MINTAILS MINING
SOUTH AFRICA (PTY) LTD

Introducing the Mintails Approach to Closure Mining

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Introduction

Mintails is a unique company, because it is a relative new-comer into South Africa, having brought Mogale Gold out of liquidation in 2005. It therefore represents confidence in the South African economy after the transition to democracy in 1994. This means that it has no baggage from the past and has nothing to defend (or protect) other than an optimistic vision for the future of a prosperous and stable democratic South Africa. The current area of operations is located in some of the most environmentally impacted landscapes and ecosystems in South Africa as a result of legacy mining. The intention is to build its operations around the concept of **Closure Mining** and thereby make an enduring and positive contribution to the transition from an extractive to a post-mining national economy, by leaving the landscape available for higher social and economic use post-closure.

What is Closure Mining?

The historic legacy of gold mining from 1886 to 1994 has left a serious impact on virtually the entire landscape centred on the Witwatersrand Goldfields. These are called **Legacy Issues** which now confront all parties: the government as the sole legitimate **regulator**; the **inhabitants** as persons directly affected by a range of issues over which they have no direct control; and the **private sector**, which needs a stable and predictable regulatory framework in which to raise capital and create employment. The impacts of these issues are widely dispersed as they enter - and are transported through - the river basins, groundwater aquifers and prevailing winds.

For purposes of simplicity, these **Legacy Issues** are the following:

- The existence of a landscape dominated by **tailings dams** (mine dumps) increasingly succumbing to the ravages of nature in the form of wind and rainwater erosion. These tailings dams are uranium-rich so they pose a growing hazard.

- The presence of large **mine voids**, now full (or filling) with water, sometimes decanting to surface in the form of **Acid Mine Drainage** (AMD) (**Photo 6**), a low pH liquid with a high concentration of dissolved heavy metals that is highly toxic.

- The presence of a large swathe of land, approximately 100 km long, stretching from Randfontein in the west to Springs in the east, running south of the centre of the city of Johannesburg, characterized by **geotechnical instability** because it was historically left un-remediated and has subsequently been undermined in a random and chaotic manner by unregulated illegal mining along all surface striking reefs (see **Photos 3a & 3b**).

- The growing presence of illegal **artisanal miners**, who excavate the last remaining reef, to be processed using **mercury** and ultimately sold into **sophisticated criminal syndicates** (see **Photo 2**).

- The growing **pressure on land for housing**, most of which is located close to mine tailings dams in what is known as a **Mine Residue Area** (MRA). This is typically characterised by geotechnical instability caused by shallow undermining, which has long-term implications for the use of that land for **human settlement**. Many MRA's are currently unfit for human habitation but are increasingly used as such.

- The fact that no mine has ever been legally closed, which means that all **old mining operations simply get abandoned at the end of their useful life**, with no effective way of preventing the **erosion of tailings dams**, the **generation of AMD** and the increase in **uncontrolled illegal artisanal mining** once this has occurred.

- The growing pressure on the **need to create and maintain viable jobs** in the wake of the collapse of the gold mining industry that has seen the shedding of livelihoods as the multiplier effect of shutdowns is felt in feeder industries.

It is clear that **these issues are extremely complex** and cannot be dealt with by one party in isolation of the actions of others. For this reason, **Mintails has adopted a partnership approach**[1] with government, society and NGO's, centred on the concept of Closure Mining.

Closure Mining can be defined as the deliberate long-term planning to optimize all mining-related processes and operations with a view to aligning the final outcome with the broader interests of society, in collaboration with all key stakeholders in a post-mining future, guided by the triple bottom line of economy, society and environment.

We can thus distinguish two distinct **forms of mining** with different **business models**:

- **Traditional Mining**, which has been practiced in the Witwatersrand Goldfields for more than a century. This maximized profits by externalizing liabilities[2] through the optimization of all mining processes and operations at the level of the shaft or pit *via* a company-centric approach that naturally favoured short-term profits over sustainability.

- **Closure Mining**, which is not yet in widespread use in the Witwatersrand Goldfields, but is currently being developed by Mintails as an adaptive response to changing circumstances. This maximizes benefits to society over time as historic externalities of mining, now manifesting as constraints to future development, are systematically dealt with in partnership with key stakeholders. In essence this optimizes the outcome of current mining at the level of society rather than at the level of the shaft or pit, by internalizing historic externalities that are now constraints. As

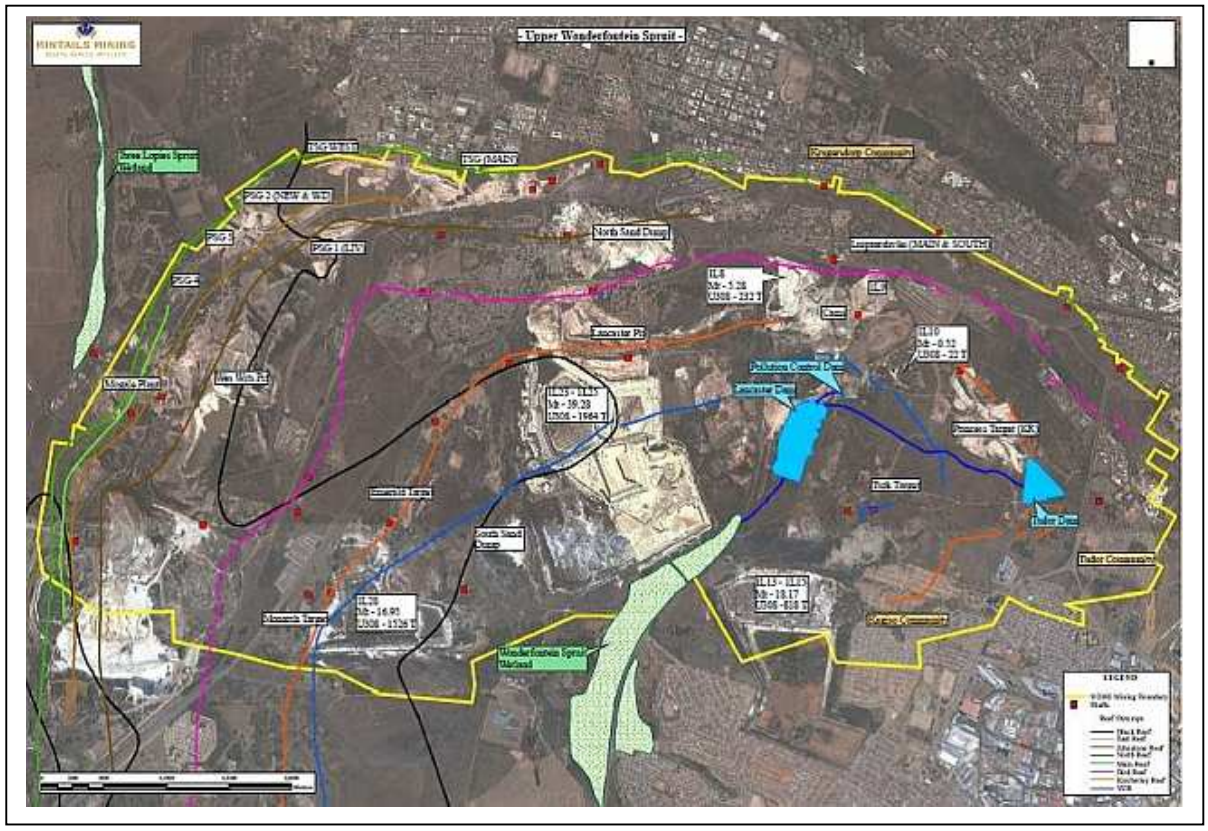
such it embraces the essence of sustainability by internalizing the triple bottom line of people, profits and planet.

The **Outcome of Closure Mining** is a rehabilitated landscape and functional ecosystem capable of supporting humans and other species while mitigating all **Legacy Issues** to the extent that they no longer act as constraints on future socio-economic development.

The Mintails Approach to Closure Mining

The **absence of a formal national mine closure strategy** for the Witwatersrand Goldfields[3] that has been **adopted by the regulator** and **implemented across the industry**, the **absence of a clear and coherent policy on the management of Mine Residue Areas** (MRA's)[4], and the lack of science, engineering and technology (SET) needed to underpin the rehabilitation of mine impacted ecosystems present as significant constraints for future investment into the regional economy. Recognizing the need to create jobs and attract investment despite these constraints, Mintails favours an approach based on **partnership** within the **ethos of stewardship** by adopting global best thinking about sustainability.

