GOLD RIDGE TAILINGS STORAGE FACILITY ASSESSMENT

Solomon Islands

United Nations Disaster Assessment and Coordination

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Union Civil Protection Mechanism

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Cover photo: Sampling is conducted by environment authority and mining company employees at the flooded tailings storage facility © UNEP/OCHA

Table of Contents

The Joint UNEP/OCHA Environment Unit (JEU) assists Member States in preparing for and responding to environmental emergencies by coordinating international efforts and mobilizing partners to aid affected countries requesting assistance. By pairing the environmental expertise of the United Nations Environment Programme (UNEP) and the humanitarian response network coordinated by the United Nations Office for the Coordination of Humanitarian Affairs (OCHA), the JEU ensures an integrated approach in responding to environmental emergencies. The Environmental Emergencies Centre (EEC) (www.eecentre.org) is an online tool designed to build the capacity of national responders to environmental emergencies developed by the JEU.

The United Nations Disaster Assessment and Coordination (UNDAC) is part of the international emergency response system for sudden-onset emergencies. UNDAC is designed to help the United Nations and governments of disaster-affected countries during the first phase of a sudden-onset emergency.

The Union Civil Protection Mechanism (UCPM) facilitates co-operation in disaster response, preparedness, and prevention among 32 European states (EU-28 and the Former Yugoslav Republic of Macedonia, Iceland, Liechtenstein and Norway). With the support of the European Commission, Participating States pool resources and experts that can be made available to disaster-stricken countries all over the world as well as for prevention and preparedness operations. When activated, the Mechanism coordinates the provision of assistance from its Participating states. The European Commission manages the Mechanism through the Emergency Response Coordination Centre (ERCC). Operating 24/7, the ERCC monitors risks and emergencies around the world and serves as an information and coordination hub during emergencies. Among other tasks, the ERCC also ensures that Participating States are fully aware of the situation on-site and can make informed decisions for providing financial and in-kind assistance. Since its creation in 2001, the Union Civil Protection Mechanism has been activated more than 180 times for disasters in Member States and worldwide, including recent activations in response to Typhoon Haiyan in the Philippines, forest fires in southern Europe and Syrian refugee crisis in neighbouring countries. For more information, please refer to the ECHO website and/or ERCC Portal. The Union Civil Protection mechanism closely cooperates with the United Nations and it participated in several joint missions.

Executive Summary

In April 2014, **heavy rains and earthquakes** led the Government of the Solomon Islands to request assistance for the assessment of the **disaster's impacts on the tailings storage facility** of the Gold Ridge goldmine. Subsequently, a United Nations Disaster Assessment and Coordination team was deployed, with the support of the European Commission's Humanitarian Aid and Civil Protection department. The objective of the mission was to assess the dam stability and to evaluate the impacts of a potential dam overspill or breach on the **8 000 people living downstream** from the tailings storage site.

Site visits, report reviews and interviews with stakeholders show the situation at the tailings storage facility to be stable, but in acute need of management and monitoring to minimize potential threats to the environment as well as health and safety threats to downstream communities.

Water levels in the tailings storage facility are extremely high and there is an **acute need to lower the water level in the tailings dam**. Without this, there is a risk that additional rain will cause an overflow from the tailings dam through the saddle dam spillway, increasing the risk of a breach. Currently, the spillway construction is not finalized – meaning that **an overflow would erode the spillway and potentially lead to an uncontrolled large spill that could include harmful tailing sediments**. Should this happen while the site is left unattended, the closest downstream villages would be at high risk of **devastating flooding and mudflows**.

Under these circumstances, a controlled dewatering of the tailings storage is considered to be the most practical if not only option from a humanitarian perspective. Given the substantial time it will take to lower the water levels, **preparations for discharge without treatment can be initiated as an emergency safety measure**. Discharge must be carried out in consultation with the potentially affected communities, under an appropriate environmental discharge license, and must take place in a controlled manner. This would lower arsenic concentrations, which is the chemical substance of primary concern to human health in the tailings water, to a level in line with the World Health Organization guidelines for drinking-water quality – an acceptable level considered safe for the environment and downstream communities.

Controlled dewatering must be accompanied by the **set-up of a comprehensive water monitoring program** to monitor both the process and its impact on the downstream river. The **water treatment facility must be safeguarded and re-commissioned as soon as possible**. Once operational, the water treatment process will allow discharge in a more sustainable manner. It is **critical that an actor with the sufficient technical, financial and human skills and capacities leads the controlled dewatering process and associated site activities**. Such skills and capacities are typically found only among experienced mining companies. Only the continuous presence of such a team at the site can ensure monitoring and prompt action in case of incidents.

Finally, the site operations need to be evaluated and a **decision taken on whether the site should remain active or be closed**. Both paths would result in associated site improvement. **Dewatering is an acceptable yet temporary solution and must be accompanied by infrastructure improvements at the tailings storage system**. This means that the construction of the tailings storage facility must either be completed to the initial engineering design, or an analysis for the current construction and its design must be conducted to assess whether the site and its management should adapted accordingly should a risk be found to exist in the current design and construction.

List of acronyms and glossary of terms

DP	Discharge/Polishing Pond
EAM	Environmental Assessment Module
ECHO	European Commission's Humanitarian Aid and Civil Protection Directorate General
GRML	Gold Ridge Mining Limited
JEU	Joint UNEP/OCHA Environment Unit
MECDM	Ministry of Environment, Climate Change, Disaster Management and Meteorology (Solomon Islands)
MID	Ministry of Infrastructure Development (Solomon Islands)
MMERE	Ministry of Mines, Energy and Rural Electrification (Solomon Islands)
mRL	Raise level in meters
OCHA	(UN) Office for the Coordination of Humanitarian Affairs
RAMSI	Regional Assistance Mission to the Solomon Islands
RW	Return Water (Dam)
TSF	Tailings Storage Facility
UCPM	Union Civil Protection Mechanism
UN	United Nations
UNDAC	United Nations Disaster Assessment and Coordination
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
WHO	World Health Organization
WTP	Water Treatment Plant

An environmental emergency is defined as a sudden onset disaster or accident resulting from natural, technological or human-induced factors, or a combination of these, that cause or threaten to cause severe environmental damage as well as harm to human health and/or livelihoods.
UNEP/GC.22/INF/5, 13 November 2002

1. Mission background and scope

1.1 Context

In early April 2014, Solomon Islands was hit by heavy rains causing flash flooding which affected the capital Honiara and areas of Guadalcanal province. At the Gold Ridge goldmine, situated about 30 km south east of the capital, 500 mm of rainfall was recorded in 24 hours. On 9 April, the Gold Ridge operator, St. Barbara, evacuated some 200 personnel and suspended operations at the mine, due to damage caused by the disaster.

An initial assessment of the damage to the Gold Ridge Mine was conducted on 11 April 2014 by the Ministry of Infrastructure Development (MID), the Ministry of Environment, Climate Change, Disaster Management and Meteorology (MECDM) and the Ministry of Mines, Energy and Rural Electrification (MMERE). The assessment highlighted the significant rise in water levels at the Tailings Storage Facility (TSF) as well as the exposure of chemicals at the water treatment plant. On 13-14 April 2014, a series of earthquakes took place off the coast of the Solomon Islands, causing additional concern about the integrity of the tailings dam. Subsequently, on 14 April 2014, the Permanent Secretary of the Solomon Islands Government and the Chair of the National Disaster Council (NDC) submitted an official request to the United Nations Resident Coordinator for technical environmental assistance from the international community (Annex 1).

In response to the request, the Office for the Coordination of Humanitarian Affairs (OCHA) triggered an environmental emergency assistance request through the United Nations Disaster Assessment and Coordination (UNDAC) system. Additional support was requested through the Union Civil Protection Mechanism (UCPM), which subsequently provided expertise with the support of the European Commission's Humanitarian Aid and Civil Protection Directorate General (ECHO).

1.2 Mission objective

The primary mission objective was to undertake a rapid assessment of the dam safety and chemical hazards posed by the Gold Ridge mine TSF - with specific evaluation of the possible impacts to the health and safety, as well as livelihoods, of downstream communities. In addition to dam safety and integrity, the mission assessed the potential for environmental and health impacts of a potential release of tailings water into the environment in instances of treated as well as untreated water release. The mission was also tasked to support sampling and analysis of water in the TSF complex and those nearby surroundings where seepage was deemed likely as well as the receiving waters where dewatering discharge was likely to be done. Finally, the current procedures for safeguarding and managing the TSF site were assessed, including the operation of the water treatment facility and the procedures for dewatering the dam. The mission terms of reference are provided in Annex 2. The assessment was conducted with the aim to support the MECDM and the Solomon Islands Government in appropriate follow-up action for managing the site.

The mission was composed of the following experts:

- Ms. Emilia Wahlstrom, United Nations Environment Programme (UNEP) / OCHA Joint Environment Unit – Team Leader (UNDAC member), Expert on chemicals management
- Mr. Niels Masselink, The Netherlands (supported by ECHO) – Expert on hazardous waste management and sampling analysis
- Ms. Christina Winckler, Sweden (supported by ECHO) – Senior Geotechnical Engineer with focus on tailings management and dam stability and safety

The team was additionally supported by Dr Paul Jagals, who was deployed by the World Health Organization (WHO) as an independent environmental health expert.

Ms. Wahlstrom and Mr. Masselink arrived in Honiara on Monday 21 April. Ms. Winckler arrived on Wednesday 24 April. The team spent approximately 2.5 weeks in country, leaving on Thursday 8 May. Dr Jagals arrived on 9 May to conduct an environmental health assessment of the impact on downstream communities using the completed assessment as the foundation. A detailed mission agenda is provided in Annex 3. The mission worked in close coordination with representatives of national authorities and UN agencies. A full list of consulted stakeholders is included in Annex 4. Reviewed background documents are listed in Section 4.

For its assessment, the team reviewed reports, conducted a number of field visits and held meetings with stakeholders. The dam integrity assessment was based on a review of the original design drawings and analysis and on field observations to reach conclusions and provide recommendations. For the chemical hazard assessment of the tailings storage water, analysis results provided by the Australian laboratory ALS through the MECDM, were used. Additionally a NITON XRF was used to assess the arsenic contaminant level in the TSF sediments, and pH was measured in the different dams. No other measurements or analysis were made; it was instead decided to conduct additional sampling by MECDM on May 6 and for the analysis to be done at the ALS laboratory.

The report and assessment were prepared on the basis of information and reports made available by stakeholders. A number of key technical reports outlining the design, construction and technical parameters of the TSF and dewatering programs were either not available to the mission, or made available at a very late stage. It is important to note that the mission was not tasked to conduct an audit of previous operations at the tailings facility, but rather to provide an assessment of the post-flooding and post-earthquake risks posed by the site to nearby communities. The lack of data and time also meant that the team did not conduct a detailed risk assessment of the TSF, nor did it rank the risks according to impact and probability. Detailed technical assessments involving all stakeholders would have to be undertaken for this to be possible. Rather, the mission focused its finding on immediate and mid-term recommendations to reduce the most likely risk of dam safety and the pollution threat of the receiving natural waters and the communities using these.

1.3 Terminology

The following terminology is used in the report:

Abutment	The dam slide slopes where the dam ties into natural topography
Core	Finer material typically clay with lower permeability used as a seepage barrier
Crest	Top surface of dam
Downstream slope	Non-water/tailings retaining side of dam
Embankment/shoulder	Main body of the dam
Filter	Coarser material typically sand that is designed to hold back finer particles due to potential seepage movement of particles
mRL	Raise level in meters
Piping	Movement of finer particles due to flowing water which could lead to preferential seepage paths and compromised dam integrity
Spillway	Lower section on a dam that conveys water
Upstream slope	Water/tailings retaining side of dam

2. Key Findings

The mission findings focus on the stability of the TSF and the impact of a potential spill and/or dewatering on downstream communities and the environment. The chapter starts with a general overview of the mining facility and tailings management, after which the stability and design of the TSF is assessed. The water treatment is then described, together with an assessment of the possible environmental and health impacts of a spill or controlled release of treated as well as untreated tailings water. Finally, a short section focuses on chemical hazards at the processing plant, which were brought to the attention of the mission.

2.1 Background and baseline data

The Gold Ridge mining area is located in a highland area on the island of Guadalcanal, Solomon Islands, approximately 30 km south east of Honiara. The area has a typical tropical climate with a mean annual temperature of 26 °C. Average annual rainfall is reported to be higher than the figures quoted in feasibility studies (4100 mm at the mining site and 3000 mm at the TSF, which is located at a lower elevation).

