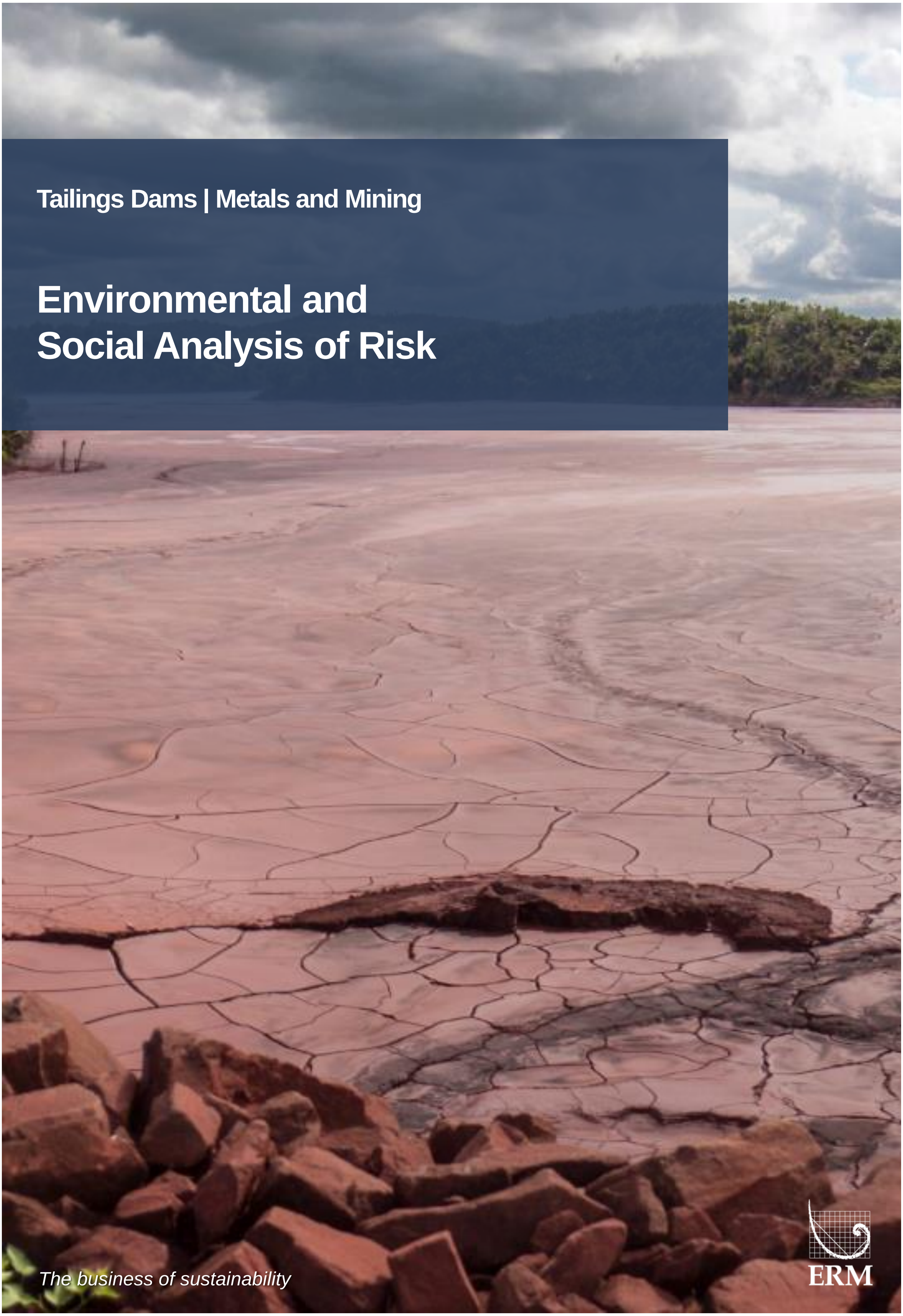
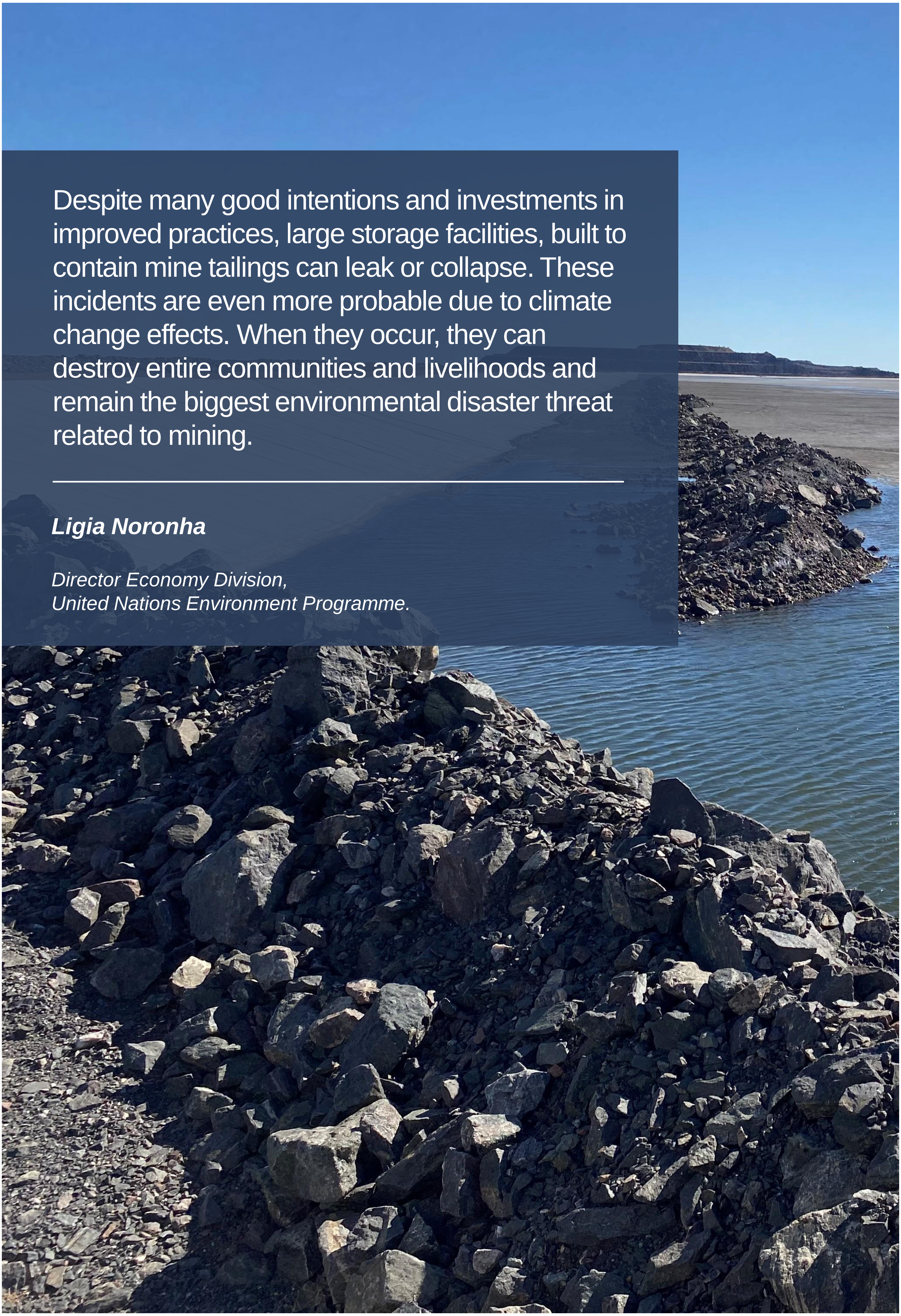
Tailings Dams | Metals and Mining

