out of the areas and no dead end roads where possible. This may not be practical to do for example Seymour River Place), the emergency plan should note these as a special case within the emergency plan for alternative action such as alternate evacuation pathways.
- Consider including an automated phone calling system to alert citizens downwind of a Chlorine release. These systems do have challenges but are a reliable tool to use in emergency communications.
- Emergency sirens activated specifically for Chlorine releases should be considered. They have a simple way of communicating serious emergencies and if their installation and

use are communicated well with the community they can be a very useful tool. They need to be routinely and regularly tested which is something that can be incorporated into regular emergency planning communications activities already conducted.

- All the recommendations need to be done in consultation with the Emergency Services department.

APPENDICES:

Appendix 1 – Study Area Information and Scope of Work

Appendix 2 – Chemical Hazard Information

Appendix 3 – Risk Management Process

Appendix 4– Maplewood Development Proposal Assessment The District of North Vancouver For "GWL Realty Advisors Inc" - FINAL report March 16th, 2009

Appendix 5 - A Review of the Maplewood Development Concept Plan Clarification - October 14th, 2008

Appendix 6 - References

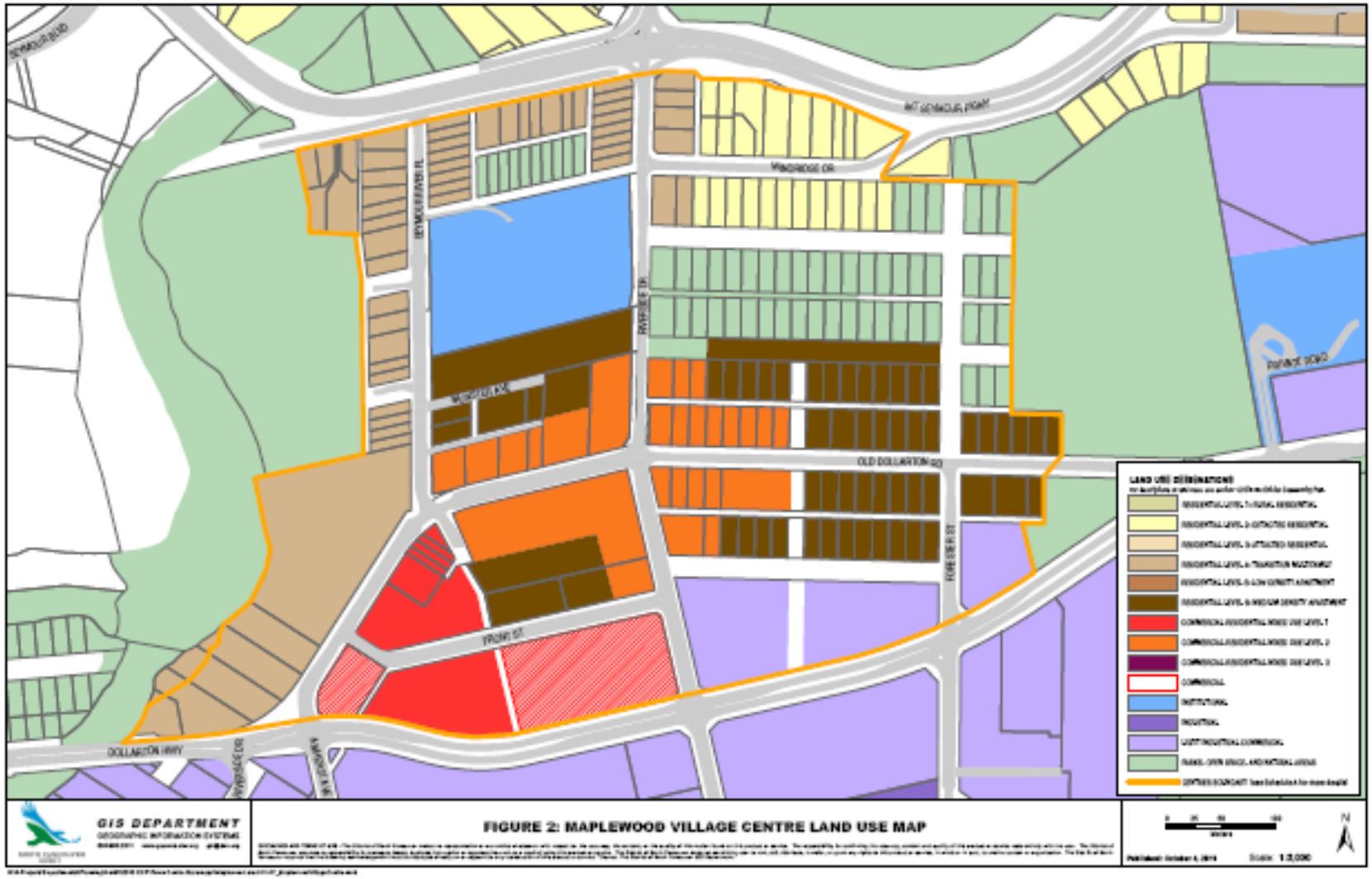
APPENDIX “1”

Study Area Information and Scope of Work

Figure 6: Study Area:

FIGURE 1: STUDY AREA

Figure 7: Maplewood Village Centre land Use Map:



Maplewood Chemical Hazard DPA Preliminary Study
DRAFT Terms of Reference

1.0 INTRODUCTION

As part of the creation of a mixed use community in Maplewood Village Centre, the District of North Vancouver seeks qualified consultants to review the potential risk of chemicals present in proximate industrial areas and provide recommendations to support the establishment of a development permit area for chemical hazards which would include guidelines regarding site planning and building design measures to reasonably mitigate this risk.

2.0 PROJECT BACKGROUND

The District Official Community Plan (OCP), adopted in June 2011, identifies Maplewood Village Centre as a site for growth and revitalization, with a high street or 'village heart' centred on Old Dollarton Road between Seymour River Place and Riverside Drive. Given the proximity of existing chemical industries to the south of the Village, District OCP policy for Maplewood Village Centre 3.3.1 commits to "Prepare a Development Permit Area with associated guidelines for chemical hazards". This current study is being commissioned as a first step to respond to this policy direction, by evaluating potential chemical risk and discussing ways site planning and building design could respond to any identified risk. The preparation of the actual Development Permit Area, and other aspects of risk preparedness (e.g. emergency response, public education, etc), are to be prepared separately and are not part of the scope of this study.

Under the authority of the *Local Government Act*, municipalities are able to designate Development Permit Areas (DPA) where specific requirements apply to certain forms of development, such as multifamily, commercial or institutional uses. DPAs are intended to respond to particular circumstances and objectives by providing guidelines that apply to development in the defined area. Any proposed building within an established DPA cannot proceed without the issuance of a Development Permit. The purpose of the DPA proposed for this study is to manage development for potential hazardous conditions that may arise due to the proximity of chemical industries. The DPA would apply to new multifamily residential, commercial and institutional developments proximate to chemical industries and not to the chemical industries themselves, which are subject to their own safety regulations, including building and fire code requirements. As the first step, the purpose of this current study will be to review potential risks and identify an area where planning/design measures could be established to mitigate any risk. This study will then be used as the basis for preparing the actual DPA, which will be part of a second separate exercise.

The Village Centre (see Study Area Figure 1) is approximately 35 hectares in size and is roughly bounded on the west by Seymour River Place, on the north by Mount Seymour Parkway, on the south by Dollarton Highway, and on the east by Forester Street. Existing uses include a mix of single family homes and older multifamily rental properties, a school, and some newer commercial and light industrial developments. A considerable proportion of the planned future Village development consists of primarily undeveloped District-owned land east of Riverside Drive. The OCP contemplates a significant intensification of use in the Village through a range of mixed use and multifamily developments, with the anticipated addition of approximately 1500

net new residential units and approximately 100,000 square feet of commercial space over the next 20 years (see Land Use Map Figure 2).

A number of industries exist outside of the Village Centre in the heavy, waterfront industrial lands to the south. Major uses in this area include shipbuilding, chemical industries, and a waste transfer station. A light industrial area exists between these heavy industrial uses and the Village Centre, with new business park developments fronting Dollarton Highway. Previous studies in this area have identified chlorine at the Canexus plant as a chemical with the potential for off-site impacts on a community level. To this end, a quantitative risk assessment (QRA) was conducted in 2006 in support of a technology conversion project at Canexus. The technology conversion project has resulted in a substantially reduced risk of a chlorine release and reduced potential for community impacts. The findings of the QRA informed the proposed land uses and densities in the adopted OCP, which are generally consistent with the Major Industrial Accidents Council of Canada (MIACC) guidelines (see Risk Contours, Figure 3). With land uses now determined, design guidelines to manage future development are required. While chlorine is currently understood to represent a potential risk to the adjacent Maplewood community, a review and consideration of other chemicals present in proximate industrial areas and associated management practices is requested to confirm or revise this understanding and define the area and relative risk of potential hazards to support the establishment of development guidelines to manage risk. The District can provide an inventory of chemicals by substance type, location and maximum theoretical quantity to interested and qualified applicants subject to completion of a non-disclosure statement.

3.0 SCOPE OF WORK

3.1 Description of Work

The objective of this study is to facilitate the responsible (re)development of the Maplewood Village Centre by identifying the area and relative risk of chemical hazards and evaluating a range of planning/design measures that would reasonably mitigate developments from the potential risk (if any) of proximate chemical industries. This has three main and sequential aspects:

2. **Review the inventory of chemicals by substance type, location and maximum quantity and assess what substances pose a theoretical risk to residents/businesses in the nearby Village Centre**. This study should assess the levels of risk posed by different substances and articulate which risks can be reasonably addressed through site planning and building design measures and which by can only be addressed by other means (e.g. emergency response).
3. **Identify the geographical scope of potential risk and recommend the boundaries of the eventual Development Permit Area**. If appropriate, this mapping should indicate the varying degrees of risk associated with different areas if alternative design measures should apply in these sub-areas.
4. **Discuss the relative merits of building, site and area-level measures to mitigate any identified theoretical risks**. The consultant is expected to provide judgement on the relative efficacy *(the capacity to produce an effect.)* of different design tools for

managing the built environment, including for example: site planning, building orientation and design; fenestration *(Openings in a building)* and ventilation controls; notification measures (e.g. sirens, sensors); shelter in place provisions. If appropriate, these recommendations should indicate the relative suitability or necessity of recommended measures as they may apply to different land uses, building forms and/or densities.

In a subsequent phase of this project, the findings and recommendations of this study will inform the establishment of a development permit area where specific design guidelines apply.

3.2 Deliverables

- Provide a draft interim report (6 copies) and in electronic form on the findings of the study.
- Prepare, conduct, facilitate and record the input from up to three meetings with District staff and Council on the recommended options and issues.
- In consultation with District staff, prepare and provide the final report (10 hard copies and in electronic format) by 7 May 2012 summarizing the process with recommendations for the proposed geographic scope of the Development Permit Area and recommendations regarding the suitability and efficacy of mitigation strategies to form the Design Guidelines.

3.3 Project Timeline

The project is anticipated to start within seven days of the award of contract, mid-March 2012, and to proceed according to the following timeline:

- March 19, 2012 Anticipated start date
- April 2, 2012 Submit Interim Report for review by District staff
- April 9, 2012 Meet with District staff to review the report and the preliminary recommendations for the Development Permit Area and Guidelines
- April 16, 2012 Based on the meeting, revise the draft report for review by District staff
- April 30, 2012 Present a summary of the report and its conclusions at a Council workshop
- May 7, 2012 Submit Final report

It is noted that **timelines may have to be varied** due to unanticipated complexities in the process.

3.4 Project Administration

The project will be administered for the District of North Vancouver by the Manager of Sustainable Community Development or designate. The project administrator will coordinate all communications and meetings with the consultant, disseminate information from the consultant to District staff and Council and coordinate feedback from the District to the consultant in a timely manner. Progress review points will be established with the consultant to monitor progress of the project. **A complete draft report is expected to be provided for review by the project administrator prior to the completion of the project**. Any proposed changes in scope to the project or changes to key personnel identified in the proposal must be approved by the project administrator.

3.5 Resources

The Manager of Sustainable Community Development will oversee all the stages of this project as outlined above. In addition the District will provide the following documents and resources to aid the project:

- Inventory of chemicals by substance, location and maximum quantity
- Peer review of the Quantitative Risk Assessment conducted for the technology conversion at Canexus

The budget for this project is set at a maximum of $ 10,000. Proposals exceeding this amount will not be considered.

