BC Ministry of Transportation and Infrastructure

Evergreen Line Rapid Transit Project - Reichhold Industries Ltd. Reciprocal Risk Assessment

Prepared by:
AECOM
3292 Production Way, Floor 4 604 444 6400 tel
Burnaby, BC, Canada V5A 4R4 604 294 8597 fax
www.aecom.com

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60274107

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AECOM
3292 Production Way, Floor 4
Burnaby, BC, Canada V5A 4R4
www.aecom.com

604 444 6400 tel
604 294 8597 fax

April 17, 2013

Wendy Itagawa, P.Eng.
Port Moody Segment Manager, Evergreen Line Rapid Transit Project
Ministry of Transportation and Infrastructure
2900 Barnet Highway
Coquitlam, BC V3B 0G1

Dear Wendy:

Project No: **60274107**

Regarding: **Evergreen Line Rapid Transit Project - Reichhold Industries Ltd. Reciprocal Risk Assessment**

AECOM is pleased to provide the final report to the Ministry of Transportation and Infrastructure, respecting the Evergreen Line Rapid Transit Project and the Reichhold Chemical plant in Port Moody, BC.

This report has employed a Failure Mode Effects and Criticality Analysis to assess reciprocal risk posed by the Reichhold chemical plant and proposed Evergreen Line Rapid Transit Project. Additionally conceptual options have been identified to mitigate certain risks, and to enhance existing operations or protocols.

We look forward to receiving feedback from your team and also Reichhold Industries. If you have any questions during your review, do not hesitate to contact me.

Sincerely,
AECOM Canada Ltd.

Mike Rankin, M.Sc., R.P.Bio., CSAP-Risk
Group Leader, Environmental Toxicology & Risk Assessment
michael.rankin@aecom.com

MR:jw
Encl.
cc:

Distribution List

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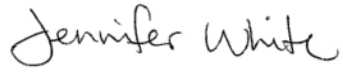
2	yes	Reichhold Chemical Company
2	yes	BC Rapid Transit Company
2	yes	BC Ministry of Transportation and Infrastructure (Evergreen Line Rapid Transit Project)
2		AECOM

Revision Log

Revision #	Revised By	Date	Issue / Revision Description
1	Mike Rankin	January 29, 2013	Address comments from Ministry of Transportation & Infrastructure
2	Mike Rankin	March 26, 2013	Address Final Comments from Ministry of Transportation & Infrastructure
3	Mike Rankin	April 16, 2013	Address additional Comments from Ministry of Transportation & Infrastructure

AECOM Signatures

Report Prepared By:



Jennifer White, P.Eng.
Engineer, Environment

Report Prepared By:

Mike Rankin, M.Sc., RPBio. CSAP-Risk
Group Leader, Environmental
Toxicology & Risk Assessment

Report Reviewed By:

Mark Westbury, B.Sc, M.Sc
Socio-economics Specialist

Executive Summary

Background: The Evergreen Line Rapid Transit Project (ELRTP) is being developed by the BC Ministry Transportation and Infrastructure (MoTI) and BC Rapid Transit Company (BCRTC), and the proposed route alignment traverses the Reichhold Industries Ltd. property in Port Moody, BC. In light of the close proximity of the proposed ELRTP to the Reichhold facility, the two entities initiated a review of reciprocal risks that each operator could pose to the other. The objectives of the risk assessment were to identify, assess and catalogue the risks to each organization (Reichhold and BCRTC). Risks were only considered in relation to the interaction between the Reichhold facility and ELRTP during operations. This report details the approach for risk analysis, the results of the assessment, and suggests conceptual mitigative options for the project including operational and safety protocols for the two organizations.

Approach: AECOM employed a broad and systematic approach known as Failure Mode Effects and Criticality Analysis (FMECA) to identify and evaluate possible issues and risks that may arise between the Reichhold facility and the ELRTP. Significant and plausible failure modes and their associated consequences were identified for each entity using the assessment protocol. The safety, regulatory, operations and maintenance risks were then assessed using a risk matrix approach. This FMECA was semi-quantitative (i.e., not based on industry statistics) and relied on the expert opinion of a risk assessment team that was formed by expert chemical plant operators, light rail transportation engineers and health scientists from the Joint Work Group, and facilitated by AECOM risk assessment staff. The results were catalogued in a Risk Register to facilitate risk management evaluation and risk communication.

Results: Fourteen (14) Evergreen Line system elements were tabulated, and thirty (30) Reichhold Facility system elements were tabulated and assessed under the FMECA protocol. Each of these system elements was associated with a plausible event that could evoke risk to the other organization (the 'receptor'). The results of the criticality analysis indicated *no system elements where risk mitigation was mandatory*. The majority of Evergreen Line elements indicated negligible risk to Reichhold. The majority of Reichhold elements indicated tolerable risk to Evergreen Line (Table 1).

Table 1. Risk Criticality Results Summary

Relative Risk Level Category	Evergreen Line Elements	Reichhold Elements
Negligible Risk	12 Elements	4 Elements
Tolerable Risk	2 Elements	19 Elements
Risk Mitigation Advisable	0 Elements	7 Elements
Risk Mitigation Mandatory	0 Elements	0 Elements

Conceptual Risk Mitigation Options: Notwithstanding the likelihood and risk of adverse events are very low, a series of conceptual risk mitigation options were developed to further reduce the likelihood of an adverse event and/or the severity of the consequence. These are detailed in Sections 3 to 5 of the report.

ELRTP Design considerations for risk mitigation include:

- Minimization of track work adjacent to the Reichhold facility;
- Strategic location of track switches;
- Implementation of a detection system for fire, smoke and trespasser activity to inform ELRTP staff if train operations warrant alteration to avoid an upset condition;
- Connectivity of Evergreen Line alarms with Reichhold alarms to assist in halting trains; and

- Full ventilation control of the Evergreen Line tunnel adjacent to the Reichhold plant.

Security Considerations: The proposed ELRTP development will increase the visibility of the Reichhold plant and operations to general public that commute along this route. Given this increased visibility it is prudent that Reichhold review and optimize security measures as a safeguard towards a potential increase in trespassers or vandalism.

The current security measures within the ELRTP were considered sufficient to cover concerns with this segment of the guideway. The Sky Train rulebook and security procedures are well defined. It is not anticipated that there would be any additional requirements based on this elevated section or tunnel section. It is important that the security fencing surrounding the guideway at its emergence from the Burnaby Mountain tunnel be effective.

The following issues and conceptual options are noted:

1. Minimize Access and Interaction between ELRTP - To enhance security, it will be desirable to minimize access to either facility through the other facility (e.g., minimal use of ladders, stairways connecting the operations).
2. Minimize Access to Tanker and Chemical Product - At the western terminus of Short Street there is a designated area for tanker trucks to load flammable finished product from the finished product storage tanks. These storage tanks are associated with event R6 (fire with black smoke potentially entering train or tunnel) and it is important, therefore, to review the procedures for opening security gates to enable truck transportation activities while ensuring site security during non-active times.
3. Manage Western Treed Area Masking Site Access - the western property boundaries have sections of dense bush and trees which provide effective cover for anyone wishing to approach the plant undetected. Conceptual options to improve security in this area would be to inspect fencing and its location with respect to treed areas, and ensure the fencing is robust and sufficiently high to deter easy access. Additional options may include closed circuit monitoring, motion sensors, and enhanced lighting.
4. Manage Eastern Treed Area Masking Site Access - the eastern wooded area adjacent to the eastern tanker truck access gate, is used periodically to park uncoupled tanker trailers. Given the proximity of these tankers to the proposed Evergreen alignment it is prudent to either relocate the parking area to one that is less shielded by tree cover, or to modify the current location (e.g., reduce foliage, increase lighting) to enhance security.
5. Conduct regular meetings between Transit Police, the local police authority and Reichhold security to discuss security.
6. It is recommended that regular tours for emergency response personnel should be held on the guideway so there is a clear understanding of the risk associated with being in this environment under normal or upset working conditions.

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1. Introduction

1.1 Project Background

The Evergreen Line Rapid Transit Project (ELRTP) is being developed by the BC Ministry Transportation and Infrastructure (MoTI) and the proposed route alignment traverses the Reichhold Industries Ltd. property in Port Moody, BC (Figure 1). In light of the close proximity of the proposed ELRTP to the Reichhold facility (Figures 2 - 4), the two entities initiated a review of reciprocal risks that each operator would pose to the other. These risks could include those related to accidents and malfunctions, air and noise emissions, changes to accessibility for the public to each of the sites, and maintenance activities.

The objectives of the risk assessment were to identify, assess and catalogue the risks to each organization (Reichhold and BC Rapid Transit Company (BCRTC). Risks were only considered in relation to the interaction between the Reichhold facility and ELRTP during operations. This report details the approach for risk analysis, the results of the assessment, and the development of mitigative options for the projects including operational and safety protocols for the two organizations (Reichhold and BCRTC) and security measures.

1.2 Proponents and Problem Definition

Key collaborators in this risk assessment were Reichhold Industries Ltd., ELRTP, Translink and BCRTC. Representatives from these organisations were brought together for the collaborative aspects of the project, and are referred to as the Joint Work Group.

Reichhold Industries operates a chemical manufacturing plant at their facility located at 50 Douglas Street, Port Moody, BC. Four classes of resin products are processed at this location: alkyd/urethane coating resins, polyester resins, latex emulsion resins and alkyd emulsion resins. Production at the facility consists of single line batch processes, including:

- Bulk raw material unloading and storage (tanker truck/rail car to storage tanks);
- Drum/package raw material unloading and storage;
- Batch chemical manufacturing;
- Thinning/blending;
- Filtration;
- Finished goods storage (bulk and drum); and
- Finished goods loading (storage tanks to tanker truck/rail car).

The ELRTP is a new 11 km rapid transit line (Evergreen Line) that will be operated and maintained by BCRTC. Evergreen Line will integrate with the existing Skytrain lines and will connect Coquitlam to Vancouver via Port Moody and Burnaby. The ELRTP has received approval under the BC Environmental Assessment Act and construction is expected to begin in the Fall of 2012 with completion by 2016. The ELRTP proposes a rail alignment such that the track emerging from a tunnel in Burnaby Mountain will then pass through the southern end of the Reichhold property on an elevated guideway. On its emergence from the tunnel, the alignment of the elevated guideway will be within approximately 35m of the Reichhold south property line, where bulk chemical products and raw material are stored. The elevated guideway will remain external to the Reichhold site for approximately one third of the east-west span of the Reichhold south property line. It will then obliquely cross into the Reichhold plant, bisect the eastern two thirds of the Reichhold site, and then descend to ground level on leaving the Reichhold site. Details of the proposed alignment showing the Reichhold site and proposed guideway are provided in Figures 1 through 4.

2. Risk Identification and Evaluation

2.1 Introduction

AECOM employed a broad and systematic approach known as Failure Mode Effects and Criticality Analysis (FMECA) to identify and evaluate possible issues and risks that may arise between the Reichhold facility and the ELRTP. FMECA examines normal and upset (failure mode) conditions of operating systems by focusing on the likelihood of events and severity of adverse consequences (Carlson 2012). Significant and plausible failure modes and their associated consequences were identified for each entity using the assessment protocol and the knowledge base of the risk assessment team. Existing controls to mitigate risk were also identified. Then the safety, regulatory, operations and maintenance risks were assessed using a risk matrix approach. This FMECA was semi-quantitative (i.e., not based on industry statistics) and relied on expert opinion of a risk assessment team that was formed by expert chemical plant operators, light rail transportation engineers and health scientists from the Joint Work Group, and facilitated by AECOM risk assessment staff.

2.2 Approach

The evaluation of potential issues and risks for this assessment was based on:

1. Review of ELRTP plans and discussion with Joint Work Group;
2. Site reconnaissance of the Reichhold facility and proposed juxtaposition of the Evergreen Project;
3. Review of proposed ELRTP operations management measures concerning access and operations and potential interactions with Reichhold's operations and systems; and
4. FMECA Risk Assessment Workshop with Joint Work Group to access and document expert knowledge on operations, failure modes, consequence severity, and existing mitigative measures.

In preparation for the FMECA Workshop, the following activities were completed:

- Acquisition of publicly available information (Translink, BC Ministry of Environment's Environmental Assessment Office Project Information Centre, City of Port Moody, among others).
- Site visit to the Reichhold facility in Port Moody.
- Review with Translink's Evergreen project representatives of the current state of planning for the alignment of the elevated guideway.
- Meetings with ELRTP and Translink representatives responsible for operations to scope issues between Evergreen Line operations and the Reichhold facility, and to understand any work that ELRTP have done so far to identify and mitigate issues and risks.
- Development of a series of plausible risk scenarios, risk tolerances (risk criticality), and materials to support risk identification and assessment in the risk evaluation workshop.

