8 Accidents, Malfunctions, and Natural Hazards

8.1 Introduction

The safety and security of the public is a core value for TransLink. TransLink proactively promotes safe environments for its employees and passengers. In this context, TransLink recognizes that accidents and malfunctions, including equipment malfunction or failure, human error, or natural events, can affect public safety and security, or have effects on the environment.

The purpose of this section is to identify specific accident and malfunction scenarios that are considered reasonably likely to occur during the life of the Surrey Newton-Guildford Light Rail Transit (LRT) Project (i.e., construction and operation), the associated public safety risks and the potential effects on the environmental and Socio-economic Review Elements. Building on this analysis, this section identifies mitigation and response measures to avoid or respond to an accidents and malfunctions scenario to limit the risk to public safety and effects on the Review Elements.

Information presented in this section to support the assessment of accidents, malfunctions and natural hazards includes:

- **Description of Scenario** - A description of the worst-case (if the scenario is a major public safety risk) or probable-case (if the scenario holds a minor public safety risk) scenario. This includes examples of the events leading to the scenario and the types of risks to public safety and to the Review Elements.
- **Preventative and Response Measures** - A description of the preventative and response measures to the scenario. Preventative measures are those that limit the probability of the scenario occurring, while response measures are those that are applied after the scenario has occurred. Preventative and response measures apply primarily in the context of avoiding injury and reducing the risk to public safety.
- **Potential Effects** - The potential long-term or permanent effects on the Review Elements after response measures have been implemented are described.
- **Conclusions** – A summary of the accidents, malfunctions, and natural hazards scenario including the likelihood of the scenario occurring during the life of the project, the potential consequence to public safety, and the potential effects on the Review Elements.

8.2 Methods

The method used to support the assessment of accidents and malfunctions includes examining specific accident and malfunction scenarios, considered to have a reasonable likelihood of occurring during the construction and/or operational phase of the Project, to identify relevant effects and mitigation/preventative measures. The review excludes consideration of intentional acts of vandalism, sabotage, or terrorism, since these scenarios are often accompanied by other unpredictable risk factors.

Such scenarios include those, described in Section 8 of the ESR Terms of Reference, related to fire, spills, loss of power, train derailments, earthquakes and extreme weather, and are described as follows:

- "Worst case" or "probable case" events and the applicable project stage
- Identification of related preventative measures intended to limit the likelihood of the event occurring and/or limit the potential risk to public safety
- Identification of related response measures intended to mitigate potential risks to public safety once the event has occurred, including actions to be taken after the event has occurred.

Preventative and response measures are discussed primarily in the context of public safety, where the primary objective is to mitigate the potential for serious harm or injury to the public and employees. The potential effect to each Review Element is also characterized if there is an interaction between a Review Element and a specific accident or malfunction scenario, as shown in Table 8-1.

The likelihood of each scenario occurring after the consideration of preventative measures is characterized (i.e., low, moderate, or high). In addition, the consequence or risk to public safety, after response measures are considered, is also characterized (i.e., negligible, low, moderate, or high).

Table 8-1: Interaction between Accident, Malfunction and Natural Hazard Scenario with Review Element

Review Element	Fire	Spill	Loss of Power	Train Derailment	Earthquake	Extreme Weather Event
Traffic and Transportation	-	✓	-	-	✓	-
Housing, Residential Properties, and Commercial Businesses	-	-	-	-	-	-
Emergency Access and Public Safety	-	-	-	✓	-	-
Fisheries and Aquatic Resources	-	✓	-	-	-	-
Archaeological and Heritage Resources	-	-	-	-	-	-
Vegetation and Wildlife	-	✓	-	-	-	-
Noise	-	-	-	-	-	-
Vibration	-	-	-	-	-	-
Air Quality and Greenhouse Gases	-	-	-	-	-	-
Contaminated Sites	-	✓	-	-	-	-
Electric and Magnetic Fields	-	-	-	-	-	-

NOTES:
- No Interaction Between Scenario and Review element
✓ Interaction Between Scenario and Review Element

The objectives of the Spill Prevention, Fuel Management and Emergency Response Plan, as referred to in the Environmental Management Plan Section 9.4.13 are to limit the potential for an accident or malfunction caused by Project-related activities and to equip Project personnel with procedures to follow in the event of an accident, malfunction, or natural hazard. At a minimum, the Spill Prevention, Fuel Management and Emergency Response Plan should include a list of materials and equipment that will be stored on site (e.g., spill abatement materials, clean-up kits, survival kits), roles and responsibilities of on-site personnel in the event of an accident or malfunction, training requirements for on-site personnel, spill response procedures, and reporting requirements. The Spill Prevention, Fuel Management and Emergency Response Plan should include measures that TransLink will implement to limit the potential for an accident or malfunction.