Figure 8: Potential Building Heights:

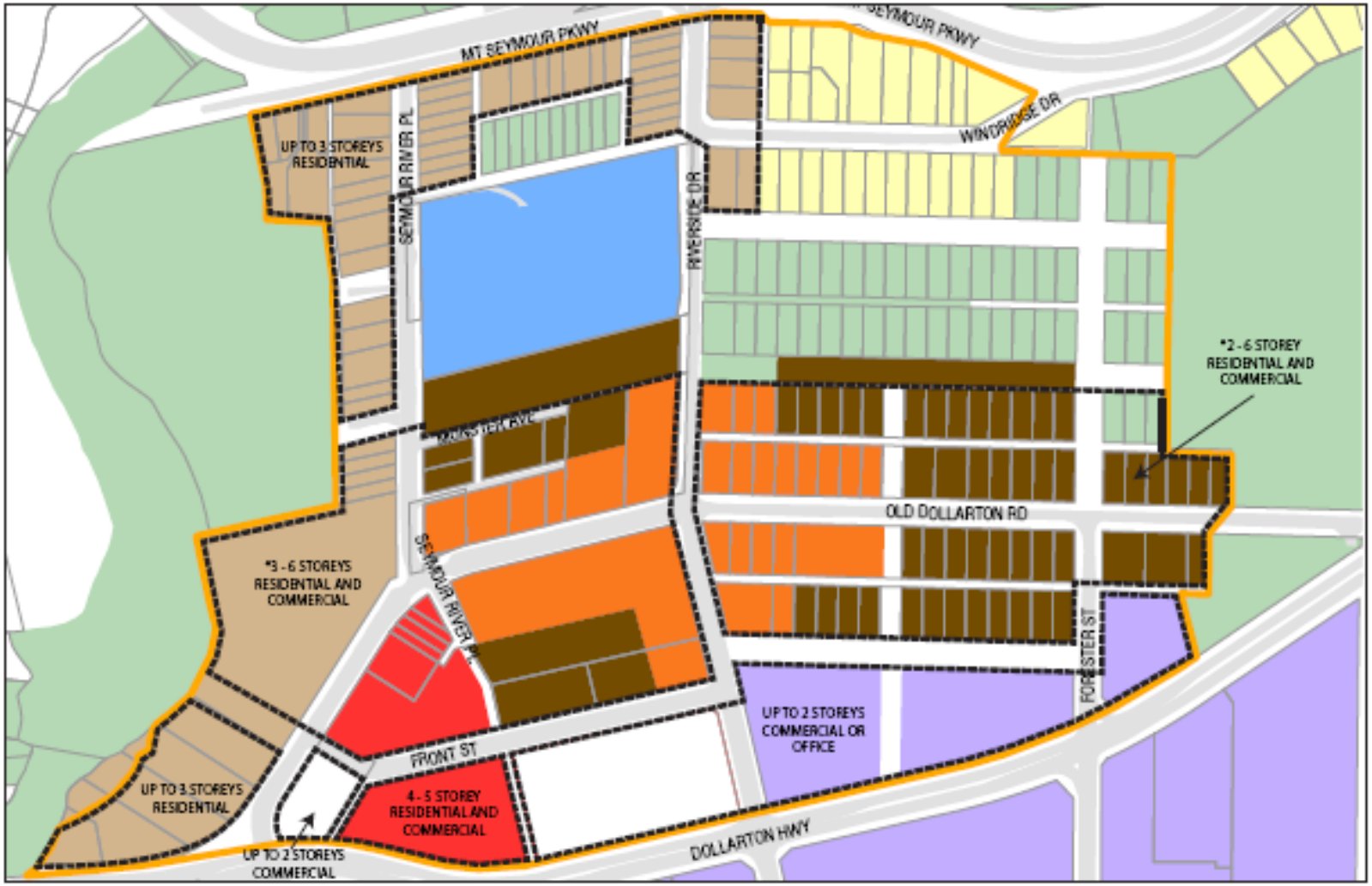


Figure 9: District of North Vancouver Maplewood Industries:

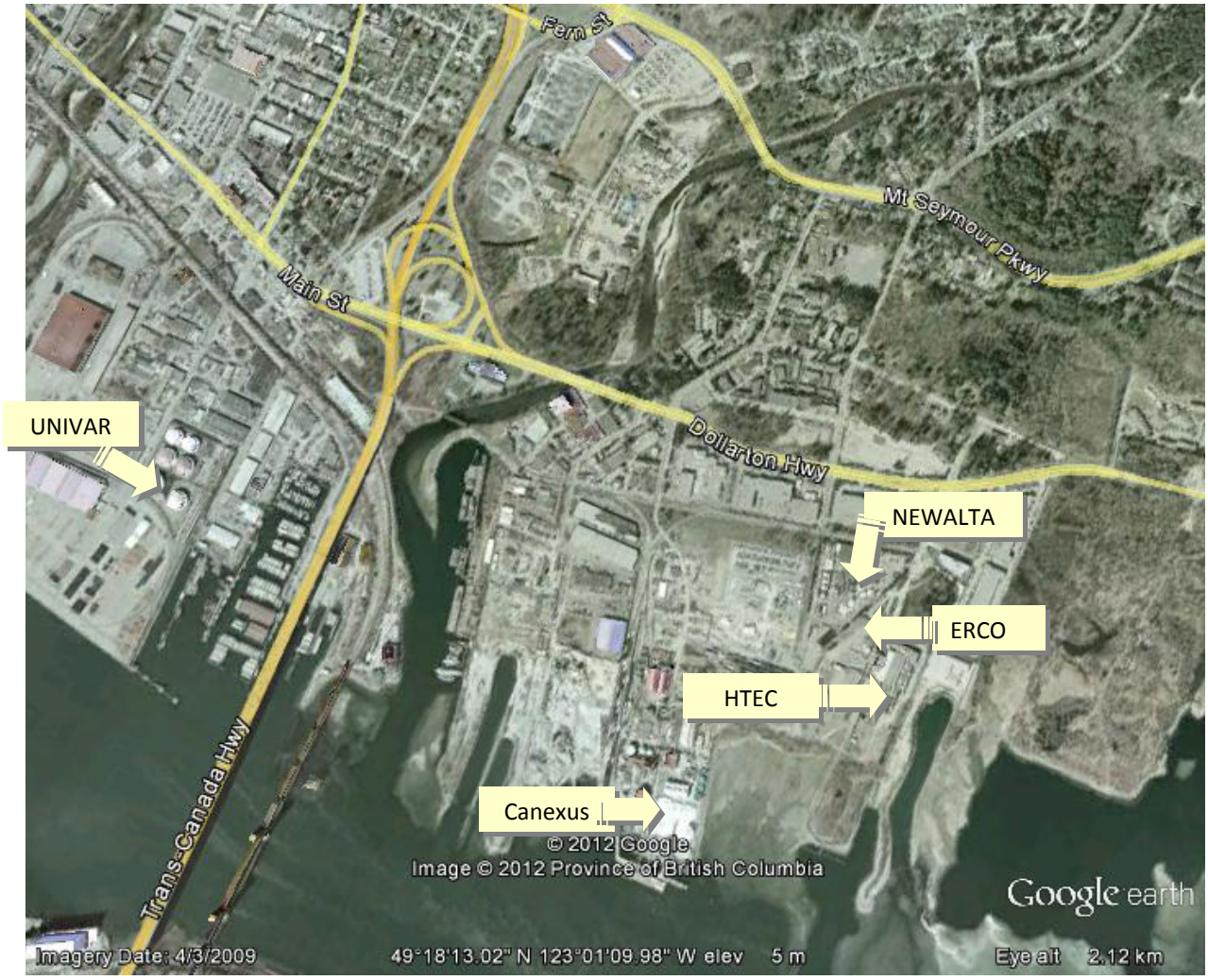


Figure 10: Maplewood Village Centre Land Use Plan Area:

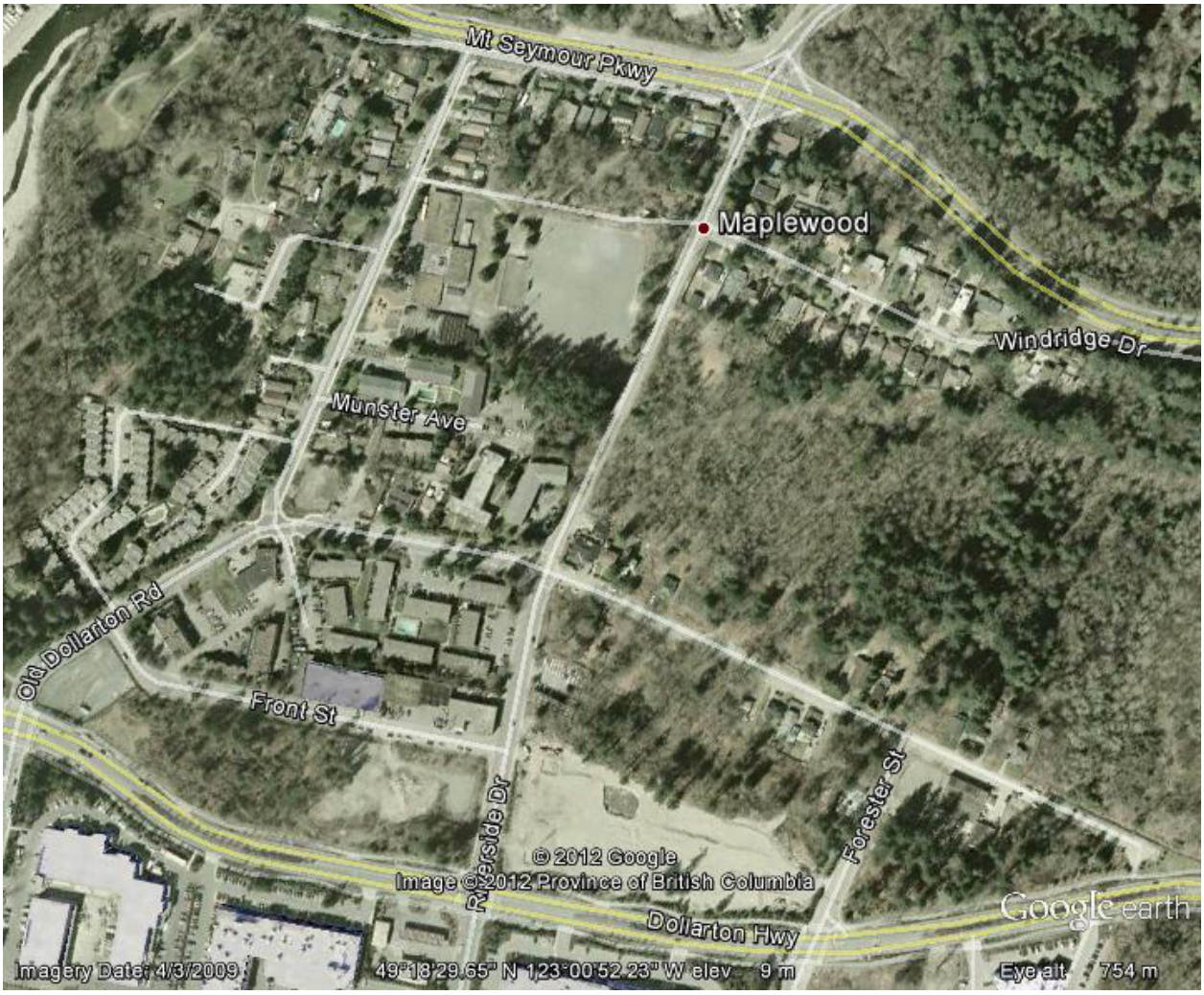
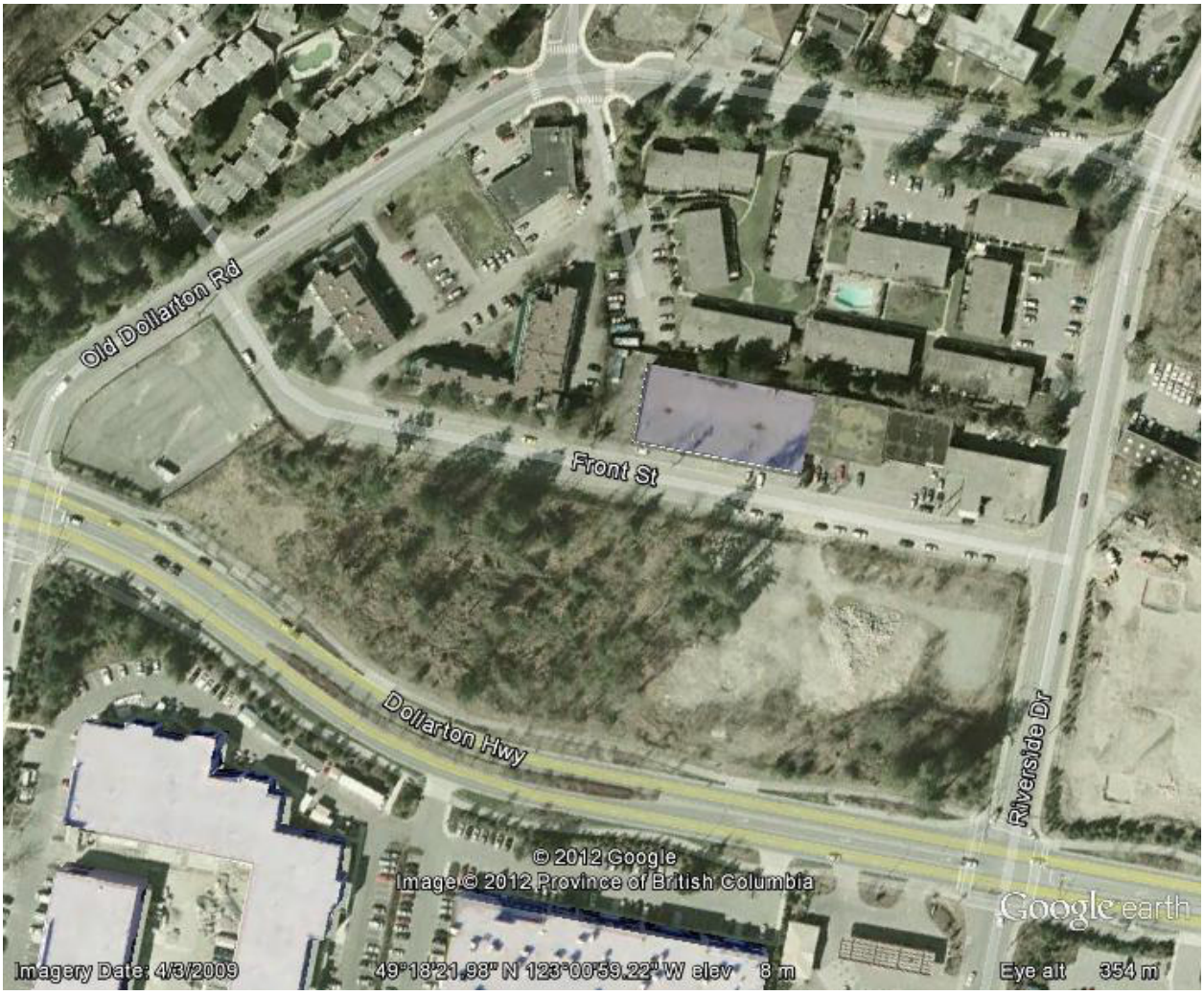


