NORTHERN STAR
RESOURCES LTD

L7815/2001/12 LICENCE AMENDMENT SUPPORTING ATTACHMENTS

Version	1.0
Date	15 August 2025
Tenements	L 36/155, L 36/157, L 36/158, L 37/61, L 37/73, L 37/142, L 37/166, L 37/199, L 37/215, L 37/216, L 37/222, M 36/35, M 36/177, M 36/421, M 36/462, M 36/473, M 36/494, M 36/503, M 36/504, M 36/512, M 36/516, M 36/525, M 36/527, M 36/541, M 36/542, M 36/582, M 36/584, M 36/585, M 36/586, M 36/587, M 36/589, M 36/599, M 36/600, M 37/339, M 37/340, M 37/356, M 37/357, M 37/358, M 37/359, M 37/360, M 37/361, M 37/367, M 37/368, M 37/437, M 37/465, M 37/1148
Licence Holder	Northern Star (Thunderbox) Pty Ltd
Mining Centre	Thunderbox Operations

[redacted]

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[redacted]

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TERMS USED

Acronym / Abbreviation	Definition
CCIR	Critical containment infrastructure report.
DMPE	Department of Mines, Petroleum and Exploration
DWER	Department of Water and Environmental Regulation
ESA	Environmentally sensitive area
EP Act	*Environmental Protection Act 1986*
IFC	Issued for construction
L7815	Operating licence L7815/2001/12
Northern Star	Northern Star (Thunderbox) Pty Ltd / Northern Star Resources Ltd
TSF	Tailings Storage Faciltiy
W6601	Works approval W6601/2021/1

1 Company Authorisation (Attachment 1C)

NORTHERN STAR RESOURCES LTD

10 June 2025

[redacted]

[redacted]

LETTER OF AUTHORITY IN REGARD TO APPROVAL APPLICATIONS

Please be advised that individuals holding the following positions (including their alternate or acting counterparts), are authorised to sign each of the following approval applications on behalf of Northern Star Resources Ltd and its subsidiaries:

Position:

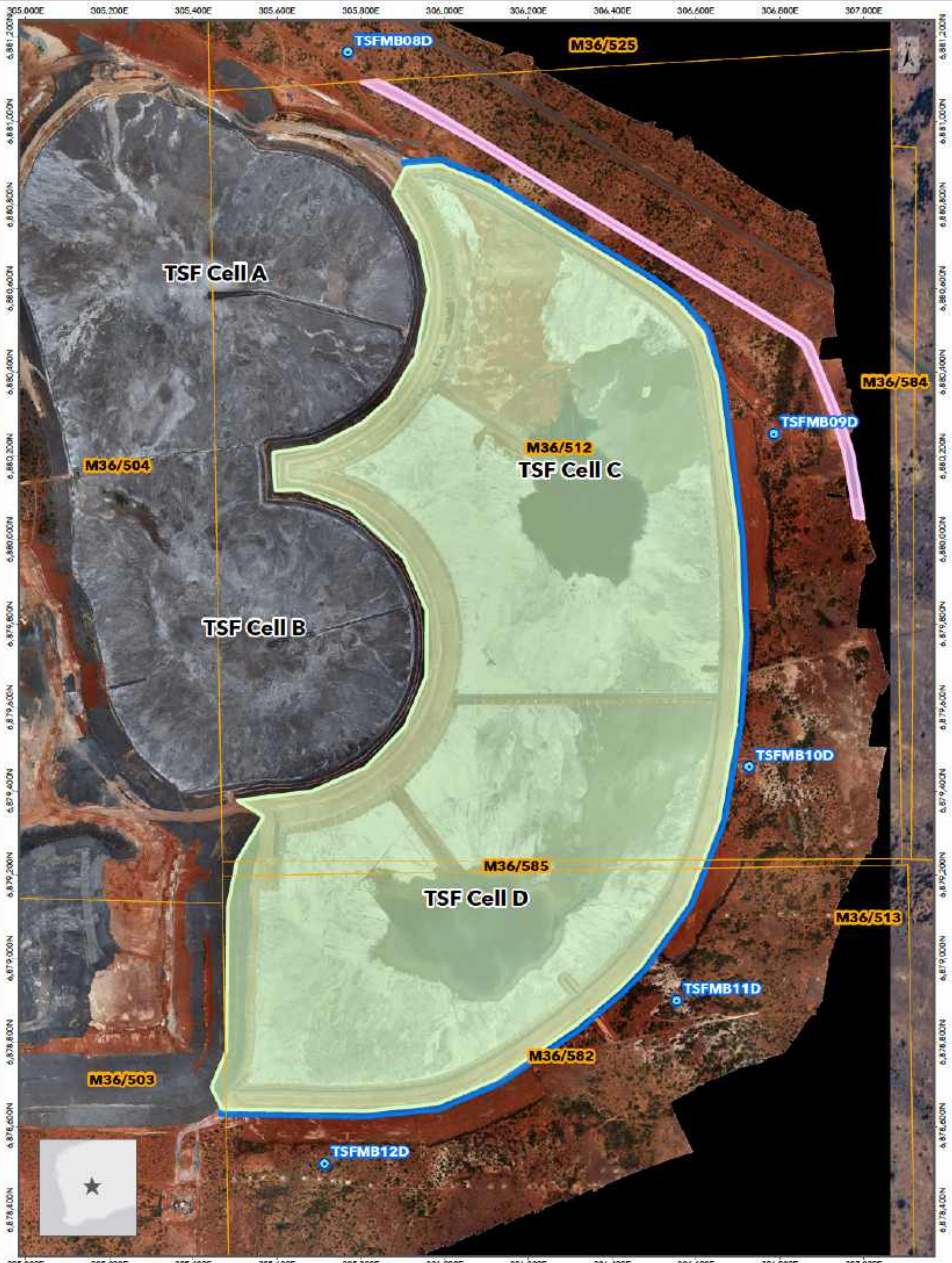
- Site Senior Executive/General Manager – Carosue Dam Operations
- Site Senior Executive/General Manager – KCGM
- Site Senior Executive/General Manager – Kalgoorlie Operations
- Site Senior Executive/General Manager – Jundee Operations
- Site Senior Executive/General Manager – Thunderbox Operations
- Site Senior Executive/General Manager – Bronzewing Operations
- Site Senior Executive/General Manager – Hemi / Pilbara Operations

Approval Applications:

- Application for: Clearing Permit (Area Permit or Purpose Permit) / Amendment to a clearing permit / Surrender a clearing permit / Notification of change of land ownership
- Application form: Works Approval / licence / Renewal / Amendment / Registration / Surrender works approval or licence / Transfer works approval or licence, or Notify new occupier of registered premises
- Application for a water licence under section 26D of the Rights in Water and Irrigation Act 1914
- Application for a 5C licence to take groundwater
- Applications for a section 11/17/21A permit to interfere with bed and banks
- Annual Audit Compliance Report
- Annual Environmental Report
- Annual and Triennial Groundwater Reviews

[redacted]

2 Premises Maps (Attachment 2)



Thunderbox TSF Cell C & D

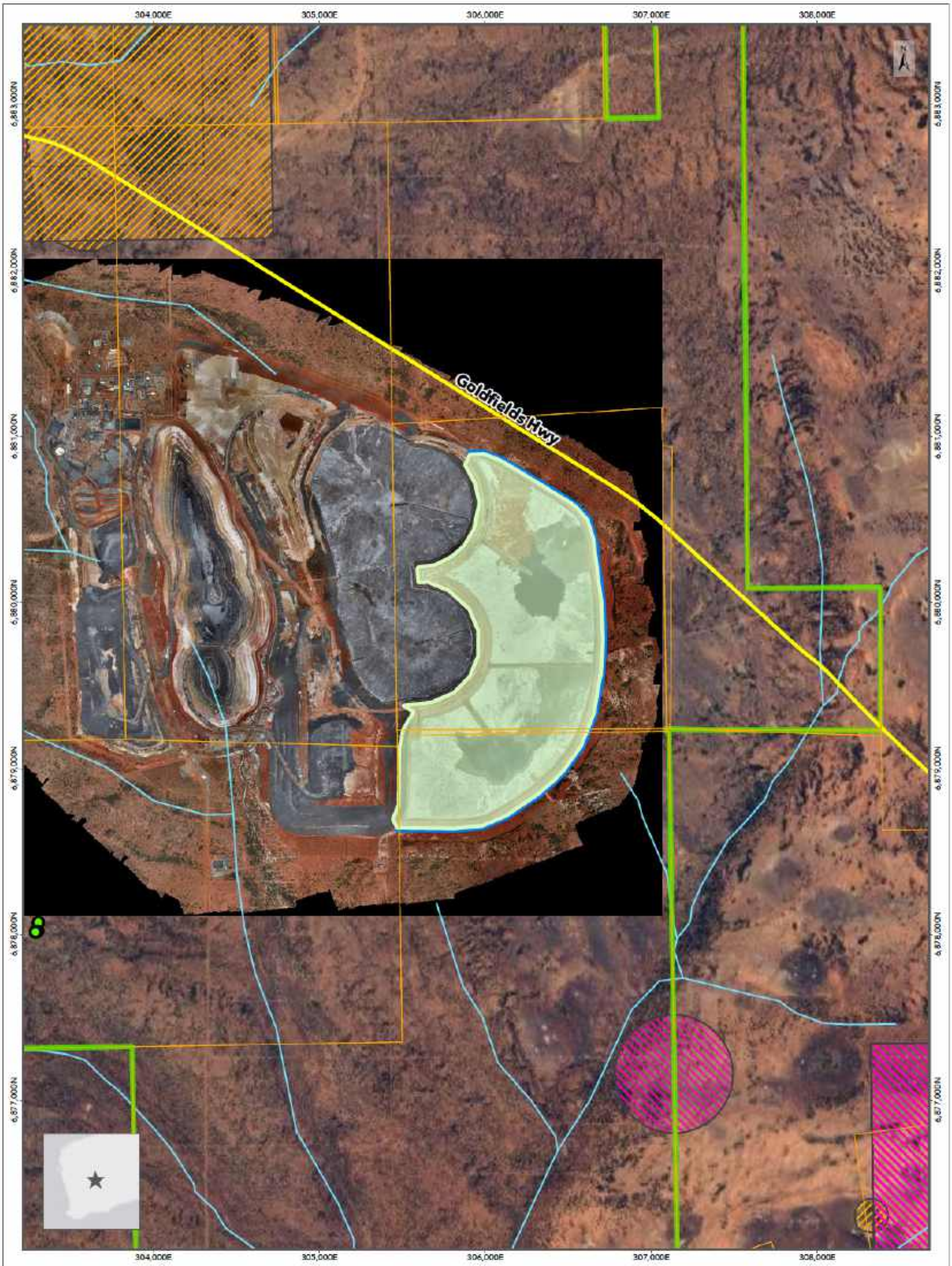
L7815/2001/12 Licence Amendment Supporting Document

