The Frieda River site jetty

Hydroelectric Project Dam safety

The Hydroelectric Project dam is the most environmentally and socially responsible solution to power the mine and will protect the environment for future generations.

KEY FACTS

- The dam's purpose is to safely store mine tailings and waste rock and generate renewable electricity for the mine and local communities.
- The dam design was undertaken by world leading engineers and consultants and has been subjected to multiple and ongoing peer reviews by independent international experts.
- It is specifically designed in accordance with international best practice standards to safely operate in the high rainfall and seismically active location.

WHY IS THE DAM REQUIRED?

The hydroelectric dam is required to:

- power the mine and local communities with renewable energy; and
- safely store waste rock and tailings so they do not pollute the environment.

The proposed mine will use large amounts of electricity and is ~200 kilometres from the coast, which means that marine tailings disposal is not feasible and there is no existing electricity source to power the project. Furthermore, the disposal of tailings and waste rock into the river systems or marine environment would cause pollution and permanent environmental damage, which is not acceptable to Frieda River Limited (FRL), the Government or local communities. The Hydroelectric Project dam is the most environmentally and socially responsible solution to power the mine and protect the environment by safely storing waste rock and tailings.

WHAT KIND OF DAM IS IT?

The safety and stability of the dam is the priority in its design. The Hydroelectric Project dam design deliberately adopts the more rigorous standards used for hydroelectric dams than those used for typical mine tailings dam like at the Panguna mine, and the one that failed during construction at OK Tedi.

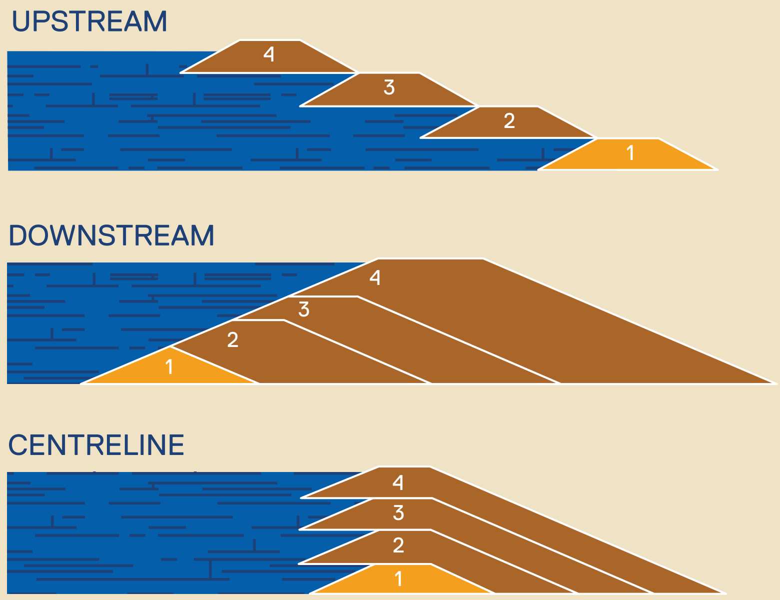
To explain how the Hydroelectric Project dam has a higher safety profile, it is important to understand firstly how typical mine tailings dams are built. There are three main types of mine tailings dams: upstream, centreline and downstream, as illustrated on the next page.

TAILINGS DAMS

The least stable design is the upstream tailings dam. The reason why it is the least stable is because it relies the most on the tailings themselves to maintain the dam wall. That is why, in response to recent upstream tailings dam failures in Brazil, the Brazilian Government imposed a ban on all upstream tailings dams.[1]

The most stable of the three types is the downstream tailings dam.[2] This is the type of tailings dam that FRL's parent company, PanAust Limited, safely operates at its mines in Laos.

In response to past tailings dam failures, in 2020, the International Council on Mining and Metals, the United Nations Environment Programme and the UN-backed Principles for Responsible Investment jointly undertook the Global Tailings Review study with the aim of establishing new standards for the safe management of mine tailings. The study concluded that a lack of proper governance is one of the key reasons behind tailings dam failures. This is because tailings dams are raised incrementally over many years, often without appropriate governance for such construction and operation, which can undermine the structural integrity of the facility[3].



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STARTER DYKE: 1

The embankment design terms, upstream, downstream and centreline, indicate the direction in which the embankment crest moves in relation to the starter dyke at the base of the embankment wall.