Figure 11: Maplewood Village Centre Land Use Area - Including Industry:

Figure 12: Maplewood Village Centre Aerial Photo – Front Street:



APPENDIX “2”

Chemical Hazard Information

Chemical Hazards: Maplewood Village Centre Land Use Plan – Industries:

Figure 13: NEWALTA Site:

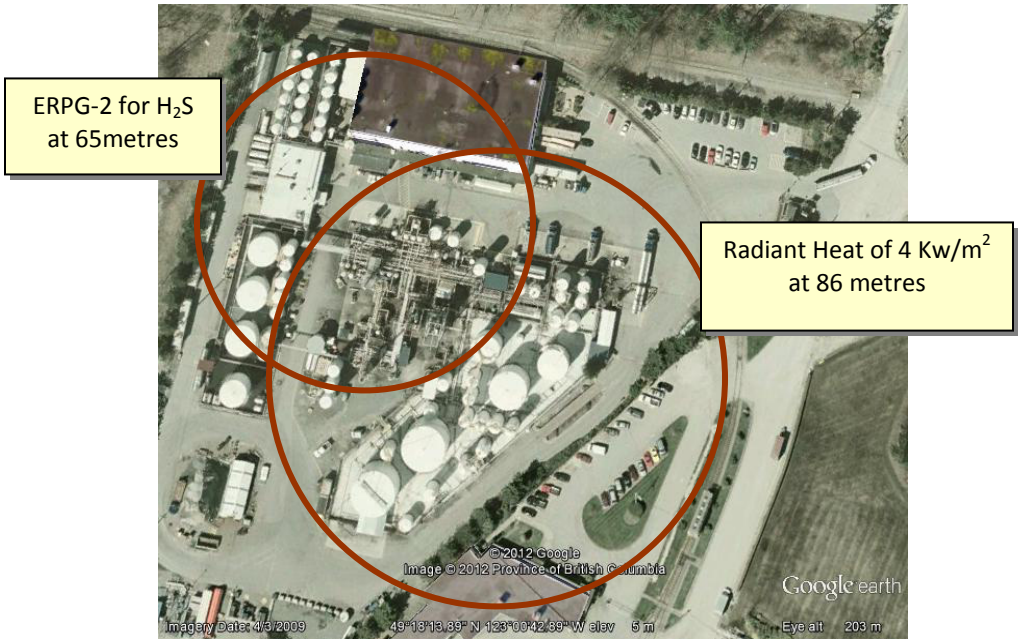


Figure 14: ERCO Worldwide:

(None of note that would have an impact beyond the property line)

However, of note is Sodium Chlorate and Hydrogen Peroxide, "oxidizing agents", which will accelerate burning when involved in a fire situation, it may ignite combustibles.

Figure 15: Proposed HTEC Fatality Risk Contours for Radiant Heat and Explosion Shockwave Impacts

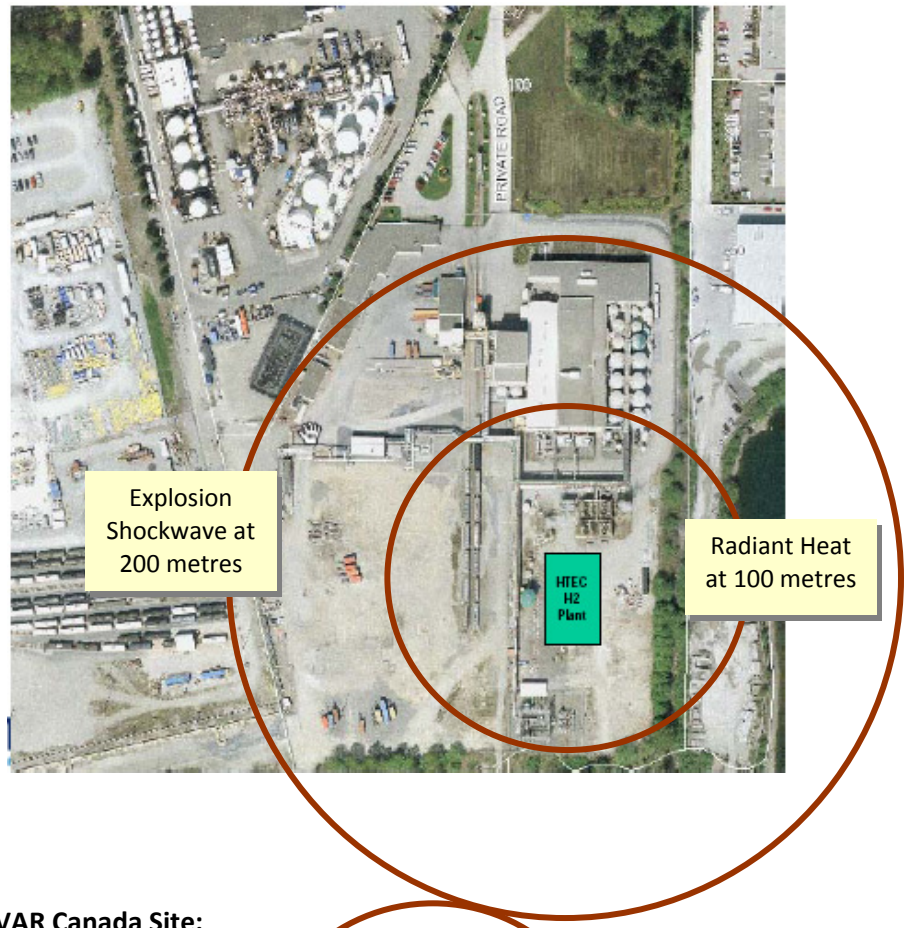


Figure 16: UNIVAR Canada Site:

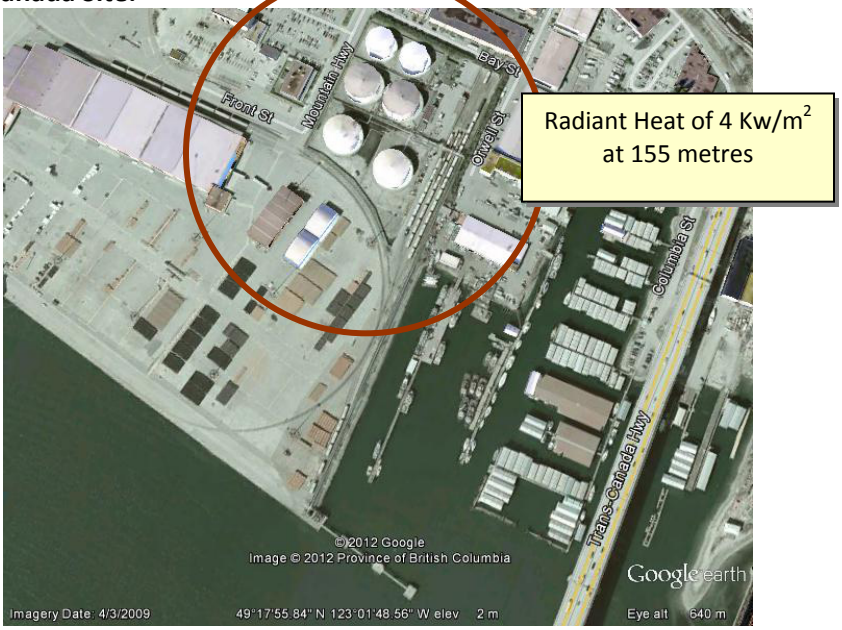
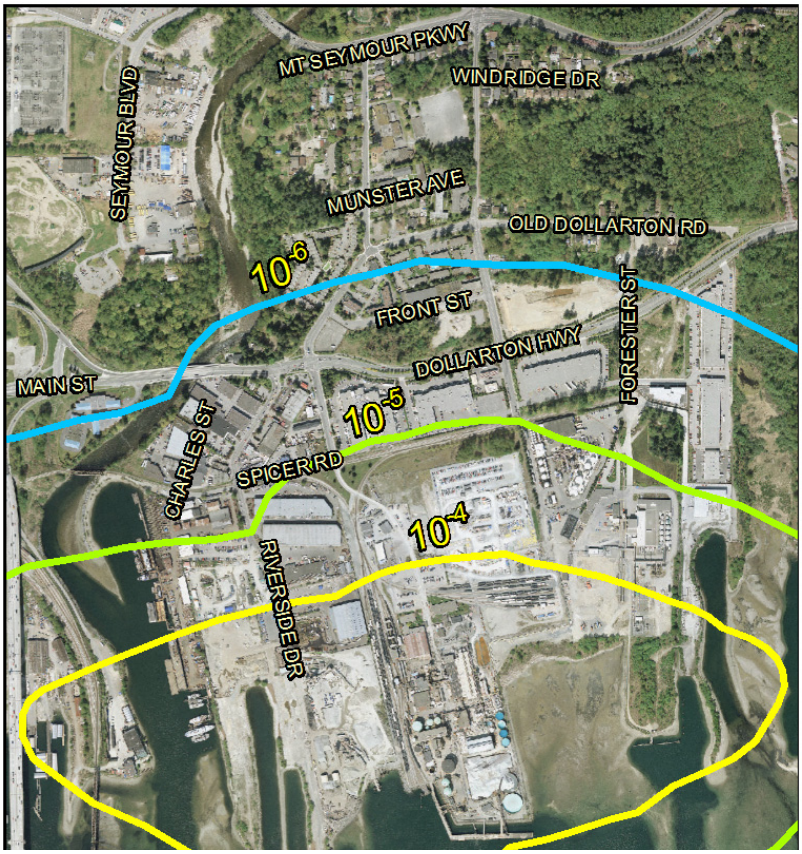


Figure 17: Canexus Site:

Figure 18: Canexus TCP Project Risk Contours:



Appendix “3”

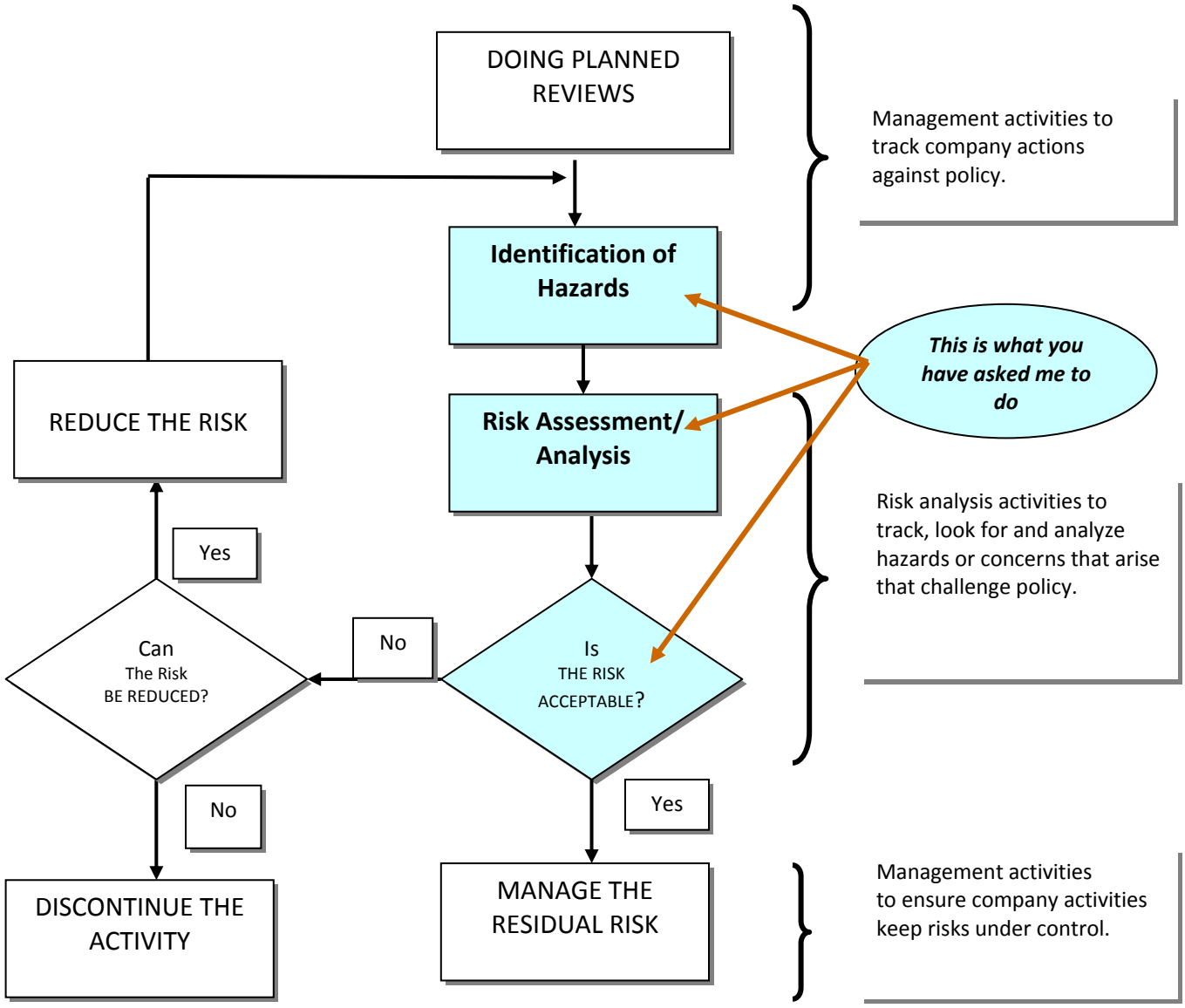
Risk Management Process

Acceptable Level of Risk Criteria (MIACC)

Figure 19: The Risk Management Process:

The process used to do Risk Assessments follow this globally accepted methodology. The proposal presented above is in line this method.

