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Case Study for TSF Liner Performance

RMK LCRF vs. Grassy Mountain TSF

July 2023

SLR

Objective

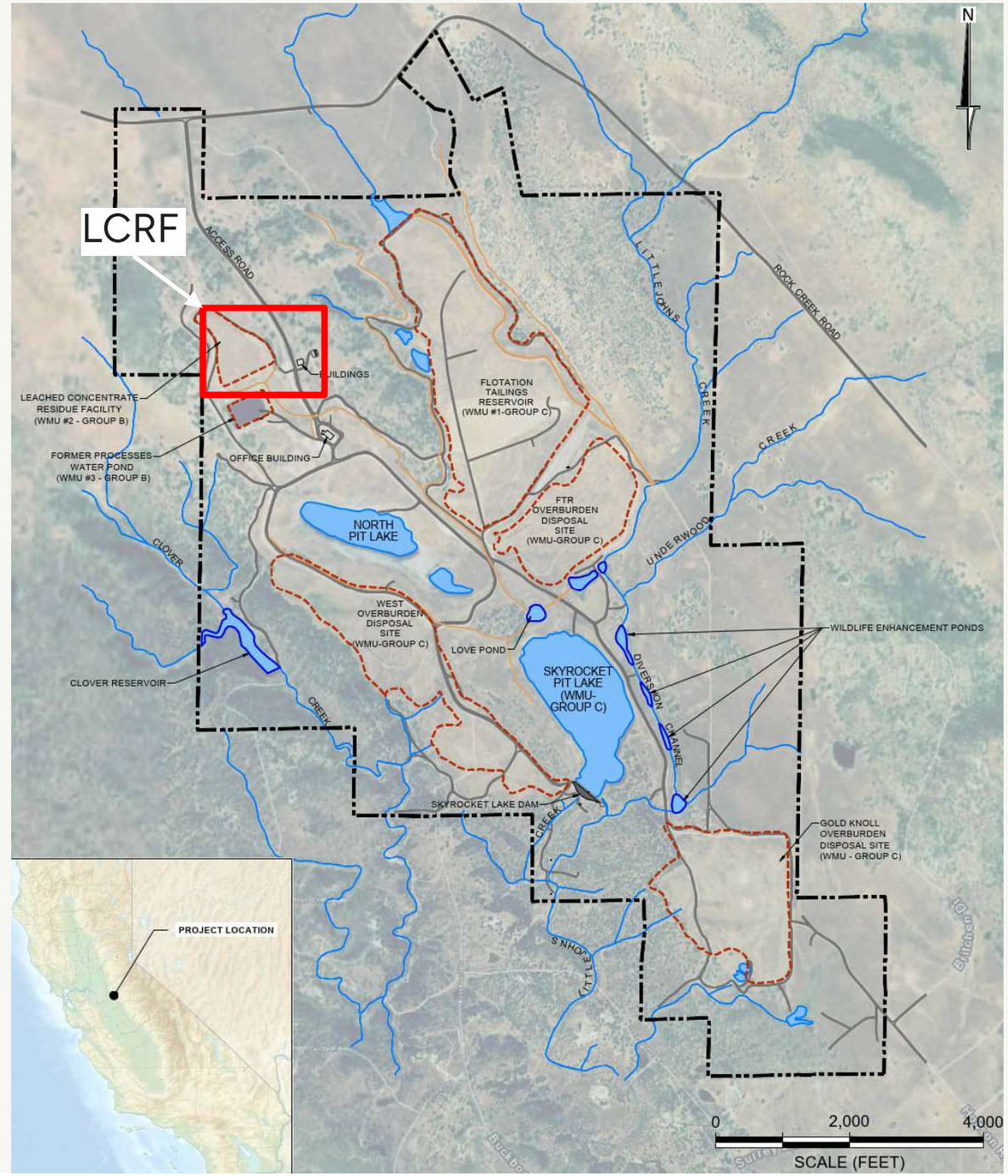
- US Fish and Wildlife Services has asked in comments to the Consolidated Permit Application if the TSF liner completely prevents leachate from entering surface or groundwater; how long will the liner last? Is there expected to be any maintenance concerns with the liner, and has this process been used successfully at other sites to prevent groundwater and surface water contamination from tailings leachate?
- This Case Study provides an example of a tailings impoundment with wastes that are much more dangerous to the environment and a containment system with a less-protective design than the Grassy Mountain TSF, and how was successfully operated and closed without releasing cyanide and generation of acid was prevented.