- Northern Star Tenements
- TSF Cell C & D Final Footprint
- Stage 2 Toe Drain & Access Road
- Berm & Diversion Drain (existing)
- TSF Monitoring Bores (existing)

0 250 500m

NORTHERN STAR RESOURCES LIMITED

Date: 1/08/2025 | Author: dmartini | Coordinate System: GDA 1994 MGA Zone 51 | Scale: 1:12,000 |



Sensitive Receptors Summary

L7815/2001/12 Licence Amendment Supporting Document

Northern Star Tenements
Prescribed Premises Boundary
TSF Cell C & D Final Footprint
Stage 2 Toe Drain & Access Road
Aboriginal Cultural Heritage - Register (DPLH-099)
Aboriginal Cultural Heritage - Lodged (DPLH-100)
Watercourses
Public Road
Priority Flora

0 500 1,000m

NORTHERN STAR RESOURCES LIMITED

Date: 1/08/2025 | Author: dmartini | Coordinate System: GDA 1994 MGA Zone 51 | Scale: 1:30,000 |

3 Proposed Activities (Attachment 3B)

3.1 Proposal Overview

Northern Star (Thunderbox) Pty Ltd (hereinafter referred to as Northern Star) is seeking an amendment to operating licence L7815/2001/12 (L7815) pursuant to Section 59B of the *Environmental Protection Act 1986* (EP Act). The purpose of this amendment is to request for future lift stages of Thunderbox Tailings Storage Facility (TSF) Cells C & D to be authorised for construction and operation under L7815. A summary of the requested amendment and justification are outlined in Table 3-1 below.

Table 3-1: Proposed Licence Amendments Summary

Schedule 1 Category	Requested Amendment	Justification
Activity Amendments		
Category 5: Processing or beneficiation of metallic or non-metallic ore	Permit construction and operation of future lift stages (Stage 2 – 5) of Thunderbox TSF Cell C & D on Licence L7815 by including conditions pertaining to the construction of each lift stage.	In accordance with written advice from DWER "the best way forward for the Thunderbox TSF Cell C and D is to amend the licence to put in the individual lift stages. This will allow for future lifts to be captured in the licence framework."

3.2 Category 5: Processing or beneficiation of metallic or non-metallic ore

3.2.1 TSF Cell C & D

Thunderbox TSF is a paddock style TSF which manages disposal of all tailings generated from mining and processing across Thunderbox Operations (TBO). Thunderbox TSF is split into Cells A & B (original cells constructed in October 2002) and Cells C & D (new cells constructed in November 2023). As a combined TSF, the cells will facilitate tailings deposition at a rate of up to a permitted 7 mega tonnes per annum (Mtpa) throughput at TBO (estimated to 2034). It is noted that Cells A & B are managed independently to C & D to allow staggered raises whilst maintaining continuous operations.

Construction of Thunderbox TSF Cell C & D was authorised under Works Approval W6601/2021/1 (W6601) in May 2022. Construction of the first stage (starter embankment) was completed to 498.2 m RL in accordance with conditions specified in W6601. Following construction completion a critical containment infrastructure report (CCIR) was submitted to the Department of Water and Environmental Regulation (DWER).

Following acceptance of the CCIR by DWER, L7815 was amended on 29 January 2025, to permit ongoing deposition of tailings into Thunderbox TSF Cell C & D and use of associated infrastructure and monitoring equipment. Northern Star plan to construct the next stage (Stage 2) of TSF Cell C & D which comprises a downstream embankment raise in January 2026 (tentative).

Future lift stages (Stages 2-6) were detailed in the original design specification prepared by engineer of record Knight Piésold and were provided to support the W6601 application; however, the Works Approval does not include conditions pertaining to these stages. Whilst L7815does not have a limit on the embankment height, there are no conditions in the licence which would permit construction of a TSF raise. Written correspondence received from DWER on 11 June 2025 confirmed that Northern Star should seek a licence amendment to L7815 facilitating the construction of future stages.

3.2.1.1 TSF Life-of-Mine Assessment

Engineer of record Knight Piésold was recently engaged by Northern Star to prepare a Life-of-Mine (LOM) assessment for Thunderbox TSF which is provided in **Attachment 8B**. The LOM assessment reviewed the disposal requirements for management of tailings at TBO until 2033 based upon the following parameters:

- amendments to tailings throughput;

- estimated achieved in-situ dry tailings densities;
- achieved tailings beach slope; and
- as-built records of existing cells.

In summary, in comparison to the original permitting design the LOM assessment has determined that in-situ dry tailings densities are higher than assumed, tailings beach slope is flatter than assumed, and throughputs between 2021 to 2024 were lower than assumed (Knight Piésold, 2025). Consequently, the LOM assessment has revised the lift heights for future stages as outlined in Table 3-2 below. No changes have been made to Stage 2 (downstream raise) parameters and consequently the overall footprint of the TSF will not change from the original permitting design.

Table 3-2: Thunderbox TSF Cell C & D Stages

Stage	Lift Type	Original Permitting Design		Revised LOM Assessment Design		
		Lift Height (m)	Operating Height (m RL)	Lift Height (m)	Operating Height (m RL)	Change (m)
Stage 1 (constructed)	Starter embankment	10.0	494.1			
Stage 2	Downstream raise	4.1	498.2	4.1	498.2	0
Stage 3	Upstream raise*	2.0	500.2	2.4	500.6	+0.4
Stage 4	Upstream raise*	2.4	502.6	2.4	503.0	+0.4
Stage 5	Upstream raise*	2.4	505.0	1.0	504.0	-1.0
Stage 6	Upstream raise*	0.8	505.8	Not required based upon LOM assessment.		

* Upstream raised against external perimeters. Embankments abutting the Eastern Waste Dump and TSF Cell A & B are downstream raised.

It is noted that these levels are best estimates based upon current information available, and that changes to tailings throughput, in-situ dry tailings densities and beach slope will impact future levels (Knight Piésold, 2025). Detailed issued for construction (IFC) design reports will be prepared by Knight Piésold prior to construction of each stage based upon updated parameters. Should this result in any material changes to lift heights, a subsequent licence amendment application will be sought by Northern Star.

3.2.1.2 Raise Construction

Construction of Stages 2 – 5 of Thunderbox TSF Cell C & D will be undertaken generally in accordance with the original permitting design drawings included in **Attachment 8C** and detailed below:

- General Arrangement – Final (801-296-D3000-115)
- Divider embankment (801-296-D3000-301)
- Embankment raises (801-296-D3000-302)
- Toe drain (801-296-D3000-302)
- Buttress (01-296-D3000-303)
- Underdrainage tower (801-296-D3000-452)
- Decant tower (801-296-D3000-551)
- Piezometer (801-296-D3000-905)

It is noted that the raise heights will vary from the original design as outlined previously in this application, and that construction will be conducted in accordance with IFC designs issued prior to each stage. Where minor deviations occur that do not present material defects from the approved design (i.e. minor variations to RLs), these will be reflected in submitted audit reports.

3.2.1.3 Suggested Licence Text

Suggested licence amendment text has been presented in Table 3-3 below.

Table 3-3: Suggested Licence Text

Infrastructure	Design and construction requirements	Infrastructure location
Thunderbox TSF Cell C & D Stage 2	(a) Embankment lift to 498.2 m RL (b) Divider embankment lift to 498.2 m RL (c) Decant tower raise to 498.2 m RL (d) Underdrainage tower raise to 498.2 m RL (e) Installation of ten new piezometers to replace decommissioned piezometers from Stage 1. (f) Installation of new perimeter toe drain and berm to replace decommissioned toe drain and berm from Stage 1.	TSF Cell C & D as shown in Figure 4 of Schedule 1.
Thunderbox TSF Cell C & D Stage 3	(a) Embankment lift to 500.6 m RL (b) Divider embankment lift to 500.6 m RL (c) Decant tower raise to 500.6 m RL (d) Underdrainage tower raise to 500.6 m RL (e) Installation of ten new piezometers to replace decommissioned piezometers from Stage 2.	TSF Cell C & D as shown in Figure 4 of Schedule 1.
Thunderbox TSF Cell C & D Stage 4	(a) Embankment lift to 503.0 m RL (b) Divider embankment lift to 503.0 m RL (c) Decant tower raise to 503.0 m RL (d) Underdrainage tower raise to 503.0 m RL (e) Installation of ten new piezometers at Stage 4 embankment crest to replace decommissioned piezometers from Stage 3.	TSF Cell C & D as shown in Figure 4 of Schedule 1.
Thunderbox TSF Cell C & D Stage 5	(a) Embankment lift to 504.0 m RL (b) Divider embankment lift to 504.0 m RL (c) Decant tower raise 504.0 m RL (d) Underdrainage tower raise to 504.0 m RL (e) Installation of ten new piezometers at Stage 5 embankment crest to replace decommissioned piezometers from Stage 4.	TSF Cell C & D as shown in Figure 4 of Schedule 1.

