**ATC WILLIAMS PTY LTD**
**Melbourne**
**t** +61 3 8587 0900
222-225 Beach Road,
Mordialloc, VIC, 3195
**atcwilliams.com.au**
**ABN 64 005 931 288**

Our Ref: 121085.01 L02

20 September 2021

Department of Mines Industry Regulation and Safety

100 Plain St

EAST PERTH, WA 6004

**ATTENTION: Ben Darby**

Dear Ben,

**BULONG TAILINGS STORAGE FACILITY CONDITION ASSESSMENT**

**SITE INVESTIGATION**

## 1 INTRODUCTION

The Department of Mines, Industry Regulation and Safety (DMIRS) Abandoned Mines Program (AMP) has engaged ATC Williams (ATCW) to undertake a condition assessment and closure design of the Bulong Tailings Storage Facility (TSF).

As part of the condition assessment, ATCW performed a site inspection of the Bulong TSF, including an investigation of the tailings strength. This document provides a summary of the inspection, including observations, photographs and investigation data.

## 2 PROJECT BACKGROUND & TSF DETAILS

The Bulong TSF is located in Western Australia, approximately 40 km east of Kalgoorlie and adjacent to Lake Yindarlgooda. ATCW understand that the mine site has been abandoned since 2005 and the TSF has remained inactive since this time.

The TSF starter embankment was constructed in 1998 to a crest height of RL 329 m. The embankment was subsequently centreline raised in 2001 to a crest height of RL 331 m. A third raise was designed to raise the embankment to RL 333 m, however this was never constructed. Throughout the operational life of the facility, tailings were discharged from the perimeter embankment to a central causeway decant structure.

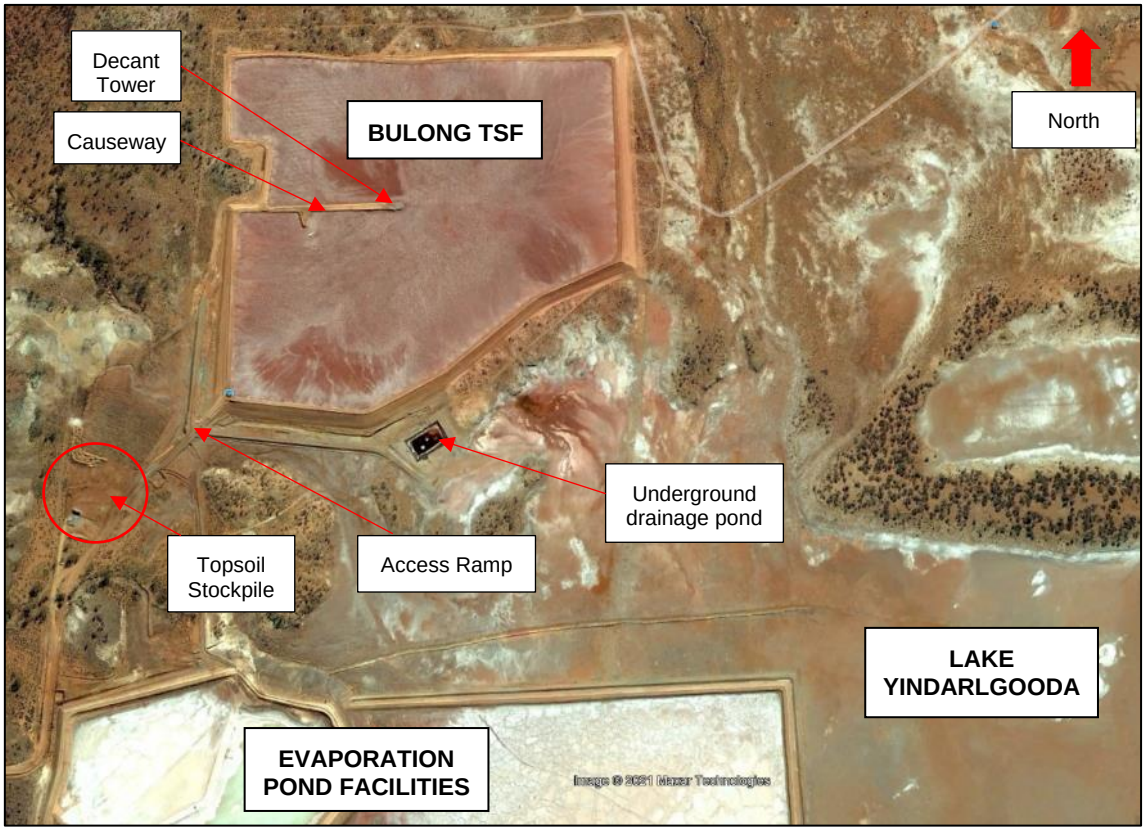
The Bulong TSF was assigned a ‘High’ hazard rating in accordance with the Western Australia DMPR guidelines.

