

SECTION B.10

***COLLECTION AND TREATMENT OF ARD
AT EQUITY SILVER***

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General Procedures for FMEA

- Tour system
- Description of system – components
- Identify possible failure modes
- Rate severity of failure (consequences)
 - based on environmental impact
- Derive likelihood of failure (probability)
 - based on expert/history
- Calculate risk
- Identify compensating factors
- Produce action plan to reduce risk

FMEA R/A of the Equity ARD Collection System

- A comprehensive list of the components and possible failure modes associated with each component of the collection system.
- Identified areas of low, medium, and high risk within the collection system. Format allowed an easy to follow listing of risks along with comments and compensating factors.
- Forced to systematically evaluate consequences and likelihood of different failure modes for each component of the collection system.
- Good format to identify action plans to improve risk levels.
- Format allows for easy updates to risk evaluation as systems are improved or more historical data becomes available.

Equity ARD Collection System

Elemental Failure Modes

Collection ditches

1. Ditch undersized for flow volume and overtops
2. Ditch blocked with ice and overflows
3. Seepage loss to environment from ditch (gravel/fractured bedrock)
4. Diversion ditch breaks and flows into collection system causing an overflow of collection ditch
5. Seismic activity causes break in ditch
6. Sloughing from side slope blocks ditch - till or snow - (partial to full blockage)
7. Siltation blocks ditch (partial to full blockage)

Collection Ponds

1. Excessive precipitation causing overflow
2. Seepage loss to environment
3. Breakage of outlet pipe
4. Earthquake causing dam failure
5. Diversion ditch break causing excessive flow to pond
6. Siltation and blockage of outlet pipe
7. Ice blockage of outlet pipe

Collection Pumphouses

1. Power failure to pumps or controllers
2. Leaking pumps and pipelines
3. Blocked inlet pipe (sediment/ice)
4. Blocked outlet pipe
5. Mechanical failure (pump(s), controllers)
6. Earthquake causing intake or discharge pipe failure
7. Fire destroys pumps and/or controllers
8. Failure of high level control/alarm (pumps not activated)

Consequence Rating

Degree of Safety	Description	Hazard Rating
Safe	No environmental damage.	I
Marginal	Minor environmental damage. Possible non-compliance, costs < \$100,000.	II
Moderate	Non-compliance, costs \$100 - 250,000	III
Unsafe	Definite environmental damage, possible charges, costs \$250,000 - 2,000,000.	IV
Very Unsafe	Severe environmental damage, non-compliance & charges, Costs over \$2,000,000.	V

Examples:

Component	Failure Mode	Consequence	Comments
Southern Tail Ditch	Siltation	I - II	low contam, low discharge rate
Main Ditch -north	Excessive precipitation	III - IV	highly contaminated but some dilution with high flow
Getty Pond	Diversion Ditch Break	III	low contam, high dilution
Main Pumphouse	Power Failure - long term	III - IV	depends on rise rate

Failure Likelihood Rating

Description	Frequency	Rating
Very Unlikely	1/35 years or >	I
Remote	1/ 16-35 years	II
Likely	1/ 6-15 years	III
Very Likely	1/ 2-5 years	IV
Highly Likely	1 or >/year	V

Examples:

Component	Failure Mode	Consequence	Failure Likelihood	Comments
Southern Tail Ditch	Siltation	I - II	I - II	relatively little silt from area
Main Ditch -north	Excessive precipitation	III - IV	II	ditch successfully handled 1:200 storm in 1994
Getty Pond	Diversion Ditch Break	III	II - III	diversion close to pond
Main Pumphouse	Power Failure - long term	III - IV	II	main power grid reliable & easy to reset

Overall Risk (Consequence + Failure Likelihood)

Component example	Failure Mode example	Consequence	Failure Likelihood	Overall Risk
Collection ditch	Partial siltation	I	I	2.0
Collection ditch	Major slough	V	V	10.0

Lowest possible risk

Highest possible risk

Compensating Factors and Additional Measures

Examples:

Component	Failure Mode	Consequence	Failure Likelihood	Overall Risk	Compensating Factors	Additional Measures
Southern Tail Ditch	Siltation	I - II	I - II	3.0	continue to remove material	establish regular maintenance program
Main Ditch -north	Excessive precipitation	III - IV	II	5.5	secondary ditch & inspections	build up shallow sections on downstream side
Getty Pond	Diversion Ditch Break	III	II - III	5.5	maintenance of diversion	clear diversion for freshet
Main Pumphouse	Power Failure - long term	III - IV	II	5.5	stationary generator available	test genset monthly- hook up for portable

Complete Component R/A without comments

Component	Failure Mode	Consequence	Failure Likelihood	Overall Risk	Compensating Factors	Additional Measures
Main Ditch -north	Excessive precipitation	III - IV	II	5.5	secondary ditch & inspections	build up shallow sections on downslope side
	Ice blockage	III	II	5.0	secondary ditch coverage	regular inspections, watch glaciation
	Seepage loss	II - III	III	5.5	secondary ditch, sumps	inspection of ditch & secondary systems
	Sloughing blockage	IV	II	6.0	secondary ditch, regular maintenance	redesign incoming ditch to reduce buildup
	Earthquake	IV	I	5.0		geotechnical review
	Diversion ditch break	III	II	5.0	secondary ditch	
	Siltation	III	II - III	5.5	secondary ditch, regular maintenance	redesign incoming ditch to reduce buildup

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