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# Ultra paste and central thickened discharge: a paradigm shift in tailings management

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## Abstract

*Tailings management remains a top priority for the mining industry, driven by the pursuit of safety, environmental sustainability and operational efficiency. The accumulation and subsequent loss of water in tailings storage facilities (TSFs) poses a significant challenge, leading to the growing popularity of schemes that reduce water content in tailings. One such scheme is central thickened discharge (CTD), where the slurry is discharged in the centre of the disposal area to create a low conical 'hill' of tailings. Retaining embankments are thus minimised. The beach slope formed by the deposited tailings plays a crucial role in its design. This slope depends on the discharge flow rate and slurry rheology, which, in turn, is influenced by the solids concentration and particle size distribution of the discharged tailings.*

*This paper focuses on the concept of ultra paste (UP) – a novel approach that utilises a combination of thickening and filtration to achieve a higher solids concentration in the slurry. The objective is to maintain a pumpable and self-distributing slurry at the TSF, but be capable of depositing at a steeper beach slope than achievable through thickening alone. By exploring the development and components of UP, this paper highlights its potential advantages compared to other non-conventional methods like filtration and paste systems.*

*Furthermore, the paper addresses the potential risks associated with UP and proposes comprehensive strategies for risk mitigation. A case study is presented to compare three schemes – paste, UP, and filter stack based on cost, water conservation and risk management. This comparative analysis provides insights into the potential benefits and limitations of each scheme, demonstrating how UP has the potential to widen the range of topographic conditions suitable for thickened tailings discharge.*

*In conclusion, the application of combined UP and CTD represents a paradigm shift in tailings management, offering a balance between solids concentration, pumpability and deposition slope. By understanding the advantages and risks associated with UP and CTD, mining industry stakeholders can make informed decisions to enhance their tailings management practices, contributing to safer and more sustainable mining operations. The adoption of this innovative approach has the potential to increase the available options for tailings management and contribute to the advancement of environmentally responsible mining operations.*

**Keywords:** *tailings management, central thickened discharge, ultra paste*

## 1 Introduction

In light of recent failures of conventional tailings management facilities worldwide, there is an increasing urgency for the adoption of modern tailings management methods. Modern tailings management necessitates the adoption of advanced practices and technologies to effectively address environmental, safety, and sustainability concerns related to tailings storage.

Key preliminary considerations include:

- Design for safety and stability: modern tailings facilities prioritise designs ensuring structural stability and safety through advanced engineering techniques, monitoring systems and comprehensive risk assessments.
- Geotechnical characterisation: in-depth geotechnical studies are conducted to comprehend the physical and mechanical properties of tailings materials, aiding in the design of storage facilities resilient to various environmental conditions.
- Water recycling and conservation: emphasising water recycling to minimise freshwater consumption and reduce environmental impact involves implementing efficient water recovery systems and strategies for reusing process water.
- Advanced dewatering technologies: the use of advanced dewatering technologies, such as high-density or paste thickeners, alongside various filters, decanters and centrifuges, helps minimise water volume in tailings, facilitating a more stable and manageable storage structure.
- Monitoring and surveillance: continuous monitoring and surveillance systems, including satellite imagery, drones and real-time instrumentation, are integrated to track stability, seepage, deposition and beach profile development and the environmental impact of tailings storage facilities (TSFs).
- Regulatory compliance: adhering to stringent environmental regulations and guidelines is crucial. This includes compliance with international standards and local regulatory requirements to ensure responsible mining practices.
- Community engagement: engaging with local communities and stakeholders is vital. Modern tailings management involves transparent communication, addressing concerns and incorporating feedback from communities affected by mining operations.
- Closure and rehabilitation planning: planning for the closure and rehabilitation of tailings facilities begins early, involving strategies for decommissioning the facility and restoring the site to its natural state.
- Innovation and research: encouraging and integrating ongoing research and innovation is fundamental, exploring new technologies, materials and methodologies to continually improve the environmental and safety performance of tailings management.

By addressing these considerations, modern tailings management aims to enhance environmental sustainability, minimise risks and contribute to responsible and ethical mining practices.

These are the primary reasons why non-conventional tailings management schemes, namely thickened tailings disposal schemes – central thickened discharge (CTD) and down-valley disposal (DVD) – and filter stack schemes, are gaining favour among mining companies, predominantly due to lower water content in the tailings.

Filter stack schemes are at the extreme end of the dewatering range. However, while they offer numerous advantages, there are also downsides and challenges associated with this approach. Here are some common downsides:

- General high initial investment.
- High maintenance and operating expenses (especially the material handling cost).
- Variable filter cake moisture content leading to material handling problems.
- Problems created by variable feed tailings characteristics.
- Possibility that placed filter cake may still be susceptible to seismic and static liquefaction.

- Climate sensitivity (in cases where evaporation is required to achieve safe external slopes and when too much precipitation becomes a prohibiting factor).
- Size limitations (i.e. utilisation of filter stacks for large mining operations may be impractical).

## 2 What is ultra paste

Ultra paste (UP) represents an additional level within the dewatering range. The applicability of thickened tailings disposal at the moment is limited by the achievable beach slope. If the natural terrain has a slope steeper than the achievable beach slope, then CTD is not feasible without at least some retaining embankments. Ultimately, this leads to down-valley discharge (DVD) to a dam. Whilst this can still be the optimum configuration, it is sub-optimal compared to CTD. Clearly, if the achievable beach slope could be increased, the range of topographies where CTD is feasible also increases (or if DVD is retained, the size of the toe dams can be decreased). This requires solids concentrations higher than paste thickener underflow. This is the area that is targeted by ultra paste.

With reference to the diagram presented by Jewell & Fourie (2015) and also reproduced in Figure 1, as the tailings water content decreases (dewatered), tailings yield stress increases in an exponential manner. In turn, the dewatering techniques becomes more complicated moving from high-rate thickeners for lower solids concentration tailings underflow to high-density thickeners and deep-cone (paste) thickeners. For further dewatering, filters, decanters and centrifuges are used.