2 3 4

DYKE: 2 – 4 OR MORE

Dykes are added to raise the embankment. This continues throughout the operation of the mine.

HYDROELECTRIC PROJECT DAM

In the design of the Hydroelectric Project dam, FRL is going a few steps further to ensure its safety, including by adopting higher design standards that apply to water dams, where appropriate.

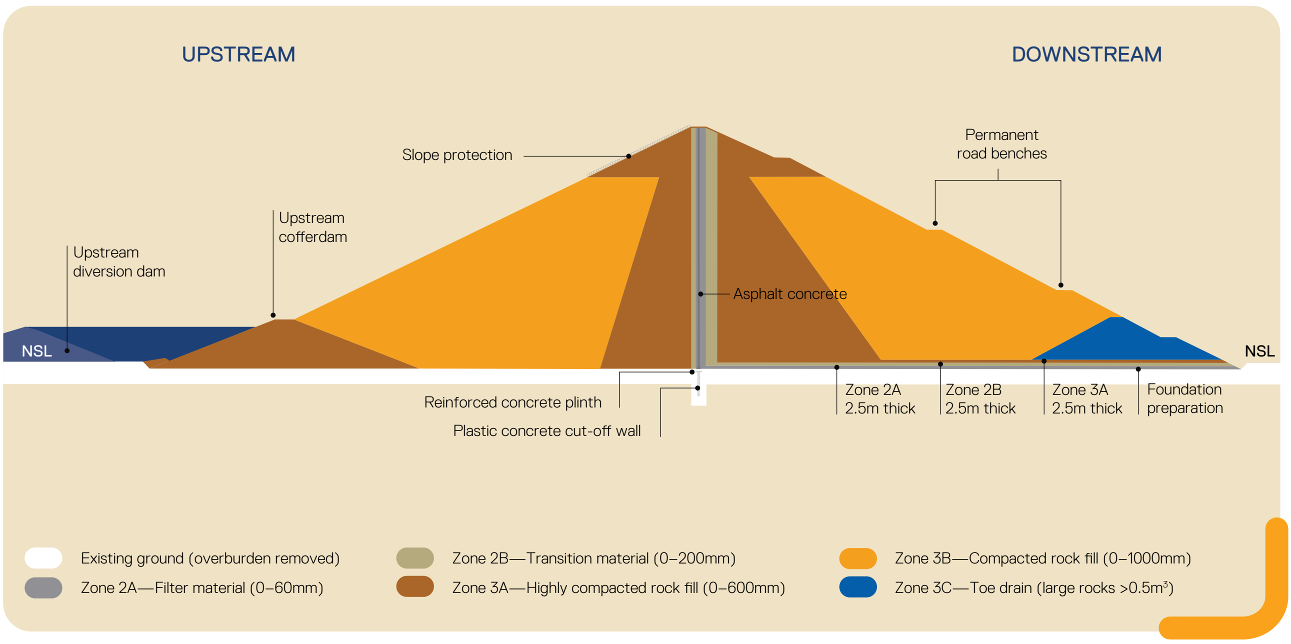
As a result, the dam will have a higher safety and stability profile than mine tailings dams because:

- it is designed to a higher standard than conventional tailings dams,
- the embankment will be built in a single construction campaign, eliminating risks associated with inconsistent design and construction practices, and
- the dam will have an asphalt core fill, rather than an earth fill core.

The basic design of the dam is shown below.

The cost of building the Hydroelectric Project dam in this manner is approximately three times more expensive than constructing a typical upstream tailings dam. This illustrates how the protection of communities and the environment has been prioritised over profitability.

The dam wall will be approximately 747 metres (m) long at its crest and the dam wall will be 191m tall. It can store up to approximately 9.6 billion cubic metres of water, making it the largest dam in PNG. The dam will be constructed on the Frieda River, approximately 70 kilometres by river from its junction with the Sepik River.



DAM LOCATION

Legend

- Village (proposed to be resettled)
- Topographic feature
- Watercourse
- Province boundary
- SML
- EL58

Infrastructure

- Proposed road
- Infrastructure
- Transmission line
- Concentrate pipeline
- Open pit
- Integrated storage facility reservoir
- Integrated storage facility embankment
- Spoil dump
- Quarry/borrow area

DAM LOCATION

How will the dam work?

Waste rock and tailings storage

The waste rock and tailings that will be produced by the mine contain metallic elements and have the potential to generate acid, both of which may be harmful to the environment.