4 Emissions & Discharges (Attachment 6A)

Potential emissions / discharges, associated risk pathways and proposed operational controls are summarised in Table 4-1 below, noting many of these controls are existing controls adopted from W6601 and L7815 with no changes.

Table 4-1: Emissions & Discharges

Activity	Potential Emissions / Discharge	Potential Risk Pathways	Controls
Construction			
Clearing, earthworks, mobile plant movements	Fugitive dust	Airborne dispersion.	**Proposed Controls** • Provision of watercarts during construction activities with regular spraying as required to prevent dust liftoff. • Monitoring of wind conditions and ceasing activities during excessive visual dusting towards Goldfields Highway.
	Noise	Airborne dispersion.	No nearby noise sensitive receptors - no specific controls required.
Operation			
Discharge of tailings into TSF	Decant water and / or tailings	Decant pipeline / tailings delivery pipeline rupture or leaks.	**Existing Controls** • Pipelines constructed from HDPE PE100 and installed in accordance with AS4130 and AS413. • Stored in V-drains sufficient to contain spillages between routine inspections. • Fitted with telemetry.
		Overtopping of TSF into surrounding environment.	**Existing Controls / Proposed Controls** • A minimum top of embankment freeboard of 500 mm maintained at all times.*
	Seepage	Seepage through base or walls of TSF into surrounding natural soils / groundwater table.	**Proposed Controls** • Seepage collection and recovery system implemented (decant and underdrainage tower raises). • Seepage is returned to the TSF, or pumped back into the mine water circuit. • Perimeter toe drain to be installed adjacent to downstream embankment (Stage 2) raise to replace existing toe drain. • Seepage recovery bores installed when trigger levels reached (standing water levels rise higher than 6 mbgl). **Existing Controls** • Low permeability compacted soil liner and underdrainage collection system installed. • Diversion drain in place to ensure natural surface water flows are diverted around TSF maintain downstream flows. • Berm positioned between toe drain and diversion drain to prevent mixing of clean and potentially contaminated water. • Cut-off trench installed. • Groundwater monitoring in accordance with licence.
	Dry tailing dusting	Airborne dispersion.	**Proposed Controls** • Capping of tailings and rehabilitation in accordance with approved Mine Closure Plan.

*existing licence condition states *or containment of a 1-in-100 year 72-hour rainfall event (whichever is greater) must be maintained*. This rainfall event is approximately 200 mm which is significantly exceeded by 500 mm and is therefore redundant.

5 Other Approvals and Consultation (Attachment 5)

Northern Star is aware of its obligation to seek approvals and comply with requirements under various Federal and State Legislation in addition to securing this Works Approval. At the time of preparing this document environmental legislation applicable to this application has been summarised in Table 5-1 below.

Table 5-1: Environmental Approvals Summary

Legislation / Regulation	Environmental Aspect(s)	Approval Status
Aboriginal Heritage Act 1972	Aboriginal heritage sites	A heritage survey was completed with representatives of Darlot Group over TSF Cell C & D in 2021. No disturbance to Aboriginal Sites will occur as part of the proposed activities.
Biodiversity Conservation Act 2016 (BC Act)	Threatened flora, fauna and ecological communities	No Threatened flora, fauna or ecological communities within the prescribed premises boundary during surveys - no Section 40 approval is required under BC Act.
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	Matters of national environmental significance	No matters of national environmental significance applicable - no referral required under EPBC Act.
Environmental Protection Act 1986 (Part IV)	Matters of state environmental significance	Not a 'significant proposal' - no triggers for referral under Section 38 of the EP Act.
Environmental Protection (Clearing of Native Vegetation) Regulations 2004	Native vegetation clearing	Clearing permit approved over Thunderbox 10369/1, clearing for downstream embankment raise will be conducted under permit conditions.
Environmental Protection (Noise) Regulations 1997 (Noise Regulations)	Social surroundings	Construction noise management plan not required - no nearby sensitive receptors nearby.
Mining Act 1978	Biodiversity Water resources Land and soils Closure and rehabilitation	Thunderbox TSF Cell C&D is approved for a maximum height of 505.8 m RL in Mining Proposal Reg ID 99935, which is greater than the proposed height of Stage 5 (504.0 m RL)
Native Title Act 1993	Land access	All tenements within the proposed prescribed premises are granted. Northern Star are in progress of negotiating an agreement with Darlot Group Native Title holders across Thunderbox.
Rights in Water and Irrigation Act 1914 (RIWI Act)	Groundwater resources	Thunderbox is covered by several groundwater licences (GWL) with a total abstraction allocation of 9,050,000 kL annually as per below: • GWL 635550 - 6,000,000 kL • GWL 154472 - 1,050,000 kL • GWL 1586766 - 2,000,000 kL

5.1 Stakeholder Engagement

Stakeholder engagement has been ongoing throughout the life of TBO commencing under previous ownership. Northern Star has a dedicated Community & Heritage team to enhance stakeholder outcomes across the business. Northen Star's stakeholder engagement strategy is informed by the principles outlined below.

- **Communication** - Communication must be open, accessible, clearly defined, two-way and appropriate.
- **Transparency** - The process and outcomes of community and stakeholder engagement should, wherever possible, be made open and transparent, agreed upon and documented.
- **Collaboration** - A co-operative and collaborative approach to seek mutually beneficial outcomes is considered key to effective engagement.
- **Inclusiveness** - Inclusiveness involves identifying and involving communities and stakeholders early and throughout the process, in an appropriate manner.
- **Integrity** - Community and stakeholder engagement should establish and foster mutual trust and respect

Key stakeholders to TBO and adopted engagement strategies for each party are summarised in Table 5-2 below, noting that this is subject to change as the project develops over time.

Table 5-2: Stakeholder Engagement Summary

Group	Key Stakeholder	Engagement	Timing
Native Title (Darlot)	Watarra Aboriginal Corporation RNTBC	Organising heritage surveys and clearance prior to any new land disturbance.	Heritage survey of TSF Cell C & D (including Stage 2 clearing footprint) completed in May 2021.
Pastoralist	Weebo Station	Overview of Thunderbox including TSF Cell C & D project.	Completed June 2021.
State Government	DMPE (formerly DEMIRS)	Overview of TBO TSF Cell C & D project.	Completed August 2021.
		Provision of updated Mining Proposal for any change to activities.	Not required - proposed TSF raise height lower than currently approved and no changes to footprint.

5.2 Stakeholder Engagement Register

Northern Star utilise INX InForm as a Stakeholder Engagement Register (SER). The purpose of this SER is to document consultation activities undertaken with all stakeholder groups and individuals, including any comments or concerns raised and follow up actions. The SER is a live database and will continue to document all consultation through the LOM.

6 Siting and Location (Attachment 7)

6.1 TSF Cell C & D

Detailed siting and location information was provided in support of TSF Cell C & D as referenced in the W6601 decision report (DWER 2022). There are no proposed changes to the design of Stage 2 (downstream raise) which has already been risk assessed and determined to have appropriate controls commensurate to the risk. Minor changes to Stages 3 – 5 will not result in any materials changes to the risk profile, as the overall footprint is unchanged and the maximum height has decreased from the original permitting design.

6.2 Environmental Sensitive Receptors Summary

Distances and directions to nearest environmentally sensitive receptors from the prescribed premises boundary have been reviewed as of July 2025 and summarised in Table 6-1 below. Attachment 2B – Sensitive Receptors Summary shows the location of these receptors in relation to TSF Cell C & D.

Table 6-1: Environmentally Sensitive Receptors

Type	Description	Distance and Direction	Proposed Controls	Data Source(s)
Environmentally Sensitive Areas (ESA)	No ESAs are located within TBO. The nearest ESA is associated with Wanjarri Nature Reserve.	70 km north of TBO.	N/A - significant separation.	DWER-046
Threatened Ecological Communities	No known TECs are located within TBO.	75 km west of TBO.	N/A - significant separation.	DWER-038
Threatened and / or Priority fauna	No known Threatened or Priority fauna are located within TBO.	12 km north (database record 91,829)	N/A – no Threatened or Priority fauna likely.	DBCA-037 Botanica (2025)
Threatened and / or Priority flora	No known Threatened flora are located within TBO. *Lysiandra baeckeoides* (P3) are located within the prescribed premises boundary but not within TSF footprint.	2,200 m southwest of TSF (within prescribed premises boundary).	N/A - significant separation.	DBCA-036 Botanica (2025)
Aboriginal and other heritage sites	Registered site 2552 (Leonora – Leinster 23).	1,500 m southeast from TSF (partially within prescribed premises boundary).	N/A - significant separation.	ACHIS 2025
Public drinking water source areas	Leonora Water Reserve is the nearest proclaimed public drinking water source area.	60 km southeast of TBO.	N/A - significant separation.	DWER-033
Rivers, lakes, oceans, and other bodies of surface water, etc.	Ephemeral watercourses traverse the proposed prescribed premises boundary.	300 m east of TSF (within prescribed premises boundary).	As detailed in Table 4-1.	GEODATA TOPO 250K (Geoscience Australia)
Acid sulphate soils	TBO is mapped as having "extremely low probability of occurrence" in the Atlas of Australian Acid Sulphate Soils*	14 km north to nearest natural high probability area.	N/A - significant separation.	CSIRO 2011
Other	Goldfields Highway	200 m from TSF (L7815 premises intersects Goldfields Highway).	As detailed in Table 4-1.	LGATE-195

* Atlas of Australian Acid Sulphate Soils mapping has incorrectly identified TSF Cell A & B as a lake.