Environmental and Social Analysis of Risk



The business of sustainability

ERM



Despite many good intentions and investments in improved practices, large storage facilities, built to contain mine tailings can leak or collapse. These incidents are even more probable due to climate change effects. When they occur, they can destroy entire communities and livelihoods and remain the biggest environmental disaster threat related to mining.

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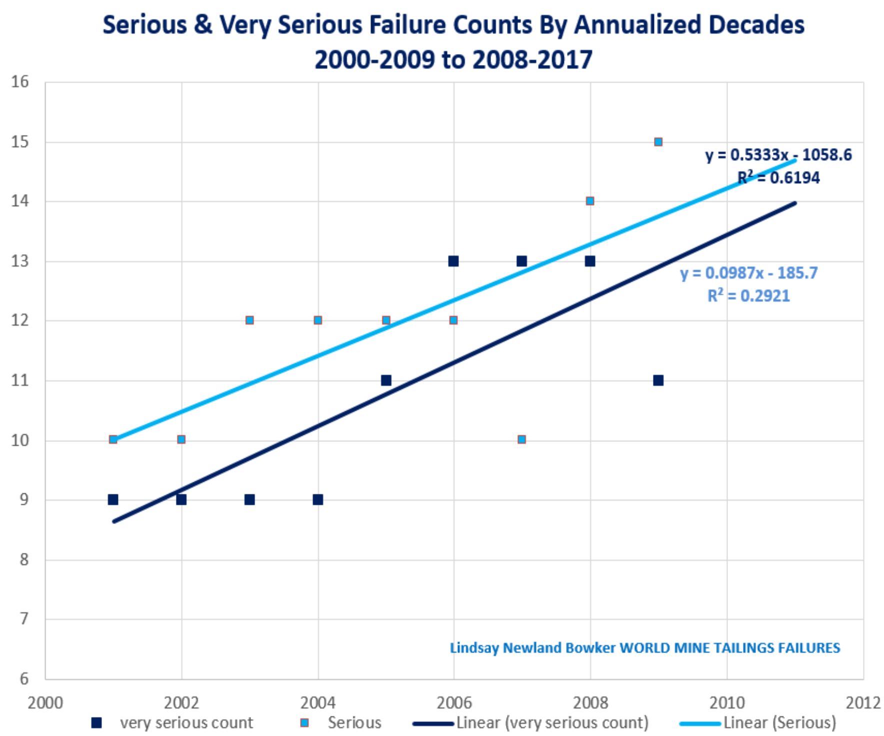
Introduction

