“Water and Mining - Impact avoidance through mine design and planning, balancing operational needs with the environmental sensitivity”

prepared for
Conference on
THE MITIGATION HIERARCHY: REDUCING THE ENVIRONMENTAL IMPACTS OF LARGE-SCALE AND SMALL-SCALE MINING
MAY 27-28
ULAANBAATAR, MONGOLIA

Field Test of Thickened Tailings Technology at Minera Esperanza, Chile

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The Esperanza TSF was commissioned in late 2010, with SRK acting as technical advisors. The facility was designed to store a maximum of 750 million tonnes of copper tailings [produced at 95,000 ton per day]. Source: - http://www.srk.cl/es/node/2375

Best Practices Methods for Water Protection and Reuse in Mining

Energy Production – Use of low-water consumption renewable energy in mining is growing and use water consuming coal and nuclear reactor power is slowing

Tailings Management – Use of maximum water and reagent recycle tailings management applying dry-stack, past and highly thickened tailings methods is growing rapidly.

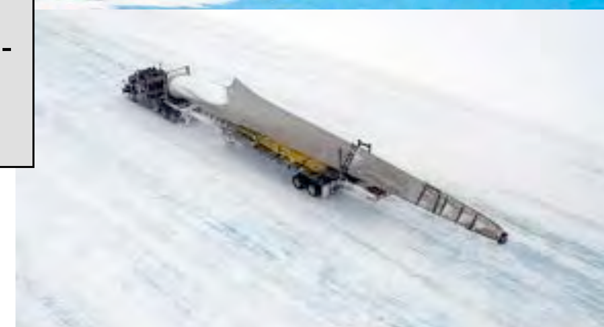
Use of below grade disposal NRC in USA recommends below grade disposal as prime option.

Mt. Polley tailings dam failure review panel recommends use of dry tailings and reduced use of water covers. "No more business as usual."

Full Hydrologic and Water Quality Characterization and Monitoring throughout project life is fundamental to avoiding long-term and irreversible impacts to water resources - New Mexico Mining Act of 1993 requires full cumulative hydrologic impact assessment before operations can begin
US Environmental Protection Agency proposed rules – 40CFR192 requires full characterization of background water quality and hydrology and water quality restoration for ore zone, adjacent portions of aquifer

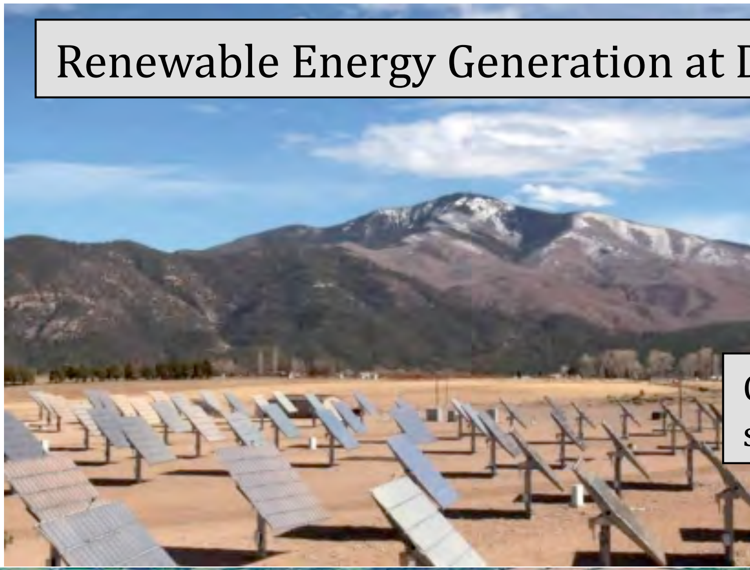
Mining with Renewable Energy Works in Difficult Conditions – Examples of Wind Power at Operating Mines includes: Diavik Mine, Canada and Punta Colorado, Chile

Diavik Diamond Mine - Rio Tinto/Harry Winston - 9.2 MW - $30 million – In operation – late 2012



Punta Colorado Copper Mine – Barrick Gold – 20 MW - $50 million – In operation 2011

Renewable Energy Generation at Decommissioned Mines



Questa, New Mexico Molybdenum Mine – 1.25 MW photovoltaic system – in operation on decommissioned portion of a tailings pile

Cornwall, England – 1.4 MW photovoltaic system at former tin mine – at: http://inhabitat.com/deserted-uk-tin-mine-transformed-into-1-4mw-solar-power-plant/

Senftenburg, Germany - 166 MW photovoltaic system being built at former open pit mine - 78 MW in operation in 2011 - at: http://inhabitat.com/abandoned-german-open-pit-mine-turned-into-worlds-largest-solar-park/

Ore Processing Mill Tailings – Best Practices – Dry Tailings in Below Grade Disposal Sites

Mt. Polley tailings spill in August 2014 has lead to its first set of recommendations from an Expert Panel that:

"…concluded that the future requires not only an improved adoption of best applicable practices (BAP), but also a migration to best available technology (BAT) . Examples of BAT are filtered, unsaturated, compacted tailings and reduction in the use of water covers in a closure setting. Examples of BAP bear on improvements in corporate design responsibilities, and adoption of Independent Tailings Review Boards ." Mt. Polley Independent Expert Panel Report, Exec Summary p. 8/156

https://www.mountpolleyreviewpanel.ca/sites/default/files/report/ReportonMountPolleyTailingsStorageFacilityBreach.pdf

Churchrock tailing tailings dam spill among events that led to adoption of US Nuclear Regulation Commission (NRC) regulatory standard since mid-1980s

- "*Criterion 3*—The "prime option" for disposal of tailings is placement below grade, either in mines or specially excavated pits (that is, where the need for any specially constructed retention structure is eliminated). "

http://www.nrc.gov/reading-rm/doc-collections/cfr/part040/part040-appa.html USC 10CFR40-Appendix A

KEY DESIGN AND OPERATION CRITERIA

- Below-grade disposal requires all tailings material to be below original land surface ("grade")

- Filtered, unsaturated, compacted tailings possible using existing technology to produce high-density thickened, paste or dry tailings. Provides for maximum recycle, reduce tailings disposal site area and reduced risk of short of long-term tailings dam failure;

- Reduction of use of water covers in a closure setting.

Mt. Polley Tailings Dam Failure and Spill

http://www.cbc.ca/news/canada/british-columbia/mount-polley-spill-blamed-on-design-of-embankment-1.2937387

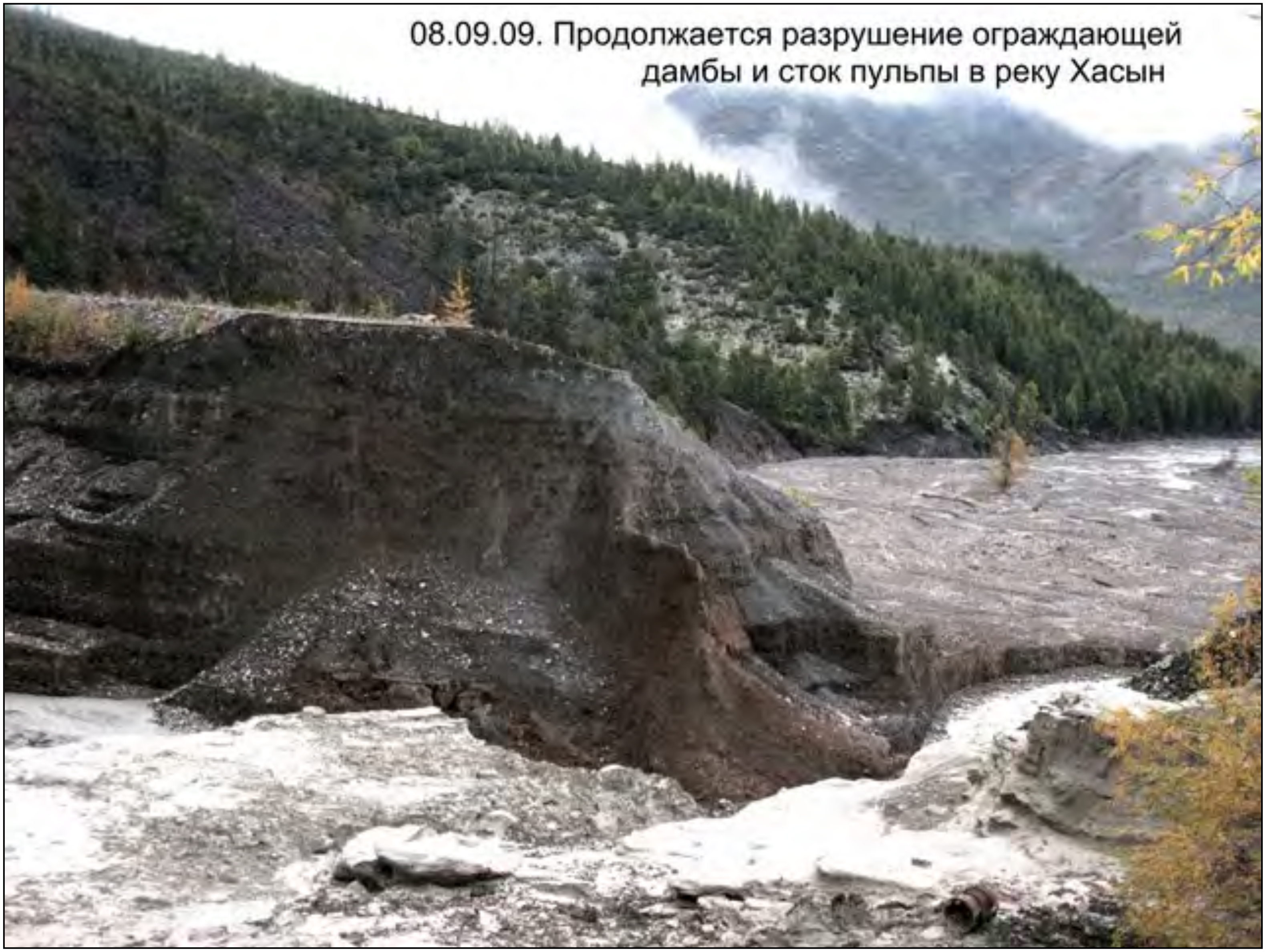
http://www.miningwatch.ca/blog/mount-polley-and-failure-compliance