7 Works Approval W6601/2021/11 (Attachment 8A)

Works Approval

Works approval number	W6601/2021/1
Works approval holder	Northern Star (Thunderbox) Pty Ltd
ACN	107 154 727
Registered business address	Level 1, 388 Hay Street, PERTH, 6008
DWER file number	DER2021/000505
Duration	3 May 2022 to 3 May 2027
Date of amendment	13/11/2024
Premises details	North Eastern Goldfields Operations Mining tenements: M36/512, M36/582, M36/585

Prescribed premises category description (Schedule 1, *Environmental Protection Regulations 1987*)	Assessed production / design capacity
Category 5: Processing or beneficiation of metallic or non-metallic ore	7,000,000 tonnes per annum

This works approval is granted to the works approval holder, subject to the attached conditions, on 13 November 2024, by:

[redacted]

Works approval history

Date	Reference number	Summary of changes
3/05/2022	W6601/1/2021	Construction of Cells C and D of Thunderbox TSF
13/11/2024	W6601/1/2021	Extension of time limited operations

Interpretation

In this works approval:

(a) the words 'including', 'includes' and 'include' in conditions mean "including but not limited to", and similar, as appropriate;

(b) where any word or phrase is given a defined meaning, any other part of speech or other grammatical form of that word or phrase has a corresponding meaning;

(c) where tables are used in a condition, each row in a table constitutes a separate condition;

(d) any reference to an Australian or other standard, guideline, or code of practice in this works approval:

  (i) if dated, refers to that particular version; and

  (ii) if not dated, refers to the latest version and therefore may be subject to change over time;

(e) unless specified otherwise, any reference to a section of an Act refers to that section of the EP Act; and

(f) unless specified otherwise, all definitions are in accordance with the EP Act.

NOTE: This works approval requires specific conditions to be met but does not provide any implied authorisation for other emissions, discharges, or activities not specified in this works approval.

Works approval conditions

The works approval holder must ensure that the following conditions are complied with:

Construction phase

Infrastructure and equipment

1. The works approval holder must:

   (a) construct the critical containment infrastructure;

   (b) in accordance with the corresponding design and construction requirements; and

   (c) at the corresponding infrastructure location;

   as set out in Table 1.

Table 1: Critical containment infrastructure design and construction requirements

	Infrastructure	Design and construction requirements	Infrastructure location
1.	Tailing Storage Facilities - Cells C and D	Seepage control and underdrainage system consisting of: • A low permeability clay/soil liner of at least 6 x 10-7 m/s permeability. • Cut-off trench; • Embankment upstream toe drain; • Basin underdrainage collection system; • Underdrainage collection tower; • Low permeability basin liner; and • External toe drain • A diversion drain sized 6m wide by 1 m deep, with a side slope of 2H:1V • A berm positioned between the external toe drain and the diversion drain 1m high by 6m wide.	Underdrainage layout – as depicted in Schedule 1, Figure 2 Cut off trench and upstream toe drain details - as depicted in Schedule 1, Figure 3 and Figure 4. External toe drain, berm and diversion drain – as depicted in Schedule 1, Figure 4 and Figure 5
2.	Pipelines carrying tailings and decant return water	• Constructed from HDPE PE100 and installed in accordance with AS4130 and AS413, and the Plastics Industry Pipe Association of Australia Limited (PIPA) Guideline POP003. • Stored in V-drains sufficient to contain spillages between routine inspections. • Fitted with telemetry (the Citect processing plant control system) which monitors pressure.	

2. The works approval holder must design, construct, and install groundwater monitoring wells in accordance with the requirements specified in Table 2.

Table 2: Infrastructure requirements – groundwater monitoring wells

Infrastructure	Design, construction, and installation requirements	Monitoring well location(s)	Timeframe
Groundwater monitoring wells TSF-CD-01, TSF-CD-02 TSF-CD-03 TSF-CD-04	<u>Well design and construction:</u> Designed and constructed in accordance with *ASTM D5092/D5092M-16: Standard practice for design and installation of groundwater monitoring bores.* Well screens must target the part, or parts, of the aquifer most likely to be affected by contamination[1]. Where temporary/seasonal perched features are present, wells must be nested, and the perched features individually screened.	As depicted in Schedule 1, Figure 1.	Must be constructed, developed (purged), and determined to be operational by no later than 14 calendar days prior to discharge of tailings to TSF Cell C and Cell D.
	<u>Logging of borehole:</u> Soil samples must be collected and logged during the installation of the monitoring wells. A record of the geology encountered during drilling must be described and classified in accordance with the Australian Standard Geotechnical Site Investigations AS1726. Any observations of staining / odours or other indications of contamination must be included in the bore log.		
	<u>Well construction log:</u> Well construction details must be documented within a well construction log to demonstrate compliance with *ASTM D5092/D5092M-16*. The construction logs shall include elevations of the top of casing position to be used as the reference point for water-level measurements, and the elevations of the ground surface protective installations.		
	<u>Well development:</u> All installed monitoring wells must be developed after drilling to remove fine sand, silt, clay and any drilling mud residues from around the well screen to ensure the hydraulic functioning of the well. A detailed record should be kept of well development activities and included in the well construction log.		
	<u>Installation survey:</u> the vertical (top of casing) and horizontal position of each monitoring well must be surveyed and subsequently mapped by a suitably qualified surveyor.		
	<u>Well network map:</u> a well location map (using aerial image overlay) must be prepared and include the location of all monitoring wells in the monitoring network and their respective identification numbers.		

Note 1: refer to Section 8 of Schedule B2 of the *Assessment of Site Contamination NEPM* for guidance on well screen depth and length.

3. The works approval holder must, within 60 calendar days of the monitoring wells being constructed, submit to the CEO a well construction report evidencing compliance with the requirements of condition 2.

4. The Licence Holder shall ensure that prior to, and during any disturbance to the 'affected area', as denoted by Figure 6 in Schedule 1, the area is continually wetted using water sprays, dribble bars or other suitable methods to ensure there is no visible windblown dust.

5. The licence holder must ensure that no visible dust generated from the construction activities crosses the boundary of the premises.

Compliance reporting

6. The works approval holder must within 30 calendar days of the Critical Containment Infrastructure identified by condition 1 being constructed:

   (a) undertake an audit of their compliance with the requirements of condition 1; and

   (b) prepare and submit to the CEO a Critical Containment Infrastructure Report on that compliance.

7. The Critical Containment Infrastructure Report required by condition 6 must include as a minimum the following:

   (a) certification by a suitably qualified geotechnical engineer that each item of critical containment infrastructure or component thereof, as specified in condition 1, has been built and installed in accordance with the requirements specified in condition 1;

   (b) as constructed plans and a detailed site plan showing the location and dimensions for each item of critical containment infrastructure or component thereof, as specified in condition 1;

   (c) photographic evidence of the installation of the infrastructure;

   (d) be signed by a person authorised to represent the works approval holder and contains the printed name and position of that person;

   (e) monitoring data indicating the baseline ambient environmental conditions at the premises prior to and immediately following construction of the items of infrastructure.

8. The monitoring of the baseline ambient environmental conditions required under condition 7(e) must

   (a) be undertaken in accordance with Table 3;

   (b) all sample analysis must be undertaken by laboratories with current accreditation from the National Association of Testing Authorities (NATA) for the relevant parameters.

Table 3: Determination of baseline ambient environmental conditions

Parameter	Monitoring location	Unit	Frequency	Averaging period	Method
					Sampling
pH[1]	Groundwater monitoring wells	-	No later than 7 calendar	Spot sample	In accordance with AS/NZS 5667.11
SWL		mbgl			

Parameter	Monitoring location	Unit	Frequency	Averaging period	Method
					Sampling
TDS	TSF-CD-01, TSF-CD-02 TSF-CD-03 TSF-CD-04	mg/L	days prior to discharge of tailings to TSF Cell C and Cell D.		
Weak acid dissociable cyanide (WAD CN)					
Total cyanide (CN)					
Arsenic (As)					
Antimony (Sb)					
Bicarbonate (HCO_3)					
Calcium (Ca)					
Carbonate (CO_3)					
Cadmium (Cd)					
Chloride (Cl)					
Chromium (Cr)					
Cobalt (Co)					
Copper (Cu)					
Iron (Fe)					
Lead (Pb)					
Magnesium (Mg)					
Manganese (Mn)					
Mercury (Hg)					
Molybdenum (Mo)					
Nickel (Ni)					
Nitrate (NO_3)					
Potassium (K)					
Selenium (Se)					
Sodium (Na)					
Sulphate (SO_4)					
Thallium (Tl)					
Zinc					

Note 1: In-field non-NATA accredited analysis permitted.

Time limited operations phase

Commencement and duration

9. The works approval holder may only commence time limited operations for an item of critical containment infrastructure identified in condition 1:

(a) where the CEO has notified the works approval holder that the Critical Containment Infrastructure Report for that item of infrastructure as required by condition 6 meets the requirements of that condition; or

(b) where at least 10 business days have passed after the Critical Containment Infrastructure Report for that item of infrastructure as required by condition 6 has been submitted to the CEO.