In the last few years Brazil has suffered two of the worlds worst mining disasters following the collapse of tailings dams. These events have led to considerable loss of life, damage to the environment, financial cost to the companies and a re-think within the mining industry around what is considered to be an acceptable risk.

The rate of tailings dam failures and the resulting consequence are gradually increasing. A study by Lindsay Newland Bowker illustrates how the decadal event frequency is increasing for both serious and very serious incidents. This is in part likely to be a result of the increase in the size of mining operations, grade of the ore but also plausibly a result of ageing infrastructure.



Do you understand the risk?

1 **What is your liability in the event of a dam failure?**

2 **How do you demonstrate the level of risk and environmental harm?**

3 **Are there viable evacuation routes to get people to safety?**

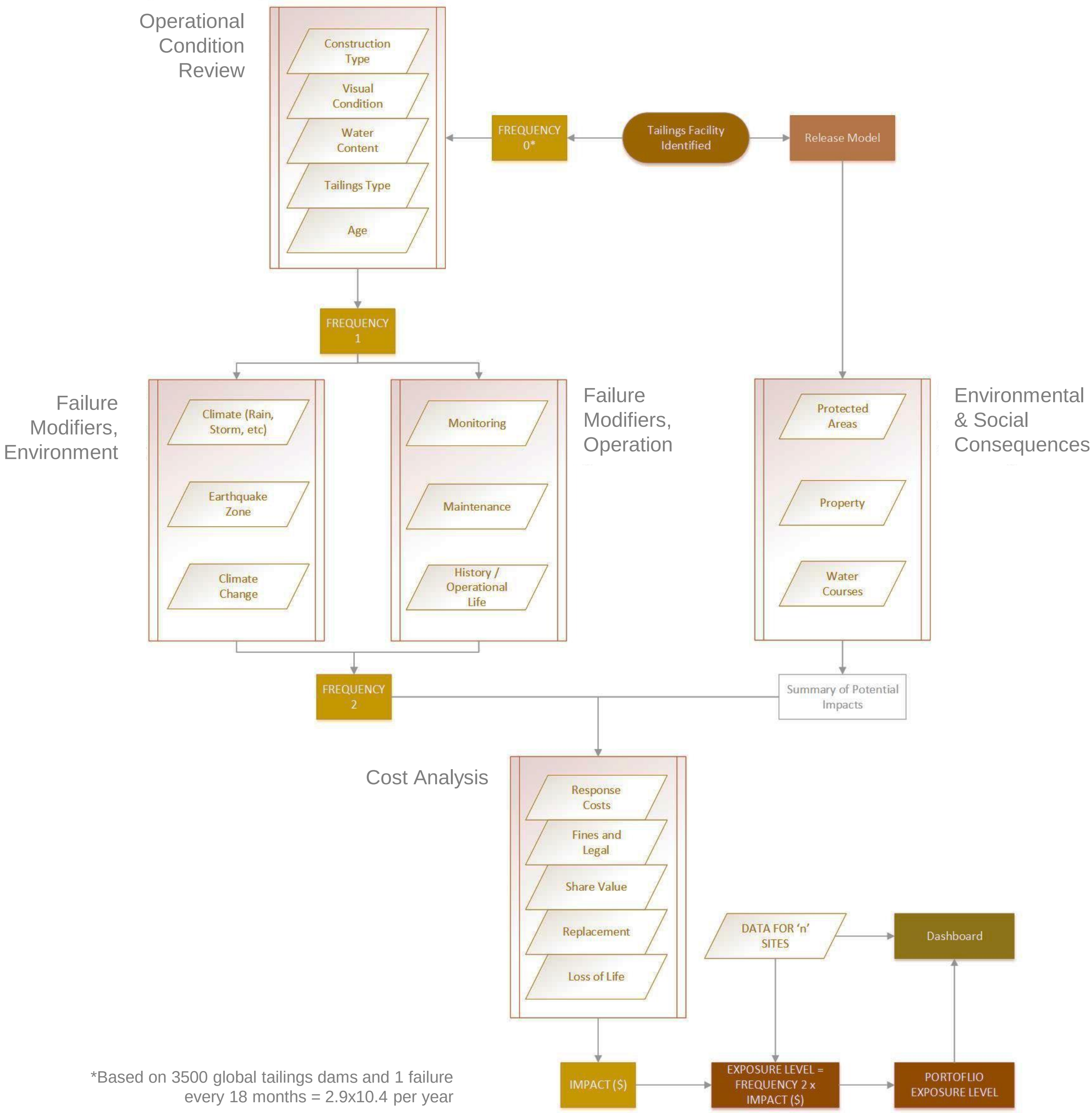
4 **Is there any critical local, state or national infrastructure in harms way?**