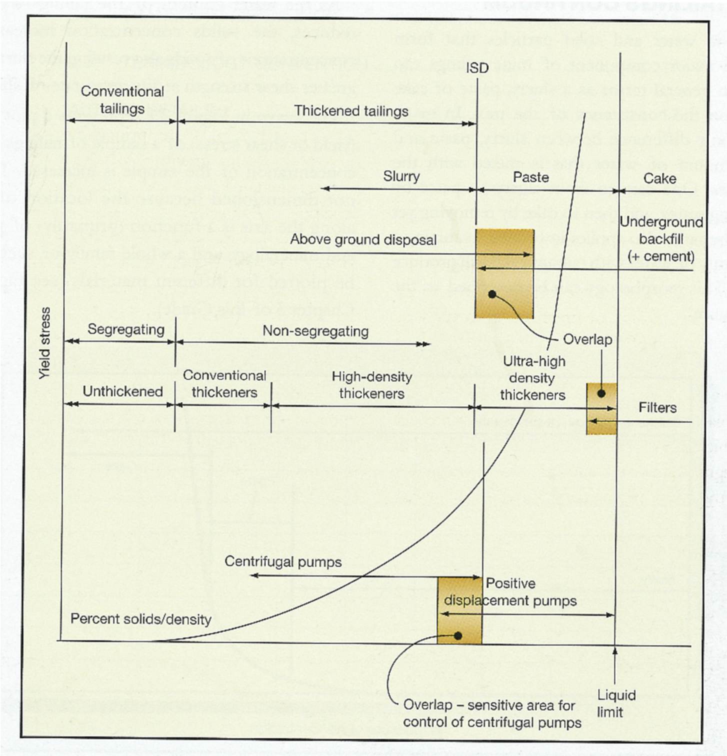

**Figure 1 Indicative relationship between tailings solids concentration and yield stress (Jewell & Fourie 2015)**

At lower solids concentrations, centrifugal slurry pumps suffice for transportation, while higher concentrations (yield stresses) eventually demand positive displacement pumps (Krimpenfort 2018). For cake transportation, dry methods like trucks and conveyor belts are used. In these cases, the tailings also have to be spread and compacted in the stack. These requirements are expensive. Slurried tailings options are attractive because they manage their own distribution.

The goal for UP is for the tailings to be dewatered to higher than paste thickener underflow densities but to still be pumpable, albeit with positive displacement pumps.

Another aspect that plays an important role in the selection of the tailings management technology is water consumption. As more sophisticated dewatering techniques are adopted, and leading to higher tailings solids concentration, the quantity of water loss (entrapped water within the TSF) decreases. The lost water in a TSF is usually considered to be equal to process make-up water that needs to be supplied from decant recovery and external sources. Figure 2 shows the relationship between the solids concentration of the tailings prior to deposition and the quantity of required make-up water in cubic metres per tonne of tailings.

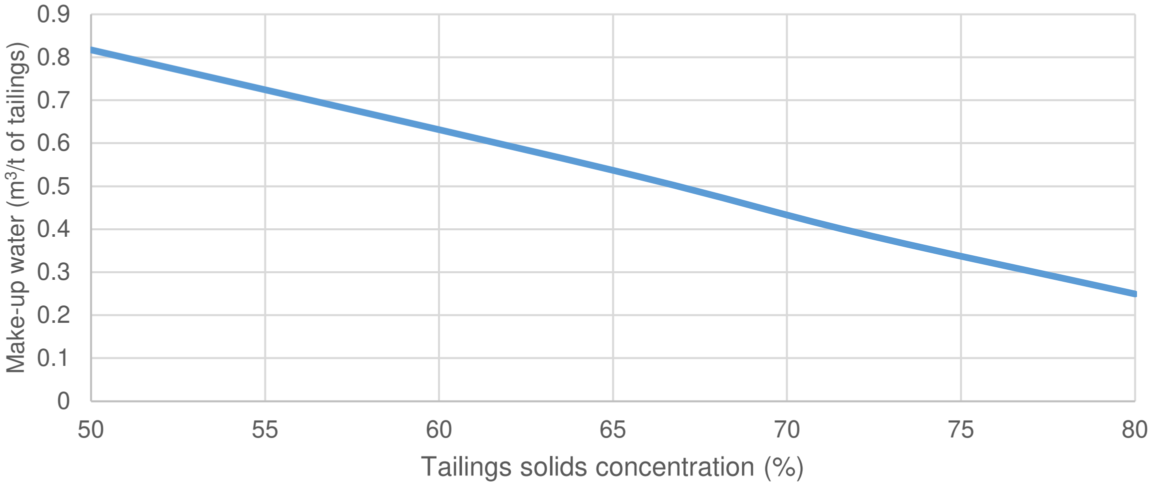

**Figure 2 Relationship between the required make-up water and tailings solids concentration**

The UP technology effectively addresses the limitations of the filter stack method while capitalising on the advantages of paste technology. Its key benefits include streamlined tailings transportation via positive displacement (PD) pumps and pipelines, eliminating the need for costly dry transportation methods. Additionally, UP schemes do not require emergency short-term tailings storage during filter downtime. The utilisation of PD pumps facilitates a laminar flow regime in the tailings pipeline, reducing wear. Although water loss in the UP scheme is slightly higher than in the filter stack method, it remains lower than traditional paste methods, representing a balanced compromise. Moreover, hydraulic transportation eliminates the need for tailings distribution and compaction, further enhancing operational efficiency. Thus, in summary, the key advantages are:

- Tailings transportation: since tailings remain in slurry form, transportation occurs via PD pumps and pipelines instead of costly dry methods like trucks and conveyor systems.
- Emergency storage: no emergency short-term tailings storage is required for UP schemes during filter downtime.
- Pipeline design: utilising PD pumps allows for a laminar flow regime in the tailings pipeline, reducing wear.
- Water loss: while not as low as the filter stack option, water loss in the UP scheme is less than the paste option, representing a compromise.
- Distribution and compaction: hydraulic transportation eliminates the need for tailings distribution and compaction.

# 3 Methodology

Achieving UP in tailings management will typically require additional dewatering mechanisms beyond deep-cone or paste thickeners. Two potential methods for producing UP tailings are:

- Option A: combination of paste thickener and filter press plus mixing.
- Option B: 'underperforming' vacuum belt filter.

## 3.1 Option A: combination of paste thickener and filter press

In this approach, as illustrated in Figure 3, the entire tailings stream undergoes paste thickening. The paste thickener's (PT) underflow is divided into two parts: one part enters a filter press (FP) unit to create filter cake, which is then mixed back into the remaining underflow. The discharge from the mixer constitutes the ultra paste tailings.