An aerial image of the Bulong TSF is presented in **Diagram 1**. As shown, to the south of the TSF there are two inactive Evaporation Pond Facilities (EPF1 & EPF2). Lake Yindarlgooda is located to the south east of the TSF.



TAILINGS.WATER.WASTE.

**DIAGRAM 1 : BULONG TSF ANNOTATED AERIAL IMAGE**




## 3 INSPECTION OVERVIEW

The site inspection and field work investigation was performed on the 27th and 28th July 2021 by Matt Williams, a Senior Engineer from ATCW. The inspection was also attended by Ben Darby, Principal Environmental Officer at DMIRS. At the time, the weather consisted of intermittent rain and strong winds. The Bureau of Meteorology (BOM) recorded 20.4 mm of rain for the week prior to the site inspection.

The field work for the TSF tailings investigation comprised:

- Visual observation of the embankment crest, downstream batter and toe, as well as the causeway, decant structure and tailings beach (refer **Section 4** for details).
- Tailings strength testing using a PANDA Instrumented Dynamic Cone Penetrometer (DCP) at 6 locations to a maximum depth of 4.2 m. Shear vane tests were also carried out at depths up to 0.4 m (refer **Section 5** for details).

## 4 FIELD OBSERVATIONS

### 4.1 Summary

A summary of observations is provided in **Table 1**. The photos referred to in the table are presented in **Section 4.2**.



TAILINGS.WATER.WASTE.

**TABLE 1 : BULONG TSF INSPECTION OBSERVATIONS**

| Item | Observations |
|---|---|
| Downstream Slope | The embankments appeared to generally be in good condition with some surface erosion. The northern and eastern walls were covered with windblown tailings possibly covering erosion. Approx. 0.5 m height of the northern wall toe had eroded possibly due to surface water movement (**Photo 4**).<br><br>The embankments have a clayey surface with some surface erosion on the downstream face of the south (**Photo 1**), southeast and southwest walls. Most of the northern downstream faces were covered with windblown tailings, the covering was thicker in the northeast (**Photo 3**). |
| Crest | The crest appeared to be flat, partially covered with gravel and large sections covered with windblown tailings (**Photo 5**). The entire crest was able to be driven across in a light vehicle (LV). In general, the surface provided good support for trafficking with no rutting observed. Some minor erosion was observed close to the downstream edge. Windrows were either small or total absent. |
| Toe Drain | An apparent toe drain runs around the TSF leading to an outflow adjacent to the pond south of the TSF (**Photo 11**). In general, the toe drain is full of soft erosion sediment and windblown tailings. A road blocks the drainage pathway near the pond with signs of localised wet ground. |
| Causeway | The causeway was flat and generally covered with gravel and windblown tailings. The surface driven across with an LV. In general, the surface provided good support with no rutting observed. Remnant windrows remain. |
| Tailings Surface | At the time of the visit, the tailings surface appeared to be relatively flat. Approximately 0.75 m tailings freeboard was observed to the embankment crest (**Photo 6, 7 & 10**). No standing water was observed anywhere on the tailings surface. Apparent cracks were infilled with windblown tailings.<br><br>The tailings surface was accessed on foot to the Panda DCP test locations (refer **Section 5**) and was generally stable under foot with occasional loose spots which were considered to be infilled cracks. |
| Decant System | Generally, the decant surrounds are surfaced with 50 mm gravel and windblown tailings and appeared stable (**Photo 8**). The decant tower was open and dry. No obvious signs of movement were observed in the tower (**Photo 9**). |
| Tailings Delivery System | In general, the pipework on and surrounding the TSF has been removed. Only a small section of partially buried pipe remains, in addition to the spigot pipes (**Photo 10**). Observations indicate the main tailings pipework originally travelled up the ramp in the southwest corner and then along the crest. |
| Underground Drainage Pond | The underground drainage pond is located to the south of the TSF. Access is restricted by wire fence surrounding the pond. The pond is below the surrounding ground surface level, lined and was partially filled with water at the time of inspection. Some pipework remains open (judged to be the underground pipes). All pumps have been removed. No warning signs or lifebuoy were observed. |