5 **What would happen to the mining company in the event of a failure?**

A tiered assessment approach

Our Approach

ERM has developed a tiered approach which can be undertaken at a simple level with limited data or can be expanded to take account of more detailed operational factors, sensitivities and potential financial impact as illustrated:



*Based on 3500 global tailings dams and 1 failure every 18 months = 2.9x10.4 per year

Screening level

In an effort to help mining organizations make appropriate decisions to reduce their risk and exposure ERM has developed a screening tool which plots the relative likelihood of a release based on tailings dam factors against the consequence of a loss. The approach works for legacy, operational, future and due diligence purposes.

This approach has been adopted as it is very difficult to determine, measure or monitor key indicators of current condition and potential for imminent failure as a result of the stratification of fines, sands and fines/sands mixtures - and the capillary effect of water on the dam wall structure.

The tool makes use of expert knowledge on construction factors, age, material, volume, etc., to provide a company with a relative view on likelihood of failure.

A social and environmental assessment is then undertaken. This involves the creation of a hypothetical flow path from a tailings dam which is then buffered to provide a theoretical impact zone stretching up to 1km across. The receptors in the line of fire from the release are then identified within a 20km impact zone down stream from the dam. This critical distance is selected based on estimated timings where people may not have sufficient time to respond and get to safety. This impact area can be reduced or extended as required for a project.

The results for the operational and consequential aspects are the categorized and ranked:

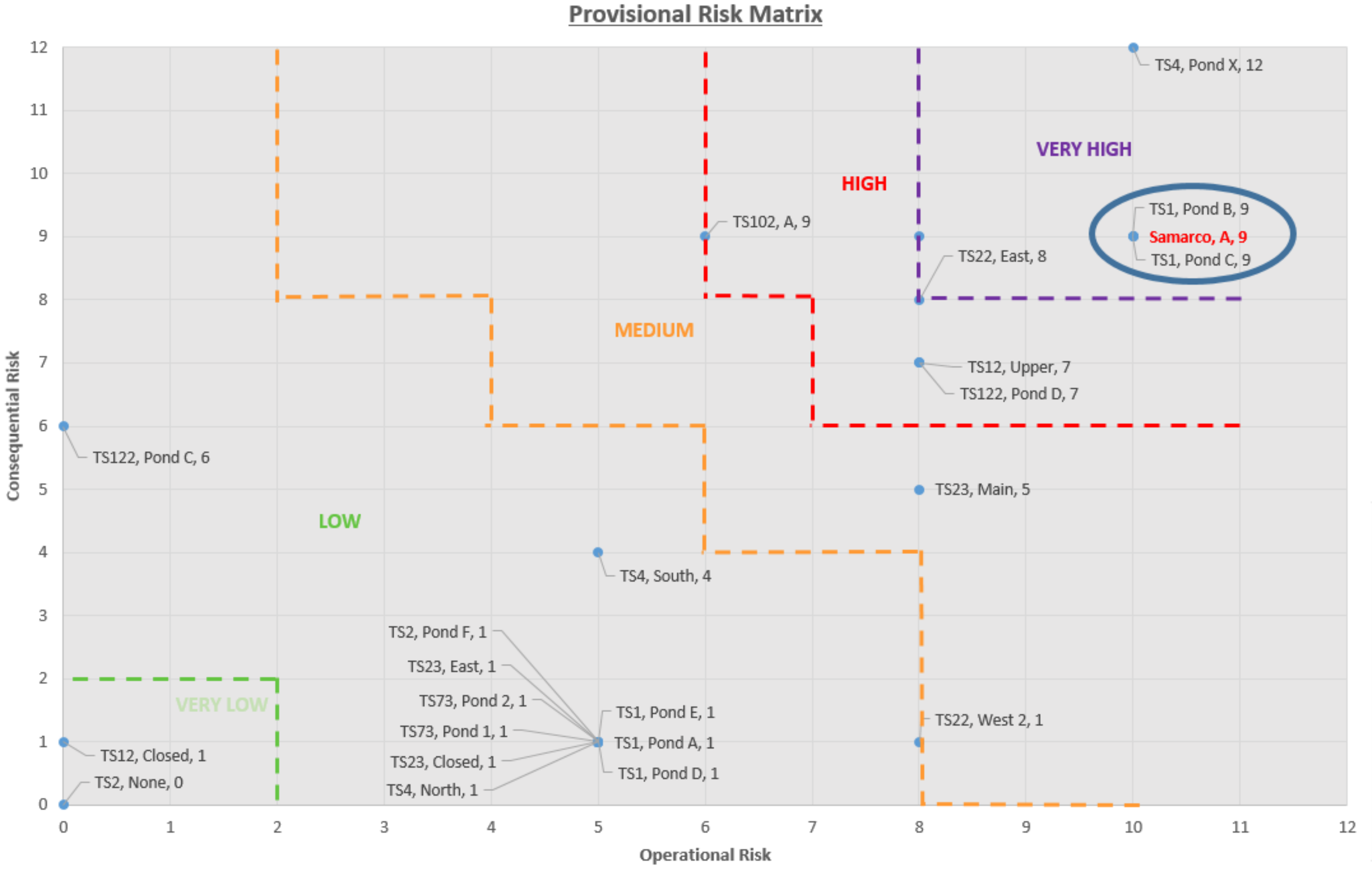
RISK LEVEL	Consequential Risk Category Definitions			Consequential Risk Score
	Surface Water	Property (within 20km)	Land Use	
VERY LOW	No surface water course	No properties	No sensitive land use	1
LOW	>1km to River. No Reservoirs within 50km	< 10 properties	Low level land classification dominant in 20km zone	2
MODERATE	<1km to River, No Reservoirs within 50km	10-100 Properties	Some mid Level (IUCN Categories I- IV) within 20km zone	3
HIGH	<500m to River and Reservoirs within 50km or <100km to the coast	100-1000 Properties	Extensive high category Protected Areas within 20km Zone	4
VERY HIGH	TBD	>1,000 Properties	TBD	7

