

Appendix 22-A

Failure Modes with Low Environmental Risk

KEMESS UNDERGROUND PROJECT

Application for an Environmental Assessment Certificate

Appendix 22-A. Failure Modes with Low Environmental Risk

Failure Mode	Risk Event Description	Phase	Environmental Consequences	Likelihood	Risk Level/Rank	Controls and Applicable Management and Monitoring Plans
Leak/spill of hazardous substances stored	KUG Electrical transformers, KS workings, oil spill	All	Negligible	Unlikely	L24	Apply transformer oil containment systems according to best IEEE and FM-Global practices
	Electrical transformers, KLV, oil spill	Construction/Operations	Negligible	Rare	L25	Apply transformer oil containment systems according to best IEEE and FM-Global practices
	Batch plant failure	Construction/Operations	Negligible	Rare	L25	Contained within site control systems
	PAG tailings pipeline failure	Operations	Low	Unlikely	L21	Design and SOPs; Emergency Response Plan; Environmental Emergency, Spill, and Hazardous Materials Plan; Mine Waste, Tailings and ML/ARD Management Plan
	Slurry pipeline failure - tailings outside process plant	Operations	Low	Unlikely	L21	Regular inspections. Pressure loss monitoring. Leaks contained by on-site water management structures
	Diesel delivery pipeline failure	Construction/Operations	Negligible	Rare	L25	Regularly tested & inspected; maintenance is documented; low working pressure; fuel tank, bowser & delivery pipe are contained in a bunded area (volume of bund is 1.2 times the maximum volume of stored fuel); AFFF fire suppression system
	Diesel storage tank failure, underground	Construction/Operations	Negligible	Rare	L25	Regularly tested & inspected; maintenance is documented; low working pressure; fuel tank, bowser & delivery pipe are contained in a bunded area (volume of bund is 1.2 times the maximum volume of stored fuel); AFFF fire suppression system
	Reagent tank failure	Operations	Low	Unlikely	L21	Adequate spill control volume within plant. Regular inspections
	Reagent pipeline failure	Operations	Low	Likely	L19	Adequate spill control volume within plant. Regular inspections
	Slurry tank failure	Operations	Low	Unlikely	L21	Adequate spill control volume within plant. Regular inspections
	Slurry pipeline failure	Operations	Low	Rare	L23	Adequate spill control volume within plant. Regular inspections
	Refuse storage/disposal failure	All	Negligible	Rare	L25	Standard Operating Procedures (SOPs) in place; Waste Management Plan
Leak/spill during road, air or water transport	Transport of fuel/propane crash/collision, off-site	All	Moderate	Rare	L17	The supplier’s management plans would be in place during transport; Environmental Emergency, Spill, and Hazardous Materials Plan; Emergency Response Plan
	Transport of explosives crash/collision, off-site	Construction/Operations	Moderate	Rare	L17	The supplier's management plans would be in place during transport; Environmental Emergency, Spill, and Hazardous Materials Plan; Emergency Response Plan
	Transport of concentrate crash/collision, Mackenzie loadout	Construction/Operations	Low	Unlikely	L21	The contractor's management plans are assumed in place; Environmental Emergency, Spill, and Hazardous Materials Plan; Emergency Response Plan
	Transport of explosives crash/collision, on-site	Construction/Operations	Low	Rare	L23	Appropriate explosives transport vehicles; when on site, will have escort vehicle(s) with hazard lights
	Transport of liquid/solid waste crash/collision, on-site	All	Low	Unlikely	L21	Emergency Response Plan; Air Quality Management Plan; Environmental Emergency, Spill, and Hazardous Materials Plan; Waste Management Plan
	Transport of concentrate crash/collision, on-site	Construction/Operations	Low	Unlikely	L21	Emergency Response Plan; Air Quality Management Plan; Environmental Emergency, Spill, and Hazardous Materials Plan
	Transport of waste rock crash/collision, on-site	All	Low	Unlikely	L21	Emergency Response Plan; Air Quality Management Plan; Environmental Emergency, Spill, and Hazardous Materials Plan
	Aircraft crash	All	Moderate	Rare	L17	Reputable airline adhering to aviation industry maintenance and operating procedures
	Transport of fuel crash/collision, underground	Construction/Operations	Low	Rare	L23	Radio communications; traffic management systems; relatively low vehicle speeds; experienced operators
	Transport of explosives crash/collision, underground	Construction/Operations	Negligible	Rare	L25	Radio communications; traffic management systems; relatively low vehicle speeds; experienced operators
	Transport of liquid/solid waste crash/collision, underground	Construction/Operations	Negligible	Rare	L25	Radio communications; traffic management systems; relatively low vehicle speeds; experienced operators
	Transport of waste rock crash/collision, underground	Construction/Operations	Negligible	Rare	L25	Radio communications; traffic management systems; relatively low vehicle speeds; experienced operators
	Concentrate spill, on-site	Operations	Low	Rare	L23	Environmental Emergency, Spill, and Hazardous Materials Plan
	Transport of process reagents crash/collision, on-site	Operations	Low	Rare	L23	Environmental Emergency, Spill, and Hazardous Materials Plan

