Boliden Aitik Mine Closure Planning-Resulting Closure Plan

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The project has been developed mainly by:

Boliden Mineral AB, Boliden, Sweden
Enchemica LLC, Loveland, Colorado, US
Lorax Environmental Services Limited, Vancouver, BC, Canada
O´Kane Consultants Inc., Saskatoon, Canada
Sweco Environment AB, Sundsvall, Sweden

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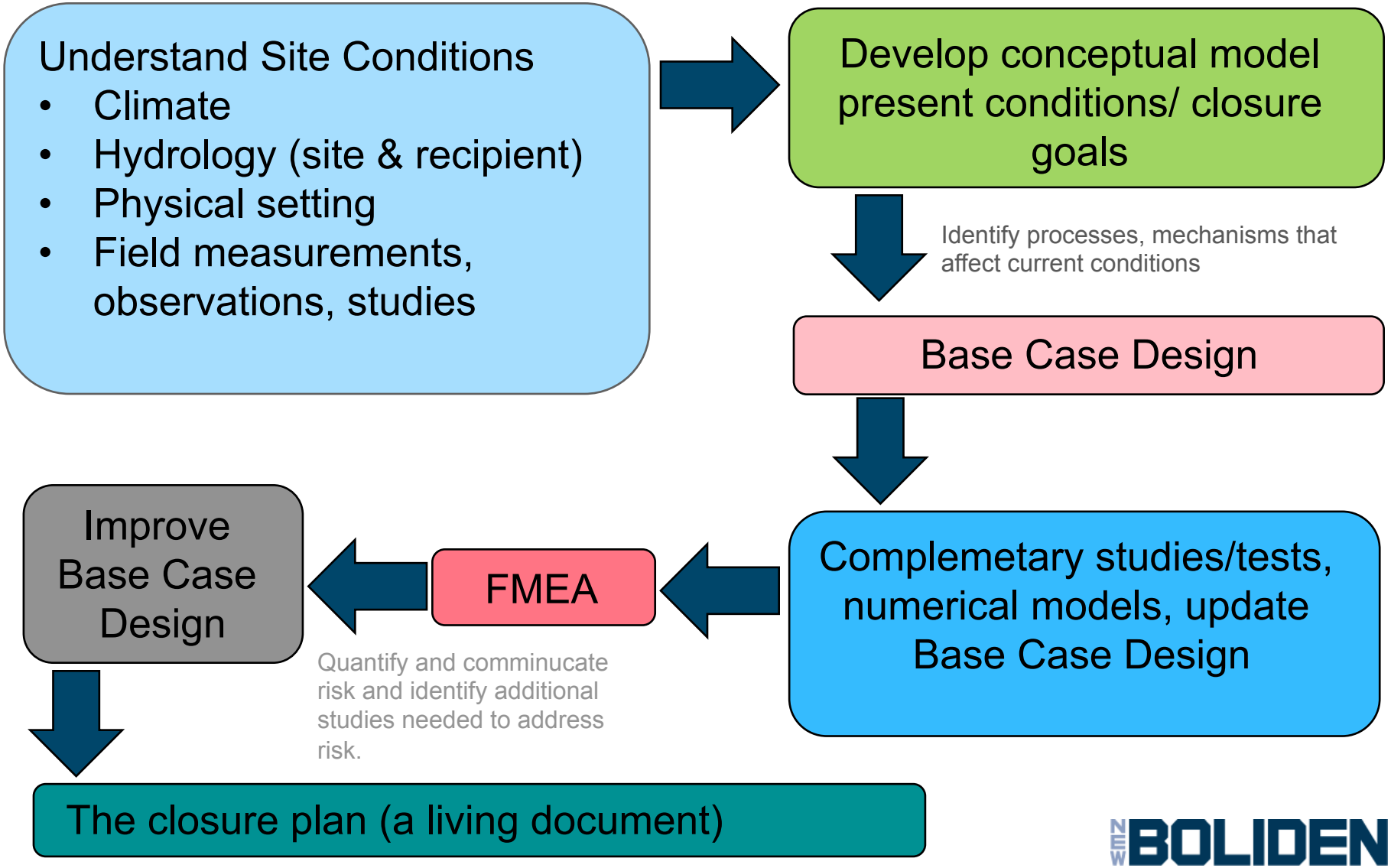
Outline