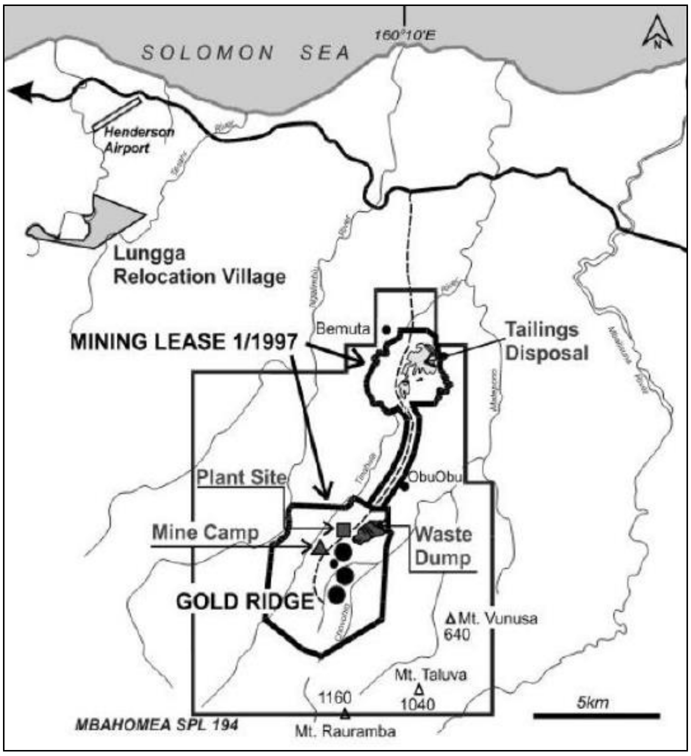

Figure 1. Map showing Gold Ridge mine area and tailings site (GRML TSF Operations Manual, 2013)

Rainfall is typically intense, causing rapid surface runoff. The area is located in a seismically active area part of the circumpacific "ring of fire", a zone of tectonic activity that is subjected to earthquakes and volcanic eruptions. The seismic risk is considered as extreme with a magnitude greater than 8 earthquake predicted to occur within 100 km of the site with an average recurrence interval of about 20 years (Golder, 1998).

Gold Ridge is a low sulphidation, disseminated epithermal gold/silver deposit. The mining lease covers an area of $30km^2$ and was signed in 1997. The lease is valid for 25 years, with an option to renew for another 10 years. The site is composed of a mining area, a processing plant and the tailings storage area consisting of the main TSF well as a return water (RW) dam. A map showing the Gold Ridge mining site is given in Figure 1.

Ore is mined in the pits and taken to the plant for processing. Tailings containing sediments and process chemicals are pumped from the processing plant to final storage in the TSF. From the TSF, water is pumped up to the RW dam from where it is pumped to the processing plant for re-use. Until April 2013, Gold Ridge Mining Ltd. (GRML) also used river water in the process. Key events at the mining site are summarized in Table 1. Historically, water has accumulated at the TSF, due to heavy rains during a period of no management or because of not enough water used for the processing. This excess water was under two occasions pumped into to the river to manage the TSF pond level – in 2009 and from October 2013 – as summarized in Table 1.

Table 1. Key events at the Gold Ridge mining site

Month, Year	**Event**
Aug 1998	Ross Mining commences gold mining operations at Gold Ridge
June 2000	Delta Gold acquired Ross Mining who abandoned operations due to civil unrest
2005	Australian Solomons Gold Limited initiates feasibility study on Gold Ridge
2009	Water level at tailings dam is lowered through a 6-month dewatering program
2010	Allied Gold acquires Gold Ridge Mining Ltd.
Mar 2011	Gold production restarts at Gold Ridge
Aug 2012	St Barbara acquires Gold Ridge Mining Ltd.
Mar 2013	Ministry raises concern over the Gold Ridge tailings facility water balance as part of dewatering consultations; water intake from the river is stopped as a result
Aug – Sept 2013	Tailings dam crest raised from 50.7 to 53.3 m in an "emergency raise" Concrete spillway is constructed at return water dam (exact month unknown)
Oct 2013	Dewatering starts, following the commissioning of the water treatment plant in July/August 2013
Nov 2013	Return water dam spillway is cut to hinder a spill over the dam crest
Dec – Jan 2014	Heavy rains cause water to spill between tailings storage facility and discharge pond
Jan 2014	Return water dam spillway is cut further
Feb 2014	Works initiated to move water treatment plant to higher ground
Apr 2014	Heavy rains; St Barbara leaves GRML
Apr 2014	Earthquakes rock Solomon Islands (13-14 April)

The people in the area surrounding Gold Ridge are of Melanesian decent and culture, living in scattered villages around the mining area and downstream, typically close to rivers. Landowners around the mine site are involved in informal gold panning, and also receive a share of GRML revenues through an existing agreement. Landowners are represented through the Gold Ridge Landowner's Association. Communities living downstream of the mine site are represented through two organizations – the Kolobisi Tailings Dam Association and the Metapono Downstream Association.

2.2 Tailings storage system

The tailings storage system at the Gold Ridge mine consists of the Return Water dam, TSF main embankment, saddle dam, settlement pond, and polishing/discharge pond, as shown in Figure 2. Each component of the tailings storage system is described in more detail below. A comprehensive independent dam safety review was performed by Damwatch, a New Zealand company, in 2013.

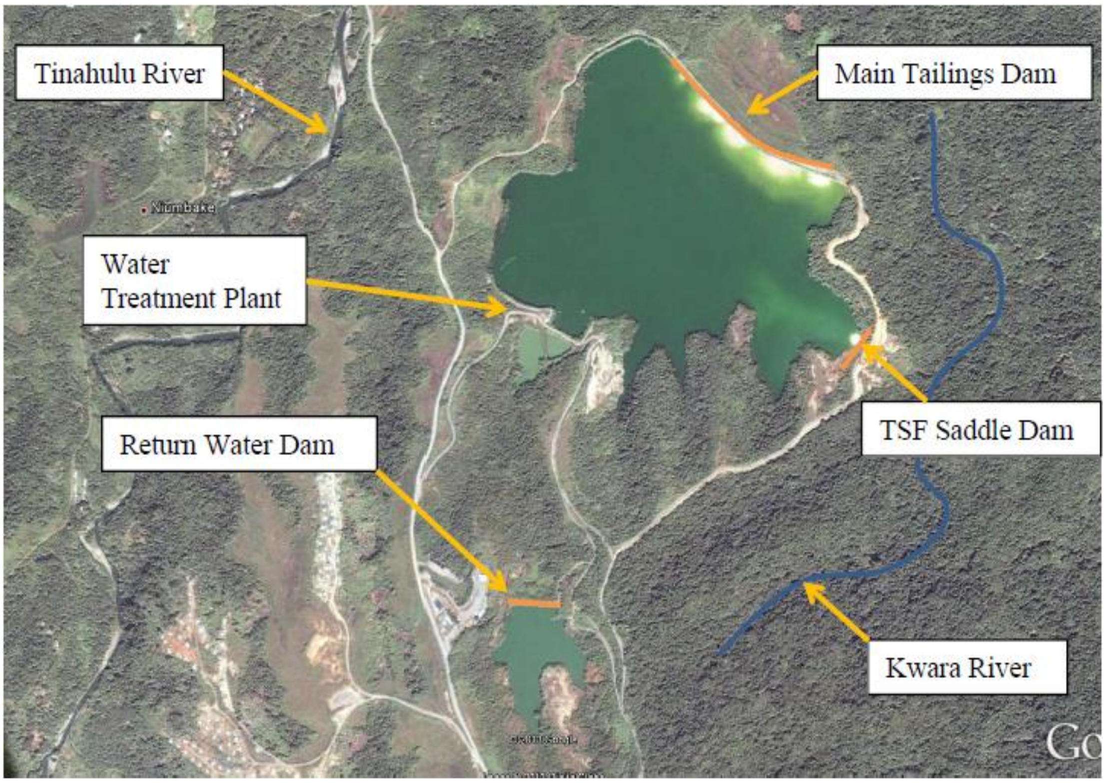

Figure 2. Photo of the Gold Ridge Mine tailings storage system. Dam crests indicated with orange lines.

The recommendations provided by the Damwatch report (Damwatch, 2013) are confirmed and are supported by the team's assessment. The 2014 site visit photos are located in Annex 5. The mine life of the operations and tailings storage system is currently under review, with closure currently planned for 2025.

2.2.1 *Return Water dam*

The Return Water (RW) dam is located upstream of the TSF. The dam is 200 m long and 30 m high toe to crest (100 mRL) with a 2.5 horizontal to 1 vertical (H:V) upstream slope, a crest width of 6 m, and 2.2 downstream slope with two benches. No major cracks or sink holes were observed in the RW dam embankment. Localized crest settlement was observed. A spillway is located at the left[1] abutment with an original designed crest elevation of 98.3 mRL. The spillway section was modified sometime in early 2013 to increase the storage capacity (based on communication with GRML). The modified crest elevation is approximately 99.5 mRL.

Photo 1. Modified spillway control section at the Return Water dam

The spillway invert elevation was lowered on November 2013 and then again in January/February 2014 to what was present in April 2014 with an approximate elevation 98.9 mRL. Water was observed flowing over the modified spillway invert v-notch in April 2014, see Photo 1.

Dam safety concerns:

- While there are elevated water levels and minimal freeboard in the TSF, the RW dam presents an increased risk if a failure would occur as it would result in overtopping and failure of the TSF.
- The dam has a significantly reduced spillway capacity and this deficiency leads to overtopping[2] in a relatively minor flood event, as observed in April 2014.
- No monitoring exists. Prudent dam safety monitoring should include piezometers, reservoir staff gage, survey settlement markers.
- Localized crest settlement was observed.
- Unclear condition of the Return Water dam embankment and foundation materials due to higher pond level with no available monitoring data.

2.2.2 *Sedimentation and polishing/discharge ponds*

The earth embankments separating the sedimentation and polishing/discharge ponds from the TSF pond were constructed in 2009 to 2010 (based on communication with mine employees). The sedimentation and the polishing/discharge ponds are located upstream of the TSF pond. The earth embankments were constructed using gravelly sand with cobbles with relatively low permeability. Water was pumped from the TSF pond to the water treatment plant (WTP) and then to the sedimentation pond. Overflow pipes in the earth embankment between the sedimentation pond and the polishing/discharge pond would transfer the treated water to the polishing/discharge pond. Note that the polishing/discharge pond is located between the TSF pond and the sedimentation pond.

In April 2014 the earth embankments separating the sedimentation and polishing/discharge ponds have been breached as well as overtopped, as shown on Photo 2, and now forms one body of water with the TSF pond.

[1] In this report, the terms left and right are based on the customary definition used in dam engineering in which they are oriented from a perspective of looking downstream.

[2] Overflowing

Photo 2. Polishing/discharge pond on the left and sedimentation pond on the right

2.2.3 Tailings storage facility – main embankment

The TSF main embankment was designed to be built in five stages (Golder, 1998) to a maximum height of 50 m (70 mRL) with a crest length of 1,000 m, as shown in Figure 3. The dam is designed to be raised in the downstream direction with an approximately 8-m wide upstream clay core on the sloping upstream face with an approximately 1-m wide filter downstream of the core (Golder, 1998).

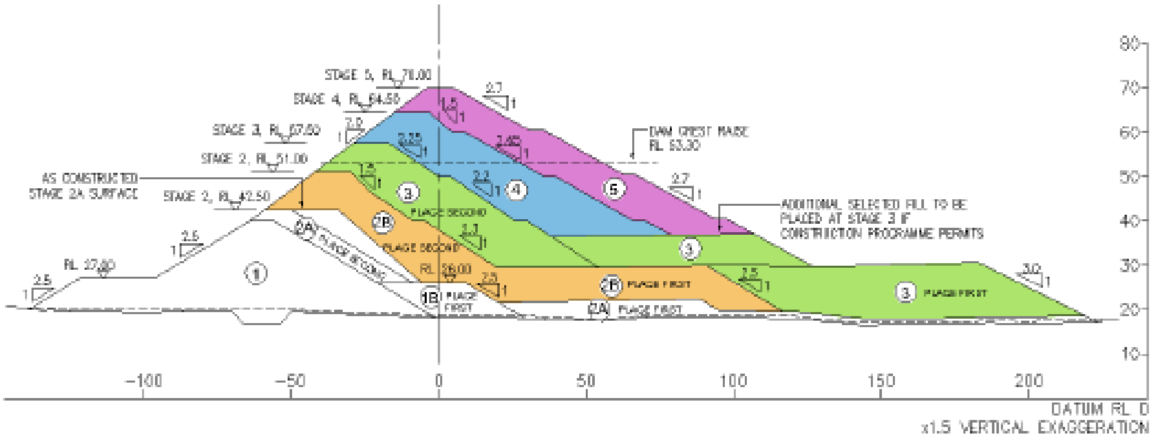

Figure 3. Proposed Construction Staging of the Tailings Dam (after DamWatch 2013)

According to the St. Barbara (2013) Operating Manual, the 2014-constructed section of the dam wall is shown in the cross section in Figure 2-3. As of April 2014 the TSF has a crest elevation of 53.3 mRL and a crest length of approximately 550 m. It appears that the lift between 50.7 mRL and 53.3 mRL was constructed using the clay core material only and with no downstream filter (based on conversation with Golder and GRML). No construction or photo documentation have been provided that show a sand filter installed downstream of the core between 42.5 mRL and 51 mRL. However based on conversation with Golder and GRLM there was a constructed filter to 51 mRL.

There are discrepancies between Figures 3 and 4 regarding the upstream and downstream slope geometry. Based on historic construction photos and an Interim Construction report (Golder, 1999), there appear to have been a wider constructed crest at 40 mRL to provide access for equipment. Whether the raise to 51 mRL was started at the upstream crest edge, middle, or downstream crest edge is not clear.