The Mintails approach to Closure Mining will thus be rolled out on its own area of legal responsibility as defined in **Map 1**, which incorporates a substantive portion, but not all, of the Western Basin.



Map 1. Mintails area of operations centred on the Randfontein Cluster of tailings dams.

From **Map 1** the following is evident:

- Mintails has rights and ownership of approximately 100 million tonnes of tailings disposal facilities (TDF's) collectively known as the **Randfontein Cluster**.

- The major concentration of these TDF's are clustered around the upper reaches of the **Wonderfontein Spruit** (WFS) located in the eastern half of the mining rights area.

- The WFS drains a highly impacted MRA (see **Map 4**), with two distinct groups of TDF being relevant:

    - The so-called **Cams Cluster** consisting of **TDF 1L 8 – 10** upstream of **Lancaster Dam**. These are sources of historical pollution for the whole system, most notably of AMD and uranium (as well as a range of other metals).

    - A cluster comprised of **TDF 1L 23 – 25** and **TDF 1L 13 – 15** downstream of **Lancaster Dam**, which acts as a natural choke point for the wetland as well as a significant source of historical and future pollution if left *in situ*.

- The WFS is fed by a natural spring, which lies under the **Mogale Solid Waste Dump**, now a surrogate in the form of a pollution control dam that captures leachate from this dump for "treatment" by the municipality prior to disposal into the system.

- The WFS is also fed from a small wetland draining the land between **TDF 1L 23** and **1L 28**, which enters the main stem of the river downstream of **Lancaster Dam**. The upper reach of this sub-system is dominated by other industries, which also impact the pollution load entering the WFS at this confluence.

- There is **urban encroachment** into the mining rights area, with the most notable being (literally) around **TDF 1L 13 – 15** and the **Tudor Dam** area central to the **Princess Pits**. Given the historic impact, many of these areas are not currently fit for human inhabitation.

- The legacy of the country is evident as the historically black areas of **Kagiso** to the south separated from the historically white areas of Krugersdorp to the north. **Tudor Dam** is a central defining feature and the area of land in which open holings sustain the illegal artisanal miner's often resident in the adjacent informal settlements.

- The whole of the mining rights area is subject to a series of decline and vertical shafts and associated ventilation infrastructure created to access the seven reef horizons that manifest on the surface in this area.

Thus, **if the Upper WFS area is to be comprehensively rehabilitated, a collaborative approach must be taken** to coordinate and address both the historic mining legacy issues as well as the current contributors to the pollution loadings. Focusing solely on the mining legacy issues will fail to achieve the requisite post-rehabilitation conditions required for prospective uses identified and prioritised by the local authority.

The Upper WFS as it pertains to the Mintails approach to Closure Mining is shown conceptually in **Figure 1**.

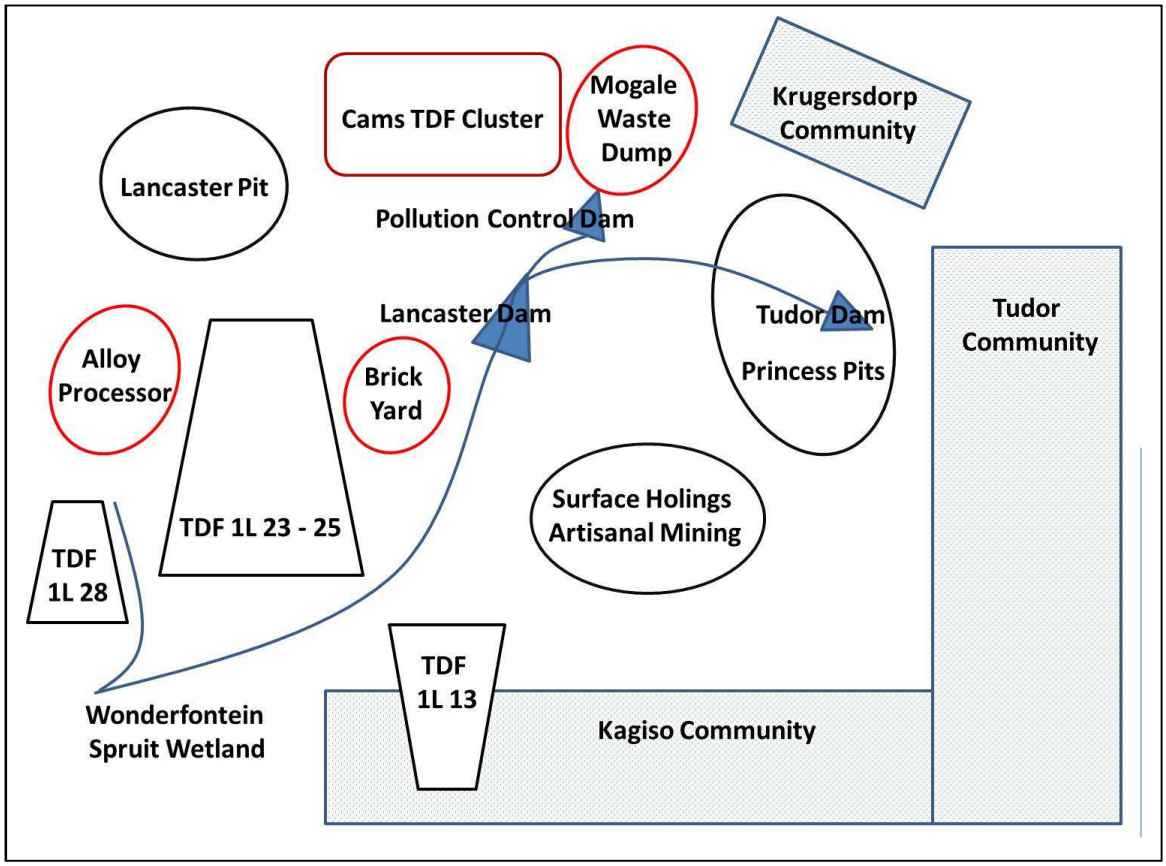


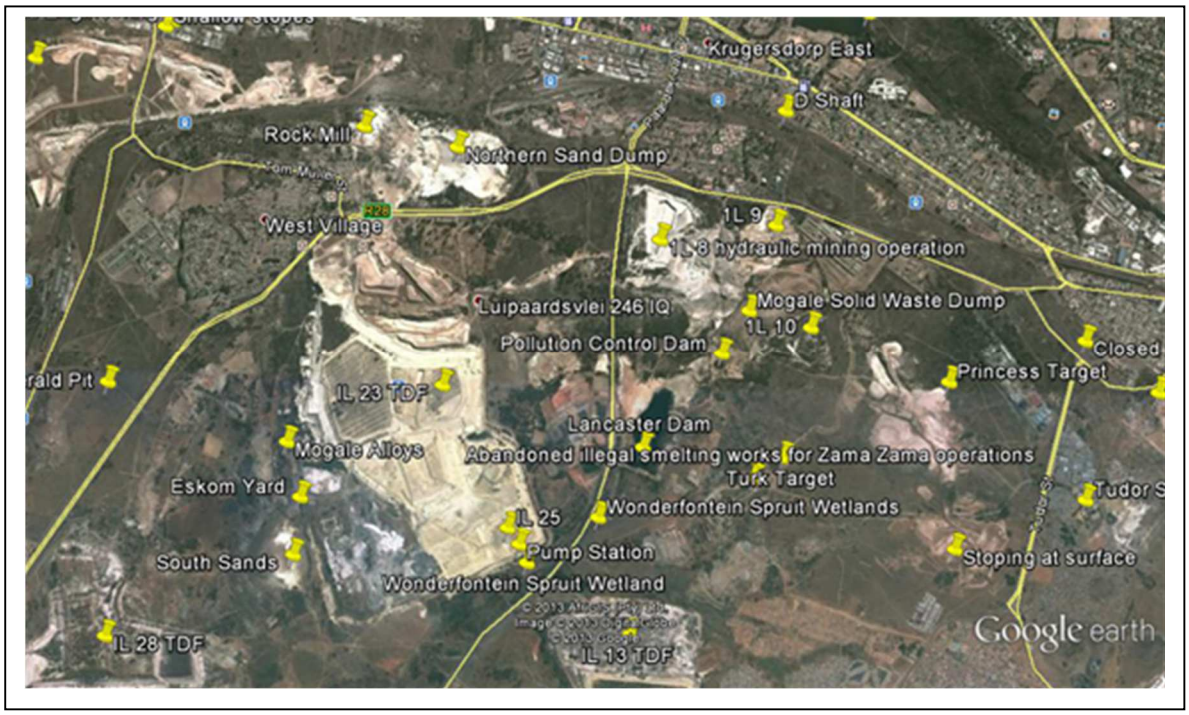
Figure 1. Conceptual layout of the Upper Wonderfontein Spruit as it pertains to the Mintails approach to Closure Mining.