Background

- Royal Mountain King (RMK) Mine was constructed in 1987 and operated until 1994.
- Located in Calaveras County California, near the town of Copperopolis
- Gold Mine – Processed over 6 million tons of ore and generated 60 million tons of waste rock from three open pits
- Ore processing consisted of flotation to separate the gold-bearing sulfide minerals as a concentrate, and then leaching the concentrate in a cyanidation circuit (carbon-in-leach)
- Tailings from the cyanidation circuit (Leached Concentrate) sent as a slurry to the Leached Concentrate Residue Facility (LCRF)
- There was no cyanide detoxification of the tailings slurry prior to disposal

RMK Mine

Location and Layout



Background (cont'd)

- LCRF covers an area of approximately 20 acres
- Contains approximately 186,000 tons of LCR and 240,000 of low grade ore that was heap-leached
- Operated from 1987 through 1994
- Interim closure with a geomembrane cover from 1994 to 2004
  - Leachate and water management during interim closure period
- Final closure cover constructed in 2004
  - Leachate managed during residual draindown
- Underdrains grouted up in 2010

RMK LCRF

Interim Closure - 1995

Current Condition from Google Earth

Geochemistry of Tailings: RMK vs. Grassy Mountain

Parameter	RMK LCR	Grassy Mtn TSF
Neutralization Potential (NP)	0 – 64	0.3 – 4.7
Potential Acid Production (AP)	674 – 1690	2.8 – 5.9
Net Neutralization Pot. (NP-AP)	*-634* – *-1658*	-3 – 1.4
Neutralization Pot. Ratio (NP/AP)	*0* – *0.061*	0.11 – 1.5

- Units for NP, AP, and NNP are tons $CaCO_3$ per ton of tailings
- NPR has no units

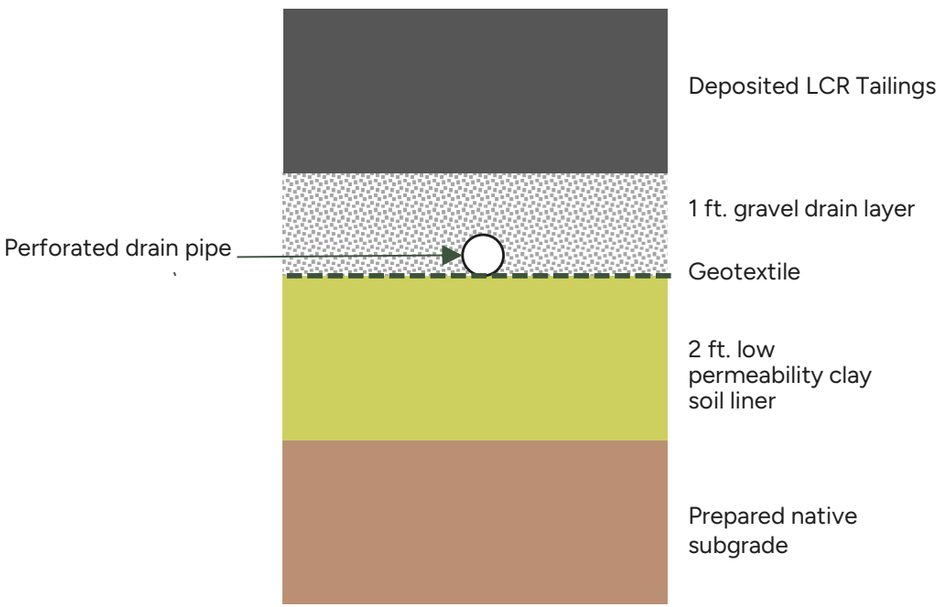
- RMK LCR is strongly acid generating and are considered PAG
- Grassy Mtn Tailings are weakly acid generating but have almost no neutralization potential; considered PAG for design purposes