July 29, 2014 August 5, 2014

http://commonsensecanadian.ca/mount-polley-spill-may-far-bigger-initially-revealed/

http://juneauempire.com/local/2014-08-08/advocates-tailings-dam-breach-warning-alaska

Tailings dam failure in Russia: Karamken, Magadan Region - 2009



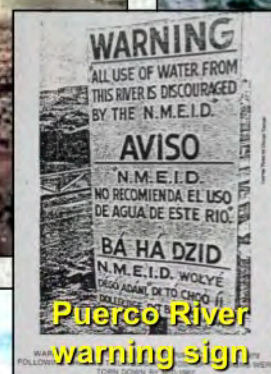
Puerco River Contaminant Source:

Church Rock Uranium Mill Tailings Spill,* July 16, 1979

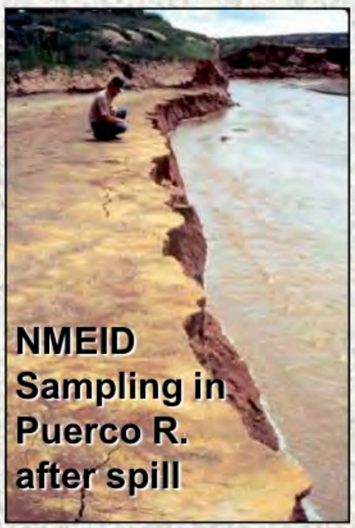
***Largest release of radioactive wastes, by volume, in US history**

United Nuclear Corp. Uranium Mill Tailings Dam, July 16, 1979

Dam breach location, July 17, 1979



Puerco River warning sign



NMEID Sampling in Puerco R. after spill

Livestock tracks in Puerco River downstream of spill, July 17, 1979

Community leaders Larry J. King (L) and Robinson Kelly addressed long-term impacts of spill in 2009.

Photos courtesy of Southwest Research and Information Center, New Mexico Environmental Improvement Division, Albuquerque Journal.

Extensive seepage into Colorado river floodplain after facility operator bankruptcy being address through tailings relocation to below –grade disposal site. Moab (Utah) Tailings Relocation Project that is excavating and transporting a 16,000,000-ton inactive tailings pile to a below grade disposal site 30 km north. Images show: 1) Atlas tailings pile before project began 2) tailings removal in progress, and 3) view after additional tailings removal

From: http://www.gjem.energy.gov/moab/
and http://www.moabtailings.org/

Crescent Junction Disposal Site uses below-grade tailings disposal with windborne particles releases controlled daily cover using material excavated to allow below grade disposal.

From: http://www.gjem.energy.gov/moab/

Below-grade tailings disposal system using phased, lined cells designed and permitted in Colorado, USA

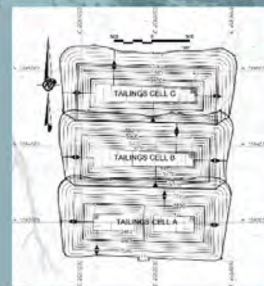
Source:"Uranium Tailings Facility Design and Permitting in the Modern Regulatory Environment "http://www.infomine.com/library/publications/docs/Morrison2008.pdf

The Piñon Ridge Project

- Design milling capacity of 500 tons per day, with expansion capacity to 1000 tons per day
- Major mill components:
  - Process plant
  - Tailings cells
  - Evaporation ponds
  - Ore stockpile pads
- Design mill life up to 40 years

Golder Associates

Tailings Cell Design Concepts



- Three tailings cells, constructed in phases
  - Each cell with capacity for 13.4 years at 500 tpd operations
  - Mostly below-grade disposal, with excess cut to be used for closure cover and other site construction
  - 3H:1V internal slopes with intermediate benches
  - 10H:1V external slopes to achieve closure requirements
  - 1% minimum slope at base

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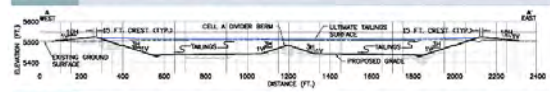
Tailings Cell Design Concepts, cont.

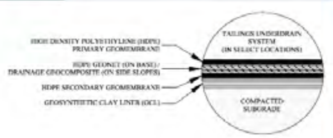


- Tailings Cell A designed as a split cell for contingency purposes
  - For instance, cell A1 could be decommissioned and repaired without disrupting operations
- Tailings Cells B and C are designed as single cells with option for split cell construction

Golder Associates

Tailings Cell Liner System Design

- Prescriptive Liner System (40 CFR 264.221) (top to bottom):
  - Primary geomembrane
  - Leak detection layer (drainage gravel or geosynthetic)
  - Secondary geomembrane
  - 3 feet of 10^{-7} cm/sec clay
- Proposed Liner System (top to bottom):
  - 60 mil HDPE primary geomembrane
  - Leak detection system layer with geonet (on base) and drainage geocomposite (on slopes)
  - 60 mil HDPE secondary geomembrane
  - Geosynthetic clay liner (GCL)



Primary Liner Characteristics

- HDPE geomembrane chosen for its long term performance due to:
  - Chemical resistance properties
  - Resistance to UV radiation
  - High tensile strength
  - High stress-crack resistance
- Light-reflective upper surface (i.e., white)
  - Additional UV resistance through UV reflection
  - Minimizes expansion/contraction wrinkles
  - Reduces heat build up and thermal expansion by reflective solar radiation
  - Reduces desiccation effects to subgrade soils
  - Improves visual detection of installation damage
- Conductive liner
  - More reliable quality assurance through spark testing

Golder Associates

Leak Detection System Layer

- Designed per 40 CFR 264.221 to minimize hydraulic head on lower geomembrane liner
  - Leaks through primary liner collected in the LDS layer and routed to a sump
  - Automated submersible pump recovers leak solutions and returns them to the tailings cell
- Leak Detection System (LDS) layer comprised of:
  - HDPE geonet on base of tailings cells
    - High transmissivity
    - Low shear strength in contact with geomembrane, so used only on base of cells
  - Drainage geocomposite on side slopes of cells
    - HDPE geonet laminated on both sides to nonwoven geotextile filtration media
    - Increased interface shear strength for use on side slopes, but decreased transmissivity

Golder Associates

Secondary Composite Liner System

- Designed to maximize the amount of solution recovered by the LDS, and act as a final flow barrier protecting the subgrade
- Design consists of:
  - 60 mil HDPE double-sided textured geomembrane
    - Resistance to chemicals in solution
    - Double-sided texturing to increase frictional resistance
  - Geosynthetic clay liner (GCL)
    - No locally-available sources of clay, and difficult to achieve requirements even by amending local soils with bentonite
    - Compatibility testing with anticipated tailings solution indicate negligible change in GCL permeability
- Analyses (Giroud et al. 1997) show that the proposed secondary liner system with GCL is more stringent than the prescriptive liner system with 3 feet of clay.

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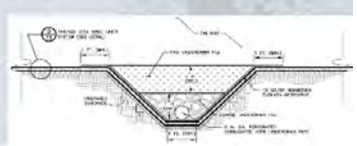
Underdrain System Design

- Underdrain system required to facilitate dewatering of the tailings (6 CCR 1007-1, Part 18, Appendix A, Criterion 5E)
  - Reduce driving head for seepage on the liner system
  - Anticipated tailings gradation is considered amenable to dewatering (i.e., relatively coarse-grained silty sands and sandy silts)
- Design consists of:
  - Perforated HDPE collection pipes at the base of the tailings cell to collect and convey solution to the underdrain sumps
  - Solution collected in underdrain sumps will be returned to the mill circuit through use of automated submersible pumps



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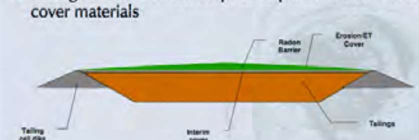
Tailings Closure Considerations

- Minimize post-closure maintenance
- Perimeter external berm side slopes designed at 10H:1V to consider closure
- Cover materials will be placed over tailings in each cell as deposition is complete
- Tailings will be dewatered prior to placement of closure cover materials



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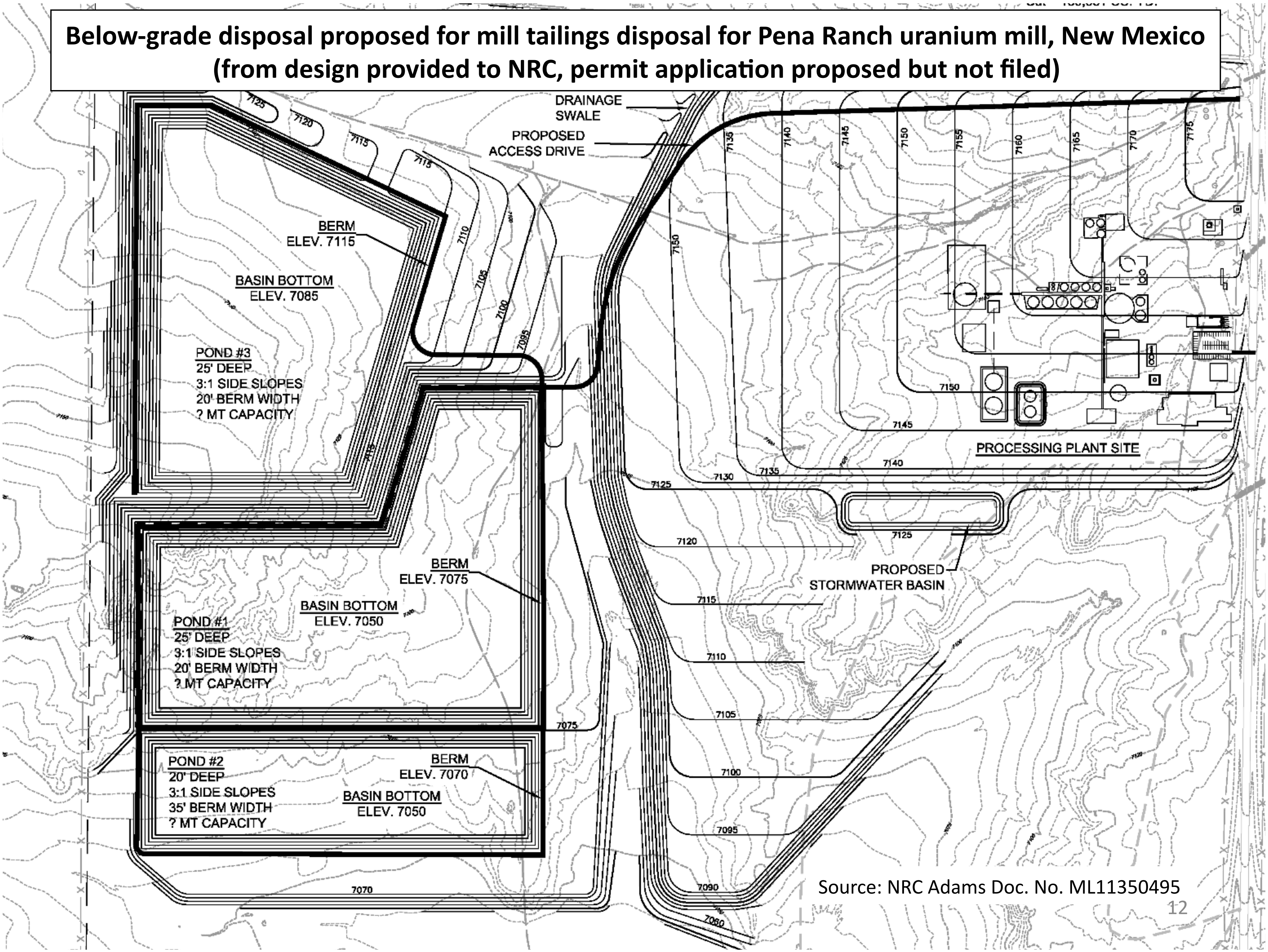
Below-grade disposal proposed for mill tailings disposal for Pena Ranch uranium mill, New Mexico (from design provided to NRC, permit application proposed but not filed)