Time limited operations requirements and emission limits

10. The works approval holder may conduct time limited operations for an item of infrastructure specified in condition 11 (as applicable):

(a) for a period not exceeding 270 calendar days from the day the works approval holder meets the requirements of condition 9 for that item of infrastructure; or

(b) until such time as a licence for that item of infrastructure is granted in accordance with Part V of the *Environmental Protection Act 1986*, if one is granted before the end of the period specified in condition 10(a).

11. During time limited operations, the works approval holder must ensure that the premises infrastructure and equipment listed in Table 4 and located at the corresponding infrastructure location is maintained and operated in accordance with the corresponding operational requirement set out in Table 4.

Table 4: Infrastructure and equipment requirements during time limited operations

	Site infrastructure and equipment	Operational requirement	Infrastructure location
1.	TSF Cell C and Cell D	• Low points are filled, and a beach is established in each cell to allow for efficient recovery of decant water within 16 weeks of commencing discharge to the TSF. • A minimum freeboard of 500mm from top of embankment. • Inspection of TSF at least twice per 12-hour shift.	As depicted in Figure 1, Schedule 1
2.	Pipelines carrying tailings and decant return water	Inspection of pipelines at least twice per 12-hour shift.	

12. The Licence Holder shall ensure that prior to, and during any disturbance to the following TSF components, these areas are continually wetted using water sprays, dribble bars or other suitable methods to ensure there is no visible windblown dust:

(a) The surface of the TSF

(b) The onsite roadways in the immediate vicinity of the TSF

(c) TSF embankments

(d) The 'TSF affected area', as denoted by Figure 6 in Schedule 1.

Monitoring during time limited operations

13. The works approval holder must:

(a) monitor the groundwater during time limited operations for concentrations of the identified parameters in accordance with Table 5.

(b) all sample analysis must be undertaken by laboratories with current accreditation from the National Association of Testing Authorities (NATA) for the relevant parameters.

Table 5: Monitoring of ambient concentrations during time limited operations

Parameter	Monitoring location	Unit	Frequency	Averaging period	Method
					Sampling
pH[1]		-	Quarterly	Spot sample	In accordance with AS/NZS 5667.11
SWL		mbgl			
TDS		mg/L			
Weak acid dissociable cyanide (WAD CN)					
Total cyanide (CN)					
Arsenic (As)					
Antimony (Sb)	Groundwater monitoring wells TSF-CD-01, TSF-CD-02 TSF-CD-03 TSF-CD-04	mg/L	Six monthly or at least once prior to the end of the limited time operations period.	Spot sample	In accordance with AS/NZS 5667.11
Bicarbonate (HCO_3)					
Calcium (Ca)					
Carbonate (CO_3)					
Cadmium (Cd)					
Chloride (Cl)					
Chromium (Cr)					
Cobalt (Co)					
Copper (Cu)					
Iron (Fe)					
Lead (Pb)					
Magnesium (Mg)					
Manganese (Mn)					
Mercury (Hg)					
Molybdenum (Mo)					
Nickel (Ni)					
Nitrate (NO_3)					
Potassium (K)					
Selenium (Se)					
Sodium (Na)					
Sulphate (SO_4)					
Thallium (Tl)					

Parameter	Monitoring location	Unit	Frequency	Averaging period	Method
					Sampling
Zinc					
Weak acid dissociable cyanide (WAD CN)	Decant	mg/L	Quarterly	Spot sample	In accordance with AS/NZS 5667.11
Arsenic (As)					

Note 1: In-field non-NATA accredited analysis permitted.

14. The works approval holder must record the results of all monitoring activity required by condition 13.

Compliance reporting

15. The works approval holder must submit to the CEO a report on the time limited operations within 60 calendar days of the completion date of time limited operations or 60 calendar days before the expiration date of the works approval, whichever is the sooner.

16. The works approval holder must ensure the report required by condition 15 includes the following:

(a) a summary of the time limited operations, including timeframes and amount of tailings discharged;

(b) a summary of groundwater monitoring results obtained during time limited operations under condition 13.

(c) a review of performance and compliance against the conditions of the works approval; and

(d) where the manufacturer's design specifications and the conditions of this works approval have not been met, what measures will the works approval holder take to meet them, and what timeframes will be required to implement those measures.

Records and reporting (general)

17. The works approval holder must record the following information in relation to complaints received by the works approval holder (whether received directly from a complainant or forwarded to them by the Department or another party) about any alleged emissions from the premises:

(a) the name and contact details of the complainant, (if provided);

(b) the time and date of the complaint;

(c) the complete details of the complaint and any other concerns or other issues raised; and

(d) the complete details and dates of any action taken by the works approval holder to investigate or respond to any complaint.

18. The works approval holder must maintain accurate and auditable books including the following records, information, reports, and data required by this works approval:

(a) the works conducted in accordance with condition 1;

(b) any maintenance of infrastructure that is performed in the course of complying with condition 11;

(c) monitoring programmes undertaken in accordance with conditions 8 and 13; and

(d) complaints received under condition 17.

19. The books specified under condition 18 must:

(a) be legible;

(b) if amended, be amended in such a way that the original version(s) and any subsequent amendments remain legible and are capable of retrieval;

(c) be retained by the works approval holder for the duration of the works approval; and

(d) be available to be produced to an inspector or the CEO as required.

Definitions

In this works approval, the terms in Table 1 have the meanings defined.

Table 1: Definitions

Term	Definition
AS/NZS 5667.11	means the Australian Standard *AS/NZS 5667.11 Water quality - sampling - guidance on sampling groundwater*.
books	has the same meaning given to that term under the EP Act.
CEO	means Chief Executive Officer. CEO for the purposes of notification means: Director General Department administering the *Environmental Protection Act 1986* Locked Bag 10 Joondalup DC WA 6919 info@dwer.wa.gov.au
critical containment infrastructure	means the items of infrastructure listed in condition 1.
Critical Containment Infrastructure Report	means a report to satisfy the CEO that works of critical containment infrastructure have been constructed in accordance with the works approval.
Department	means the department established under section 35 of the *Public Sector Management Act 1994* and designated as responsible for the administration of Part V Division 3 of the EP Act.
discharge	has the same meaning given to that term under the EP Act.
emission	has the same meaning given to that term under the EP Act.
Environmental Compliance Report	means a report to satisfy the CEO that the conditioned infrastructure and/or equipment has been constructed and/or installed in accordance with the works approval.
EP Act	*Environmental Protection Act 1986* (WA).
mg/l	Milligrams per litre
mbgl	Metres below ground level
EP Regulations	*Environmental Protection Regulations 1987* (WA).
Quarterly	means the 4 inclusive periods from 1 April to 30 June, 1 July to 30 September, 1 October to 31 December and in the following year, 1 January to 31 March.

Term	Definition
premises	the premises to which this licence applies, as specified at the front of this licence and as shown on the premises map in Schedule 1 to this works approval.
prescribed premises	has the same meaning given to that term under the EP Act.
Six monthly	means the two inclusive periods 1 October to 31 March and 1 April to 30 September
suitably qualified geotechnical engineer	means a person who: a) holds a Bachelor of Engineering recognised by the Australian Institute of Engineers; and b) has a minimum of five years of experience working in geotechnical engineering including experience in the design of tailings storage facilities.
SWL	Standing water level
time limited operations	refers to the operation of the infrastructure and equipment identified under this works approval that is authorised for that purpose, subject to the relevant conditions.
TSF	Tailings storage facility
works approval	refers to this document, which evidences the grant of the works approval by the CEO under section 54 of the EP Act, subject to the conditions.
works approval holder	refers to the occupier of the premises being the person to whom this works approval has been granted, as specified at the front of this works approval.

END OF CONDITIONS

Schedule 1: Maps

Premises map

The boundary of the prescribed premises is shown in the map below (Figure 1).