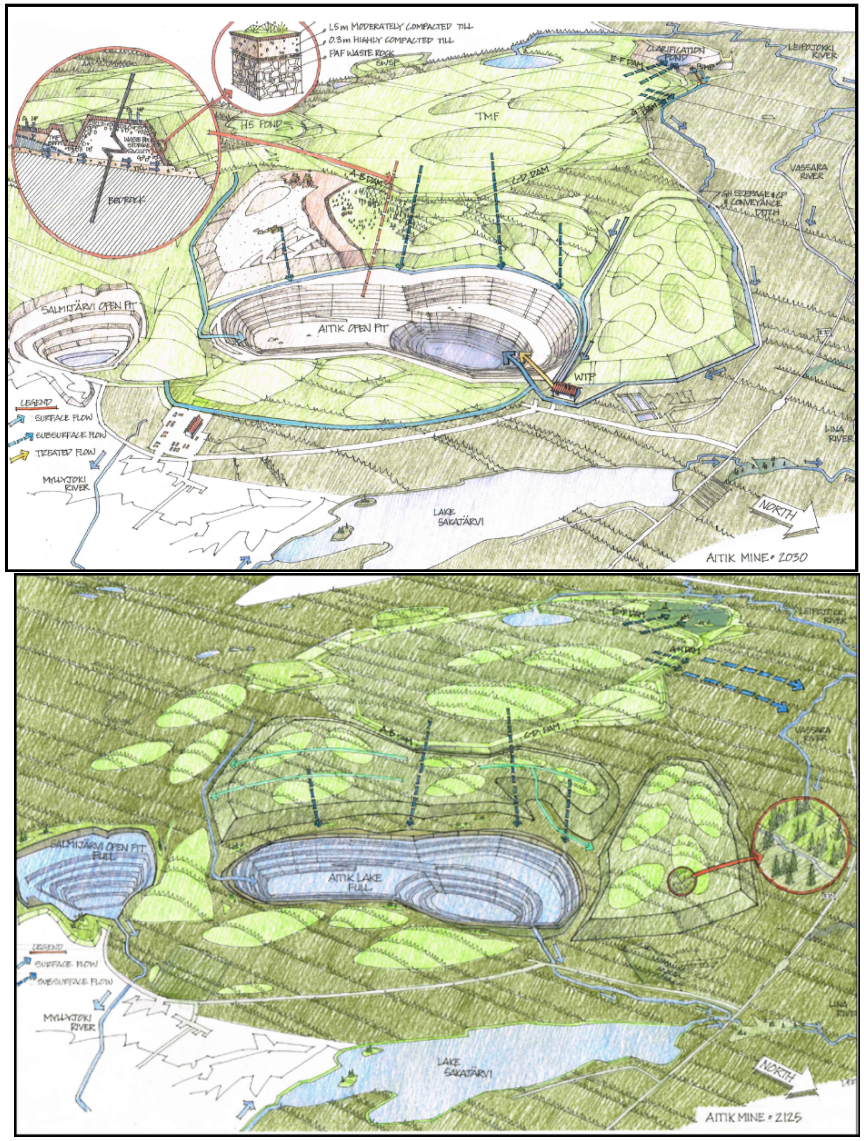
- Closure plan
- Permitting Process
- Moving forward

Overview of Base Case Design Process



Resulting Closure Plan

- Holistic and systematic
- Achieves the environemtnal quality standards (EQS) for recipient water bodies.
- Cover system designs based on site specific criteria for both the waste rock and tailings.
- Water Management designed on site-specific climate, site requirements including open pit filling and discharge.
- Constructable