Source: NRC Adams Doc. No. ML11350495

High Density Thickened Tailings (HDTT) Storage

- Thickened tailings, as the name suggests, involves the mechanical process of dewatering low solids concentrated slurry. This is normally achieved by using compression (or high rate) thickeners or a combination of thickeners and filter presses. High Density Thickened Tailings (HDTT) are defined as tailings that have been significantly dewatered to a point where they will form a homogeneous non-segregated mass when deposited from the end of a pipe

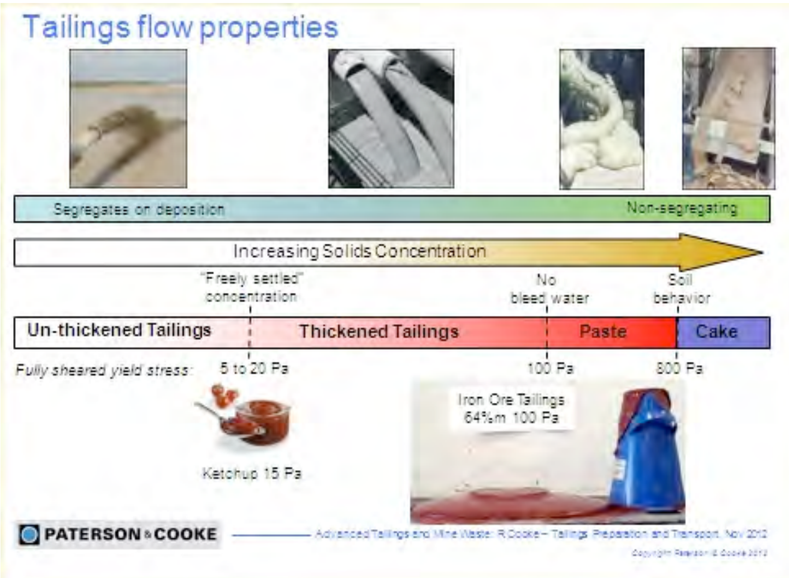
Surface Paste Tailings Disposal

Paste tailings are defined as tailings that have been significantly dewatered to a point where they do not have a critical flow velocity when pumped, do not segregate as they deposit and produce minimal (if any) bleed water when discharged from a pipe

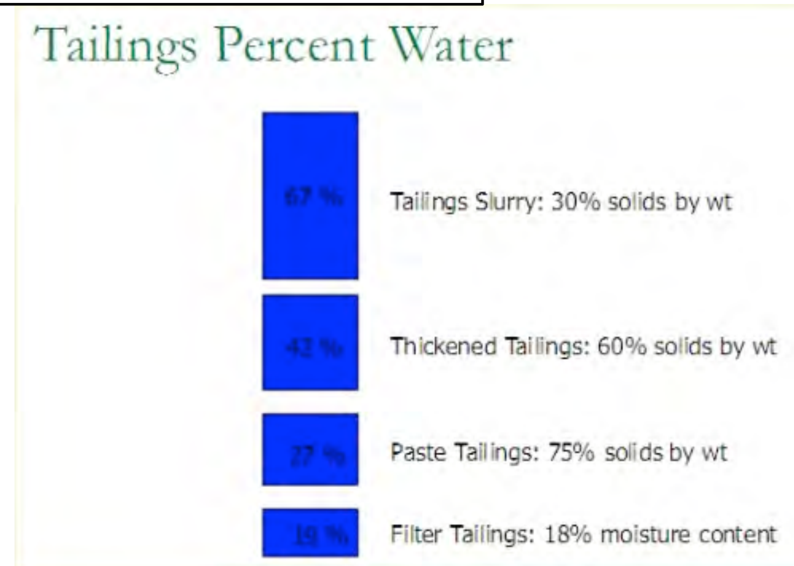
Dry Stacking of Tailings (Filtered Tailings)

- Dewatering tailings to higher degrees than paste produces a filtered wet (saturated) and dry (unsaturated) cake that can no longer be transported by pipeline due to its low moisture content

Illustrations for Understanding Tailings Dewatering Options



http://technology.infomine.com/reviews/PasteTailings/



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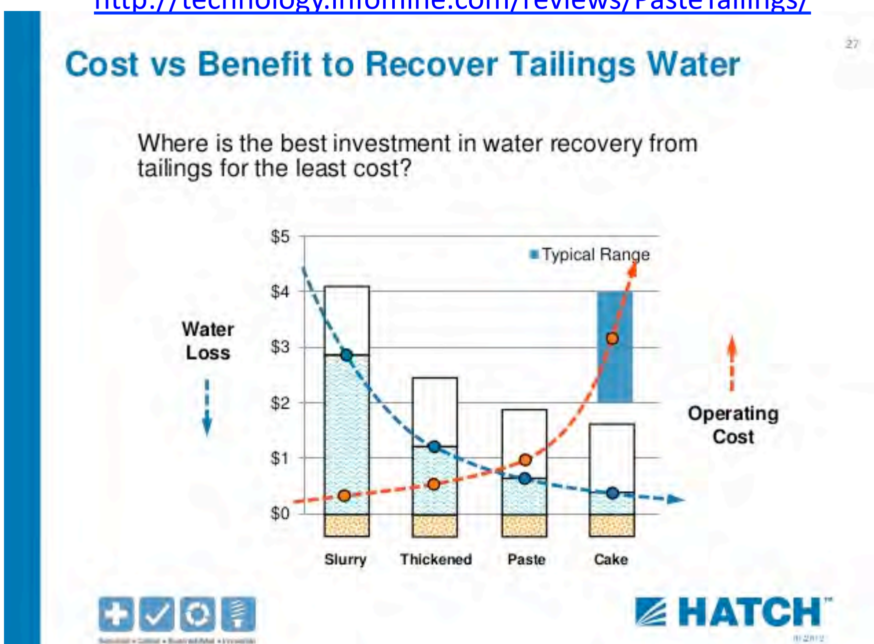
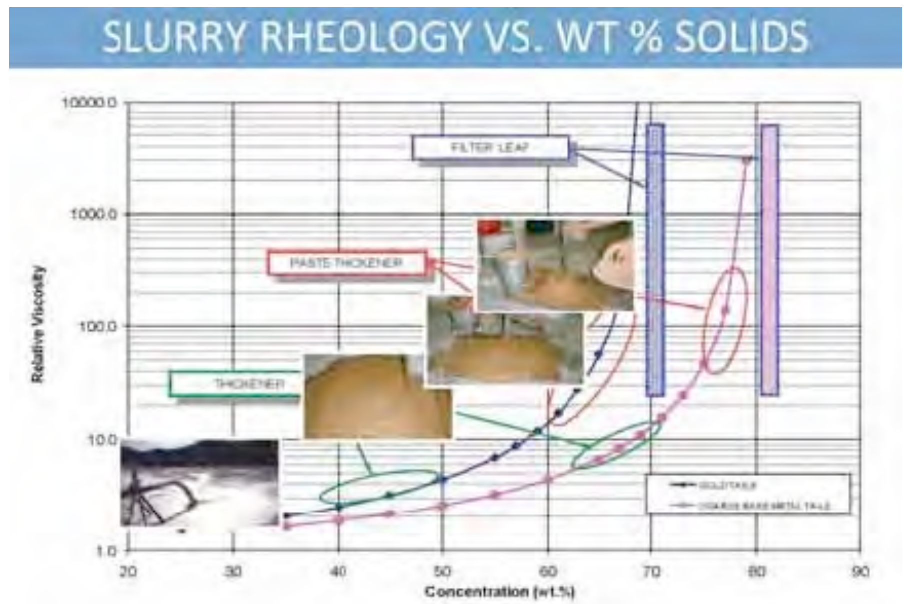