The **Upper WFS** can thus naturally be divided into the following sub-systems, all crucial to the evolution of Closure Mining:

- **Upstream of Lancaster Dam**, which is a major pollution control device for the runoff of contaminated water from the entire MRA consisting of:
  - the **Cams TDF Cluster**
  - the **Mogale Waste Dump**
  - and the **Princess Pits** centred on **Tudor Dam**.

- **Downstream of Lancaster Dam**, consisting of the largely uncontrolled flow of water draining the western portion of the MRA between **TDF 1L 23-25** and **TDF 1L 28**, with further impact from current industrial activities.

The **Upper Wonderfontein Spruit** as it pertains to Mintails is shown on **Map 2**.



Map 2. Wonderfontein Spruit area of Mintails operations as they existed on 15/9/2013.

Mintails Operations in the Context of the Greater Wonderfontein Spruit

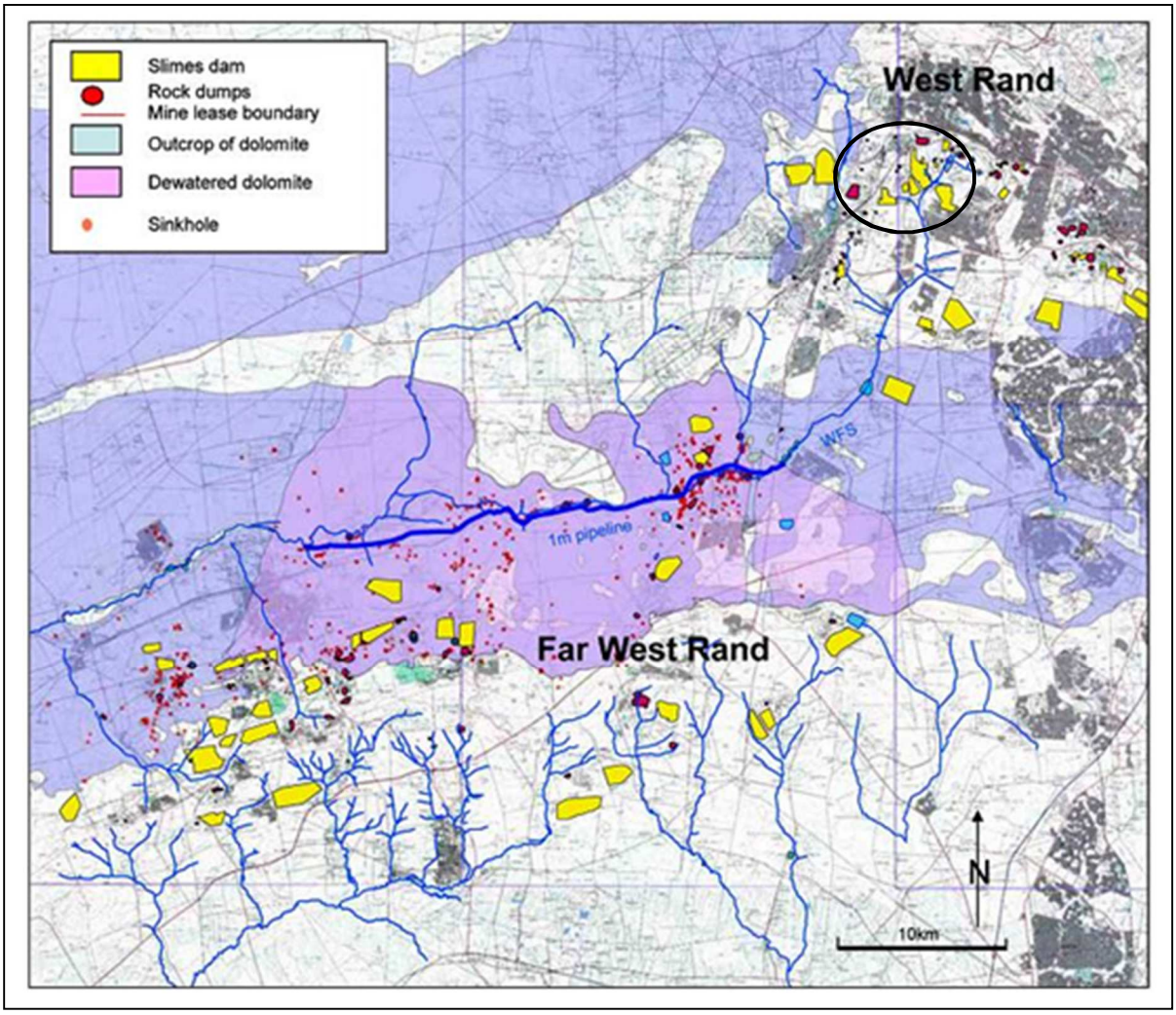
It is known that the WFS is a pivotal issue for society in general, but most notably for the inhabitants of Tlokwe/Potchefstroom, because the water flowing in that system enters their drinking water resource. **The Mintails operations therefore need to be considered within the context of the entire system.** In effect no viable rehabilitation of the overall system will ever be possible without the adequate removal of all surface tailings located in the upper WFS that contribute to the pollution loadings, irrespective of ownership.

This has two significant **implications** in the context of Closure Mining:

- On the **negative side of the equation**, all of the pollution load originating from the Upper WFS (historical mining legacy and current industrial users) will impact on the overall system in a cumulative way. This has major implications for the post-mining future of the regional economy when understood in the context of the dolomite that forms an integral part of the geohydrology of the WFS (**Map 4**).

- On the **positive side of the equation**, everything that Mintails (and other users) does in its area of operations, removes a quantifiable amount of pollution from the overall system, which cascades downstream in a cumulative sense. This has major implications when one considers the **multiplier effect of benefits** to off-mine interested and affected parties arising from Closure Mining.

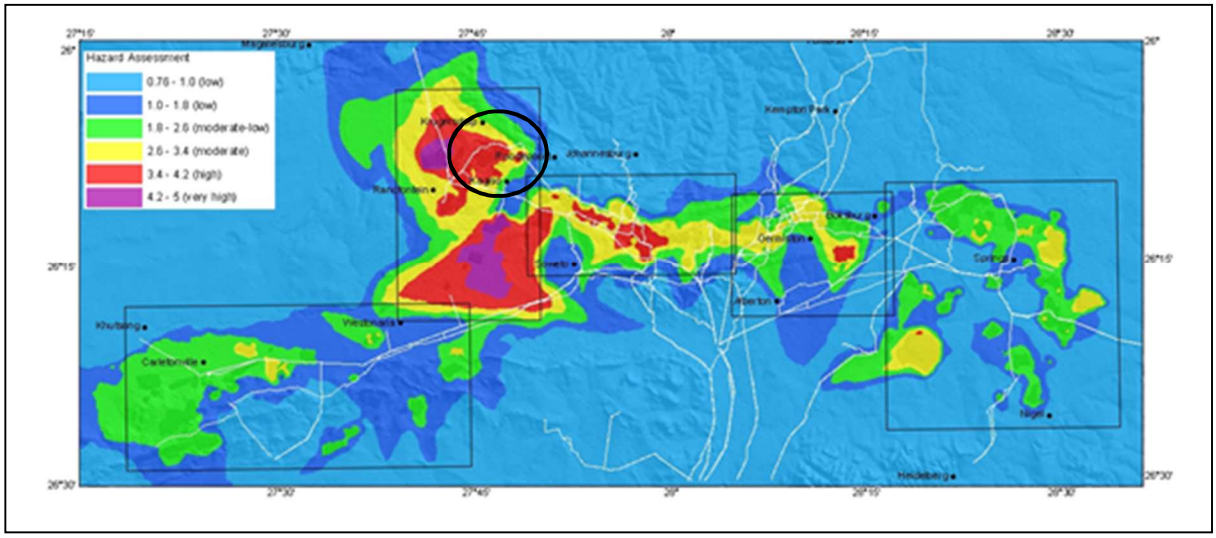
The Wonderfontein Spruit is shown in **Map 3**, which also contextualizes the **dolomite** and the location of all TDF's in both the Western and Far Western Basins of the Witwatersrand Goldfields.