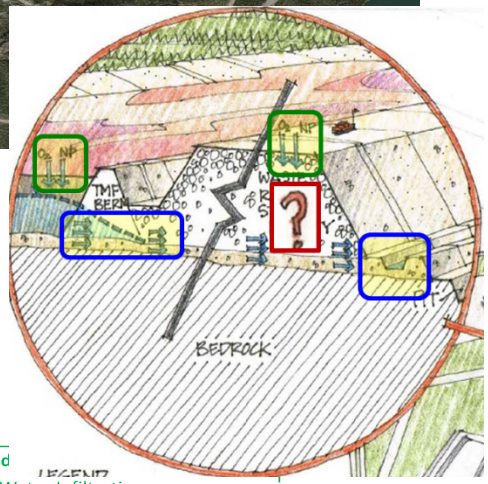


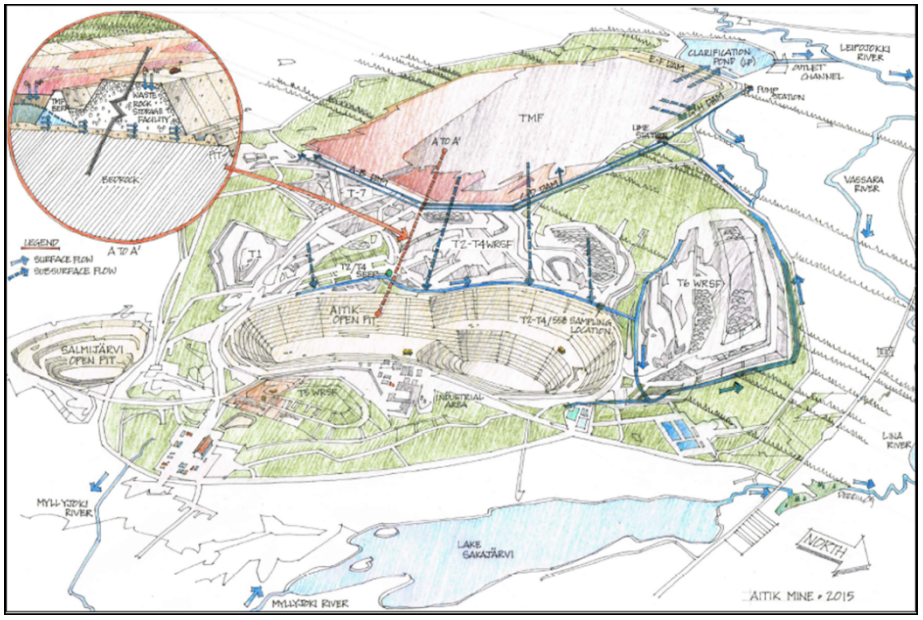
Permiting/Acceptance

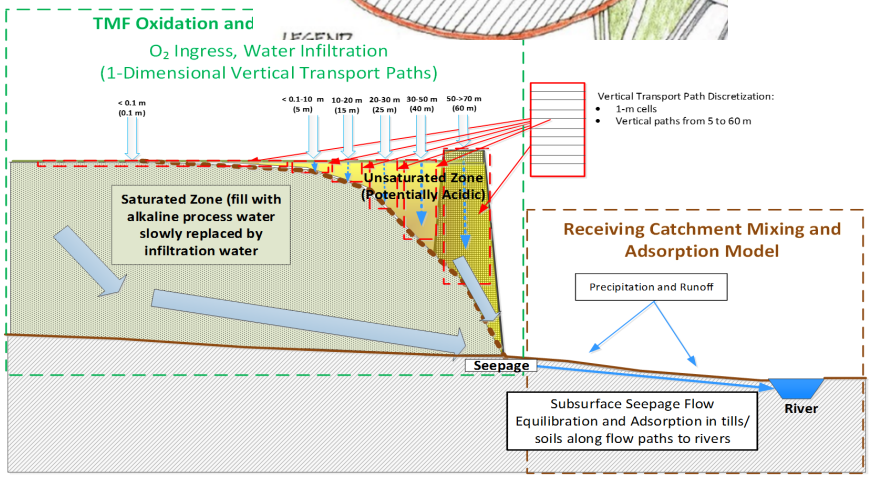
- Closure plan appealed for the second time to the Environmental Court of Appeals.

Permitting/Acceptance

- New presentation of same material
- Closure goals set for recieving waters
- **Not** Closure goals for each object based on theoretical ”ideal” values.