Appendix 22-A. Failure Modes with Low Environmental Risk

Failure Mode	Risk Event Description	Phase	Environmental Consequences	Likelihood	Risk Level/Rank	Controls and Applicable Management and Monitoring Plans
Release of contaminant from ore/ waste stockpile	Access tunnel south portal OB stockpile failure	Construction/Operations	Low	Rare	L23	Stockpiles will be developed at shallow slopes for stability and far away from water courses
	Access tunnel south portal waste rock stockpile failure	Construction	Negligible	Rare	L25	Stockpiles will be developed at shallow slopes for stability and far away from water courses
	Triple decline portal (KLV) OB stockpile failure	Construction/Operations	Low	Rare	L23	Stockpiles will be developed at shallow slopes for stability and far away from water courses
	Triple decline portal (KLV) waste rock stockpile failure	Construction	Negligible	Rare	L25	Stockpiles will be developed at shallow slopes for stability and far away from water courses
	Conveyor belt failure	Construction/Operations	Negligible	Unlikely	L24	Adequate FOS for planned duty. Tear detection system
	KLV ore stockpile failure	Construction	Negligible	Rare	L25	Stockpiles will be developed at shallow slopes for stability and far away from water courses
	Process plant ore stockpile failure	Operations	Negligible	Unlikely	L24	Design and SOPs. Established foundations. Pile at angle of repose
	Conveyor belt failure	Operations	Low	Likely	L19	Adequate belt Factor of Safety (FOS) for duty. Regular inspections
Breach/failure of tailings dam or other containment structure	Camp fresh water tank failure, water release	All	Low	Rare	L23	SOPs, inspections and maintenance; Potable water tracking system in place to detect water loss in the system (slow leaks); Emergency Response Plan; Groundwater Monitoring Plan
	Process plant fire water tank failure, water release	Construction/Operations	Low	Rare	L23	Procedural inspections and maintenance; Emergency Response Plan
	Process plant potable water tank failure, water release	Construction/Operations	Low	Rare	L23	Procedural inspections and maintenance; Emergency Response Plan
	Process plant water tank failure, water release	Construction/Operations	Negligible	Rare	L25	Procedural inspections and maintenance; Environmental Emergency, Spill, and Hazardous Materials Plan; Emergency Response Plan; Surface Water Management Plan
	Triple decline bulkhead failure	Closure	Low	Rare	L23	Design and SOPs; Emergency Response Plan
	<i>BXL sediment ponds sediment release</i>	Construction/Operations	Moderate	Rare	L17	Procedural Inspections and pump maintenance; Surface Water Management Plan; Surface Erosion and Sediment Control Plan
	<i>BXL sediment ponds water release</i>	Construction/Operations	Negligible	Expected	L20	Procedural Inspections and pump maintenance; Surface Water Management Plan; Surface Erosion and Sediment Control Plan; Fish and Aquatic Effects Monitoring Plan
	<i>BXL pipeline failure, water release</i>	Construction/Operations	Negligible	Rare	L25	Procedural Inspections; Surface Water Management Plan
	Dump pond 1 sediment release	Construction/Operations	Moderate	Rare	L17	Procedural Inspections and pump maintenance, and Surface Water Management Plan; Surface Erosion and Sediment Control Plan
	Dump pond 1 water release	Construction/Operations	Moderate	Rare	L17	Procedural Inspections and pump maintenance, and Surface Water Management Plan
	Dump pond 1 pipelines failure, water release	Construction/Operations	Negligible	Rare	L25	Procedural Inspections and maintenance, and Surface Water Management Plan
	<i>Dump pond 2 sediment release</i>	Construction/Operations	Negligible	Rare	L25	Procedural Inspections and pump maintenance, and Surface Water Management Plan
	<i>Dump pond 2 water release</i>	Construction/Operations	Negligible	Rare	L25	Procedural Inspections and pump maintenance, and Surface Water Management Plan
	<i>Dump pond 2 pipeline failure, water release</i>	Construction/Operations	Negligible	Rare	L25	Surface Water Management Plan
	<i>Dump pond 4 sediment release</i>	Construction/Operations	Moderate	Rare	L17	Procedural Inspections and pump maintenance, and Surface Water Management Plan
	<i>Dump pond 4 water release</i>	Construction/Operations	Moderate	Rare	L17	Procedural Inspections and pump maintenance, and Surface Water Management Plan
	<i>Dump pond 4 pipeline failure, water release</i>	Construction/Operations	Negligible	Rare	L25	Surface Water Management Plan
	<i>Reduction station pipeline failure, water release</i>	Construction/Operations	Moderate	Rare	L17	Pipeline inspections as per procedure
	Process pond water release	Construction/Operations	Moderate	Rare	L17	Procedural Inspections and pump maintenance, and Surface Water Management Plan
	Process pond pipeline failure, water release	Construction/Operations	Low	Rare	L23	Procedural Inspections and maintenance, and Surface Water Management Plan
	Green pond water release	All	Moderate	Rare	L17	Procedural Inspections and pump maintenance, and Surface Water Management Plan
	KUG Green pond pipeline failure, water release	All	Moderate	Rare	L17	Procedural Inspections and maintenance, and Surface Water Management Plan