The objective of the Hazardous Building and Demolition Materials Management Plan, as referred to in the Environmental Management Plan Section 9.4.9 is to limit the risk of a spill or safety incident involving dangerous goods and materials during construction of the Project. At a minimum, the Hazardous Building and Demolition Materials Management Plan should identify procedures for the transport of dangerous goods and materials, training requirements for Project personnel and contractors, measures for proper inventory and storage of dangerous goods and materials in environmentally sensitive areas, and servicing and inspection requirements for transport and storage equipment.

The objective of the Hazardous Building and Demolition Materials Management Plan, as referred to in the Environmental Management Plan Section 9.4.10 is to provide Project personnel with a plan should hazardous building materials be encountered during demolition activities. At a minimum, the Hazardous Materials Management Plan should include procedures and BMPs for the identification, abatement, verification, transportation, and disposal of hazardous building materials encountered during the demolition of structures required for the Project.

The likelihood of each scenario occurring after the consideration of preventative measures is characterized (i.e., low, moderate, or high). In addition, the consequence or risk to public safety, after response measures are considered, is also characterized (i.e., negligible, low, moderate, or high).

Table 8-2 in Section 8.9 summarizes each accident, malfunction and natural hazard scenario, the applicable Project phases, description of the scenario, preventative measures, response measures, and potential effects on the Review Elements.

8.3 Fire

8.3.1 Description of Fire Scenario

During Project construction, Project-related fires could result from the use of machinery and vehicles, but the likelihood of a fire posing significant risk to public safety is low since these types of fires are likely to be small in scale and segregated from the public because public access to the construction area is restricted. Therefore, the fire scenario for this review applies to the operations phase of the Project only. Fuel leaks and spills during construction, and potential for ignition of spilled substances, are discussed in Section 8.4.

The worst-case fire scenario would be an incident on a train that is extensive enough to require evacuation of people from the train. A train fire may be caused by a malfunction of the electrical or mechanical systems on the train, or collision with a vehicle carrying flammable materials. The risk to passengers on the incident train, as well as to bystanders and nearby vehicles would be primarily from smoke inhalation and direct exposure to fire.

Fires may also occur at traction-powered sub-stations (TPSS) or the Operating and Maintenance Facility (OMF). These scenarios would typically be electrical fires or chemical fires due to battery malfunction. The OMF is located in an industrial area, and has perimeter fencing to make it inaccessible to the public, while the TPSS are approximately 8 m by 25 m brick structures with a metal roof. The exteriors of the TPSS will not be used for advertisements or public art displays to limit public interaction with these structures. While a fire at these facilities are of low risk to public safety, these facilities will be equipped with fire suppression equipment for electrical fires.

8.3.2 Preventative and Response Measures

8.3.2.1 Preventative Measures

Preventative measures for a train fire are intended to prevent a fire from starting or to prevent the spread of an existing fire. Response measures are intended to mitigate the risk to public safety once a fire has started. Preventative and response measures are integrated into the design and operation of the Project.

Fire prevention is a key consideration in train design. Electrified train components and electrical contact points (which pose greater risk of fire) will incorporate fire safety features, such as low flammability, low combustibility and low smoke production. Regular maintenance is another key preventative measure to limit the likelihood of a train fire from equipment failure or malfunction. This maintenance will be included as part of TransLink's maintenance program over the life of the Project. Fire suppression equipment such as dry powder fire extinguishers for electrical fires will be available in each train compartment.

The Project design also incorporates road safety features (e.g., LRT guideway separated from vehicle traffic lanes, advanced signal control systems and signalized road intersections) to mitigate the risk of vehicle collision.

8.3.2.2 Response Measures

Fire response measures will include the evacuation of the incident train by the train operator who will be trained to evacuate passengers to a safe location. In most cases, the train will be evacuated before a fire can progress into the passenger compartment.