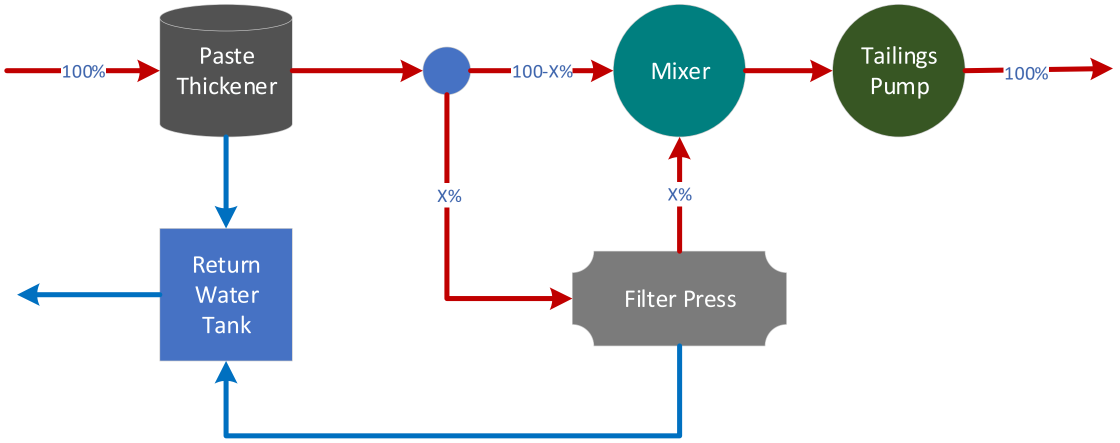

**Figure 3 Flow diagram of UP scheme option A: combination of PT and FP plus mixing**

## 3.2 Option B: 'underperforming' vacuum belt filter

In this alternative, a high-rate thickener (HRT) replaces the PT, and the entire tailings stream is directed into this thickener. The underflow (100% of the flow) is then directed to a filter unit – specifically a vacuum belt filter (VBF). However, these filters operate at less than maximum capacity, termed underperforming filter units (note that resulting product will still be pumpable). Unlike FPs, belt filters are continuous process units, providing consequential operational advantages. The components of option B are detailed in Figure 4. It is noted, however, that the effectiveness of VBFs appears to material dependent, and this option may not be applicable in some cases.

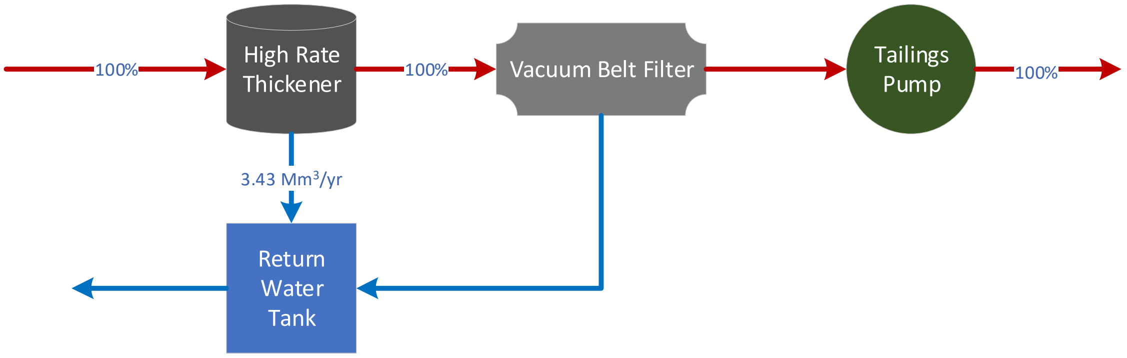

**Figure 4 Flow diagram of ultra paste scheme option B – 'underperforming' VBF**

# 4 A case study

## 4.1 Overview

The focal point of this case is a mine characterised by a nominal throughput rate of four million tonnes per annum (Mtpa) and a projected mine life of 12 years. The fundamental parameters are outlined in Table 1.

**Table 1 Basic parameters of example project**

| Component | Unit | Quantity |
|---|---|---|
| Life-of-mine | Years | 12 |
| Throughput | Mtpa | 4 |
| Total tonnage | Mt | 48 |

For the purpose of this exercise, the typical design factors applied to throughput rates have been omitted

## 4.2 Tailings properties

The sizing and design of components for tailings and water management scheme options studies critically hinge on the properties of the tailings. It is imperative to exert every effort to procure and test a representative sample in the laboratory before commencing a study. There might be instances where the timing of a study needs to be postponed until a suitable sample becomes available (e.g. from metallurgical studies) and the requisite tests are completed.

In this particular example, it is assumed that a tailings sample has been provided and subjected to testing, with results summarised in Table 2.

**Table 2 Summary of tailings properties**

| Property | | Value |
|---|---|---|
| Soil particle density | | 2.80 t/m$^3$ |
| Particle size: | | |
| | $D_{80}$ | 75 micron |
| | $D_{50}$ | 20 micron |
| Initial settled density (ISD) | | 1.20 t/m$^3$ |
| Solids concentration at ISD | | 67.5 % |
| In situ densities: | | |
| | Paste option | 1.50 t/m$^3$ |
| | Ultra paste option | 1.50 t/m$^3$ |
| | Filter stack option | 1.60 t/m$^3$ |

The aspect of tailings rheology stands as a fundamental factor in the design of thickened tailings schemes. The presumed rheological properties of the tailings in this example are detailed in Table 3.

**Table 3 Summary of tailings properties**

| Solids concentration (%) | Yield stress (Pa) [1] | K [1] | n [1] |
|---|---|---|---|
| 55 | 4 | 0.73 | 0.47 |
| 59 | 10 | 0.68 | 0.54 |
| 65 | 24 | 1.50 | 0.54 |
| 68 | 35 | 5.16 | 0.44 |
| 70 | 43 | 2.66 | 0.49 |
| 73 | 65 | 3.78 | 0.49 |
| 74 | 75 | 4.23 | 0.49 |

[1] Herschel–Bulkley fluid represented by Equation 1.

$$\tau = \tau_y + K\gamma.^n \tag{1}$$

where:

$\tau$ = the shear stress

$\tau_y$ = the yield stress

$K$ = the consistency index

$\gamma.$ = the shear rate

$n$ = the power law index.

## 4.3 Project area terrain and climate

For the purpose of this illustration, a physically tangible candidate storage site has been chosen. The selection aims to provide a genuine example site suitable for a TSF, relating to an actual mining operation. However, to maintain confidentiality, the name of the mine is withheld, rendering it a more generic case.

The proposed TSF site is approximately 1.5 km away (pipeline distance) from the dewatering site location within the plant footprint, positioned at a similar elevation (i.e. the elevation head differences included in the comparison of pumping head requirements).

In order to streamline the water balance, this paper assumes an extremely arid climate and does not account for the collection of any water from the tailings storage.

## 4.4 Design considerations

### *4.4.1 Dewatering*

Within the tailings industry, two primary dewatering methods prevail: thickening and filtration. Thickened tailings schemes can adopt three broad levels of thickening: HRT, high density or high compression (HDT/HCT) and PT. Filtration methods encompass VBF or pressure-based (filter press) filters (FP). Laboratory bench-scale testing is deemed essential, at a minimum, to procure representative parameters for incorporation into an options study. The results for various thickener types in this case are summarised in Table 4.