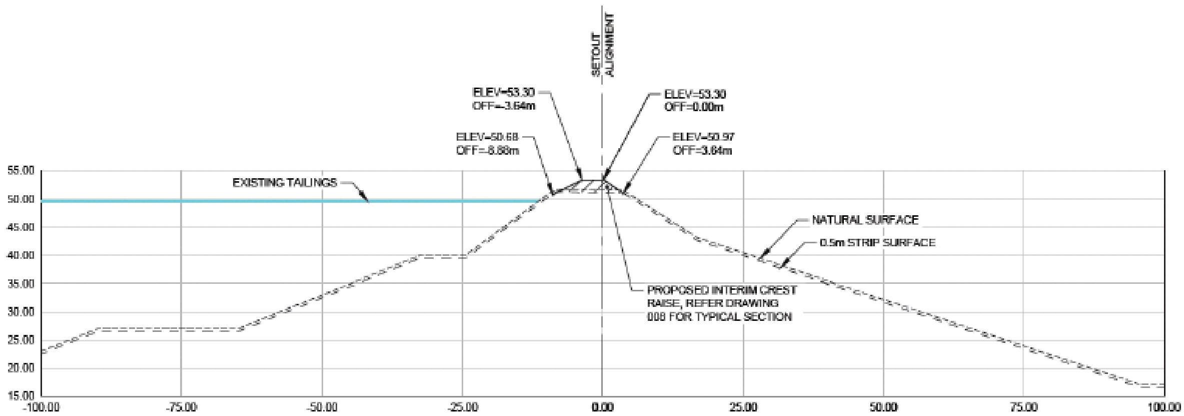

Figure 4. TSF cross section of the 2013 crest raise (after GRML TSF Dewatering Management Plan V3, dated October 2013)

Based on the information provided and conditions observed in the field in April 2014, it appears that the upstream and the downstream slopes have been raised steeper than designed (i.e. 1.7H:1V vs. 2.2H:1V on the downstream side and 1.5H:1V vs. 2H:1V on the upstream side). No stability analysis for the revised current geometry was available.

As of April 2014 the water level in the TSF was estimated to be 51.6 mRL (based on communication with mine employees). The depth of the tailings could not be observed below the water level. However, the proposed construction staging of the dam limits tailings filling to 46 mRL for a downstream berm at 32 mRL (Golder, 1998). This implies that there could approximately be over 5 m of water stored and approximately 0.9 m vertical head of water against the upstream slope that does not have a filter downstream of the core material, assuming the filter has been constructed to 50.7 mRL.

Photo 3. View of downstream slope of TSF looking right

Five survey prisms were installed in 2014 along the crest of the TSF with approximate distance between 100 and 150 feet apart. No survey data was available at the time of this report. Piezometers were previously installed on the TSF. However, most of these have been destroyed. No piezometer data was available for this assessment.

The embankment appears in general good condition. No cracking or sink holes was observed during the April site inspections. The upstream slope has erosion gullies due to rain water runoff. The downstream slope is shown in Photo 3. Minor sloughing in localized areas on the downstream slope and standing water on the crest and downstream bench (40 mRL) was observed. The lower and wider downstream bench had flowing water. No cloudy seepage was observed. The downstream weir was sampled but flow was not measured

Dam safety concerns:

- 0.9 m or greater vertical head of water against the upstream slope that does not have a filter, providing a vulnerability to seepage and piping failure if cracks were to develop through the core. The risk of piping would be unacceptably high with water against the embankment and lack of filter.
- The TSF embankment is not designed to store water. This was also noted in the Golder (2005) report, which states:

"The TSF embankment, unlike the Return water dam wall, was designed to retain tailings, not water. Under normal operating conditions the decant pond was designed to be held a considerable distance from the embankment, up the eastern valley, with an operating pond depth of between 2 and 3 m, holding less than 150,000 m3 of water."

- Steeper than designed embankment section with no constructed downstream fill and berms as per design drawings.
- No upstream slope protection is present.
- No monitoring exists. Prudent dam safety monitoring should include piezometers, reservoir staff gage, survey settlement markers.
- Unclear condition of the TSF embankment and foundation materials due to higher pond level with no available monitoring data.

2.2.4 Saddle Dam

The saddle dam is constructed to 53.3 mRL with a crest width of approximately 13 m and a crest length of 121 m. The upstream and downstream slopes were estimated in the field to be approximately 1.5H:1V. At this stage of the saddle dam construction only the upstream embankment shell has been constructed (based on conversation with mine employees). The core and filter will be constructed as the section is raised.

Photo 4. Upstream end of spillway at saddle dam with geotextile and old conveyor belts anchored down using sand bags

A 21-m long and 10-m wide earth lined spillway channel covered by geotextile and old conveyor belts is located at the left abutment, see Photo 4. The conveyor belts are overlapped and held in place using sand bags, which are likely to shift if water flows over the spillway. The downstream spillway channel is un-lined. Based on conversations with GRLM the spillway is located at 52.2 mRL, which is approximately 0.9 m above the water level.

The saddle dam embankment show erosion gullies on the upstream slope due to rain water runoff. The downstream toe does not appear to have seepage exits and no sink holes or cracks were observed. The downstream channel was observed to have large erosion gullies from recent rain events, which are likely to erode further if the spillway ever discharges.

Dam safety concerns:

- The spillway is unlined and is not intended for permanent use. The integrity of the spillway could be compromised during a discharge event, which could lead to uncontrolled release of tailings.
- No upstream slope protection is present.

2.3 Tailings water treatment

2.3.1 Plant operation

A license for dewatering the TSF was issued by the MECDM in April 2013[3] with dewatering procedures laid out in the GRML TSF Dewatering Plan (St Barbara, 2014). The license allows for the removal of 1,937,500 m^3 of water from the tailings dam. GRML was aware that this amount of water release was not enough to decrease the water level to correspond to the engineering design (operational freeboard of 2m from spillway and 3.5m from embankment crest). In March 2014 the company applied for a permit to increase the discharge amount[4].

As tailings water contains a number of harmful substances, a water treatment plant (WTP) was constructed to treat tailings water before its discharge into the river. The key chemicals of concern are cyanide – which is used to leach gold from the ore – as well as arsenic and other heavy metals. The WTP was commissioned in July/August 2013 and consists of two units. The first unit treats arsenic and other heavy metals by using hydrated lime and ferric chloride, which causes the metals to precipitate. The second unit removes cyanide (simultaneously removing bacterial coliforms) through treatment with sodium chlorite and hydrochloric acid.

Once treated, the water is led to a settlement pond (SP) from where the treated supernatant water flows by gravity into a discharge pond (DP) (Figure 5). From there the treated water is pumped via a considerable length of pipe into the Tinahulu river. The pump has a maximum capacity of 500 m^3/h. The WTP was designed as a continuous water treatment process – treating approximately 12 000 m^3/day. After its installation, it was estimated that the WTP needed to operate for 225 days in order to achieve design freeboard levels. After this had been achieved, an approximate of 215 days of operation annually was foreseen to manage catchment and process water inputs.

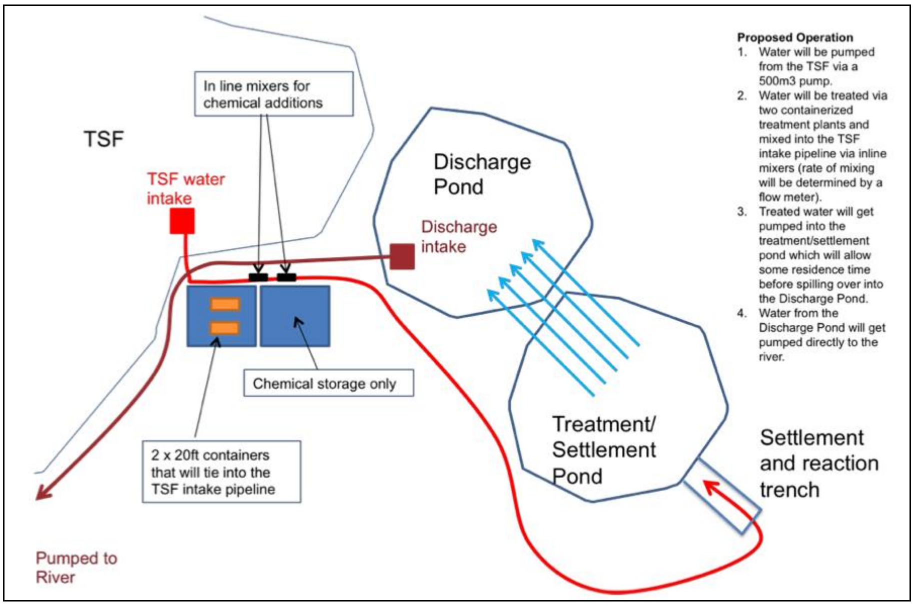

Figure 5. Configuration of dewatering infrastructure at GRML (GRML TSF Dewatering Management Plan V3)

The dewatering was monitored by GRML, who submitted weekly dewatering reports to MECDM, who also produced their own weekly monitoring reports. GRML and MECDM reports from October 2013 – March 2014 show that the plant had experienced some issues during its operation. Water flowing from the TSF into the DP was observed in late October 2013, and in mid-January heavy rains led the SP to overtop into the DP and subsequently into the TSF. Bank erosion between DP and TSF broadened the overflow.

[3] The license was given under Section 39(4) of the Solomon Islands Environment Act on April 12, 2013 and revised on October 2, 2013.

[4] At the time of the team's assessment, this permit application had not yet been processed by the MECDM.

Photo 5. TSF (left) has merged with DP (right)

Photo 6. Damaged discharge pipe, Tinahulu river

In early February it was identified that the water treatment plant was located lower than the TSF spillway, and the decision to move the facility to higher ground was taken[5]. In March a culvert between the two ponds was constructed to balance water levels in case of heavy rains – with the intent to always keep levels in the DP higher than the TSF in order for tailings water not to flow into the clean water in the DP. At the time of the mission's site visits, the three ponds had merged completely due to the rise in water levels (Photo 5) and the river end of discharge pipe been damaged (Photo 6). Other concerns reported by MECDM since the start of the WTP's operations included issues with low pH at the plant, later attributed to the accumulation of lime in the distribution lines.

2.3.2 Monitoring results

The objective of the water treatment is to lower the levels of arsenic and cyanide to the Australian and New Zealand Environment Conservation Council (ANZECC) / World Health Organization (WHO) drinking water quality guidelines, as follows:

Water Quality Guidelines	
Arsenic	0.01 mg/L
Cyanide – Free	0.07 mg/L

GRML used their own laboratory for analyzing chemicals concentration, and additionally sent weekly samples of the water in the TSF, the DP and the river discharge point to an outside accredited laboratory for analysis (St Barbara, GRML Dewatering Plan, 2014). Sediments were analyzed on a monthly basis for heavy metals. The mission made use of these analysis results to review the levels of arsenic and cyanide, the contaminants of main concern, in the tailings. GMRL weekly monitoring results of the TSF sampling point (TSFSP02) for arsenic and cyanide (free), from October 2013 – May 2014, are shown in Figures 6 and 7 (ALS 2013-2014).

[5] GRML Dewatering Weekly Report, 07.02.2013

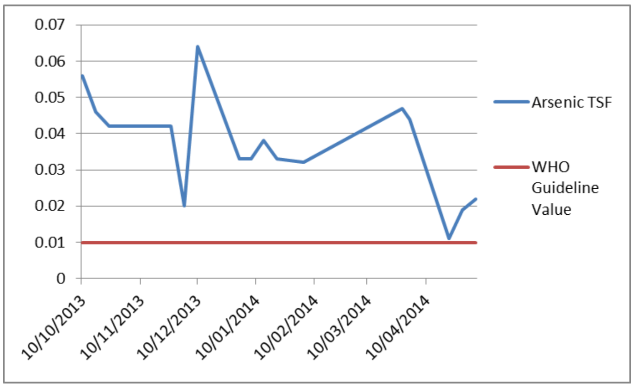

Figure 6. Arsenic levels in the TSF

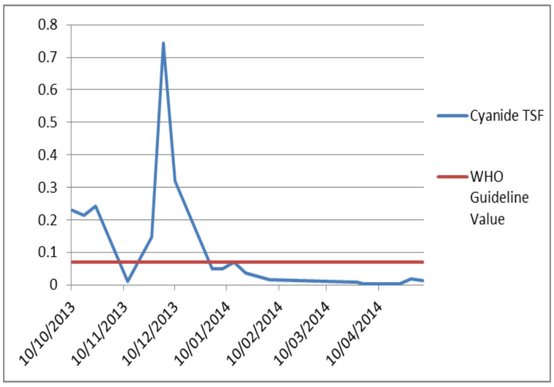

Figure 7. Free cyanide levels in the TSF

It should be noted that Figures 6 and 7 give the arsenic and cyanide concentrations in the TSF, not the levels measured in the DP prior to discharge. As the three ponds have merged, an evaluation of contaminant levels in the TSF over the past six months is considered more relevant than an assessment of treated water discharge arsenic and cyanide levels in the past. The last results obtained by the team were from samples taken on May 6[6]. A sharp drop in arsenic levels in early April can be observed, which is most likely due to the heavy rainfall and the merging of the three separate ponds into one. These levels have subsequently risen (end April and early May samples). The average levels (October 2013 – May 2014) at this sampling point are 0.037 mg/kg for arsenic and 0.128 mg/kg from cyanide. The total cyanide concentration in the tailings water is however higher[7] than the free cyanide levels, meaning that the water free cyanide levels can still rise, for instance in case of a drop in water pH.