Context Criteria:

- NNP < -20 and/or NPR < 1.0: Material is Potentially Acid Generating
- -20 < NNP < 20 and/or 1.0 < NPR < 2.0: Uncertain
- NNP > 20 and or NPR > 2.0: Non-Acid Generating

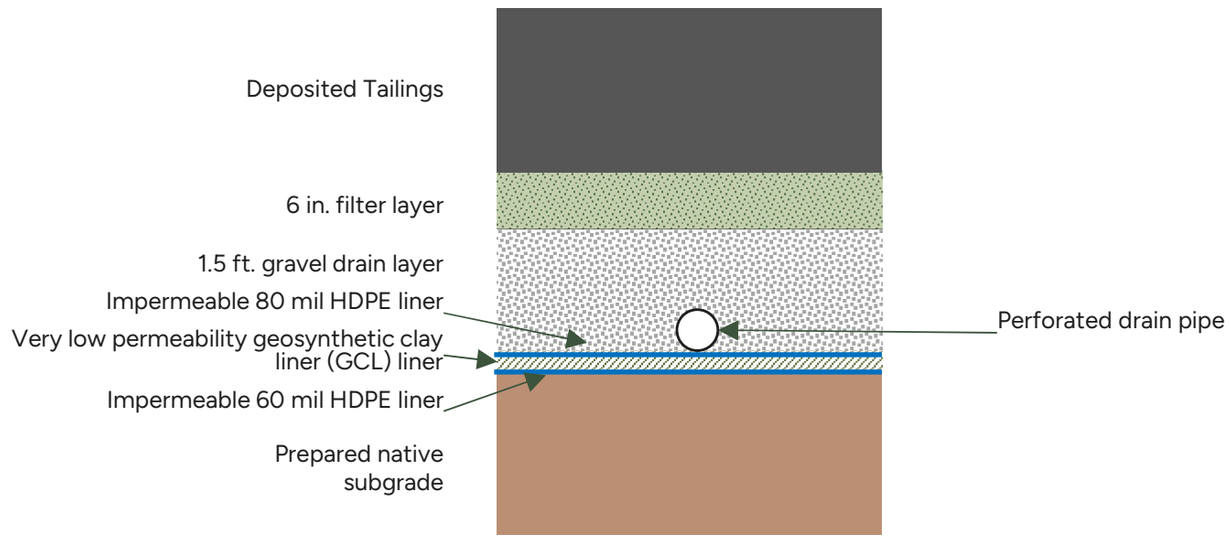
Liner Design Comparison

RMK LCRF



RMK liner system is considered a double liner with a drainage layer between (LCRS). The deposited tailings form the inner liner. There was also a spine drain below the clay layer for leak detection.