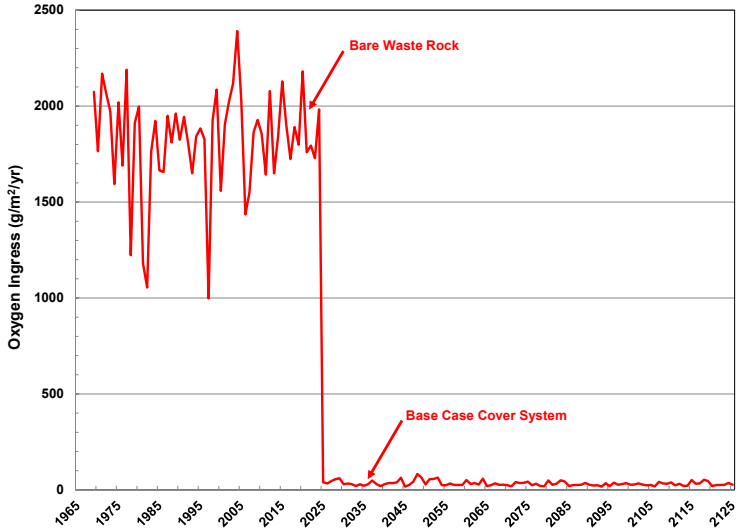


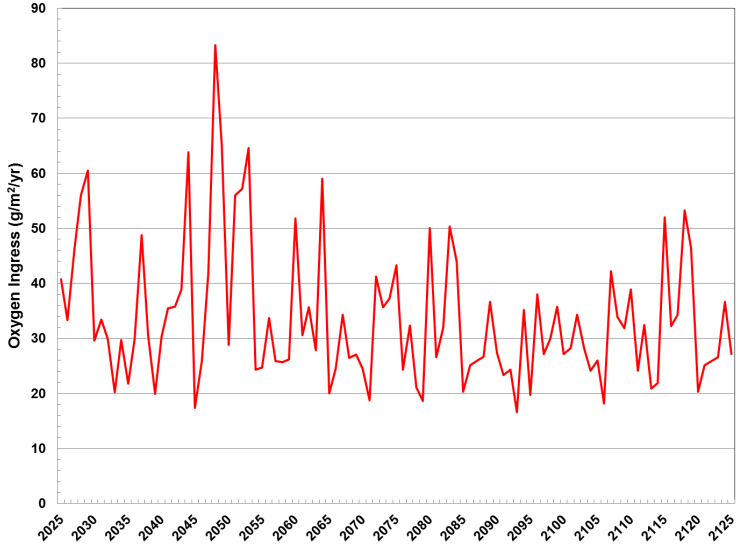


Permitting/Acceptance

Example: Waste Rock Cover Design

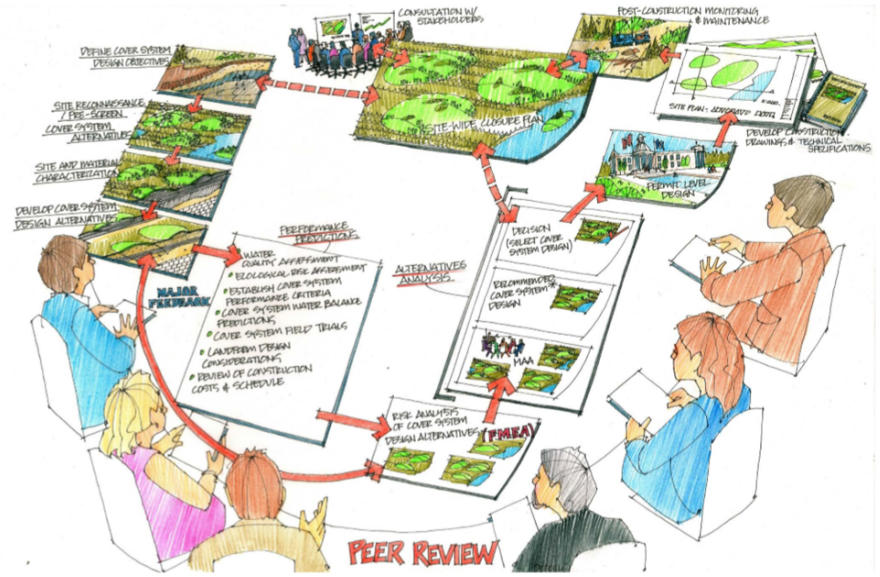
- Oxygen ingress was previously a goal
- Modelling based on measured site data-achieves goal in recipient.
- Focus still on oxygen ingress goal for just the cover system, not on what oxygen ingress is required to achieve EQS in the receiving water quality.