To protect the environment and waterways, and the communities that rely upon them, FRL will deposit tailings and waste rock from the mine into the hydroelectric dam reservoir. The dam is designed so that waste rock and tailings deposited will remain submerged.

under at least 40 metres of water, in all foreseeable weather conditions. The water cover inhibits oxidation of waste rock and tailings, which inhibits the formation of acid and prevents pollution flowing down stream.

Underwater storage of mine tailings and waste rock is considered one of the most effective methods for preventing pollution from mine waste. For a more detailed explanation of how the environment will be protected and safeguarded for future generations, please refer to the **Measures to Protect the Environment** fact sheet.

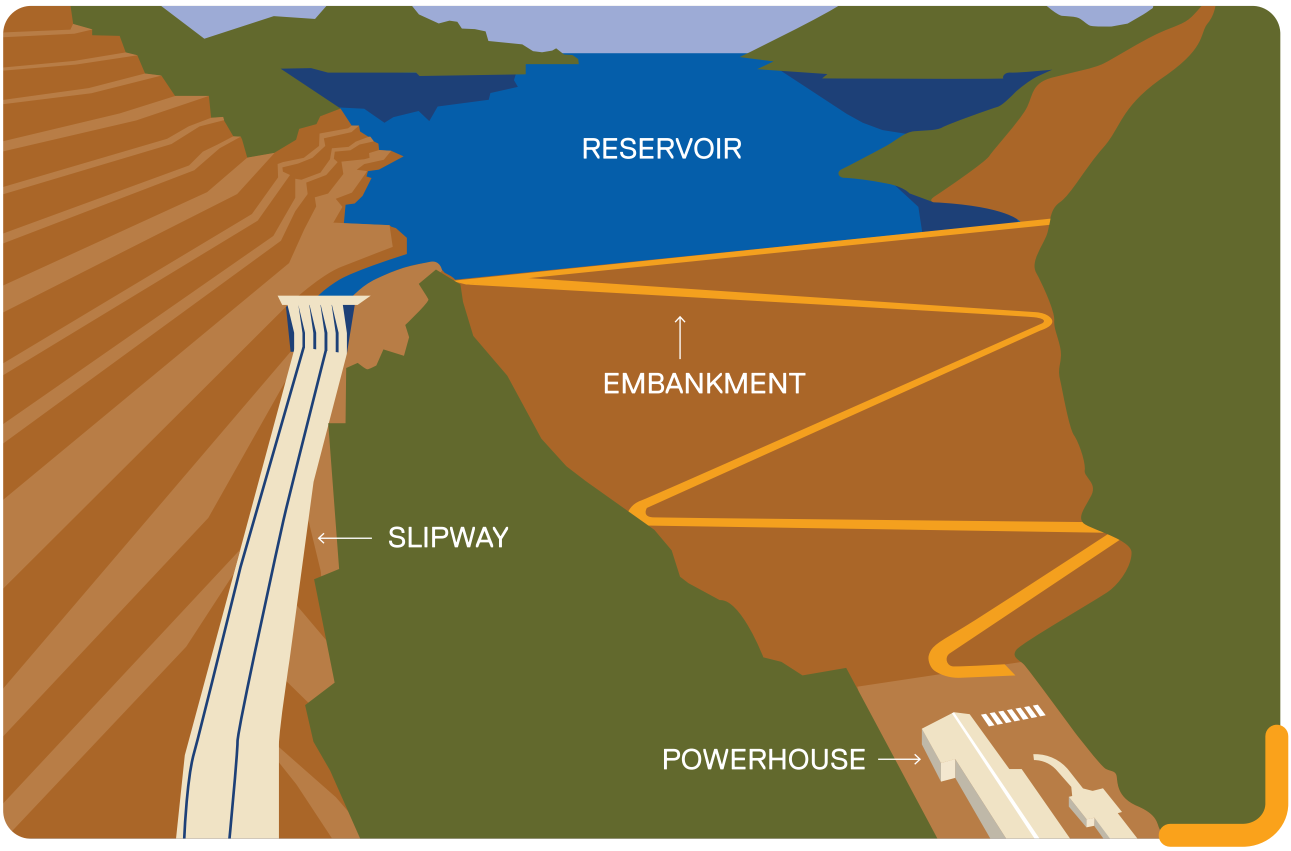
Renewable power generation

Water from the dam will be channelled to a powerhouse with 10 turbines that will have the capacity to generate the electricity required to power the mine and local communities.