The latest GRML sediment samples are from March 28, and show arsenic concentrations in the sediment of the discharge pond to be 15 mg/kg. The level in the sediment of the Tinahulu river is 10 mg/kg, which is higher than the average 6,7 mg/kg concentration measured at the same sampling point on average (October 2013 – February 2014). pH tests carried out by the mission at four different points (one in RW, one in DP and two in the TSF) showed the water to have a pH of about 6.5. A scan of TSF sediments using the NITON XRF shows an arsenic level of 80 mg/kg. It should be noted that the NITON gives only a rough estimate of arsenic levels.

As there was an existing monitoring program in place, it was decided in consultation with the MECDM, not to carry out additional sampling and analysis by the team. Instead, duplicate samples were taken on May 6 – by the MECDM and by GRML employees – both to be sent to ALS in Australia for analysis (Photos 7 and 8 show sampling being done from the Tinahulu and Kwara rivers).

[6] It should be noted that GRML monitoring is continuing on a weekly basis despite their departure from the site.
[7] The total cyanide concentration in the DP on 22 April was measured to be 0,071 m/L, while it was 0,007 and 0,008 at the two TSF sampling points.

Photo 7. Sampling at Tinahulu river upstream of discharge point. People playing in the background.

Photo 8. Sampling at Kwara river downstream of TSF saddle dam.

2.4 Dewatering

Site observations confirm the extremely high level of water in the TSF, with water observed flowing from the RW into the TSF on April 26. From a dam integrity perspective, the current primary concern is the effect an overflow will have on the not-yet-completed spillway of the saddle dam. Should there be a flow through the spillway, there is a risk of erosion causing an uncontrolled release of tailings into the Kwara river. Uncontrolled discharge should be avoided at all costs, since it would involve a higher amount of harmful sediments being released and could also involve large amounts of mud and soil flowing into the environment, potentially compromising the integrity of the saddle dam. The Kwara river has a low flow rate and would not be able to dilute a water release, and much less a tailings release. The main available option for avoiding this scenario is to dewater the TSF, i.e. decrease the water levels by pumping out water into the river system.

The mission chose to focus its impact assessment on the scenario deemed to be the most likely – a controlled and staged release of first untreated tailings water followed by partly treated water, with the aim to lower the current excessively high water levels in the TSF to a safe level. It is assumed that this water could be discharged through the existing water pipe to the Tinahulu river, which flows into the Matepono river and reaching the sea east of Honiara (see map in Annex 6). The impacts of a dam breach at the TSF crest were considered less likely. The reasons for this are that the dam construction, although not ideal, for the moment is performing its retaining function with no visual signs of damage due to flood loading to be observed of the structures. As such, the mission in consultation with MECDM decided to focus the assessment on the potential impacts of a release of untreated water. In order to evaluate the likelihood and impacts of various dam breach scenarios (scope, width/length, volume) a separate technical assessment would need to be undertaken (see recommendations).

2.4.1 Required dewatering needs

Satellite imagery (Annex 7) shows the current area of the TSF to be approx. 57 hectares. With an approximate minimum necessary decrease of water levels in the TSF by 0.9 meters this translates[8] to a need to discharge approximately 513 000 m^3 of tailings water. With a pump capacity of maximum 500 m^3 / hour this translates to approximately 43 days of pumping – if operated continuously (24/7). Should the WTP be made operational, it has the capacity to treat approximately 12 000 m^3 daily (full pump capacity).

Should the WTP not be operational, tailings water can be discharged without treatment from the very surface of the water body – where the lowest concentration of these contaminants is likely to

[8] This is a very rough estimate, as areas around the TSF edges are quite shallow. On the other hand, it is also not feasible to operate the pumps continuously.

be. Further reduction of arsenic and cyanide concentrations will be achieved by dilution with river water. When evaluating the dilution level which is safe for humans and the environment, a number of factors must be taken into account: river water flow, arsenic and cyanide concentrations in TSF, pump intake level and speed.

River water flow is estimated to be on average 5 313 m^3 / hour during the dry season (data from May-July 2011[9], St. Barbara GRML Dewatering Management Plan V4, 2014). Discharge should, however, be carried out based upon real flow levels and not on estimates. Arsenic and cyanide concentrations vary according to depth, and are lower closer to the surface of the waters in the TSF. Currently sampling is done at surface level only. Correspondingly, the pump intake level must be carefully chosen and pumps operated in a controlled fashion and at a lower speed to ensure that sediments containing higher levels of contaminants are not discharged.

A rough calculation, using average TSF surface water contaminant concentrations (October 2013 – May 2014), gives an approximation of the necessary dilution level. Average arsenic and cyanide levels were used for the assessment instead of the latest (May 6, 2014) levels. Average concentration levels give a better picture of the overall chemical concentration than recent surface water samples, as these have been diluted by rainwater and cyanide levels additionally reduced through exposure to air.

This rough estimate shows that a factor of 1:6 is required, at a minimum, to ensure that the final concentration in the river stays below WHO guideline limit values. While cyanide levels are lower at the surface, and have remained quite close to guideline limit values, it is arsenic that is the main contaminant of concern requiring dilution. A dilution factor of six translates to a maximum discharge flow of 885 m^3 / hour which is still higher than current pump capacity. Using the current pump capacity, 500 m^3 / hour, it would take approximately two months to discharge the necessary volume of water. To this one must add the time required for the process of repairing the pumps and discharge pipes, as well as necessary pauses in operations due to maintenance. Continuous monitoring must ensure that discharged water is appropriately diluted especially when it is detected that chemical concentrations increase.

2.4.2 Dewatering impacts on humans and the environment

Dewatering with or without treatment would have an impact on the approximately 8 000 people living downstream of the TSF. Based on the latest available census data from 2009, 3 463 people live in the communities directly bordering the Matepono river (which the Tinahulu river flows into) (Annex 6). The nearest villages, as well as the discharge points, are shown in Figure 8 (Damwatch, 2013). Other downstream communities could be affected through the indirect impacts on livelihoods and agriculture.

Interviews with health and environment authorities, with representatives of the downstream communities' associations as well as with members of the communities themselves in the villages indicate that the communities use the river water primarily for body washing, laundry and recreation. (Photo 9). Drinking water is usually sourced from boreholes in the villages (mainly close to the river banks) as well as sometimes smaller tributaries (streams). During the dry season, wells might also be dug close to river banks.

[9] Data was obtained from GRML Dewatering Management Plan. For the dry season, only data from April – July 2011 is available. This average, 5 313 m3 / hour, is considered a better indication of the dry season than the only other provided date (average velocity for July 2013 – February 2013; 9 792 m3/hour).

People rely primarily on agriculture for living, and have communal gardens where they grow vegetables – which are also sold in cities. As the community gardens are often not set up for irrigation, river water would rarely be used for crop irrigation and these gardens mainly rely on rain water. During dry periods the river water could be used to water the garden, although this is indicated to be rare. The rivers are also used for fishing although this appears to be limited. The health-related quality of the Tinahulu and Matepono river water is therefore important for the people living in these areas. Field observations confirm a number of communities living directly along the river, with some spread wider inland up to a couple hundred of meters from the river (Photo 10). Earlier assessments (Damwatch, 2013) have in detail mapped the location of these villages. A large number of palm oil plantations are also located in the Guadalcanal plains downstream of the TSF.

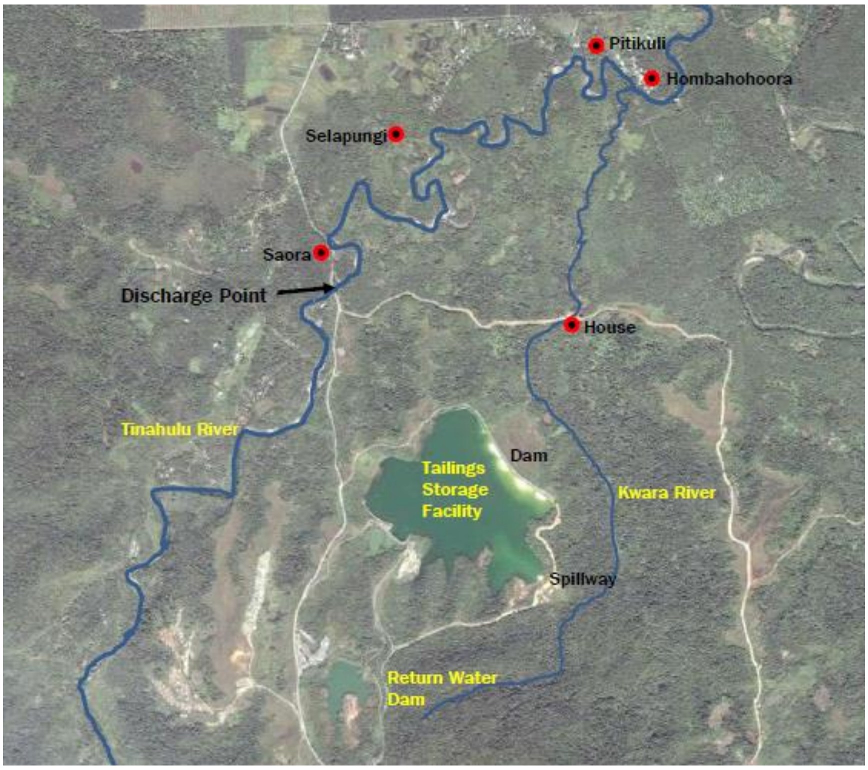

Figure 8. Discharge point and nearby villages

Photo 9. Settlement on Matepono river, downstream of TSF

The primary concern of villagers is the safety of the dam and it is essential that the people be continually briefed on the status of the operation the team will be recommending below.

The other main concern is about the health-related water quality. The downstream villagers have intuitively stopped intensive use of the water since the beginning of the mining operations in the 1990's – especially when the operations are in full process. While they limit deliberate interaction with the river, they have to rely on the river for body washing and laundry. It is also not possible to keep children out of the water. The villagers report on skin itchiness that follows contact with the water. However, as this is not a typical symptom following exposure to arsenic or cyanide, the cause for this itchiness will remain uncertain until a full environmental epidemiology study can be conducted and the communities informed about the real causes and how this could be managed.

No long-term continuous monitoring program on the impact of mining operations on downstream communities or the aquatic environment is being undertaken. As part of the Gold Ridge project feasibility study initiated in 2005, environmental baseline studies were carried out in the surroundings of the mining complex and downstream river system. Rock and river sediment samples taken during these studies showed elevated arsenic concentrations in many rock and river sediments – with higher concentrations recorded closer to ore bodies and waste rock dumps. The sampling conducted by GRML shows arsenic concentrations in the Tinahulu river to be 3.8 to 4.7 mg/kg. Hydrobiology reports from 2006 show some evidence of mine-related sustained elevation of metal bioaccumulation by some species but also showed the fish and crustacean river system fauna to have maintained its natural biodiversity.

The average arsenic level in the TSF (October 2013 – May 2014) is 0.0367 mg/l. The average free cyanide level during the same period was 0.128 mg/l. With a total tailings volume of 513 000 m^3 to be discharged this corresponds to approximately 65 kg of cyanide released, and 18 kg of arsenic released to the river system during this dewatering should the whole process be conducted without any treatment. From a human health perspective, arsenic is the main concern as arsenic compounds are classified as human carcinogens. There is still scientific uncertainty on the exact risks and effects of continued arsenic exposure, which means that WHO drinking water guideline values generally are used in what can be considered a conservative, but safe, assessment of possible impacts. Moreover, arsenic is a naturally occurring substance, especially near metal deposits. Given that no baseline data of arsenic levels in other rivers away from the mine site could be found, it cannot be certain what the normal back ground levels of arsenic would be. When it comes to cyanide, it is a highly toxic substance when present in large concentrations (well above those in the tailings water), but does not accumulate in natural surroundings since it degrades rapidly.

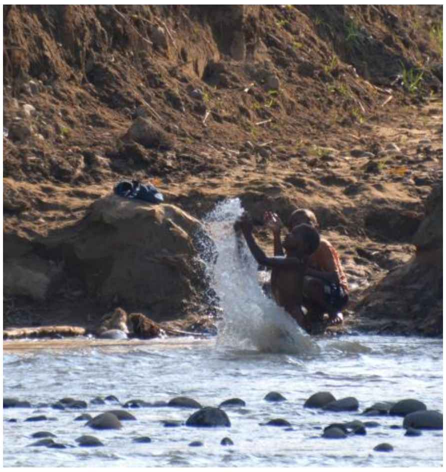

Photo 10. Children playing in Tinahulu river

Therefore a dilution factor of six should achieve levels below internationally accepted drinking water quality guideline values (0.01 mg/L for arsenic and 0.07 mg/L for cyanide) and should render the health risks posed by the dewatering of the TSF acceptable in terms of human exposure. Given the risk of significant harmful impact of an uncontrolled spill (the exact extent of which needs to be established), controlled dewatering - initially without treatment provided certain special conditions are met (see conclusions below) - is considered by the mission to be a preferred option. As the Tinahulu river has a higher flow rate than the Kwara river, discharge through the existing pipe system after its repair is recommended. This is a first step in the operation. Discharge water should be treated as soon as water treatment can be resumed. This should be achievable once a solution for storing treated water has been found – either in separate tanks or by upgrading existing, flooded, ponds. Continuous monitoring of arsenic and cyanide levels in the receiving water is imperative as will be continuous communication with downstream communities to keep them updated with the process. Sediments should be monitored along the river (see Annex 9. Sampling Plan) to assess the possible delayed release of heavy metals that would have accumulated there. This could be a source of contaminants that could pose a deferred risk for on human health not only for inhabitants of the downstream plains, but also to monitor toxicity transfer to the ocean and potential effects on the livelihood of fisher folk.