Permitting/Acceptance

- Handling uncertainty
- Failure Modes Effects Analysis
- Understanding the FMEA process and results
- Acceptance of the FMEA process and results
- **Requires dialogue**

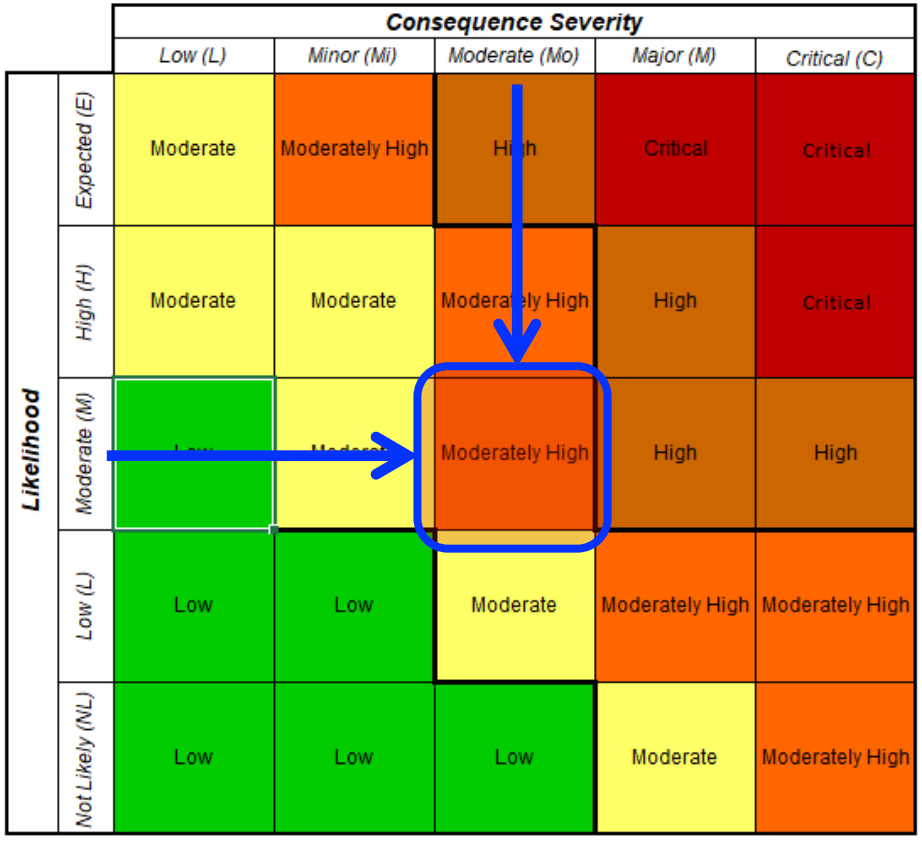


Permitting/Acceptance- FMEA

Failure Mode	Effects and Pathways	Likelihood	Env. Impact	Cost	Human Health	Safety	Highest Risk Rank
Underestimate stored acidity in WRSF	Higher CoCs from WRSF seepage for longer period of time	Moderate **1-10%**	Moderate	Moderate **$5-15 million**	Low **No anticipated Effects**	Low	Moderately High

Sporadic intervals of guideline exceedance within initial dilution zone. Water will be treated to ensure it does not reach downstream receptor

Infrastructure for this occurrence is in place in Base Case scenario. Treatment plant will have design life to treat poorer than predicted water quality for longer than predicted