Appendix 22-A. Failure Modes with Low Environmental Risk

Failure Mode	Risk Event Description	Phase	Environmental Consequences	Likelihood	Risk Level/Rank	Controls and Applicable Management and Monitoring Plans
Breach/failure of tailings dam or other containment structure (<i>cont'd</i>)	KUG South mill drain system water release	Construction/Operations	Negligible	Unlikely	L24	Surface Water Management Plan
	KUG West mill ditch sediment release	Construction/Operations	Negligible	Rare	L25	Surface Water Management Plan
	West mill ditch water release	Construction/Operations	Negligible	Rare	L25	Surface Water Management Plan
	East mill ditch sediment release	Construction/Operations	Negligible	Rare	L25	Surface Water Management Plan
	East mill ditch water release	Construction/Operations	Negligible	Rare	L25	Surface Water Management Plan
	<i>Land farm drainage water release</i>	Construction/Operations	Negligible	Rare	L25	Surface Water Management Plan
	West side fuel island water release	Construction/Operations	Negligible	Rare	L25	Surface Water Management Plan
	East side fuel island water release	Construction/Operations	Negligible	Rare	L25	Surface Water Management Plan
	North sump sediment release	Construction/Operations	Negligible	Rare	L25	Surface Water Management Plan
	North sump water release	Construction/Operations	Negligible	Rare	L25	Surface Water Management Plan
	North sump pipeline failure, water release	Construction/Operations	Negligible	Rare	L25	Surface Water Management Plan
	<i>Bent Lake ponds sediment release</i>	Construction/Operations	Negligible	Likely	L22	Surface Water Management Plan
	<i>Bent Lake ponds water release</i>	Construction/Operations	Negligible	Likely	L22	Surface Water Management Plan
	<i>Western Collection Ditch sediment release</i>	Construction/Operations	Negligible	Unlikely	L24	Surface Erosion and Sediment Control Management Plan
	<i>Western Collection Ditch water release</i>	Construction/Operations	Negligible	Rare	L25	Surface Erosion and Sediment Control Management Plan; Surface Water Management Plan
	<i>Western Collection Ponds water release</i>	Construction/Operations	Negligible	Rare	L25	Surface Erosion and Sediment Control Management Plan; Surface Water Management Plan
	<i>Southern Collection Ditch sediment release</i>	Construction/Operations	Negligible	Rare	L25	Surface Erosion and Sediment Control Management Plan; Surface Water Management Plan
	<i>Southern Collection Ditch water release</i>	Construction/Operations	Negligible	Rare	L25	Surface Erosion and Sediment Control Management Plan; Surface Water Management Plan
	<i>Southern Collection Pond water release</i>	Construction/Operations	Negligible	Unlikely	L24	Surface Erosion and Sediment Control Management Plan; Surface Water Management Plan
	Selenium Retention Pond pipeline failure, water release	Construction/Operations	Moderate	Rare	L17	Procedural inspections and maintenance; Surface Water Management Plan
	KS Pit to Se-IX plant pipeline failure, water discharge	All	Negligible	Unlikely	L24	Leakage from pipeline would gravity drain back to pit or other containment areas in KS infrastructure
	KS Pit to metals plant pipeline failure, water discharge	All	Negligible	Unlikely	L24	Leakage from pipeline would gravity drain back to pit or other containment areas in KS infrastructure
	Water treatment plant(s) discharge pipeline failure, water discharge	All	Low	Unlikely	L21	Treated water is clean but would still be reported as a spill
	KUG TSF East Dam toe pond sediment release	Operations	Low	Rare	L23	Toe pond is bounded by wide roadway and gravity drains back to pumphouse #1, limiting impounded water volume to small amount.
	KUG TSF East Dam toe pond water release	Operations	Low	Rare	L23	Toe pond is bounded by wide roadway and gravity drains back to pumphouse #1, limiting impounded water volume to small amount
	NAG tailings pipeline failure	Operations	Low	Unlikely	L21	Design and SOPs; Emergency Response Plan; Environmental Emergency, Spill, and Hazardous Materials Plan; Mine Waste, Tailings, and ML/ARD Management Plan
	Pump house #1 pump failure, tails release	Operations	Negligible	Unlikely	L24	Surface Water Management Plans; Design
	KUG TSF reclaim water pipeline failure	Operations	Negligible	Rare	L25	Design and SOPs; Emergency Response Plan; Environmental Emergency, Spill and Hazardous Materials Plan; Mine Waste, Tailings, and ML/ARD Management Plan
	KS Pit to Attichika Creek pipeline failure, water discharge	All	Low	Rare	L23	Adequate design and construction of pipeline; add pipeline protection in areas of higher traffic; monitoring to allow early detection
	Refuse storage/disposal failure	All	Negligible	Rare	L25	SOPs in place; Waste Management Plan