This risk management process represents what is practiced around the world particularly for hazardous industries but including others. Each step requires different activities to be conducted in differing formats. The result is a process that has been used successfully globally for over20 years and is considered to be the best we currently have.



What does each box mean?

1. **Doing Planned Reviews:**
   This is a management function. Here you would be conducting what ever reviews you need to do that will provide the data needed to monitor your operations or new project designs. Here is the database for your safety and loss management system. It would include incident investigations, insurance company reviews, regulatory activities (pressure vessel inspections, environmental reporting, asset renewal needs, changes to laws, code updates, etc.). Not to mention the regular data you collect on your business operations and maintenance activities. The point is you want to be proactive so gathering the data and doing trend analyses in conjunction with statistical analyses will keep you ahead of trouble.

2. **Identification of Hazards:**
   One of the outcomes of doing the reviews you mandate as a management team as well as listening to industry activities in general through associations and the news, will be the identification of hazards (or for a better term concerns). Your management team will receive the data and in the wisdom of the team will determine what needs to be further analyzed through doing a risk analysis or analyses.

   You may wish to do formal reviews of projects for hazards and this is where a Hazard and Operability Study (HazOp) will come into play. Other tools are available but for the processing industries HazOp's are well thought of. A HazOp can be done on an existing process as well.

   It should be noted that legally a hazard analysis is required and once a hazard is identified action to correct the hazard and communicate the concerns is required under the provincial OH&S Act requirements. This emphasizes the need for effective due-diligence by all companies.

3. **Risk Assessment/ Analysis:**
   There are many tools available to help do the risk assessment. There are many tools available to quantify the consequences of all kinds of hazards. Explosions, toxic cloud dispersion models, toxic exposures, lethality, noise, water pollution plumes, etc. etc. All these provide the accurate consequence data you would need to make the right choices.

   Probability specifically pertains to the failure of systems, humans, equipment, etc. Data is available generically but the best data is in the company's own database with respect to maintenance records and operational records. Probability (frequency) is also quantifiable.

4. **Is the Risk Acceptable?**
   In order to enjoy the standard of living we as a society would like to have we need to be aware there is a certain amount of risk associated with that. To this end globally, it has been determined it is okay to expose an individual to one chance in a million ($1 X 10^{-6}$) of a fatality on an annual basis due to an industrial activity nearby. For more detail on this see Appendix "6" and the MIACC criteria (Major Industrial Accidents Council of Canada).

   Most company management have developed a risk matrix to describe and communicate company policy. The matrix is used to describe what is a low (acceptable) level risk, medium (acceptable with certain conditions) level risk and high (unacceptable) level risk.

These matrices clarify to employees what they must do and what is acceptable. The low-level risks are usually acceptable without any further management involvement or design additions. Medium risk is the one where management needs to be involved to ensure the risk is kept under control and it is worthwhile noting here management's responsibilities come to the front line as they are assuming the responsibility for taking the risk.

5. Manage the Residual Risk:

Once a risk is determined to be acceptable it must be managed. This is the largest box in the process as you now have the responsibility for assuming the risk and preventing any incident from happening. This is outlined further in the Process Safety Management systems, which are found around the world as the accepted methods for managing risks.

These consist of 10 – 20 management elements that must be carried out to manage the risks in an acceptable way. Don't forget that once a risk is accepted it does not go away. It is there waiting for an opportunity to happen unless your management systems are actively monitoring your operation for concerns and take proactive actions to correct potential problems.

6. Can the Risk be Reduced?

Often there are ways to reduce the risk once a risk is determined to be unacceptable. The term "Inherently Safe" implies methods, which will eliminate or reduce the risk. Further controls, management systems, protective features, etc. can be added to reduce the risk to an acceptable level.

7. Reduce the Risk:

If the proposed change is viable then do the necessary changes.

Note that once the change is made the process is once again used to evaluate for possible new hazards and risks. Changes in processes often create potential problems upstream or downstream. If they are not uncovered your operational risk may go up unknowingly to yourselves.

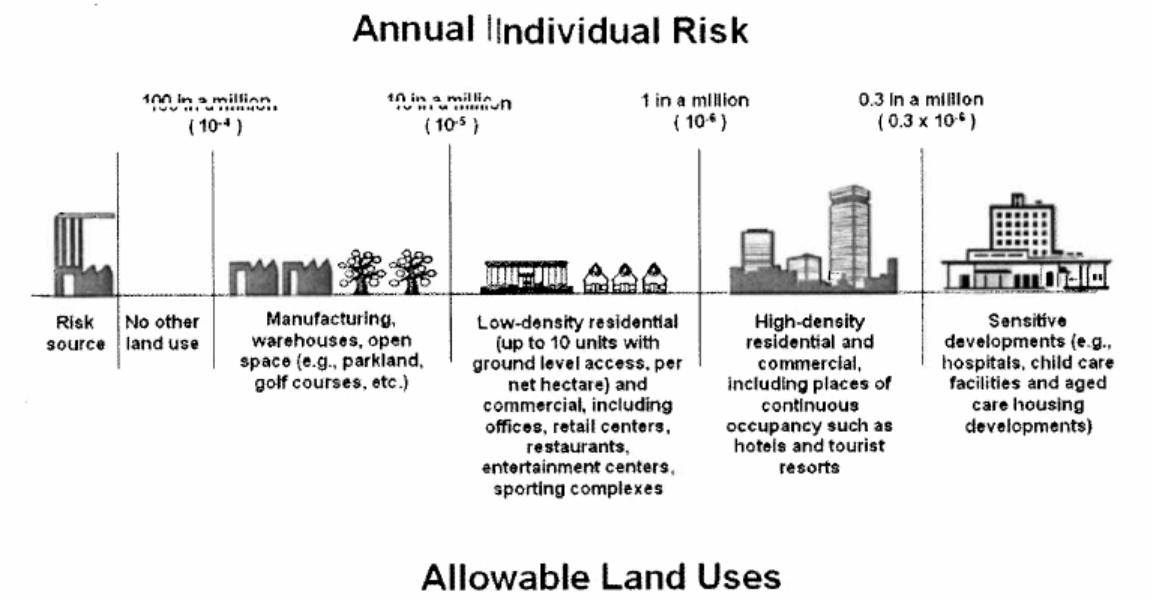
8. Discontinue the Activity:

A very important step is to recognize the risk is too high. Management needs to be clear on this one and make the right decisions. Company values, objectives, etc. all come to play in this box including the idea of lost profits, personal promotions, professional defeat, etc.

This statement is a key one because it says you will not do something that is unsafe, pollutes, damages assets, risks your business needlessly, or impacts the public's view of you negatively. Also, your employees are watching your performance and their support for your management decisions is something you need.

There is a psychological component to this too. People will not easily admit defeat when trying to do their jobs. Unless management says and demonstrates that it is okay to stop people will continue to try and succeed which often leads to taking unacceptable risks.

Figure 20: Acceptable Level of Risk Criteria (MIACC):



The MIACC Risk Acceptability Criteria describes the level of risk for a member of the public who is inadvertently exposed to an industrial incident must be better than a 1×10^{-6} chance of a fatality. However as the risk contour moves towards the source of the risk the risk level increases understandably. But note that this risk cannot be higher than 1×10^{-4} of a fatality. With this in mind special focus on the workplace is needed to further lessen the exposure potential for workers.

This acceptable risk criteria is Canada's approach to a global consensus around industrial risks and land use planning. The concept is developed from a legal conclusion that from a public point of view it is acceptable to have an individual exposed to one chance in a million of being fataly injured over a one year time frame. With this information through the consensus organization called the Major Industrial Accidents Council of Canada the above criteria was agreed on.

The type of activity along with the exposure level and density of people all play a part in the determination of the acceptable level for Canada. This is completely in line with the rest of the industrial world.

Strathcona County refers to the MIACC criteria in their land-use planning bylaws. Both have not made any special additions to the criteria.

APPENDIX "4"

Maplewood Development

Proposal Assessment

Maplewood Development Proposal Assessment

The District of North Vancouver

For

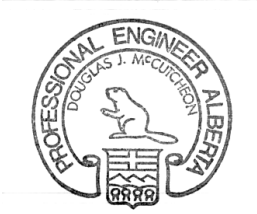
"GWL Realty Advisors Inc"

FINAL REPORT

MARCH 16th, 2009

Prepared By:

DOUG MCCUTCHEON AND ASSOCIATES, CONSULTING
A DIVISION OF "HUMAN FACTORS IMPACT LTD."



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Executive Summary:

The intention of this report is to assess the proposed development of 83 units along the northern boundary of the open space next to Front Street and near the risk level of 1 x 10^{-6} for the Canexus TCP project. This assessment is based upon the risk based land use criteria as originally set out through the Major Industrial Accidents Council of Canada (MIACC).

The proposed project includes the development of a mixed-use building on the remaining Great West Life vacant lands located in the Maplewood area (see Figure "3" in Appendix "1"). The suggested dwelling units are to be located at the north-west corner of the two remaining vacant parcels. The form of development will be a low-rise apartment building consisting of mainly studio and one bedroom units, situated over-top of commercial space located at grade. The balance of the vacant lands will be used for non-residential uses.

The report is intended to clarify the MIACC risk based land-use criteria and relate it to the proposal by Great West Life (GWL) to develop a commercial and residential development in the area directly north of Dollarton Highway and known as Maplewood.

The MIACC risk based land-use planning criteria as shown on **Figure 5 in Appendix "2"** of this report is a direct result of Canada's approach to managing industrial risks as a result of the Bhopal India incident of 1984. The Bhopal incident raised the question in Canada and around the world asking if it could happen in our country and what do we have that will prevent it from happening. To answer the questions a consensus organization of industrial experts, government (federal and provincial) and academia was formed and we know it as MIACC. That body of Canada's best experts developed many resources of which one was the answer directly associated with the Bhopal India incident around proper land use planning in and adjacent to industrial areas.

The process involved a global view of what best practices there are as well as developing a means to "measure risk" so decisions can be made to properly address risk to people's health and safety. That measurement focused on what would be an acceptable level of risk for an individual located in the same location for 24 hours per day over one year. Without such a number making appropriate decisions could not happen. That risk number was universally accepted and tested in the courts in the United Kingdom which gives us an acceptable level of risk to expose people to, in order to enjoy the standard of living we desire as people. That value is; *"industry can impact beyond their property lines as long as the risk to an individual staying in one location for an entire year is not greater than one chance in a million of a fatality as a result of an incident on the industrial property."* This risk level is in the same order of magnitude as an individual being struck by lightening, a very low number, but one that has been termed acceptable in the eyes of the public. And definitely a number any company can now design and operate their businesses and meet.

Canexus was asked to provide these risk calculations for their current operation and their new operation after the TCP project is operating. They showed for the new operation the 1 X 10^{-6} risk level to be north of Front Street (see **Figure 2 Appendix "1"**).

One thing the MIACC risk based land use criteria did not do was to prescribe the numbers of people that could be located in each risk zone. It did imply though, that population density would increase the further away one gets from the risk source. Again see **Figure 5 in Appendix "2"** which demonstrates this point. This allowed for effective risk calculations based on what ever industrial activity was there, to determine population density. Also of note is the MIACC criteria does not define distances either just risk levels.

This left open the opportunity for jurisdictions to determine what would be an acceptable population density to use. Again MIACC does not get into this detail. However from a 2000 study conducted through Cornell University and support previously given to this study by A D Little to the District of North Vancouver (April 2002), along with corroborating studies in the Twin Cities area of Minnesota, a land use planning view shows 8 units/acre (average) represents the transition from an urban to rural designation or a low density definition (see Appendix "3" for these reports and my summary). It is my understanding the District of North Vancouver agreed at the time this was a reasonable definition for low density residential and from my view appears to represent just what the MIACC criterion is suggesting. As there is nothing to prescribe the 8 units/acre (average) density it appears to be a very reasonable value to use to help define low density residential use and it would be an acceptable level of risk and one I can support, in my opinion.

The MIACC criteria, as shown in the drawing on **Figure 5 Appendix "2"** shows low density residential development is allowed within the 1 X 10^{-5} and the 1 X 10^{-6} risk zones. And the drawing specifically shows that low density residential needs to be near to the lower risk level of 1 X 10^{-6} within that zone. This concurs with the GWL proposed development and the 1 X 10^{-6} risk contour for the Canexus TCP project. It is also important to note the proposed development design also restricts the numbers of people in the residents by designing mainly studio and one bedroom residences. By restricting the numbers of people the probability of a fatality will be reduced and support the MIACC criteria.