Map 3. The Wonderfontein Spruit and surroundings showing MRA features (TDF's – yellow; waste rock dumps – red) and dolomite outcrop (grey-blue with the pinkish tone indicating dewatered compartments in the Far Western Basin[5]). The Mintails area of operations is shown in the black circle.

From the information shown on **Map 3** it is evident that while legacy issues in the Mintails area of operations are clearly a contributor to the pollution load of the WFS, it is actually a relatively small player in the overall context. The significance of this became quantifiable for

the first time in a recent hazard assessment conducted for a parastatal authority. **This process generated the first known empirical methodology that was capable of assessing the risk profile of each TDF across the entire Witwatersrand Goldfields**, which then enabled a numerical value to be given to each MRA. A valuable by-product of this process was the generation of the first known **Hazard Diffusion Model** of the entire Witwatersrand Goldfields. The results of the Hazard Diffusion Model show that the Western Basin is in fact a disaster area, but with two distinct sub-systems inherent to it. This is shown in **Map 4**.

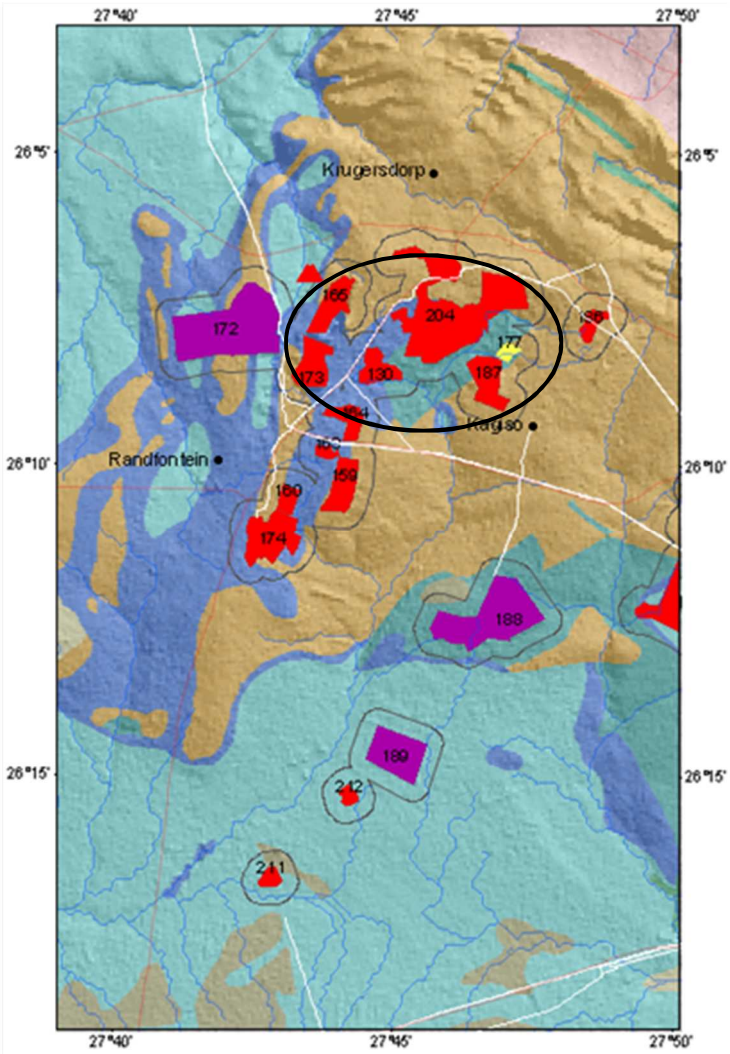


Map 4. The results of the Hazard Diffusion Model[6] show the Western Basin to be the most impacted of all mining basins in the Witwatersrand Goldfields, but with two distinct sub-systems. The Western Basin should be considered a national disaster area because of the AMD flows that have breached environmental critical levels (ECL) in a karstic system (Photo 6). The Mintails area of operations is shown in the black circle.

We are now capable of building up a highly nuanced understanding of the overall WFS system, specifically insofar as individual TDF's are drivers of risk at that level of scale. The empirical risk assessment model has quantified the specific hazard rating for each MRA down to a fine level of resolution. Unfortunately that project used the GDARD MRA identification numbers, which differ from the normal identifiers used in the mining sector. Notwithstanding this small technical issue, **we now know, with a high level of confidence, what the risk profile of each MRA is**. **In the Mintails area of operations, there are five MRA's that score high on the overall hazard rating (see Map 5)**. The scores of these individual MRA's shown from worst to best are as follows:

- MRA 204 (**Cams Cluster** including **TDF 1L 23-28**) – Hazard Rating of 4.2.
- MRA 173 (area between No 9 and No 8 Shafts) – Hazard Rating of 3.8.
- MRA 165 (**West Wits Pit**) – Hazard Rating of 3.8.
- MRA 186 (**Princess Pits** and **Tudor Dam**) – Hazard Rating of 3.6.
- MRA 187 (**TDF 1L 13-15**) – Hazard Rating of 3.5.

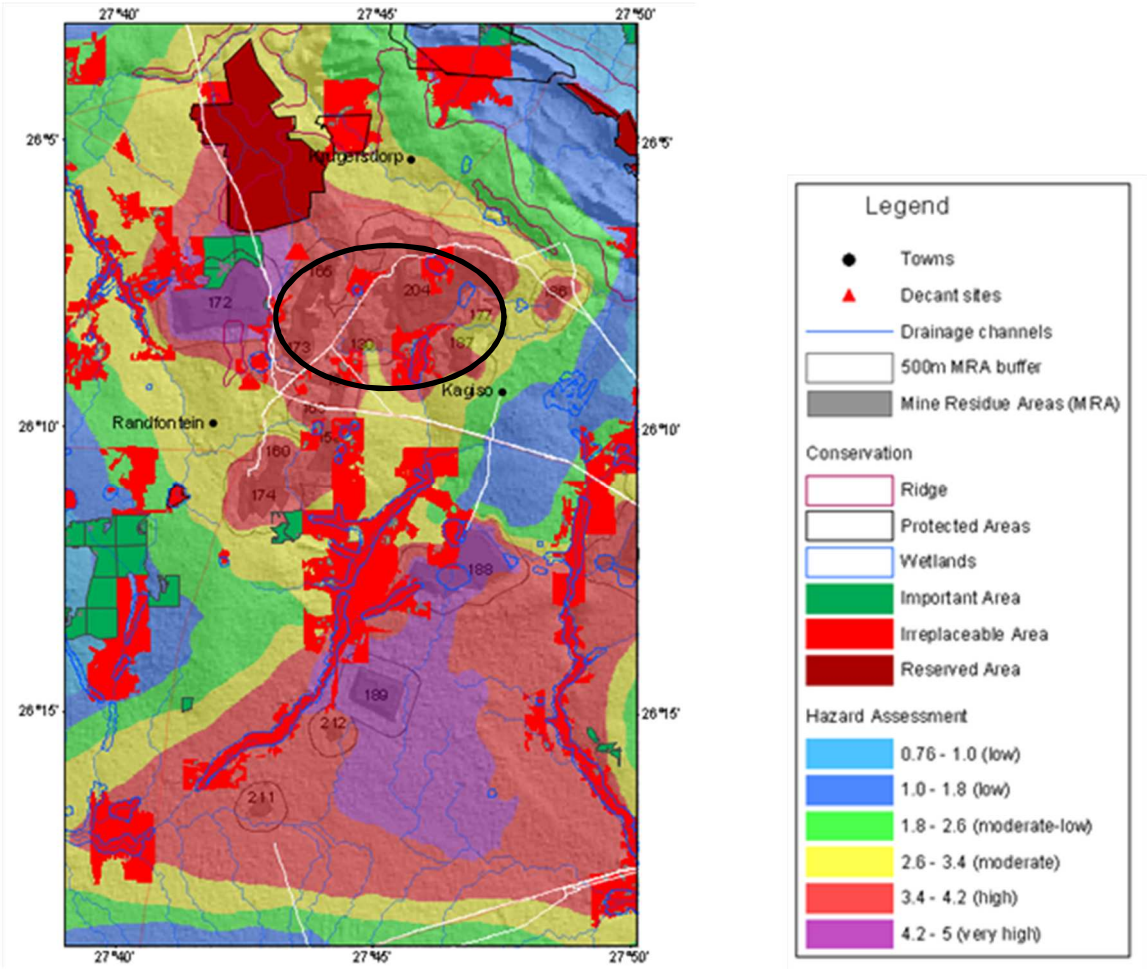
This is shown on **Map 5** clearly indicating that the Mintails area of operations, while scoring high in an overall context, is less critical than MRA's 172, 188 and 189. These are not part of the Mintails mining right, but their impact is significant (see **Maps 4 & 6**).