From an environmental perspective, the impacts of continuous discharge of not only arsenic, but also other metals (even when below quality criteria), could cause long-term impacts on the aquatic river environment. As metals are present as a mixture, their combined possible effect on the aquatic environment is impossible to predict without detailed studies. Further studies and use of existing research on the subject would be warranted. At the same time it should be noted that there is little scientific consensus on ecosystem-based limits for heavy metals and other contaminants, as most research had been undertaken for the purpose of establishing limits for human drinking water.

2.5 Chemical Hazards and Infrastructure

Chemical hazards at the WTP have been confirmed by the mission site visit and are described in section 2.5.1. Infrastructure damage is described as it relates to dewatering operations only. The team has not assessed the chemical management practices of GMRL, and also was not provided with detailed lists of chemicals in use and stored at the site. As the mission focus was on the TSF, the team did not visit or assess the processing plant. An indication of potential impacts (possible hazards and pathways) was estimated using the Flash Environmental Assessment Tool (FEAT). In addition, a number of unverified accounts of chemical incidents at the plant, as well as a MECDM monitoring report from April 15 were brought to the team's attention. The team raised its concerns about these safety issues in the mission preliminary findings, which were submitted to the authorities on 28 April. The key recommendation at the time was to deploy a hazardous materials and explosive ordnance detection team to the processing plant to do a detailed assessment (Annex 8. Chemical Hazards Preliminary Assessment). On May 2 the team was informed that these issues had been assessed in mid-April by a hazardous materials team supported by the Regional Assistance Mission for the Solomon Islands (RAMSI), and that results had been shared with the Office of the Prime Minister and Cabinet. Assessment reports were subsequently shared with the UNDAC team.

2.5.1 Water treatment plant

At the water treatment plant, the team observed bulk containers of hydrochloric acid (35%) and corrosive chemicals (Photo 11). At the last site visit, these were within a few centimetres of the TSF water surface level. The Ministry monitoring report from April 11 reports one container to be open and fuming with a photo showing the container to be full. The fuming was likely to be caused by water or water vapour entering the container and causing an exothermic reaction.

Photo 11. Chemicals stored next to the TSF

As acid may drip over container edges the container poses a personal safety risk. At the time of the mission visit, the container was already less than half full. The leak could be a cause of the lower pH levels measured close to the WTP.

The majority of stored chemicals remain in sealed containers but are located very close to the TSF water level. If released, both the acid and the corrosive substances will have an effect on the water quality. The hydrochloric acid can lower the pH leading to a mobilization of heavy metals from the sediment. There is a possibility of both exposure both to humans and the environment through release of the chemicals through air and water pathways. Currently chemical containers are still intact, but they should be secured immediately in order to reduce the possibility of a release.

Photo 12. WTP Control Room broken into, right hand side

Photo 13. WTP Electrical cabinets opened, level of damage unclear

At the last site visit on May 6, it was observed that the control room of the WTP had been broken into (Photo 2-13), and that the electrical equipment had been tampered with (Photo 2-14). These had still been intact at the team's first site visits. The WTP stood unguarded and the longer it remains so the higher the risk that it will be vandalized and key parts, wiring and equipment stolen. The chemical containers pose a hazard to locals accessing the site. Despite the fact that the containers are sealed and marked, they could be damaged causing harm to humans and the environment – in addition to lowering the pH of the TSF water. Police guarding the GRML facility were briefed on the acuteness of the situation by the team and GRML national employees.

3. Summary

3.1 Conclusions

GRML and Ministry monitoring reports make it clear that concerns surrounding the TSF have been known for a long time. In the past years a number of reports and assessments have been carried out by GRML, by independent experts and consultants as well as by Government authorities. These reports contain detailed recommendations for improving tailings management at GRML. While the team has not been able to in detail review the technical details of the reports, their general observations and conclusions are in line with the mission's findings. The Damwatch 2013 report contains a number of recommendations for improving TSF stability. These recommendations conform to the mission's findings concerning technical dam safety aspects, given in Section 2.2. Mission site visits confirm that GRML had initiated some of the recommended improvements before April flooding. The most important one, from an environmental health perspective, was the installation and operation of the WTP.

The mission concludes that the TSF has been performing well considering it was originally not designed for these quantities of water. There is no physical evidence to show that it is under threat of an immediate breach or overflow from the recent earthquakes or floods. However, the current situation is concerning primarily due to the lack of site management and continuous monitoring. The necessary structural improvements and the operation of the WTP demand a long-term plan and a continuous presence at the site. Without this, the water level will only increase, and will eventually reach the spillway with the potential to cause spillway erosion – as it is not yet structurally completed. The impacts of an ensuing breach would be catastrophic, as it would entail the release of large amounts of tailings entering river systems in the form of mud containing harmful substances. The mission estimates that a 1.3 m decrease in water levels would provide the operational freeboard of 2 m at the spillway section as outlined in the Dewatering management plan (St Barbara 2014). An estimated 0.9 m of decrease in water level would provide at least some safety with respect to having water against the upstream slope of the TSF where there is no filter.

The mission conclusion is that preparations for dewatering need to be started as soon as possible. A license for discharge must be applied for as soon as possible, and should contain the specific discharge and monitoring parameters. Communities must be informed of the planned operations and pumps need to be repaired and put in working order to be able to start a controlled release of tailings water into the Tinahulu river. All this will take time, and must be initiated immediately. Treatment of tailings water prior to discharge remains the preferred option and the WTP must be re-commissioned as soon as the system is sufficiently recovered. As a first phase of dewatering, a balanced and slow release of untreated tailings water is a viable option, provided a discharge license is acquired from environmental authorities. This discharge should be carried out carefully in order for the tailings water to be diluted by the receiving river water which would keep the cyanide and arsenic levels below WHO guideline values. Safe dilution depends on a number of factors, including river water flow, pump intake level (always from the surface of the water body) and varying TSF contaminant levels. Initial calculations indicate that approximately two months[10] are needed to safely discharge the necessary amount – underlining the urgency in taking action without delay.

Dewatering must be carried out according to license conditions and supported by a comprehensive monitoring program, recommendations for which are given in Annex 9. Simultaneously, action must be taken immediately to secure the water treatment chemicals. During the initial discharge phase the water treatment plant must be moved to higher ground to be ready to start the water treatment operations as soon as possible. Efficient water treatment entails a separate storage pond where water can be stored and tested prior to release. This would also assist in identifying and rectifying

[10] This estimate does not take into account surface run-off or rain, and also does not take into account the time needed to engage various actors in the work, inform communities, and receive the necessary permits. With rainy season expected to start in November, urgent action is needed in the coming five months.

any problems with the treatment process. An emergency response plan and communication system must be set up to keep communities informed in case of discharge problems.

The mission remains concerned about the current lack of oversight and monitoring at the TSF and processing plant. For such a large site and complex type of operations, management of the site is essential to ensure that appropriate action is taken as soon as need arises. Currently the site and its operations pose a health risk to downstream and nearby communities primarily through the lack of control, oversight and monitoring of the situation. Early warning and good ongoing communication between site managers and employees, landowners, downstream communities and authorities is key to reduce the risks posed by any type of mining facility.

Sufficient technical capacity to manage and to provide site supervision of an active mine site is typically found only within experienced mining operators. Such an actor should be allowed access to, and control of, the site in order to manage the controlled dewatering and associated site activities and to ensure safe operation of the structures. Ultimately, after the risks have been sufficiently reduced, the total operation should be evaluated and a decision be taken on whether the site should remain active or be closed. Both paths would result in associated site improvement.

3.2 Recommendations

These recommendations are given to the Government, with the understanding that many of these would be taken on board by the actor responsible for on-site management and monitoring.

IMMEDIATE ACTION

1. Taking into account the substantive time needed to lower water levels in the tailings storage facility: Commence preparations for dewatering without prior treatment and apply for a discharge license

No filter was constructed within the raised crest embankment, providing a vulnerability to seepage and piping failure if cracks were to develop through the core. The risk of piping would be unacceptably high with water against the embankment and lack of filter. The dam appears to be constructed different than designed. The dewatering effort should focus on reducing the water level at or below the level that has a current filter in place. An assessment of the current working pumps on site should be performed to evaluate the dewatering capacity. Dewatering must take place at a slow pace to allow for sufficient and further dilution of arsenic and cyanide in the river to ensure it remains below the internationally accepted guideline values. Pump intake elevation is essential – the contaminant concentration will be higher lower down in the TSF. Treatment of the water to be discharged should commence as soon as the whole treatment system can be recovered.

Discharge flow should be based on actual river flow – which implies consistent supervision of the process. Considering the current capacity of the pumping equipment and the varying flow in the river, this is expected to take months. Considering that the “dry” season lies ahead, these dewatering steps should be undertaken without delay to get a head start before the wet season commences in a few months from now.

Consultations with communities should be initiated immediately to inform them about the current situation and the urgent need to commence dewatering. A license for discharge, detailing operation parameters and conditions, should be applied for as soon as possible.

2. Ensure on site management/site supervision to ensure continuous monitoring and prompt action to prevent incidents

No active management or equipment is available to monitor the situation or reduce the water level in the RW dam and the TSF. The RW dam and TSF will continue to fill with additional rain until flow goes over the spillways. Continuous site management will provide daily monitoring and appropriate immediate notifications, for example changes in water levels and dam performance. Sufficient technical, human and financial capacities to manage and supervise an active mine site is typically found only among experienced mining operators. It is critical that such an actor be allowed access and control of the site in order to manage the controlled dewatering and associated site activities and to ensure safe operation of the structures on site. Ultimately, site operation should be evaluated and a decision be taken on whether the site should remain active or be closed. Both paths would result in associated site improvement.

3. **Safeguard and re-commission the water treatment plant**

   Treating tailings water prior to discharge into the river system is the best way to ensure that arsenic and cyanide levels in discharged water are kept at a level below internationally accepted guideline values. Treating tailings water is the best way to reduce any human and environmental health risks posed by the dewatering process. The water treatment plant is currently under serious threat of looting, and must be guarded. It should, together with the treatment chemicals, moved to higher elevation as soon as possible. Options for storing treated water prior to its discharge should be explored (isolated holding areas or construction/improvement of existing ponds). Previous construction of the discharge/sedimentation pond is not ideal since the earth embankment separating the ponds was relatively permeable which led to contamination between the areas.

4. **Monitor site continuously and after each natural hazard event, as laid out in site operations manual, and perform additional geometric survey or obtain and incorporate results from recent survey**

   Perform continuous monitoring of structures, reservoir rim, and downstream areas at least until water level has receded below the raised crest portion constructed without a filter. A more detailed inspection should follow after each heavy rain event. Perform a topographic and bathymetric survey of the current crest, slope, and water levels of the RW dam and the TSF. Establish what height of dam raise was placed without a constructed filter.

5. **Continue sampling and monitoring program as laid out in discharge license, with the inclusion of additional sampling points**

   The existing monitoring programme can be enhanced through the inclusion of additional sampling points, as described in Annex 9. A license for dewatering must be obtained, and must include the realistic amounts of untreated / treated water to be discharged, as well as the details of the monitoring programme. Monitoring must be continuous and be based upon baseline measurements taken before the dewatering starts. In case limit values are exceeded, dewatering must stop immediately. Dewatering must follow the river flow rate in order to ensure sufficient dilution levels.

6. **Construct tailings storage facility to design drawings or conduct analysis for the current design**

   Dewatering is an acceptable yet temporary solution and must be accompanied by infrastructure improvements at the tailings storage system. Water level is currently observed against the upstream slope of the raised crest section of the TSF. According to the Designer, this interim section was not designed to contain water without an appropriate tailings beach and the remainder of the downstream section. The Designer should work with the Owner to complete the design as outlined in the design documents and any modifications to the water treatment plant, spillways, and pond pumping system required to reduce the flood and environmental risks. If a modified design is to be used going forward, design documents needs to be prepared to demonstrate a safe design that meets industry standards. A robust spillway section must be provided throughout all phases of TSF crest raise.

MID-TERM ACTIONS (3 – 6 months, after which ongoing)

7. Maintain dewatering monitoring program and update mine site emergency action plan and incident notification system

Monitoring and sampling results must be made available to downstream communities, and can be supported through existing consultation and information-sharing mechanisms. The mine site emergency response plan should be updated, with clear allocation of the roles and responsibilities of involved actors. As part of the plan, an emergency notification system should be established and periodically tested, to ensure that information to communities is provided immediately in case of critical incidents. Awareness and preparedness to accidents at local level should be supported through the full involvement of all concerned stakeholders – communities, local and national emergency and environmental authorities, and mine operator/s[11].