TAILINGS.WATER.WASTE.

| Item | Observations |
|---|---|
| Surrounding Area | The general topography surrounding the TSF falls to the east. Windblown tailings have covered vegetation in a local area predominantly in a north easterly direction turning the natural the vegetation red-brown as seen on **Photo 14**. |
| Topsoil Stockpile | A topsoil stockpile was observed at the base of the access ramp on the western side, see **Photo 145**. Measurements on google earth suggests the stockpile is approx. 145 m x 120 m. Observation on site indicated an average height of 1.5 m. Thus, approx. 26,000 $m^3$. |

## 4.2 Photographs

The following 15 photos provide a general view of the key areas of the TSF as discussed in **Table 1**.

**PHOTO 1 : SOUTHERN EMBANKMENT SURFACE EROSION**



TAILINGS.WATER.WASTE.

**PHOTO 2 : SOUTHERN EMBANKMENT DOWNSTREAM TOE**

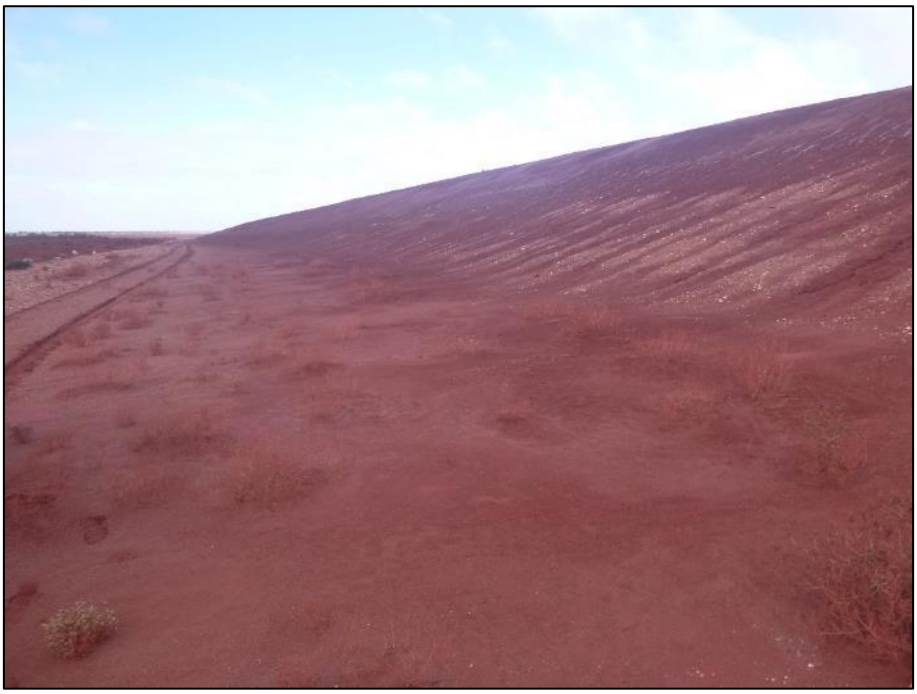


**PHOTO 3 : NORTHERN EMBANKMENT**



TAILINGS.WATER.WASTE.

**PHOTO 4 : NORTHERN EMBANKMENT TOE EROSION**

**PHOTO 5 : SOUTHEAST EMBANKMENT CREST**



TAILINGS.WATER.WASTE.

## PHOTO 6 : TAILINGS SURFACE SOUTHWEST CORNER

## PHOTO 7 : CAUSEWAY LOOKING EAST



TAILINGS.WATER.WASTE.

**PHOTO 8 : CAUSEWAY AND DECANT TOWER**

**PHOTO 9 : DECANT TOWER**



TAILINGS.WATER.WASTE.