MRA ID	Severity	Probability	Hazard (S+P)
130	2.0	5	3.5
159	2.2	5	3.6
160	2.3	5	3.6
163	2.0	5	3.5
164	2.3	5	3.6
165	2.6	5	3.8
172	4.3	5	4.7
173	2.7	5	3.8
174	2.7	5	3.8
177	1.8	5	3.4
186	2.3	5	3.6
187	2.1	5	3.5
188	3.6	5	4.3
189	4.3	5	4.7
204	3.3	5	4.2
211	2.6	5	3.8
212	2.5	5	3.8

Map 5. Assessed MRA Hazard[7] within the Western Basin showing individual composite scores. The Mintails area of operation is shown in the black circle.

This fact is born out in greater detail on **Map 6**, which shows the overall hazard distribution across the entire Western Basin, superimposed on the MRA areas (including buffers), but also showing rivers, wetlands and areas of ecological significance. From this it is clearly evident that if the Mintails area of operations is rehabilitated to a point where ecological functionality can be restored, and landscape damage can be mitigated to the point where the land can be returned to higher value fit-for-purpose use post-closure, then **the cumulative benefit of this will accrue to all downstream users as well**. This benefit can thus be claimed as a legitimate offset against current liability in all Closure Mining planning. The exact mechanism for the calculation of this still needs to be refined.



Map 6. Modelled MRA hazard distribution in the Western Basin[8] showing conservation areas. The Mintails area of operation is shown in the black circle.

Attention is drawn to the existence of a conservation area defined as being "reserved" immediately north of MRA 172. This is the Krugersdorp Game Reserve centred on the **Tweelopies Spruit**, which is the receiving environment for AMD flows from the Western Basin decant (**Photo 6**). Attention is also drawn to the existence of an "irreplaceable" area centred on the wetlands of the **Wonderfontein Spruit**. Areas most significantly impacting both of these receiving environments (marked "Reserve" and "Irreplaceable" on **Map 6**) are outside Mintails' area of control and thus demonstrate why it is important to collaborate with all key stakeholders within an area for coordinated remediation efforts to be most effective at a societal level. More importantly this raises the issue about **cumulative impact** if nothing is done, or conversely, **cumulative benefit** if fit-for-purpose rehabilitation is achieved through the adoption of Closure Mining as an overall business model.

Hydraulic Mining as a Key Component of Closure Mining

Now that we understand the relevance of Mintails operations in the overall context of other larger systems (Wonderfontein Spruit), we need to deal with the removal of tailings. The

Mintails mining right is dominated by TDF's. This means that the reprocessing of these resources is a key aspect of the core business. This reprocessing is done as follows:

- AMD is abstracted from the void and neutralized using the patented **Tailings Water Treatment** (TWT) process.
- This becomes **process water** that is used to mine the tailings as slurry (**Photo's 1a and 1b**). Over 80% of Mintails' total water usage is treated mine water, up from 0% 5 years ago. This is the highest use of safely processed AMD in the industry.
- This slurry is pumped back to the processing plant, where it is **blended with ore** at the mill to improve run of mine (ROM) throughput and thus economic viability.
- This blend of recovered tailings slurry and crushed ore becomes feedstock into the **Carbon in Leach (CiL) recovery process**.
- The **barren tailings** stream, now depleted of all gold (but still containing uranium), is disposed of into the West Wits Pit (WWP) at a relatively high pH (>8), thereby sequestering the uranium away from storage facilities vulnerable to wind and rainwater erosion.
- These barren tailings **neutralize the AMD in the adjacent void area** to a value of > 5, thereby precipitating out the uranium as an oxide and thus sequestering it in a relatively stable format, as long as this pH value is maintained[9] (see **Photo 6**).

Photo 1(a) (left). The remnants of TDF 1L 8 after hydraulic mining. Photo 1(b) (right). Hydraulic cannon used to cut the tailings pile in the Cams TDF Cluster.

Once the tailings have been removed, the footprint of the dump is rehabilitated to the safety standard required for the purpose for which it will be used in future. This means that large quantities of tailings are moved by Mintails, raising the issue of efficiency. It has been shown that the safest and most economical way to move the tailings, from the hydraulic mining operation at the Cams Cluster, to the processing plant, is by means of pipeline. This raises the issue of pipeline safety. **Figure 2** shows the record of all pipeline failures from July 2011 until November 2013. The number of failures per month is shown as a vertical bar, with the actual spillage of tailings expressed as a percentage of total tailings processed for the month

shown as a line. **The average spillage for the reporting period was 0.28%, which means that 99.72% of all tailings recovered by hydraulic mining were safely processed**.

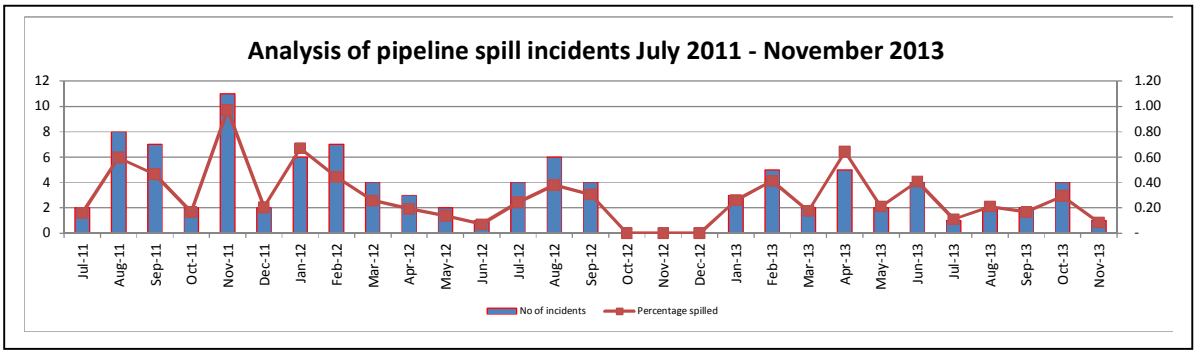


Figure 2. Analysis of pipeline spill incidents involving tailings at Mintails from July 2011 to November 2013. (Left scale - number of incidents; right scale - % of total).

Given that tailings are a resource that is reprocessed, it is not in Mintails interest to tolerate spillages, as they cause plant shutdown, escalate costs and create an incident requiring remedial action. However, we are working with machinery and people, so breakdowns are inevitable. From a management perspective the Mintails internal targets are to reduce spillages to < 0.25% of all tailings pumped. Once a spill occurs, it is immediately recorded as an incident, consistent with the requirements of the Water Use License, and a formal procedure is triggered that is designed to contain the spillage within the pipeline servitude area, repair the pipeline in the shortest possible time, report it to the relevant regulatory authority and then recover the spilled tailings as soon as they are dry enough to be handled.

The **Mintails internal management target is** to attain **a < 0.25% spillage of all tailings** pumped.

Open Cast Mining Operations as an Element of Closure Mining

Mintails has a number of surface striking reef packages. It is common to the industry that each surface striking reef has a holing to surface roughly every 100 metres apart, arising from earlier shallow mining operations that made use of natural ventilation. This means that there are literally hundreds of access points from surface into gold-bearing reef in Mintails' area of operation alone. When large scale mining operations ceased, they also left behind significant quantities of reef, mostly in the form of crown pillars, but also as pillars around haulages and drives left *in situ* to protect the miners in these structures from the fall of ground. The **unintended consequence** of this fact is summarized as follows:

- There are a large number of **illegal artisanal miners** operating in these many abandoned workings. While no exact figures are known, it is not improbable that there are at least as many artisanal miners now operating illegally as there are formal miners working for registered mining companies.