The likely series of events for a fire incident would be:

- a fire, burning smell, or smoke is detected by passengers and the incident is communicated to the train operator using the intercom
- the train operator makes an evacuation announcement on the train communication system, and provides instructions for passengers to evacuate to a safe location
- the train doors are opened by the train operator or manually opened by passengers. Once passengers have exited the train, the safety risk to the public from fire is mitigated.
- the train operator calls for emergency response support, and may attempt to extinguish the fire with an on-board fire extinguisher

Response measures also include support by police, ambulance and firefighters for security, medical and firefighting purposes. If a train fire occurs between the Guildford Exchange and 96th Avenue stations, emergency vehicles can bypass traffic in the general-purpose lanes by driving on the guideway because the top of the tracks is flush with the running surface. If a train fire occurs between the 96th Avenue and Newton Exchange stations, emergency vehicles will use the general-purpose lanes because the guideway tracks are raised above-ground in a manner that does not allow vehicles to drive on it. If the general-purpose lanes are blocked, police will be able to re-direct traffic to the next parallel street to detour around the incident area.

The TPSS and OMF buildings have separate fire suppression rooms with equipment to suppress electrical fires.

8.3.3 Potential Effect to Review Elements

A train fire is unlikely to result in long-term effects on the Review Elements.

A fire may have short-term, intermittent effects on some aspects of the Review Elements, but their long-term viability would not be affected. For example, the volume of smoke and combustion products produced during the worst-case train fire scenario, would have a temporary effect on local air quality and would only contribute a negligible amount of greenhouse gases. Train stoppage along the Alignment and presence of emergency response crews at the incident location would result in temporary motor and transit traffic disruptions

8.3.4 Conclusion

The likelihood of a train fire scenario with passengers on-board during the life of the Project is high, based on previous incidents of train fires on TransLink lines. However, the frequency is considered to be low, possibly occurring once every several years. Fire safety features incorporated into design of rail cars, passenger stops, and electrical components of the system, as well as regular maintenance, will limit the likelihood of an equipment failure or malfunction causing a fire. However, other causes of train fires such as collisions with vehicles are not completely preventable. The potential risk to public safety from a train fire is negligible. Previous fire incidents on TransLink trains began with a burning smell in the passenger compartment that slowly progressed to a visible smoke or haze, which alerted passengers to a potential train fire. Passengers had ample time to evacuate the trains. Upon exiting the incident train, the safety risk was effectively mitigated. For this Project, passengers can evacuate at any location once the train has been stopped by the train operator.

A fire scenario on a train is not expected to result in potential effects on the Review Elements beyond a negligible amount of emissions of smoke and greenhouse gases, a short-term disruption in traffic.

8.4 Spill

8.4.1 Description of Spill Scenario

The worst-case spill scenario includes a train collision with a fuel tanker or other vehicle carrying large volumes of materials during the operation phase. In this scenario, the uncontrolled release of a large volume of material poses a high risk to public safety. The risk to public safety can include direct injury from the collision, exposure to vapours from the spilled material, or the risk of fire and explosion if the material is flammable. Spilled liquids can spread rapidly, affecting soils, vegetation, groundwater, and enter storm drains, affecting downstream aquatic resources.

Spills of other substances (e.g., lubricants, cleaners, degreasers, transformer oil) during construction and operations are generally not a risk to public safety. These small-scale spills will be managed according to the environmental management plans (EMPs) described in Section 9.0 (i.e., Spill Prevention, Fuel Management and Emergency Response Plan, Hazardous Materials Management Plan).

8.4.2 Preventative and Response Measures

8.4.2.1 Preventative Measures

Preventative measures to address a major spill from a vehicle collision primarily involve design features to limit train interaction with general purpose traffic. Trains on the guideway are separated from general purpose traffic, except at intersections. At linear intersections, signalling lights will indicate the right-of-way for trains and road vehicles. When approaching an intersection that requires the train to turn (e.g., intersection of 104 Avenue and King George Boulevard, entrance to Newton Exchange station), the train will come to a complete stop because it will not have the right-of-way. Once the train reaches the intersection, it will trigger the signal lights to give the train the right-of-way to turn. Having the train stop before making the turn will provide train operators to observe oncoming traffic before initiating the turn.