Appendix 22-A. Failure Modes with Low Environmental Risk

Failure Mode	Risk Event Description	Phase	Environmental Consequences	Likelihood	Risk Level/Rank	Controls and Applicable Management and Monitoring Plans
Discharge of off-specification effluent from treatment plant	Se-IX treatment plant off-spec discharge	All	Low	Likely	L19	Process has been piloted on worst-case water including assessment of feed water fluctuations and process upset SOPs; suspend water treatment On-line performance indicators including pH trends of eluate treatment circuit. Retreatment of off-spec eluate. Daily samples of effluent Process interlocks Skilled, trained operators Process design, commissioning and operation conducted by the same party
	Metals treatment plant off-spec discharge	All	Low	Likely	L22	Lab study conducted Online process performance indicators (pH, ORP, turbidity) Interlocks between process indicators and reagent dosing SOPs; suspend water treatment Daily samples of effluent Skilled, trained operators Process design, commissioning and operation conducted by the same party
	Sewage treatment facility failure	All	Moderate	Rare	L17	Design and Procedural inspections and maintenance; Waste Management Plan
	Sewage treatment facility capacity exceeded, off-spec effluent	All	Low	Unlikely	L21	Design and Procedural inspections and maintenance; Waste Management Plan
Sediment release into watercourse, erosion	Borrow pit 10 sediment release	Construction / Operations	Negligible	Likely	L22	Surface Erosion and Sediment Control Plan; Ecosystem Management Plan
	Borrow pit 10 water release	Construction / Operations	Negligible	Likely	L22	Surface Water Management Plan
	East pit quarry sediment release	Construction / Operations	Negligible	Likely	L22	Surface Erosion and Sediment Control Plan; Surface Water Management Plan
	East pit quarry water release	Construction / Operations	Negligible	Likely	L22	Surface Water Management Plan
	Conveyor & access road sediment release	Construction / Operation	Low	Likely	L19	Sediment control plans for Construction and Operations
	Conveyor & access road water release	Construction / Operations	Low	Unlikely	L21	Access road and surface infrastructure protected by ditches and sedimentation ponds
	Access tunnel south portal sediment/water release	Construction / Operations	Negligible	Likely	L22	Portal areas developed primary in bedrock but slopes away to the downstream, no streams nearby, sediment control plans in place
	Access tunnel north portal sediment/water release	Construction / Operations	Negligible	Likely	L22	Portal areas developed primary in bedrock but slopes away to the downstream, no streams nearby, sediment control plans in place
	Triple decline portal sediment/water release	Construction / Operations	Negligible	Likely	L22	Portal areas developed primary in bedrock but slopes away to the downstream, no streams nearby, sediment control plans in place
	KLV laydown area sediment/water release	Construction / Operations	Negligible	Likely	L22	Laydowns and surrounding areas will all drain towards central sedimentation pond to protect against release
	Failure or malfunction of the High Wall Diversion Ditch	All	Low	Likely	L19	Adequate design; regular inspection and maintenance
	<i>BXL sediment ponds sediment release</i>	Construction / Operations	Moderate	Rare	L17	Procedural Inspections and pump maintenance; Surface Water Management Plan; Surface Erosion and Sediment Control Plan
	<i>BXL sediment ponds water release</i>	Construction / Operations	Negligible	Expected	L20	Procedural Inspections and pump maintenance; Surface Water Management Plan; Surface Erosion and Sediment Control Plan; Fish and Aquatic Effects Monitoring Plan
	<i>BXL pipeline failure, water release</i>	Construction / Operations	Negligible	Rare	L25	Procedural Inspections; Surface Water Management Plan

