

**APPENDIX 35-A  
FAILURE MODE & EFFECTS ANALYSIS (FMEA)  
SUMMARY TABLE FOR OCTOBER 2009 WORKSHOP**

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**Appendix 35-A. Failure Mode & Effects Analysis (FMEA) Summary Table for October 2009 Workshop**

COMPONENT	ID	FAILURE MODE	EFFECTS	PERIOD of INTEREST	LIKELIHOOD	CONSEQUENCES					LEVEL OF CONFIDENCE	HIGH CONCERN ISSUE	MITIGATION/ COMMENTS	OPPORTUNITIES
						COSTS	BIOLOGICAL IMPACT	REGULATORY IMPACT	PUBLIC CONCERNS	HEALTH & SAFETY				
<b>TAILINGS DAM</b>	<b>A</b>													
<b>Embankments</b>	A.1													
	A.1.1	Weak layer foundation failure	Breaching failure, discharge of tailings to Teigen Ck or Treaty Ck, runoff to Bell-Irving River, with erosion of solids further downstream	O	NL	E	E	E	E	H	H		Engineered to good practice.	
	A.1.2	liquefaction of foundation Central Dam	Breaching failure, discharge of tailings to Treaty Ck, runoff to Bell-Irving River, with erosion of solids further downstream	O, PC	L	E	E	E	E	H	L	M	site investigations - if liquefiable soils identified, remove soils, or move dam location.	
	A.1.3	Foundation piping failure	Breaching failure, discharge of tailings to Teigen Ck or Treaty Ck, runoff to Bell-Irving River, with erosion of solids further downstream	O, PC	NL	E	E	E	E	H	M			
	A.1.4	Embankment slip failure	Loss of freeboard, leading to breaching failure, discharge of tailings to Teigen Ck or Treaty Ck, runoff to Bell-Irving River, with erosion of solids further downstream	O, PC	NL	E	E	E	E	H	M			
	A.1.5	Embankment piping failure	deformation leading to differentials settlement cracks core and pipes, and then excessive seepage	O, PC	M	M	L	L	L	N	H			
	A.1.6	Erosion of downstream face leading to breaching	Breaching failure, discharge of tailings to Teigen Ck or Treaty Ck, runoff to Bell-Irving River, with erosion of solids further downstream	PC	NL	E	E	E	E	H	H		Assumes continuous monitoring care and maintenance. Design to minimize erosion during peak events. Degradation would be slow, allowing opportunity to respond.	
	A.1.7	Drain blockage due to sulphate and hydroxide precipitates	Long term efficiency required. Precipitation raises phreatic surface and instability. Stabilization measures required.	PC	NL	M	N	L	L	N	H		Assumes long term care and maintenance with phreatic surface monitoring using piezometers. Stabilization berms installed if required.	
	A.1.8	Excessive seepage	Degrading water quality at Teigen or Treaty Ck	O	L	M	M	M	M	N	L		Interception wells, pump back to TMF	
	A.1.9	Excessive seepage	Degrading water quality at Teigen or Treaty Ck	PC	H	M	L	M	M	N	L	M	Interception wells and treatment	
	A.1.10	Excessive seepage	Seepage can not be released to environment without treatment.	PC	H	M	L	M	M	N	L	M	Treatment of seepage prior to release to streams	
	A.1.11	Flood overtopping	Water in excess of design events, settlement with time, avalanche wave, landslide wave. Dynamic breaching failure, discharge of tailings to Teigen Ck or Treaty Ck, runoff to Bell-Irving River, with erosion of solids further downstream.	O, PC	L	E	E	E	E	H	M	M	Designed with freeboard and tailings beach to accommodate PMF and flood waves.	
	A.1.12	Seismic induced downstream slip failure	Either slip displacement or liquefaction of saturated base layer causes Breaching failure, discharge of tailings to Teigen Ck, runoff to Bell-Irving River, with erosion of solids further downstream.	O	NL	E	E	E	E	H	H		Designed to MCE / 10,000 yr event, sand compacted to be non-liquefiable, dam under-drained to maintain low phreatic surface. Requires adequate QA/QC on sand compaction during operations. Install piezometers to monitor phreatic surface and drain performance. Seismic hazard assessment.	