8.4.2.2 Response Measures

If a vehicle such as a fuel tanker or other vehicle carrying large volumes of materials collides with the train and releases a large volume of material, a train evacuation will be required. Train operators will be trained to evacuate and direct passengers to a safe location and call for emergency response. Emergency responders would be required to treat injuries and address spilled materials.

8.4.3 Potential Effect to Review Element

A collision that releases a large volume of materials is expected to result in potential effects on multiple Review Elements. The uncontrolled release of large volumes of material can result in contamination to the surrounding area including vegetation, wildlife, fisheries and aquatic resources. There would be a moderate-term disruption to traffic and transportation to respond to the incident and subsequently clean up the affected area. Contaminated materials will be managed and disposed at an approved facility designed to accept contaminated material. Effects on fisheries, aquatic resources and groundwater may require remediation and long-term monitoring.

8.4.4 Conclusion

The likelihood of a vehicle collision resulting in the uncontrolled release of large volumes of materials is low since the trains are separated from general purpose traffic in most locations except at intersections. Signalling at intersections, giving trains and general purpose traffic the right-of-way, will limit the likelihood of a collision. The risk to public safety can range from low to high depending on the severity of the collision and the type of materials released. Response measures focus on keeping the public safe by evacuating passengers on the trains to a safe location and calling for emergency services.

This scenario is expected to have effects on multiple Review Elements including contaminated sites, vegetation and wildlife, fisheries and aquatic resources, and traffic and transportation. Contaminated materials will be managed and disposed at an approved facility that accepts contaminated materials, while monitoring may be required to confirm the effectiveness of clean-up efforts.

8.5 Loss of Power

8.5.1 Description of Loss of Power Scenario

A loss of power scenario applies to the operations phase only. There is no public access to the construction zone, and a loss of power during Project construction is unlikely to result in a risk to public safety or other Review Elements. If necessary, construction work would be postponed until power is restored.

During Project operations, electrical power is supplied to the trains by overhead catenary system. Loss of power during this phase may result in one or more of the following: a loss of primary power along the line causing trains to stall, and a loss of power to communication systems. Loss of power may be the result of a spontaneous failure in the Project's electrical infrastructure (e.g., downed catenary line), or the indirect result of a widespread power outage in the area. A downed catenary line could contact the ground or a rail car, electrifying the area and posing an electrocution risk to pedestrians and passengers.

The likelihood of a loss of power scenario during the life of the Project is high but the likelihood of a loss of power posing significant risk to public safety is low. Therefore, the worst-case scenario is based on the duration of the event, rather than the risk to public safety. There are many potential causes of a loss of power scenario that are beyond the control of TransLink. Loss of power may be short-term (e.g., lasting several hours), moderate-term (e.g., lasting up to 24 hours), or long-term (e.g., worst-case scenario, lasting days), depending on the cause and time required to repair the problem.

8.5.2 Preventative and Response Measures

8.5.2.1 Preventative Measures

The primary preventative measure to avoid a loss of power scenario is a dual feed power supply, where power is supplied by two TPSS. Power outages limited to one of the substations will not result in a loss of power to the trains. In addition, preventative maintenance of the Project's electrical infrastructure, in accordance with TransLink standard practices, will limit the likelihood of loss of power from equipment failure. However, maintenance cannot entirely prevent the spontaneous failure of equipment or limit the likelihood of power loss scenarios caused by factors beyond TransLink's control (e.g., local or regional power outages, vehicle accidents affecting overhead catenary power lines). Trains will be equipped with backup battery power lasting for at least 30 minutes that will maintain basic train functionality to evacuate the trains (e.g., doors, communications systems), but it will not provide traction power to the trains.

Electrocution risks due to a downed catenary line contacting the train are prevented by circuit breaker design that automatically cuts the power in the event of a power line being grounded.

8.5.2.2 Response Measures

Generally, a loss of power does not pose a risk to public safety. Passengers may remain on the stalled train, or they may be asked to disembark if the loss of power is prolonged. Train operators will be trained to evacuate the trains and direct passengers to a safe location. Buses can be deployed to provide temporary service to passengers and mitigate the disruption to traffic and transportation.

8.5.3 Potential Effect to Review Elements

A loss of power is not expected to result in effects on the Review Elements.