2.2.1 FMECA Workshop

The 2-day workshop was convened on August 21-22, 2012 at the Reichhold facility with representatives from MoTI, Reichhold, and ELRTP present. The workshop was facilitated by AECOM and followed the FMECA process of expert interrogation (Carlson 2012). A pre-workshop briefing was sent to workshop participants to explain the process and their roles. Following a brief presentation and reconnaissance of the chemical plant and proposed rail guideway alignment, the facilitators guided the group to explore plausible risk scenarios arising between Reichhold

and ELRTP. The group's expert knowledge was used to explore event likelihood and consequence severity of normal operations, upset conditions and accident safeguards. Various risk scenarios identified by the expert team were evaluated for consequence to (i) operations; (ii) worker and passenger health; and (iii) maintenance and mitigation. The FMECA focus was on major systems and elements that account for plausible events, and did not explore root cause and smaller components within a system or element. Each organization (Reichhold and ELRTP) was interrogated respecting their plausible operation events (normal and upset conditions). For a given event, the reciprocal organization (the receptor) provided context on how the event could affect their operations/systems and described the corresponding consequence severity. Typically dialogue followed amongst the Joint Work Group leading to a consensus on index scores for event likelihood and consequence severity.

AECOM recorded the data in real time to generate preliminary results during the workshop. However, visualization of risk matrices during an FMECA workshop may potentially cause optimistic bias in expert opinion (i.e., under estimation of event likelihood or consequence severity). Therefore only the input information was tabulated during the Workshop; synthesis of risk matrices with criticalities was deferred to draft reporting to avoid bias. The findings of the work were generated from the work group during the workshop and so were effectively validated in real-time by the group; AECOM has not done any detailed studies to validate the findings outside of the workshop.

2.2.2 Risk Matrices

FMECA risk matrices were constructed based on likelihood and consequence severity. Prior to the workshop, AECOM examined definitions for likelihood and risk criticality provided by both Reichhold and BCRTC, and found significant differences. Accordingly, AECOM devised a unified risk matrix that was used in the workshop for both organizations. Additionally, the proponents shared specific corporate criteria defining consequence severity across the various receptor categories. Following minor adjustments during the inception of the workshop, the team reached a consensus and adopted the resultant risk indices and risk criticality criteria detailed in Appendix A (Tables A1 to A9). The risk criticality (i.e., relative risk tolerance) defined for this FMECA is illustrated in Table A4. The reader will note four conditions of relative risk (Negligible; Tolerable (no mitigation needed, but monitor); Risk Mitigation Advisable; and Risk Mitigation Mandatory), each of which is colour coded according to a defined distribution within the risk matrix. The Joint Work Group discussed and reached consensus on the locations of these relative risk levels within the risk matrix prior to implementation.

2.2.3 Environment Receptor Excluded

The original terms of reference for the risk assessment also identified Environment as a category of receptor that should be evaluated in the context of reciprocal risk. However, a consensus opinion developed early in the process that led to the exclusion of Environment as a risk receptor. The rationale was that an event and adverse consequence to the Environment was not relevant within the context of assessing reciprocal risks posed by each proponent. Specifically, any event that yields impact or risk to the environment would be directly attributable to and accountable by the responsible party, and not the second party. Therefore Environment as a category of risk was removed from the assessment process, with the understanding that each proponent may wish to evaluate environmental risk using an internal process only (i.e., not using the paradigm of reciprocal risk).

2.2.4 Regulatory Consequence Excluded

The original terms of reference also identified Regulatory status as a category of consequence that should be evaluated in the context of reciprocal risk. Risk that an event posed to the Regulatory status of the impacted organization was contemplated for each event, however it was invariably considered to be negligible (severity level "A"). This was based on the collective view that the affected organization would/could not be found to be out of

regulatory compliance if the cause for the condition was attributable to a third party event. Accordingly, a consensus opinion developed during the process that concluded in the exclusion of Regulatory status as a category of consequence, because the severity result was always “negligible” and provided no means to distinguish mitigative priorities.

2.2.5 Documentation of Risk

AECOM catalogued the results in a Risk Register to facilitate risk management evaluation and risk communication. The risk register (Appendix A, Table A7) contains all risk details for each scenario assessed including (i) a brief description on the nature of the risk; (ii) severity score of the potential impact; (iii) likelihood of risk; (iv) expert opinion (relative score) on predictability of the risk; (v) uncertainties associated with the risk and its outcome; and (vi) potential mitigation option.

2.3 Results

Fourteen (14) Evergreen Line system elements were tabulated, and thirty (30) Reichhold Facility system elements were tabulated. Based on the consequence severity and relative risk level, a level of criticality was assigned to each system element based on each consequence category. Copies of all the results from the FMECA Workshop are provided in Appendix A.

2.4 Discussion

The results of the criticality analysis indicated no system elements where risk mitigation was mandatory. All but two of Evergreen Line elements indicated negligible risk to Reichhold, and the remaining two were categorized as tolerable risk (no mitigative action warranted; monitoring advisable). The majority of Reichhold elements indicated tolerable risk to Evergreen Line, and risk mitigation was advisable for the following seven Reichhold elements:

- R6: Flammable Finished Goods storage vessel - Fire;
- R12: Phthalic Acid Anhydride storage vessel - Fire;
- R18: Flammable Raw Material Valve Failure Off-Loading Tanker Truck - Vapour Cloud;
- R19: Toxic Raw Material Valve Failure Off-Loading Tanker Truck - Vapour Cloud;
- R25: Heat transfer fluid - hot vapour release - Explosion/Fire;
- R26: Heat transfer fluid - hot liquid release - Explosion/Fire; and
- R29b: Vent Collection System - Major Flashback (with cascading effects for fire/explosions).

The elements above, for which risk mitigation is advisable, are associated only with low probability upset conditions/accident, and not due to normal daily operations. The risk register results are summarized by Risk Category in Table 1 below and are provided in detail in Appendix A.

Table 1. Risk Criticality Results Summary

Relative Risk Level Category	Evergreen Line Elements	Reichhold Elements
Negligible Risk	12 Elements	4 Elements
Tolerable Risk	2 Elements	19 Elements
Risk Mitigation Advisable	0 Elements	7 Elements
Risk Mitigation Mandatory	0 Elements	0 Elements

Note: Based on the highest risk category consequence noted per element

The following scenarios were discussed at the workshop, however were not included in the risk matrix due to lack of impact to the reciprocal organization, or due to planning activities currently underway that would eliminate the risk prior to construction:

1. Loss of water supply at Reichhold facility – no impact on Evergreen Line operations.
2. Loss of power at the Reichhold facility – no impact on Evergreen Line operations as site has back-up generator.
3. Reichhold shut down/start up modes – no impact on Evergreen Line operations.
4. Worker injury due to Reichhold or ELRTP truck activity. Risk is limited to worker exposure on public roads (i.e., consequence of a substandard act of driving); therefore no increase in risk to Reichhold or ELRTP is perceived, because of the duty to safely operate vehicles.
5. Radio frequency disruptions at the Reichhold site. EMI effects are possible with 10m of the track, however this will be pre-tested and Reichhold equipment altered if necessary prior to operation of the Evergreen Line.
6. Explosion of propane tank at Reichhold facility. The existing tank will be relocated away from the proposed Evergreen Line path prior to construction.
7. Sources of ignition on the Sky Train track. Potential ignition sources are associated with normal operations of Sky Train. However, expert opinion and history of operations, indicates the potential for ignition influences would have no impact on Reichhold based on the track design.

3. Potential Mitigation Measures

3.1 Approach and Method

Risk mitigation was examined with the goal of establishing safeguards that would either reduce/eliminate the likelihood of a particular event, or that reduce/eliminate the consequence severity. To explore conceptual risk mitigation strategies, documents provided by both organizations were reviewed. These included:

- Drawings and photographs of the site and proposed Evergreen Line route;
- National Fire Protection Association 130;
- Sky Train Rule Book (rev 9);
- Sky Train Emergency Response Handbook; and
- Evergreen Line Rapid Transit Project Environmental Assessment Certificate Application:
  - Chapter 12 (Figures);
  - Chapter 17 (Accidents and Malfunctions);
  - Chapter 18 (Effects of the Environment on the Project);
  - Section 10 (Figures); and
  - Section 20 (Figures).

Risk mitigation measures are described below for the seven specific events identified where mitigation was advisable. These seven events relate only to potential upset conditions at the Reichhold facility. Additional suggested risk mitigation concepts are described for the scenario of the ELRTP adjacent to the Reichhold plant.

While the likelihood is very small for an event to present elevated risks to users and employees of the Evergreen Line, or associated infrastructure,, the worst case scenarios were utilized to scope potential mitigation measures suggested in the following sections. Importantly, some recommended mitigative measures below are common to various events (e.g., detection systems, alarms and relays); these should not be viewed as cumulative recommendations that are blindly repeated. Rather, a critical amount of equipment and certain degree of redundancy is appropriate to manage safety of a prescribed area without implementing the recommendation each time it is recorded.

3.2 R6: Flammable Finished Goods Storage Vessel - Fire

Cause: Uncontrolled ignition source or uncontrolled hot work in vicinity of storage vessels.

Existing Preventative Measures

- Electrical classification and associated electrical code governs plant activities and future design.
- Controlled ignition source defined on site (Reichhold hot work permit system SOP 0109).
- Existing fire alarms.

Mitigative Design

Detection System: A system for heat detection should be considered in proximity to the guideway to signal fire, smoke, or chemical release; this may be an expansion of measures currently implemented by Reichhold, but with detection signal relayed to the ELRTP staff to inform decisions. The signal system would signify to stop trains outside the potential impact zone. If the trains have not passed the stations on either side of the Reichhold site, the trains could also be stopped at those stations to prevent access into the impacted zone.

Alarms: Alarms are already present in the Reichhold facility to signal that a fire/dangerous situation exists; these should be utilized to trigger an automatic communication response to the Evergreen Line, similar to an event detection (as described above). These alarms should be utilized in conjunction with verbal communication between Reichhold and ELRTP, and would allow the Evergreen Line to initiate an appropriate response.

Tunnel Ventilation: There is potential for smoke/fumes to enter tunnel and this warrants tunnel ventilation control (pressurization and smoke/fumes evacuation). Consideration should be given for a tunnel ventilation system, which could operate in conjunction with the detection/alarm system and can be manipulated by operators beyond normal operating parameters to expedite the purging of smoke/fumes during an emergency. As a secondary measure to existing Reichhold plant detectors and alarms, it is also recommended that a detection system be associated with the tunnel opening to signal presence of chemical vapours or smoke. National Fire Protection Association (NFPA) 130 provides best-recommended practice for tunnel ventilation.

Mitigative Maintenance and Operation

- Periodic inspection and maintenance of existing sensors and fire alarms.
- Periodic update of electrical classification and SOP 0109 to control the activities in the area that can become a source of ignition in case there as an explosive atmosphere.
- Inspection and review of suitability of Reichhold plant fire-fighting equipment for the designated area.

3.3 R12: Phthalic Acid Anhydride Storage Vessel - Fire

Cause: Fire with possible over-pressurization of tank or uncontrolled heating and ignition source

Existing Preventative Measures

- Tank inerting, interlocks, pressure/temperature alarms.
- Electrical classification and associated electrical code governs plant activities and future design.
- Controlled ignition source defined on site (Reichhold hot work permit system SOP 0109).

Mitigative Design

Detection System: A system for heat detection should be considered in proximity to the guideway to signal fire, smoke, or chemical release; this may be an expansion of measures currently implemented by Reichhold, but with detection signal relayed to the ELRTP staff to inform decisions. The signal system would signify to stop trains outside the potential impact zone. If the trains have not passed the stations on either side of the Reichhold site, the trains could also be stopped at those stations to prevent access into the impacted zone.

Alarms: Alarms are already present in the Reichhold facility to signal that a fire/dangerous situation exists; these should be utilized to trigger an automatic communication response to the Evergreen Line, similar to an event detection (as described above). These alarms should be utilized in conjunction with verbal communication between Reichhold and ELRTP, and would allow the Evergreen Line to initiate an appropriate response.

Tunnel Ventilation: There is potential for smoke/fumes to enter tunnel and this warrants tunnel ventilation control (pressurization and smoke/fumes evacuation). Consideration should be given for a tunnel ventilation system, which could operate in conjunction with the detection/alarm system and can be manipulated by operators beyond normal operating parameters to expedite the purging of smoke/fumes during an emergency. As a secondary measure to existing Reichhold plant detectors and alarms, it is also recommended that a detection system be associated with the tunnel opening to signal presence of chemical vapours or smoke. National Fire Protection Association (NFPA) 130 provides best-recommended practice for tunnel ventilation.

Mitigative Maintenance and Operation

- Periodic update of electrical classification and SOP 0109 to control the activities in the area that can become a source of ignition in case there as an explosive atmosphere.
- Inspection and review of suitability of Reichhold plant fire-fighting equipment for the designated area.