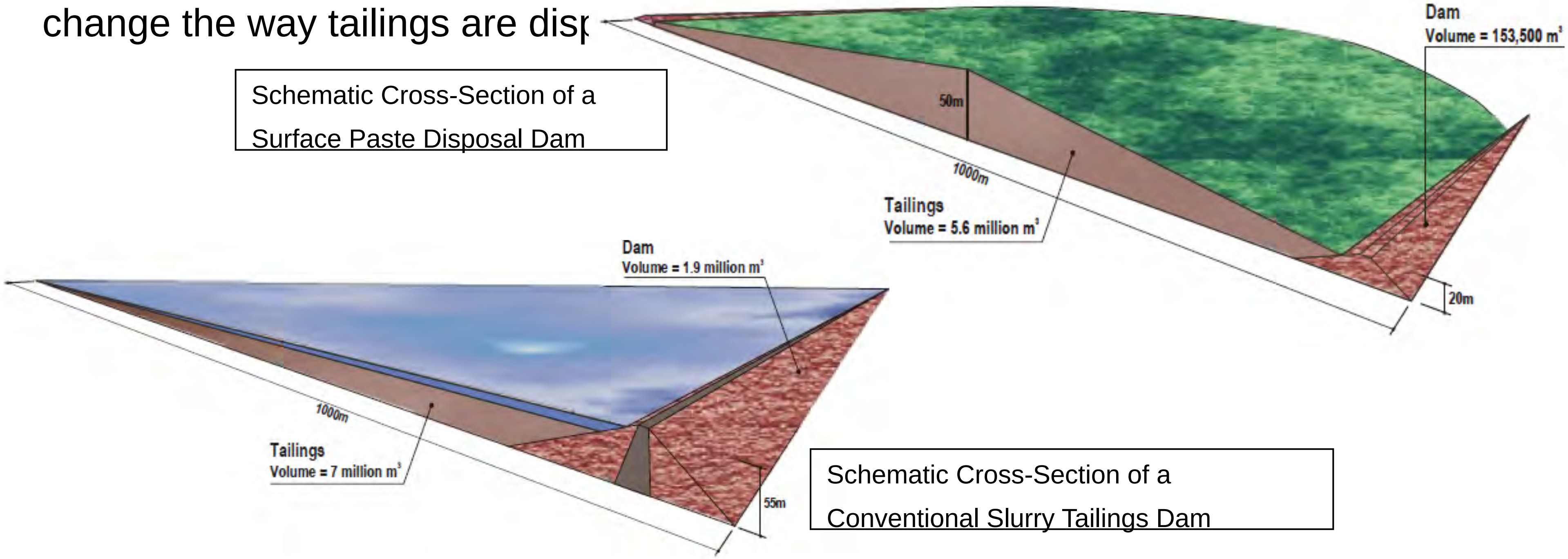
http://www.convencionminera.com/perumin31/encuentros/tecnologia/jueves19/1230-Jerry-Rowe.pdf



http://www.womp-int.com/story/2011vol09/story025.htm

“Paste – The Future of Tailings Disposal?

- In the last decade paste technology has progressed from a research based backfill idea to a widely accepted, cost effective backfill method with the potential to radically change the way tailings are disp



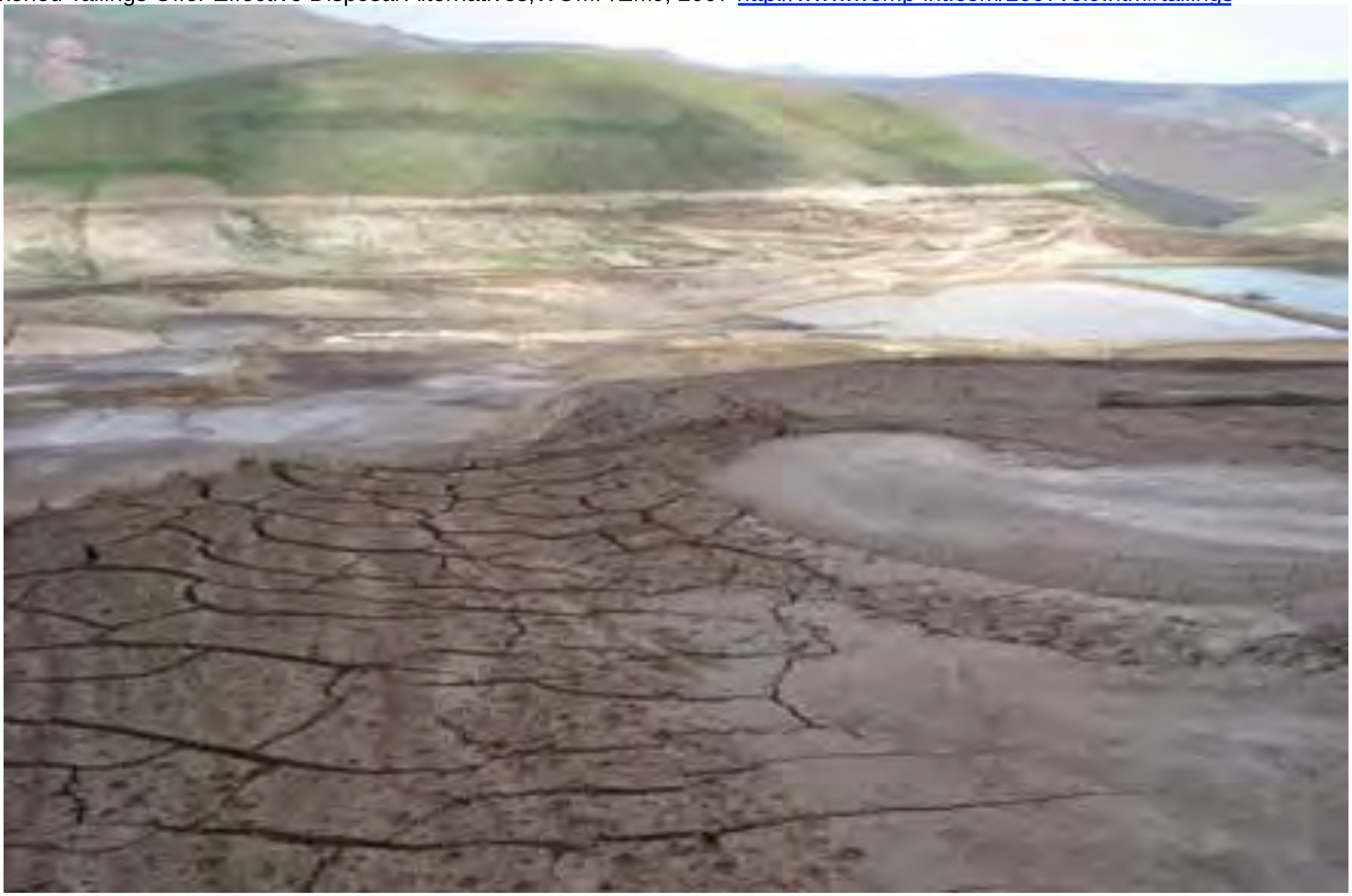
Paste is simply dewatered tailings with little or no water bleed that are non-segregating in nature. It can be ‘stacked’ on surface and the risks associated with dam failure significantly reduces since there is no liquid containment and therefore no mechanism for the tailings to travel for tens of kilometres downstream in the event of a containment failure.

- The operating costs for the preparation and transportation of paste may be higher but life-of-mine cost analysis shows comparable costs to conventional disposal with significant environmental benefits. In addition, the eco-political impact of non water-retaining tailings dams could reduce permitting time considerably.

Paste-The Future of Tailings Disposal, 1Golder Associates (UK) Ltd, 2001
http://www.golder.com/archive/skelleftea2001pastedisposal.pdf

“Highly-Thickened Tailings, Such as “Paste tailings,” offer effective disposal alternatives as standard industry methods for tailings disposal receive mounting economic and social scrutiny, paste may become an increasingly attractive option.”

Frank Palkovits, Thickened Tailings Offer Effective Disposal Alternatives,WOMP/EMJ, 2007 http://www.womp-int.com/2007vol9.htm#tailings



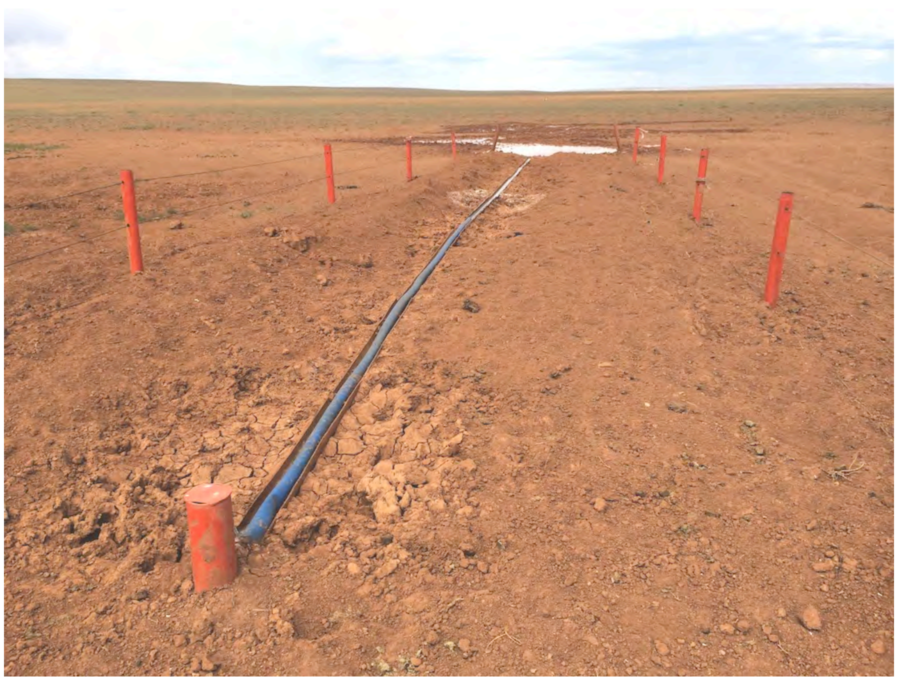
A paste deposit, as shown here, is one alternative among many in a range of possible thickened tailings formulations. The right choice for any specific tailings application depends on a variety of factors.

Full hydrologic and water quality characterization fundamental to water resource protection

Uncontrolled flow from released from artesian wells created for use in aquifer tests at uranium exploration site has resulted in significant drop in flow at a natural spring that is sole water source for a Soum (county) in southeast Mongolia.