8.5.4 Conclusion

The overall likelihood of a loss of power during the life of the Project is high, with short-term events (e.g., lasting hours) being more common than long-term events (e.g., worst-case scenario lasting days). Regular maintenance is anticipated to limit the likelihood of a loss of power from equipment failure or malfunction, but other causes (e.g., wind storms, vehicle accidents that affect overhead catenary system) are not completely preventable. However, the risk to public safety, including the risk of electrocution from a grounded catenary line, is negligible based on design of the electrical system to cut the circuit.

A loss of power is not anticipated to result in long-term effects on the Review Elements, beyond a temporary disruption to the flow of traffic and transportation, which can be mitigated by the deployment of additional buses.

8.6 Train Derailment

8.6.1 Description of Derailment Scenario

A worst-case scenario for train derailment would be an incident during operations when there are passengers on board. Potential causes of a train derailment include equipment malfunction (e.g., rail switch failure, broken track), natural hazard (e.g., seismic activity, ice on the tracks) or human error (e.g., collision with a vehicle or other object on the tracks).

The likelihood of a train derailment occurring over the life of the Project is high, although the frequency of occurrence is anticipated to be low. Most LRT systems in North America have experienced a train derailment during the life of the project, typically due to equipment malfunction or human error. The worst-case train derailment scenario would include a vehicle collision, train rollover, and resulting fuel fire with injuries to train passengers, vehicle occupants or pedestrians. The most probable cause of a train derailment is a vehicle collision or the train operating above its design speed of 60 km/h on a rail curve. Both causes are considered the result of human error. The risk to public safety ranges from low to high, as the potential for injury is related to the conditions and severity of the derailment.

8.6.2 Preventative and Response Measures

8.6.2.1 Preventative Measures

Preventative measures to mitigate the risk of a train derailment vary depending on the cause of the derailment. Routine maintenance is the main preventative measure to mitigate train derailments resulting from equipment malfunction (e.g., rail switch malfunction or broken rails). Derailments resulting from a vehicle collision are mitigated by design features, including the separation of the LRT guideway from vehicle traffic lanes, advanced signal control systems along the right-of-way, and signalized road intersections that prioritize and give right-of-way to the trains.

The design speed for the Alignment is 60 km/hour, although the average operating speed of the train will be 25-35 km/hour. Trains are not expected to exceed the design speed of 60 km/hour along the Alignment. An automated warning system incorporated into the controls is recommended to alert the train operator if the train is travelling above the design speed. Similarly, a kill switch incorporated into the controls is recommended to stop the train if the train operator does not maintain contact with the switch at regular intervals. Such a system would maintain the attention of the train operator and mitigate risks in an emergency (e.g., if train operator is in medical distress).

When approaching an intersection that requires the train to turn (e.g., intersection of 104 Avenue and King George Boulevard, entrance to Newton Exchange station), the train will come to a complete stop because it will not have the right-of-way to turn. Once the train reaches the intersection, it will trigger the signal lights to give the train the right-of-way to turn. Trains will initiate the turn from a complete stop at the intersections at city parkway and the Newton Exchange, reducing the risk of derailment.

Unlike SkyTrain, which has automated braking when there is detection of foreign objects on the tracks, LRT train operators will be able to stop a train manually, if needed.

8.6.2.2 Response Measures

In the event of a train derailment, the backup power supply will allow the braking systems to function, which will limit the distance the train can travel. However, friction with the ground will be the primary stopping force for a derailed train. Train operators will be trained to evacuate the trains, direct passengers to a safe location, and call for emergency response. If a derailment occurs between the Guildford Exchange and 96th Avenue stations, emergency vehicles can bypass traffic in the general-purpose lanes by driving on the guideway because the tracks are flush with the running surface. If a derailment occurs between the 96th Avenue and Newton Exchange stations, where the guideway is on raised tracks, emergency vehicles will use the general-purpose lanes. Emergency support needs may include passenger rescue from the incident train and medical services for injured passengers. If a derailment results in a blockage to vehicle traffic lanes, detours will be implemented to re-direct traffic around the incident area.

8.6.3 Potential Effect to Review Elements

A train derailment may temporarily affect emergency access to the Surrey Memorial Hospital if a derailment occurs between 92 Avenue and 96 Avenue. Emergency response crews may prioritize the flow and redirection of traffic to and from the hospital for emergency vehicles.