Strathcona County and Sturgeon County municipal jurisdictions in Alberta who have heavy industrial activities have adopted the MIACC criteria and developed risk zones to manage development. The point here is the companies in the heavy industrial areas that have the potential to cause off site impacts have endorsed this approach as it allows them the opportunity and freedom to do business as long as their operations meet the risk criteria. Something they have desired and have found acceptable towards being a viable business. I would expect Canexus, based upon the risk assessment they have conducted and the existing development already in the area, would see this in the same light as the distances from their risk source is well within these criteria of 1 X 10^{-5} and 1 X 10^{-6} as defined by MIACC for low density residential use.

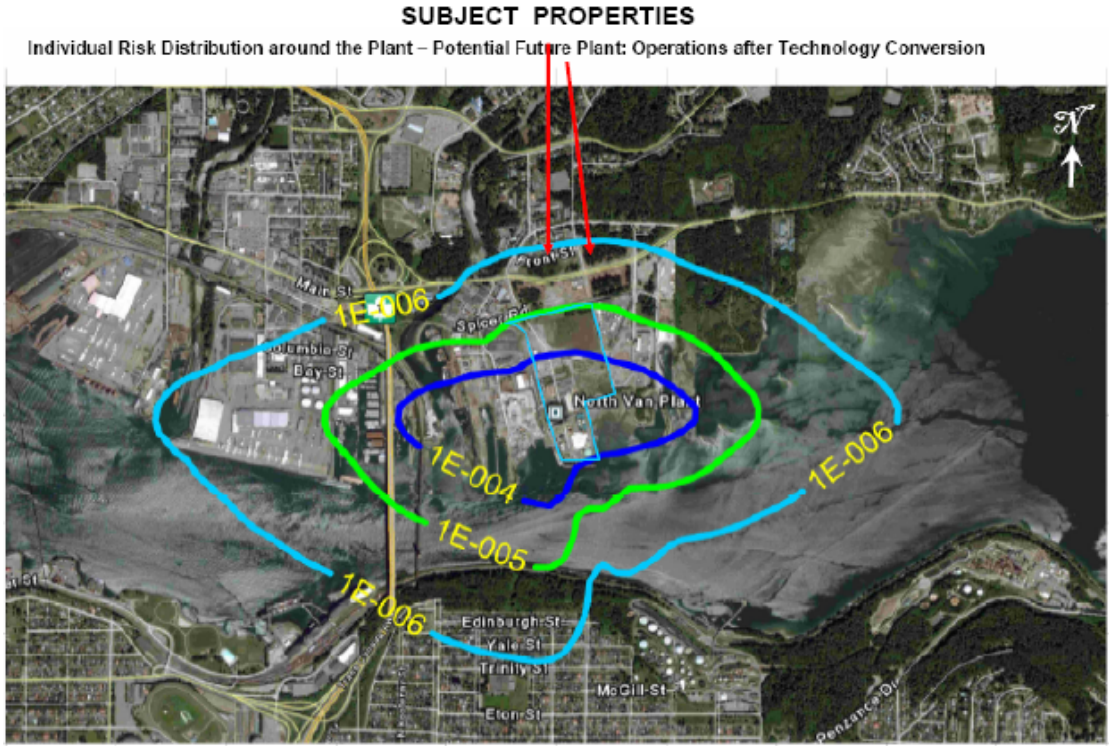
As there is no specific distances designated by the MIACC criteria but the criterion does put low density housing within the 1 x 10^{-5} and the 1 x 10^{-6} risk zones and close to the 1 x 10^{-6} risk contour, and the GWL proposal is to develop the northern edge of their property for low density residential, I look at this as meeting the MIACC criterion. Further with the choice to develop based on a "low density residential" density of 8 units/acre (average). I would conclude the GWL proposal which includes the two vacant parcels in the calculation does meet the MIACC criteria.

I believe this analysis is appropriate for the study area. Please let me know of any questions. Thank you for asking me to develop this review.

Doug McCutcheon, P. Eng

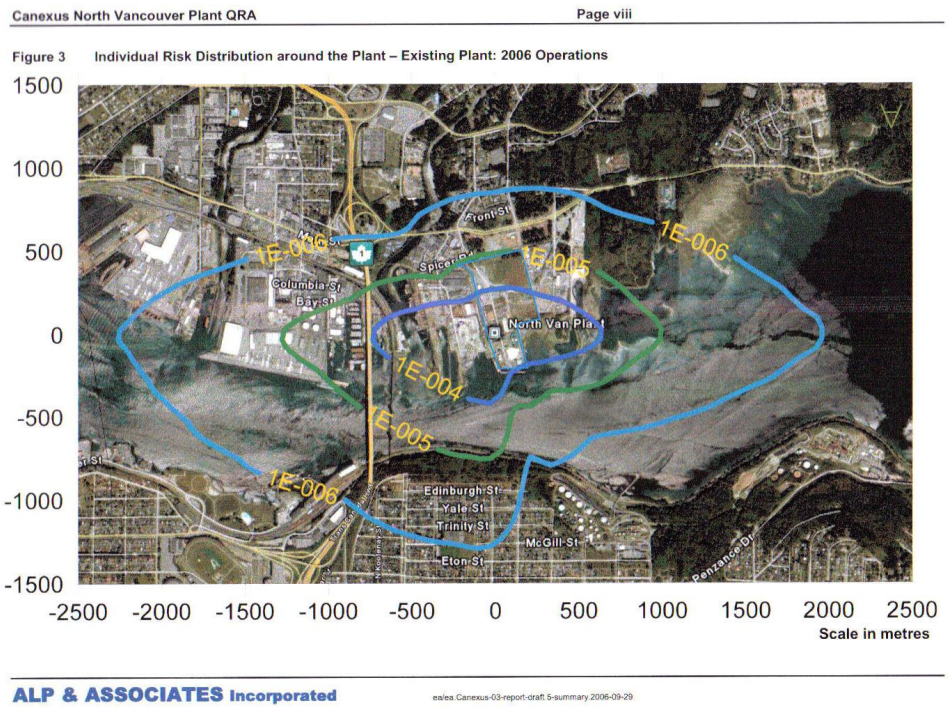
Area Information

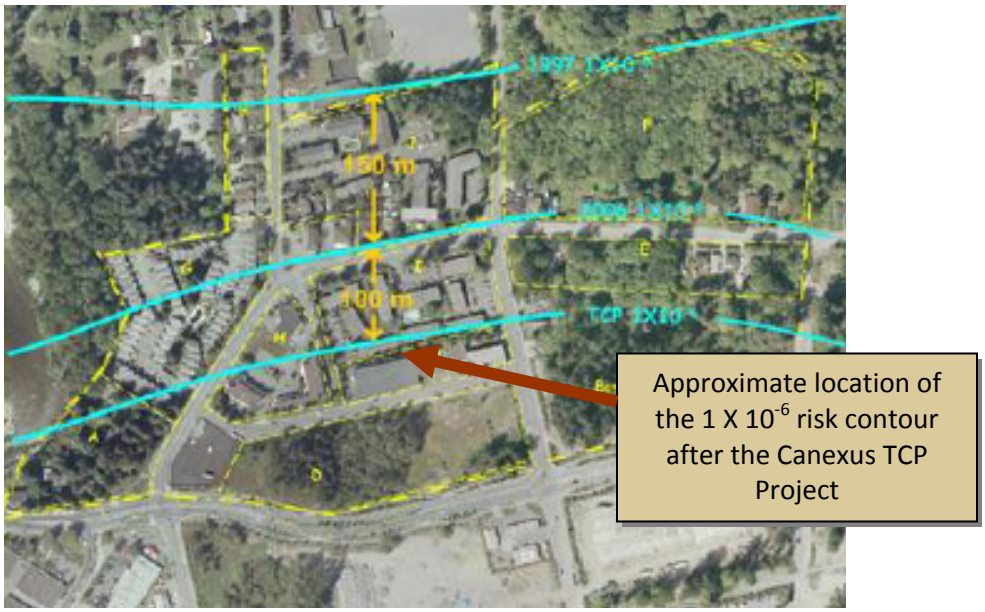
SUBJECT SITES LABELED "FUTURE BUILDINGS"



(Figure 1)

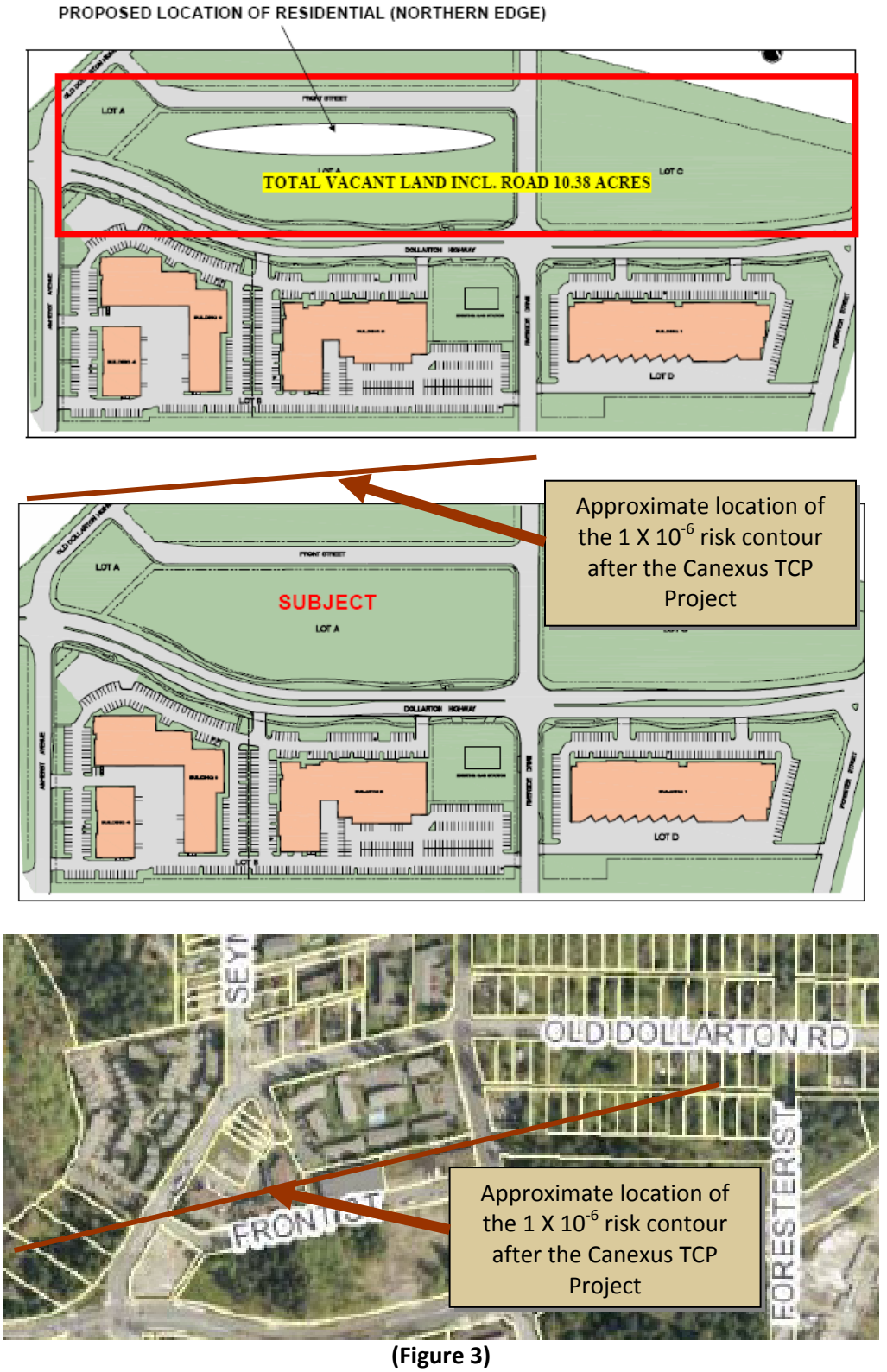
Alp & Associates Quantitative Risk Assessment