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	A.1.13	Seismic induced downstream slip failure	Either slip displacement or liquefaction of saturated base layer causes Breaching failure, discharge of tailings to Teigen Ck, runoff to Bell-Irving River, with erosion of solids further downstream.	PC	L	E	E	E	E	H	H		Designed to MCE / 10,000 yr event, sand compacted to be non-liquefiable, dam under-drained to maintain low phreatic surface. Requires adequate QA/QC on sand compaction during operations. Install piezometers to monitor phreatic surface and drain performance. Seismic hazard assessment.	
	A.1.14	Seismic induced upstream slip failure	Slumping of dam core. Repairs required.	O	M	L	N	L	L	N	M		Failure of crest can not allow overtopping of dam.	
	A.1.15	Crest tailings line failure	Erosion issue leads to release off site	O	M	L	M	M	M	N	M			
	A.1.16	Operational Error	Erosion issue leads to release off site	O	M	L	M	M	M	N	M			
	A.1.17	Sabotage and Vandalism	Erosion issue leads to release off site	O	L	L	M	M	M	N	M			
	A.1.18	ML/ARD in downstream shell	0.1% sulphides in tailings oxidize and leachates exceed water quality guidelines	PC	M	M	L	M	M	N	L	M	Additional evaluation of ML/ARD on tailings	
	A.1.19	Excessive beach ARD (rougher tails)	Degrades pond water quality.	PC	M	M	L	M	L	N	L	M	Additional evaluation of ML/ARD on tailings. Cover beaches to reduce loading rates	
	A.1.20	Exposed sulfide pyrite tails at closure	Degrades pond water quality.	PC	L	M	L	M	L	N	L		Treatment, or flood waste or dry cover? Monitoring will be undertaken as part of closure long term	
	A.1.21	Water balance out (too much water)	Excess water leads to discharge, storage or increased treatment needs	O	M	H	L	M	M	N	M	M	Assumes discharge permit, though may require amendments.	
	A.1.22	Diversion efficiency less than estimated	Excess water leads to discharge, storage or increased treatment needs	O	M	H	L	M	M	N	M	M	Assumes discharge permit, though may require amendments.	
	A.1.23	Debris flow Central Dam impacts	Significant dam erosion, requires repair.	O, PC	M	L	L	M	L	L	L		relocate dam and reduce problem	
	A.1.24	excessive dusting	dusting of tailings on downstream environment.	O	H	M	M	M	M	M	H	M	Re-evaluate dust control methods	
	A.1.25	volcanic activity	minor dust accumulations	O, PC	NL	N	N	N	N	N	H			
<b>Coffer Dam</b>	A.2													
	A.2.1	Slip Failure	slip failure leads to breach	C	L	M	M	H	H	H	L			
	A.2.2	Piping Failure	piping failure leads to breach	C	L	M	M	H	H	H	L			
	A.2.3	Overtopping	overtop by exceeding design event leads to breach	C	M	M	M	H	H	H	L	M		
<b>Center (Saddle) Dam (if flooded)</b>	A.3													
	A.3.1	Flooding results in higher phreatic surface	Breaching failure leads to overtopping of South Dam.	O	L	E	E	E	E	H	M	M	Discharge tailings in south impoundment to buttress toe of central dam.	
<b>WASTE ROCK</b>	B													
<b>Slope Failure (McTagg), No downslope risk to people/infrastructure (dump height &gt; 300 m)</b>	B.1													
	B.1.1	Shallow (Sliver)	Availability of dump faces is limited, affects production schedule. Potential loss of equipment.	O	E	E	N	M	L	M	H	H	Operational monitoring, management plans/procedures, multiple dump headings	
	B.1.2	Deep, circular in dump	Large volume failure, could result in loss of truck. Repairs to the dump required to ensure stability.	O	M	M	N	M	L	H	H	M	Multiple dumps, crest dumping	
	B.1.3	Boulder Runout	Boulders run into valley	O	E	N	N	N	N	N	H		Exclusion zone	
	B.1.4	Foundation	Large volume failure, could result in loss of truck. Repairs to the dump required to ensure stability.	O	L	M	N	M	L	H	H		Foundation interface stronger than dump material. Avoid or remove areas of weak surficial materials. Primary risk during establishment of dump.	