3.4 R18: Flammable Raw Material Off-Loading Tanker Truck - Vapour Cloud

Cause: Failure of connection coupling and internal valve failure, hose burst, vehicle accident, complete emptying of tank onto ground leading to potentially flammable condition.

Existing Preventative Measures

- Tank inspection and monitoring program.

Mitigative Design

Detection System: A system to detect chemical vapour release and level with respect to lower explosive limit (e.g., 20% LEL) should be considered in proximity to the guideway to signal fire, smoke, or chemical release. This may be an expansion of measures currently implemented by Reichhold, but with detection signal relayed to the ELRTP staff to inform decisions. The signal system would signify to stop trains outside the potential impact zone. If the trains have not passed the stations on either side of the Reichhold site, the trains could also be stopped at those stations to prevent access into the impacted zone.

Alarms: Alarms are already present in the Reichhold facility to signal that a fire/dangerous situation exists; these should be utilized to trigger an automatic communication response to the Evergreen Line, similar to an event detection (as described above). These alarms should be utilized in conjunction with verbal communication between Reichhold and ELRTP, and would allow the Evergreen Line to initiate an appropriate response.

Tunnel Ventilation: There is potential for smoke/fumes to enter tunnel and this warrants tunnel ventilation control (pressurization and smoke/fumes evacuation). Consideration should be given for a tunnel ventilation system, which could operate in conjunction with the detection/alarm system and can be manipulated by operators beyond normal operating parameters to expedite the purging of smoke/fumes during an emergency. As a secondary measure to existing Reichhold plant detectors and alarms, it is also recommended that a detection system be associated with the tunnel opening to signal presence of chemical vapours or smoke. National Fire Protection Association (NFPA) 130 provides best-recommended practice for tunnel ventilation.

Mitigative Maintenance and Operation

- Periodic update of electrical classification and SOP 0109 to control the activities in the area that can become a source of ignition in case there as an explosive atmosphere.
- Inspection and review of suitability of Reichhold plant fire-fighting equipment for the designated area in case the vapour cloud ignites.

3.5 R19: Toxic Raw Material Off-Loading Tanker Truck - Vapour Cloud

Cause: Failure of connection coupling and internal valve failure, hose burst, vehicle accident, complete emptying of tank onto ground leading to potentially toxic vapour cloud

Existing Preventative Measures

- Tank inspection and monitoring program.

Mitigative Design

Detection System: A system to detect chemical vapour release and level with respect to safe short-term personal exposure limits should be considered in proximity to the guideway to signal fire, smoke, or chemical release. This may be an expansion of measures currently implemented by Reichhold, but with detection signal relayed to the ELRTP staff to inform decisions. The signal system would signify to stop trains outside the potential impact zone. If the trains have not passed the stations on either side of the Reichhold site, the trains could also be stopped at those stations to prevent access into the impacted zone.

Alarms: Alarms are already present in the Reichhold facility to signal that a fire/dangerous situation exists; these should be utilized to trigger an automatic communication response to the Evergreen Line, similar to an event

detection (as described above). These alarms should be utilized in conjunction with verbal communication between Reichhold and ELRTP, and would allow the Evergreen Line to initiate an appropriate response.

Tunnel Ventilation: There is potential for smoke/fumes to enter tunnel and this warrants tunnel ventilation control (pressurization and smoke/fumes evacuation). Consideration should be given for a tunnel ventilation system, which could operate in conjunction with the detection/alarm system and can be manipulated by operators beyond normal operating parameters to expedite the purging of smoke/fumes during an emergency. As a secondary measure to existing Reichhold plant detectors and alarms, it is also recommended that a detection system be associated with the tunnel opening to signal presence of chemical vapours or smoke. National Fire Protection Association (NFPA) 130 provides best-recommended practice for tunnel ventilation.

Mitigative Maintenance and Operation

- Training and periodic refresher courses for vapour cloud emergency and evacuation procedures should be provided to BCRTC staff, who may be required to work on the transit guideway in the proximity of the Reichhold plant.
- A standard operating procedure should be established defining communication and reporting by BCRTC to Reichhold to advise of daily work plans.

3.6 R25: Heat Transfer Fluid - Hot Vapour Release - Explosion/Fire

Cause: Release at thermal unit, malfunction, pipe failure, with possible over-pressurization of tank or uncontrolled heating and ignition source leading to fire/explosion.

Existing Preventative Measures

- Pressure/temperature monitoring, alarms and interlocks.
- Electrical classification and associated electrical code governs plant activities and future design.
- Controlled ignition source defined on site (Reichhold hot work permit system SOP 0109).

Mitigative Design

Detection System: A system to detect chemical vapour release and level with respect to safe short-term personal exposure limits should be considered in proximity to the guideway to signal fire, smoke, or chemical release. This may be an expansion of measures currently implemented by Reichhold, but with detection signal relayed to the ELRTP staff to inform decisions. The signal system would signify to stop trains outside the potential impact zone. If the trains have not passed the stations on either side of the Reichhold site, the trains could also be stopped at those stations to prevent access into the impacted zone.

Alarms: Alarms are already present in the Reichhold facility to signal that a fire/dangerous situation exists; these should be utilized to trigger an automatic communication response to the Evergreen Line, similar to an event detection (as described above). These alarms should be utilized in conjunction with verbal communication between Reichhold and ELRTP, and would allow the Evergreen Line to initiate an appropriate response.

Tunnel Ventilation: There is potential for smoke/fumes to enter tunnel and this warrants tunnel ventilation control (pressurization and smoke/fumes evacuation). Consideration should be given for a tunnel ventilation system, which could operate in conjunction with the detection/alarm system and can be manipulated by operators beyond normal operating parameters to expedite the purging of smoke/fumes during an emergency. As a secondary measure to

existing Reichhold plant detectors and alarms, it is also recommended that a detection system be associated with the tunnel opening to signal presence of chemical vapours or smoke. National Fire Protection Association (NFPA) 130 provides best-recommended practice for tunnel ventilation.

Mitigative Maintenance and Operation

- Periodic update of electrical classification and SOP 0109 to control the activities in the area that can become a source of ignition in case there is an explosive atmosphere.
- Inspection and review of suitability of Reichhold plant fire-fighting equipment for the designated area.

3.7 R26: Heat Transfer Fluid - Hot Liquid Release - Explosion/Fire

Cause: Release at thermal unit, malfunction, pipe failure, with possible over-pressurization of tank or uncontrolled heating and ignition source leading to fire/explosion

Existing Preventative Measures

- Pressure/temperature monitoring, alarms and interlocks.
- Electrical classification and associated electrical code governs plant activities and future design.
- Controlled ignition source defined on site (Reichhold hot work permit system SOP 0109).

Mitigative Design

Detection System: A system for heat detection should be considered in proximity to the guideway to signal fire, smoke, or chemical release; this may be an expansion of measures currently implemented by Reichhold, but with detection signal relayed to the ELRTP staff to inform decisions. The signal system would signify to stop trains outside the potential impact zone. If the trains have not passed the stations on either side of the Reichhold site, the trains could also be stopped at those stations to prevent access into the impacted zone.

Alarms: Alarms are already present in the Reichhold facility to signal that a fire/dangerous situation exists; these should be utilized to trigger an automatic communication response to the Evergreen Line, similar to an event detection (as described above). These alarms should be utilized in conjunction with verbal communication between Reichhold and ELRTP, and would allow the Evergreen Line to initiate an appropriate response.

Tunnel Ventilation: There is potential for smoke/fumes to enter tunnel and this warrants tunnel ventilation control (pressurization and smoke/fumes evacuation). Consideration should be given for a tunnel ventilation system, which could operate in conjunction with the detection/alarm system and can be manipulated by operators beyond normal operating parameters to expedite the purging of smoke/fumes during an emergency. As a secondary measure to existing Reichhold plant detectors and alarms, it is also recommended that a detection system be associated with the tunnel opening to signal presence of chemical vapours or smoke. National Fire Protection Association (NFPA) 130 provides best-recommended practice for tunnel ventilation.

Mitigative Maintenance and Operation

- Periodic update of electrical classification and SOP 0109 to control the activities in the area that can become a source of ignition in case there is an explosive atmosphere.
- Inspection and review of suitability of Reichhold plant fire-fighting equipment for the designated area.

3.8 R29B: Vent Collection System - Major Flashback (with associated effects for fire/explosions)

Cause: process upset, vent header enters flammable range leading to large downstream fire/explosion capable of triggering cascading fire/explosions at adjacent flammable storage tanks.

Existing Preventative Measures

- Detonation arrestor.
- Oxygen monitor.
- Engineering design and best practices.
- Foam fire suppression system.
- Controlled ignition source defined on site (Reichhold hot work permit system SOP 0109).

Mitigative Design

Detection System: A system for heat detection should be considered in proximity to the guideway to signal fire, smoke, or chemical release; this may be an expansion of measures currently implemented by Reichhold, but with detection signal relayed to the ELRTP staff to inform decisions. The signal system would signify to stop trains outside the potential impact zone. If the trains have not passed the stations on either side of the Reichhold site, the trains could also be stopped at those stations to prevent access into the impacted zone.

Alarms: Alarms are already present in the Reichhold facility to signal that a fire/dangerous situation exists; these should be utilized to trigger an automatic communication response to the Evergreen Line, similar to an event detection (as described above). These alarms should be utilized in conjunction with verbal communication between Reichhold and ELRTP, and would allow the Evergreen Line to initiate an appropriate response.

Tunnel Ventilation: There is potential for smoke/fumes to enter tunnel and this warrants tunnel ventilation control (pressurization and smoke/fumes evacuation). Consideration should be given for a tunnel ventilation system, which could operate in conjunction with the detection/alarm system and can be manipulated by operators beyond normal operating parameters to expedite the purging of smoke/fumes during an emergency. As a secondary measure to existing Reichhold plant detectors and alarms, it is also recommended that a detection system be associated with the tunnel opening to signal presence of chemical vapours or smoke. National Fire Protection Association (NFPA) 130 provides best-recommended practice for tunnel ventilation.

Mitigative Maintenance and Operation

- Inspection and review of suitability of Reichhold plant fire-fighting equipment for the designated area.
- Maintenance of vent header, thermal oxidizer ventilation system and monitoring system.
- Training and periodic refresher courses for vapour cloud emergency and evacuation procedures should be provided to BCTRC staff who may be required to work on the transit guideway in the proximity of the Reichhold plant.
- A standard operating procedure should be established defining communication and reporting by BCRTC to Reichhold to advise of daily work plans.

3.9 Ancillary Mitigative Design Concepts

In addition to the mitigative design concepts described above for seven specific potential upset conditions at the Reichhold chemical plant, ancillary mitigative design concepts are described below that may be considered for this initiative as a whole.

3.9.1 Track Work

Some of the activities associated with switch maintenance may introduce a low probability risk to wayside maintenance personnel working in the vicinity of Reichhold if an upset condition occurred. Activities such as switch point welding and grinding tend to be of a longer duration and increase exposure time to a potential event on the site. The nature of this type of maintenance activity means there is the source of combustion if there were a failure on the Reichhold site. To the extent practical these activities should be coordinated to reduce time in the Reichhold area if possible. These considerations are linked to risk registry items E3, E4, E5, E7, and E11.

3.9.2 Track Switches

Although the likelihood for even a minor train derailment is extremely low within this transit technology, the likelihood may increase slightly due to a misaligned switch, a switch throwing under a train, broken switch point or split switch. Ideally such risk in the vicinity of the Reichhold chemical plant should be reduced to the extent feasible. It may be useful to locate track switches away from the Reichhold facility to simplify evacuation of a derailed train without concern for proximity to the chemical plant. This consideration is linked to risk registry item E11.

3.9.3 Maintenance Interactions

Preventive and corrective maintenance are key processes to reduce the risk of unexpected release of substances and potential for spills, fire and explosions. The majority of events/consequences with risk level orange (i.e., risk mitigation advisable) are due to potential unplanned releases that may lead to fire and/or explosion. Reichhold maintains a “Process Safety Management Program” based on the USA’s OSHA 20CFR1910.119 which includes standards operating procedures (SOP) that address process hazard analysis (SOP 0103) and a written maintenance procedures and mechanical integrity (SOP 0108). This program and its associated procedures need to be maintained and periodically revised to ensure they are up to date and appropriate to ensure the mechanical integrity of the facility and that it is fit for use. This consideration relates to risk registry item R6, R12, R25.

3.10 Physical Elements and Access

Ideally, there should be no means to gain access to the guideway or the Reichhold site from each other. The guideway is currently planned to have adequate means for safe evacuation of passengers and employees, and the physical separation provides an element of security for both entities. In addition, on exit from the Burnaby Mountain tunnel, the guideway will have adequate fencing to deter access to the guideway by trespassers.

Careful planning of how emergency responders will get to the site should be considered as part of the design, and it is recommended that the emergency response agencies provide design input. Responders should also be informed that they may be entering a tunnel that could contain toxic vapours or fumes. Emergency response personnel will need to approach these areas up-wind and the presence of these personnel should be considered when designing the tunnel access points. This consideration relates to risk registry item E7.