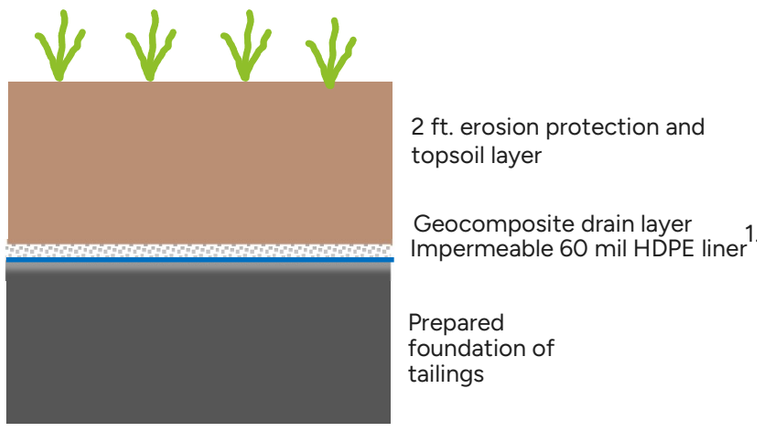
Grassy Mtn TSF



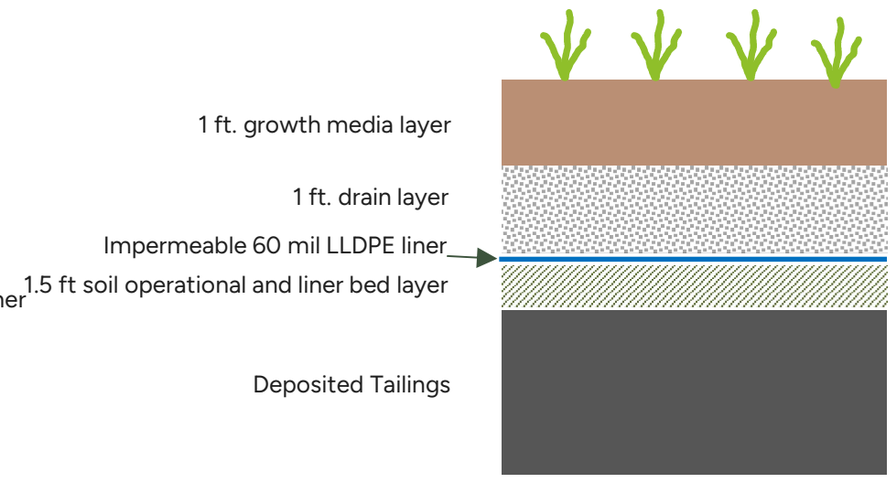
Grassy Mtn TSF liner system is considered a double liner with a composite lower liner (GCL and HDPE). The drainage layer between (LCRS) overlies the liner system. The deposited tailings are not considered as part of the liner system. There is also a leak detection drain between the upper liner and the composite liner.