**PHOTO 10 : PIPEWORK SOUTHWEST CORNER**

**PHOTO 11 : TOE DRAIN SOUTH SIDE**



TAILINGS.WATER.WASTE.

## PHOTO 12 : BLOCKED DRAIN ADJACENT TO POND

## PHOTO 13 : UNDERGROUND DRAINAGE POND



TAILINGS.WATER.WASTE.

**PHOTO 14 : WINDBLOWN TAILINGS COVERING VEGETATION**

**PHOTO 15 : TOPSOIL STOCKPILE**



TAILINGS.WATER.WASTE.

# 5 PANDA DCP TESTING

## 5.1 Overview

PANDA DCP testing was performed at six locations across the tailings beach to a maximum depth of 4.2 m. Test locations are presented in **Figure 1**. Testing was conducted by an ATCW engineer.

The PANDA is a lightweight (approximately 20 kg) handheld Dynamic Cone Penetrometer (DCP) which uses variable energy. The tests results are recorded as cone tip resistance ($q_d$) versus depth.

All PANDA tests were undertaken with a 2 $cm^2$ cone tip attached to the end of an extendable set of rods. The tip and rods are driven into the ground using a fixed weight hammer but with variable force. An accelerometer on the head of the tool measures the speed of impact of each hammer blow and the penetration depth is measured by a retractable tape. The tip resistance was automatically calculated and stored on the equipment along with the test GPS location, and subsequently downloaded.

The PANDA results were correlated to estimate undrained shear strengths by ATCW, using an empirical formula (refer **Section 5.2**).

## 5.2 Testing Results

Cone resistance profiles were obtained for each of the six PANDA DCP tests and are presented in **Diagram 2**. The cone resistance values were correlated to a general consistency classification for the Panda DCP, developed by Miguel, Benz & Navarrete **[2]**, as presented in **Table 2**.

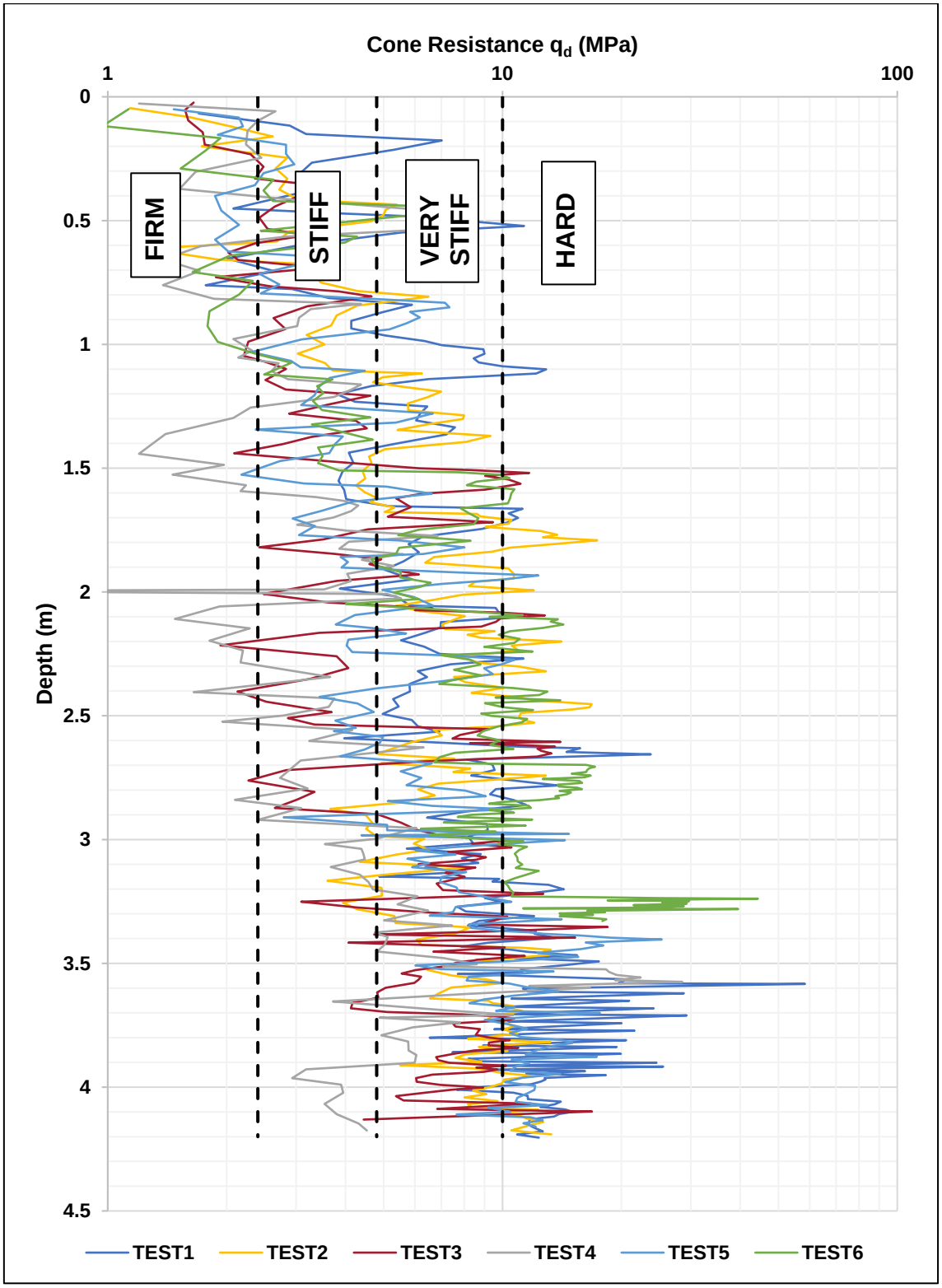
As shown in **Diagram 2**, the tailings profiles can generally be classified as having a ‘Stiff’ to ‘Very Stiff’ consistency up to the investigated depth of 4.2 m.