4. Operational and Safety Protocols

4.1 Reichhold Facility

4.1.1 General Mitigation of Fire Risk

Two key operational protocols are required and are currently in place to reduce the risk of fire in the event of an unplanned/uncontrolled release of flammable finish goods from the storage vessels:

1. electrical classification of the areas, to reduce potential source of ignitions; and
2. hot work permit system (SOP 0109) to control the activities in the area that can become a source of ignition in case there as an explosive atmosphere.

These procedures should be periodically revised and reviewed and implementation enforced at all times. This consideration relates to risk registry item R6, R25.

4.1.2 Operation Safeguards

Reichhold's safeguards to avoid disruptions and emergencies caused by flammable products may be divided into three concepts:

1. Engineering controls (alarms, interlocks, etc);
2. Administrative controls (standard operating procedures, training, etc); and
3. Physical protection (relief valves, dikes, etc).

The engineering controls and physical protections should be maintained and tested for its mechanical integrity and adequacy either with or without the presence of the Evergreen Line. The administrative controls should be revised to include the interactions of the Evergreen Line infrastructure, workers and users. At least the following procedures should be reviewed and revised:

- **Procedure for Vehicles Entering the Plant Site (SOP 005):** to include the potential considerations and safety measures due to the Evergreen Line.
- **Contractor Training and Safety Program (SOP 0106):** to include the need to create awareness, educate and train Evergreen line maintenance workers about the Reichhold site, hazards, alarms etc. As an alternative to include Evergreen line workers in the SOP 0106 a new administrative procedure is strongly recommended to ensure that Evergreen Line employees are aware, knowledgeable and trained in Reichhold's operations and its Emergency Response Plan. An implementation plan and training with the updated procedures should then follow collaboratively between the two companies.
- **Personal Training Program (SOP 0105**): to include the need for awareness on the Evergreen Line operation, risk and potentially adverse events to Reichhold employees.
- **Emergency Planning and Response Program (SOP 0112):** see 4.1.2.

4.1.3 Updating of Hazard Analysis

Reichhold's procedure "Process Hazard Analysis" (SOP 0103) should address the need to revise the hazards associated to the operation once changes occur to the operation (covered by the Management of Change Program – SOP0110) or the surroundings. Even if the procedure itself may not be required to be updated, the risk assessments

and evaluations (i.e. HAZOPs, FTAs, Event Tree, among others) should be revised to include the Evergreen Line, its workers and users, as well as its infrastructure and equipment. This consideration relates to risk registry item R6, R12, R25. That changes/updates to these documents have occurred should then be communicated to staff.

4.1.4 Incident Events and Updates to Emergency Response Plans

In case maintenance or operational control fails to avoid a potential adverse event, emergency response plans should be in place to control the event and minimize the consequence severity. As the principal responsibility for detection and response to an upset condition at their facility, Reichhold has a comprehensive “Emergency Response Manual” which defines roles and responsibilities; emergency classification guide; general response guidelines; standard operational procedures for specific possible emergencies in each plant; as well as drills, training and emergency response evaluation and upgrading to ensure that potential emergencies are properly managed. This emergency response plan should be updated in light of the potential new emergency scenarios that may occur in the presence of Evergreen Line operations; additionally the emergency response should be tested and well communicated with the Port Moody Fire Department and other responders to ensure the required resources are available and orchestrated in case they are needed. This consideration is relevant to all events and scenarios, and especially (R6, R12, R25)

4.1.5 Reichhold Alarms and Communication

In addition to recommendations for hardwiring alarms between both Reichhold and BCRTC operations as previously described, these alarms should be utilized in conjunction with verbal communication between Reichhold and ELRTP, and should allow the Evergreen Line to initiate a proper response. In the absence of hardwiring between Reichhold alarms and Evergreen Line operators, a critical point for failure may arise (e.g., a message could be missed or misinterpreted through human error). Accordingly, it is recommended that dual systems be employed to communicate alarms (i.e., both electrical alarms and operator verbal communication) , and it is recommended that a standard operating procedure be established for emergency communications which defines responsibilities during emergencies and consolidates standard statements to enable clarity and avoid ambiguity. These considerations are linked to risk registry items R1 to R21 and R24 to R29.

4.1.6 Containment of Emergency Disruption to <4hrs

The Joint Work Group defined an “Extreme” adverse effect to Evergreen Line operations as the potential to disrupt operations for more than four hours. Accordingly, a revision of the emergency plan, its potential scenarios and the planned responses with the Port Moody Fire Department is recommended to identify the length of time require to control a fire in the Finished Goods and Raw Material storage vessels, and also the duration in which a massive chemical release and vapour cloud may dissipate. The revision of the emergency plan should include the potential improvements in the control and extinguishment methods to enable cessation of potential fires to less than four hours if practical. This consideration is relevant to scenarios R6, R12, R25.

4.1.7 Consideration of Potential New Receptors

With the construction and operation of the Evergreen Line the surroundings of the Reichhold plant in port Moody will change, as well as the potential receptors of unplanned events in the plan. Therefore, the Emergency Response Plan should be revised to address all related interactions of the plant with the Evergreen Line, its workers and users, as well as its infrastructure and equipment.

4.2 Evergreen Line

4.2.1 Operations Interactions

Excessive Vapour Leak Detection at Guideway: If a leak is detected or reported above the Reichhold site, ELRTP staff should take measures as soon as possible to prevent passengers arriving at the event. These considerations are linked to risk registry items R8, R9, and R20

If a train is in the vicinity of the vapour, a spark or arcing caused by the trains' progress along the guideway may ignite the vapour. The recommended protocol is to keep the train moving as the movement of air from the train would likely induce vapour dilution and prevent ignition. These considerations are linked to risk registry items R7, R13, and R20.

Communications During Chemical Plant Upset Conditions: An emergency communications SOP for application within Evergreen Line operations is recommended to complement that which Reichhold would implement under a chemical plant upset. In addition to establishing cooperative tasks to mitigate the event and mobilizing corporate assistance, the communication SOP should have as a priority a procedure to (i) engage emergency responders and (ii) direct passengers to through safety procedures if train or guideway evacuation is necessary near a chemical plant upset condition.

A priority contact number should be provided from the Reichhold offices to BCRTC so that if there are events that are unfolding on either system, a prior notification can be given and possible mitigations or protocols can be initiated. Additionally, BCRTC should be enabled to also communicate (radio/phone and direct rescue responders (police, ambulance, fire fighters) towards centres of need. These considerations are linked to risk registry items R1 to R21 and R24 to R29.

Orientation Sessions: A good working relationship will be beneficial to both organizations. In order to develop this relationship, an orientation session is recommended so that each organization can develop a rudimentary understanding of the challenges and concerns faced by both. This awareness will translate into a more informed decision process when events occur as to when to notify and to understand the message being transmitted.

Staff Safety Orientation: BCRTC staff, who are assigned for maintenance work on the guideway adjacent to the chemical plant, should attend Reichhold's staff orientation and safety training to ensure they are fully versed in Reichhold's alarms, sensors, and protocols for evacuation, fire extinguishing and other mitigative measures. Staff should become trained on methods associated with first responders, which includes chain of command, first aid, evacuation of individuals and problem scoping.

4.2.2 Safety Protocols

General Considerations: After careful review of the Sky Train rule book and safety procedures manual, it is noted that the Sky Train currently has emergency response solutions needed to deal with incidents that may happen as a result of an incident at the Reichhold facility. AECOM also noted that Sky Train has detailed rules and procedures on how to appropriately respond to ensure public and employee safety. Review and optimization of these principles with Reichhold's principles of emergency response (see above) is recommended.

4.2.3 Maintenance Interactions

Track Maintenance: One of the issues identified in the documentation provided for review by AECOM is the need for track maintenance, such as rail grinding, welding, and inspections. It is recommended that these activities be

notified to Reichhold so that adequate protection of their assets can be put in place. For example, Reichhold may need to protect on-site storage with tarps, or implement a fire watch. These considerations should be defined and the process described in a set of SOPs that are linked to risk registry items E3, E4 and E5.

Detection System Maintenance: If sensors are used to detect an event, these sensors should be tested and scheduled maintenance performed. It is noted that NFPA 130 does not deal specifically with the elevated guideway as used by the Evergreen Line, but does include several references to installation of life safety systems. It is recommended that any type of detection system be made with built-in redundancy such as those utilized with life safety systems, and that the reference to tunnel applications in NFPA 130 be followed.

Personal Monitors and Breathing Filters: Consideration should be given to making personal monitors available to BCRTC personnel to provide early warning detection for any toxic substances that may be harmful if inhaled; this may or may not be found to be practical in terms of work that would be undertaken by others. In addition, BCRTC personnel assigned to work in the vicinity of the Reichhold facility should be in possession of, or in close proximity to, breathing apparatuses. These personnel should receive certification in the use of these devices and have demonstrated competency in their use. These considerations are linked to risk registry items R1 to R21 and R24 to R29.

4.2.4 Incident Events

Wind Impacts: The danger zone arising from a spill, fire or explosion may spread further from source with a breeze or wind, than in a static condition. Definition of the danger zone should incorporate the area of a worst case scenario rather than use sensory equipment to try to determine the affected area. This approach allows for simplicity in the emergency plan and increases the opportunity for successful execution, as emergency personnel and employees from both organizations will have a better understanding of what needs to be done as all situations require the same action. These considerations are linked to risk registry items R1 to R21 and R24 to R29.

Emergency Response: The key to success in an event of any type of emergency will be the Sky Train Attendant and Transit Police being well versed in how to respond to the incident. This will be dependent on the location and type of emergency. After review of the Sky Train rule book and emergency response documents, it appears that Sky Train is well prepared for any emergency response.

Chain of Command

First responders and incident management protocols will dictate who is in command and the duration of the event. Sky Train should not be willing to take on the risk of opening the line without the proper mitigations or inspections being completed. These considerations are linked to risk registry items E8, E12, R4, R6 to R13, R15, R16, R20 to R26, and R28.

Resumption of Service

The decision to resume revenue service will have to rely on the proper authority that will make the decision based on expert advice and testing. The ELRTP may have to re-commission the section of the line dependant on the amount of damage sustained to any infrastructure to the guideway. These considerations are linked to risk registry items E8, E12, R4, R6, R7, R9, R10, R11, R12, R13, R15, R16, R20, R21, and R24 to R26.

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6. Closure

This report has employed a Failure Mode Effects and Criticality Analysis to assess reciprocal risk posed by the Reichhold chemical plant and proposed Evergreen Line Rapid Transit Project, in Port Moody BC. The findings of the work were generated from the work group during the risk workshop and so were effectively validated in real-time by the group; AECOM has not done any detailed studies to validate the findings outside of the risk workshop. Conceptual options have been identified to mitigate certain risks, and to enhance existing operations or protocols. We trust this information meets with your expectations.

7. References

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Unknown. Two Aerial Photographs of Reichhold Site showing proposed Evergreen Line Route.