Closure Cover Design Comparison

RMK LCRF



Grassy Mtn TSF

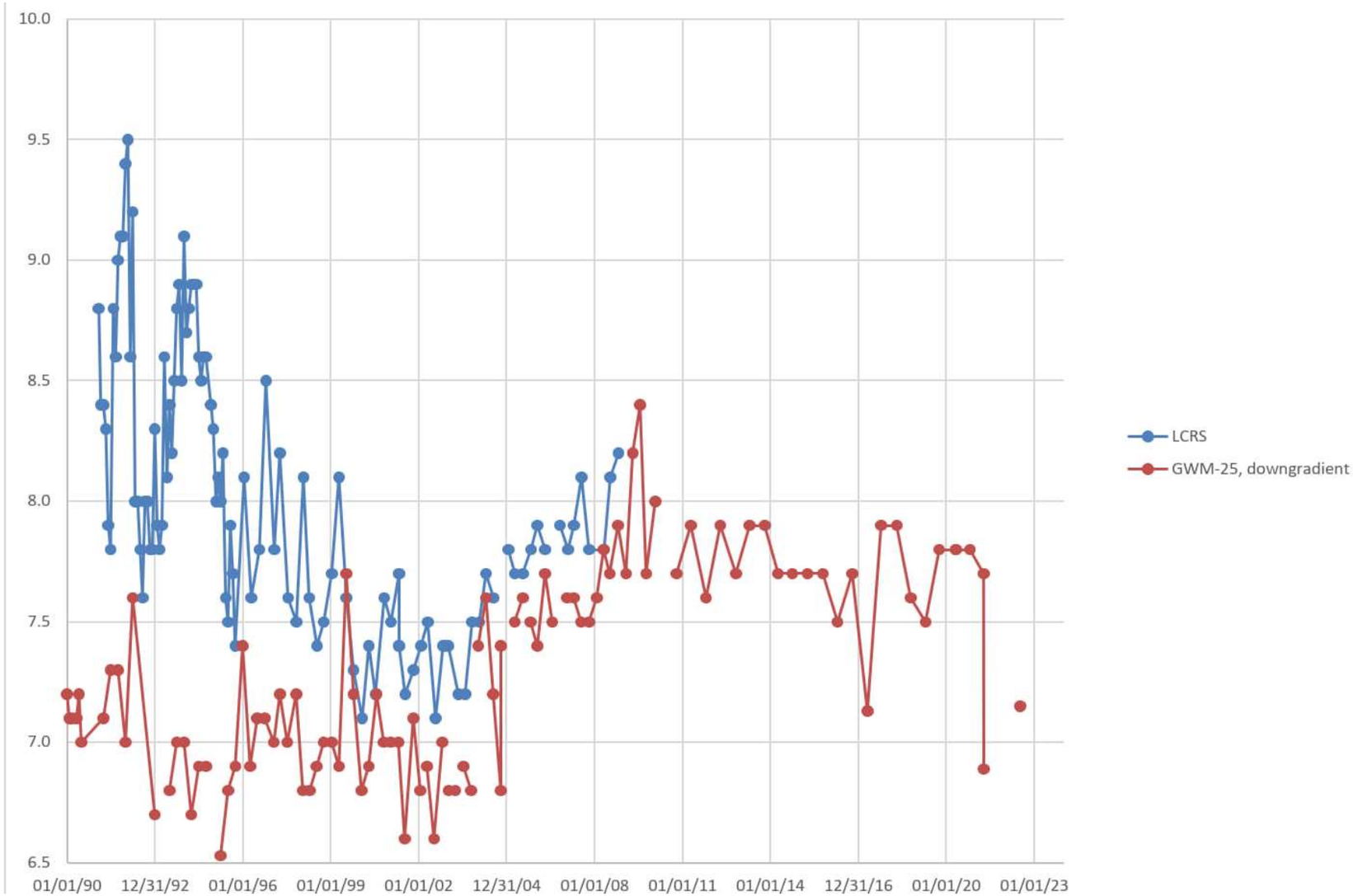


The two cover systems are functionally identical with a drain layer overlying an impermeable barrier (60 mil geomembrane).