**Table 4 Summary of dewatering parameters used in this case**

| | Unit | HRT | PT | VBF | FP |
|---|---|---|---|---|---|
| Surface loading | $t/m^2.h$ | 0.6 | 0.75 | 0.8 | 0.2 |
| Flocculant dosage | g/t | 15 | 20 | None | None |
| Underflow or cake solids content | % | 50 | 65 | 72 | 80 |

Many successful thickened tailings schemes have been implemented solely using high-rate thickening (Williams et al. 2008). Nevertheless, in this study, HRT is not considered alone.

### *4.4.2 Tailings transport*

In this study, the following tailings transportation systems have been considered for different tailings properties:

- The underflow from the HRT with a nominal solids concentration of 50% is assumed to be transported using centrifugal slurry pumps, and the adopted flow regime would be turbulent flow.
- The underflow from the PT with a nominal solids concentration of 65% is assumed to be transported to the TSF utilising centrifugal slurry pumps. The adopted flow regime in this case is also assumed to be turbulent flow.
- Ultra paste tailings with a nominal solids concentration of 72% is assumed to be transported to the TSF using positive displacement pumps. The adopted flow regime in this case is assumed to be laminar flow.

The mixing requirements are estimated with reference to Roshdieh et al. (2021).

### *4.4.3 Deposition of tailings in TSF*

All the wet tailings options are structured around a CTD scheme employing a five-way split discharge. Provisions have been made for a concave beach profile to account for variability in thickener performance (Seddon et al. 2015). The resulting beach profiles, summarised in Table 5, have been employed to model the beach and storage capacity, forming the basis for calculating embankment height and quantities.

**Table 5 Thickened tailings beach profiles**

| Case | Solids content (%) | Adopted beach slopes (%) | | | |
|---|---|---|---|---|---|
| | | Upper | Middle | Lower | Run out |
| Paste | 65 | 3.10 | 2.35 | 1.75 | 0.5 |
| Ultra paste | 72 | 5.60 | 4.20 | 3.20 | 0.5 |

In the case of the filter (dry) stacking (FS) option, the assumption is made that deposition will be carried out using trucks, dozers and compactors. The maximum height of the stack is set at 25 m, and it is further assumed that the stack will feature an encapsulating shell comprising a 10 m layer of rockfill for stability and erosion control purposes. Additionally, for reasons of stability, at least half of the stack is assumed to be compacted, forming the structural zone.

## 4.5 Options development

Based on the preceding discussions, a total of four options have been formulated, as outlined in Table 6. These options are derived from four dewatering combinations and three deposition schemes.

## Table 6 Summary of considered options

| Option | Name | Solids concentration (%) | In situ density (t/m$^3$) | Storage volume (Mm$^3$) |
|---|---|---|---|---|
| Option 1 | PT + CTD | 65 | 1.50 | 32 |
| Option 2a | PT + FP + mixer + CTD | 72 | 1.50 | 32 |
| Option 2b | VBF + CTD | 72 | 1.50 | 32 |
| Option 3 | FS | 80 | 1.60 | 30 |

Figure 5 presents the comprehensive flow diagram adopted for option 1 in this case study.

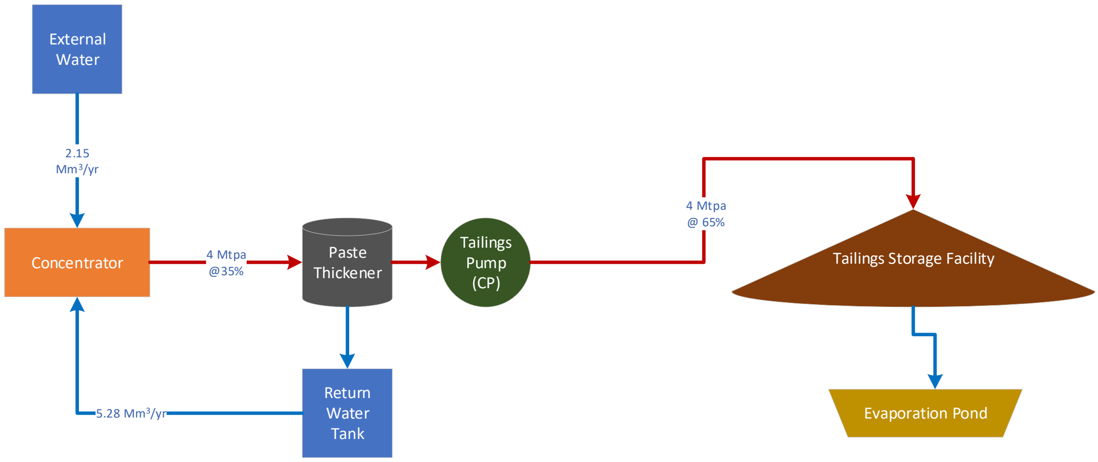

**Figure 5 Flow diagram – option 1 – paste and CTD scheme**

Similarly, Figures 6 and 7 present the overall flow diagrams adopted for options 2a and 2b, representing the UP options, respectively.