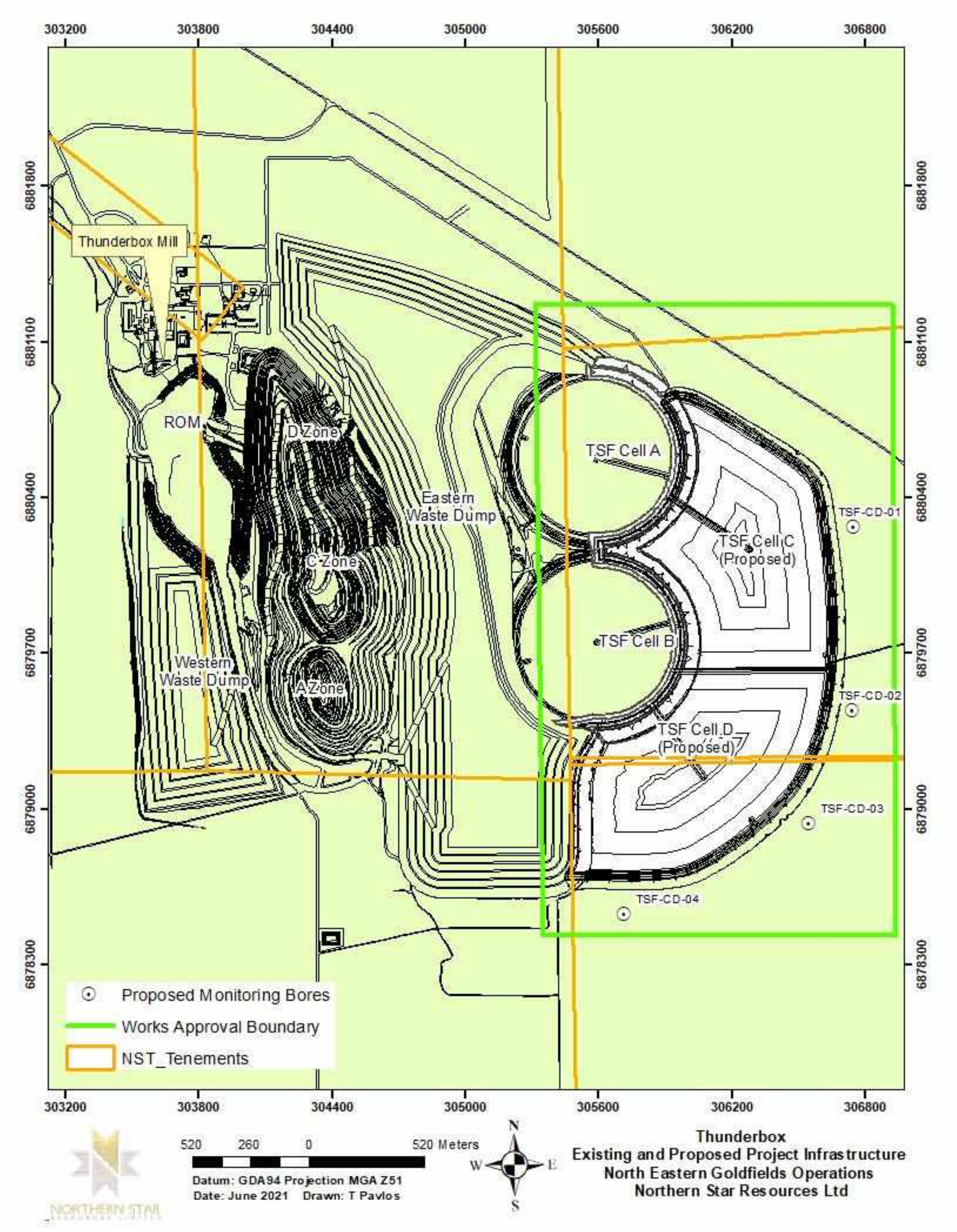


Figure 1: Map of the boundary of the prescribed premises

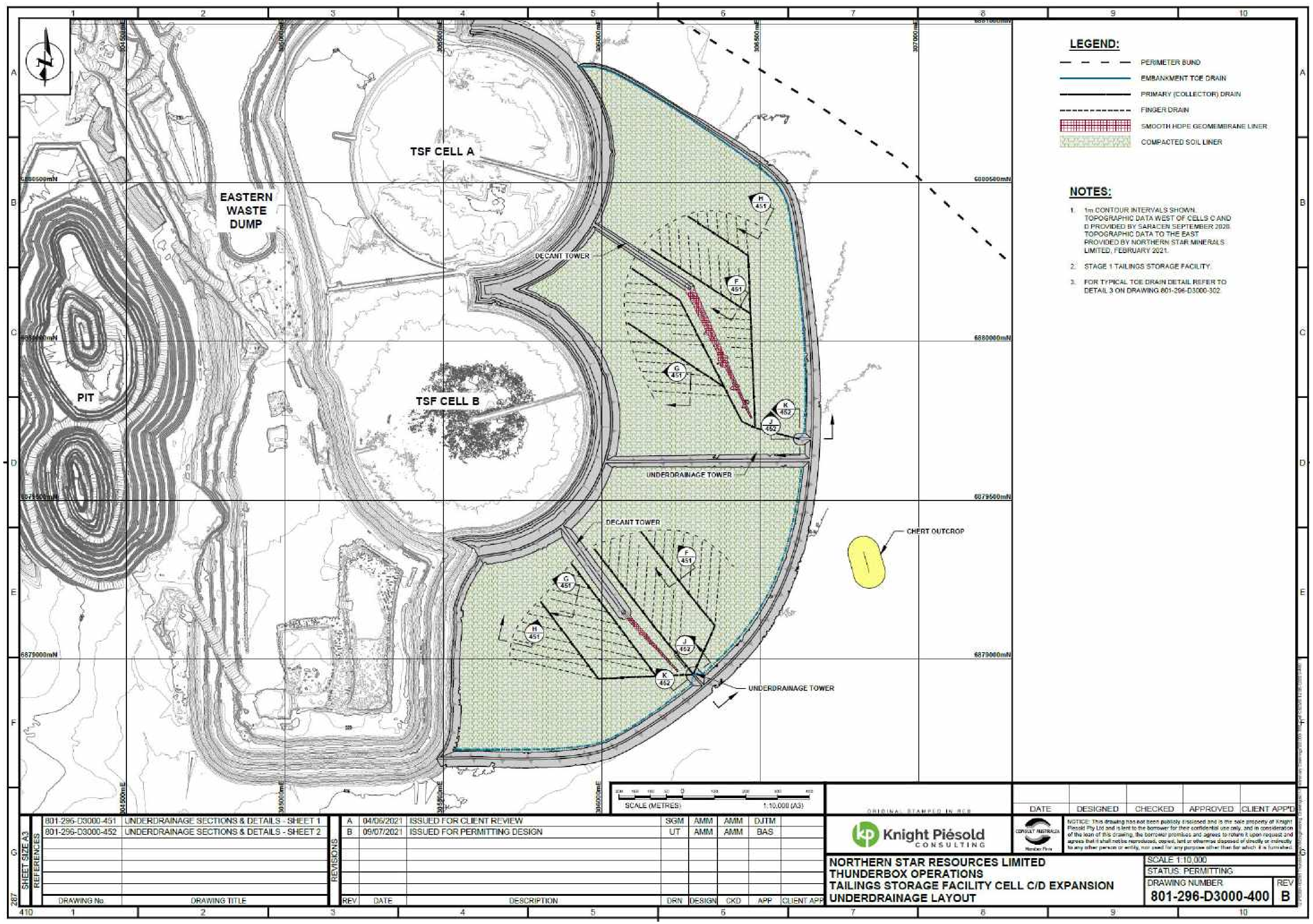


Figure 2: Underdrainage layout

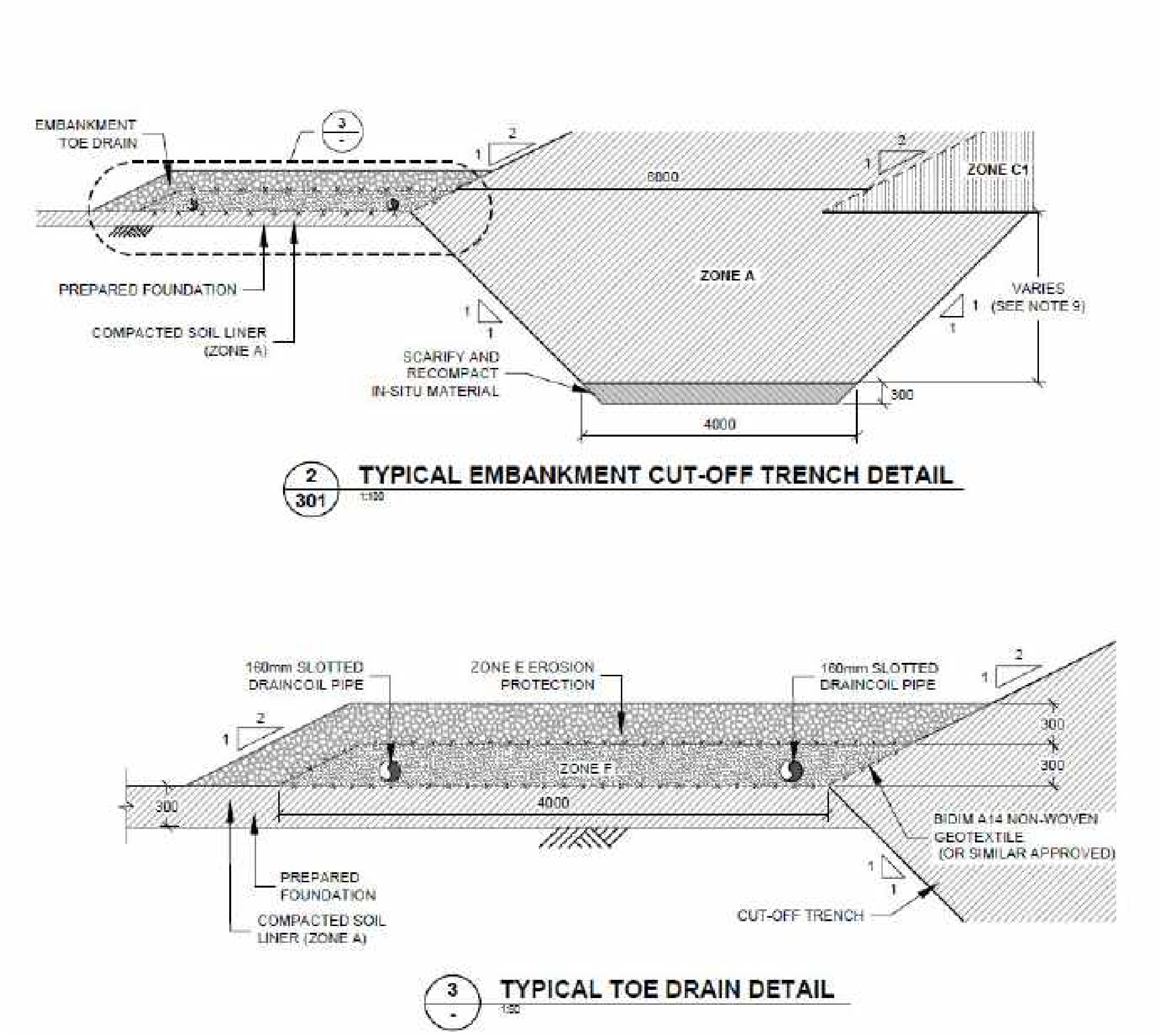


Figure 3: Cut off trench and toe drain details

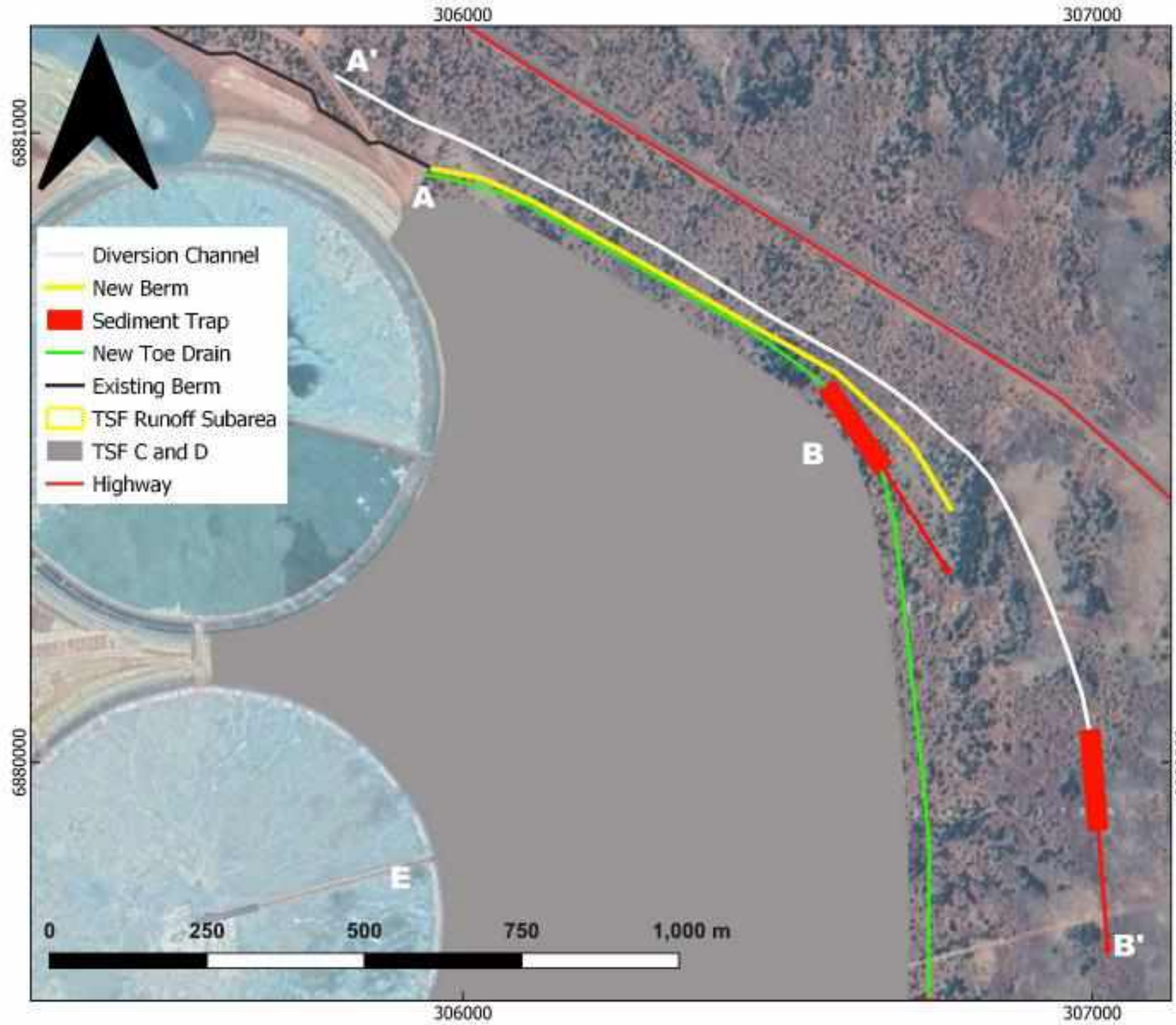


Figure 4: Positions of external toe drain, berm and diversion channel

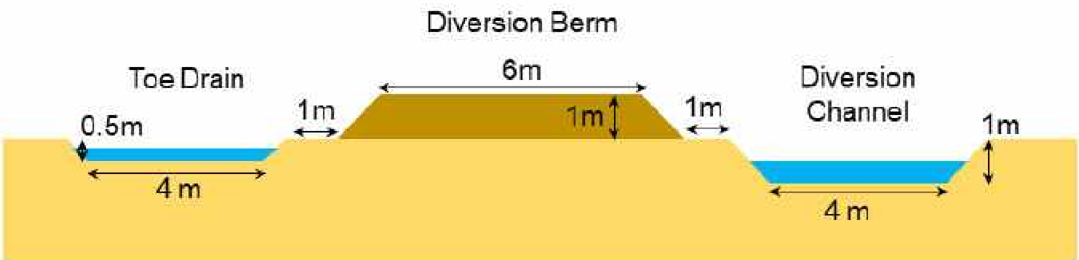


Figure 5: Schematic of toe drain, berm and diversion channel

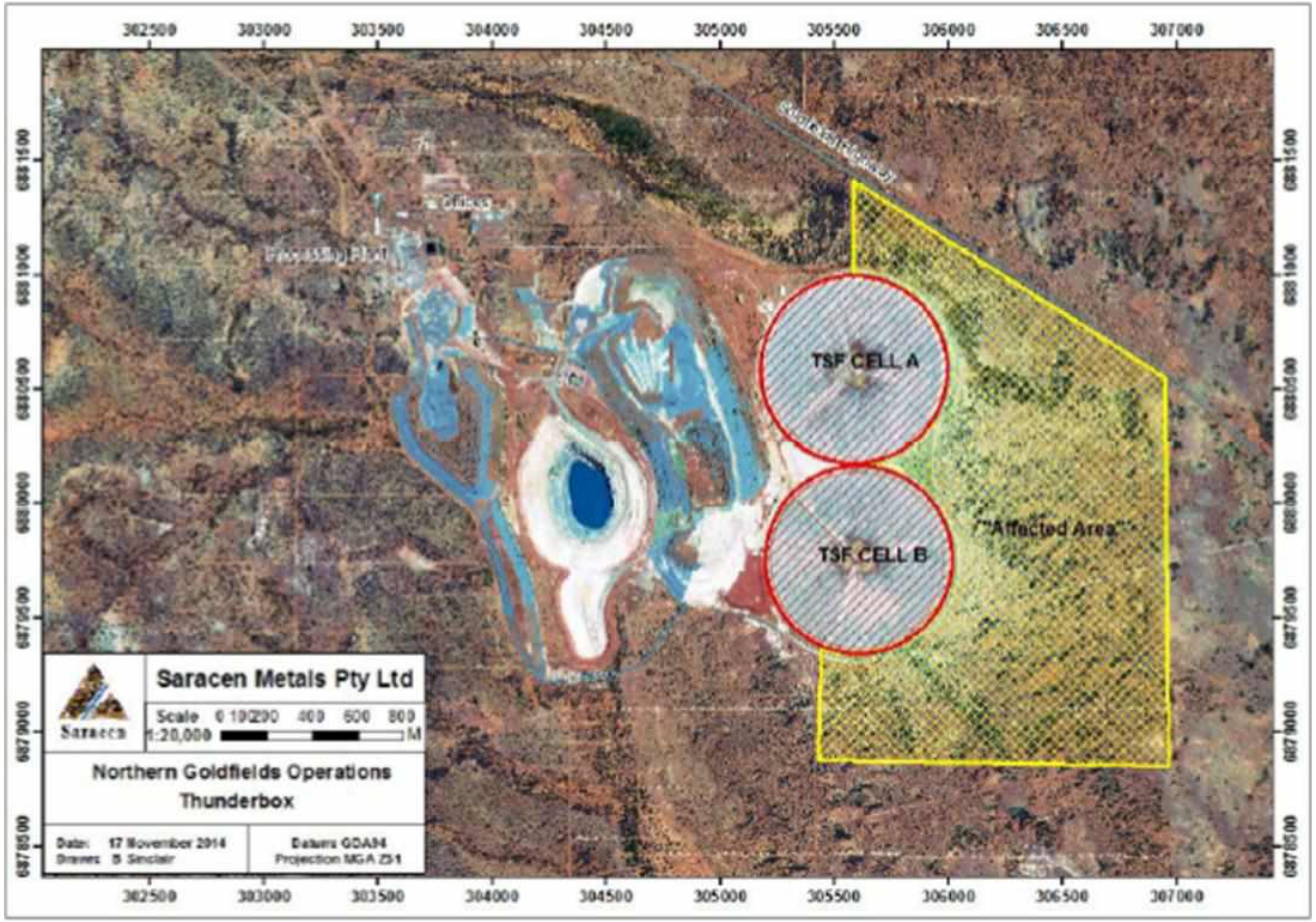


Figure 6: TSF Cell A and Cell B and Affected Area

8 Thunderbox TSF Life of Mine Assessment (Attachment 8B)

MEMORANDUM

To:	Northern Star Resources Limited	Date:	28 July 2025
[redacted]		Our Ref:	PE25-00885
		KP File Ref.:	PE801-00296/52-A djtm M25005
		From:	[redacted]

RE: THUNDERBOX GOLD PROJECT – TAILINGS STORAGE FACILITY LIFE OF MINE ASSESSMENT

1. INTRODUCTION

As requested by Northern Star Resources, please find herein a Life of Mine (LOM) assessment of the Thunderbox Gold Project (Thunderbox) tailings storage facility (TSF).