Pre-drilling environmental assessment identifying water sources and hydrologic conditions may have been able to prevent this damage

Ongon Soum, Sukhbaatar Aimag,



Water waste and unknown groundwater conditions leads to dramatic reduction in water supply

Failure to conduct hydrologic characterization or monitoring water sources results in reduced flow at the sole water source for people and their livestock in Ongon Soum, Sukhbaatar Aimag, Mongolia

Water resources in desert regions are unique and irreplaceable – Avoidance of impact is fundamental to water resource protection as mitigation likely to be difficult to impossible

Herder born at Bor Ovoo and his son looking at rust-stained water in 2013 being provided by Oyu Tolgoi at proposed Bor Ovoo Spring replacement site

Livestock of family that lived at and used Bor Ovoo Spring to which they will never be able to return

Figure 6.1: Undai Flowing at Bor Ovoo location following Rainfall Higher up the Catchment

Wild Ass near OT fenceline

Figure 6.22: Bor Ovoo Spring Located on the Southern Part of the Oyu Tolgoi Mine Licence Area

Herder born at Bor Ovoo Spring said the spring was used regular by 10 – 20 families and their livestock

but was only water available in early winter – into January - and was used by 50 - 100 families and their livestock as well as wild animals.

Lack of extra land and water in region eliminates application of "mitigation by offsets" and effective family or livestock relocations

Water from pipes inside OT fence flowing toward Proposed Bor Ovoo Spring replacement site in 2013

Water at proposed Bor Ovoo Spring appears to soak into ground completely within 200 meters of pipes from which it flows in 2013

Camels waiting at decades old Watering well now dry as a result of draining of soil water due to erroneous monitoring well construction that has yet to be repaired

Camels reacting to people approaching well hoping for water to be filled into their drinking trough

"The cascading well" is one of the six improperly constructed monitoring that wells that has drained the soil water decades old wells into top Gunii Hooloi deep aquifer; none of which have been repaired to prevent continued draining of soil water to the deep aquifer

Decades old livestock water well where the soil water level has dropped significantly due to the lowering of the water level in the soil water aquifer due to faulty and unrepaired monitoring wells nearby

Failure to construct boreholes as designed creates devastating water losses – Oyu Tolgoi's ESIA says "Typical Borehole Design" – ESIA Water Resources Management Plan p. 32 of 48

"The design of boreholes in the Gunnii Hooloi and elsewhere has evolved over the life of the Project such that the permitted design is more protective of the shallow groundwater aquifers present in the basin. A typical well design (GH05-PB01) is presented below. Pertinent points being:

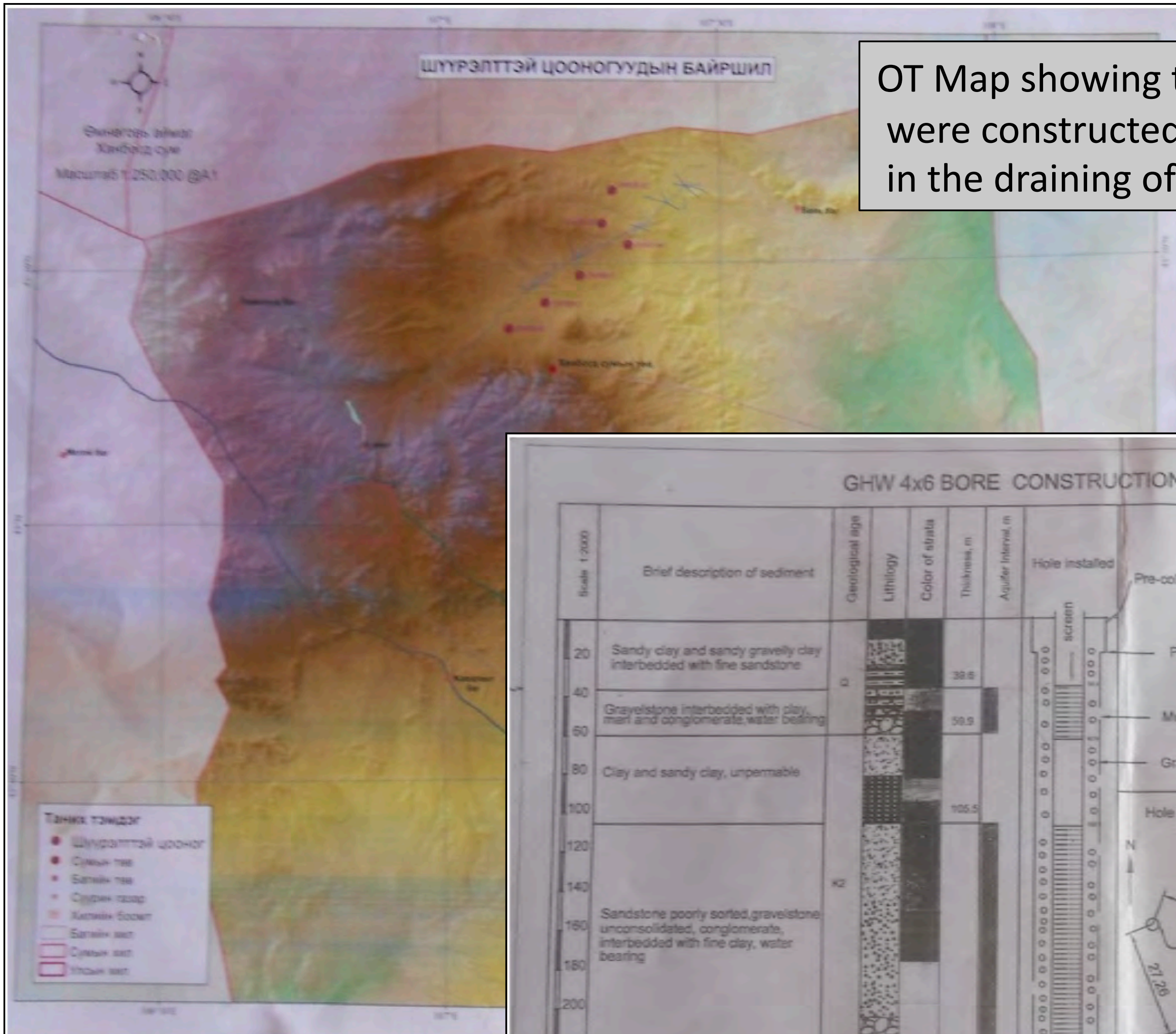
1.Surface seal around the borehole to prevent any infiltration from the surface into the annulus.

2.Solid casing from surface down to the aquifer unit.

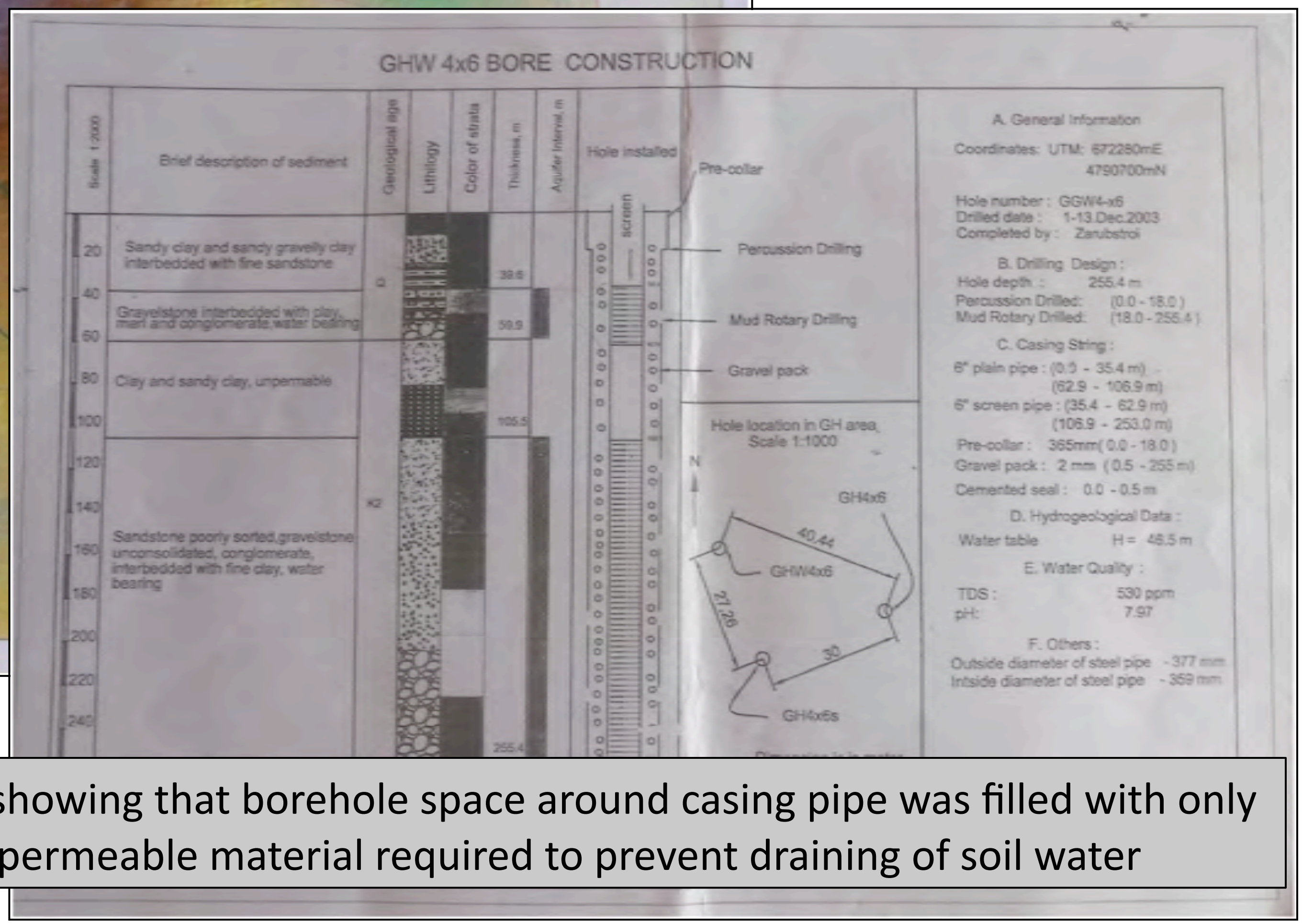
3. **Upper sections of the well bore grouted with impermeable material (bentonite or similar) to ensure that any surface or shallow aquifers units in the borehole are sealed and cannot flow into the annulus**.