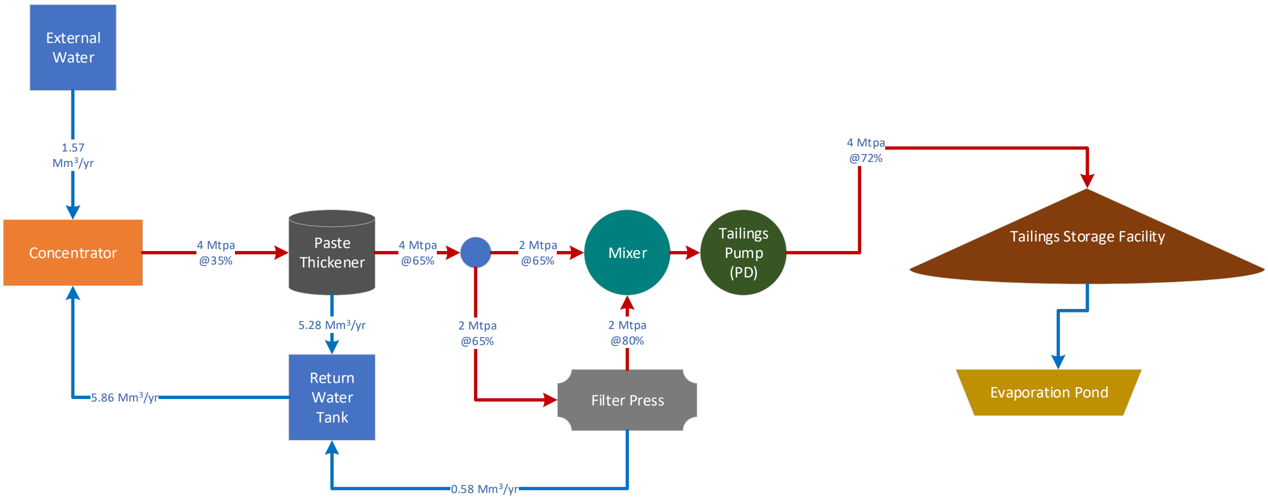

**Figure 6 Flow diagram – option 2a – ultra paste (PT + FP + mixing) and CTD scheme**

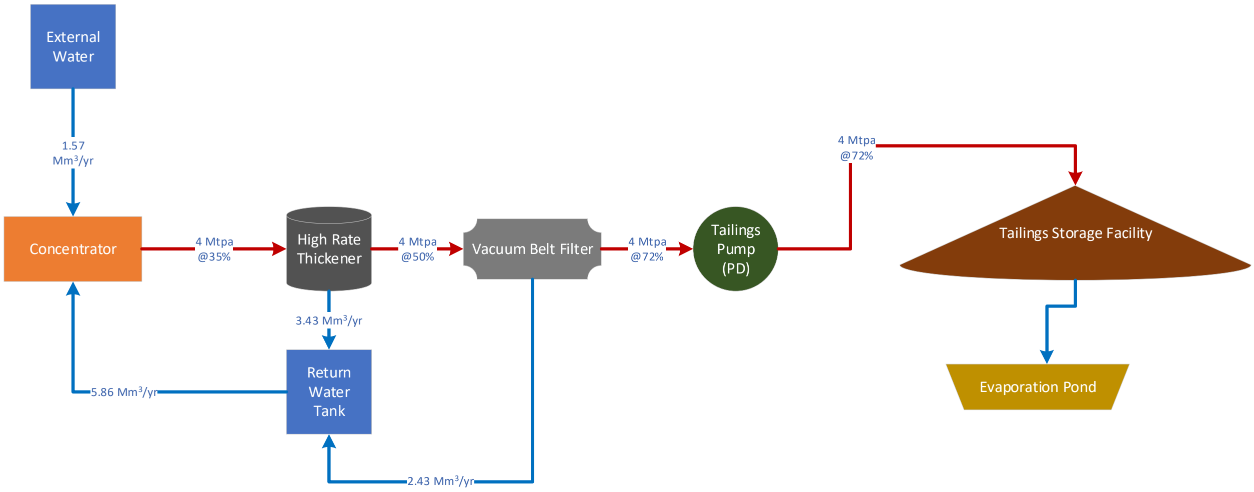

**Figure 7 Flow diagram – option 2b – ultra paste (underperformed VBF) and CTD scheme**

Figure 8 presents the overall flow diagram adopted for option 3 (the filter stack option). It's worth noting that, in this option, an emergency wet tailings storage has been considered for approximately 10% of the tailings volume.

The corresponding deposition plans for paste, ultra paste, and filter stack options are illustrated in Figures 9, 10 and 11, respectively. It is important to note that it has been assumed that all options require lining. In this instance, the assumption is that all the considered TSFs will be lined with a layer of high-density polyethylene (HDPE) liner.