- One commentator[10] has noted that the value of ore lost to artisanal miners by registered mining companies is in the order of ten to twenty billion Rand per annum.

- These **artisanal miners are linked to criminal syndicates**[11] that provide them explosives (see **Photo 2a**), also used in ATM bombings. These **explosives are used by unskilled miners** to bring down pillars left in place to hold the hanging wall up.

- These actions are not coordinated in any way, with rival gangs fighting a **turf war over control of these resources** (see **Photo 2b**). This has left many artisanal miners dead[12] as a result of conflict and other hazards associated with entry into abandoned workings and unregulated re-mining of the residual resource.

- The **chaotic aspect of artisanal mining has left large swathes of land geotechnically unstable** and thus incapable of being used for any social or economic activity, until it has been rendered safe through rehabilitation. As the activity of illegal miners is not mapped, it is not understood specifically where artisanal mining has created geotechnical instability. This renders all historic mapping of the Goldfields redundant, so all accessible areas need to be reserved as potentially impacted areas. This includes roads, railways, power lines and buildings.

Photo 2(a) (left). Explosives confiscated from an artisanal miner arrested in December 2013. Photo 2(b) (right). Police teams responding to a murder scene in Florida on 8 January 2014 when two rival gangs clashed over control of a specific resource.

The Mintails view is that **the only viable solution to this is to remove all surface striking reef through open-cast operations**. This creates a long but relatively narrow pit, which is then backfilled in order to start the re-stabilisation and rehabilitation process. Given that there are a number of surface striking reef packages on the Mintails mining rights area, it is possible to run open cast operations in parallel and concurrently. The advantage of multiple pits is that the waste from one can be immediately backfilled into another, consistent with the Water Use Licence, without the need to stockpile and thus reduce the overall cost. Aspects of this are shown in **Photos 3(a)** and **3(b)**. The benefits of this approach are threefold:

- **Entry points for artisanal miners** are closed out reducing illegal activity.
- **Ingress points for water** are restricted, thereby reducing the flow of AMD into, and thus eventually out of, the void (**Photo 6**).
- **Geotechnical stability is restored** so the land can be rehabilitated (**see Photo 4(e)**) to a point where it is fit-for-purpose post-closure.

Photo 3(a) (left). A shallow underground working exposed through Closure Mining. Photo 3(b) (right). A typical cross section of an entry point into the void used by artisanal miners. The gold bearing reef targeted by these miners is visible as a grey band running parallel to the lower haulage that has been exposed.

The Mintails approach to the Closure Mining of surface striking reef is best illustrated by the case of **PSG 4**. This was a small package of surface striking reef running parallel to the **Tweelopies Spruit** upstream of the **Black Reef Incline** (BRI) and **18 Winze AMD Decant Point.** The Google Earth image in **Photo 4(a)** shows the site before operations commenced. The Tweelopies Spruit is on the left of that image flowing towards the north (upwards). **Photo 4(b)** shows the commencement of mining operations with the trenches clearly visible across the strike of reef. These are used to characterize the reef profile and thus develop the most efficient pit shell design. **Photo 4(c)** shows backfilling in progress, using waste extracted from another pit being mined concurrently. **Photo 4(d)** shows the site as it was reported by the SABC TV environmental program 50-50[13] flighted on 2 December 2013. **Photo 4 (e)** shows the rehabilitated site as it appears in March 2014.

This is the blueprint for the Mintails approach going forward as lessons are being learned about how to conduct the process in a responsible manner. In similar manner lessons being learned from the grassing experiment being run at the **Frik Site** are also being used to understand the process of acidification over time, thereby informing the selection of grass species and methodology for pre-seeding footprints in preparation for final rehabilitation.

Photo 4(a)(top left) shows PSG 4 before open cast operations began. Photo 4(b) (top right) shows operations in progress. Photo 4(c) (bottom left) shows backfilling in progress. Photo 4(d) (bottom right) shows the site being reported on by the TV program 50-50 in late 2013.

Photo 4 (e) shows the rehabilitated PSG 4 as it stood in March 2014 with Tweelopies Spruit draining to the right and MRA 172 in the background (see Maps 5 & 6).

Regarding the geotechnical stability aspects of Closure Mining by means of open cast operations, it is important to note that the ground will always be impacted, irrespective of how it is backfilled. A backfilled open cast pit remains an artefact of mining and thus will always be subject to restricted land use post-closure. It is therefore important to emphasize that **Mintails will take the land to a point where it can be rehabilitated for a specific purpose that needs to be clearly defined and agreed to before the process commences**. It is to this aspect that we now turn our attention.

Scheduling of Closure Mining Upstream of the Lancaster Dam

From the assessment presented thus far it is evident that a critical area of operations is in the Upper Wonderfontein Spruit. From **Figure 1** and **Map 2** it is evident that the area upstream of **Lancaster Dam** is being prioritized. While this work can be completed within 18 months, all processes supporting this are not in the control of Mintails, so this has a direct impact on both the timing and the outcome. Assuming that there is no disruption to the planned process however, the following could be completed by that time:

- The **Cams Cluster** could be removed to the point where final rehabilitation on the footprint can commence.

- The **Princess Pits** could have all surface striking reef removed and be backfilled.

- **Tudor Dam** could no longer exist as it will have been processed as part of the Princess Pit operations and rehabilitated to resemble PSG 4 (see **Photo 4(e)**).

Three **Constraints** exist **to the final rehabilitation process** at the time of writing. These are:

- There is **no scientific, engineering and technology (SET) basis** that is robust and coherent enough to form an uncontested foundation for rehabilitation. As a direct result of this **there is no consensus on how rehabilitation should actually be done**.

- There is **no institutional arrangement** in place between all major stakeholders **that supports a cooperative desire to achieve a common vision**.

- There is **no vision for a post-closure landscape** capable of defining what the purpose of rehabilitation will be, and consequently the standard to which the rehabilitation needs to take place.

In order to meet its obligations **Mintails has initiated the following actions and processes** to effectively overcome these constraints:

- Regarding the **Absence of an SET Basis** the following has been done:

- A request was made to the **Water Research Commission** (WRC) on 3 April 2013 to consider the creation of a **National Program for the Rehabilitation of Mine Impacted Aquatic Ecosystems**. This will define the national context and structure the research questions while mobilizing the necessary funding needed to meet the national need.

- Discussions have been held with international **NGO**'s that have technical expertise in both aquatic and terrestrial ecosystem rehabilitation with a view to partnering with them. **WESSA** has been engaged in a partnership because of their specialist knowledge in grassland ecology. They are scheduled to do the first ecological assessment of both the Wonderfontein Spruit and Tweelopies Spruit using the SASS methodology in the near future. This will provide the baseline against which future rehabilitation will be planned.

- An outreach has been launched to enable Mintails to develop and consolidate global best thinking, with formal connections now in place with **UNESCO IHP** at a number of levels (International Year of Water Cooperation at The Hague, World Water Week groundwater specialist group, University of Strathclyde project on cooperation in transboundary aquifers, University of Western Cape Groundwater Chair). The objective here it to create the networks needed to inform the technical processes underpinning the rehabilitation of impacted groundwater systems on a basin and aquifer wide basis.

- An invitation has been extended to several **Universities** and institutions of research and tertiary education to cooperate in research. This will feed into the corpus of knowledge needed for rehabilitation. The **NWU** is formally engaged in a project on the biophysics of grasses in acid generating environments at the Frik site as well as an assessment of Closure Mining as a concept.

- Linkage has been established with **LARSSA** with a view to embracing the knowledge base that exists within that community of professionals.

- Regarding the **Absence of Appropriate Institutional Arrangements** the following is relevant:

  - Mintails has created an **Environmental Management Forum** (EMF) to be used as a foundation for this process. This EMF is envisaged to exceed the legal requirement insofar as it will eventually evolve into the appropriate institutional structure needed to coordinate the actions of other stakeholders and provide the requisite feedback loop with society and relevant contributors to the process.

- The Water Use Licence mandates engagement with the **Wonderfontein Spruit Forum**. A meeting held in the Mogale Town Council chambers on 5 March 2014 to re-launch the failed **Remediation Steering Committee** of the Wonderfontein Spruit Catchment Area was used to state the Mintails case that the absence of an institutional structure capable of bringing all stakeholders together in a consensus-based approach remains a significant impediment. Mintails has committed to participate within the **Remediation Steering Committee** in recognition of the need to create a viable institutional structure for the coordination of the actions of all parties and is awaiting a decision from the Chairman regarding their admissibility as a partner.