	B.1.5	Seismic Loads	Seismic event induces sliver or deep seated failure.	O	L	L	N	M	L	H	M			

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						COSTS	BIOLOGICAL IMPACT	REGULATORY IMPACT	PUBLIC CONCERNS	HEALTH & SAFETY					
Slope Failures (Mitchell, Sulphurets), with downslope risk to crusher, tunnel portal, treatment plant, personnel. (dump height < 300 m)	B.2														
	B.2.1	Shallow (Sliver)	Availability of dump faces is limited, affects production schedule. Potential loss of equipment.	O	E	L	N	M	L	L	H	M	slope base impact berm, multiple dumps, more stringent dump operating practices.		
	B.2.2	Deep, circular within dump material	Large volume failure, could result in loss of truck. Potential to overtop impact berm. Repairs to the dump required to ensure stability.	O	H	L	L	M	M	M	M	M	slope base impact berm, multiple dumps, decrease lift heights if necessary (e.g., 150 m), more stringent dump operating practices.		
	B.2.3	Boulder Runout and overtop impact barrier	Boulders run into valley, and across road and impact development.	O	M	N	N	M	L	H	M	H	Impact barriers, laybacks		
	B.2.4	Foundation	Large volume failure, could result in loss of truck. Potential to overtop impact berm. Repairs to the dump required to ensure stability. May impact site access. Impacts to production scheduling.	O	M	E	L	H	M	M	M	M	M	Placement strategy, limited initial lift heights and loading rates, monitoring, laybacks	
	B.2.5	Seismic loads	Seismic event induces sliver or deep seated failure.	O	L	L	L	M	M	M	M	M	M	Small areas with potential for liquefaction to be avoided or designed around.	
	B.3	Snow avalanche	Impacts to personnel, equipment or infrastructure	C, O	L	H	L	M	L	M	M	M	Avalanche monitoring program is in place. Consider control structures in initiation zones.		
	B4	Emission of toxic gas from waste rock dumps due to temperature differential external to internal	Potential for accumulation areas of toxic gas leading to fatalities	O, PC	L	L	L	M	L	E	L	L	Safe Confined Space Work Practices, respirable air quality monitoring		
<b>WATER MANAGEMENT</b>	<b>C</b>														
<b>Diversion Features</b>	<b>C.1</b>														
	C.1.1	Event in excess of design flow at Mitchell tunnel	Excess water to manage, bypassing pit to water treatment pond.	O	H	L	N	L	N	N	L	L	Water routed around pit into treatment pond via emergency pit diversion. Maintain surge capacity in treatment pond.		
	C.1.2	Event in excess of design flow at Mitchell tunnel	Excess water to pit and through water treatment pond.	PC	E	L	N	L	N	N	L	H	Maintain pit lake level to allow surge capacity.		
	C.1.3	Mitchell tunnel failure or inlet blockage	Excess water to manage, bypassing pit to water treatment pond.	O	L	M	M	M	L	L	L	L	Water routed around pit into treatment pond via emergency pit diversion.		