Using the output

The presence of protected areas, ground cover type, surface water bodies and properties are then evaluated in a GIS system. Results of the simulations can be visualized and the GIS system used to highlight high risk areas both in terms of the detail of the affected receptor but also through estimation of cost.

The results of the construction risk and consequence are then plotted on a graph to help identify the most sensitive of tailings facilities. The highest risk assets can then undergo more detailed assessment from both operational and consequence perspectives. The subsequent section illustrates how more detailed analysis may be undertaken and how a tailings asset management app can be developed and used to keep track of the risk.

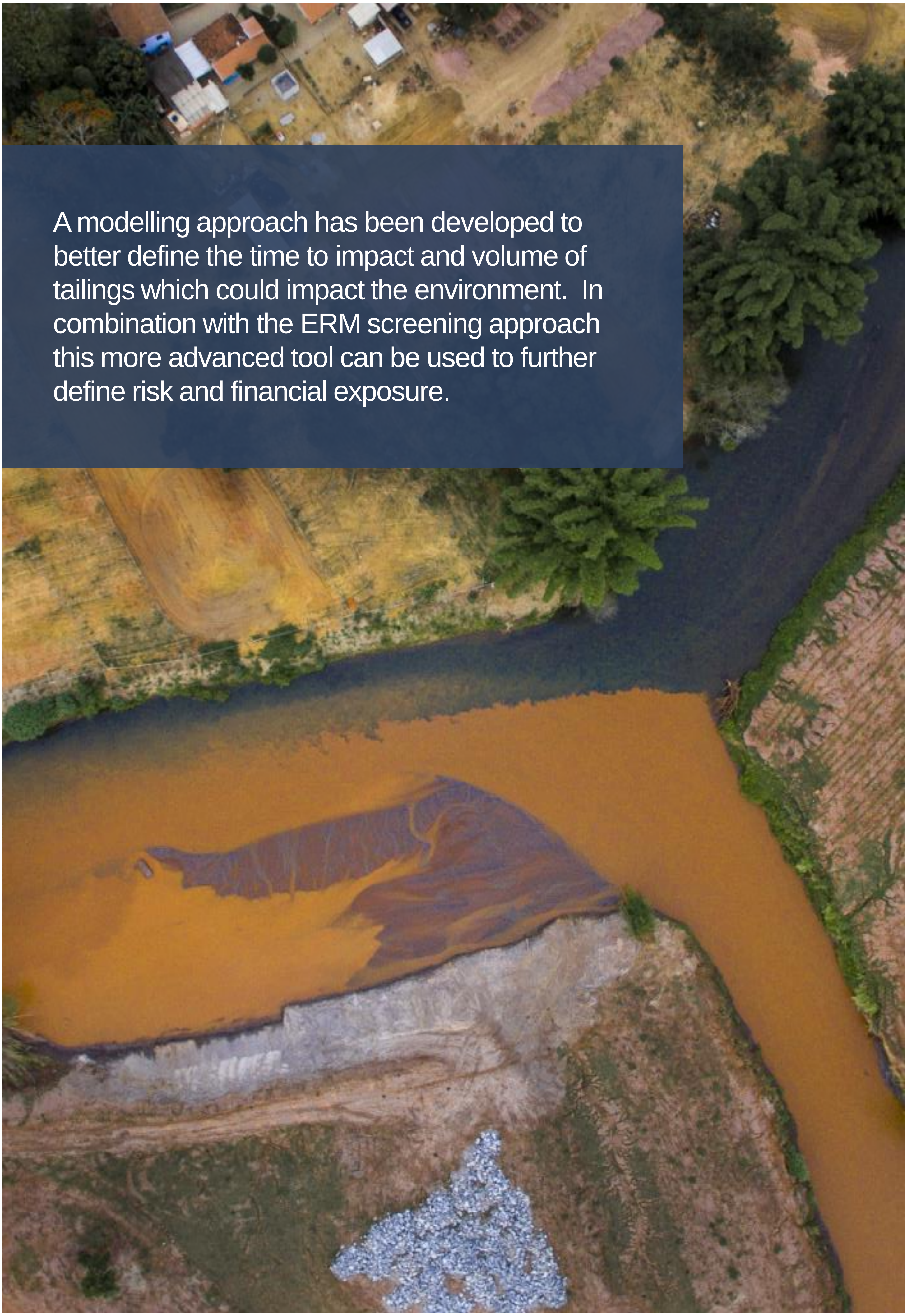
The graphic illustrates the relative risk from a tailings release for a portfolio of assets:



Tailings Dams

Modelling the consequence from higher risk assets

A modelling approach has been developed to better define the time to impact and volume of tailings which could impact the environment. In combination with the ERM screening approach this more advanced tool can be used to further define risk and financial exposure.



Looking at the past

In November 2015, the tailings dam at the Samarco iron ore mine in Minas Gerais State, Brazil, suffered a catastrophic failure which released a toxic mudflow of mine waste into the adjacent Santarém river valley. This resulted in multiple deaths and persistent contamination across a wide area down river. It has been described as the worst environmental disaster in Brazil's history.

More recently a similar failure of the iron ore tailings dam at Feijao once again demonstrated the catastrophic impact such failures can have in terms of loss of life and environmental harm.

Unfortunately, these incidents are not without precedent; globally, there have been over 70 major failures of tailings dam impoundments reported since 1970, often with significant loss of life and long-term damage to communities and ecosystems. The risks posed by the growing number of tailings dams across the world are potentially increasing because of the growing vulnerability to extreme events because of climate change.

Model problem statement

Social and environmental damage from tailings disasters can be catastrophic as shown in the aftermath of the Samarco dam failure

The approach developed by ERM illustrates how a model for simulating a release can be successfully validated by visual comparison of model output with the actual extent of release recorded after the Samarco dam failure.

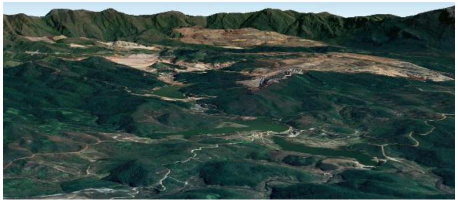
Application of satellite remote sensing analysis and time-series GIS data can be used to evaluate how the level of social and environmental impact may evolve over time.

The extent of mine waste dispersal from accidental release from tailings dams will be controlled principally by local topography (i.e. valleys, gradients, channels, obstacles), fluvial systems, the hydrodynamic properties of the tailings material, and release volumes and rates. Therefore, predicting the impact extent of a release will require gathering and constraining the data for these aspects as far as possible.

Tailings are a mix of ground rock slurry and mine waste water, depending on the processing and ore. Modelling the dispersal of tailings is complex because of the unique and variable physico-chemical properties of tailings produced at every mine site property. Uncertainties in the hydrodynamic properties of the tailings material include: water volume in the storage pond, particle-dependent rheology of the sediment load, and fluid behaviour (i.e. Newtonian or Binghamplastic) which is controlled by the nature of the failure event (seismic action, static liquefaction, slide, etc.), of the suspension.

Different outflow volumes from dam failures will relate to different failure scenarios and mine water planning at the time of the event.

Modelling Approach

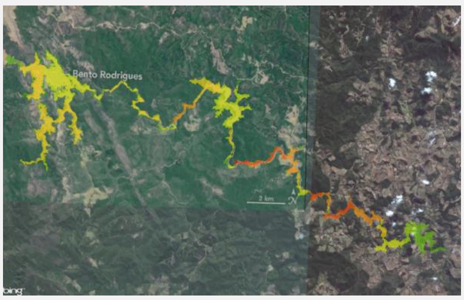


Images courtesy of Google Earth

We are able to gather relevant data and model the extent of a release from a dam as illustrated opposite where the model results are draped over satellite imagery collected shortly after the Fundao tailings release:

This modelling technique has the additional benefit that the output can be used for planning emergency response for the most critical areas. Another advantage is that the model results can be combined with geospatial data of vulnerable receptors in the catchment (population centres, roads, aquifers, rivers, lakes etc.). This data can help the operator in making decisions around how to manage the risk at a specific site or as part of a portfolio wide management process.

This modelling approach demonstrates that even with relatively simple assumptions about the tailings properties and the relatively coarse resolution of digital elevation data (30m), this technique can produce meaningful results and can be applied confidently for forward modelling hypothetical tailings releases at facilities in vulnerable settings around the world.