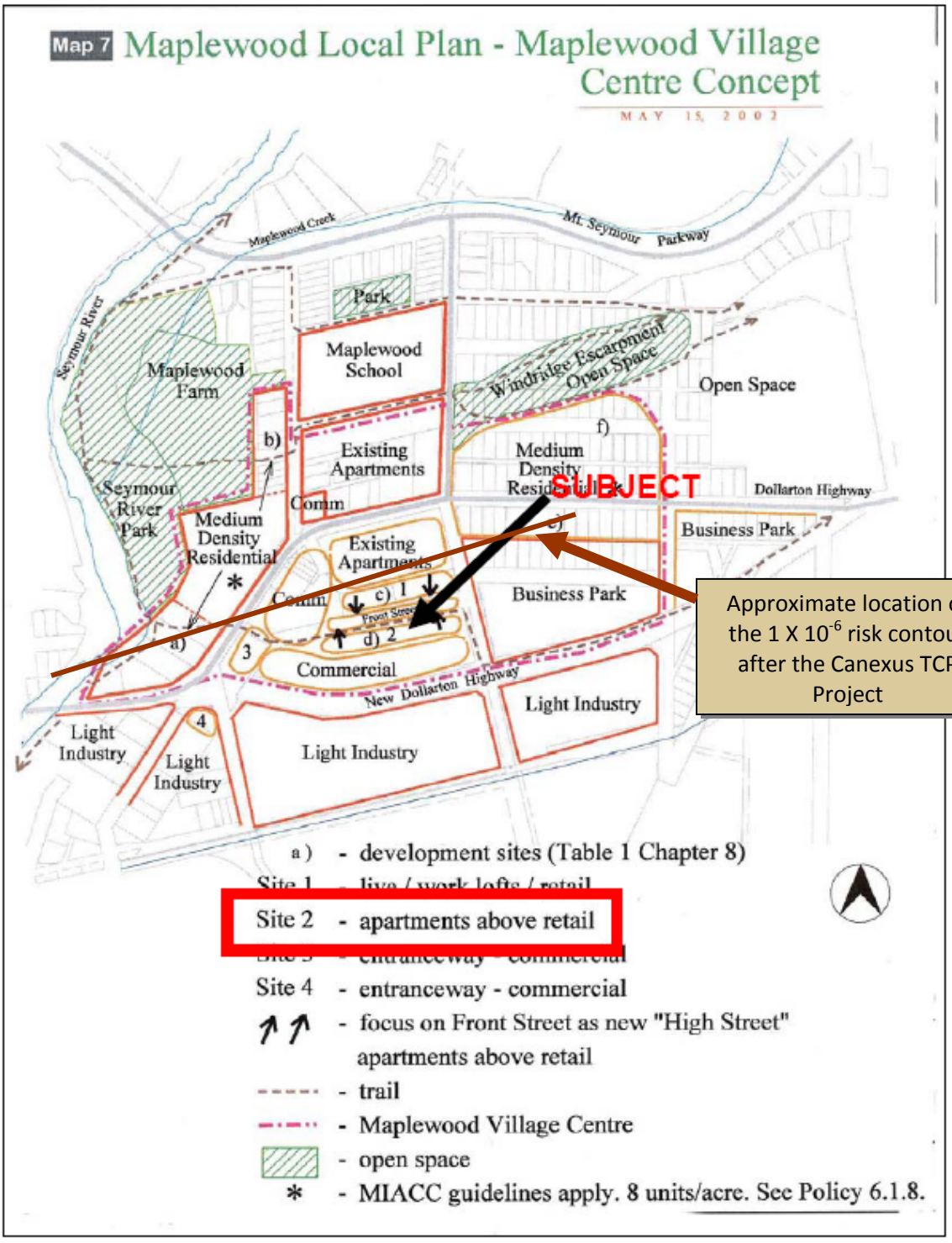


(Figure 2)

Great West Life Subject Area under Review



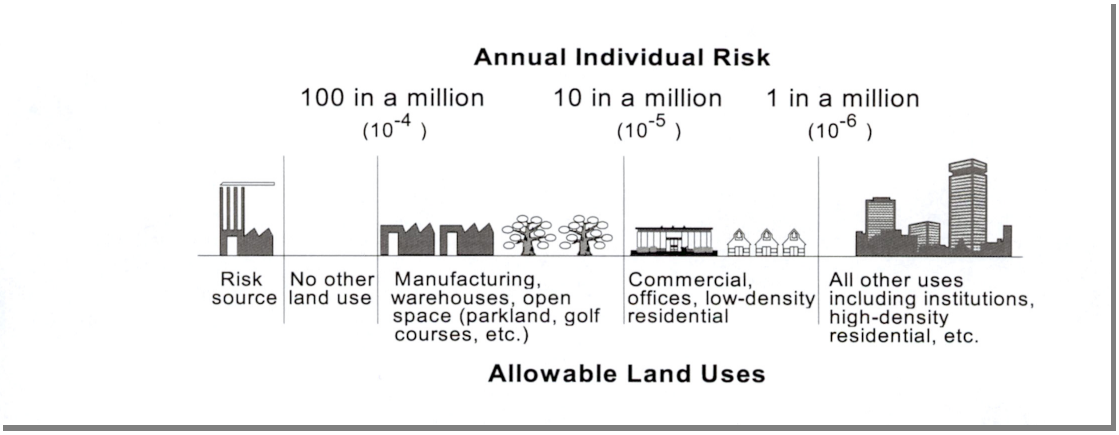
(Figure 3)

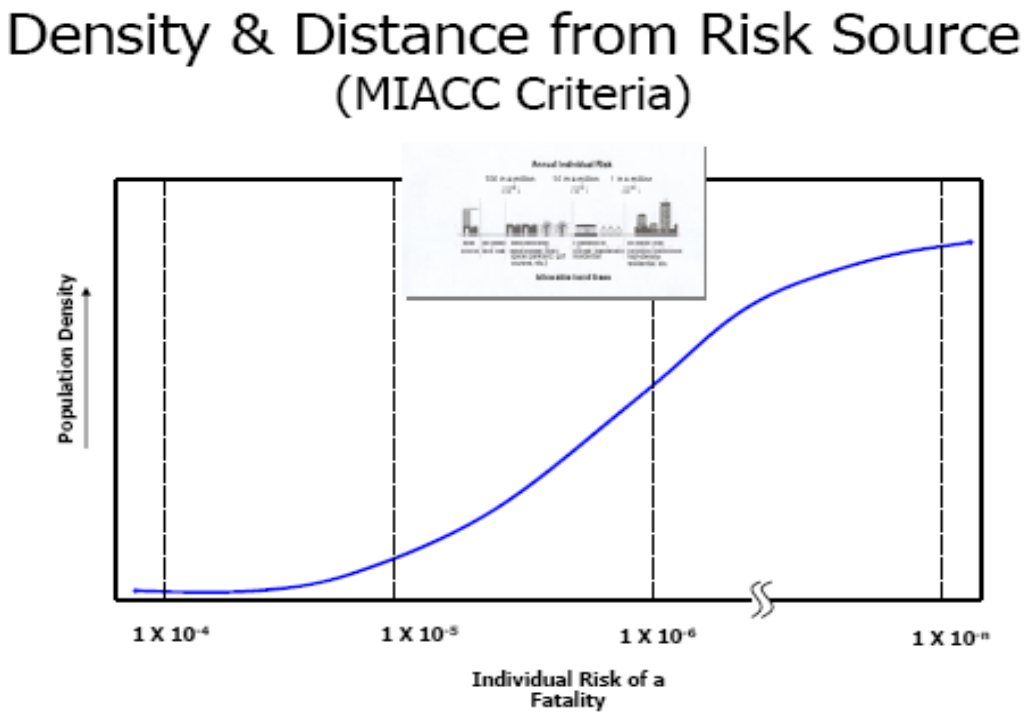

Map 7 Maplewood Local Plan - Maplewood Village Centre Concept
MAY 15, 2002
Maplewood Creek
Mt. Seymour Parkway
Seymour River
Park
Maplewood School
Maplewood Farm
Windridge Escarpment Open Space
Open Space
Existing Apartments
Medium Density Residential
SUBJECT
Dollarton Highway
Seymour River Park
Medium Density Residential
Comm
Existing Apartments
Business Park
Front Street
Commercial
New Dollarton Highway
Light Industry
Light Industry
Light Industry
Light Industry
Approximate location of the 1 X 10-6 risk contour after the Canexus TCP Project
a) - development sites (Table 1 Chapter 8)
Site 2 - apartments above retail
Site 4 - entranceway - commercial
- focus on Front Street as new "High Street" apartments above retail
- trail
- Maplewood Village Centre
- open space
* - MIACC guidelines apply. 8 units/acre. See Policy 6.1.8.

(Figure 4)

MIACC Criteria

MIACC Risk Based Land Use Planning Criteria





(Figure 5)

Low Density Residential Studies

Summary:

The following reviews were conducted as part of an ongoing risk analysis of the chlorine facility now owned by Canexus. As I see it, over the years the District of Vancouver has been trying to determine a safe distance for development in the area near the Chlorine plant site. Several risk assessments were conducted to determine risk contours. Arthur D Little Inc. was commissioned to evaluate a previous 1997 risk assessment and they were able to provide along with their report an "opinion" as to what is considered to be a reasonable definition of "low density residential" as 8 units/acre (average). Again the MIACC criteria does not specify population densities for the risk criteria so making this determination is one that is primarily up to the local jurisdiction to determine.

The initial reference to low density residential lands is one that is not specific to heavy industrial activity near residential neighbourhoods but does provide a basis to work from. I chose to consider one other source developed in Minneapolis and St Paul Minnesota which is included below and they too reference a definition of 7 – 9 units/acre as an average for low density residential. Their choice to compare urban and rural does represent a change and in my view adequately reflects the MIACC criteria for changing population densities as one moves further away from an industrial risk source (Appendix "2" Figure 5).

Also included below is an opinion expressed by Lisa Bendixen in a letter to the District of North Vancouver indicating her evaluation of the Cornell study and application to low density residential development. Again the opinions are just that in relation to the MIACC criteria as MIACC did not determine population density in reference to their risk based land use criteria. However the application of 8 units/acre (average) does have a basis as a definition for low density residential development as based on the two sources recognized here. And they are a reasonable basis in my opinion and one that I can support as GWL moves forward.

EXHIBIT 4

Arthur D Little

Arthur D. Little, Inc.
Acorn Park
Cambridge, Massachusetts
02140-2390 U.S.A.

Telephone (1) 617.498.5000
Fax (1) 617.498.7200

April 22, 2002

J. Irwin Torry
Manager of Community Planning
The District of North Vancouver
355 West Queens Road
North Vancouver
British Columbia
V7N 4N5

Re: ADL Reference No. 75818

Dear Irwin:

Arthur D. Little, Inc. has reviewed the revised Maplewood Plan (as documented in your letter of April 17, 2002) against the 1997 risk contours for the Nexen plant and the MIACC Guidelines on risk levels. We based this review on the facility conditions captured in the 1997 risk assessment prepared by Bovar Environmental, thus any recent changes or improvements at the site that would affect the contours are not reflected.

The MIACC Guidelines use the phrase "low density residential" without providing any specific definition of low density. Although there are many different definitions of "low density residential" in use in various communities, they generally seem to be limited to 8 units/acre or less. Furthermore, a survey by Cornell University examining the impact of low-density-only zoning on housing choices used a definition of less than 8 units/acre in a survey of over a thousand communities.

The District's proposal to allow a limited number of multiple dwelling or mixed-use housing units between the 10^{-5} and 10^{-6}/year contours appears to be consistent with the intent of the MIACC Guidelines. The proposed use of an average of 8 units/acre, rather than a maximum of 8 units/acre also seems reasonable, in part because the variations in density that lead to the average of 8 units/acre are not excessive and because the overall areas involved are relatively small. The proposed plan also recognizes that the density could increase (somewhat) near the 10^{-6}/year contour, but should decrease near the 10^{-5}/year contour (corresponding to the non-linearity of the risk levels). Totally new areas of development are also limited near the 10^{-5}/year contour, in turn limiting the potential risk exposure.

Sincerely,

Lisa M. Bendixen
Principal, Global Environment & Risk

Does Low-Density Zoning Affect Low Minority Populations?

by Lew Sichelman

A Cornell University study might just provide the first hard evidence that low-density-only zoning has an exclusionary effect on housing choices for Blacks and Hispanics in the country's major metropolitan areas.

Federal reports as far back as the 1960s have suggested such a correlation, but no comprehensive study has ever been undertaken to prove that assertion.

Now, though, research by Assistant Professor of City and Regional Planning Rolf Pendall at the Ithaca, N.Y. school found that compared to other communities, there were about half as many Blacks and two-thirds as many Hispanics in the jurisdictions with lower housing densities.

Pendall's study, which was published in the spring 2000 issue of the Journal of the American Planning Association (JAPA), is being hailed as "a major breakthrough" by Stuart Meck, principal investigator of the APA's Growing SmartSM project.

"Until now," Meck said, "no surveys have ever nailed down with good statistical analysis the contention, made by other studies as far back as the late 1960s, that low-density-only zoning has an exclusionary effect on housing choices for minorities."

The study covered 1980 and 1990 Census Bureau data and included a survey of 1,510 jurisdictions in the country's 25 largest metropolitan areas.

Altogether 77 percent or 1,168 communities representing 32 percent of the nation's 1990 population responded to Pendall's survey. Ninety percent of the jurisdictions that replied to the survey had zoning ordinances, although only 15 percent had **low-density-only zoning (fewer than eight housing units per acre)**.

"I conducted the study to determine whether exclusionary zoning is still a problem in major metropolitan areas," Pendall said, "and to see whether other land-use controls reduced ethnic and racial diversity in American communities."

If the housing dynamics in the jurisdictions with low-density-only zoning had been similar to those in communities without exclusionary zoning, he pointed out, the former areas would have some 31,300 more Blacks and 21,600 more Hispanics.

Pendall found that low-density only zoning is especially prevalent in metropolitan Boston, New York, Philadelphia, Pittsburgh, Cleveland and Atlanta. Municipalities in the West, Florida and Maryland tend to accommodate higher density residential development, regulating new housing more actively via greenbelts, building permit caps and adequate public facilities ordinances. Midwestern municipalities tend to regulate less actively with any of these tools.

The study also uncovered some anomalies. For example, places that used building permit caps and urban growth boundaries had lower concentrations of African Americans but not significantly lower concentrations of Hispanics.

Pendall suggests that communities with low-density-only zoning became more exclusive during the 1980s as a result of growing more slowly, shifting from multi-family to more single-family housing units, and shifting away from renter occupancy.

Published: June 5, 2000

Housing Density Fact Sheets for Minneapolis and Saint Paul

These two-page documents present local examples of housing and neighborhoods in and near Minneapolis and Saint Paul. The housing examples range in density from seven dwelling units per acre (du/ac), to 110 (du/ac). Each is presented with ground and aerial photographs, as well as a location map. Descriptions of the housing and site characteristics and census data—at the census tract and block levels—provide detailed information about each example.