	C.1.4	Mitchell tunnel failure or inlet blockage	Excess water to manage, bypassing pit and water treatment pond.	PC	H	M	M	M	L	L	L	H			
	C.1.5	Event in excess of design flow at McTagg Tunnel	Excess water to manage, increased water treatment requirements	O	H	L	N	L	N	N	L	L			
	C.1.6	Event in excess of design flow at McTagg Tunnel	Excess water to manage, increased water treatment requirements	PC	E	L	N	L	N	N	L	H			
	C.1.7	McTagg tunnel failure or inlet blockage	Excess water to manage, increased water treatment requirements	O	L	M	M	M	L	L	L	L			
	C.1.8	McTagg tunnel failure or inlet blockage	Excess water to manage, increased water treatment requirements	PC	H	M	M	M	L	L	L	H			
	C.1.9	Water treatment pond perimeter diversions blocked by landslide/avalanche or ice accumulation	Excess water to manage, increased water treatment requirements	O, PC	E	M	N	M	M	N	L	H	Surge capacity in water treatment pond		

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	C.1.10	Water treatment pond perimeter diversions blocked by landslide/avalanche or ice accumulation	Injury during ice removal and maintenance	O, PC	H					E	L	H		
	C.1.11	Failure of pond diversion channel capacity (storms)	Excess water to manage, increased water treatment requirements	O, PC	E	M	N	M	M	N	L	H		Surge capacity in water treatment pond. Fuse plugs in ditch to avoid long term repair.
<b>Water Treatment Dam</b>	C.2													
	C.2.1	Overtopping due to flood wave	Release of contaminants, dam repair	O, PC	M	H	H	H	H	M	L	H		Site assessment and design evaluation of wave potential.
	C.2.2	Piping failure of dam	Dam breach	O, PC	N	E	E	E	E	H	M			Site investigation
	C.2.3	Foundation/dam failure	Dam breach	O, PC	N	E	E	E	E	H	M			Site investigation
	C.2.4	Seepage bypasses collection	Aquatic degradation downstream	O, PC	L	H	H	H	H	N	L	M		Monitoring, grouting
	C.2.5	Spillway blockage (trees, ice)	Dam breach	O	N	E	E	E	E	H	M			Monitoring and maintenance
	C.2.5	Spillway blockage (trees, ice)	Dam breach	PC	M	E	E	E	E	H	M	M		Monitoring and maintenance. Spillway design
	C.2.6	Storage loss due to sediment or sludge	Loss of storage - potential need to raise dam	O, PC	M	M	L	L	L	N	M			Sediment ponds downstream of McTagg dump
<b>Water Treatment Plant</b>	C.3													
	C.3.1	Process failure	cannot meet WQ criteria, potential need to release water if insufficient storage	O, PC	M	H	M	M	M	N	L	H		Pilot plant of treatment process, ML/ARD studies
	C.3.2	Flow rate increases substantially above design	Treatment efficiency decreases, may not meet WQ criteria. Need to expand plant capacity	O, PC	E	H	M	M	M	N	M	H		Design overcapacity
	C.3.3	Mechanical or electrical failure at critical time	cannot meet WQ criteria, potential need to release water if insufficient storage	O, PC	H	L	M	M	M	N	M	M		
	C.3.4	Collection pipe breaks	Spill of untreated water en route to treatment pond from Sulphurets and Kerr.	O, PC	E	L	M	M	M	N	M	M		Assumes buried HDPE pipe. Potential for high head, may require energy dissipation. Spill management and response plans. Inspection and maintenance.
<b>Sludge</b>	C.4													
	C.4.1	Break of sludge pipeline from water treatment plant to crushing facility	On site spillage of sludge, requires clean up.	O	H	L	L	M	L	N	M	M		Inspection and maintenance, spill management plan.
	C.4.2	Break of sludge pipeline from water treatment plant to pit lake	On site spillage of sludge, requires clean up.	PC	E	L	L	M	L	N	M	M		Inspection and maintenance, spill management plan.