Shear vane tests were undertaken adjacent to all PANDA DCP tests. Due to the hard tailings crust layer, all in-situ shear vane tests reached refusal.



TAILINGS.WATER.WASTE.

## DIAGRAM 2 : TAILINGS CONE RESISTANCE PROFILES






TAILINGS.WATER.WASTE.

**TABLE 2 : TYPICAL PANDA DCP CONSISTENCY CORRELATIONS [2]**

| Consistency of Cohesive soils (silts and clays) | | |
|---|---|---|
| **Consistency** | **Strength (kPa)** | **$q_d$(*) (MPa) PANDA DCP** |
| Very soft | 0 - 25 | 0 – 0.4 |
| Soft | 25 - 50 | 0.4 – 0.9 |
| Firm | 50 - 100 | 0.9 – 2.4 |
| Stiff | 100 - 200 | 2.4 – 4.8 |
| Very stiff | 200 - 400 | 4.8 – 10.0 |
| Hard | > 400 | >10 |

* *Obtained from Instrumented French Lightweight Dynamic Cone Penetrometer P.A.N.D.A. and by means of Dutch Formulae*

## 6 CLOSURE

The work described in this letter was undertaken in accordance with ATCW's proposal for the work dated May 2021 **[1]**.

If you have any queries, please contact the undersigned.