8. Remove return water dam spillway section

The spillway constructed in 2013 should be removed in order to allow safe passage of the design floods and maintain minimum freeboard

9. Install dam monitoring on return water dam and tailings storage facility main embankment

Dam monitoring includes, but is not limited to, piezometers to evaluate pore pressures within the embankments, reservoir staff gage to monitor reservoir water levels, and settlement monuments / inclinometers to monitor movement of structures.

10. Improve and implement tailings management monitoring programme

A monitoring / surveillance system should be developed in consultation with relevant authorities. This would include provisions for regular inspections, monitoring visits and evaluations, and should be developed in accordance with existing international guidelines on tailings management, dam safety and chemicals management. Involvement of site management, government, dam safety engineers and environmental experts in these activities increases transparency and involvement in the on-going management of the site.

11. Perform detailed dam stability and integrity assessment using physical monitoring results

Perform stability analysis to evaluate the existing conditions and the proposed final crest raise configurations or closure conditions of the return water dam and tailings storage facility. These analyses should incorporate the phreatic condition develop under normal and extreme loading conditions for both structures. The phreatic condition should be based on water level measurements obtained within the structures and their foundations.

12. Upgrade existing structures to prudent dam safety requirements

Place slope protection on the upstream slopes of the tailings storage facility main embankment and saddle dam and return water dam – as outlined in previous reports.

13. Conduct a dam safety review and risk assessment of the facility

Once the immediate danger has passed, a thorough dam safety review of the facility along with a risk assessment, would be warranted.

[11] The UNEP Awareness and Preparedness to Emergencies at Local Level (APELL) could be a possible framework under which to initiate such preparedness and communication measures.

LONG-TERM ACTIONS (6 – 18 months, after which ongoing)

14. Include key environmental emergency response actions and corresponding responsibilities into legislation

Appropriate preparedness and response to environmental emergencies can only be insured by including necessary provisions and responsibilities into legislation. For example, environmental impact assessment, environmental permit and mining operation legislation and guidelines should include reference to, and procedures for, periodic inspections, emergency response plans, communication in case of accidents, monitoring – just to name a few. Responsibilities between line Ministries, local authorities and mine operators should be clearly lined out.

15. Raise key authority institutional capacities for monitoring and enforcement

Monitoring and enforcement of mining operations is a long-term commitment which demands the participation of all stakeholders. Monitoring can in itself be a way to improve communication between mine operators, community representatives as well as national and provincial authorities. Through the set-up of a long-term plan and allocation of human and financial resources for monitoring, the capacities of involved actors can be raised in a systematic manner. Results of monitoring should be shared with all concerned stakeholders in a transparent and open manner, enabling trust to build between actors.

16. Raise awareness and engage in networks working on issues related to sustainable mining

Best practices on monitoring and decreasing the environmental impacts of mining operations should be shared nationally, regionally and globally. A lot of quality research and studies are being undertaken, which can benefit operators, authorities, communities and academia alike. The Environmental Emergencies Centre (www.eecentre.org), and other networks, can act as platforms for knowledge sharing.

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Annexes

ANNEX 1. REQUEST FOR ASSISTANCE

NATIONAL DISASTER COUNCIL

MINISTRY OF ENVIRONMENT, CLIMATE CHANGE, DISASTER MANAGEMENT & METEOROLOGY

PO Box 21
Honiara
Solomon Islands

Phone: (677) 27936/27836, Mobile: 7500837
Fax: (677)-24293
e-mail : directorndc@ndmo.gov.sb

Ref: NEOC 1/2 14th April 2014

United Nations Resident Coordinator,
Suva, Fiji

Dear Osnat,

Subj: Goldridge Mine Tailing Storage Facility – Request for Technical Assessment

Following recent heavy rains and earthquakes in Solomon Islands, the Solomon Island Government is very concerned about the potential failure of a tailings treatment dam at the Goldridge mine south-east of Honiara. We would like to request technical expertise to assess the earthen dam and understand the immediate risks and remedial measure that must be undertaken.

Specific objectives will be to:

1. Undertake a rapid assessment of the stability and integrity of the tailings dams, with a particular focus on the impact of tropical cyclones and heavy rains resulting sudden rise in pond levels, as well as risks stemming from earthquakes and subsidence in the area.
2. Conduct scientific sampling in the vicinity of the tailings dam and hazardous waste site to screen for any immediate and/or potential threats to communities and the environment;
3. Assist the emergency management organizations in identifying appropriate preparedness and risk reduction measures to minimize impacts to the population;
4. Draft mission report and present findings to government authorities and international partners in Solomon Islands.

Many of the families downstream of the tailings treatment pond where the dam is located are currently sheltering in evacuation centers and some are reluctant to return home for a number reasons including the possible failure of the dam following the cessation and abandonment of all operations by mine operator last week. Should the dam fail SIG fear is a flood of toxic mine slurry into the meandering river system below potentially impacting dozens of rural communities (estimated population of 8,000).

We look forward to your positive and quick response on this matter.

Melchior Mataki,
Chair of NDC
Permanent Secretary

CC: OCHA, ROP

ANNEX 2. MISSION TERMS OF REFERENCE

TERMS OF REFERENCE
United Nations Tailings Site Assessment Mission

These Terms of Reference describe the tasks of an Assessment Mission to a tailing storage facility located on the Solomon Islands. The mission is undertaken at the request of, and in coordination with, the National Disaster Council of the Solomon Islands. The mission is in response to flash floods and earthquakes affecting the islands from 7 to 14 April 2014. The mission objective is to conduct a rapid assessment of the stability and integrity of the Gold Ridge Mine tailings dam, to conduct sampling of the tailings water and nearby locations and to screen for any immediate and/or potential threats to communities and the environment posed by the tailings site. The mission is undertaken with the support of the European Commission's Humanitarian Aid and Civil Protection Directorate General (ECHO).

Background

Effect of flash floods and earthquakes on mining activities in the Solomon islands

Since 7 April 2014, heavy rains in the Solomon Islands have caused flash flooding that turned into Tropical Cyclone Ita, with the worst affected areas the capital Honiara and areas of Guadalcanal. The flash floods have also affected the area where the Gold Ridge Mine is located, with 500 millimetres of rainfall recorded in 24 hours. The Gold Ridge gold mine is located about 30 km south east of the capital Honiara. Since the floods, water levels in the pond of the mine's tailing dam have risen continuously leading to concerns about possible overflow and/or loss of dam integrity. On 9 April, the Gold Ridge operator, St. Barbara, evacuated some 200 personnel and suspended operations at the mine, due to damage to mine access roads.

An initial assessment of the Gold Ridge Mine was conducted on 11 April 11 2014, by the Ministry of Infrastructure Development (MID), the Ministry of Environment, Climate Change, Disaster Management and Meteorology (MECCDM) and the Ministry of Mines, Energy and Rural Electrification (MMERE). National staff from St Barbara was also present at the assessment. The assessment highlighted concerns over the rise in water levels and risks of potential spillage. The report recommended that the water treatment plant be made operational and that dewatering be commenced. In addition it was recommended to continue sampling of the tailings dam and ponds, and to additionally sample nearby pools of water. It was noted that consultations with communities should take place in order to address the lack of information on the possible risks posed by the dam.

On 14 April 2014, a series of earthquakes took place off the coast of the Solomon Islands, which caused additional concern about the integrity of the tailings dam. Subsequently, on 14 April 2014, the Permanent Secretary of the Solomon Islands Government and the Chair of the National Disaster Council (NDC) submitted an official request to the United Nations Resident Coordinator for technical environmental assistance from the international community (Annex 1).

Objective

The mission objective is to undertake a rapid assessment of the stability and integrity of the Gold Ridge Mine tailing dam. Dam integrity and stability should be assessed with specific evaluation of the possible effect to the dam by recent heavy rains in combination with the earthquakes. Sampling of the water in the tailings dam, the settling pond, the discharge pond, and puddles near to the tailing storage facility should be conducted. This works includes the development of a sampling plan, identification of an appropriate laboratory for conducting analysis and the interpretation of analysis results. In addition, the current procedures for safeguarding and managing the tailing storage site should be assessed, including the operation of the water treatment facility and the procedures for dewatering the dam. The above considerations should be combined into an overall assessment identifying any immediate and/or potential threats to communities and the environment. Recommendations for appropriate immediate and mid-term action should be provided. Where feasible, recommendations for longer-term actions should be developed. The assessment should also provide recommendations to the national authorities, including disaster management and environmental authorities, for appropriate preparedness and risk reduction measures to minimize potential impacts from the tailing site to the local communities living downstream of the Gold Ridge Mine. Specific focus should be on communication and information-sharing with nearby communities.

The technical mission team will be composed of international experts, as follows:

- Ms. Emilia Wahlstrom, OCHA Geneva- Team Leader (UNDAC member) and expert on chemicals management
- Mr. Niels Masselink, The Netherlands (supported by ECHO) - International Expert on hazardous waste management and sampling analysis
- Ms. Christina Winkler, Sweden (supported by ECHO) - International Dam Safety Engineer with focus on tailings management and dam stability

The mission will work in close coordination with representatives of UN agencies, NDC, MECCDM, MERE and MID, including national experts with focus on mining, environmental sampling and assessments, hazardous waste, community awareness and communication.

The expert team will conduct field visits to the Gold Ridge Mine and facilities, with specific focus on the Tailing Storage Facility. National experts and authority representatives will accompany the mission. The Gold Ridge mine operator St. Barbara will be requested to provide background information for the mission. Full access to the facilities will be ensured by national counterparts, who will also support the sampling and subsequent export of samples to an accredited laboratory outside the country.

The mission is scheduled to begin on 22 April 2014.

Activities

The expert team is expected to undertake a 3 week mission (including travel time) to the Solomon Islands. Ahead of the mission, the experts are expected to study the materials provided (assessment reports, documentation) by the government, JEU and partners. The expert team will:

- o Participate in the mission to the Solomon Islands and the site visits to the Gold Ridge Mine southeast of the capital Honiara;
- o Assess the integrity and stability of the Gold Ridge tailing am following the flash floods, heavy rains and earthquakes;
- o Participate in sampling of the wastewater in the tailing dams, associated ponds and pools in the vicinity, and analysis of the chemical composition (cyanide, arsenic, target analyte metals); assess the environmental, health and safety implications of the results

- Assess suitability of tailing waste management options currently in use at the facility (water treatment, dewatering) and provide recommendations for follow-up actions
- Make recommendations for addressing immediate and mid-term threats of the tailings dam, particularly to the downstream communities and the environment
- Contribute to elaboration of detailed recommendations and support to the emergency management organizations in identifying appropriate preparedness and risk reduction measures to minimize impacts to the local communities living downstream of the mine.

Deliverables:

- Input into the joint UNDAC mission report which will include: 1) findings of the assessment on dam stability integrity; 2) findings of the sampling and analysis of the chemical composition of the wastewater in the ponds and pools; 3) based on above; recommendations on appropriate options for managing the tailings site; 4) recommendations for appropriate risk reduction and preparedness measures to be taken by national authorities.
  Deadline: first draft – before mission departure, Final report – two weeks from EOM;

Duration

The team members are expected to be available for a 3-week mission deployment (includes travel time). The mission should be in country by 22 April. The exact duration of the mission (days on-ground) will be decided in consultation with the mission team, the Government of the Solomon Islands and local stakeholders.