Figures

ELRTP – Reichhold Reciprocal Risk Assessment

- **Figure 1: Site Location**
- **Figure 2: Reichhold Industries and Proposed Evergreen Line**
- **Figure 3: Drawing RFP-FIGURE 4.0-01 A, Reference Concept Alignment Plan/Profile Station 518+800 to Station 519+160, June 2011.**
- **Figure 4: Drawing RFP-FIGURE 4.0-02 A, Reference Concept Alignment Plan/Profile Station 519+160 to Station 519+520, June 2011.**

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Appendix A

FMECA Workshop Tables

- Table A1: Acronyms
- Table A2: Event Frequency Index
- Table A3: Consequence Severity Index
- Table A4: Relative Risk Level Category and Risk Management Strategy
- Table A5: Event Registry
- Table A6: Event Consequence
- Table A7: Risk Register
- Tables A8-1 to A8-8: Risk Matrix
- Tables A9-1 to A9-8: Risk Criticality Matrix

Table A 1. Acronyms

BCRTC	BC Rapid Transit Commission
EL/EG	Evergreen Line
IDLH	Immediately Dangerous to Life or Health
LEL	Lower Explosive Limit
SMS	Safety Management System
STEL	Short Term Exposure Limit
TDI	Toluene di-isocyanate
TO	Thermal Oxidizer

Table A2: Event Frequency Index

Event Frequency Index	
Frequency	**Index Descriptor**
Incident has occurred or could be expected to occur **more than once per year**	**5. Frequent**
Incident has occurred or could be expected to occur **once every 1 to 5 years**	**4. Occasional**
Incident has occurred or could be expected to occur **once every 5 to 10 years**	**3. Seldom**
Incident has occurred or could be expected to occur **once every 10 to 30 years**	**2. Unlikely**
Incident is **very unlikely to occur** within the operation lifetime	**1. Improbable**

Table A3: Consequence Severity Index

Receptor Category	Consequence Severity Index				
	(A) Negligible	(B) Low	(C) Moderate	(D) High	(E) Extreme
Evergreen Line Operations	Service disruption less than 10 minutes per event or less	Service disruption longer than 10 minutes and less than 30 minutes per event	Service disruption longer than 30 minutes and less than 1 hour per event	Service disruption longer than 1 hour and less than 4 hours per event	Service disruption longer than 4 hours
Evergreen Line Worker and Passenger Health, Safety & Security	W-Internal first aid P-no treatment required or less	W- Reportable incident, no lost time P- treated on site	W-Single lost time injury <6 months P-taken by ambulance	W-Single lost time injury >6months or multiple lost time injuries P-taken by ambulance, irriversible injury	W&P -fatalities
Evergreen Line Regulatory	Non-Reportable minor infraction noted and immediately corrected in-house, or less	Written infraction notice received from regulatory body, fines <$1,000	Corrective actions mandated by regulatory body, fines >$1,000	Corrective actions mandated by regulatory body, fines >$1,000 and threat of suspension of operating license	Corrective actions mandated by regulatory body, fines >$1,000 and suspension of operating license
Evergreen Line Maintenance & Mitigation	Expenditures or Damage to assets does not exceed $1,000	Expenditures, claims, legal penalties or damage to assets >$1,000 and <$10,000	Expenditures, claims, legal penalties or damage to assets >$10,000 and <$100,000	Expenditures, claims, legal penalties or damage to assets >$100,000 and <$1million	Expentitures or damage >$1 million
Reichhold Facility Operations	Operations disruption less than 1 hour per event	Operation disruption longer than 1 hour and less than 1 day	Operation disruption longer than 1 day	Operation disruption longer than 1 week	Significant operation distruption lasting weeks or months
Reichhold Facility Worker Health, Safety & Security	W-Internal first aid or less	W- Reportable incident, no lost time	W-Single lost time injury <6 months	W-Single lost time injury >6months or multiple lost time injuries	W-fatalities
Reichhold Facility Regulatory	Non-Reportable minor infraction noted and immediately corrected in-house, or less	Written infraction notice received from regulatory body, fines <$1,000	Corrective actions mandated by regulatory body, fines >$1,000	Corrective actions mandated by regulatory body, fines >$1,000 and threat of suspension of operating license	Corrective actions mandated by regulatory body, fines >$1,000 and suspension of operating license
Reichhold Facility Maintenance & Mitigation	Expenditures or Damage to assets does not exceed $1,000	Expenditures, claims, legal penalties or damage to assets >$1,000 and <$10,000	Expenditures, claims, legal penalties or damage to assets >$10,000 and <$100,000	Expenditures, claims, legal penalties or damage to assets >$100,000 and <$1million	Expentitures or damage >$1 million

Table A4: Relative Risk Level Category and Risk Management Strategy

Relative Risk Level Category		Risk Management Strategy
	Negligible Risk	Relative risk level is considered negligible and therefore acceptable. No mitigative action warranted, but periodic monitoring warranted to document and verify stability of risk level.
	Tolerable Risk	Relative risk level is considered tolerable. No mitigative action warranted, but regular monitoring warranted to document and verify stability of risk level.
	Risk Mitigation Advisable	Relative risk level is considered unacceptable. Reassess to verify, consider uncertainties, and develop options to mitigate risks to a tolerable level as a minimum.
	Risk Mitigation Manadatory	Relative risk level is considered unacceptable. Develop mitigative options, select and implement the preferred option with an aggressive schedule to mitigate risks to a tolerable level as a minimum.

Event Frequency Index		Consequence Severity Index				
Frequency	**Index Descriptor**	**A Negligible**	**B Low**	**C Moderate**	**D High**	**E Extreme**
Incident has occurred or could be expected to occur more than once per year	**5. Frequent**	**Negligible Risk**	**Risk Mitigation Advisable**	**Risk Mitigation Mandatory**	**Risk Mitigation Mandatory**	**Risk Mitigation Mandatory**
Incident has occurred or could be expected to occur once every 1 to 5 years	**4. Occasional**	**Negligible Risk**	**Tolerable Risk**	**Risk Mitigation Advisable**	**Risk Mitigation Mandatory**	**Risk Mitigation Mandatory**
Incident has occurred or could be expected to occur once every 5 to 10 years	**3. Seldom**	**Negligible Risk**	**Tolerable Risk**	**Risk Mitigation Advisable**	**Risk Mitigation Mandatory**	**Risk Mitigation Mandatory**
Incident has occurred or could be expected to occur once every 10 to 30 years	**2. Unlikely**	**Negligible Risk**	**Tolerable Risk**	**Tolerable Risk**	**Risk Mitigation Advisable**	**Risk Mitigation Advisable**
Incident is very unlikely to occur within the operation lifetime	**1. Improbable**	**Negligible Risk**	**Negligible Risk**	**Tolerable Risk**	**Tolerable Risk**	**Tolerable Risk**

Table A5: Event Registry

Evergreen Line **System Element**							
Element Number	**Element Name**	**Potentially Adverse Event**	**Reason(s) for Adverse Event**	**Existing Preventative Measures**	**Event Detection (1=Highly detectable, 5=not detectable**	**Event Predictability (1=predictable, 5=not predictable)**	**Frequency of Event (1 to 5)**
E1	Power Substation NPZ	Power/Control Loss of Process	Weather, Hydro equipment error	multiple power feeds	1	5	4
E2	Power Substation NPZ	Minor thermal combustion/smoke, housing, electrical arc	lightening strike, component failure	station design, grounding of components, maintenance/management protocol, electrical code	1	3	2
E3	Track Maintenance & Inspections	Discontent receptor present on track	employee complaint re odours	employee awareness and orientation, work within regulatory guidelines	2	3	5
E4	Track Maintenance	Hot work, Rail grinding	throw sparks from grinder, welding	planned activities, shield around grinder keeps sparks within track	1	1	5
E5	Track Maintenance	hose breaks and glycol mix spils on track (while train moving)	De-icing with 200L glycol train (50:50 mix) sprays select ice buildups	spill will stay within guideway based on guideway design	2	3	4
E6	High energy moving parts (wheels)	Fragmentation and loss of component from train	daily wear	guideway design	3	4	1
E7	Operations	Stationary Train at Chemical plant and/or passenger exits train	train failure, switch failure, power failure, communication to exit train, passenger voluntarily exits train	rescue train to location, emergency procedures/ staff/ communications/ alarms	1	4	5
E8	Operations	2 Train collision	human error	operation policy and procedures	1	4	1
E9	Operations	sound, odour or visual impacts related to daily operations	Normal Moving Train	preventative maintenance (train and track), monitor track noise level, ventilation in trains	1	2	5
E10	Operations	complaints related to noise, odour or visual impacts (perceived or actual) related to daily operations	Normal Moving Train	preventative maintenance (train and track), monitor track noise level, ventilation in trains	1	2	5
E11	Operations	train derailment, rail support damage	adverse weather, component failure, seismic event, driving error	training, operating procedures, train design, BC safety authority	1	5	1
E12	Operations	collapse of guideway	seismic event	design code standard 2475 (no collapse)	1	5	1
E13	Operations	Radio frequency disruptions	EMI effects possible with 10 m of the track	test once track installed, or confirmation next to existing guideways	1	1	requires testing in field for site-specific interactions - see report text Section 2.1
E14	Operations	Weather impacts	wind, rain, snow, hail	procedures to address icy patches on ground as needed, arborist assessments	1	3	3
Reichhold Facility System Element							
Element Number	**Element Name**	**Potentially Adverse Event**	**Reason(s) for Adverse Event**	**Existing Preventative Measures**	**Event Detection (1=Highly detectable, 5=not detectable**	**Event Predictability (1=predictable, 5=not predictable)**	**Frequency of Event (1 to 5)**
R1	Thermal Oxidizer	Release of untreated vapours	TO failure, low temperature, power failure/bump, process upset, etc.	interlocks, real time monitoring	1	5	4
R2	Thermal Oxidizer	Release of black smoke	incomplete combustion	interlocks, real time monitoring	1	5	3
R3	Flammable Finished Goods Storage Vessels	Passive Venting to atmosphere (normal operations)	Filling the tank (normal operation)	Part of normal operation and process design	1	1	5
R4	ble Finished Goods Storage	Vessel Failure, Leak or Spill (complete loss)	overpressurization, mechanical failure, implosion	mechanical integrity inspection program, pressure/vacuum relief on storage tanks	1	4	1
R5	Flammable Finished Goods Storage Vessels	Vessel Failure, Leak or Spill (partial loss)	overpressurization, mechanical failure, implosion	mechanical integrity inspection program, pressure/vacuum relief on storage tanks	3	4	3
R6	Flammable Finished Goods Storage Vessels	Fire	uncontrolled ignition source, hot work in vicinity of storage vessels	electrical classification, controled ignition sources	2	5	2
R7	Flammable Raw Material Storage Vessels	vapour above LEL and ignited by substation or train	Vessel Failure - Spill (Major)	fire supression, LEL monitors, mechanical integrity inspection program	1	4	1
R8	Flammable Raw Material Storage Vessels	vapours at 25% LEL	Vessel Failure - Spill (Minor)	fire supression, LEL monitors, mechanical integrity inspection program, spill containment	1	4	3

Reichhold Facility System Element							
Element Number	**Element Name**	**Potentially Adverse Event**	**Reason(s) for Adverse Event**	**Existing Preventative Measures**	**Event Detection (1=Highly detectable, 5=not detectable**	**Event Predictability (1=predictable, 5=not predictable)**	**Frequency of Event (1 to 5)**
R9	Toxic Raw Material Storage Vessels (Vinyl Acetate)	toxic vapour less than than 0.25 LEL but higher than STEL	Minor Spill	fire supression, LEL monitors, mechanical integrity inspection program, spill containment	2	4	2
R10	Toxic Raw Material Storage Vessels (TDI)	toxic vapour plume greater than STEL	Vessel Failure - Spill (major)	Mechanical integrity and spill containment, fixed monitoring	1	4	1
R11	Toxic Raw Material Storage Vessels (TDI)	toxic vapour plume greater than permissionable exposure level but less than STEL	Vessel Failure - Spill (minor)	Mechanical integrity and spill containment, fixed monitoring	1	4	1
R12	Phthalic Anhydride (raw material)	Fire with possible overpressurization of tank	uncontolled heating and ignition source	tank inerting, interlocks, pressure/temperature alarms	1	3	2
R13	Maintenance Shop	Hot works Fire	ignition of combustible materials (rags, etc.)	fire extinguishers, housekeeping	2	2	1
R14	Garbage Storage Area	Fire	substandard act	policies and procedures	3	5	2
R15	Raw Materials Warehouse	Fire beyond incipient stage	uncontrolled ignition source	electrical classification, controled ignition sources, approved sprinkler protection	1	5	1
R16	Finished Goods Warehouse	Fire beyond incipient stage	uncontrolled ignition source	electrical classification, controled ignition sources, approved sprinkler protection	1	5	1
R17	Flammable Raw Material Offloading (railcars)	vapour cloud due to complete emptying of tank on ground	failure of bottom valve on tank railcar and no cap	inspection monitoring program	2	4	1
R18	Flammable Raw Material Offloading (tank trucks)	vapour cloud due to complete emptying of tank on ground	failure of connection coupling and internal valve failure, hose burst, vehicle accident	inspection monitoring program	1	4	2
R19	Toxic Raw Material Offloading (tank trucks)	toxic vapour plume greater than permissionable exposure level but less than STEL	failure of connection coupling and internal valve failure, hose burst, vehicle accident	inspection monitoring program	1	4	2
R20	Plant Operations	tank failure, spill, ignition, vapour source, etc. (flammable)	seismic event	fire supression, LEL monitors, mechanical integrity inspection program	1	4	1
R21	Plant Operations	tank failure, spill, ignition, vapour source, etc. (toxic)	seismic event	Spill containment, fixed monitoring, fire supression, LEL monitors, mechanical integrity inspection program	1	4	1
R22	Trucking	Damage to ELRTP concrete pillar or guideway	substandard act	driver training, certification, pillar design and placement	4	2	3
R23	Trucking	Damage to Substation by truck	substandard act	driver training, certification	3	5	2
R24	Trucking	Truck fire under guideway	truck overheats, uncontrolled combustion	corporate travel requirements, contract procurement methods	1	5	1
R25	Heat Transfer Fluid	Explosion and fire due to vapour release	release at thermal unit, malfunction, pipe failure	pressure monitoring, temperature monitoring, interlocks	1	3	2
R26	Heat Transfer Fluid	Explosion and fire due to liquid release	release at thermal unit, malfunction, pipe failure	pressure monitoring, temperature monitoring, interlocks	1	3	2
R27	Steam Boiler	Boiler explosion (combustion)	overpressurization	BC Boiler inspection program, interlocks, alarms	1	3	1
R28	Propane Tank	Explosion	puncture of tank by forklift, etc.	pillars, regular service inspections by provider	1	5	1
R29a	Vent Collection System	Small flashback through vent header to connected flammable vessels	process upset, vent header enters flammable range	detonation arrestor, oxygen monitor, engineering design, best practices, foam fire supression system	2	3	3
R29b	Vent Collection System	Large flashback through vent header to connected flammable vessels	process upset, vent header enters flammable range	detonation arrestor, oxygen monitor, engineering design, best practices, foam fire supression system	2	3	2