4.Gravel pack around the casing and screen through the aquifer section. This design will be adapted as required to reflect the local hydrogeology; however the key principle of preventing flows between hydraulically distinct shallow and deep aquifer horizons will be maintained in all designs."

OT acknowledges that contractors failed to include "**grouted with impermeable material (bentonite or similar) to ensure that any surface or shallow aquifers units in the borehole are sealed and cannot flow into the annulus**" in 6 of 10 monitoring wells resulting in the surface and shallow aquifers being drained of water which flowed in down into the deeper aquifer. None of the erroneously constructed wells have been repaired and the damage to the soil water aquifer continues. Other traditionally used wells show dropping water levels as the effect of the drainage of the soil water aquifer spreads

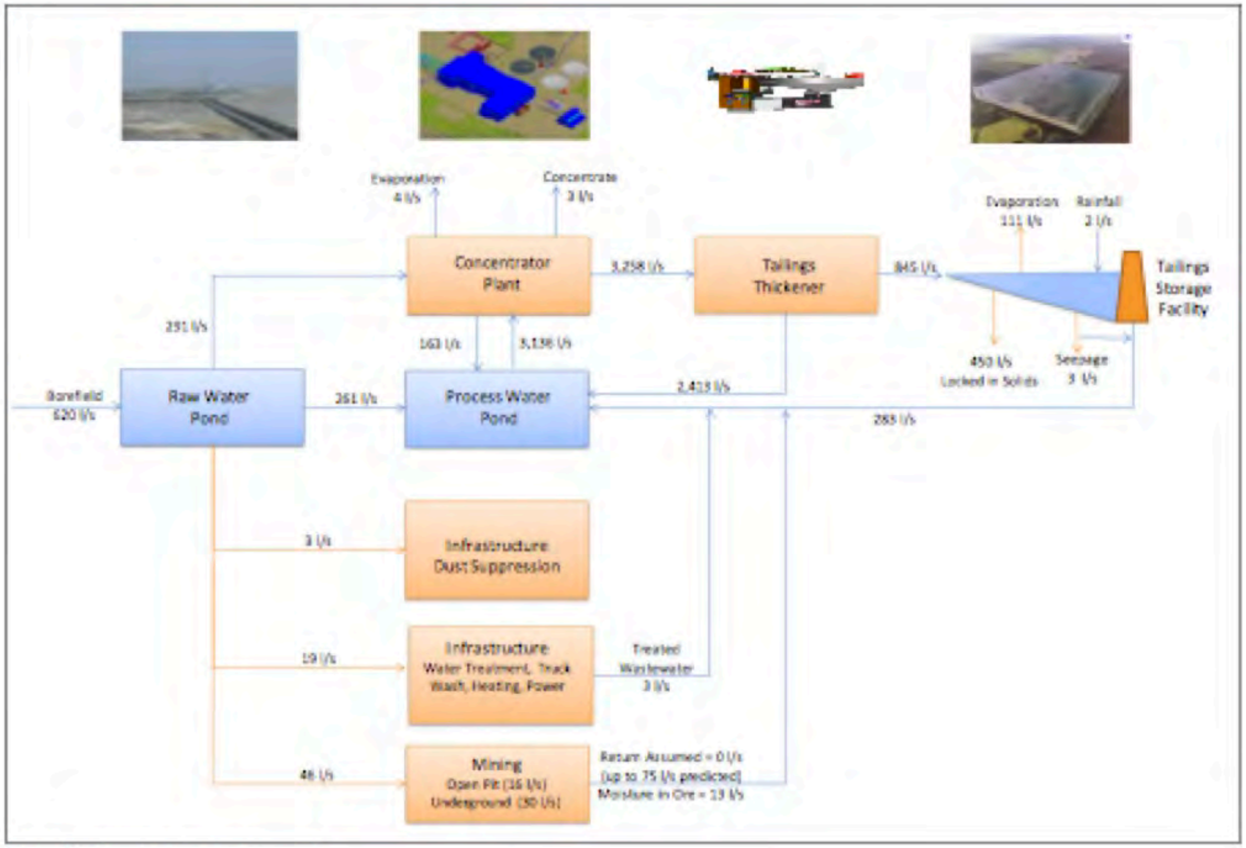


OT Map showing the 6 wells it acknowledges were constructed incorrectly resulting in the draining of the soil water aquifer



OT well completion record showing that borehole space around casing pipe was filled with only gravel pack without any impermeable material required to prevent draining of soil water

Figure 4.16: Water Balance 100,000tpd case



Note: Values in litres per second

Oyu Tolgoi estimates 561 l/s of water will be lost by evaporation at the tailings site (111 l/s) or locked in tailings (450 l/s).

"The average water demand during the initial years of 100,000 tpd mine production is predicted to be 696 L/s [if there is] no water recovery from the underground or open pit mines."
Project Description p. 42 of 77

This water is potentially recoverable by paste or dry tailings disposal and represents up to 80% of the water needed from the Gunii Hooloi groundwater extraction zone

450 l/s = 3.8 trillion cubic meters per year

The March 2013 Oyu Tolgoi Technical Report states,
"In 2005, Golder Associates completed an alternative TSF design with central discharge of a tailings paste thickened to densities as high as 70% solids. The capital and operating costs, and operational complexities, of a paste tailings system were found to be high compared to those associated with conventionally thickened tailings, and the reduction of water consumption by using paste was small. Therefore, this option was not pursued further. "

In its February 2013 Tailings Brief, Oyu Tolgoi states,
In 2006/2007 when Oyu Tolgoi was planning its tailings storage facility, further reducing the water content to 20% through the use of dry stack technology was not identified as a realistic option. Even a middle ground option, so called 'paste tailings' (containing 22-24% water), was not found to be justified due to the complexity and high costs that would be required at an operation on the scale of OT.

In sharp contrast to those conclusions, Oyu Tolgoi's 2006 Mining and Processing EIA finds: "The combined use of high-compression thickeners to increase the deposition density of tailings and of decant towers to reduce the size of the tailings pond area has the potential to reduce make-up water requirements and thereby reduce the water demand form the Gunii Hooloi well field. These water saving opportunities increase the rate of recirculation of process water and investigations are continuing as to the feasibility and cost implications" states in Section 2.4 Project Alternatives.

Since 2006-7 when Oyu Tolgoi's tailings facility design was developed, the use of high-density thickened, paste and dry-stack tailings disposal tailings systems at large mines has grown rapidly.

Existing large-scale mine operations as large or larger than Oyu Tolgoi that use high-density thickened tailings, paste or dry stack technology include: Chuquicamata, Chile – 230,000 tons per day; Quebrada Honda, Peru – 147,000 tons per day and Esperanza, Chile – 95,000 tons per day.

Perceived and realized benefit of High-Density Thickened, Paste and Dry Stack Tailings management include both reduced operating cost and potentially large reductions in water use

Table I

Perceived benefits of P&TT, after Tacey and Ruse (2006), with suggested gradings

Feature	Economic/engineering benefits	Environmental/social benefits	Grade
1. Similar capital cost and reduced operating cost compared with wet disposal	Overall economic benefit	Less resources applied to end of pipe and less corrective action	B
2. Costs accrued during operations	Reduced requirement for bonds and provisioning	Costs met by operator, no long-term y liability to communit	B
3. Increased deposit strength	Reduced risk of facility failure	Avoids offsite environmental and safety impacts	C
4. Decreased land footprint by at least doubling practical stacking height	Reduced land purchase cost	Reduced sterilization of productive land, reduced clearing	D
5. Decreased demand for borrow materials for construction	Less transport and construction	Reduced clearing for borrow materials, reduced greenhouse gas production in construction	A
6. Reduced risk of leachate seepage	Better leachate and reagent recovery	Reduced risk of ground- and surface water contamination	B
7. Reduces or eliminates ponding and low-strength mud deposits	Increased surface accessibility	Reduced injury to fauna, increased operator safety	B
8. Prompt creation of firm, convex draining surface at completion	Early creation of trafficable surface	Progressive or more rapid rehabilitation	C
9. Earlier, better surface leaching and drainage	Early leaching of toxicants from surface	More rapid establishment of vegetation, reduced duration of dust generation	D
10. Potentially large reductions in water use	Reduced need for water collection and supply facilities, pumping energy savings	Reduced footprint from water collection structures or impacts from diversion or abstraction	A
11. Reduced potential for liquefaction	Deposit remains firm and will not flow	Reduced offsite environmental and safety impacts	D
12. Potentially reduced heating, lower water demand	Reduced energy use, cost savings	Lower greenhouse gas emissions	C
13. Reduced reagent requirements	Potential operating cost savings	Reduced pollution risk	C

Source: Fourie 2012 "**Perceived and realized benefits of paste and thickened tailings for surface deposition,**" by A.B. Fourie, in The Journal of The Southern African Institute of Mining and Metallurgy, Volume 112, November 2012 , available at: http://www.saimm.co.za/journal-papers

Mine Waste and Tailings Reclamation Plans to Achieve Impact Avoidance and Mitigation Prior to Construction in Law

New Mexico Mining Act of 1993
Chapter 69 Section 39 Parts 1 – 37 New Mexico Statutes Annotated (NMSA)

Purposes - The purposes of the New Mexico Mining Act include **promoting responsible utilization and reclamation of lands affected by exploration, mining or the extraction of minerals that are vital to the welfare of New Mexico**. (69-39-2)

"Reclamation" means the employment during and after a mining operation of **measures designed to mitigate the disturbance of affected areas and permit areas and to the extent practicable**, provide for the stabilization of a permit area following closure that will **minimize future impact to the environment from the mining operation and protect air and water resources**. (69-36-3-K)

Financial Assurance – “require by regulation that the applicant file with the director, prior to the issuance of a permit, financial assurance. **The amount of the financial assurance shall be sufficient to assure the completion of the performance requirements of the permit, including closure and reclamation, if the work had to be performed by the director or a third party contractor and shall include periodic review to account for any inflationary increases and anticipated changes in reclamation or closure costs**. The regulations shall specify that financial requirements shall neither duplicate nor be less comprehensive than the federal financial requirements. **The form and amount of the financial assurance shall be subject to the approval of the director as part of the permit application; provided, financial assurance does not include any type or variety of self-guarantee or self-insurance**; (69-39-7-Q)

Effective Environmental Impact Assessments require fully design and financial guaranteed reclamation plans before project development

Waste Rock Management Plan "Intentionally Omitted" from ESIA

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"Preliminary environmental test work has shown that some open pit waste, mainly in the central pit, is potentially acid forming (PAF), but that a significant proportion of waste also has an acid neutralizing potential….