- Mintails has established a formal relationship with the **Alliance for Water Stewardship** (AWS) and has become the first mining company in the world to voluntarily submit to the testing of the **Beta Standard**. This has been facilitated by the **Water Stewardship Council of Southern Africa** (WSCSA). This trailblazing process has been used to inform Mintails of the necessary internal reforms needed to make it compliant with international best practice, most notably in the evolution of the EMF into an institutional structure capable of meeting the needs of Closure Mining.

- Formal linkage has been created with the GiZ in terms of their **International Water Stewardship Program**. The stated objective in this regard is to bring the donor community capability to bear on the empowerment and capacity building processes needed to create a stable and functioning institutional structure capable of delivering the objective of Closure Mining.

- Regarding the **Absence of a Vision** for a post-closure landscape the following is relevant:

  - An agreement has been reached with **Wits University** to build national capacity in the fields of strategic planning, town planning, urban design and landscape architecture. The first post-graduate student was fielded in late 2013, with a second group of approximately 20 students fielded in February 2014 with the objective of starting to develop a visioning process capable of informing all key stakeholders as we collectively transition from an extractive to a post-mining future economy. This will feed into the institutional processes once they have been established by defining what the ultimate purpose of rehabilitation will be. Given that **the Mintails commitment is for rehabilitation to be fit-for-purpose**, this is a critical element of the process, without which this commitment cannot be met.

Scheduling of Closure Mining Downstream of the Lancaster Dam

As the Closure Mining operations upstream of Lancaster Dam wind down to a conclusion, so the activities downstream of that point will be ramped up in parallel. The key elements of this transition will be the removal of all possible gold-bearing reef and tailings as an economic resource before shifting focus. In practice, Mintails will need to make some sequential release of land, because the increasing urban pressure leads to a higher prioritisation of land availability for low cost housing, even if the piecemeal nature leads to a suboptimal usage of that post-mining land. Mintails activities will create significant uplift in the land values, anticipated to be many multiples, and how that land is released has an impact on this value, both economically and socially. **This needs an uncontested Post-Closure Vision if it is to be optimally beneficial to all parties**. Assuming a clear post-closure vision can be generated to the point where mining becomes uncontested then the following will take place:

- Hydraulic mining of **TDF 1L 23 – 25** will commence in the near term future. Parts of the pipeline from the pumping station have been stolen and need to be replaced; and the Gold 2 plant needs final commissioning to process the increased production. Once these two current constraints have been overcome, the recovery of TDF 1L 23 – 25 will commence irrespective of the status of the process upstream of Lancaster Dam. Both are dependent on approval (and availability) of required capital funding, implying the need for investors to be comfortable with the economic performance of the project over the required project lifespan. Prolonged contestation undermines investor confidence, so it is vital that a Post-Closure Vision be generated as soon as possible if this dump is to be removed.

- The removal of TDF 1L 23 – 25 will take a decade to complete, but will enable the western bank of the Wonderfontein Spruit to be rehabilitated, using the knowledge yielded from the **National Program for the Rehabilitation of Mine Impacted Aquatic Ecosystems,** which will then be in place (assuming the WRC delivers).

- A decision will be taken on the removal of **TDF 1L 13**, but only if there is full community support for the process. At present there is urban encroachment right up to the toe of the dam and this is anticipated to become worse by the time recovery operations can be considered.

- Assuming that community support is gained for the removal of TDF 1L 13, then both the eastern and western banks of the **Wonderfontein Spruit can be fully restored to ecological functionality once the tailings are removed**. This will have obvious benefits to all parties downstream of that system (see **Map 3**).

- These actions will be closely coordinated *via* the **Remediation Steering Committee of the Wonderfontein Spruit Catchment Area** assuming that it can be revitalized

into a viable consensus-driven institution and that Mintails membership is not contested.

- Underground mining will replace open cast operations as all pits are closed out. The initial focus on this aspect is centred on **D Shaft** and its associated infrastructure, which has recently been equipped for this purpose.

Photo 5. D Shaft being shown to the media and the Wits University Landscape Architect and Town Planning team in November 2013. Underground operations will ramp up as open cast operations are closed out on the Mintails mining right.

Closure Mining and AMD

The AMD problem has been well documented, most notably in terms of growing public anxiety and a loss of confidence from the investment community. **Map 4** shows the extent of the environmental damage caused by the breach of ECL in the Western Basin. Mintails takes this very seriously and has developed the **TWT Process** for its own operations. Details of this are available in a confidential document currently awaiting approval from the regulator, so this will not be expanded upon here beyond the following summary in the context of **Closure Mining**:

- **Mintails does not concur with the prevailing view that AMD need be a perpetual problem that the taxpayer has to pay for alone and forever.**

- The **TWT process neutralizes AMD** to the extent that it is safe to use in all of the current operations being conducted by Mintails or other mining or industrial processes.

- Mintails is the only mining company that currently uses **grey (or treated) mine water** produced by the TWT process for all of its production and the majority of its processing.

- **The return of barren tailings to the West Wits Pit at a relatively high pH (>8) has effectively neutralized the AMD water** in the pit to the extent that it is now consistently being abstracted at a pH value >5 at No 8 Shaft, which is the critical threshold for uranium solubility. This fact alone has attenuated the disaster arising from the uncontrolled decant in March 2014 (see **Photo 6**).

- **The consolidation of all small TDF's into the WWP**, which will then be engineered to 21st century standards for final closure, **is thus a central element in the Closure Mining planning within Mintails**.

- **Mainstream research suggests that the majority of AMD is created in the void**, but we now know that this is not true. The contribution made by surface tailings needs to be understood in the context of national decisions on the mitigation of the problem.

- New data shows that **rainfall at a pH < 4 is in fact the genesis of the acidification process**, because it attacks the hydroxide covering of the tailings particle and triggers the further oxidization of pyrite. This is part of the emerging new thinking on the problem[14], which also raises the question of the efficacy of current policies in dealing with AMD decant (see **Photo 6**).

- This means that **the concept of Closure Mining cannot be understood in isolation of AMD management by the regulatory authorities**. Closure Mining is in fact a key component of the long-term solution to AMD, which addresses the interlinking environmental, social and economic imperatives.

- **The TWT plant** is only being used for Mintails' process water at present, but if it is given regulatory approval it **can be brought to full production within four months** of such a decision being announced. This will bring additional dewatering and neutralization capacity to bear on the Western Basin with considerable relief to the taxpaying public. The significance of this needs to be evaluated against the factual background that the recent decanting of untreated AMD from 17 & 18 Winze Shafts (see **Photo 6**) provides a stark reminder that despite the investment of significant sums of taxpayer's money, the government cannot solve this problem alone.

- **The TWT process yields virtually the same results as HDS, but at a fraction of the cost**. The added benefit is that of **cyanide destruction.** The TWT process consistently yields values of 1 ppm WAD Cyanide, in contrast to the regulatory requirement of 50 ppm for disposal onto a TDF. The current value of 1 ppm WAD Cyanide would meet the environmental limits in some jurisdictions, such as the United States, but there are currently no regulatory limits in SA other than the 50 ppm threshold that deals with discharge to a TDF. Mintails is currently working on cyanide destruction processes in conjunction with various parties to continue to lower these levels, irrespective of ultimate environmental regulations.

Photo 6. The uncontrolled decant of AMD from 18 Winze shaft in March 2014 creates a window of opportunity for all parties to rethink the logic currently being applied in the expenditure of taxpayers money to solve the AMD problem. Mintails has the ability to bring significant additional pumping and neutralization capacity into the system, as an emergency measure at a fraction of the cost when compared to the current failed approach, and is awaiting regulatory approval.