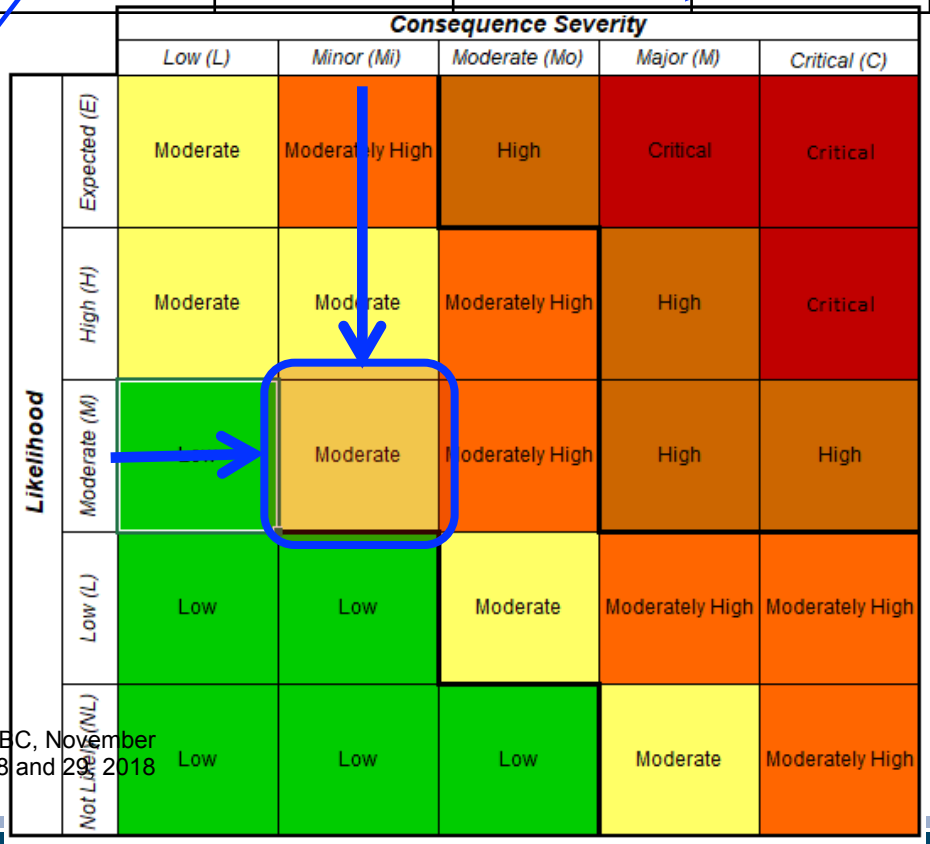


Permitting/Acceptance-FMEA

Failure Mode	Effects and Pathways	Likelihood	Env. Impact	Cost	Human Health	Safety	Highest Risk Rank
Overestimate magnitude of PAF seepage WQ improvement	Increased CoCs from WRSF seepage persist over long-term	Moderate **1-10%**	Minor	Minor **$1-5 million**	Low **No anticipated Effects**	Low	Moderate

Measurable water quality effect within initial dilution zone. Water will be treated to ensure it does not reach the downstream receptor

Infrastructure to manage this occurrence is included in Base Case Design. Water treatment facility will have capacity and design life to treat as necessary. Time to investigate and refine source terms