Table A6: Event Consequence

System Element			Reichhold Facility Consequence Severity and Relative Risk Level								
Element Number	Element Name	Potentially Adverse Event	Operations		Worker Health, Safety & Security		Regulatory		Maintenance & Mitigation		Comments, Uncertainty, and Recommendations
			Description	Index Value (A-E)	Description	Index Value (A-E)	Description	Index Value (A-E)	Description	Index Value (A-E)	
E1	Power Substation NPZ	Power/Control Loss of Process	no effect	A	no effect	A	no effect	A	no effect	A	not plausible
E2	Power Substation NPZ	Minor thermal combustion/smoke, housing, electrical arc	alter truck route	A	no effect	A	no effect	A	no effect	A	
E3	Track Maintenance & Inspections	Discontent receptor present on track	potential for WorkSafe BC to visit site, pull permits, request additional monitoring, etc.	A	no effect	A	No impact, but option for additional infractions to be noted	A	assist potential investigation	A	confirm if odour enforcement is possible. Coordinate ELRPT employee training/awareness with Reichhold. No complaints noted in last 15 years
E4	Track Maintenance	Hot work, Rail grinding	no effect	A	no effect	A	no effect	A	no effect	A	post signage to coordinate activities in vicinity of facility
E5	Track Maintenance	hose breaks and glycol mix spils on track (while train moving)	no effect	A	no effect	A	no	A	no effect	A	inconsequential to Reichhold
E6	High energy moving parts (wheels)	Fragmentation and loss of component from train	no effect	A	no effect	A	no effect	A	no effect	A	if loss of train component, will likely stay within guideway
E7	Operations	Stationary Train at Chemical plant and/or passenger exits train	presence of additional people in the vicinity of the site	A	no access to Reichhold from train platform	A	no effect	A	no effect	A	likely mitigated within 30 minutes. Confirm if odour enforcement is possible
E8	Operations	2 Train collision	train in yard, structures, possible chemical release	E	train in yard, impacts staff	E	no effect	A	limits access to site and expensive repairs	E	highly improbable event
E9	Operations	sound, odour or visual impacts related to daily operations	no effect in office, outside sound impacts brief (~5 seconds per train)	A	possible complaints	A	no effect	A	no effect	A	
E10	Operations	complaints related to noise, odour or visual impacts (perceived or actual) related to daily operations	no effect	A	no effect	A	no effect	A	no effect	A	
E11	Operations	train derailment, rail support damage	presence of additional people in the vicinity of the site	A	no effect	A	no effect	A	no effect	A	one wheel off the track is considered a derailment. During a derailment, train will likely stay within the track guideway.
E12	Operations	collapse of guideway	low effect compared to existing considerations	D	high effect on workers, and safety	E	potential to cause release of chemicals	A	limits access to site and expensive repairs	E	incremental effect due to collapse only
E13	Operations	Radio frequency disruptions	if communication interference, could delay message relay	A	if communication interference, could delay message relay	A	no effect	A	no effect	A	possible interference will be evaluated and procedure could be altered if necessary
E14	Operations	Weather impacts	no effect	A	no effect	A	no effect	A	no effect	A	substation access via public road , no issues on guideway affecting Reichhold

System Element			Evergreen Line Consequence Severity and Relative Risk Level								
Element Number	Element Name	Potentially Adverse Event	Operations		Worker & Passenger Health, Safety & Security		Regulatory		Maintenance & Mitigation		Comments, Uncertainty, and Recommendations
			Description	Index Value (A-E)	Description	Index Value (A-E)	Description	Index Value (A-E)	Description	Index Value (A-E)	
R1	Thermal Oxidizer	Release of untreated vapours	train is ~50m away, impact lasts ~10seconds as train passes	B	inhalation of vapours	B	no effect	A	no effect	A	Non-TDI impacts only
R2	Thermal Oxidizer	Release of black smoke	investigate occurance	A	passenger complaints	A	no effect	A	no effect	A	may be a perceptual issue
R3	Flammable Finished Goods Storage Vessels	Passive Venting to atmosphere (normal operations)	no effect	A	odours detected, passenger complaints	A	no effect	A	no effect	A	may have regulator concerns
R4	Flammable Finished Goods Storage Vessels	Vessel Failure, Leak or Spill (complete loss)	trains will be stopped away from property	E	could exceed STEL, but not exceed IDLH	B	proactive planning, due dilligence for possible event	A	no effect	A	consider installation of LEL detectors in substation
R5	Flammable Finished Goods Storage Vessels	Vessel Failure, Leak or Spill (partial loss)	pause operations to confirm safe operating conditions	B	effects possible if in vicinity of event	B	no effect	A	no effect	A	
R6	Flammable Finished Goods Storage Vessels	Fire	black smoke towards train and tunnel	E	smoke inhalation	C	no effect	A	no effect	A	heat effects not likely but potential for smoke impacts
R7	Flammable Raw Material Storage Vessels	vapour above LEL and ignited by substation or train	trains could be stopped	E	effects in vicinity of site	E	no effect	A	installation of LEL monitors in substation, tunnel entrance and in vicinity of guideway	C	also needs to consider air intake into tunnel, LEL monitors set to 25% of LEL
R8	Flammable Raw Material Storage Vessels	vapours at 25% LEL	depends on Reichhold response time and correction	B	no effect	A	defaults to EG SMS	A	standard emergency procedures	A	could trigger notification to EG, covered by internal EG SMS policy
R9	Toxic Raw Material Storage Vessels (Vinyl Acetate)	toxic vapour less than than 0.25 LEL but higher than STEL	pause operations to confirm safe operating conditions	C	if worker present at event	B	no effect	A	potential for claims by public against EG	C	currently, vinyl acetate monitored through LEL, but not via electronic system for health exposure
R10	Toxic Raw Material Storage Vessels (TDI)	toxic vapour plume greater than STEL	trains will be stopped away from property	E	if worker or train present at event based on potential sensitization	D	no effect	A	no effect	A	unlikely to reach levels to cause fatality to EG
R11	Toxic Raw Material Storage Vessels (TDI)	toxic vapour plume greater than permissionable exposure level but less than STEL	trains will be stopped away from property	C	due to inhalation by workers or passengers on the train	B	no effect	A	no effect	A	media/public effect of shutdown and wording of public notification
R12	Phthalic Anhydride (raw material)	Fire with possible overpressurization of tank	no vapour cloud, smoke only	D	possible minor injury	B	no effect	A	no effect	A	scoring based on no agency intervention
R13	Maintenance Shop	Hot works Fire	pause operations to confirm safe operating conditions	C	smoke inhalation	B	no effect	A	installation of heat detectors	A	Note: only need to install heat monitors once per site (no duplication of cost)
R14	Garbage Storage Area	Fire	pause operations to confirm safe operating conditions	B	smoke inhalation	A	no effect	A	no effect	A	
R15	Raw Materials Warehouse	Fire beyond incipient stage	if a significant fire, potential to disrupt service	E	due to inhalation by workers or passengers on the train	B	no effect	A	install heat monitor on guideway in vicinity of plant	C	Note: only need to install heat monitors once per site (no duplication of cost)

System Element			Evergreen Line Consequence Severity and Relative Risk Level								
			Operations		Worker & Passenger Health, Safety & Security		Regulatory		Maintenance & Mitigation		
Element Number	Element Name	Potentially Adverse Event	Description	Index Value (A-E)	Description	Index Value (A-E)	Description	Index Value (A-E)	Description	Index Value (A-E)	Comments, Uncertainty, and Recommendations
R16	Finished Goods Warehouse	Fire beyond incipient stage	if a significant fire, potential to disrupt service	E	due to inhalation by workers or passengers on the train	B	no effect	A	install heat monitor on guideway in vicinity of plant	C	Note: only need to install heat monitors once per site (no duplication of cost)
R17	Flammable Raw Material Offloading (railcars)	vapour cloud due to complete emptying of tank on ground	trains will be stopped away from property	D	effects in vicinity of site	C	no effect	A	installation of LEL monitors in substation, tunnel entrance and in vicinity of guideway and install heat monitor on guideway	B	operations severity assumes emergency responders enable resumption of trains within 4hrs of their cessation
R18	Flammable Raw Material Offloading (tank trucks)	vapour cloud due to complete emptying of tank on ground	trains will be stopped away from property	D	effects in vicinity of site	C	no effect	A	installation of LEL monitors in substation, tunnel entrance and in vicinity of guideway and install heat monitor on guideway	C	also needs to consider air intake into tunnel, LEL monitors set to 25% of LEL. Note: only need to install heat monitors once per site (no duplication of cost)
R19	Toxic Raw Material Offloading (tank trucks)	toxic vapour plume greater than permissionable exposure level but less than STEL	trains will be stopped away from property	D	due to inhalation by workers or passengers on the train	C	no effect	A	no effect	C	eg. TDI. media/public effect of shutdown and wording of public notification
R20	Plant Operations	tank failure, spill, ignition, vapour source, etc. (flammable)	trains could be stopped	E	effects in vicinity of site	E	no effect	A	installation of LEL monitors in substation, tunnel entrance and in vicinity of guideway	C	also needs to consider air intake into tunnel, LEL monitors set to 25% of LEL
R21	Plant Operations	tank failure, spill, ignition, vapour source, etc. (toxic)	trains will be stopped away from property	E	if worker or train present at event based on potential sensitization	D	no effect	A	no effect	A	unlikely to reach levels to cause fatality to EG
R22	Trucking	Damage to ELRTP concrete pillar or guideway	no effect	A	no effect	A	no effect	A	inspect column, might require engineer review	B	option to add high visibility paint and no post barriers around pillars
R23	Trucking	Damage to Substation by truck	truck travelling at low speeds, effects managed by design	A	no effect	A	no effect	A	limited damage to exterior	B	option to add no post barriers, fencing around substation along exposed side
R24	Trucking	Truck fire under guideway	trains will be stopped away from property	E	potential for smoke inhalation	B	no effect	A	heat monitors in vicinity of guideway. Depending on severity, could require replacement of infrastructure	E	Note: only need to install heat monitors once per site (no duplication of cost)
R25	Heat Transfer Fluid	Explosion and fire due to vapour release	trains will be stopped away from property	E	would occur away from site, with delay until effects noticed by worker	B	no effect	A	no effect	A	potential for passengers/workers to notice similar to other major fire incidents
R26	Heat Transfer Fluid	Explosion and fire due to liquid release	trains will be stopped away from property	E	would occur away from site, with delay until effects noticed by worker	B	no effect	A	no effect	A	potential for passengers/workers to notice similar to other major fire incidents
R27	Steam Boiler	Boiler explosion (combustion)	trains will be stopped away from property	E	worker on guideway could be hit by debris	C	no effect	A	no effect	A	

System Element			Evergreen Line Consequence Severity and Relative Risk Level								
Element Number	Element Name	Potentially Adverse Event	Operations		Worker & Passenger Health, Safety & Security		Regulatory		Maintenance & Mitigation		Comments, Uncertainty, and Recommendations
			Description	Index Value (A-E)	Description	Index Value (A-E)	Description	Index Value (A-E)	Description	Index Value (A-E)	
R28	Propane Tank	Explosion	pause operations to confirm safe operating conditions	C	potential for impact from debris or noice effects	B	no effect	A	no effect	A	tank will be moved from current location prior to construction of EG Line
R29a	Vent Collection System	Small flashback through vent header to connected flammable vessels	trains will be stopped away from property	B	effects in vicinity of site	A	no effect	A	installation of LEL monitors in substation, tunnel entrance and in vicinity of guideway	A	small flash back events
R29b	Vent Collection System	Large flashback through vent header to connected flammable vessels	trains will be stopped away from property	E	effects in vicinity of site	E	no effect	A	installation of LEL monitors in substation, tunnel entrance and in vicinity of guideway	A	based on major flashback event