Yours sincerely,

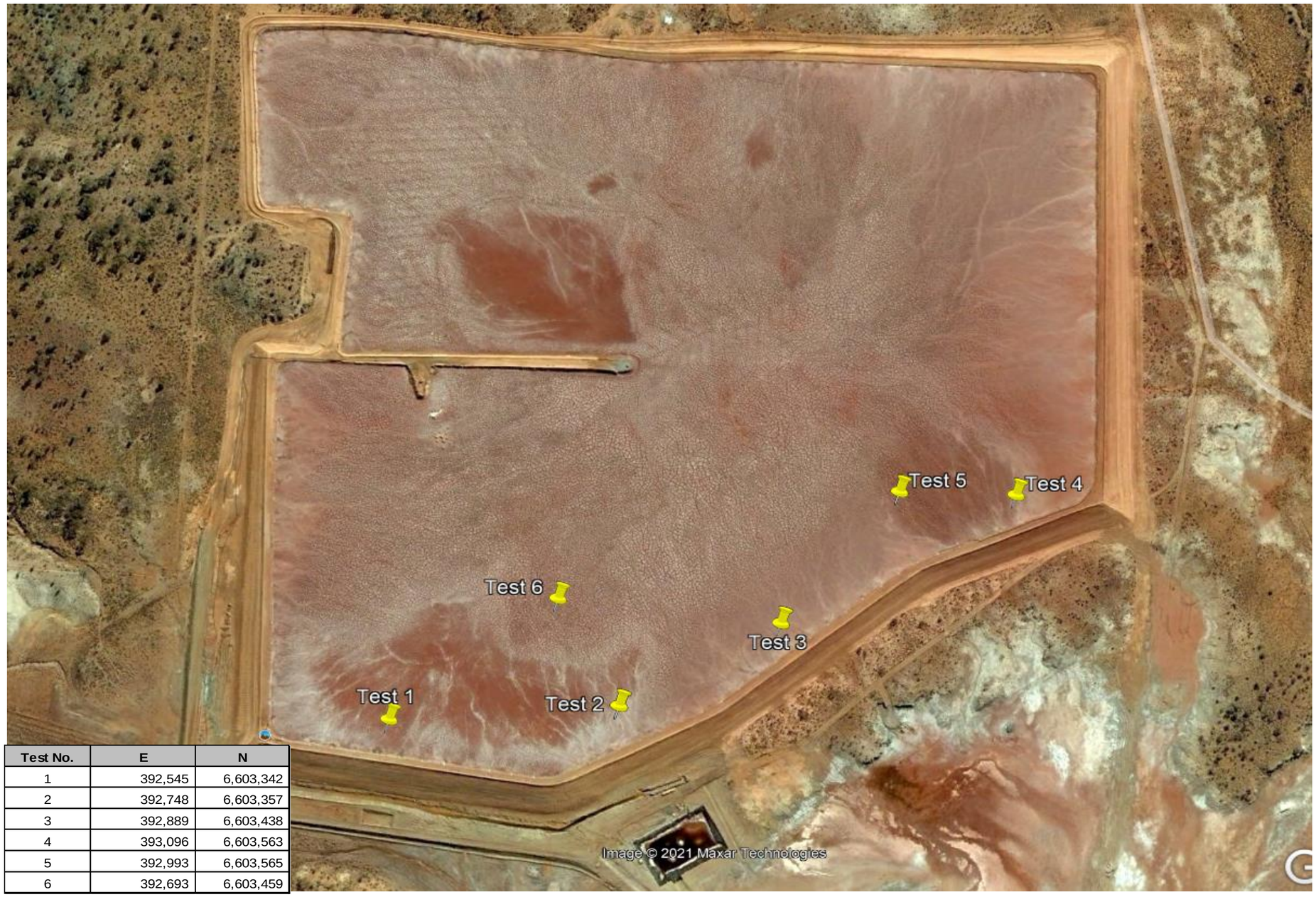
**Matt Williams**
Senior Engineer
**ATC Williams Pty Ltd**

**Dale Ross**
Associate Engineer
**ATC Williams Pty Ltd**

## REFERENCES


**[1]** ATC Williams, (May 2021), “Department of Mines Industry Regulation and Safety, Bulong Tailings Storage Facility, Proposal for Geotechnical Assessment and Final Closure Report”. Ref. 121085.01.

**[2]** Miguel Benz Navarrete (July 2021), “Typical field values of penetration resistance for density and consistency of soils”




| Test No. | E | N |
|---|---|---|
| 1 | 392,545 | 6,603,342 |
| 2 | 392,748 | 6,603,357 |
| 3 | 392,889 | 6,603,438 |
| 4 | 393,096 | 6,603,563 |
| 5 | 392,993 | 6,603,565 |
| 6 | 392,693 | 6,603,459 |

ATC WILLIAMS

www.atcwilliams.com.au

**DMIRS ABANDONED MINES PROGRAM**

**BULONG TSF ASSESSMENT**

**Tailings Investigation Plan**

| **Date:** | 20/08/2021 | **Job No:** | 121085.01 | **FIGURE 1** |
|---|---|---|---|---|

*K:\Projects\121\121085 DMIRS Abandoned Mines Program\01 Bulong TSF Assessment\Data and Calcs\Investigation\Investigation Plan  Plan*