Appendix 22-A. Failure Modes with Low Environmental Risk

Failure Mode	Risk Event Description	Phase	Environmental Consequences	Likelihood	Risk Level/Rank	Controls and Applicable Management and Monitoring Plans
Sediment release into watercourse, erosion (<i>cont'd</i>)	KUG Dump pond 1 sediment release	Construction / Operations	Moderate	Rare	L17	Procedural Inspections and pump maintenance, and Surface Water Management Plan; Surface Erosion and Sediment Control Plan
	Dump pond 1 water release	Construction / Operations	Moderate	Rare	L17	Procedural Inspections and pump maintenance, and Surface Water Management Plan
	Dump pond 1 pipelines failure, water release	Construction / Operations	Negligible	Rare	L25	Procedural Inspections and maintenance, and Surface Water Management Plan;
	<i>Dump pond 2 sediment release</i>	Construction / Operations	Negligible	Rare	L25	Procedural Inspections and pump maintenance, and Surface Water Management Plan;
	<i>Dump pond 2 water release</i>	Construction / Operations	Negligible	Rare	L25	Procedural Inspections and pump maintenance, and Surface Water Management Plan
	<i>Dump pond 2 pipeline failure, water release</i>	Construction / Operations	Negligible	Rare	L25	Surface Water Management Plan
	<i>Dump pond 4 sediment release</i>	Construction / Operations	Moderate	Rare	L17	Procedural Inspections and pump maintenance, and Surface Water Management Plan
	<i>Dump pond 4 water release</i>	Construction / Operations	Moderate	Rare	L17	Procedural Inspections and pump maintenance, and Surface Water Management Plan
	<i>Dump pond 4 pipeline failure, water release</i>	Construction / Operations	Negligible	Rare	L25	Surface Water Management Plan
	<i>Reduction station pipeline failure, water release</i>	Construction / Operations	Moderate	Rare	L17	Pipeline inspections as per procedure
	Process pond water release	Construction / Operations	Moderate	Rare	L17	Procedural Inspections and pump maintenance, and Surface Water Management Plan
	Process pond pipeline failure, water release	Construction / Operations	Low	Rare	L23	Procedural Inspections and maintenance, and Surface Water Management Plan
	Green pond water release	All	Moderate	Rare	L17	Procedural Inspections and pump maintenance, and Surface Water Management Plan
	Green pond pipeline failure, water release	All	Moderate	Rare	L17	Procedural Inspections and maintenance, and Surface Water Management Plan
	South mill drain system water release	Construction / Operations	Negligible	Unlikely	L24	Surface Water Management Plan
	West mill ditch sediment release	Construction / Operations	Negligible	Rare	L25	Surface Water Management Plan
	West mill ditch water release	Construction / Operations	Negligible	Rare	L25	Surface Water Management Plan
	East mill ditch sediment release	Construction / Operations	Negligible	Rare	L25	Surface Water Management Plan
	East mill ditch water release	Construction / Operations	Negligible	Rare	L25	Surface Water Management Plan
	North sump sediment release	Construction / Operations	Negligible	Rare	L25	Surface Water Management Plan
	North sump water release	Construction / Operations	Negligible	Rare	L25	Surface Water Management Plan
	North sump pipeline failure, water release	Construction / Operations	Negligible	Rare	L25	Surface Water Management Plan
	<i>Bent Lake ponds sediment release</i>	Construction / Operations	Negligible	Likely	L22	Surface Water Management Plan

Appendix 22-A. Failure Modes with Low Environmental Risk

Failure Mode	Risk Event Description	Phase	Environmental Consequences	Likelihood	Risk Level/Rank	Controls and Applicable Management and Monitoring Plans
Sediment release into watercourse, erosion (<i>cont'd</i>)	KS Bent Lake ponds water release	Construction / Operations	Negligible	Likely	L22	Surface Water Management Plan
	<i>Western Collection Ditch sediment release</i>	Construction / Operations	Negligible	Unlikely	L24	Surface Erosion and Sediment Control Management Plan
	<i>Western Collection Ditch water release</i>	Construction / Operations	Negligible	Rare	L25	Surface Erosion and Sediment Control Management Plan; Surface Water Management Plan
	<i>Western Collection Ponds water release</i>	Construction / Operations	Negligible	Rare	L25	Surface Erosion and Sediment Control Management Plan; Surface Water Management Plan
	<i>Southern Collection Ditch sediment release</i>	Construction / Operations	Negligible	Rare	L25	Surface Erosion and Sediment Control Management Plan; Surface Water Management Plan
	<i>Southern Collection Ditch water release</i>	Construction / Operations	Negligible	Rare	L25	Surface Erosion and Sediment Control Management Plan; Surface Water Management Plan
	<i>Southern Collection Pond water release</i>	Construction / Operations	Negligible	Unlikely	L24	Surface Erosion and Sediment Control Management Plan; Surface Water Management Plan
	Selenium Retention Pond pipeline failure, water release	Construction / Operations	Moderate	Rare	L17	Procedural inspections and maintenance; Surface Water Management Plan
	KS Pit to Se-IX plant pipeline failure, water discharge	All	Negligible	Unlikely	L24	Leakage from pipeline would gravity drain back to pit or other containment areas in KS infrastructure
	KS Pit to metals plant pipeline failure, water discharge	All	Negligible	Unlikely	L24	Leakage from pipeline would gravity drain back to pit or other containment areas in KS infrastructure
	Water treatment plant(s) discharge pipeline failure, water discharge	All	Low	Unlikely	L21	Treated water is clean but would still be reported as a spill
	KUG TSF East Dam toe pond sediment release	Operations	Low	Rare	L23	Toe pond is bounded by wide roadway and gravity drains back to pumphouse #1, limiting impounded water volume to small amount
	KUG TSF East Dam toe pond water release	Operations	Low	Rare	L23	Toe pond is bounded by wide roadway and gravity drains back to pumphouse #1, limiting impounded water volume to small amount
	KUG TSF spillway failure, sediment release	Construction / Operations	Negligible	Rare	L25	Spillway is armored to protect against erosion under IDF with sill founded in bedrock
	KUG TSF spillway failure, water release	All	Negligible	Rare	L25	Spillway is meant to release water and is armored to protect against erosion under IDF with sill founded in bedrock such that failure leading to release of additional pond is extremely rare
	Pump house #1 pump failure, tails release	Operations	Negligible	Unlikely	L24	Surface Water Management Plans; Design
Construction or operation of underground facilities	KUG TSF reclaim water pipeline failure	Operations	Negligible	Rare	L25	Design and SOPs; Emergency Response Plan; Environmental Emergency, Spill, and Hazardous Materials Plan; Mine Waste, Tailings, and ML/ ARD Management Plan
	KS Pit to Attichika Creek pipeline failure, water discharge	All	Low	Rare	L23	Adequate design and construction of pipeline; add pipeline protection in areas of higher traffic; monitoring to allow early detection
	Access tunnel ventilation failure	All	Negligible	Likely	L22	Regular fan maintenance. Employee training for awareness
	Access tunnel blasting fumes/ gassing	Construction	Negligible	Rare	L25	Re-entry procedures, including gas testing. Adequate ventilation
	Access tunnel mobile equipment excess emissions	All	Negligible	Rare	L25	Vehicle maintenance procedures followed. Emissions checks as per procedure
	KUG workings ventilation failure	Construction / Operations	Negligible	Likely	L22	Regular fan maintenance. Employee training for awareness. Refuge stations & emergency egress procedure
	KUG workings blasting fumes/ gassing	Construction / Operations	Negligible	Unlikely	L24	Re-entry procedures, including gas testing. Adequate ventilation