Table A7: Risk Register

Evergreen Line System Element								Reichhold Facility Consequence Severity and Relative Risk Level				
Element Number	Element Name	Potentially Adverse Event	Reason(s) for Adverse Event	Existing Preventative Measures	Event Detection (1=Highly detectable, 5=not detectable	Event Predictability (1=predictable, 5=not predictable)	Frequency of Event (1 to 5)	Operations	Worker Health, Safety & Security	Regulatory	Maintenance & Mitigation	Comments, Uncertainty, and Recommendations
E1	Power Substation NPZ	Power/Control Loss of Process	Weather, Hydro equipment error	multiple power feeds	1	5	4	A	A	A	A	not plausible
E2	Power Substation NPZ	Minor thermal combustion/smoke, housing, electrical arc	lightening strike, component failure	station design, grounding of components, maintenance/management protocol, electrical code	1	3	2	A	A	A	A	
E3	Track Maintenance & Inspections	Discontent receptor present on track	employee complaint re odours	employee awareness and orientation, work within regulatory guidelines	2	3	5	A	A	A	A	confirm if odour enforcement is possible. Coordinate ELRPT employee training/awareness with Reichhold. No complaints noted in last 15 years
E4	Track Maintenance	Hot work, Rail grinding	throw sparks from grinder, welding	planned activities, shield around grinder keeps sparks within track	1	1	5	A	A	A	A	post signage to coordinate activities in vicinity of facilty
E5	Track Maintenance	hose breaks and glycol mix spils on track (while train moving)	De-icing with 200L glycol train (50:50 mix) sprays select ice buildups	spill will stay within guideway based on guideway design	2	3	4	A	A	A	A	inconsequential to Reichhold
E6	High energy moving parts (wheels)	Fragmentation and loss of component from train	daily wear	guideway design	3	4	1	A	A	A	A	if loss of train component, will likely stay within guideway
E7	Operations	Stationary Train at Chemical plant and/or passenger exits train	train failure, switch failure, power failure, communication to exit train, passenger voluntarily exits train	rescue train to location, emergency procedures/ staff/ communications/ alarms	1	4	5	A	A	A	A	likely mitigated within 30 minutes. Confirm if odour enforcement is possible
E8	Operations	2 Train collision	human error	operation policy and procedures	1	4	1	E	E	A	E	highly improbable event
E9	Operations	sound, odour or visual impacts related to daily operations	Normal Moving Train	preventative maintenance (train and track), monitor track noise level, ventilation in trains	1	2	5	A	A	A	A	
E10	Operations	complaints related to noise, odour or visual impacts (perceived or actual) related to daily operations	Normal Moving Train	preventative maintenance (train and track), monitor track noise level, ventilation in trains	1	2	5	A	A	A	A	
E11	Operations	train derailment, rail support damage	adverse weather, component failure, seismic event, driving error	training, operating procedures, train design, BC safety authority	1	5	1	A	A	A	A	one wheel off the track is considered a derailment. During a derailment, train will likely stay within the track guideway.
E12	Operations	collapse of guideway	seismic event	design code standard 2475 (no collapse)	1	5	1	D	E	A	E	incremental effect due to collapse only
E13	Operations	Radio frequency disruptions	EMI effects possible with 10 m of the track	test once track installed, or confirmation next to existing guideways	1	1	requires testing in field for site-specific interactions - see report text Section 2.1	A	A	A	A	possible interference will be evaluated and procedure could be altered if necessary
E14	Operations	Weather impacts	wind, rain, snow, hail	procedures to address icy patches on ground as needed, arborist assessments	1	3	3	A	A	A	A	substation access via public road , no issues on guideway affecting Reichhold

Reichhold Facility **System Element**								Evergreen Line **Consequence Severity and Relative Risk Level**				
Element Number	**Element Name**	**Potentially Adverse Event**	**Reason(s) for Adverse Event**	**Existing Preventative Measures**	**Event Detection (1=Highly detectable, 5=not detectable**	**Event Predictability (1=predictable, 5=not predictable)**	**Frequency of Event (1 to 5)**	**Operations**	**Worker & Passenger Health, Safety &**	**Regulatory**	**Maintenance & Mitigation**	**Comments, Uncertainty, and Recommendations**
R1	Thermal Oxidizer	Release of untreated vapours	TO failure, low temperature, power failure/bump, process upset, etc	interlocks, real time monitoring	1	5	4	B	B	A	A	Non-TDI impacts only
R2	Thermal Oxidizer	Release of black smoke	incomplete combustion	interlocks, real time monitoring	1	5	3	A	A	A	A	may be a perceptual issue
R3	Flammable Finished Goods Storage Vessels	Passive Venting to atmosphere (normal operations)	Filling the tank (normal operation)	Part of normal operation and process design	1	1	5	A	A	A	A	may have regulator concerns
R4	Flammable Finished Goods Storage Vessels	Vessel Failure, Leak or Spill (complete loss)	overpressurization, mechanical failure, implosion	mechanical integrity inspection program, pressure/vacuum relief on storage tanks	1	4	1	E	B	A	A	consider installation of LEL detectors in substation
R5	Flammable Finished Goods Storage Vessels	Vessel Failure, Leak or Spill (partial loss)	overpressurization, mechanical failure, implosion	mechanical integrity inspection program, pressure/vacuum relief on storage tanks	3	4	3	B	B	A	A	
R6	Flammable Finished Goods Storage Vessels	Fire	uncontrolled ignition source, hot work in vicinity of storage vessels	electrical classification, controled ignition sources	2	5	2	E	C	A	A	heat effects not likely but potential for smoke impacts
R7	Flammable Raw Material Storage Vessels	vapour above LEL and ignited by substation or train	Vessel Failure - Spill (Major)	fire supression, LEL monitors, mechanical integrity inspection program	1	4	1	E	E	A	C	also needs to consider air intake into tunnel, LEL monitors set to 25% of LEL
R8	Flammable Raw Material Storage Vessels	vapours at 25% LEL	Vessel Failure - Spill (Minor)	fire supression, LEL monitors, mechanical integrity inspection program, spill containment	1	4	3	B	A	A	A	could trigger notification to EG, covered by internal EG SMS policy
R9	Toxic Raw Material Storage Vessels (Vinyl Acetate)	toxic vapour less than than 0.25 LEL but higher than STEL	Minor Spill	fire supression, LEL monitors, mechanical integrity inspection program, spill containment	2	4	2	C	B	A	C	currently, vinyl acetate monitored through LEL, but not via electronic system for health exposure
R10	Toxic Raw Material Storage Vessels (TDI)	toxic vapour plume greater than STEL	Vessel Failure - Spill (major)	Mechanical integrity and spill containment, fixed monitoring	1	4	1	E	D	A	A	unlikely to reach levels to cause fatality to EG
R11	Toxic Raw Material Storage Vessels (TDI)	toxic vapour plume greater than permissionable exposure level but less than STEL	Vessel Failure - Spill (minor)	Mechanical integrity and spill containment, fixed monitoring	1	4	1	C	B	A	A	media/public effect of shutdown and wording of public notification
R12	Phthalic Anhydride (raw material)	Fire with possible overpressurization of tank	uncontolled heating and ignition source	tank inerting, interlocks, pressure/temperature alarms	1	3	2	D	B	A	A	scoring based on no agency intervention
R13	Maintenance Shop	Hot works Fire	ignition of combustible materials (rags, etc.)	fire extinguishers, housekeeping	2	2	1	C	B	A	A	Note: only need to install heat monitors once per site (no duplication of cost)
R14	Garbage Storage Area	Fire	substandard act	policies and procedures	3	5	2	B	A	A	A	
R15	Raw Materials Warehouse	Fire beyond incipient stage	uncontrolled ignition source	electrical classification, controled ignition sources, approved sprinkler protection	1	5	1	E	B	A	C	Note: only need to install heat monitors once per site (no duplication of cost)
R16	Finished Goods Warehouse	Fire beyond incipient stage	uncontrolled ignition source	electrical classification, controled ignition sources, approved sprinkler protection	1	5	1	E	B	A	C	Note: only need to install heat monitors once per site (no duplication of cost)
R17	Flammable Raw Material Offloading (railcars)	vapour cloud due to complete emptying of tank on ground	failure of bottom valve on tank railcar and no cap	inspection monitoring program	2	4	1	D	C	A	B	operations severity assumes emergency responders enable resumption of trains within 4hrs of their cessation
R18	Flammable Raw Material Offloading (tank trucks)	vapour cloud due to complete emptying of tank on ground	failure of connection coupling and internal valve failure, hose burst, vehicle accident	inspection monitoring program	1	4	2	D	C	A	C	also needs to consider air intake into tunnel, LEL monitors set to 25% of LEL. Note: only need to install heat monitors once per site (no duplication of cost)
R19	Toxic Raw Material Offloading (tank trucks)	toxic vapour plume greater than permissionable exposure level but less than STEL	failure of connection coupling and internal valve failure, hose burst, vehicle accident	inspection monitoring program	1	4	2	D	C	A	C	eg. TDI. media/public effect of shutdown and wording of public notification
R20	Plant Operations	tank failure, spill, ignition, vapour source, etc. (flammable)	seismic event	fire supression, LEL monitors, mechanical integrity inspection program	1	4	1	E	E	A	C	also needs to consider air intake into tunnel, LEL monitors set to 25% of LEL
R21	Plant Operations	tank failure, spill, ignition, vapour source, etc. (toxic)	seismic event	Spill containment, fixed monitoring, fire supression, LEL monitors, mechanical integrity inspection program	1	4	1	E	D	A	A	unlikely to reach levels to cause fatality to EG
R22	Trucking	Damage to ELRTP concrete pillar or guideway	substandard act	driver training, certification, pillar design and placement	4	2	3	A	A	A	B	option to add high visibility paint and no post barriers around pillars
R23	Trucking	Damage to Substation by truck	substandard act	driver training, certification	3	5	2	A	A	A	B	option to add no post barriers, fencing around substation along exposed side
R24	Trucking	Truck fire under guideway	truck overheats, uncontrolled combustion	corporate travel requirements, contract procurement methods	1	5	1	E	B	A	E	Note: only need to install heat monitors once per site (no duplication of cost)
R25	Heat Transfer Fluid	Explosion and fire due to vapour release	release at thermal unit, malfunction, pipe failure	pressure monitoring, temperature monitoring, interlocks	1	3	2	E	B	A	A	potential for passengers/workers to notice similar to other major fire incidents
R26	Heat Transfer Fluid	Explosion and fire due to liquid release	release at thermal unit, malfunction, pipe failure	pressure monitoring, temperature monitoring, interlocks	1	3	2	E	B	A	A	potential for passengers/workers to notice similar to other major fire incidents
R27	Steam Boiler	Boiler explosion (combustion)	overpressurization	BC Boiler inspection program, interlocks, alarms	1	3	1	E	C	A	A	
R28	Propane Tank	Explosion	puncture of tank by forklift, etc.	pillars, regular service inspections by provider	1	5	1	C	B	A	A	tank will be moved from current location prior to construction of EG Line
R29a	Vent Collection System	Small flashback through vent header to connected flammable vessels	process upset, vent header enters flammable range	detonation arrestor, oxygen monitor, engineering design, best practices, foam fire supression system	2	3	3	B	A	A	A	small flash back events
R29b	Vent Collection System	Large flashback through vent header to connected flammable vessels	process upset, vent header enters flammable range	detonation arrestor, oxygen monitor, engineering design, best practices, foam fire supression system	2	3	2	E	E	A	A	based on major flashback event

Table A8-1 : Risk Matrix

Event Frequency Index		Evergreen Line Operations Consequence Severity Index				
Frequency	**Index Descriptor**	**A Negligible**	**B Low**	**C Moderate**	**D High**	**E Extreme**
Incident has occurred or could be expected to occur more than once per year	5. Frequent	**R3**				
Incident has occurred or could be expected to occur once every 1 to 5 years	4. Occasional		**R1**			
Incident has occurred or could be expected to occur once every 5 to 10 years	3. Seldom	**R2, R22**	**R5, R8**			
Incident has occurred or could be expected to occur once every 10 to 30 years	2. Unlikely	**R23**	**R14, R29a**	**R9**	**R12, R18, R19**	**R6, R25, R26, R29b**
Incident is very unlikely to occur within the operation lifetime	1. Improbable			**R11, R13, R28**	**R17**	**R4, R7, R10, R15, R16, R20, R21, R24, R27**
Notes:						

Table A8-2: Risk Matrix

Event Frequency Index		Evergreen Line Worker and Passenger Health, Safety & Security Consequence Severity Index				
Frequency	**Index Descriptor**	**A Negligible**	**B Low**	**C Moderate**	**D High**	**E Extreme**
Incident has occurred or could be expected to occur more than once per year	5. Frequent	**R3**				
Incident has occurred or could be expected to occur once every 1 to 5 years	4. Occasional		**R1**			
Incident has occurred or could be expected to occur once every 5 to 10 years	3. Seldom	**R2, R8, R22, R29a**	**R5**			
Incident has occurred or could be expected to occur once every 10 to 30 years	2. Unlikely	**R14, R23**	**R9, R12, R25, R26**	**R6, R18, R19**		**R29b**
Incident is very unlikely to occur within the operation lifetime	1. Improbable		**R4, R11, R13, R15, R16, R24, R28**	**R17, R27**	**R10, R21**	**R7, R20**
Notes:						