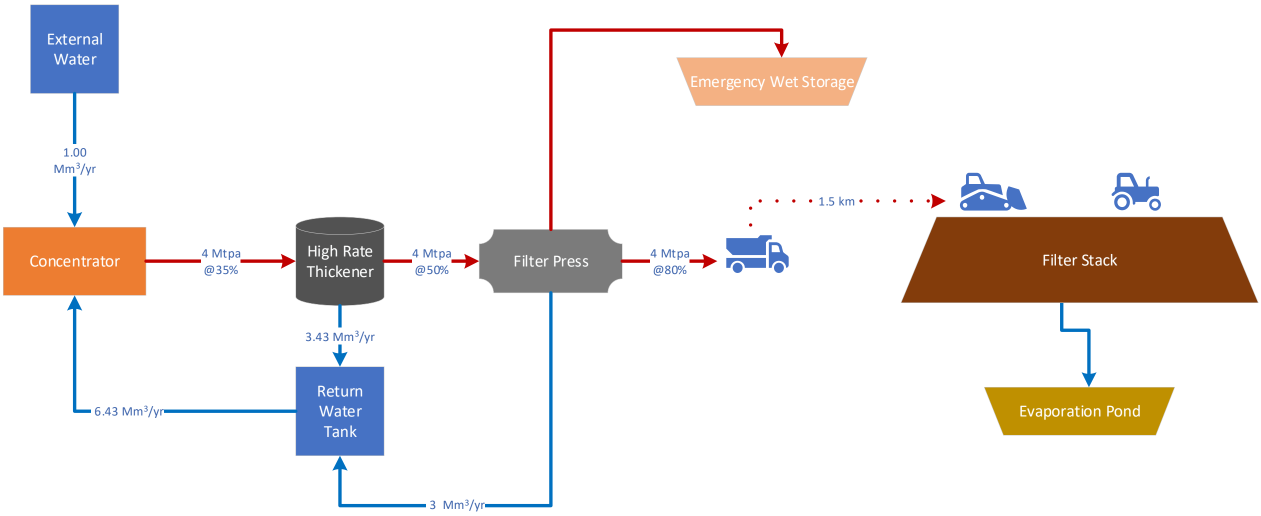

**Figure 8 Flow diagram – option 3 – filter stack option**

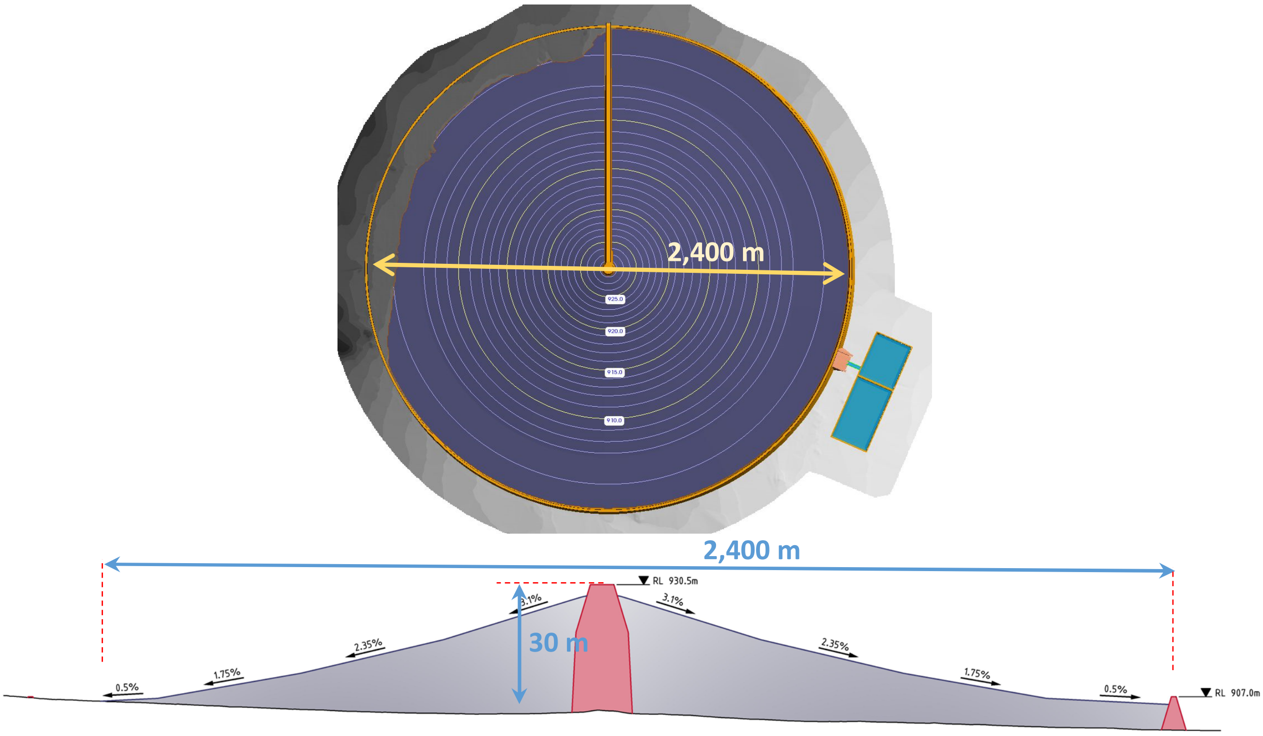

Figure 9 Deposition plan – paste and central thickened discharge scheme option 1

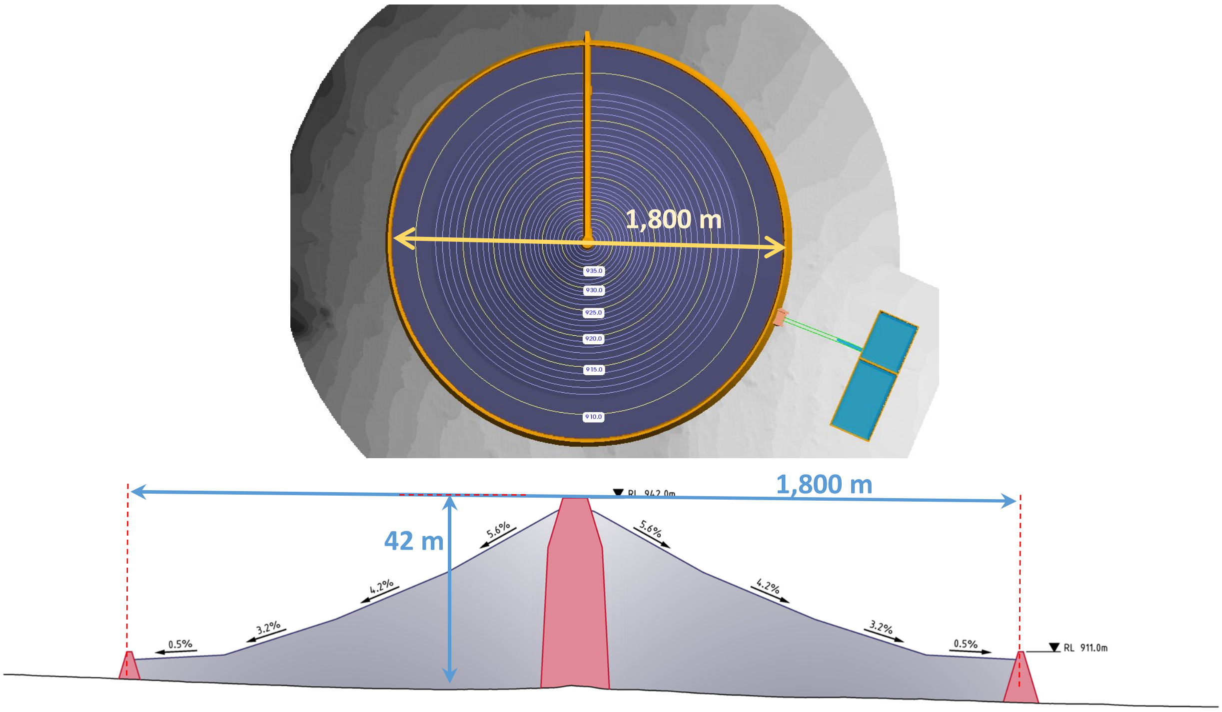

Figure 10 Deposition plan – ultra paste and central thickened discharge scheme – options 2a and 2b