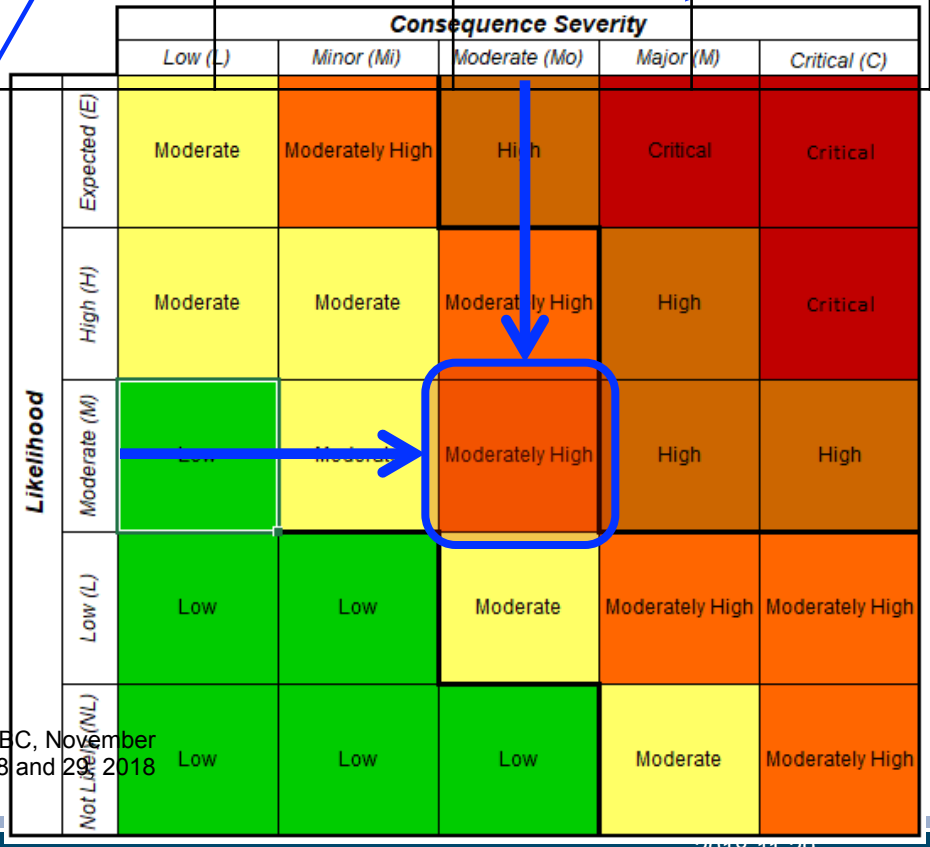


Permitting/Acceptance-FMEA

Failure Mode	Effects and Pathways	Likelihood	Env. Impact	Cost	Human Health	Safety	Highest Risk Rank
Inadequate quality control assurance during cover system construction	Poorer than predicted PAF source term WQ persists over long term due to poor cover system performance	Moderate **1-10%**	Minor	Moderate **$5 - 15 million**	Low **No anticipated Effects**	Low	Moderately High

A comprehensive QA/QC assurance plan will be developed for full-scale construction

Consequence costs reflect potential replacement of cover system sections or importing cover system materials



Permitting/Acceptance
FMEA:Our perspective

- Motivate specific investigations to reduce uncertainty.
- Motivate mitigations to minimize risk.

Related Studies, Work, Research to address these FMs (and similar FMs), which are in progress and/or planned in near future

i. *Multi-criteria assessment – WRSF Construction*
   - *Evaluate opportunities to reduce oxygen ingress into WRSF during operations*

ii. *PAF WRSF Drilling program completed*
   - *Waste rock samples collected and monitoring system installed*

   Factual report on drilling / sampling program

iii. *2017 PAF WRSF borehole instrumentation monitoring and Interpretation.*

iv. *Cover system field trials ongoing*

Permitting/Acceptance
FMEA:Reaction

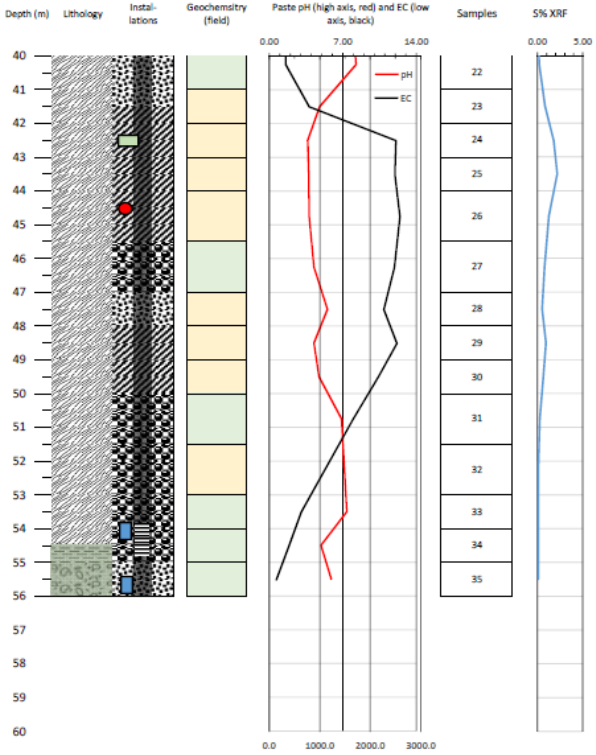
- No risk acceptable.
- Uncertainty exists- scientifically reasonable doubt exists.
- Risk costs become Economic Security/ Bond costs