Table A8-3: Risk Matrix

Event Frequency Index		Evergreen Line Regulatory Consequence Severity Index				
Frequency	**Index Descriptor**	**A Negligible**	**B Low**	**C Moderate**	**D High**	**E Extreme**
Incident has occurred or could be expected to occur more than once per year	5. Frequent	**R3**				
Incident has occurred or could be expected to occur once every 1 to 5 years	4. Occasional	**R1**				
Incident has occurred or could be expected to occur once every 5 to 10 years	3. Seldom	**R2, R5, R8, R22, R29a**				
Incident has occurred or could be expected to occur once every 10 to 30 years	2. Unlikely	**R6, R9, R12, R14, R18, R19, R23, R25, R26, R29b**				
Incident is very unlikely to occur within the operation lifetime	1. Improbable	**R4, R7, R10, R11, R13, R15, R16, R17, R20, R21, R24, R27, R28**				
Notes:						

Table A8-4: Risk Matrix

Event Frequency Index		Evergreen Line Maintenance & Mitigation Consequence Severity Index				
Frequency	**Index Descriptor**	**A Negligible**	**B Low**	**C Moderate**	**D High**	**E Extreme**
Incident has occurred or could be expected to occur more than once per year	5. Frequent	**R3**				
Incident has occurred or could be expected to occur once every 1 to 5 years	4. Occasional	**R1**				
Incident has occurred or could be expected to occur once every 5 to 10 years	3. Seldom	**R2, R5, R8, R29a**	**R22**			
Incident has occurred or could be expected to occur once every 10 to 30 years	2. Unlikely	**R6, R12, R14, R25, R26, R29b**	**R23**	**R9, R18, R19**		
Incident is very unlikely to occur within the operation lifetime	1. Improbable	**R4, R10, R11, R13, R21, R27, R28**	**R17**	**R7, R15, R16, R20**		**R24**
Notes:						

Table A8-5: Risk Matrix

Event Frequency Index		Reichhold Facility Operations Consequence Severity Index				
Frequency	**Index Descriptor**	**A Negligible**	**B Low**	**C Moderate**	**D High**	**E Extreme**
Incident has occurred or could be expected to occur more than once per year	5. Frequent	**E3, E4, E7, E9, E10**				
Incident has occurred or could be expected to occur once every 1 to 5 years	4. Occasional	**E1, E5**				
Incident has occurred or could be expected to occur once every 5 to 10 years	3. Seldom	**E14**				
Incident has occurred or could be expected to occur once every 10 to 30 years	2. Unlikely	**E2**				
Incident is very unlikely to occur within the operation lifetime	1. Improbable	**E6, E11**			**E12**	**E8**
Notes:						

Table A8-6: Risk Matrix

Event Frequency Index		Reichhold Facility Worker Health, Safety & Security Consequence Severity Index				
Frequency	**Index Descriptor**	**A Negligible**	**B Low**	**C Moderate**	**D High**	**E Extreme**
Incident has occurred or could be expected to occur more than once per year	5. Frequent	**E3, E4, E7, E9, E10**				
Incident has occurred or could be expected to occur once every 1 to 5 years	4. Occasional	**E1, E5**				
Incident has occurred or could be expected to occur once every 5 to 10 years	3. Seldom	**E14**				
Incident has occurred or could be expected to occur once every 10 to 30 years	2. Unlikely	**E2**				
Incident is very unlikely to occur within the operation lifetime	1. Improbable	**E6, E11**				**E8, E12**
Notes:						

Table A8-7: Risk Matrix

Event Frequency Index		Reichhold Facility Regulatory Consequence Severity Index				
Frequency	**Index Descriptor**	**A Negligible**	**B Low**	**C Moderate**	**D High**	**E Extreme**
Incident has occurred or could be expected to occur more than once per year	5. Frequent	**E3, E4, E7, E9, E10, E13**				
Incident has occurred or could be expected to occur once every 1 to 5 years	4. Occasional	**E1, E5**				
Incident has occurred or could be expected to occur once every 5 to 10 years	3. Seldom	**E14**				
Incident has occurred or could be expected to occur once every 10 to 30 years	2. Unlikely	**E2**				
Incident is very unlikely to occur within the operation lifetime	1. Improbable	**E6, E8, E11, E12**				
Notes:						

Table A8-8: Risk Matrix

Event Frequency Index		Reichhold Facility Maintenance & Mitigation Consequence Severity Index				
Frequency	**Index Descriptor**	**A Negligible**	**B Low**	**C Moderate**	**D High**	**E Extreme**
Incident has occurred or could be expected to occur more than once per year	5. Frequent	**E3, E4, E7, E9, E10**				
Incident has occurred or could be expected to occur once every 1 to 5 years	4. Occasional	**E1, E5**				
Incident has occurred or could be expected to occur once every 5 to 10 years	3. Seldom	**E14**				
Incident has occurred or could be expected to occur once every 10 to 30 years	2. Unlikely	**E2**				
Incident is very unlikely to occur within the operation lifetime	1. Improbable	**E6, E11**				**E8, E12**
Notes:						

Table A9-1: Risk Criticality Matrix

Event Frequency Index		Evergreen Line Operations Consequence Severity Index				
Frequency	**Index Descriptor**	**A Negligible**	**B Low**	**C Moderate**	**D High**	**E Extreme**
Incident has occurred or could be expected to occur more than once per year	5. Frequent	**R3**				
Incident has occurred or could be expected to occur once every 1 to 5 years	4. Occasional		**R1**			
Incident has occurred or could be expected to occur once every 5 to 10 years	3. Seldom	**R2, R22**	**R5, R8**			
Incident has occurred or could be expected to occur once every 10 to 30 years	2. Unlikely	**R23**	**R14, R29a**	**R9**	**R12, R18, R19**	**R6, R25, R26, R29b**
Incident is very unlikely to occur within the operation lifetime	1. Improbable			**R11, R13, R28**	**R17**	**R4, R7, R10, R15, R16, R20, R21, R24, R27**
Notes: *** in reference to project life cycle**						

	Negligible Risk
	Tolerable Risk
	Risk Mitigation Advisable
	Risk Mitigation Manadatory

Table A9-2: Risk Criticality Matrix

Event Frequency Index		Evergreen Line Worker and Passenger Health, Safety & Security Consequence Severity Index				
Frequency	**Index Descriptor**	**A Negligible**	**B Low**	**C Moderate**	**D High**	**E Extreme**
Incident has occurred or could be expected to occur more than once per year	5. Frequent	R3				
Incident has occurred or could be expected to occur once every 1 to 5 years	4. Occasional		R1			
Incident has occurred or could be expected to occur once every 5 to 10 years	3. Seldom	R2, R8, R22, R29a	R5			
Incident has occurred or could be expected to occur once every 10 to 30 years	2. Unlikely	R14, R23	R9, R12, R25, R26	R6, R18, R19		R29b
Incident is very unlikely to occur within the operation lifetime	1. Improbable		R4, R11, R13, R15, R16, R24, R28	R17, R27	R10, R21	R7, R20

Notes:
*** in reference to project life cycle**

	Negligible Risk
	Tolerable Risk
	Risk Mitigation Advisable
	Risk Mitigation Manadatory

Table A9-3: Risk Criticality Matrix

Event Frequency Index		Evergreen Line Regulatory Consequence Severity Index				
Frequency	**Index Descriptor**	**A Negligible**	**B Low**	**C Moderate**	**D High**	**E Extreme**
Incident has occurred or could be expected to occur more than once per year	5. Frequent	**R3**				
Incident has occurred or could be expected to occur once every 1 to 5 years	4. Occasional	**R1**				
Incident has occurred or could be expected to occur once every 5 to 10 years	3. Seldom	**R2, R5, R8, R22, R29a**				
Incident has occurred or could be expected to occur once every 10 to 30 years	2. Unlikely	**R6, R9, R12, R14, R18, R19, R23, R25, R26, R29b**				
Incident is very unlikely to occur within the operation lifetime	1. Improbable	**R4, R7, R10, R11, R13, R15, R16, R17, R20, R21, R24, R27,**				

Notes:
*** in reference to project life cycle**

	Negligible Risk
	Tolerable Risk
	Risk Mitigation Advisable
	Risk Mitigation Manadatory

Table A9-4: Risk Criticality Matrix

Event Frequency Index		Evergreen Line Maintenance & Mitigation Consequence Severity Index				
Frequency	**Index Descriptor**	**A Negligible**	**B Low**	**C Moderate**	**D High**	**E Extreme**
Incident has occurred or could be expected to occur more than once per year	5. Frequent	**R3**				
Incident has occurred or could be expected to occur once every 1 to 5 years	4. Occasional	**R1**				
Incident has occurred or could be expected to occur once every 5 to 10 years	3. Seldom	**R2, R5, R8, R29a**	**R22**			
Incident has occurred or could be expected to occur once every 10 to 30 years	2. Unlikely	**R6, R12, R14, R25, R26, R29b**	**R23**	**R9, R18, R19**		
Incident is very unlikely to occur within the operation lifetime	1. Improbable	**R4, R10, R11, R13, R21, R27, R28**	**R17**	**R7, R15, R16, R20**		**R24**
Notes: *** in reference to project life cycle**						
	Negligible Risk					
	Tolerable Risk					
	Risk Mitigation Advisable					
	Risk Mitigation Manadatory					

Table A9-5: Risk Criticality Matrix

Event Frequency Index		Reichhold Facility Operations Consequence Severity Index				
Frequency	**Index Descriptor**	**A Negligible**	**B Low**	**C Moderate**	**D High**	**E Extreme**
Incident has occurred or could be expected to occur more than once per year	5. Frequent	**E3, E4, E7, E9, E10**				
Incident has occurred or could be expected to occur once every 1 to 5 years	4. Occasional	**E1, E5**				
Incident has occurred or could be expected to occur once every 5 to 10 years	3. Seldom	**E14**				
Incident has occurred or could be expected to occur once every 10 to 30 years	2. Unlikely	**E2**				
Incident is very unlikely to occur within the operation lifetime	1. Improbable	**E6, E11**			**E12**	**E8**
Notes: *** in reference to project life cycle**						
	Negligible Risk					
	Tolerable Risk					
	Risk Mitigation Advisable					
	Risk Mitigation Manadatory					

Table A9-6: Risk Criticality Matrix

Event Frequency Index		Reichhold Facility Worker Health, Safety & Security Consequence Severity Index				
Frequency	**Index Descriptor**	**A Negligible**	**B Low**	**C Moderate**	**D High**	**E Extreme**
Incident has occurred or could be expected to occur more than once per year	5. Frequent	**E3, E4, E7, E9, E10**				
Incident has occurred or could be expected to occur once every 1 to 5 years	4. Occasional	**E1, E5**				
Incident has occurred or could be expected to occur once every 5 to 10 years	3. Seldom	**E14**				
Incident has occurred or could be expected to occur once every 10 to 30 years	2. Unlikely	**E2**				
Incident is very unlikely to occur within the operation lifetime	1. Improbable	**E6, E11**				**E8, E12**
Notes: *** in reference to project life cycle**						
	Negligible Risk					
	Tolerable Risk					
	Risk Mitigation Advisable					
	Risk Mitigation Manadatory					

Table A9-7: Risk Criticality Matrix

Event Frequency Index		Reichhold Facility Regulatory Consequence Severity Index				
Frequency	**Index Descriptor**	**A Negligible**	**B Low**	**C Moderate**	**D High**	**E Extreme**
Incident has occurred or could be expected to occur more than once per year	5. Frequent	**E3, E4, E7, E9, E10, E13**				
Incident has occurred or could be expected to occur once every 1 to 5 years	4. Occasional	**E1, E5**				
Incident has occurred or could be expected to occur once every 5 to 10 years	3. Seldom	**E14**				
Incident has occurred or could be expected to occur once every 10 to 30 years	2. Unlikely	**E2**				
Incident is very unlikely to occur within the operation lifetime	1. Improbable	**E6, E8, E11, E12**				
Notes: *** in reference to project life cycle**						
	Negligible Risk					
	Tolerable Risk					
	Risk Mitigation Advisable					
	Risk Mitigation Manadatory					

Table A9-8: Risk Criticality Matrix

Event Frequency Index		Reichhold Facility Maintenance & Mitigation Consequence Severity Index				
Frequency	**Index Descriptor**	**A Negligible**	**B Low**	**C Moderate**	**D High**	**E Extreme**
Incident has occurred or could be expected to occur more than once per year	5. Frequent	**E3, E4, E7, E9, E10**				
Incident has occurred or could be expected to occur once every 1 to 5 years	4. Occasional	**E1, E5**				
Incident has occurred or could be expected to occur once every 5 to 10 years	3. Seldom	**E14**				
Incident has occurred or could be expected to occur once every 10 to 30 years	2. Unlikely	**E2**				
Incident is very unlikely to occur within the operation lifetime	1. Improbable	**E6, E11**				**E8, E12**
Notes: *** in reference to project life cycle**						
	Negligible Risk					
	Tolerable Risk					
	Risk Mitigation Advisable					
	Risk Mitigation Manadatory					