<b>Closure</b>	C.5													
	C.5.1	NAG not economically available for cover	Borrow cover materials, reduced cover effectiveness, increased water treatment	PC	M	H	L	M	L	N	M	M		
	C.5.2	Not enough low conductivity moraine/till material	Borrow cover materials, reduced cover effectiveness, increased water treatment	PC	H	H	L	M	L	N	M	H		
	C.5.3	Slope failure due to geochemical degradation	Slumps, cover displaced, requires repairs	PC	L	M	M	M	L	N	M			Inspection and repairs as necessary
	C.5.4	Seismic deformation	Slumps, cover displaced, requires repairs	PC	L	M	M	M	L	N	M			Inspection and repairs as necessary
	C.5.5	Cover erosion	Increased water treatment	PC	E	M	L	L	L	N	M	M		Inspection and repairs to cover as necessary
	C.5.6	Blockage of closure spillway on north side of Mitchell valley	Temporary ponding, potential WQ upset	PC	E	M	M	M	M	N	L	M		Assumes tunnels are still in place. Inspection and repairs as necessary

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	C.5.7	Piping failure of closure dam between pit and waste rock dump	Increase water treatment volumes	PC	L	H	H	H	M	H	M			
<b>ACCESS ROADS</b>	D													
<b>Access Roads</b>	D.1													
	D.1.1	Avalanche	Temporary road closure, sedimentation	O, PC	E	L	L	L	L	L	H	M	Assumes avalanche monitoring and control. Additional mitigation includes snow sheds.	
	D.1.2	Avalanche	Avalanche resulting in injury or loss of life, and contamination.	O, PC	L	M	M	L	L	H	H		Assumes avalanche monitoring, control, road closures	
	D.1.3	Geohazards	Temporary road closure, sediment transport, fisheries impacts	C, O, PC	E	L	M	M	L	L	M	H	Geohazard assessments	
	D.1.4	Geohazards	Geohazard resulting in injury or loss of life, and contamination.	C, O, PC	L	L	M	M	L	H	M		Geohazard assessments	
	D.1.5	Road slope failure	Temporary road closure, sediment transport, loss of life if road fails under a vehicle or if vehicle fails to stop at failure site	C	H	L	M	H	M	M	M	H	Detailed evaluation of cut/fill slopes. Assume short initial period of instability during construction	
	D.1.6	Road slope failure	Temporary road closure, sediment transport, loss of life if road fails under a vehicle or if vehicle fails to stop at failure site	O, PC	L	L	M	H	M	M	M		Detailed evaluation of cut/fill slopes. Ongoing monitoring	
	D.1.7	Drainage structures	Culverts plug or wash out, resulting in road closure, sedimentation, fisheries impacts	O, PC	L	L	M	M	L	L	H		Regular maintenance and inspection	
	D.1.8	Higher number of closures due to weather than expected	Increased costs, scheduling challenges, health and safety	C, O	M	L	N	N	N	M	H		Controlled access, monitoring and inspection, radio communication	
	D.1.9	Chemical/reagent spillage (including cyanide)	Contamination, fisheries impacts	C, O	M	L	H	H	H	L	H	M	Hazardous goods management and emergency/spill response plans and procedures	
	D.1.10	Fuel spill during transport	Contamination, fisheries impacts	C, O	M	L	H	H	H	L	H	M	Hydrocarbon management and emergency/spill response plans and procedures	
	D.1.11	Concentrate spillage during transport	Contamination, fisheries impacts	O	M	L	M	M	M	L	H		Concentrate handling and emergency/spill response plans and procedures	
	D.1.12	Wildlife collisions	Impact to wildlife populations, equipment damage, potential for injury	C, O	H	L	M	M	L	M	H	M	Wildlife management plans	
<b>Bridges</b>	D.2													
	D.2.1.1	Flooding	Temporary road closure, sedimentation, reduced safety	C, O	L	L	L	M	M	L	H		Assumes bridges designed and constructed to handle 100 year return period flows.	
	D.2.1.2	Flooding	Temporary road closure, sedimentation, reduced safety	PC	M	L	L	M	M	L	H		Assumes bridges designed and constructed to handle 100 year return period flows.	