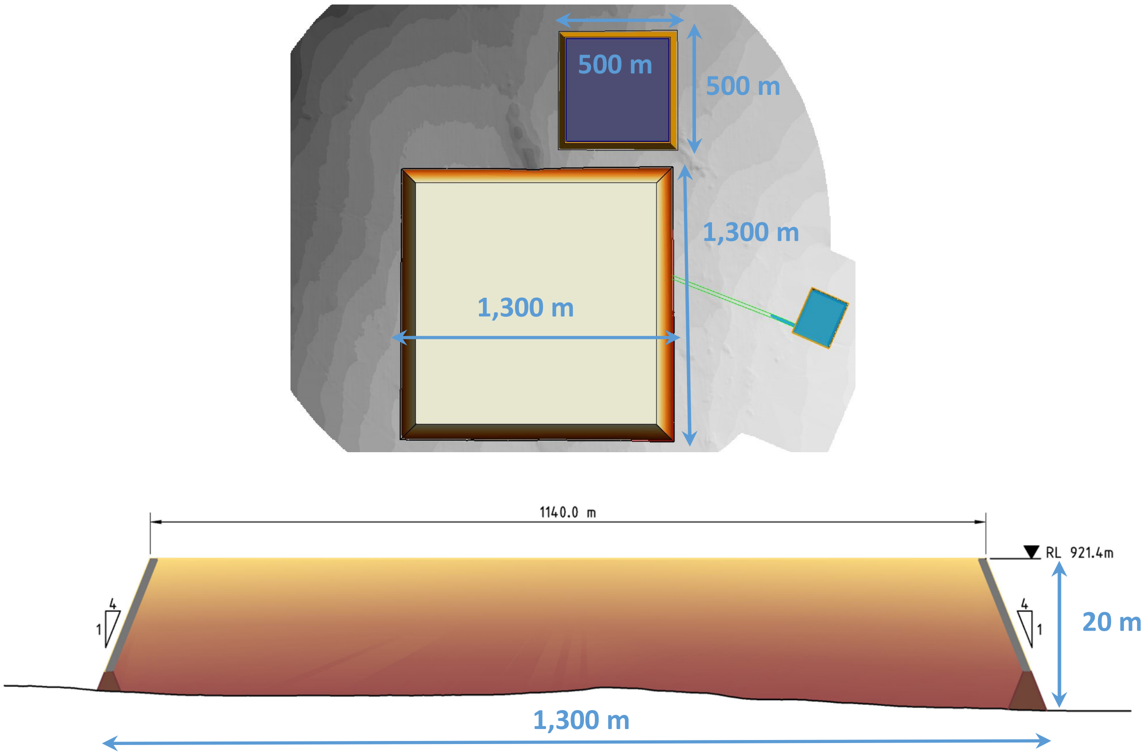

**Figure 11 Deposition plan – filter stack scheme – option 3**

Summaries of the TSF design and earthfill volumes for each option are presented in Tables 7 and 8, respectively.

**Table 7 Summary of considered TSFs**

| Option | Shape | Dimension | Max. height |
|---|---|---|---|
| Option 1 | Circular | R = 1,200 m | 30 m |
| Option 2a | Circular | R = 900 m | 42 m |
| Option 2b | Circular | R = 900 m | 42 m |
| Option 3 | Rectangular | L = B = 1,300 m | 20 m |

**Table 8 Summary of earthworks required for each option**

| Option | Embankment volume ($Mm^3$) | Ramp volume ($Mm^3$) | Emergency TSF embankment volume ($Mm^3$) | TSF area ($Mm^2$) |
|---|---|---|---|---|
| Option 1 | 0.9 | 0.95 | N/A | 4.52 |
| Option 2a | 1.3 | 1.3 | N/A | 2.55 |
| Option 2b | 1.3 | 1.3 | N/A | 2.55 |
| Option 3 | 1.0 | N/A | 0.8 | 1.69 |

## 4.6 Costs and financial assessment

The capital expenditures (capex) and operational expenditures (opex) for each option have been developed based on the costs and rates summarised in Tables 9 and 10. A relatively high unit cost of water has been adopted, as would apply in cases where the inclusion of a water treatment plant (e.g. reverse osmosis) was being considered in the overall project. The impact of variations in this cost is discussed further in the sensitivity section.

Table 9 Cost summary (capex)

| Item | Unit | Rate USS/unit | Total cost (MUSD) |
|---|---|---|---|
| **Thickeners** | | | |
| High rate | Each | N/A | 6.7 |
| Paste | Each | N/A | 2.3 |
| **Filter installations** | | | |
| Filter press (option 2a) | Item | N/A | 15 |
| Filter press (option 3) | Item | N/A | 30 |
| Vacuum belt filter | Item | N/A | 12 |
| **Paste and cake mixer** | | | |
| Mixer | Item | N/A | 3.75 |
| **Pipes** | | | |
| 250 mm steel pipe | m | 415 | 0.62 |
| 200 mm steel pipe | m | 350 | 0.52 |
| **Slurry pump installations** | | | |
| Centrifugal | Item | N/A | 1.55 |
| Positive displacement | Item | N/A | 4.69 |
| **TSF construction** | | | |
| Embankment construction | $m^3$ | 10 | |
| HDPE liner | $m^2$ | 10 | |
| Excavation | $m^3$ | 5 | |
| Placement of rehabilitation cover | $m^3$ | 5 | |

Table 10 Cost summary (opex)

| Item | Unit | Rate USS/unit |
|---|---|---|
| Power | Mw.h | 100 |
| Flocculent | Tonne | 4,000 |
| Make-up water | $m^3$ | 4 |
| Financial rate of return | % | 8 |
| **Machinery** | | |
| Articulated truck (20 T) | h | 50 |
| Front wheeled loader | h | 80 |
| Bulldozer (D9) | h | 150 |
| Compactor | h | 40 |

The results of the capex, opex and net present value (NPV) costing of the options are summarised in Table 11.

**Table 11 Total cost analysis of options (USD)**

| | | Dewatering | Transport | Civil work | Personnel | External water | Total |
|---|---|---|---|---|---|---|---|
| **Option 1** | Capex | $6.7 | $2.5 | $76.1 | – | – | $85.2 |
| | Opex | $0.6 | $0.7 | $0.6 | $0.8 | $8.6 | $11.3 |
| | **NPV** | **$11.5** | **$7.4** | **$80.9** | **$6.0** | **$64.8** | **$170.7** |
| **Option 2a** | Capex | $25.4 | $5.5 | $55.7 | – | – | $86.7 |
| | Opex | $1.5 | $0.9 | $0.5 | $1.2 | $6.3 | $10.5 |
| | **NPV** | **$37.1** | **$12.6** | **$59.4** | **$9.0** | **$47.3** | **$165.5** |
| **Option 2b** | Capex | $14.3 | $5.5 | $55.7 | – | – | $75.6 |
| | Opex | $0.8 | $0.9 | $0.5 | $1.2 | $6.3 | $9.7 |
| | **NPV** | **$20.2** | **$12.6** | **$59.4** | **$9.0** | **$47.3** | **$148.6** |
| **Option 3** | Capex | $32.2 | $0.9 | $44.1 | – | – | $77.1 |
| | Opex | $1.5 | $9.4 | $0.4 | $1.8 | $4.0 | $17.1 |
| | **NPV** | **$43.4** | **$72.0** | **$47.1** | **$13.6** | **$30.1** | **$206.2** |

This information is visually represented in Figure 12, providing a summary of capex, opex and NPV.