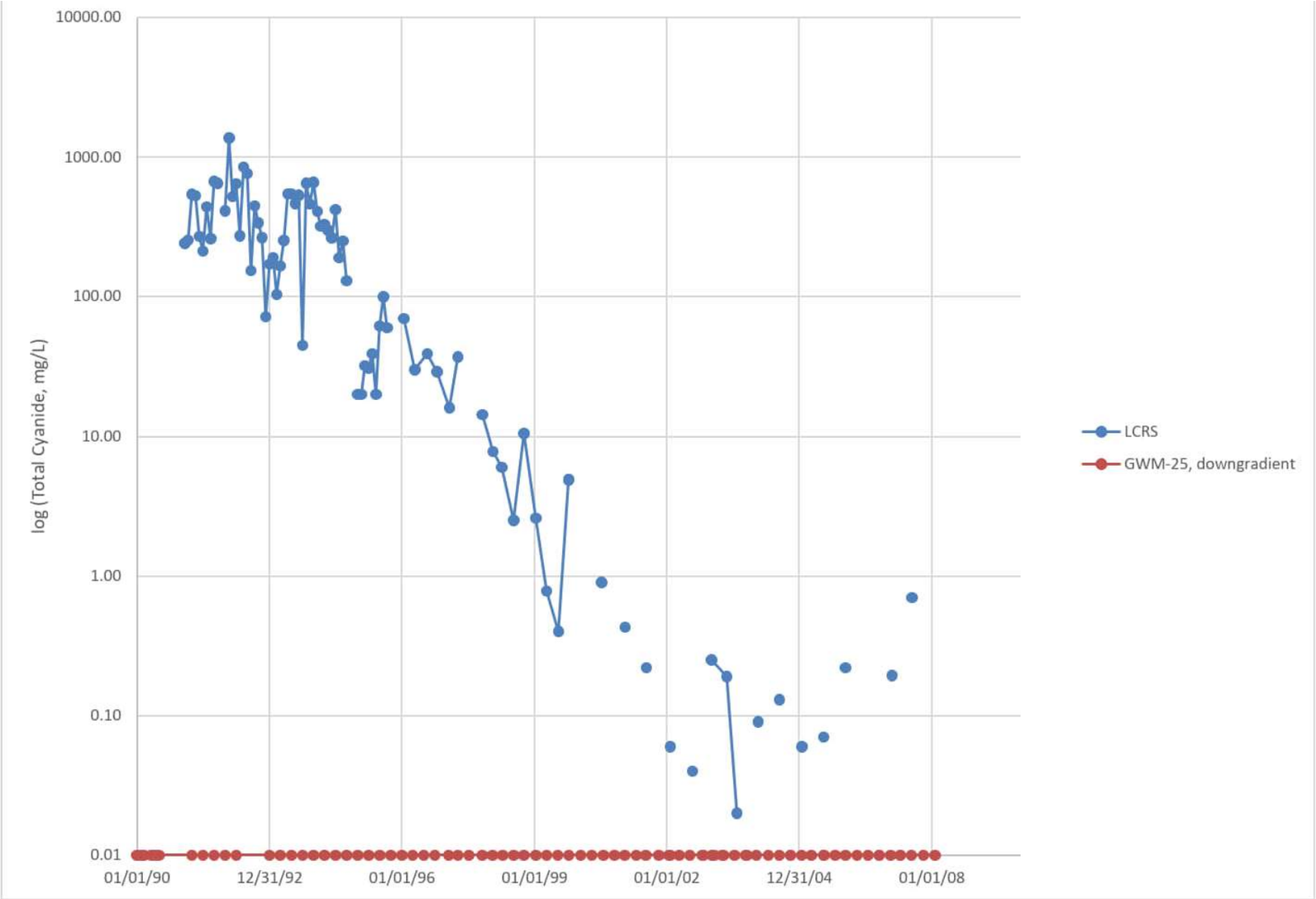
RMK LCRF Monitoring Observations

- LCRS pH remained above neutral throughout operations, interim closure, and closure periods
- Total Cyanide
  - Ranged from 150 to 1370 mg/L during operations (Grassy Mtn Operational Target is <15 mg/L)
  - Naturally degraded to < 1.0 mg/L between 1994 and 1999 (interim closure)
  - Never detected in downgradient groundwater (monitoring is ongoing)
- No flow, ever, in the spine drain (leak detection outside liner)
- Flows of LCRS (between liners) dropped to < 0.02 gpm by 2010 when the LCRS was grouted up for final closure

Monitoring data - pH



Monitoring data – Total CN



Note logarithmic vertical scale

Conclusions

- The liner and cover systems for the RMK LCRF performed as intended
  - Contaminants have never been detected in surface or groundwater
  - The tailings mass drained during closure
  - The closure cover successfully isolates the tailings from oxygen and water, so no acid is generated
  - The closure cover prevents formation of leachate
- The overall approach for the Grassy Mtn TSF is the same as what was applied at the RMK LCRF
  - Liner design for Grassy Mtn is more robust
  - Waste conditions at RMK were more aggressive than what is expected at Grassy Mtn
- Grassy Mtn TSF liner and cover designs are expected to be protective of the environment during the life of mine and through the post-closure period