"Design work on the waste rock dump is ongoing and further information on how the Project will ensure that the design, construction, operation and closure of the WRD incorporates good international practice and meets applicable Mongolian standards and IFC and EBRD requirements to mitigate potential impacts is set out in *Chapter D9: Waste Rock Management Plan."*

"SECTION D: ENVIRONMENTAL AND SOCIAL CONSTRUCTION MANAGEMENT PLANS

CHAPTER D9: WASTE ROCK MANAGEMENT PLAN

This section is intentionally omitted and will be included with the operations- phase management plans which will be prepared in due course."

No reclamation plan was provide for waste rock in the ESIA either, only conceptual goals, though waste is the largest volume of material being generated at the open pit mine and that will be left at the site after mining ceases.

Oyu Tolgoi Intentionally Omitted its Tailings Management Plan from the ESIA

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"An Independent Tailings Review Board (ITRB) has been established in accordance with IFC Performance Standard 4 to provide independent review and oversight of TSF design and operational management. The ITRB will:

- Review TSF design and operational monitoring during construction and the initial phase of construction;
- Ensure that TSF design, construction and operation is undertaken in accordance with good international industry practice;
- Review the final TSF designs prior to financial close of project financing; and
- Review the final TSF construction as part of the Physical Facilities Completion Certificate for project financing."

"SECTION D: ENVIRONMENTAL AND SOCIAL CONSTRUCITON MANAGEMENT PLANS
CHAPTER D10: TAILINGS MANAGEMENT PLAN
This section is intentionally omitted and will be included with the operations- phase management plans which will be prepared in due course."

No reclamation plan was provided for the tailings disposal site, though tailings are the second largest volume of waste material to be left at the site after mining ceases

Best Practices enhanced by Citizen Enforcement

"**Citizen Suit**" means "**A person having an interest that is or may be adversely affected may commence a civil action on his own behalf to compel compliance with the New Mexico Mining**. Such action may be brought against:
the department of environment, the energy, minerals and natural resources department or the commission alleging a violation of the New Mexico Mining Act (NMMA) or of a rule, regulation, order or permit issued pursuant to that act;… a person who is alleged to be in violation of a rule, regulation, order or permit issued pursuant to the NMMA; or…the department of environment, the energy, minerals and natural resources department or the commission alleging a failure to perform any nondiscretionary act or duty required by the NMMA;" ….(69-39-14)

Civil Penalties may be assessed by the director or the commission for violations of the NMMA including a violation of a regulation of the commission, an order of the director, a permit condition and the order resulting from a hearing. Civil penalties assessed by the director or the commission shall be imposed pursuant to regulations adopted by the commission. Any penalty assessed shall not exceed ten thousand dollars ($10,000) per day of noncompliance for each violation….. (69-39-17)

Criminal Penalties - Any person who knowingly or willfully violates the NMMA, regulations adopted by the commission or a condition of a permit issued pursuant to the NMMA … or fails or refuses to comply with a final decision or order of the commission or the director is guilty of a misdemeanor and is subject to a fine not to exceed ten thousand dollars ($10,000) per day of violation or imprisonment of up to one year, or both. (69-39-18)

Full text of New Mexico Mining Act available in compilation of New Mexico Statutes at:
http://www.conwaygreene.com/nmsu/lpext.dll?f=templates&fn=main-h.htm&2.0
New Mexico Mining Act Regulations available at:
http://www.emnrd.state.nm.us/MMD/MARP/MARPRulesandRegulations.htm

Design and Operational Practice to minimize or eliminate failures at Existing Tailings Dams:

1) Operations establish and maintain tailings beach to keep liquids from saturating dam;
2) Constructed using engineering multi-layer liner with seepage detection systems
   A) protecting upstream face of dam and
   B) on prepared and compacted “pillotka” below tailings disposal area to prevent infiltration;
3) constructing (or reconstructing) dam with below ground cutoff trench to prevent subsurface flow below and through dam;
4) constructing (or reconstructing) dam with wide base structural engineered to prevent infiltration;
5) Distribute tailings from multiple discharge points into dam to establish thin layers of tailings to reduce infiltration potential and
6) Use of dry, paste or highly-thickened tailings technology maximizes recycle of liquids fand minimize liquids volume in tailings dam and cut potential for short and long-term seepage.

Samarta Tailings Dam, Buryatia - Example of (1) tailings beach established to keep liquids from saturating dam, (5) use of multiple tailings discharge points to establish thin layers of tailings to reduce infiltration potential and (6) tailings liquid recycle to reduce volume of liquids behind dam.

Full hydrologic system and water quality characterization of water resource monitoring fundamental protection of water resources and prevention of irreversible impacts due to conventional and solution mining

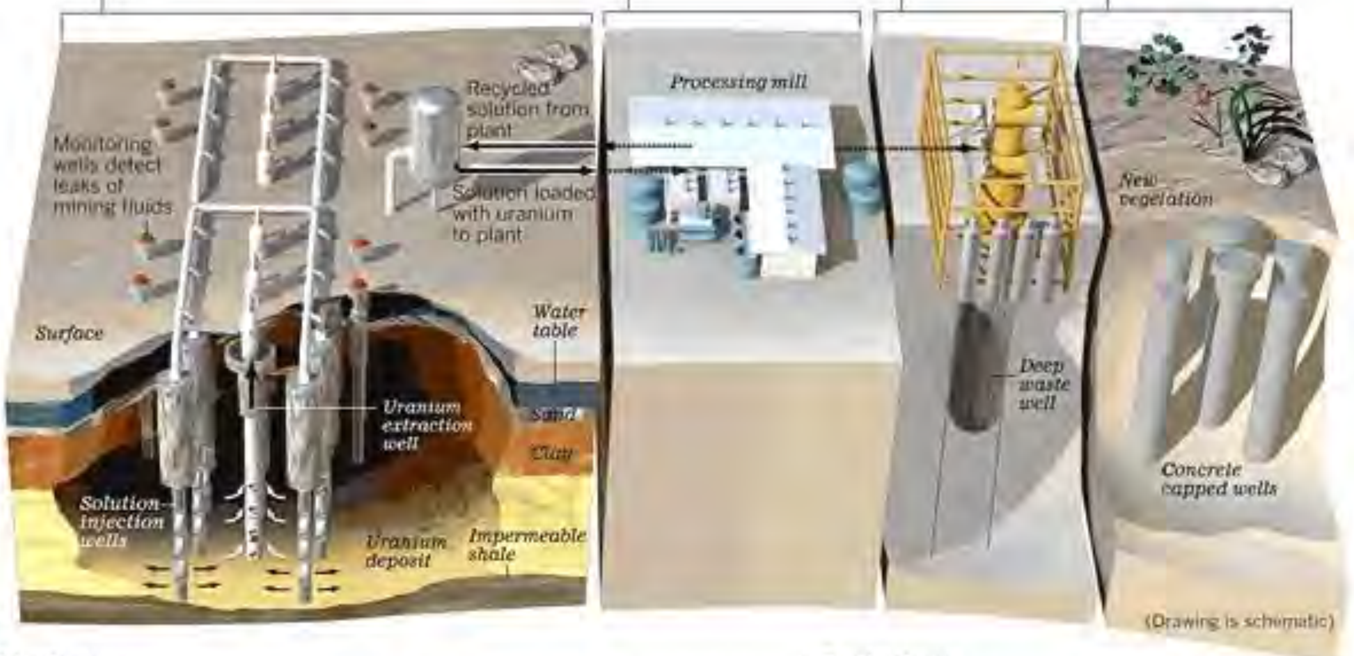
Solution mining

Extraction
A solution of groundwater and oxygen is pumped into injection wells drilled through layers of sandstone. Oxygen rusts uranium in the sandstone. Uranium dissolves in the water, and the solution is pumped to the surface.

Processing
The solution is pumped to a plant, where uranium is removed. Water is reoxygenated and pumped back down injection wells. It recirculates until uranium in the deposit is depleted.

Waste management
Wastewater is treated and pumped into disposal wells, evaporated or sprinkled into the soil at the surface. Solids are sent to a waste disposal site.

Restoration
Water is purified and reinjected into the well field. Wells are later filled with concrete and capped below the surface. Surface soil is decontaminated if necessary.



Advantages
- Minimal surface disturbance.
- No mine to rehabilitate.
- Does not create excess rock piles or tailings from processing.
- Can be used for small deposits that are not economical for conventional mining.
- Uranium can be processed on site.
- Less time is needed for establishing and maintaining mining facilities.

Disadvantages
- Cannot be used at sites without the necessary geological layering.
- Requires water in the uranium deposit.
- Rock being mined must be permeable.
- Restoring water to an acceptable level of purity can be difficult.