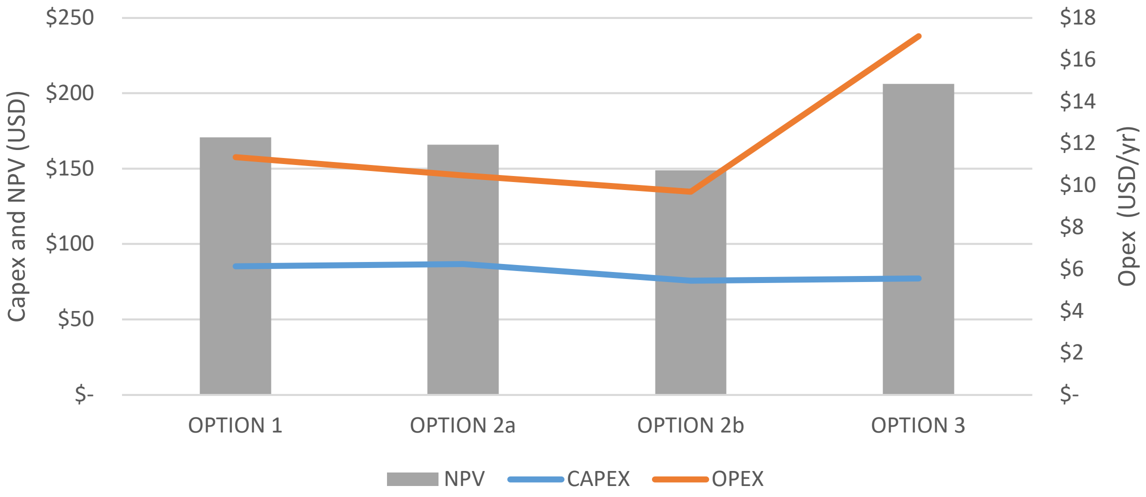

**Figure 12 Summary of capex, opex and NPV**

Option 2b stands out as the most cost-effective choice, closely followed by option 2a and option 1, with a negligible difference between the latter two. As expected, option 3 proves to be the most expensive, primarily due to its high opex. Notably, option 1 is anticipated to be more cost-effective compared to traditional tailings disposal methods (Roshdieh et al. 2016).

Additionally, a high-level analysis was conducted for an alternative option involving CTD scheme with an HRT. The results indicate that the NPV of this option would be approximately USD 254 million, surpassing that of option 1. It is crucial to acknowledge that the cost of water supply significantly influences this NPV.

It is essential to emphasise that this paper does not seek to establish a universal case for the superiority of any particular method or solution. The optimal solution will always be contingent on numerous site-specific factors. Nevertheless, UP is clearly competitive on a cost basis with belt filters providing a simpler and cheaper alternative to FP technology.

It is further noted that the presented example is based on an essentially flat site, and perimeter/toe embankment construction is comparatively modest for all cases. It is expected that on site located over natural ground with higher slopes (e.g. 1–2%) the UP option will provide enhanced benefits and will extend the range of sites where the CTD method can be applied.

Whilst this paper is limited to CTD options, similar advantages are likely in cases utilising DVD approaches.

The study also underscores the extensive work and analysis required to determine the optimal solution for a given context.

## 4.7 Sensitivity analysis

A sensitivity analysis has been conducted on the results of the options evaluation, yielding the following insights specific to this case:

- The ranking of options exhibits insensitivity to the cost of power or flocculant.
- The ranking is notably influenced by the price of water. If the water cost is excluded, option 2b emerges as the most cost-effective, followed by option 1. This trend continues up to water rates of USD 3.5/m$^3$, at which point option 2a becomes similarly priced with option 1.
- The ranking is responsive to the cost of embankment construction; an increase in embankment cost improves the comparative ranking of option 1 against option 2a. However, option 2b maintains its position as the most cost-effective.
- The ranking is influenced by the need for lining. It is clear that lining the entire facility significantly adds to the overall cost. While the practice of lining the entire facility, especially when dealing with thickened tailings, has not been prevalent in the industry, it is gaining recent traction. Subsequently, an additional assessment has been conducted after excluding the lining cost, and the findings are depicted in Figure 13. Notably, option 2b and option 1 remain the most cost-effective choices. Perhaps owing to factors such as a smaller footprint (resulting in less dust) and other considerations, option 2b might be a preferred alternative.

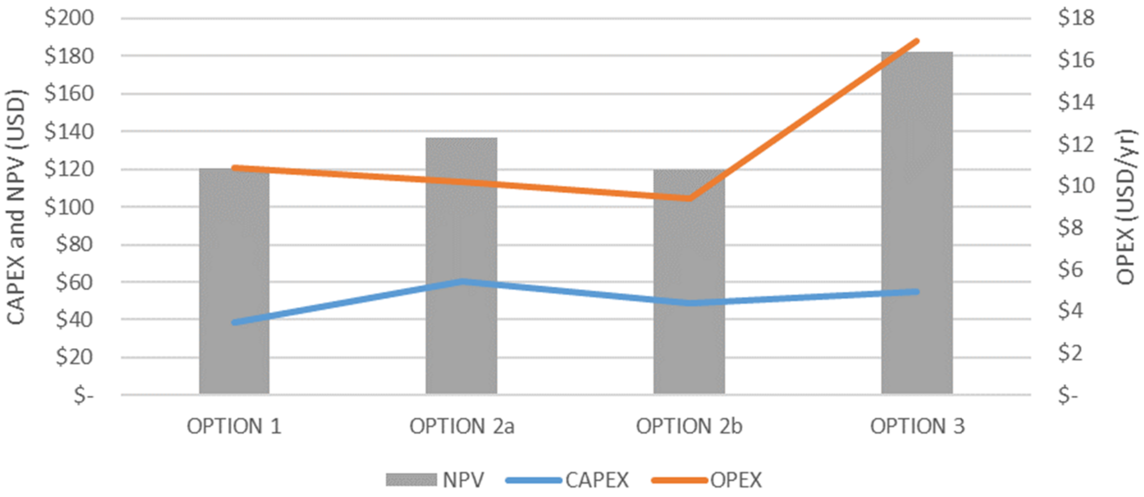

**Figure 13 Summary of capex, opex and NPV excluding the lining cost**

These findings highlight the nuanced impact of various factors on the economic viability of each option, emphasising the importance of site-specific considerations in tailings management decision-making.

# 5 Conclusion

The purpose of this paper is to introduce an addition to the range of dewatering options that currently exist for tailings, prior to disposal. The product has been given the name ultra paste. A hypothetical case study is presented to compare the benefits and costs of a range of dewatering technologies. Several key conclusions can be drawn from the comprehensive evaluation:

- Ultra paste technology with CTD deposition: the ultra paste technology, particularly when coupled with a CTD deposition scheme, emerges as an appealing option for effective tailings and water management. It is strongly recommended that this scheme be included in future options studies.
- No shortcut solutions: there are no shortcut solutions for selecting the best option. Each option must undergo thorough design, costing and evaluation processes to ensure a comprehensive understanding of its feasibility and effectiveness.
- Site topography and storage site availability: results across all options are always heavily dependent on site topography and the availability (or lack) of suitable storage sites. Site-specific factors play a critical role in determining the optimal tailings management solution.
- Need for representative tailings parameters: a complete and representative set of tailings parameters is essential for proper comparison. Options should not be prematurely discarded if suitable parameters are not available for analysis.
- Balanced approach with ultra paste technology: ultra paste technology offers a balanced approach in tailings management, providing a viable compromise between various dewatering methods, transportation efficiency and environmental considerations.

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