Images and split model results showing extent (purple line) and colour coded volume/accumulation after approximately 8 hours.

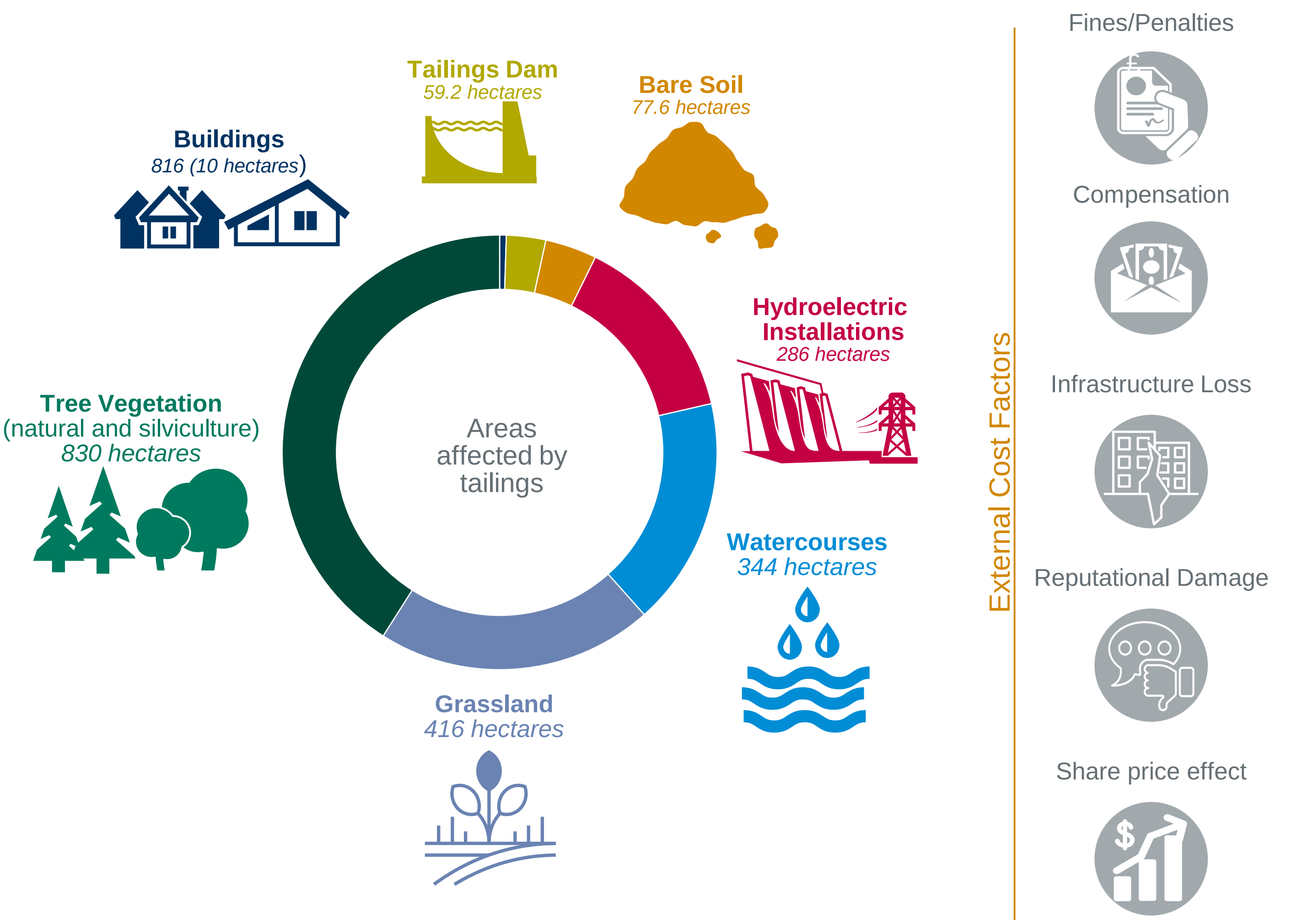
We are now able to model the extent of a release from a dam as illustrated below where the model results are draped over satellite imagery collected shortly after the Fundao tailings release.

Estimating the financial impact

In addition to the modelling of spills ERM has developed an application in conjunction with Ecometrica which provides mining organisations with a platform from which to obtain an overview of the human and natural capital which lies downstream from its tailings facilities. When overlaid with the predictive spill modelling described above it can be used to estimate the potential loss of life and environmental damage which could result from a disaster.