Sources: Uranium Producers of America, Environmental Protection Agency, National Energy Institute, Bureau of Land Management, Utah Geological Survey, Uranium Resources, Inc.
Graphics reporting by Tom Reinken; *Graphic by* Lorena Iniguez *Los Angeles Times*

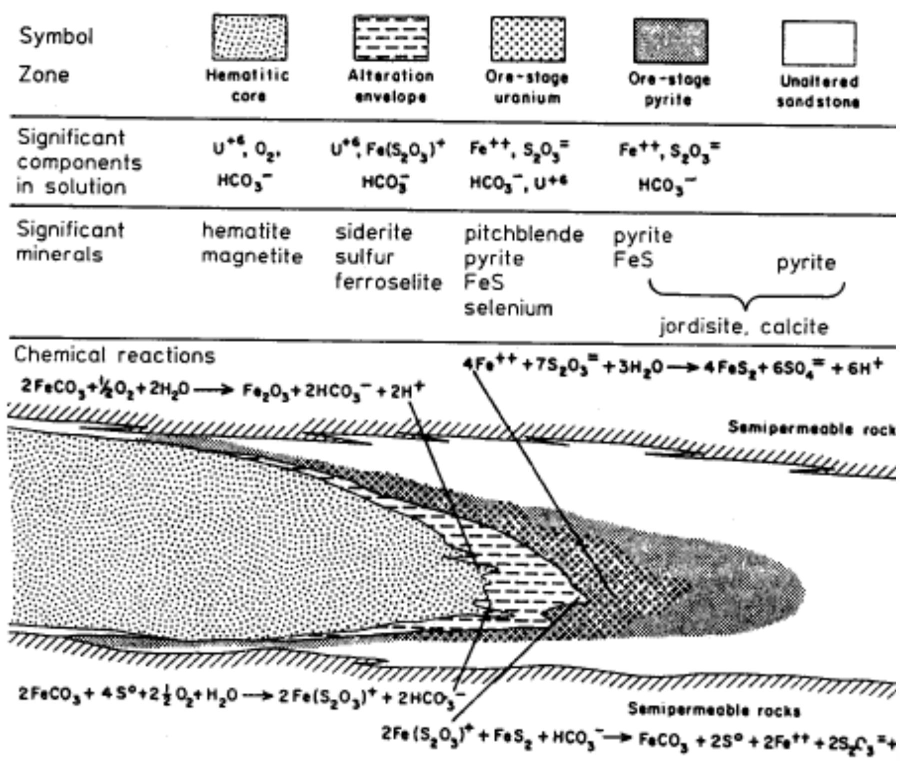


Figure 3. Schematic of idealized Wyoming Basin uranium roll front deposit showing alteration zones, related mineral components, solution components, and important aqueous chemical reactions for Fe, S, O, and CO_2 (after Granger and Warren, 1974).

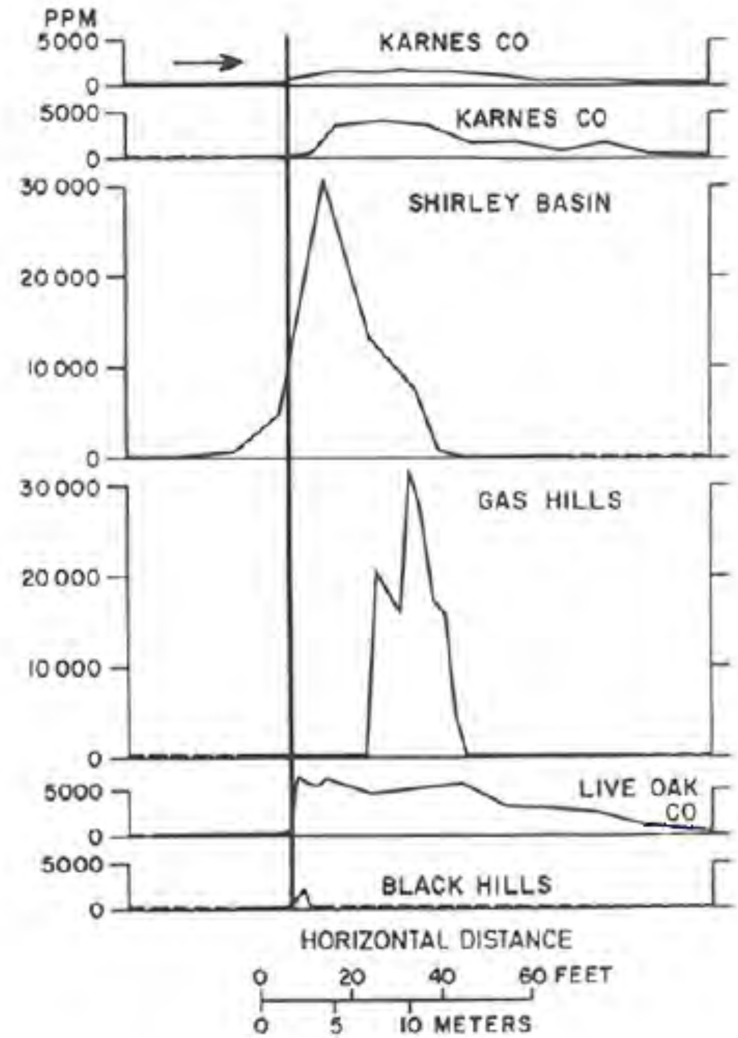


Figure 5. Concentration and distribution of uranium in various roll front deposits (after Harshman, 1974).

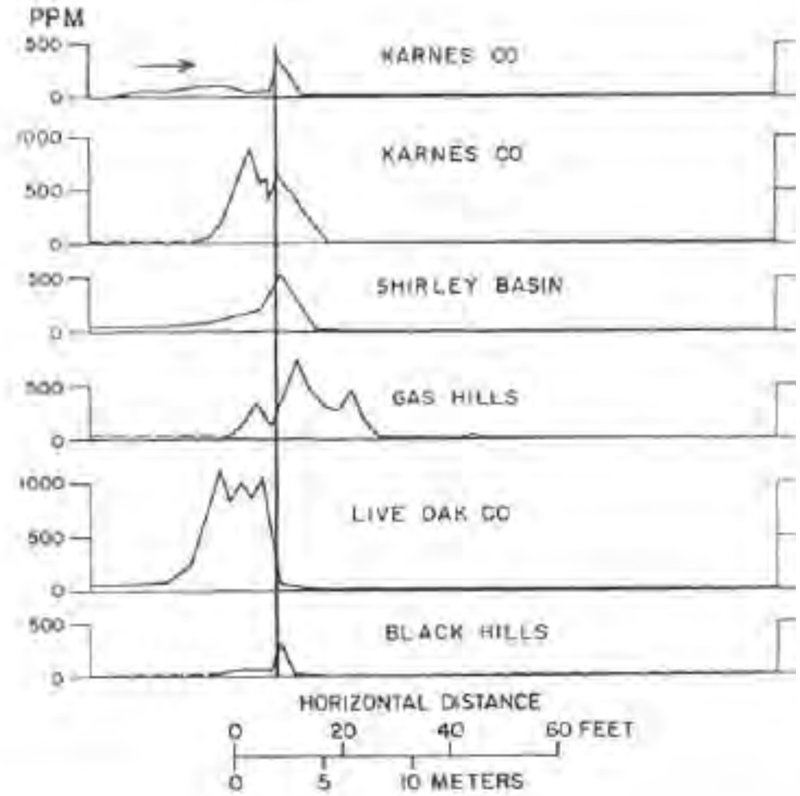


Figure 6. Concentration and distribution of selenium in various uranium roll fro
deposits (after Harshman, 1974).

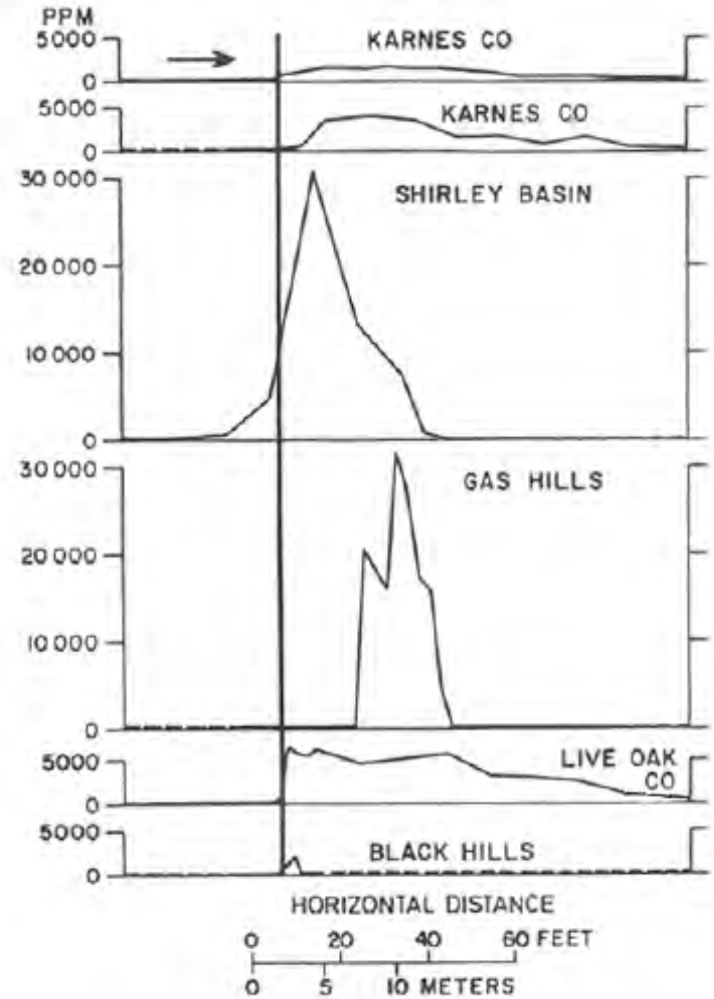


Figure 8. Concentration and distribution of arsenic in various uranium roll front
deposits (after Harshman, 1974).

Why is restoration to pre-mining background is so difficult at ISR Mine?:

Consideration of Geochemical Issues in Groundwater Restoration at Uranium
In Situ Leach Mining Facilities,NUREG/CR-6870, January 2007
Prepared by USGS for NRC,
http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr6870/

…Because of heterogeneities in the aquifers, the fresh groundwater that is brought into the ore zone does not completely displace the residual lixiviant….

…groundwater sweep may cause oxic groundwater from upgradient of the deposit to enter into the mined area, making it more difficult to re-establish chemically reducing conditions...

…it is difficult to predict how much time is required or even if the reducing conditions will return via natural processes. The mining disturbance introduces a considerable amount of oxidant to the mined region.....

Injection of lixiviant - leaching fluid - destroys water quality
oxidizes & mobilizes contaminants
changes the redox potential of the rock

Restoration to baseline is not possible as contaminants continue to bleed with time

'Restored' water migrates downgradient and follows paleochannel flow paths carrying elevated levels of U, Ra, SO_4, O_2

Natural attenuation is unlikely because the net charge on rock particles is negative therefore anions will not adsorb to rock particle contamination plume grows with time.

Erdenet Ore Processing Mill Tailings Pond

With its current tailings disposal site approaching its capacity limit, the need for additional tailings disposal capacity provides an opportunity for innovative site selection process, design and operation technology for long-term stability of operations and reduced impact on water and air

Thank you for your time and attention