EMBANKMENT AND POWERHOUSE

The Hydroelectric Project will provide up to 490 megawatts of renewable energy for the Frieda Copper-Gold Project and other users of electricity in the area.

The hydroelectric facility is planned to have an operating life over 100 years, preceded by a five-year construction period, meaning the Hydroelectric Project will continue to operate and provide renewable power to local communities for decades after mine closure.



WHO DESIGNED THE DAM?

The feasibility study design was undertaken by international engineering consultancies, SRK Consulting and Stantec.

The initial design was adopted after assessment and consideration of the risks associated with potential seismic activity in the Project area, and the necessity for the structure to remain stable under very high rainfall and flood events. The dam is designed to Australian National Committee on Large Dams Incorporated (ANCOLD) and International Commission on Large Dams (ICOLD) guidelines to withstand the maximum credible magnitude of earthquake, and the maximum credible risk of flood in the Project area. In the event of a major earthquake, the dam is designed to move and reform without failure.

Relevantly, continued tests and design analysis are ongoing to gather more data and make the dam as safe as possible.

In undertaking the initial dam design, FRL also engaged an independent team of international engineering experts and consultants to review the design. Furthermore, as part of the PNG Government approval process, the design was peer-reviewed by SMEC, an Australian-based engineering firm which specialises in such projects.

The dam design has been the subject of intense scrutiny by many highly regarded and independent international experts, who all agree it can be safely built in accordance with the above guidelines—considering the earthquakes, high rainfall and flood events that could occur in the project area.

DAM KEY DESIGN FEATURES

The Project has been designed in accordance the best environmental standards with its classification under the Australian National Committee on Large Dams (ANCOLD) Guidelines, considering the potential seismic activity and high rainfall conditions of the site, to ensure protection of the enviroment.

Key design elements for this classification include the requirement for the embankment and spillway to provide for, or withstand, the following extreme operating and post-closure conditions.

- Probable Maximum Precipitation (PMP)—the theoretical greatest volume of precipitation for a given duration that is physically possible for the catchment.
- Probable Maximum Flood (PMF)—the largest flood resulting from PMP coupled with the worst flood-producing catchment conditions that can be realistically expected.
- The dam can cope with four times the one in 100-year rainfall event.
- Maximum Credible Earthquake (MCE)—the largest hypothetical earthquake and peak ground acceleration that may be reasonably expected to occur along a given fault or other seismic source.

The Project design is supported by data from a seismic refraction survey and over 70 drill holes which provide geotechnical information for the embankment, spillway, powerhouse and supporting infrastructure.

RISKS AND MITIGANTS DURING THE LIFE OF THE DAM

If the dam were to fail completely and instantaneously, it would cause wide-spread environmental damage and loss of life downstream along the Sepik River basin.

However, similar risks apply to many dams constructed upstream of urban populations around the world and these risks can be effectively managed by appropriate design requirements. Large water dams, like the proposed Hydroelectric Project dam, are routinely and safely built in seismically active and high rainfall locations and international standards have been developed to ensure that is the case.

The Hydroelectric Project dam feasibility design is in accordance with best practice, international standards to ensure there is no credible risk of failure over its 100+ years of operation. The initial design has been scrutinised by a range of independent, international engineering experts, who have advised it can be safely built.

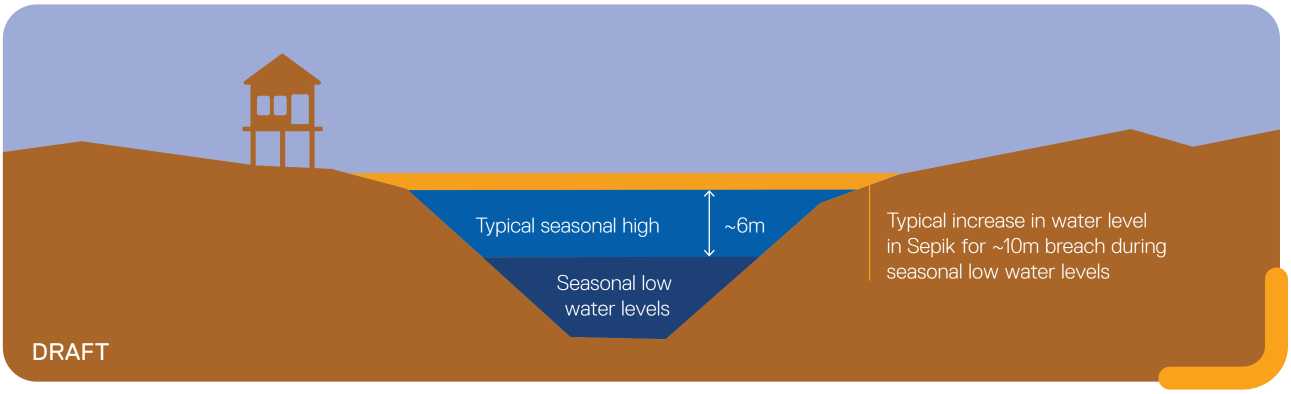
Furthermore, strict measures will be put in place to protect people downstream of the dam in the rare event of a dam failure. These include:

- undertaking further detailed seismic and geotechnical studies to ensure the earthquake risk is fully accommodated by the dam design;
- subjecting all aspects of the construction, operation and closure to peer review by an independent expert panel;
- engaging and involving potentially affected communities downstream of the Storage Facility to identify community risks and develop appropriate management strategies;
- early warning surveillance monitoring of the embankment, consistent with the international standards;
- dam safety inspections;
- alert and communication system and procedures for potentially affected communities;
- discussions with the Provincial Government to develop a special purpose authority, responsible for overseeing and assisting with the maintenance of the dam and an early warning system;
- evacuation plan for the site and potentially affected communities; and
- emergency support plan for essential services to affected communities.

RISK SCENARIOS CONSIDERED

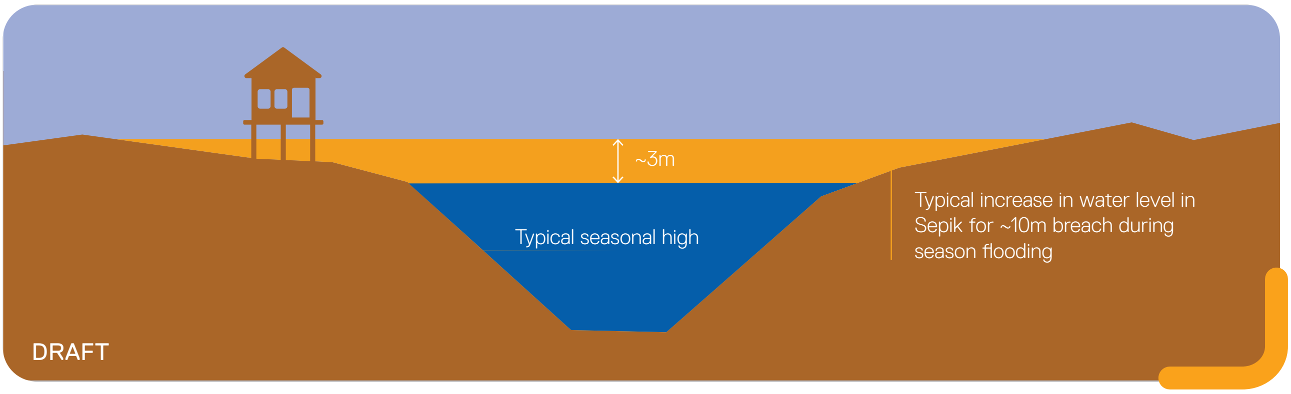
Scenario 1

Scenario 1 considers a dam breach of 10 metres or less that occurs during seasonal low water levels. For dam breaches of 10 metres or less that occur during seasonal low water levels, the incremental change in water level is similar to that of the seasonal flooding water level. Such a partial dam breach is unlikely. If this occurs, there is a very low likelihood of environmental damage and loss of life.