A train derailment is unlikely to result in long-term effects on the Review Elements. Short-term traffic disruptions and limited access to residences and commercial properties may occur depending on clean-up activities or whether the area still poses a public safety concern after the derailment incident. However, these effects are negligible given the infrequent likelihood of such events and their short duration.

8.6.4 Conclusion

The likelihood of a train derailment occurring over the life of the Project is high, although the frequency of occurrence is low. The risk to public safety ranges from low to high, as the potential for injury is related to the conditions and severity of the derailment. The most probable cause of a derailment is a vehicle collision with a train. Trains operate in lanes that are separated from general purpose traffic lanes, and signalized intersections help mitigate the risk of collision. However, the risk of a vehicle collision at an intersection cannot be fully mitigated due to the potential for human error. Train operators will be trained to evacuate the trains, direct passengers to a safe location, and call for emergency response. Police, ambulance and firefighters responding to a train derailment can access the incident area using the guideway if the traffic lanes are blocked.

A train derailment is not expected to have long-term effects on the Review Elements. There may be short-term disruptions to local traffic, and access to residences, commercial businesses, and the Surrey Memorial Hospital may also be affected.

8.7 Earthquake

8.7.1 Description of Earthquake Event

An earthquake scenario applies to the operations phase of the Project only. During construction, public access is restricted in the construction area. Seismic disruption of Project infrastructure and construction work would pose a low risk to public safety.

During operations, an earthquake could result in loss of electrical power, downed catenary lines, fire, objects falling onto the tracks, loss of structural integrity of the guideway, and train derailment. Passengers on a train during an earthquake are protected to a certain extent from falling objects; however, they are at risk of injury if the train derails. Passengers waiting at a station may be partially protected by the station canopy from some falling objects because the canopy is designed to protect passengers from rain and snow. The canopy is unlikely to provide full protection against heavy falling objects.

8.7.2 Design and Response Measures

8.7.2.1 Design Measures

During an earthquake, the standard operating procedure is for the train operator to stop the train and advise passengers when it is safe to disembark. The train operator would be trained to instruct passengers to remain in the train for safety purposes, and to protect against falling objects outside until it was deemed safe to exit the train. For safety, train windows are composed of laminated plexiglass, which would not shatter if struck by an object. After an evaluation of the situation, the train operator would announce whether passengers should remain in the train to be brought to the nearest station, or if passengers should evacuate the train. If evacuation is necessary, train operators will direct passengers to a safe location.

Passengers waiting at a station would be partially protected by the overhead canopy. In the case of downed catenary lines, refer to Section 8.5 (Loss of Power).

Preventative measures for Project infrastructure include design and construction of LRT stops, and OMF and TPSS facilities to meet the applicable building codes and Project requirements for seismic risks and building stability. The British Columbia Building Code specifies that buildings withstand a 1-in-2,475-year return period seismic event. As there are no regulations that apply to rail construction with respect to earthquake safety, the Project will specify requirements to meet public safety design criteria.

8.7.2.2 Response Measures

During an earthquake, the standard operating procedure will be for the train operator to stop the train and advise passengers when it is safe to disembark. Train operators will be trained to instruct passengers to remain in the train to protect against falling objects outside until it is deemed safe to exit the train. After an evaluation of the situation, the train operator will either:

- announce whether passengers should remain on the train while it is brought to the nearest station, or
- instruct passengers to evacuate the train, and direct them to a safe location.

If the scenario involves a train derailment, the response measures will be similar to those described in the train derailment scenario. If the safety of passengers is at immediate risk, emergency support will be requested from firefighters, ambulance and police. If there is no safety risk, passengers will be evacuated from the trains.

8.7.3 Potential Effect to Review Elements

Although a major earthquake would have a significant effect on the environment, it is not expected to affect the Project in a manner that would subsequently result in effects on the Review Elements, except for moderate effects on traffic and transportation. The rails, overhead catenary system, TPSS and OMF may require inspection, repairs and maintenance before the trains are operational after a substantial earthquake. An earthquake could lead to other scenarios such as a train fire, loss of power, or train derailment but these independently assessed scenarios would not have anticipated potential effects on Review Elements.