ANNEX 3. MISSION AGENDA

Day	Time	Activity	Present
Monday 21 April	13,45	Arrival of UNDAC Team; Emilia Wahlstrom (OCHA) and Niels Masselink, supported by ECHO	
	14.30 - 15.30	Meeting with Permanent Secretary Mr. Mataki and Mr. Horokou, Director, MECDM	Mr. Mataki, Permanent Secretary (PS); MECDM: Mr. Horokou, MECDM Director; Ms. Apa, Senior Environment Officer (SEO), Ms. Beti, Environment Officer (EO); UNDAC: NM, EW
	16.00 - 17.00	Meeting with UNDP DRR, Ms. Suzaki and UNDSS, Mr. Temangutaua	UNDP: Ms. Suzaki, DRR; UNDSS: Mr. Temangutaua, Security Officer; UNDAC: NM, EW
Tuesday 22 April	10.00-12.00	Meeting at MECDM	MECDM: Mr. Horokou, Director, Ms. Apa, SEO, Ms. Beti, EO; Landowner's association: Dr. Vehe, Independent Consultant; UNDAC: NM, EW
	12.00 - 15.00	MECDM; Review of background documents	UNDAC: NM, EW
	16.00 - 16.45	Meeting	UNDP: Ms. Suzaki; OCHA: Mr. Grimsich; UNDAC: NM; EW
	17.00 - 20.00	Review of background information	UNDAC: NM, EW
Wednesday 23 April	9.00 - 13.00	Review of background information; Administrative arrangements (UNDP)	UNDAC: NM, EW
	13.45	Arrival of UNDAC Team Member Christina Winckler, supported by ECHO	
	15.00 - 18.00	Team briefing; Site visit preparations	UNDAC: NM, CW, EW
Thursday 24 April	10.00 - 11.00	Meeting with Ministry of Energy, Mines and Rural Electrification (MEMRE)	MECDM; MEMRE; UNDAC: NM, EW, CW
	11.30 - 12.30	Travel to site	MECDM: Mr. Horokou, Ms. Beti; UNDAC: NM, EW, CW
	12.30 - 16.30	Site visit	
	16.30 - 17.30	Return to Honiara	
	20.00 - 21.30	Meeting ; OCHA, UNDAC	OCHA: G. Grimsich; UNDAC: NM, CW, EW
Friday 25 April	9.00 - 12.00	Review of mining company reports; MEMRE	UNDAC: NM, CW, EW
	12.00 - 15.00	Site visit	MECDM: Ms. Beti; UNDAC: CW, NM
	12.00 - 15.00	Review of mining company reports	UNDAC: EW
	15.00 - 16.15	Briefing with PS Mataki	OCHA: Mr. Grimsich; UNDAC: NM, CW, EW

	17.00 - 18.00	Meetings with UNDP DRR; OCHA; WHO	UNDP: Ms. Suzaki; OCHA: Mr. Grimsich; WHO, UNDAC: NM, CW, EW
	19.00 - 21.00	Situation review	UNDAC: NM, CW, EW
Saturday 26 April	8.00 - 13.00	Work on site assessment and initial recommendations	UNDAC: NM, CW, EW
	12.00 - 17.00	Site visit	MECDM: Ms. Beti, Ms. Potakana; UNDAC: CW
	17.00 - 18.00	Meeting with Dr. Vehe, environmental expert, landowners' associations	UNDAC: NM, CW, EW
	14.00 - 20.00	Work on site assessment and initial recommendations	UNDAC: NM, EW
Sunday 27 April	Full day	Finalizing preliminary recommendations	UNDAC: NM, CW, EW
Monday 28 April	9.00 - 16.00	Work with OCHA on impact maps; work on report; discussions with PS	UNDAC: NM, CW, EW
	16.00 - 17.00	Teleconference with Golder Associates and St Barbara	UNDAC: NM, CW, EW
	17.00 - 19.00	Work on impact assessment	UNDAC: NM, CW, EW
Tuesday 29 April	Full day	Sampling at mine site	UNDAC: EW, NM
		Tailings site facility detailed assessment	UNDAC: CW
Wednesday 30 April	9.00 - 10.30	Meeting with Ministry of Health and Medical Services (MoHMS)	MoHMS: L. Ross (PS) and T. Nanau (Director); UNDAC: NM, CW, EW
	11.00 - 12.30	Meeting with MECDM Director Horokou to discuss initial recommendations and next steps	MECDM: Mr. Horokou, Director, UNDAC: NM, EW, CW
	14.00 - 15.00	Meeting with European Union Delegation to SI, Charge d'Affaires Eoghan Walsh	EU Delegation: E. Walsh; UNDAC: NM, EW, CW
	15.00 - 19.00	Work on first draft of report	UNDAC: NM, CW, EW
	19.00 - 19.30	Teleconference; EU ERCC, JEU, UNDAC on mission status and next steps	ERCC: P. Billing, S. Dolhia; JEU: WQ, RN; UNDAC: NM, EW, CW
Thursday 1 May	Full day	Work on first draft of report and sampling plan	UNDAC: NM, CW, EW
Friday 2 May	PM	Finalization of first draft of report	UNDAC: NM, CW, EW
Saturday 3 May	AM	Work on report; submission of draft report to MECDM	UNDAC: NM, CW, EW
Sunday 4 May	Day off		

Monday 5 May	9.00 – 13.00	Updating final report	UNDAC: NM, CW, EW
	13.00 – 14.00	Meeting with Provincial Government Secretary James Taeburi	Provincial Government : PS Taeburi; UNDAC: NM, CW, EW
	14.00 – 19.00	Updating final report	UNDAC: NM, CW, EW
Tuesday 6 May	Full day	Sampling at mine site Final dam construction assessments	UNDAC: NM, CW, EW
Wednesday 7 May	10.00 – 12.00	Stakeholder briefing on mission results; gathering feedback on final draft report	All interested stakeholders
	13.00 – 18.00	Briefings ; MECDM, UNDP, OCHA	
Thursday 8 May	AM	UNDAC Team Departure	UNDAC: NM, CW, EW
Monday 12 May		Stakeholder feedback incorporated; final report shared for comments with consulted stakeholders; DL for feedback May 21	
Wednesday 28 May		Final report completed and shared	UNDAC: NM, CW, EW

ANNEX 4. LIST OF CONSULTED STAKEHOLDERS

Organization	Abbreviation	Name	Position
Ministry of Environment, Climate Change, Disaster Management and Meteorology	MECDM	Melchior Mataki	Permanent Secretary
		Joe Horokou	Director, Environment and Conservation Division
		Rosemary Apa	Chief Environment Officer
		Wendy Beti	Environment Officer
		Debra Potakana	Senior Environment Officer
Ministry of Energy, Mines and Rural Electrification	MEMRE	Donn Tolia	Director of Mines
		Hefford Panapio	Officer
		Jeremiah Kisi	Officer
Ministry of Health and Medical Services	MoH	Dr. Lester Ross	Permanent Secretary
		Tom Nanau	Director, Environment Health Division
		Jimmy Hilly	Officer, Environment Health Division
Office of the Prime Minister and Cabinet	OPM	Dr. Philip Tagini	Special Secretary to the Prime Minister
Provincial Government, Guadalcanal province	PG, Guadalcanal	James Taeburi	Provincial Secretary
Kolobisi Tailings Dam Association; Metapono Downstream Association	KTDA; MDA	Dr. Christopher Vehe	Independent Consultant
United Nations Development Programme	UNDP	Akiko Suzaki	Deputy Resident Representative
United Nations Department for Safety and Security	UNDSS	Morris Temangutaua	Security Officer
World Bank	WB	Denis Jean-Jacques Jordy	Post-Flood Assessment Advisor
		Samantha Cook	Post-Flood Assessment Advisor
World Health Organisation	WHO	Dr Audrey Aumua	WHO Representative, Solomon Islands
		Dr. Rokho Kim	Environmental Health Specialist, WHO Western Pacific Regional Office
		Dr. Paul Jagals	Independent expert
Regional Assistance Mission to Solomon Islands	RAMSI	Richard Griffith	Deputy Special Coordinator
Delegation of the European Union to the Solomon Islands	EU Delegation to SI	Eoghan Walsh	Charge d'Affaires

St Barbara / Gold Ridge Mining Limited	GRML	Stean Barrie	General Manager
		Jeff Waddington	Communication and Environmental Manager
		John De Vries	Technical Director
		Ruth Lulogula	Community / environment
		Gaheris Porovai	Process / Structural Engineering
		Ian Bobby	Structural Engineering
		Junior Suhara	Environment / sampling
Golder Associates	GA	Donovan Rowe	
		Mike Gowan	

ANNEX 5. SITE VISIT FINDINGS RELATED TO DAM STABILITY, PHOTO LOG AND DOCUMENTATION

1. Upstream slope of the Return Water dam. Photo taken near the spillway at the left abutment looking right.

2. Downstream slope of the Return Water dam. Photo taken near the right abutment looking left.

3. Crest of Return Water dam, looking right. Localized crest settlement was observed as shown by arrow.

4. A close-up view of area shown by arrow in Photo 3 indicating localized crest settlement at the Return Water dam.

5. Return Water dam spill way crest, looking upstream. Arrow show lowered spillway invert notch elevation. Original design has no concrete block. Observed freeboard was approximately 100 mm on April 25, 2014.

6. Return Water dam spill way crest, looking downstream. The spillway was operating with a flow of approximately 20 mm on April 26, 2014 and 50 mm on April 29, 2014.

7. Spillway channel looking upstream. Arrow show concrete block modification which should be removed to provide adequate freeboard for the dam.

8. Control section at downstream end of stilling basin at Return Water dam spillway, looking left. Note minor debris in the basin.

9. Arrow shows instability of reservoir rim at the Return Water dam, looking upstream.

10. Arrow shows instability of reservoir rim at the Return Water dam, looking upstream toward the right side.

11. Upstream crest of the TSF, looking right. Note erosion of upstream slope and lack of slope protection. Estimated vertical freeboard distance between the TSF crest and the pond water level is approximately 1700 mm.

12. Freeboard near the right abutment of the TSF, looking left. Estimated vertical freeboard distance between the TSF crest and the pond water level is approximately 1700 mm.

13. Standing water observed on TSF crest after rain event, looking left.

14. Downstream slope of the TSF, looking right. Arrows indicate upper lift that was recently placed with an approximate slope of 1.5H:1V and no downstream filter.

15. View of the downstream toe area with water present near the left abutment. It is not clear if this is from water seeping through the embankment or the abutment. Arrow showing approximate location of standpipe piezometer shown on Photos 17 and 18.

16. Water flowing near the right abutment. It is not clear if this is from water seepage through the embankment or the abutment. No cloudy seepage was observed.

17. Stand pipe piezometer with steel casing located in the downstream toe area on lower wide bench, approximately indicated by arrow on Photo 15.

18. Piezometer MH107 installed in 2005 constructed using bell jointed 50 mm ND Class 9 uPVC casing installed to a depth of 19.8 m below ground level with a slotted length of 3 m (Golder, 2005). Water was recorded 5.9 m below the ground surface in October of 2005 (Golder, 2005). Water was not recorded during the April-May 2014 site visits.

19. One of five survey prism installed in 2014 located on the TSF crest.

20. Spillway channel with geotextile underlain by old conveyor belts, looking right. Available freeboard is approximately 600 mm.

21. Spillway channel, looking upstream.

22. Spillway channel at Saddle dam, looking downstream and right. Note erosion in spillway channel due to surface water runoff, also shown on Photo 23.

23. Spillway channel, looking downstream beyond spillway section. Note erosion gullies due to surface water runoff.

24. Crest of Saddle dam, looking left towards spillway. Arrow indicates recent sloughing of material downstream and left of the spillway, as shown on Photo 25.

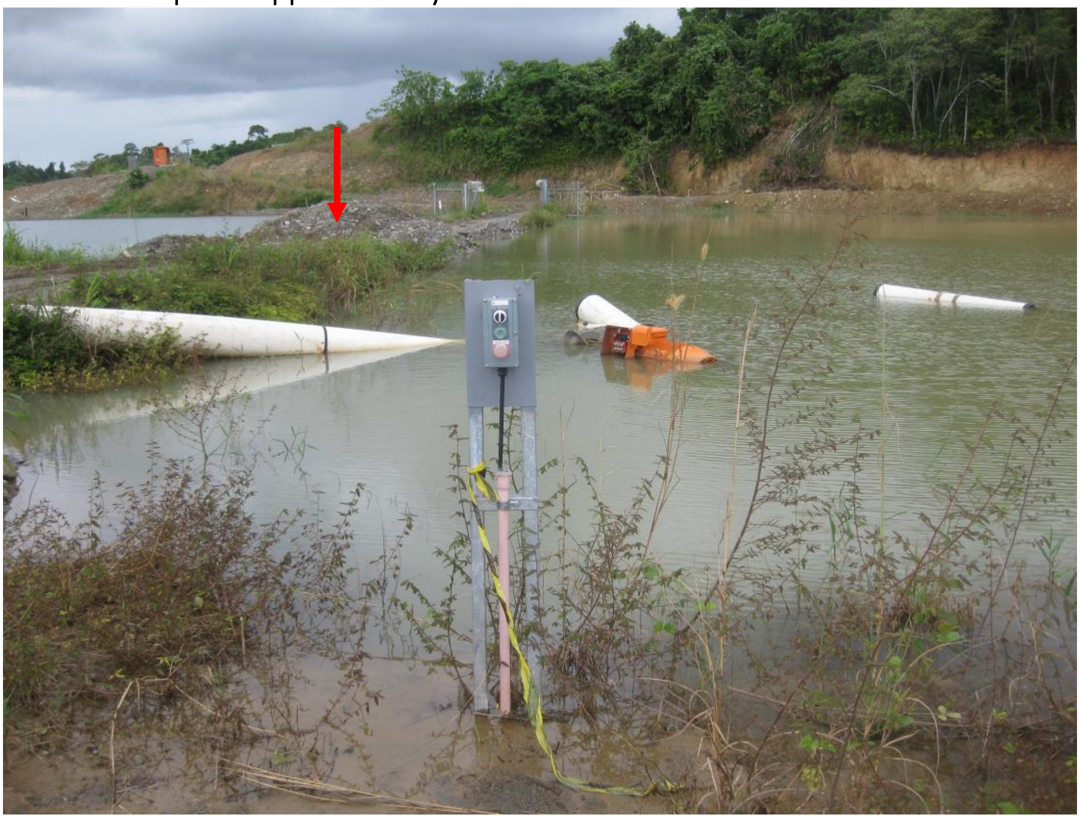
25. Recent sloughing of near vertical cut located downstream and left of the Saddle dam spillway channel.

26. Upstream slope of Saddle dam, looking right.

27. Downstream slope of Saddle dam, looking right.

28. Downstream slope of Saddle dam with ditch, looking left. Water in ditch is most likely due to surface water runoff. No water was observed in ditch on the last site visit.