Minneapolis and Saint Paul

- Density Fact Sheets: includes entire series (14.2 MB)
- Humboldt Greenway: 7 (du/ac) (692 KB)
- Portland Place: 8 (du/ac) (658 KB)
- Hennepin Avenue and 32nd Street: 11 (du/ac) (803 KB)
- Crocus Hill: 18 (du/ac) (1.19 MB)
- Lyndale Avenue and 25th Street: 19 (du/ac) (740 KB)
- Riverplace / Saint Anthony: 20 (du/ac) (1 MB)
- Mill District: 24 (du/ac) (753 KB)
- Shingle Creek Commons: 27 (du/ac) (1.4 MB)
- Riverside / West Bank: 28 (du/ac) (632 KB)
- Linden Hills: 32 (du/ac) (914 KB)
- Cathedral Hill: 34 (du/ac) (1.5 MB)
- Stonehouse Square: 40 (du/ac) (1.09 MB)
- East Village: 62 (du/ac) (936 KB)
- Laurel Village: 89 (du/ac) (672 KB)
- Uptown: 110 (du/ac) (707 KB)

Small Towns

- Density Fact Sheets: includes entire series (23.29 MB)
- Chaska: 9 (du/ac) (3.87 MB)
- Cannon Falls: 9 (du/ac) (3.83 MB)
- Stillwater: 12 (du/ac) (4.44 MB)
- Red Wing: 13 (du/ac) (2.36 MB)
- Hastings: 15 (du/ac) (4.09MB)
- Hastings: 18 (du/ac) (4.24 MB)
- Stillwater: 22 (du/ac) (4.12 MB)

Suburbs

- Density Fact Sheets: includes entire series (29.63 MB)
- Woodbury: 8 (du/ac) (2.39 MB)
- New Brighton: 8 (du/ac) (2.25 MB)
- Robbinsdale: 9 (du/ac) (2.08 MB)
- Eden Prairie: 9 (du/ac) (2.56 MB)
- Robbinsdale: 9 (du/ac) (2.54 MB)
- Woodbury: 10 (du/ac) (2.26 MB)

- North Saint Paul: 10 (du/ac) (2.01 MB)
- Woodbury: 11 (du/ac) (1.89 MB)
- Eden Prairie: 18 (du/ac) (4.74 MB)
- Woodbury: 21 (du/ac) (2.32 MB)
- Woodbury: 32 (du/ac) (2.25 MB)
- Minnetonka: 50 (du/ac) (2.72 MB)

Outside of the Twin Cities Area

- River City Center (673 KB)
- River Gables (766 KB)
- Housing Density in the Twin Cities Scale Poster (2.33 MB)
- Housing Density in the Suburbs and Small Towns Scale Poster (24.73 MB)
  These are photographs of individual buildings and developments of varying densities.

References

References

MIACC, Risk-based Land Use Planning Guidelines (1995)

Does Low-Density Zoning Affect Low Minority Populations? *by Lew Sichelman Published: June 5, 2000*

Metropolitan Design Center, College of Architecture and Landscape Architecture, University of Minnesota, 1 Rapson Hall, 89 Church St SE, Minneapolis MN 55455, wwwdesigncenter.umn.edu

Arthur D Little Letter to the District of North Vancouver, April 22, 2002 from Lisa Bendixen

APPENDIX "5"

A Review of the Maplewood Development Concept Plan Clarification - October 14th, 2008

Risk Based Land Use Planning

For the

District of North Vancouver

A Review of the

Maplewood Development Concept Plan

Clarification

OCTOBER 14TH, 2008

Prepared By:

DOUG MCCUTCHEON AND ASSOCIATES, CONSULTING
A DIVISION OF "HUMAN FACTORS IMPACT LTD."

PROFESSIONAL ENGINEER ALBERTA
DOUGLAS J. McCUTCHEON

es, Consulting
Division of Human Factors Impact Ltd.

Professor Doug McCutcheon, P. Eng
10957 – University Avenue
Edmonton, Alberta, Canada, T6G 1Y1
Phone: 780 492 6931
Fax: 780 492 3409
Email: doug.mccutcheon@ualberta.ca

The question to me was:
"On Page 3 of your June 11, 2008 opinion, you state, "I really want to point out this is not the correct approach and is not supported by MIACC criteria." You then go on to say "I do not agree that such an approach can be used here." Yet, under the Summary paragraphs, suggest that the 'concept' works and you could support it. …… we'd like to have a more definitive statement from you that we can use in discussions with Council and also with both GWL and Canexus."

Also, a second question:
"As an alternative, if the idea of 200 units is not defensible from a risk hazard perspective, we're wondering if we can make an argument to Canexus to allow residential uses on Lot A at 8 units/acre based on the combine area of both Lots A and C. By my calculation, that would represent about 9.3 acres and permit in the order of 74units (excluding the vacant service station site currently being remediated which GWL will eventually obtain title to and consolidate with the rest of Lot A)."

In order to answer the question I chose to work my way through the rationale in my June 11, 2008 report.

First, the MIACC work has not developed specific population densities to be used in conjunction with the risk-based land use planning criteria as described in my report. That is why I wrote my comments the way I did. MIACC was not going to as much detail as you have with respect to defining the 8 units/acre. Basically the MIACC criteria is intended to describe an ever increasing density of population as one moves further from the risk source. And the MIACC criteria will allow for low density residential dwellings with in the 1 X 10^{-5} to 1 X 10^{-6} risk contours. The provision being the residential developments would be on the outer limit of the zone closest to the 1 X 10^{-6} contour.

I did research the 8 units/acre with respect to industrial development and specific to heavy industry and could not find a relationship although it is used to describe a transition to a rural environment. Hence I can see where your District has arrived at this as a means to measure development. And as my June 11, 2008 Opinion states makes sense to me. But I do need to reiterate there is no connection to the MIACC criteria.

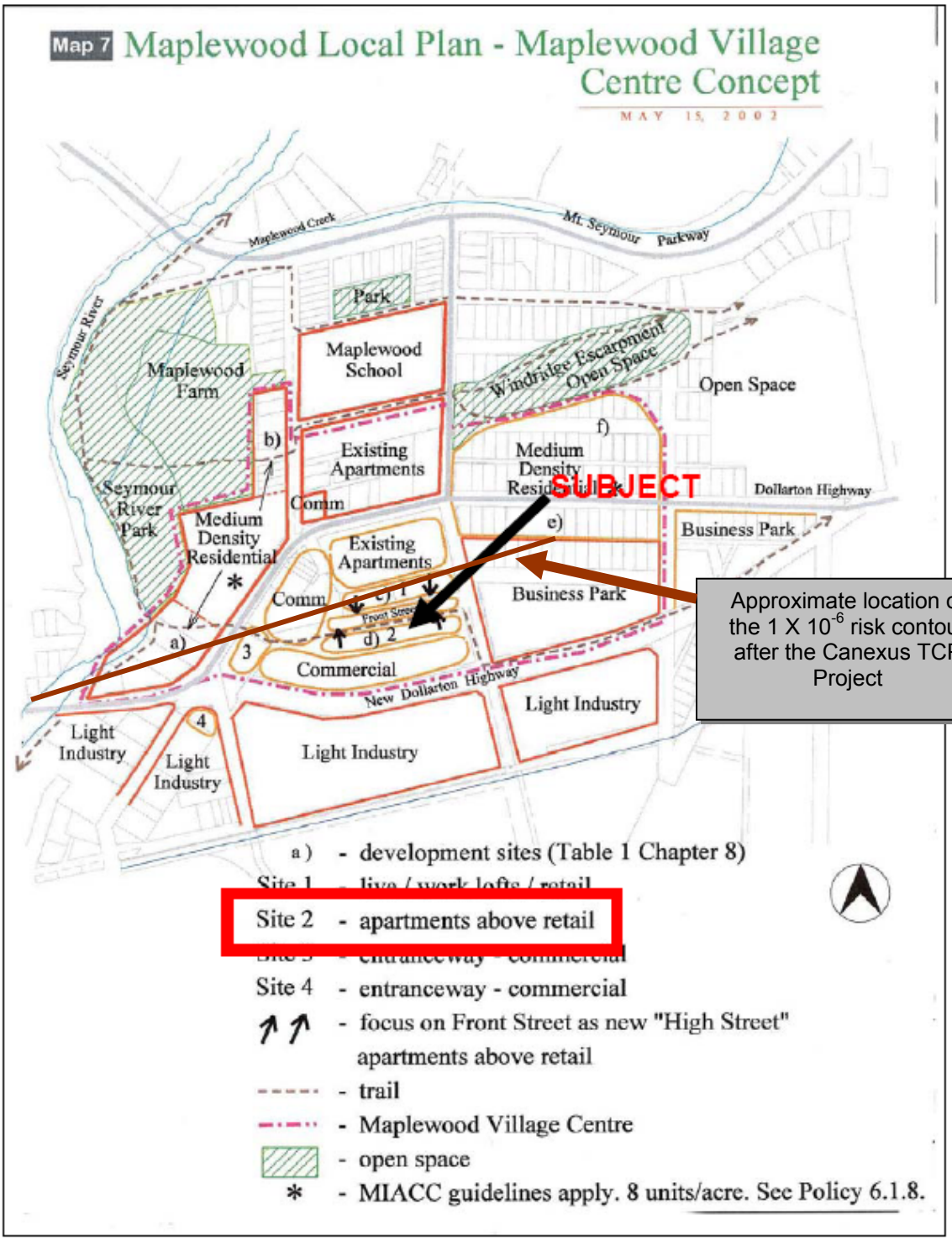
However, with that in mind the MIACC criteria does allow for some means to measure low density residential development. It is not specific but I am okay with the 8 units per acre. I also need to reiterate the 8 units/ acre population density needs to be closest to the 1 X 10^{-6} risk contour near Front Street. As the 1 X 10^{-6} contour represents the risk to an individual the risk level rises as the population density rises hence why MIACC indicates the development would need to be near Front Street.

The second question of a reduced density would be supported but again with the higher density units closest to the 1 X 10^{-6} contour. The point again being the further from the risk source the population is housed the less the risk will be.

The risks are low. The District of North Vancouver has done an excellent job in considering the risk impact on the community of Maplewood. I would not hesitate in supporting the proposals by GWL as long as the higher density residential component is located next to the 1 X 10^{-6} risk contour and not in any other quadrants of the zone in question.

I hope this helps you out. Please let me know if you have any questions. Thanks for the opportunity to clarify my earlier opinion.

Doug McCutcheon, P. Eng.