8.7.4 Conclusion

The likelihood of a major earthquake occurring over the life of the Project is moderate to high. The risk to public safety resulting from a Project-related effect caused by seismic activity is negligible. The safety risk to the public is not expected to increase because of the Project and could in fact decrease because it is generally safer to be inside a train or under the station canopy for protection during an earthquake. Train operators would stop the train during an earthquake to limit the risk of injury and train derailment. Emergency services would be summoned only if there are serious injuries or an immediate risk to public safety, to avoid utilizing emergency services during a time of potential crisis. An earthquake does not affect the Project in a manner that could subsequently affect the Review Elements.

8.8 Extreme Weather Event (Wind Storms, Heavy Rain and/or Snow)

8.8.1 Description of Event or Interaction

A severe weather event includes wind storms, heavy rain or heavy snow, ice storms or rain-on-snow events (e.g., high peak flows), which can occur several times per year. These weather events may result in power outage or train derailment scenarios similar to those already described. For example, wind storms may lead to a power outage from downed catenary lines or transmission lines. Heavy snowfall may result in snow and ice compacting between the rails and, as a result, increasing the risk of a derailment. Heavy rain or rain-on-snow events could result in guideway flooding, which could disrupt train operations, electronics, or mechanical systems. Flooding of the guideway may also cause long-term structural damage to the floors of the train if the water levels were to reach above 300 mm and were to flood train passenger compartments. Extreme weather events may cause damage to the infrastructure but the consequence to public safety is negligible.

8.8.2 Preventative and Response Measures

8.8.2.1 Preventative Measures

Effects of extreme weather events are considered in the Project design and operational measures to limit the potential effects.

For potential flooding scenarios, the stormwater drainage system will be designed in accordance with the *Metro Vancouver Stormwater Management Plans* to limit flooding potential during heavy rain or snow. In areas along the right-of-way that are more prone to localized flooding (e.g., part of 104th Avenue near Guildford Mall), the guideway and train rails will be raised higher than normal so that trains can remain operable at water depths of at least 300 mm.

The structural design load of the train considers the potential for destabilization due to high winds and will be designed to withstand the wind forces recorded for the region.

8.8.2.2 Response Measures

During periods of heavy snow or ice accumulation, operational measures, such as reducing train velocity to increase train stability on the tracks, will be implemented as appropriate. During periods of heavy snow, rail de-icing will be performed before daily operation begins. De-icing of the rails through physical measures (e.g., operating empty trains during off-hours to regularly clear the tracks) will likely be sufficient for most extreme weather situations. Regular steel on steel contact between the rail and trains will prevent ice build-up on the rails.

Reducing train velocity during poor weather also mitigates the risk of collision with vehicles. Wind speeds in the Project area do not generate enough force to derail a train.

8.8.3 Potential Effect to Review Elements

An extreme weather event is not expected to affect the Project in a manner that would result in potential effects on the Review Elements.

8.8.4 Conclusion

The likelihood of an extreme weather event occurring over the life of the Project is high, with a frequency of any extreme weather event occurring up to several times per year. Although naturally occurring weather events are not preventable, design and operational measures will lessen their adverse effects and risk to public safety. Design features, winter maintenance and operational adjustments by train operators in response to poor weather conditions can effectively mitigate the potential risk to public safety. Project measures to address extreme weather events are unlikely to substantially affect Review Elements.

8.9 Summary

The risk to public safety, and the potential effect to the Review Elements were reviewed in relation to accidents, malfunctions, and natural hazard scenarios. Table 8-2 provides a summary of the scenarios that were reviewed, a description of the scenarios, the preventative and response measures, and the potential residual effects on the review elements. Considering the preventative measures to mitigate the likelihood of these events and the response measures to limit the potential effect of these scenarios, the risk to public safety is low. The Project is designed with mitigation and response measures to address accidents and malfunctions, and extreme weather events. These mitigation and response measures are effective in protecting public safety and in limiting most types of effects on the Review Elements. If train operations are disrupted for a prolonged period, additional buses can be deployed along the route.