Closure Mining and Uranium

It must be understood by all parties that the uranium issue is not going to simply disappear. It is known that for every tonne of gold mined over 120 years, between 10 and 100 tonnes of uranium were also brought to surface[15], depending on the particular reef horizon being mined. Most of this has been discarded in the numerous TDF's that exist in Gauteng. Mintails therefore believes that **a sensible discussion needs to be had with all parties interested in finding solutions to this enduring environmental hazard**. In order to commence with this discussion, it is noted that there are only two possible known alternatives. These are:

- The **Recovery of Uranium** as a strategic mineral while gold recovery is being undertaken and the consolidation of TDF's is underway. This will remove uranium from the environment and thus be beneficial for society in general. However, the economics of this process are a limiting factor, so it cannot be achieved on the scale desired at current market prices. The first phase of removal onto resin *via* an ion exchange process, for further beneficiation at a different plant, is technically possible, but would require a subsidy to be sustainable. Society needs to be empowered to understand the potential costs and benefits of this approach.

- The **Sequestration of Uranium** in a format that is chemically stable and thus no longer hazardous even if it remains present in the environment. This will not remove the uranium, but will render it safer than it is left in an abandoned TDF being eroded by wind and acidic rainwater and thus distributed over an increasingly larger impact footprint. In similar vein, society needs to be empowered to understand the overall risks and benefits of this approach as well.

In the context of Closure Mining **Mintails is currently sequestering uranium from the water through the TWT process.**

Mine Dumps and Society

Mining companies will not always be present, but the dumps will, so the issue of how these are managed in a post-mining future will increasingly become a key policy-related concern for all parties.

Conclusion

Mintails is a responsible company that is pioneering the concept of Closure Mining. This is a complex transition from a known business model of traditional mining in which profits were maximized by externalising liabilities by optimizing processes at the level of the shaft or pit. **The sustainable approach to mining involves dealing with the historic externalities by removing them as constraints to future development while optimizing all processes at the level of society**. This has many complexities embedded within it so the transition will not be easy. The **management of conflict** and the deliberate **desire to build consensus at many levels and between diverse actors** both need to be built into the institutional framework if Closure Mining is to become viable. The prognosis for success will be greatly enhanced if: an uncontested vision for the future of a post-mining economy and landscape can be developed; and a robust institutional structure can emerge to embrace that vision in the near-term future. **Mintails has chosen to adopt the ethos of stewardship as the very core of its corporate culture**. Stewardship implies many things so it is a fundamental part of Closure Mining. The most important elements of the stewardship ethos are the willingness to cooperate and the acceptance of accountability for outcomes. Consistent with this ethos, Mintails has initiated a range of interactions designed to overcome the constraints noted in this document. More

importantly, Mintails commits itself to being a responsible partner in that process and will do whatever it is capable of to deliver on its commitments. Mintails therefore calls on all parties to act in a responsible manner and invites a broad-based, collaborative approach to actively seek solutions to the point where contestation can be reduced to manageable levels. This will enable the raising of capital to create jobs and deliver on the desired outcomes of closure mining noted in the text box on page 4. Mintails affirms its commitment to the future of South Africa by making this document publically available for comment and discussion by solution-seeking entities. The recent decant from 17 & 18 Winze shafts (see **Photo 6**) offers an opportunity to rethink the logic underpinning the solution that has been used until now, by showing that Government cannot solve these complex problems alone. As a clear statement of intent, Mintails wants to be part of the solution, rather than being part of the problem confronting society as a whole.

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[1] See Case Study No 31 on page 62 of the Policy Shapers Project Report entitled "Dispatches from the Policy Frontline: Examining the Response to the Water-Energy-Food- Climate Stress Nexus" that has been compiled by **Xynteo** (available online at http://www.xynteo.com/projects/policy-shapers).

[2] See **Adler, R., Claassen, M., Godfrey, L. & Turton, A.R.** 2007. Water, Mining and Waste: A Historical and Economic Perspective on Conflict Management in South Africa. In *The Economics of Peace and Security Journal*, Vol. 2, No. 2 (2007), Pp 32 – 41. Available online at http://www.ehrn.co.za/publications/download/119.pdf

[3] See **Van Tonder, D. & Coetzee, H.** 2008. *Regional Mine Closure Strategy for the West Rand Goldfield.* Council for Geosciences Report No. 2008-0175. Pretoria: Department of Minerals and Energy; **Van Tonder, D.** 2008. *Regional Mine Closure Strategy for the Far West Rand Goldfield.* Council for Geosciences Report No. 2008-0248. Pretoria: Department of Minerals and Energy; and **Strachan, L.K.C., Ndengu, S.N., Mafanya, T., Coetzee, H., Wade, P.W., Msezane, N., Kwata, M. & Mengistu, H.** 2008. *Regional Gold Mining Closure Strategy for the Central Rand Goldfield*. Council for Geosciences Report No. 2008-0174. Pretoria: Department of Mineral Resources. While these documents exist, they have not been formally adopted by the regulatory authorities, which means that in effect there is no accepted framework that is supported by science, policy and the industry.

[4] See **GDARD**, 2011. *Feasibility Study on Reclamation of Mine Residue Areas for Development Purposes: Phase II Strategy and Implementation Plan, Summary Report*, July 2011, 788/06/01/2011, Final. Umvoto Africa (Chris Hartnady, Andiswa Mlisa, Masibulele Fubesi, Michael Baleta, Oliver Barker, Amanda Fitschen, Harold Annegarn) in association with TouchStone Resources (Anthony Turton).

[5] See **Winde, F.** 2010. Uranium Pollution of the Wonderfontein Spruit, 1997-2008. Part 1: Uranium Toxicity, Regional Background and Mining-related Sources of Pollution, In *Water SA*, Vol. 36: No.3; 239-256.

[6] See **Hartnady, C., Mlisa, A., Turton, A.R., Blake, D., Goyns, A., Simpson, G., von Scherenberg, L., Khudzai, A., Burgher, K. & Seyler, H.** 2012. *Research Project to Investigate Acid Water Plumes, Decants and Intersects with Rand Water's Potable Water Pipelines: Phase 1*. Report No. 810-04/01/2012. Johannesburg: Rand Water.

[7] See **Hartnady, C., Mlisa, A., Turton, A.R., Blake, D., Goyns, A., Simpson, G., von Scherenberg, L., Khudzai, A., Burgher, K. & Seyler, H.** 2012. *Research Project to Investigate Acid Water Plumes, Decants and Intersects with Rand Water's Potable Water Pipelines: Phase 1*. Report No. 810-04/01/2012. Johannesburg: Rand Water.

[8] See **Hartnady, C., Mlisa, A., Turton, A.R., Blake, D., Goyns, A., Simpson, G., von Scherenberg, L., Khudzai, A., Burgher, K. & Seyler, H.** 2012. *Research Project to Investigate Acid Water Plumes, Decants and Intersects with Rand Water's Potable Water Pipelines: Phase 1*. Report No. 810-04/01/2012. Johannesburg: Rand Water.

[9] The significance of this is best demonstrated by the uncontrolled decant from 17 & 18 Winze shafts in March 2013. The pH of the water flowing from these shafts is considerably higher than it would be without the deposition of alkaline barren tailings into the WWP. So while the current decant shows us that the approach adopted thus far has failed, it is not a disaster by virtue of the fact that uranium and other hazardous metals have been sequestered due to the pH value being > 5 (the threshold value for uranium solubility).

[10] **Matthew Hart** in *Gold* (2013) states that, "thieves steal about a billion dollars a year worth of ore, or maybe twice as much".

[11] See http://dailysun.mobi/news/read/4014/illegal-miners-claim-cops-are-involved for an example of alleged police involvement in corrupt dealings.
[12] See http://en.wikipedia.org/wiki/2009_Harmony_Gold_mine_deaths and http://www.sabc.co.za/news/a/35b094804c35a0e19b8fffecb51a2d14/Search-for-illegal-miners-presumed-dead-continues-20120308
[13] Available *via* You Tube as follows: PART 1http://www.youtube.com/watch?v=LupTH-fop3A and PART 2 http://www.youtube.com/watch?v=-Twg8fP1BvI
[14] See **Turton, A.R.** 2013. Debunking Persistent Myths about AMD in the Quest for a Sustainable Solution. *SAWEF Paradigm Shifter* No.1. Johannesburg: South African Water, Energy and Food Forum (SAWEF).
[15] See **Winde, F.** 2006. Inventory of sources and pathways in the catchment. Chapter 3 in **Coetzee, H., Winde, F. & Wade, P.W.** *An assessment of sources, pathways, mechanisms and risks of current and potential future pollution of water and sediments in gold-mining areas of the Wonderfonteinspruit catchment*. Water Research Commission, WRC Report No. 1214/1/06. Pp 35-53.