Appendix 22-A. Failure Modes with Low Environmental Risk

Failure Mode	Risk Event Description	Phase	Environmental Consequences	Likelihood	Risk Level/Rank	Controls and Applicable Management and Monitoring Plans
Construction or operation of underground facilities <i>(cont'd)</i>	KUG workings mobile equipment excess emissions	Construction / Operations	Negligible	Rare	L25	Regularly tested and inspected; maintenance is documented; modern mining equipment using low sulphur fuel in low-emission diesel engines; underground equipment will be tested regularly for emission levels
	Drawpoint dust control failure	Operations	Negligible	Rare	L25	Operators in air-conditioned, sound-suppressed cabin; primary ventilation system will draw the air to the return airway
	Ore/waste pass dust control failure	Construction / Operations	Negligible	Rare	L25	Operators in air-conditioned, sound-suppressed cabin; primary ventilation system will draw the air to the return airway
	Truck chute dust control failure	Construction / Operations	Negligible	Rare	L25	Operators in air-conditioned, sound-suppressed cabin; primary ventilation system will draw the air to the return airway
	Crusher dust control failure	Operations	Negligible	Rare	L25	Operators in air-conditioned, sound-suppressed cabin; primary ventilation system will draw the air to the return airway
Fires or explosions	KUG Electrical transformers, KS workings, fire	All	Negligible	Unlikely	L24	Apply transformer protection systems and fire separation distances and barriers according to best IEEE and FM-Global practices
	Electrical transformers, KLV, fire	Construction / Operations	Negligible	Rare	L25	Apply transformer protection systems and fire separation distances and barriers according to best IEEE and FM-Global practices
	Electrical powerline/cable arcing, off-site, causing bush fire	All	Moderate	Rare	L17	With adequate vegetation management, this likelihood could be lowered to "rare", but if the present vegetation levels are allowed to increase, the likelihood would go up to "likely"
	Electrical powerline/cable current leak, off-site, electric shock	All	Negligible	Rare	L25	Continue with routine preventative maintenance, inspections, and vegetation management to keep this risk low
	Kemess site propane tank fire/explosion	All	Moderate	Rare	L17	Environmental Emergency, Spill, and Hazardous Materials Plan
	KLV propane tank fire/explosion	Construction / Operations	Low	Rare	L23	Propane safeguards in place, propane should burn up quickly
	Explosives surface magazine storage fire/explosion	Construction / Operations	Moderate	Rare	L17	Explosives Management Plan
	Explosives accessories surface magazine storage fire/explosion	Construction / Operations	Moderate	Rare	L17	Explosives Management Plan
	Conveyor belt fire	Construction / Operations	Negligible	Rare	L25	Fire detection & suppression systems. Fire resistant belt
	Mobile equipment fire, off-site	All	Negligible	Rare	L25	On- board fire suppression. Proper vehicle maintenance.
	Transport of fuel/propane crash/collision, off-site	All	Moderate	Rare	L17	The seller's management plans would be in place during transport; Environmental Emergency, Spill, and Hazardous Materials Plan; Emergency Response Plan;
	Transport of explosives crash/collision, off-site	Construction / Operations	Moderate	Rare	L17	The seller's management plans would be in place during transport; Environmental Emergency, Spill, and Hazardous Materials Plan; Emergency Response Plan
	Mobile equipment fire, on-site	All	Negligible	Unlikely	L24	Emergency Response Plan; Air Quality Management Plan; Environmental Emergency, Spill, and Hazardous Materials Plan
	Transport of explosives crash/collision, on-site	Construction / Operations	Low	Rare	L23	Appropriate explosives transport vehicles; when on site, will have escort vehicle(s) with hazard lights
	Transport of liquid/solid waste crash/collision, on-site	All	Low	Unlikely	L21	Emergency Response Plan; Air Quality Management Plan; Environmental Emergency, Spill, and Hazardous Materials Plan; Waste Management Plan
	Transport of concentrate crash/collision, on-site	Construction / Operations	Low	Unlikely	L21	Emergency Response Plan; Air Quality Management Plan; Environmental Emergency, Spill, and Hazardous Materials Plan
	Transport of waste rock crash/collision, on-site	All	Low	Unlikely	L21	Emergency Response Plan; Air Quality Management Plan; Environmental Emergency, Spill, and Hazardous Materials Plan
	Aircraft crash	All	Moderate	Rare	L17	Reputable airline adhering to aviation industry maintenance and operating procedures