- From the 3 examples shown:
  - 45 Million US dollars
- There were 88 failure modes identified….

Moving Forward-Lessons Learned and Value Added

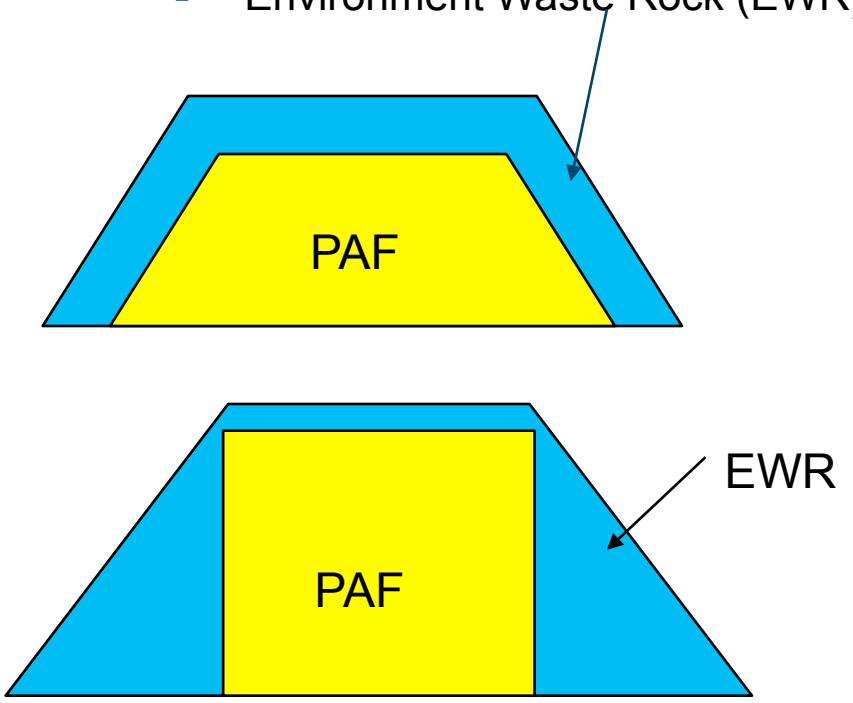
- Identify the closure goals and work back to what is required for closure measures.
- FMEA is a valuable process
- FMEA- Prioritized list of areas requiring investigation.
- Allows for systematic, well defined investigations with meaningful goals.
- Key for adaptive management and continuous improvement.
- Look at the entire system together, not individual objects.
- Get internal and external stakeholders involved early/often.
- FMEA being used in mutliple closure projects as the starting point.
- Short and long term plans for developing/updating closure plans.
- Tool to implement cultural change?

Moving Forward-Lessons Learned and Value Added



Moving Forward-Lessons Learned and Value Added

- Environment Waste Rock (EWR)



Moving Forward- Challenges

- Managing change in Life of Mine Plan
  - Changing culture of mine planning
- Investigate, Conceptualize, Simulate, Evaluate, Update.
- Demonstrating those closure measures that will result in both better closure w.r.t environment and cost.
- Teaching stakeholders the FMEA process.
- Managing uncertainty using FMEA process.

Conclusions

- An iterative and systematic approach focused on acheiving specific EQS has led to the development of Aitik's closure plan.
- Value was added to the process by using the FMEA tool
- The FMEA tool requires stakeholder dialogue to be understood and accepted.
- FMEA has helped define and prioritize the current and future investigations needed to further improve Aitik's closure plan.

Thank you!