	D.2.2.1	Scour	Abutments damaged, reduced safety	C, O	L	L	L	M	M	N	H		Bridges constructed to handle 100 year return period flows, inspected and maintained	
	D.2.2.2	Scour	Abutments damaged, reduced safety	PC	M	L	L	M	M	L	H		Bridges constructed to handle 100 year return period flows, inspected and maintained	
	D.2.3.1	Structural Damage	Bridge requires repairs, road closure, safety reduced	C, O	L	L	L	M	M	N	H		Bridges constructed to handle 100 year return period flows, inspected and maintained	
	D.2.3.2	Structural Damage	Bridge requires repairs, road closure, safety reduced	PC	M	L	L	M	M	L	H		Bridges constructed to handle 100 year return period flows, inspected and maintained	
<b>Glacier Route</b>	D.3													
	D.3.1	Avalanche	Temporary closure of route until safety assured and route cleared, safety reduced in interim	C	M	L	L	L	L	M	H		Assumes continuous avalanche monitoring and control	
	D.3.2	Geohazards	Temporary closure of route until safety assured and route cleared, safety reduced in interim	C	M	L	N	N	N	M	H		Assumes prior geohazard survey and appropriate mitigation	
	D.3.3	Unexpected crevasses and voids along road route	Damage to vehicle/load, potential for injury and spillage	C	L	L	M	M	M	M	H		Assumed GPR Surveys ahead of construction, and regularly through haul period	

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	D.3.4	Spillage	Costs, contamination	C	L	M	L	M	M	N	H		Hazardous materials management plan, hydrocarbon management plan, emergency/spill response plans and procedures	
	D.3.5	Stream crossing washout or collapse	Temporary closure, safety compromised	C	L	M	M	M	N	M	L		Design consistent with Fish Stream Crossing Guidebook. Ongoing monitoring and inspection. Emergency response plan.	
	D.3.6	Lack of snow for fill	No road, project delayed for a year or far greater reliance on helicopter support	C	L	H	N	M	N	N	H		Backup alternative is use of large helicopters to deliver construction machinery and supplies	
	D.3.7	Higher number of weather-related closures than expected	Increased costs, scheduling challenges, health and safety	C	H	M	N	L	N	M	M		Vehicles follow GPS route, avalanche monitoring and control	
<b>TUNNEL</b>														
<b>Ore Haulage Tunnel</b>														
	E.1.1	Poor ground conditions	Increase costs, schedule extension	C	M	M	N	L	N	L	H		probe holes and preparedness	
	E.1.2	major water inflow	Increase costs, water treatment capacity	C	H	L	L	M	L	L	H	M	probe holes and grouting	
	E.1.3	Higher volume of ARD rock than expected	Increase costs, schedule extension	C	H	L	L	L	L	N	M		storage facility, more geo info	
	E.1.4	ML/ARD water inflow	Increase costs, water treatment capacity	C	M	L	L	M	L	L	H		treatment capacity	
	E.1.5	Rock fall	Schedule extension	C	L	M	N	H	L	M	H		ground support engineering, inspection	
	E.1.6	Large fire underground	Loss of process	C	L	M	N	M	L	L	H		safety practices (e.g., fire suppression systems)	
	E.1.7	Loss of electrical power	Short-term loss of process	C	L	L	N	N	N	N	H		backup power source	
	E.1.8	Excessive release of ammonium nitrate	Increased ammonium nitrate concentrations	C	L	L	L	L	L	N	H		good housekeeping practices, sufficient water treatment capacity	
	E.1.9	Loss of access for emergency situations	Stop work, loss of process	C	H	L	N	N	N	N	H		Especially early in construction phase until road access is established. Appropriate instrumentation to ensure helicopter access	
	E.1.10	Large fire in transport tunnel	Stop production	O, PC	M	M	N	M	L	L	H		equipment maintenance, management plan re: transportation of flammables/explosives	
	E.1.11	Large fire in service tunnel	Stop production	O, PC	M	M	N	M	L	L	H		equipment maintenance	
	E.1.12	Slurry pipe failure	Slurry accumulates in tunnel, short-term reduction in production.	O	L	L	N	L	N	L	H		inspection and maintenance. Leak detection/pressure monitoring system and shut-off valves.	