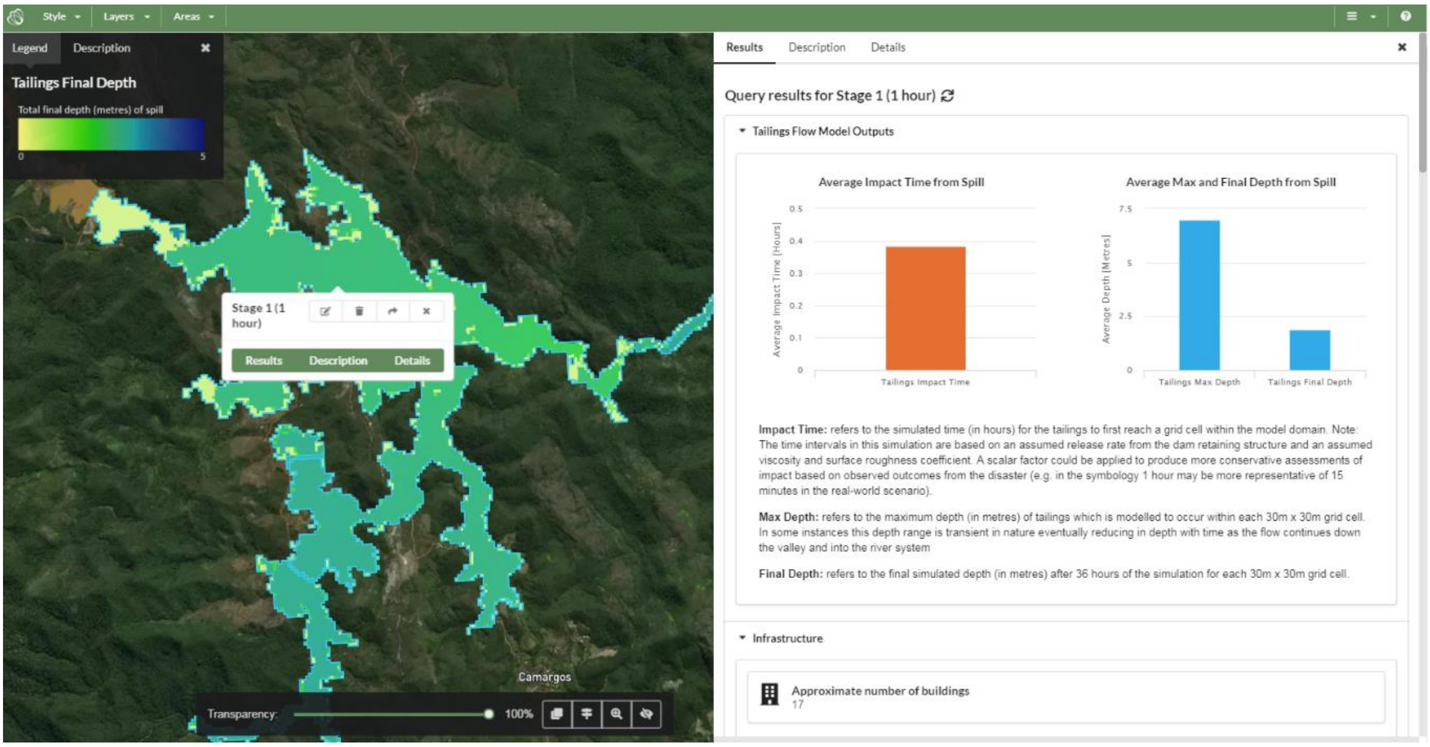
These data in turn can be used to estimate the potential financial exposure of an operator to an incident. Aspects relating to fines and the longer term impact on the economy due to lost tourism, fishing, etc may also be factored in.

The graphic illustrates the extent and range of impacts caused by the Fundão tailings dam release:



Creating a data asset

The platform for viewing data is there to provide mining companies with the opportunity to review the social and environmental risk associated with its tailings dams. Together with reliable information on engineering design and maintenance it can help in prioritising those areas where the impact may be greatest – allowing companies to make changes to emergency warning and response and where appropriate to consider development of protective measures downstream of dams to provide for a greater chance of escape.



The application can be used for facilities worldwide and identification of downstream areas can help produce rapid screening output from which decision making can be based. More detailed simulations of releases can then be used to place those higher risk locations in context.

This application not only provides a current assessment of sensitivity but it can also be used in retrospective and predictive modes to analyse how the area downstream of each dam has evolved with time – including changes in land cover and population. Identification of the most vulnerable populations will enable mining organisations to consider implementation of meaningful evacuation procedures which could, one day, save countless lives

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About ERM

ERM is the business of sustainability.

As the largest global pure play sustainability consultancy, ERM partners with the world's leading organizations, creating innovative solutions to sustainability challenges and unlocking commercial opportunities that meet the needs of today while preserving opportunity for future generations.

ERM's diverse team of 7,000+ world-class experts in over 170 offices in more than 39 countries supports clients across the breadth of their organizations to operationalize sustainability. Through ERM's deep technical expertise, clients are well positioned to address their environmental, health, safety, risk, and social issues. ERM calls this capability its "boots to boardroom" approach - a comprehensive service model that allows ERM to develop strategic and technical solutions that advance objectives on the ground or at the executive level.

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