Appendix 22-A. Failure Modes with Low Environmental Risk

Failure Mode	Risk Event Description	Phase	Environmental Consequences	Likelihood	Risk Level/Rank	Controls and Applicable Management and Monitoring Plans
Fires or explosions (<i>cont'd</i>)	Explosives transport, underground, fire/explosion	Construction / Operations	Low	Rare	L23	Emulsion explosives will be transported as two inert parts; other explosives will be transported in secure containers; transport vehicles will have warning/hazard lights
	Explosives underground magazine storage fire/explosion	Construction / Operations	Low	Rare	L23	Secure location; restricted access; fire suppression systems; direct connection to return airways
	Explosives accessories underground magazine storage fire/explosion	Construction / Operations	Low	Rare	L23	Secure location; restricted access; fire suppression systems; direct connection to return airways
	Explosives charging, underground, fire/explosion	Construction / Operations	Low	Rare	L23	Operator training; safe work procedures; equipment is designed for this activity
	Compressor failure	Construction / Operations	Negligible	Rare	L25	Compressor (and air receiver) is regularly tested and inspected; maintenance is documented
	Electrical equipment fire/explosion	Construction / Operations	Negligible	Rare	L25	Follow IEEE and CSA-M421 best practices for electrical design and protection systems. Follow NETA standards for preventative maintenance. Use only dry-type (not oil-filled) transformers underground
	Mobile equipment fire, underground	Construction / Operations	Negligible	Rare	L25	Equipment regularly tested & inspected; maintenance is documented; AFFF fire suppression system; operator training
	Transport of fuel crash/collision, underground	Construction / Operations	Low	Rare	L23	Radio communications; traffic management systems; relatively low vehicle speeds; experienced operators
	Transport of explosives crash/collision, underground	Construction / Operations	Negligible	Rare	L25	Radio communications; traffic management systems; relatively low vehicle speeds; experienced operators
	Transport of liquid/solid waste crash/collision, underground	Construction / Operations	Negligible	Rare	L25	Radio communications; traffic management systems; relatively low vehicle speeds; experienced operators
	Transport of waste rock crash/collision, underground	Construction / Operations	Negligible	Rare	L25	Radio communications; traffic management systems; relatively low vehicle speeds; experienced operators
	Conveyor belt fire	Construction / Operations	Low	Unlikely	L21	Fire detection and suppression system. Operator awareness
	Electrical equipment fire/explosion	All	Negligible	Rare	L25	Follow IEEE and CSA-M421 best practices for electrical design and protection systems. Follow FM Global requirements for fire-ratings and separations of electrical equipment
	Pressure vessel failure (compressor air receivers)	Construction / Operations	Low	Rare	L23	Limited access. Pressure monitoring. Regular inspections
	Transport of process reagents crash/collision, on-site	Operations	Low	Rare	L23	Environmental Emergency, Spill, and Hazardous Materials Plan
Waste rock dump or stockpile failure	Access tunnel south portal OB stockpile failure	Construction / Operations	Low	Rare	L23	Stockpiles will be developed at shallow slopes for stability and far away from water courses
	Access tunnel south portal waste rock stockpile failure	Construction	Negligible	Rare	L25	Stockpiles will be developed at shallow slopes for stability and far away from water courses
	Triple decline portal (KLV) OB stockpile failure	Construction / Operations	Low	Rare	L23	Stockpiles will be developed at shallow slopes for stability and far away from water courses
	Triple decline portal (KLV) waste rock stockpile failure	Construction	Negligible	Rare	L25	Stockpiles will be developed at shallow slopes for stability and far away from water courses
	<i>OB #1 stockpile failure</i>	All	Low	Unlikely	L21	Environmental Emergency, Spill and Hazardous Materials Plan; Emergency Response Plan; Soil Handling Management Plan
	<i>OB #4 stockpile failure</i>	All	Low	Rare	L23	Environmental Emergency, Spill and Hazardous Materials Plan; Emergency Response Plan; Soil Handling Management Plan
	<i>OB #5 stockpile failure</i>	All	Low	Rare	L23	Environmental Emergency, Spill and Hazardous Materials Plan; Emergency Response Plan; Soil Handling Management Plan