	E.1.13	Ground failure	Delay	O, PC	L	M	N	M	L	L	H		inspection and maintenance	
	E.1.14	Seismic event causing damage to services/infrastructure	Increased wear and tear on infrastructure, increase maintenance. Potential for failure.	O, PC	L	L	N	L	N	N	H		inspection and maintenance	
	E.1.15	Power cable short	Short-term stop in production	O, PC	L	L	N	L	N	N	H		differential protection	
	E.1.16	Fuel line failure	Delay	O, PC	L	L	M	M	L	L	H		Storage of fuel in Mitchell Valley. Leak detection and valving.	
	E.1.17	Snow avalanche blocks portals	Short-term loss of access, potential damage to infrastructure and injury to personnel.	C, O, PC	M	L	L	M	L	L	H		avalanche control measures at portal.	
<b>Diversion Tunnels</b>														
	E.2.1	Ground failure during storm event	Loss of diversion of water	O, PC	L	M	H	H	H	N	M	M	annual inspection and maintenance	
<b>PIT WALLS</b>														
	F.1	Bench failure	Filling up berms, minor rockfall hazard, unsafe working conditions, unable to achieve final wall	O	H	N	N	L	N	M	H	M	Bench clean up as necessary in critical areas. Operational procedures to limit access to areas with risk.	
	F.2	Interramp instability	Loss of ramps (Partial or complete), loss of productivity, unable to achieve final wall	O	M	H	N	M	N	M	M	M	Limit heights between interramps. Pit slope monitoring program. Alternative mill feed available if failure occurs.	
	F.3	Overall slope instability	Major economic loss	O	M	E	N	H	M	M	L	H	Pit slope monitoring program. Depressurization with horizontal drains as necessary.	

**Appendix 35-A. Failure Mode & Effects Analysis (FMEA) Summary Table for October 2009 Workshop**

COMPONENT	ID	FAILURE MODE	EFFECTS	PERIOD of INTEREST	LIKELIHOOD	CONSEQUENCES					LEVEL OF CONFIDENCE	HIGH CONCERN ISSUE	MITIGATION/ COMMENTS	OPPORTUNITIES
						COSTS	BIOLOGICAL IMPACT	REGULATORY IMPACT	PUBLIC CONCERNS	HEALTH & SAFETY				
	F.4	Overall slope instability	Failure into pit lake, overtopping of closure spillway, infiltration/inundation of dump	PC	H	H	M	H	M	L	L	H	Maintain pit lake level to mitigate flood wave. Evaluate post closure pit slopes to minimize failure risk. Minimize downstream effects (e.g., backfill ARD material to pit).	
<b>PIT DEWATERING SYSTEM/SEEPAGE RECOVERY</b>	<b>G</b>													
	G.1	Failure of horizontal drains	Bench/inter-ramp scale instability	O	H	H	N	M	N	M	M	M	Redundant wells and drains	
	G.2	Temporary shutdown of wells (> 1 week)	Inability to meet dewatering targets. Could lead to interramp, overall failure.	O	L	E	N	H	M	M	L	M	Redundant wells/access	
	G.3	Long-term loss of wells	Inability to meet dewatering targets. Could lead to interramp, overall failure. Requires additional wells to be drilled.	O	M	H	M	H	M	M	L	M	Redundant wells/access	
<b>PLANT SITES</b>	<b>H</b>													
<b>Mitchell</b>	<b>H.1</b>													
	H.1.1	Subsurface water flows in plant site area	Foundation construction difficulties	C	H	H	L	L	L	L	L	H	Site investigation to determine extent of potential problems. Depressurizing or surface collection of any water to treatment pond	
	H.1.2	South old landslide re-mobilized into north plant site area	Stability and availability of plant site unsuitable	C	L	H	L	L	L	L	L	M	Site investigation. Build stabilization protection. Adjust site location as necessary.	
	H.1.3	Avalanche (snow) potential	Facilities damage, impaired operations, tunnel blockage	O	L	M	L	L	L	M	L		Evaluation of snow packs. Avalanche monitoring and control.	