Table 8-2: Summary of Accidents, Malfunctions and Natural Hazards Assessment

Accident, Malfunction or Natural Hazard Scenario	Description of Scenario	Likelihood of Event and Consequence to Public Safety	Preventative Measures	Response Measures	Potential Effects on Review Elements
Fire (O)	An equipment malfunction or vehicle collision that results in a train fire that requires the evacuation of passengers	Likelihood: Moderate Consequence: Negligible to Low	• Regular maintenance of electrified train components • Use of electrical components with low smoke and low flammability properties • Fire suppression equipment (e.g., fire extinguishers) on each train for electrical fires • LRT guideway separate from vehicle traffic lanes, advanced signaling that prioritizes LRT trains, signalized intersections to prevent vehicle collisions	• Train operator will be trained to evacuate the train by opening all doors and directing passengers to a safe location • Emergency response support by police, ambulance, and firefighters for security, medical, and firefighting purposes	No anticipated potential effects on Socio-economic Review Elements
Spill (C)	A collision between a train and a vehicle carrying large volumes of material	Likelihood: Low Consequence: Low to High	• Design features including separated LRT guideway from regular traffic lanes, advanced signaling control systems along guideway, and signalized road intersections that prioritize LRT movements • Trains fully stop prior to turns.	• Train operator will be trained to evacuate the train, direct passengers to a safe location, and call for emergency response	Effects on contaminated sites, vegetation and wildlife, fisheries and aquatic resources, and traffic and transportation. See Section 8.4.3 for more details.
Loss of Power (O)	Long-term loss of power resulting from a downed catenary line, posing a risk of electrocution to pedestrians Area-wide power outage or failure of electrical equipment and infrastructure pose a low risk to public safety	Likelihood: High Consequence: Negligible	• Dual feed power supply will maintain power to catenary line in the event of a TPSS malfunction • Regular maintenance of electrical infrastructure, rail switches and guideway • Grounding of overhead catenary lines will trigger a circuit breaker to stop the flow of power to prevent risk of electrocution	• Train operator will be trained to instruct passengers to evacuate the train and direct them to a safe location if the loss of power is prolonged	No anticipated potential effects on Socio-economic Review Elements
Train Derailment (O)	Train derailment resulting from a vehicle collision with a fuel fire and injuries to train passengers, vehicle occupants or pedestrians	Likelihood: Low Consequence: Low to High	• Design features including separated LRT guideway from regular traffic lanes, advanced signaling control systems along guideway, and signalized road intersections that prioritize LRT movements • Trains fully stop prior to turns. • Regular maintenance, particularly of rail switches and rail infrastructure • Winter maintenance during snow and ice storm events	• Emergency response including police, ambulance, and firefighters • Guideway designed for emergency response vehicle access if regular traffic lanes are blocked • Traffic re-directed around incident area	No anticipated potential effects on Socio-economic Review Elements
Earthquake (O)	A major earthquake could result in a train fire, loss of power, or low-speed train derailment	Likelihood: Moderate to High Consequence: Negligible	• Train operators would stop the train during an earthquake and instruct passengers to shelter in place • Passengers waiting at stations are partially protected by the overhead canopy • Grounding of overhead catenary lines will trigger a circuit breaker to stop the flow of power to prevent risk of electrocution	• Train operators will assess the situation after an earthquake and evacuate the trains when it is deemed safe to do so • Emergency responders will be summoned if there are injuries or immediate safety risk to passengers	Moderate disruption to traffic and transportation. See Section 8.7.3 for more details.
Extreme Weather Event (Wind storm, heavy rain, or heavy snow) (O)	Heavy winds can destabilize an operating train. Heavy rain may cause localized floods that could affect train electronics and operability if water levels exceed 300 mm and enter the passenger compartment; heavy snow could result in ice formation in the rails, or prevent rail switches from operating correctly, leading to a train derailment	Likelihood: High Consequence: Negligible	• LRT structural design load will withstand local wind forces • Stormwater drainage systems will be designed in accordance with Metro Vancouver stormwater management planning guidance to mitigate flooding risk • Guideway elevation will be increased in areas at higher flooding risk	• During extreme weather events, limit LRT velocity to increase train stability and to limit risk of vehicle collisions at road intersections • LRT to operate continuously (including off-hours) to keep tracks clear of ice	No anticipated potential effects on Socio-economic Review Elements

NOTES:
(C) = Construction, (O) = Operations
Likelihood rankings: low, moderate, high
Consequence to public safety rankings: negligible, low, moderate, high