Map 7 Maplewood Local Plan - Maplewood Village Centre Concept
MAY 15, 2002
Maplewood Creek
Mt. Seymour Parkway
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Park
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Business Park
Existing Apartments
Comm
Front Street
d) 2
a)
3
Commercial
New Dollarton Highway
Business Park
Light Industry
Light Industry
4
Light Industry
Light Industry
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Site 1 - live / work lofts / retail
Site 2 - apartments above retail
Site 3 - entranceway - commercial
Site 4 - entranceway - commercial
- focus on Front Street as new "High Street" apartments above retail
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- Maplewood Village Centre
- open space
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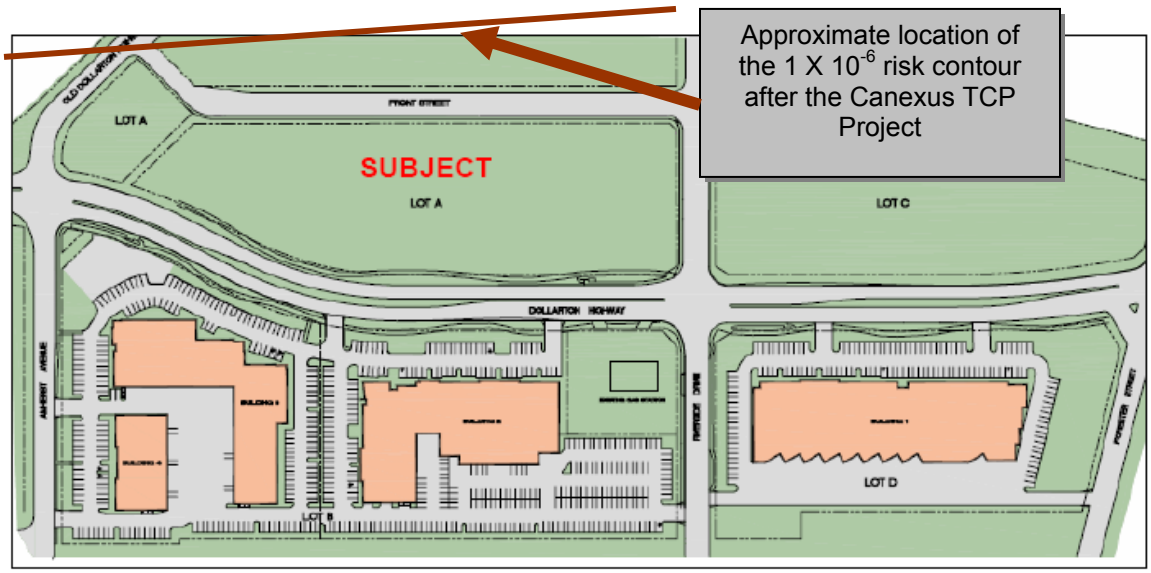
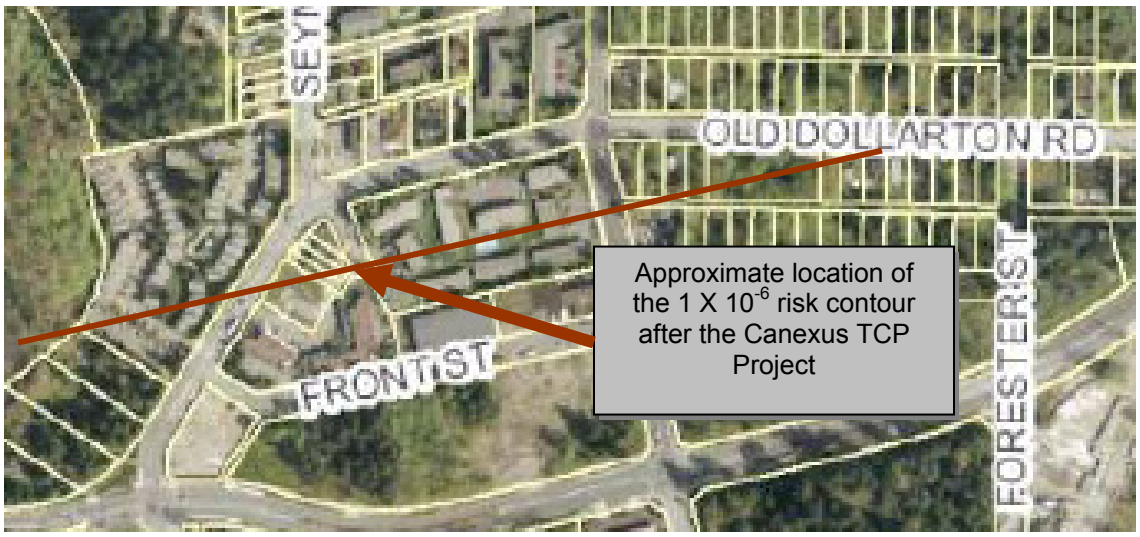
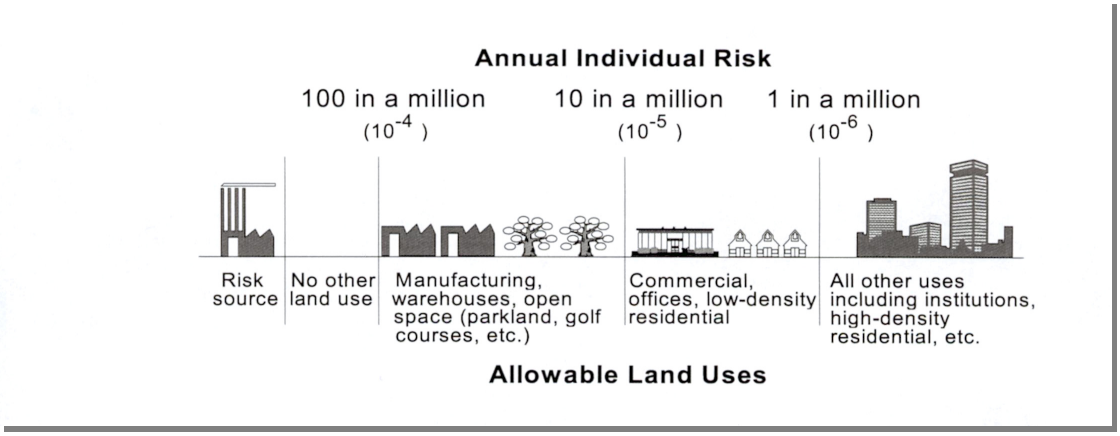
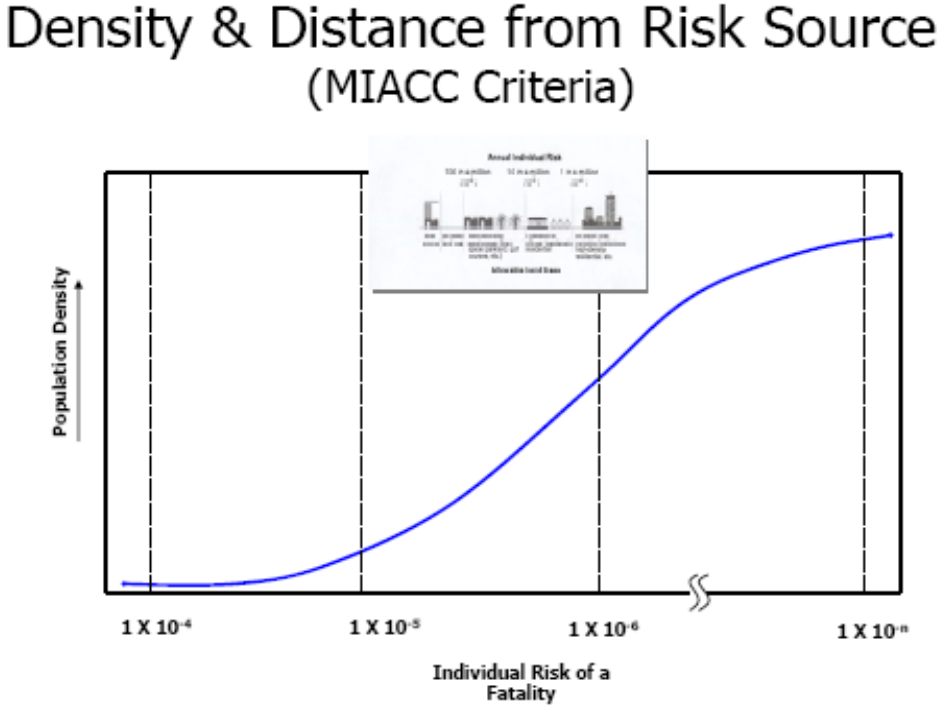
Great West Life Subject Area under Review



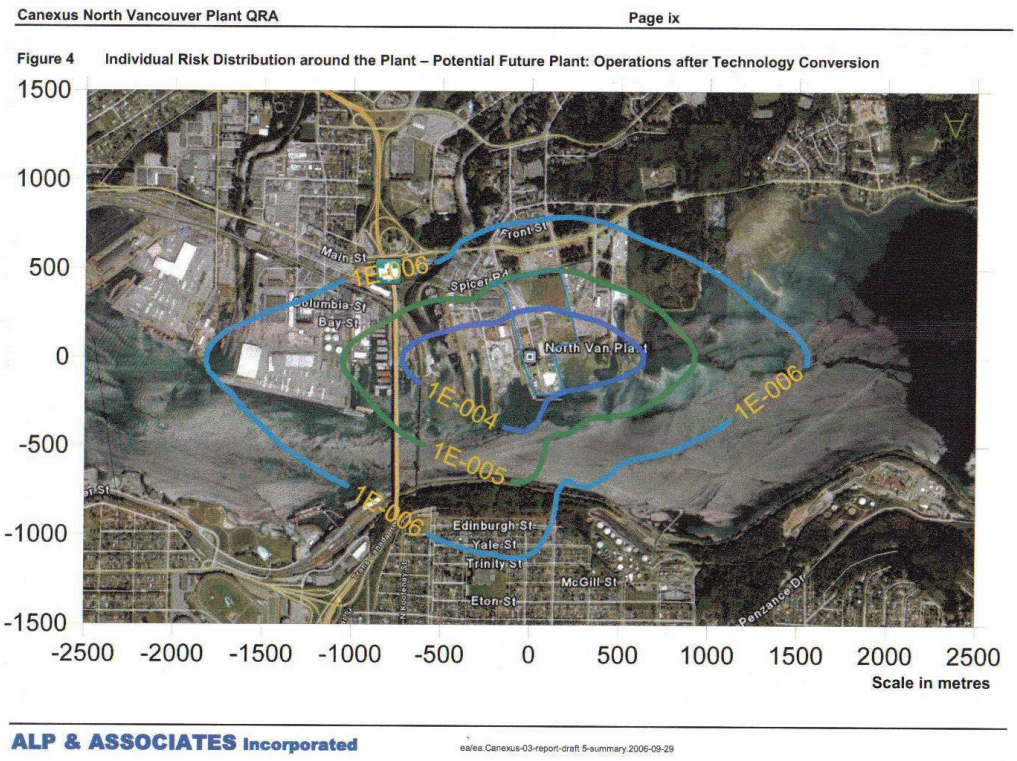


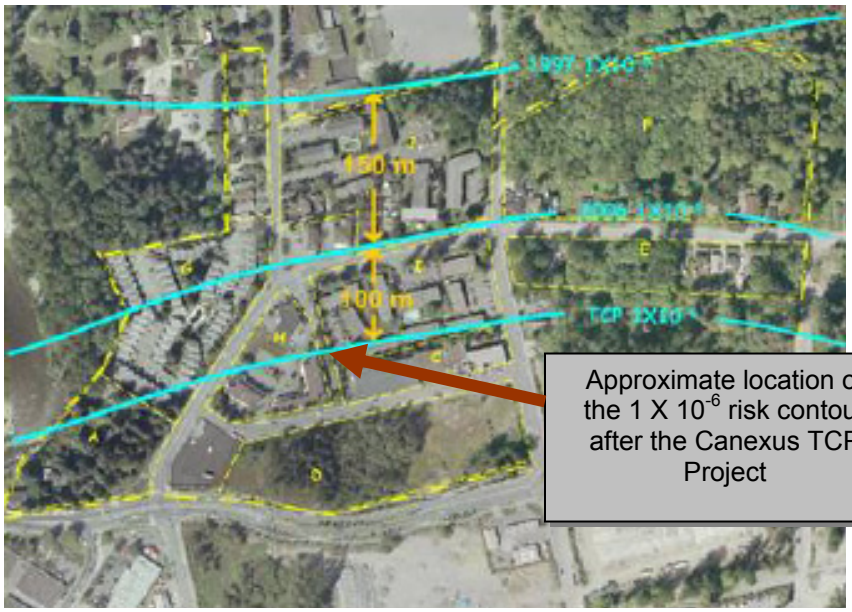
MIACC Risk Based Land Use Planning Criteria

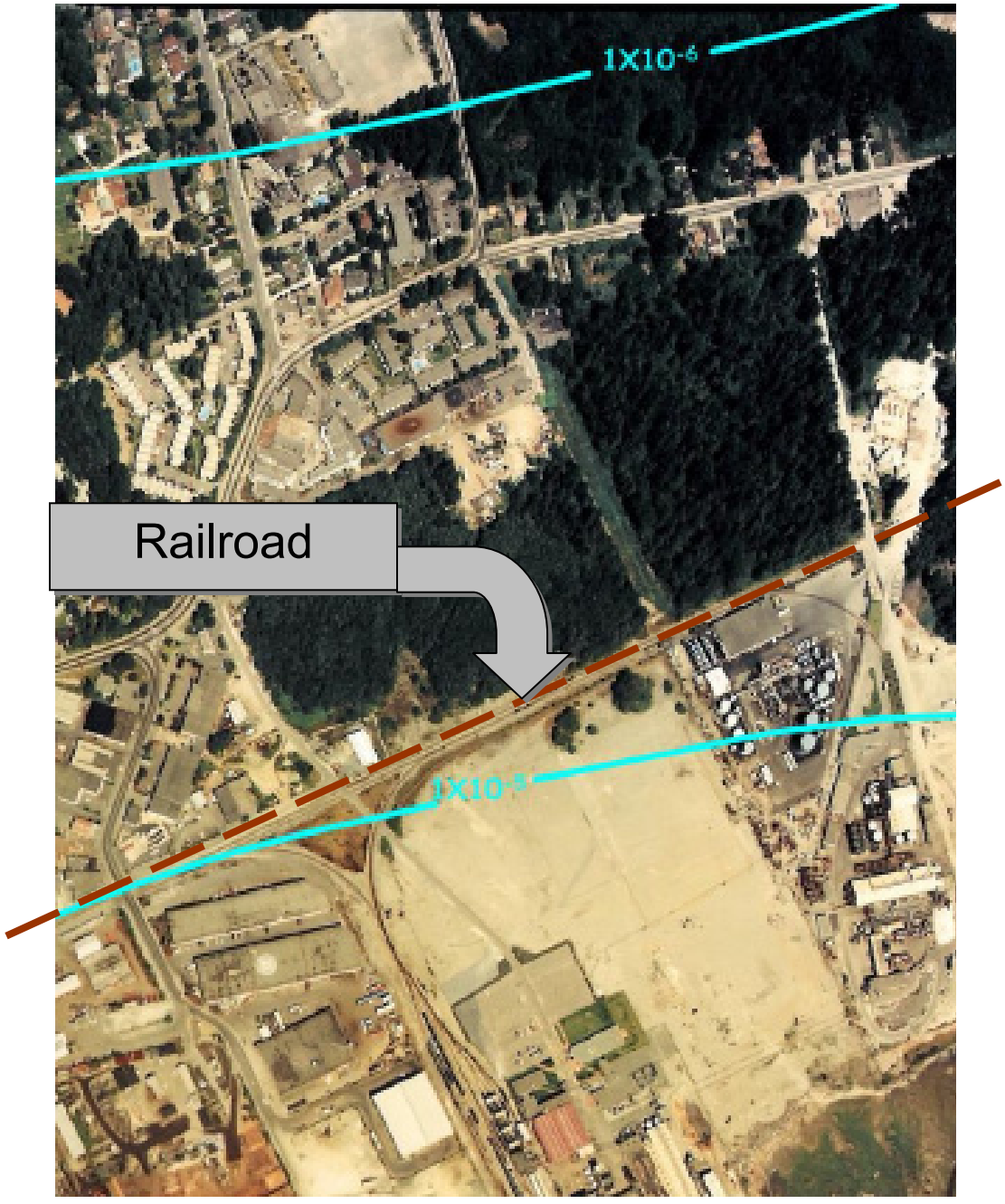




Canexus 2006 Risk Assessment Results






1X10-6
Railroad
1X10-3

APPENDIX “6”

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Disclaimer

"Maplewood Chemical Hazard DPA Preliminary Study"

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