	H.1.4	Geohazard potential	Facilities damage, impaired operations, tunnel blockage	O	L	M	L	L	L	M	L		Geohazard assessment. Maintenance and management	
	H.1.5	Seismic Event	Damage to equipment & infrastructure = short-term plant shutdown	O	L	M	L	L	L	L	L		Designed to code for structures (1:675 yr)	
	H.1.6	Slurry pump/pipe system rupture	Spill of slurry, plant shutdown, repair costs	O	M	M	M	M	M	M	L	M	Drain sumps, leak detection system. Regular inspection and maintenance. Cross connects between the two pipelines.	
<b>Teigen</b>	<b>H.2</b>													
	H.2.1	Seismic event	Damage to equipment & infrastructure = plant shutdown	O	L	M	L	L	L	L	L		Designed to code for structures (1:675 yr)	
	H.2.2	Slurry pump/pipe rupture	Spill of slurry, plant shutdown, repair costs	O	M	M	L	L	L	L	L		Drain sumps, leak detection system. Regular inspection and maintenance. Cross connects between the two pipelines.	
	H.2.3	Cyanide spill	Contamination of area and release to streams	O	L	L	H	H	H	H	L	M	Emergency response plans. Runoff collected and sent to cyanide destruction.	
	H.2.4	Cyanide recovery process malfunction	Deadly gases emitted to atmosphere	O	L	H	M	H	H	H	L		Emergency response plans. Separate ventilation system in isolated building. Cyanide monitoring and warning system.	



Appendix 35-A. Failure Mode & Effects Analysis (FMEA) Summary Table for October 2009 Workshop

Consequences Severity (Direct Costs)	Biological Impacts and Land Use	Regulatory Impacts and Concerns	Public Concern and Image	Health and Safety
Extreme (>\$100 M)	Catastrophic impact on habitat (irreversible and large)	Unable to meet regulatory obligations or expectations; shut down or severe restriction of operations	Local, international and NGO outcry and demonstrations, results in large stock devaluation: severe restrictions of 'licence to practice'; large compensatory payments etc.	Fatality or multiple fatalities expected
High (\$50 - \$100 M)	Significant, irreversible impact on habitat or large, reversible	Regularly (more than once per year) <b>or severely</b> fail regulatory obligations or expectations - large increasing fines and loss of regulatory trust	Local, international or NGO activism resulting in political and financial impacts on company 'license to do business' and in major procedure or practice changes,	Severe injury or disability likely: or some potential for fatality
Moderate (\$10 - \$50 M)	Significant, reversible impact on habitat	Occasionally (less than one per year) <b>or moderately</b> fail regulatory obligations or expectations - fined or censured	Occasional local, international and NGO attention requiring minor procedure changes and additional public relations and communications	Lost time or injury likely: or some potential for serious injuries; or small risk of fatality.
Low (\$1 - 10 M)	Minor impact on habitat	Seldom or <b>marginally</b> exceed regulatory obligations or expectations. Some loss of regulatory tolerance, increasing reporting.	Infrequent local, international and NGO attention addressed by normal public relations and communications	First aid required; or small risk of serious injury.
Negligible (<\$1 M)	No measurable impact	Do not exceed regulatory obligations or expectations	No local/international/ NGO attention	No concern

Likelihood	Safety Consequences	Environmental and Public Concern Consequences
Not Likely (NL)	<0.01% chance of occurrence (<1:10,000)	<0.1% chance of occurrence (<1:1,000)
Low (L)	0.01 – 0.1% chance of occurrence (1:10,000 - 1:1,000)	0.1 - 1% chance of occurrence (1:1,000 - 1:100)
Moderate (M)	0.1 - 1% chance of occurrence (1:1,000 - 1:100)	1 - 10% chance of occurrence (1:100 - 1:10)
High (H)	1 - 10% chance of occurrence (1:100 - 1:10)	10 - 50% chance of occurrence (1:10 - 1:2)
Expected (E)	>10% chance of occurrence (>1:10)	>50% chance of occurrence (>1:2)