29. Water treatment plant located at upstream edge of TSF pond. Available freeboard distance between pond water level and water treatment foundation concrete pad is approximately 100 mm.



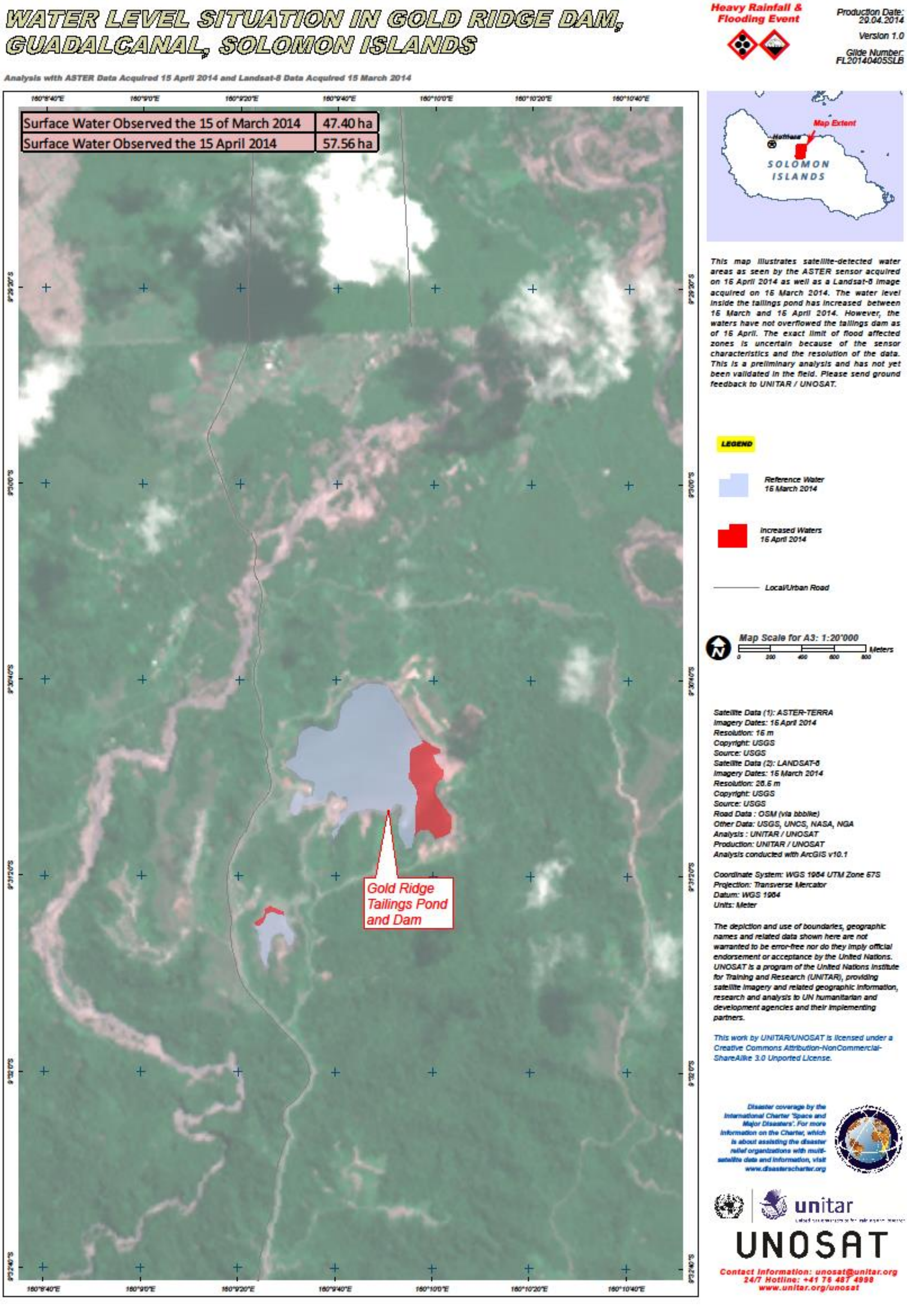
30. Earth embankment between TSF pond and discharge/polishing pond. Arrow shows location of breach shown in close-up view on Photo 31.

31. Breach of earth embankment between TSF pond (to the left) and discharge/polishing pond (to the right). Note gravelly sand with cobbles used to construct the embankments.

32. Overtopped earth embankment between discharge/polishing pond (to the left) and sedimentation pond (to the right).

ANNEX 6. MAP SHOWING RIVERS AND DOWNSTREAM COMMUNITIES

ANNEX 7. SATELLITE IMAGERY - TAILINGS DAM WATER INCREASE



ANNEX 8. CHEMICAL HAZARDS PRELIMINARY ASSESSMENT

(Excerpt from full UNDAC mission preliminary observations, sent to the Government of the Solomon Islands through the MECDM, on April 28. It was later made known to the mission that these concerns had already been addressed through the deployment of a hazardous materials and explosive ordnance disposal team through RAMSI)

Preliminary assessment related to management of risks at the Gold Ridge tailings storage facility and processing plant

This brief report outlines a number of risks at the Gold Ridge mining and tailings facility identified by the United Nations Disaster Assessment and Coordination (UNDAC) team, supported by the European Commission's Humanitarian Aid and Civil Protection Directorate General (ECHO). Concerns and observations are based upon three site visits (Thursday 24 April – Saturday 26 April), company and Ministry reports, as well as select interviews. These observations should be seen as preliminary only. The team has not been provided with all necessary data, nor had sufficient time, to assess the risks posed by the site in detail.

(1. Dam Safety Concerns – included in main report)

2) Chemical Hazards

Hazards at the water treatment plant have been confirmed by the mission site visit. The team has not independently verified the current situation and the reports of chemical incidents at the processing plant, and this location is also not the key focus of the mission[12]. However, the report of the Ministry of Environment, Climate Change, Disaster Management and Meteorology (MECDM) on the April 15 monitoring visit to the processing plant raises a number of serious safety concerns.

2.1 Potential leak at processing plant

At the processing plant, Ministry monitors found one carbon-in-leach tank leaking due to a pulley not being closed properly. This had in turn led to the tanks bunding overflowing resulting in leaks to a nearby drain leading into Chovohio and Charivunga rivers. The leakage flow was estimated to be approximately 408 liters / hour. There was also evidence of acid leakage at the site, which in the combination with a cyanide leak could have dire consequences in case hydrogen cyanide gas is formed. Exposure to hydrogen cyanide, even in small quantities, can be fatal. In areas with unknown levels of contaminant, full protective suits and self-containing breathing apparatus must be used by hazardous material (hazmat) first responders.

2.2 Chemicals storage and use at mine site

The Ministry monitoring team noted that chemicals, warehouse and other materials were not properly stored at the site and thereby vulnerable to vandalism. Police officers guarding the facility report that intrusions were made before their arrival. On Friday 25 April the mission received reports of a chemicals accident. Upon further investigation, it turned out that the person involved had been exposed at the mine pit. A can of unknown chemical had reportedly turned over and spilt while he was sleeping. It is not clear to the mission at which hospital/clinic and how chemicals poisoning was diagnosed. A number of people are reported to be engaged in illegal digging at the site, an activity which is usually accompanied by chemicals use and associated harmful chemicals exposure. The team received reports of police experiencing skin rashes after visits to the chemicals storage. The police guarding and patrolling the site are currently at risk from the chemical hazards.

[12] Refer to UNDAC mission terms of reference for mission scope and objective.

2.3 Water treatment chemicals

At the water treatment plant, the team observed bulk containers of hydrochloric acid (35%) and corrosive chemicals. The Ministry monitoring report shows one container to be open and fuming. The photo shows the container to be full. At the time of the mission visit, the container was less than half full. The chemicals are currently very close to the TSF water level. If released, both the acid and the corrosive substances will have an effect on the water quality. The hydrochloric acid can lower the pH leading to a mobilization of heavy metals from the sediment. The open containers also pose a personal safety risk.

2.4 Other

At the processing plant, there is reported concern of the impacts of the earthquakes on the explosives storage. The possible risks posed by cesium at the site have been raised to the team by a number of interviewees. However, former company employees interviewed by the team stated that the radioactive sources of monitoring equipment had been assessed and found to remain intact after the earthquakes. Interviewees also showed the team pictures of the intact containers[13].

3) OBSERVATIONS (as given April 27, 2014)

The Ministry mission findings and reports of chemicals exposure and poisoning are extremely worrying, and warrant a detailed assessment by a properly equipped team of hazmat first responders. The mission's preliminary recommendations for **immediate action** are to:

1. **Conduct a full chemical hazard assessment of the processing plant site.**
   The site should be inspected by a properly equipped hazmat first responder team, wearing personal protective suits, self-containing breathing apparatus and detection equipment.
2. **Secure site perimeters, including pit area, with sufficient police and security force.**
   Police and security force should ensure that informal gold digging ceases immediately as it puts diggers under risk of chemicals exposure; taking into note security implications of these actions.
3. **Move the chemicals at the water treatment plant to a higher elevation, which will reduce the risk of a spill into the TSF.**
   Inspect and seal the open hydrochloric acid container by a properly equipped hazmat first responder team, wearing personal protective suits, self-containing breathing apparatus and detection equipment.
4. **Explosive Ordnance Disposal (EOD) team to assess risks at explosives storage.**

[13] In these types of equipment, cesium is contained in a special container held within a double-walled steel container, designed to withstand severe physical damage. More information can be found on:
http://www.epa.gov/radiation/radionuclides/cesium.html
http://www.iaea.org/Publications/Booklets/SealedRadioactiveSources/sealedradsource1013.pdf

ANNEX 9. SAMPLING PLAN

The current sampling program excites of the following sampling locations:

- TSF01 - North end embankment wall
- TSF02 - TSF discharge pond, near water treatment plant
- TSF03 - Centre of RWD embankment wall
- SW14 - Tinahulu River discharge point

If a decision has been made to release untreated TSF water into the river Tinahulu, the upstream sediment and water conditions within the river will need to be assessed in order to conduct an evaluation to establish controlled discharge levels of the TSF water. Two additional sampling locations to evaluate the possible contamination of the seepage water from the TSF and one sampling location to evaluate the TSF water near the saddle dam spillway are also recommended to be part the on-going monitoring program.

1. Sampling and frequency

1.1. Current sampling program

1.1.1. Label all sampling bottles with the following information:

- Client Ref
- Sample location (TSF01, TSF02, etc)
- Name of Sampler
- Date of sampling

1.1.2. Wear latex gloves when sampling.

1.1.3. Fill all bottles as instructed.

1.1.4. Store all filled bottles in an Esky and keep cool.

1.2. Additional requested sampling program

1.2.1. Go approximately 500m **UPSTREAM** from SW14 - Tinahulu river discharge point.

1.2.2. Give this point the name US01.

1.2.3. Record this new sampling location with GPS to be able to relocate it for future sampling.

1.2.4. Take a photograph, only first time, of the new location.

1.2.5. Take sample of the sediment as instructed in current sampling program.

1.2.6. Take a sample of the water as instructed in current sampling program.

1.2.7. Go approximately 1500m **DOWNSTREAM** from SW14 - Tinahulu river discharge point.

1.2.8. Call this point DS01.

1.2.9. Repeat above steps 2.2.3 – 2.2.6.

1.2.10. Go to the nearest **DOWNSTREAM** settlement where people/livelihood is depending on the water.

1.2.11. Call this point DS02.

1.2.12. Repeat above steps 2.2.3 – 2.2.6.

1.2.13. Go to the piezometer located on downstream bench at the TSF.

1.2.14. Call this point PS01.

1.2.15. Record this new sampling location with GPS to be able to relocate it for future sampling

1.2.16. Take a photograph, only first time, of the new location.

1.2.17. Measure the level of the groundwater using a water level indicator.

1.2.18. Take the water samples at a depth of encountered using a water bailer.

1.2.19. Go to the seepage weir located downstream of the TSF.

1.2.20. Call this point PS02.

1.2.21. Record this new sampling location with GPS to be able to relocate it for future sampling

1.2.22. Take a photograph, only first time, of the new location.
1.2.23. Take only a water sample as instructed in current sampling program.
1.2.24. Measure height of water in weir location.

1.3. Frequency

Merge the current and additional requested program into one monitoring program.
See below table the frequency of sampling the different points. If levels of arsenic and cyanide are on acceptable levels (below WHO standards), you can consider a less more frequent sampling program.

Table 1. Type of sample and their frequency in which they should be taken.

Location	Water	Frequency	Sediment	Frequency
TSF01	Yes	Weekly	Yes	Monthly
TSF02	Yes	Weekly	Yes	Monthly
TSF03	Yes	Weekly	Yes	Monthly
TSF04	Yes	Weekly	Yes	Monthly
PS01	Yes	3 Monthly	No	-
PS02	Yes	3 Monthly	Yes	Yearly
US01	Yes	Weekly	Yes	Monthly
DS01	Yes	Weekly	No	-
DS02	Yes	Weekly	Yes	Monthly

If dewatering is started, it is advisable to take a daily water sample at all points with exception of the both PS locations (PS01, PS02) to be analyzed for arsenic and cyanide with in-house technical capacities.