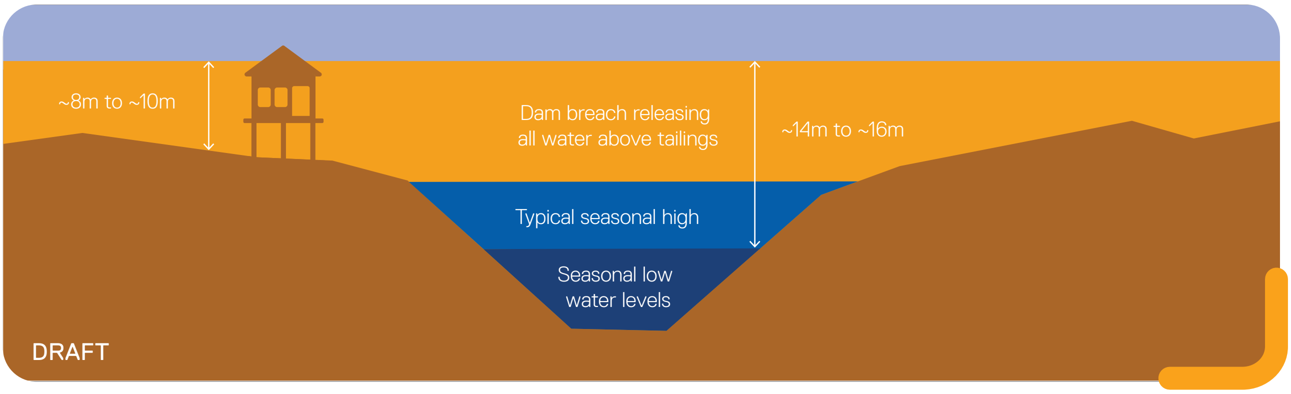
Scenario 2

Scenario 2 considers a dam breach of 10 metres or less that occurs during seasonal flooding. For dam breaches of 10 metres or less, that occur during seasonal flooding, the incremental change in water depth is generally 3 metres or less. Such a partial dam breach is unlikely. There is a low likelihood of environmental damage and loss of life.



Scenario 3

Scenario 3 considers a dam breach of 66.7 metres. The chances of a complete breach occurring is very low. However, if this circumstance were to occur, there could be a high likelihood of environmental damage and loss of life. The dam is being designed to the highest standards and also to include early warning measures, so that residents will be able to evacuate to nearby high places and avoid water. There would be between 5-20 hours before the water reached populated areas. Regardless of initial water level, for a dam breach that releases all water stored above the waste (66.7 metres), the flood depth would be much greater than seasonal variation.



FURTHER STUDIES AND DESIGN REQUIRED

While the final Hydroelectric Project design has not yet been completed, the detailed feasibility study designs have determined that the dam can be built to these high standards.

The engineering designs will be completed as the Project proceeds towards development, contingent on receiving the required regulatory approvals. Further geotechnical surveys also need to be undertaken to ensure the dam wall meets the standards. The final designs will be peer reviewed as part of the final design approval process.

FRL will not proceed (and will not be permitted by the PNG Government to proceed) with the development unless these strict design standards can be met, and the safety of the Sepik River communities and the protection of the environment can be assured.

MANAGEMENT OF RISKS AFTER CLOSURE

After the end of the 33+ year mine life, the Hydroelectric Project will continue to produce renewable electricity for the community for its 100+ design life.

Post-closure, the dam will remain as a permanent water body to prevent pollution of the environment downstream. The water quality in the Sepik River and Frieda Rivers is expected to be as good as, or better than, current conditions.

At the time of the closure, the long-term responsibilities for the maintenance and operation of the Hydroelectric Project must be agreed with the Government of Papua New Guinea. Detailed plans for post-closure maintenance and monitoring criteria will be developed prior to closure to ensure the protection of the environment and communities downstream of the dam in perpetuity.

These should include:

- Embankment surveillance: continued inspections and monitoring as per the dam safety program developed in the later design stages, which is based on ANCOLD and ICOLD guidelines.
- Maintenance and monitoring requirements: routine and event-driven maintenance of the embankment and spillway.
- A decommissioning plan.
- The potential establishment of a trust fund, developed over the course of the Frieda River Copper-Gold Project, which would ensure financial surety to conduct the necessary monitoring, maintenance and decommissioning post-closure.

The overall design requirement for the Hydroelectric Project is to ensure the environment and communities downstream of the dam are protected in perpetuity.

Endnotes

1 See "Brazil to decommission all upstream tilings dams by 2021: Australian Mining, 19 February 2019: **https://www.australianmining.com.au/news/brazil-to-decommission-all-upstream-tailings-dams-by-2021/**

2 See Chapter VII, "Lessons from Tailings Facility Data Disclosures", in "Towards Zero Harm: A compendium of papers prepared for the Global Tailings Review": **https://globaltailingsreview.org/compendium/**

3 See Chapter II, "Mine Tailings Facilities: Overview and industry Trends", in "Towards Zero Harm: A compendium of papers prepared for the Global Tailings Review": **https://globaltailingsreview.org/compendium/**

FRIEDA RIVER