Appendix 22-A. Failure Modes with Low Environmental Risk

Failure Mode	Risk Event Description	Phase	Environmental Consequences	Likelihood	Risk Level/Rank	Controls and Applicable Management and Monitoring Plans
Inrush/inundation to underground mine	Access tunnel water inundation	All	Negligible	Unlikely	L24	Tunnel rock is tight, if more permeable zone encountered, ground support will be modified, all tunnel runoff will report to the KLV sediment pond and be pumped back to open pit
	KUG workings water inundation	Construction / Operations	Negligible	Unlikely	L24	All boreholes grouted where possible; mine planning approval procedure ensure that all planned development is cross-checked against borehole database prior to approving the development, so that appropriate precautionary measure can be taken. Reconcile water inflow to cave to pumping volumes.
	KUG workings mud rush inundation	Operations	Negligible	Likely	L22	Cave monitoring; ground water monitoring & management; rainfall monitoring; use of remote controlled equipment’s during periods when risk of mud rush is elevated
Air blast in underground mine	KUG workings air blast	Operations	Negligible	Unlikely	L24	Cave monitoring systems to help estimate the gap between the top of the cave and the rock mass; cave management systems to ensure the cave is not overdrawn to the extent that air blast become a risk; pre-conditioning
Fly rock from blasting	East pit quarry flyrock	Construction / Operations	Negligible	Likely	L22	SOPs; Explosives Management Plan
	Access tunnel south portal flyrock	Construction	Negligible	Likely	L22	Flyrock likely during initial portal development but safe blasting procedures will be in place
	Access tunnel north portal flyrock	Construction	Negligible	Likely	L22	Flyrock likely during initial portal development but safe blasting procedures will be in place
	Triple decline portal flyrock	Construction	Negligible	Likely	L22	Flyrock likely during initial portal development but safe blasting procedures will be in place
	Access tunnel flyrock	Construction	Negligible	Rare	L25	Flyrock to be controlled by safe blasting procedures. Blasts within tunnel, no personnel present
	KUG workings flyrock	Construction / Operations	Negligible	Rare	L25	Management system in pace to ensure personnel are not directly exposed to blasting; as a minimum, all personnel will be required to use a manual tagging system; modern electronic tagging systems may be implemented
Ground instability or failure	Borrow pit 10 wall/slope failure	All	Negligible	Unlikely	L24	Slope design based on geotechnical evaluation. Operating history
	East pit quarry wall/slope failure	All	Negligible	Unlikely	L24	Slope design based on geotechnical evaluation. Operating history
	KUG TSF (KS Pit) wall failure	All	Low	Unlikely	Low	Wall failure during dewatering has higher likelihood or during operations when water level increases. Could generate wave against dam or spillway. Dam protected by additional wave run-up freeboard and spillway sized to consider landslide generated waves.
	Access tunnel south portal wall/slope failure	All	Negligible	Rare	L25	Portal slopes designed with good FOS to applicable standards with ground support
	Access tunnel north portal wall/slope failure	All	Negligible	Rare	L25	Portal slopes designed with good FOS to applicable standards with ground support
	Triple decline portal wall/slope failure	All	Negligible	Rare	L25	Portal slopes designed with good FOS to applicable standards with ground support
	KLV laydown area wall/slope failure	All	Negligible	Rare	L25	Laydown cut/fill slopes will be developed at shallow slopes for stability and far away from water courses
	Access tunnel rock mass instability	Construction / Operations	Negligible	Rare	L25	Tunnel designed to applicable standards with ground support
	KUG workings rock mass instability	Operations	Negligible	Unlikely	L24	Geotechnical evaluations; ground support management plan; ground support installed & monitored; regular, documented check scaling program; remedial ground support installed as required; remote controlled equipment used in areas considered to be high risk
	KUG cave subsidence beyond planned zone	Operations	Negligible	Unlikely	L24	The extent of the subsidence zone will be estimated using various methods; buffer zone; access to this area will be restricted/managed

Italics = KS infrastructure only