The Thunderbox TSF comprises four cells, Cell A, Cell B, Cell C and Cell D, and occupies an area of approximately 301 ha. The historical development of the TSF is summarised below in Table 1.1.

Table 1.1: TSF historical development sequence

Stage	Cell A		Cell B		Cell C		Cell D	
	Crest mRL	Completed	Crest mRL	Completed	Crest mRL	Completed	Crest mRL	Completed
1	497.0	Oct 2002	493.5	Oct 2002	494.1	Nov 2023	494.1	Nov 2023
2	499.5	Jul 2003	496.0	Sept 2003				
3	502.0	Oct 2004	498.5	Oct 2005				
4	504.5	Nov 2006	501.0	Mar 2007				
5	507.0	Mar 2016	503.5	Apr 2017				
6	509.7	Apr 2018						
6a	503.5	Dec 2018	503.5	Jan 2019				
7	506.0	May 2019	506.0	May 2019				
8	508.8	Mar 2020	508.8	Aug 2020				
9	511.4	Jan 2021	511.4	Dec 2021				
10	514.6	Nov 2022	514.6	Jun 2023				
11	516.7	Ongoing	516.7	Ongoing				

Cell C and Cell D Stage 1 are currently in operation and are forecast to reach capacity in Q2/Q3 2026, after which deposition will be relocated to Cell A and Cell B Stage 11.

2. PERMITTING DESIGN

A permitting design was completed for Cell A and Cell B in October 2021 (Ref. 1), and Cell C and Cell D in July 2021 (Ref. 2). The levels determined as part of these designs are summarised below in tables 2.1 and 2.2.

Table 2.1: Permitted design levels (Cell A and Cell B)

Stage	Storage Capacity (Months)	Storage Capacity (Mt)	Storage Capacity (Mm^3)	Permitted Level (mRL)
10	12	4.76	3.53	514.6
11	8	3.21	2.38	516.7
Total	**20**	**7.97**	**5.91**	**516.7**

Note: Storage capacity based on throughputs and other information available at the time of design.

Table 2.2: Permitted design levels (Cell C and Cell D)

Stage	Stage Storage Capacity (Months)	Total Storage Capacity (Mt)	Storage Capacity (Mm^3)	Permitted Level (mRL)
1	24	9.5	6.15	494.1
2	24	9.5	6.08	498.2
3	12	4.9	3.18	500.2
4	12	5.8	3.75	502.6
5	12	6.0	3.87	505.0
6	4	2.0	1.29	505.8
Total	**88**	**37.70**	**24.32**	**505.8**

Note: Storage capacity based on throughputs and other information available at the time of design.

3. LIFE OF MINE

3.1 GENERAL

As requested by NSR an update to the forecast levels was completed to reflect the following:

- Amendments to the tailing's throughput.
- Estimated achieved in-situ dry tailings densities.
- Achieved beach slope estimated from capacity reviews.
- As Built records for the existing cells.

The revised stage storages for each of the cells are provided in figures 3.1 and 3.2. The differences between the designs are summarised in the sections below.

3.2 THROUGHPUT

A comparison between the density used in the permitting design and the revised basis is summarised below in Table 3.1. The throughputs are shown in figures 3.3 to 3.5.

Table 3.1: Throughput comparison

Financial Year	Revised Basis			Permitting Basis		
	To TSF (Mt)	Paste Backfill (Mt)	Total (Mt)	To TSF (Mt)	Paste Backfill (Mt)	Total (Mt)
2021	2.88	0.04	2.92	2.95	0.05	3.00
2022	2.52	0.53	3.05	2.15	0.85	3.00
2023	3.28	0.56	3.84	4.75	1.04	5.79
2024	4.82[3]	0.89[3]	5.71[3]	4.85	1.15	6.00
2025	6.06	0.83	6.89	4.86	1.14	6.00
2026	4.97	1.33	6.30	4.97	1.03	6.00
2027	5.29	1.04	6.34	5.35	0.65	6.00
2028	5.56	0.97	6.53	5.75	0.25	6.00
2029	6.00	0.55	6.55	6.00	-	6.00
2030	5.74	0.79	6.53	6.00	-	6.00
2031	6.11	0.42	6.53	6.00	-	6.00
2032	5.72	0.27	5.99	-	-	-
2033	3.23	-	3.23	-	-	-
Total	**62.18**	**8.22**	**70.41**	**53.63**	**6.16**	**59.79**

Note:
1 – Throughputs provided by NSR during the design.
2 – Red values represent actual throughput recorded to the TSF as provided by NSR.
3 – No accurate record provided by NSR.

Total Tonnage (Paste and Tailings to TSF):

From FY2025 onwards the total throughput (paste and tailings reporting to the TSF) for the revised schedule is higher than the permitting design. The total tonnage (paste and tailings reporting to the TSF) for the revised schedule is also higher than the permitting design.

Tailings to the TSF:

The throughput reporting to the TSF in the revised schedule is similar to the permitting design, however the total tonnage is higher for the revised schedule. The duration of deposition has also increased to allow for the increased total tonnage. Assuming that the beach slope and in-situ tailings density are unchanged then the embankment levels will increase, due to the higher total tonnage.

Paste tailings:

The throughput of paste tailings is similar between the revised schedule and the permitting design; however, the paste life has extended resulting in a higher overall paste tailings tonnage.

3.3 DENSITY

A comparison between the density used in the permitting design and the revised basis is summarised below in Table 3.2.

Table 3.2: Density comparison

Cell	Measured Value (t/m^3)	Permitting Design (t/m^3)
A	1.37	1.35
B	1.37	1.35
C	1.61	1.55
D	1.61	1.55

Note: Density based on capacity reviews completed for the existing facility to reflect actual conditions.

The revised in-situ tailings dry density has improved from the permitting design basis; therefore, the existing facilities will have more storage capacity which will extend the estimated filling date for the facility. The increased densities will assist in reducing the final embankment height required for the Thunderbox TSF.

3.4 BEACH SLOPE

A comparison between the density used in the permitting design and the revised basis is summarised below in Table 3.3.

Table 3.3: Beach slope comparison

Cell	Measured Value (_H:1V)	Permitting Design (_H:1V)
A	150	125
B	150	125
C	150	100
D	150	100

Note: Beach slopes based on capacity reviews completed for the existing facility to reflect actual conditions.

The tailings beach slope is flatter in the revised design compared with the permitting design. The tailings beach slope assumptions have been based on the available beach surveys at the time of design to inform the beach slope used in design. The tailings beach slope is impacted by many factors such as throughput, grind size, percent solids, ore type and ore weathering therefore changes to the achieved beach slope are possible. Regular capacity reviews are recommended to ensure that any changes to beach slope are captured in design and raise planning.

The flatter beach slope has increased the tailings storage capacity which has extended the filling date. It is noted that the stormwater capacity has reduced due to the flatter beach slope, which has been considered in current raise designs. The flatter beach slope will assist in reducing the final embankment height required for the Thunderbox TSF.

3.5 AS BUILT CAPACITY

Following the construction of Cell C and Cell D Stage 1 a capacity assessment was completed using the as-built survey which indicated a 0.7 Mm^3 (+11%) increase to storage capacity from design (Ref. 3).

The improvement in storage capacity was due to clearing, grubbing, topsoil removal and borrowing from within the TSF basin, which has increased the storage capacity. The increase in the Stage 1 storage capacity will help lower the overall embankment levels.

3.6 REVISED LEVELS

A summary of the permitting design levels presented in the reports (Ref. 1 and 2) compared with the current estimated levels are provided below in tables 3.4 and 3.5.

Table 3.4: Permitted design levels (Cell A and Cell B)

Stage	Current Design Estimate (mRL)	Permitted Level (mRL)	Change (m)
10	514.6	514.6	-
11	516.7	516.7	-
12	518.7*	*	-
13	520.7*		-
14	522.8*		-

Note: *No permitting design completed for stages 12+.

Table 3.5: Permitted design levels (Cell C and Cell D)

Stage	Current Design Estimate (mRL)	Permitted Level (mRL)	Change (m)
1	494.1	494.1	-
2	498.2	498.2	-
3	500.6	500.2	+0.4
4	503.0	502.6	+0.4
5	504.0	505.0	-1.0
6	-	505.8	-1.8

It is noted that these levels should be considered indicative, as changes to throughput, tailings densities and beach slope will impact the future levels. A detailed design report will be prepared for all future levels based on the best available information at the time, which will estimate the required level for each raise.

Cell A and Cell B:

The Cell A and Cell B embankment levels are the same as the permitting design levels. A permitting design should be completed for Cell A and Cell B, and submitted to the regulator for approval to allow the construction of stages 12, 13 and 14.

Cell C and Cell D:

The revised estimate for the Stage 1 and Stage 2 Cell C and Cell D embankment levels are the same as the permitting design. Stage 3 and Stage 4 are slightly higher (+0.4 m). Stage 5 is lower (-1.0 m) than the permitting design as the overall density achieved in the facility is improved and a flatter beach slope has increased the tailings storage capacity. Stage 6 is no longer required based on the revised estimates, and the final level is 1.8 m lower than the permitting design basis, due to higher in situ dry density, flatter beach slope and increased storage capacity.

4. CONCLUSIONS

The following conclusions are drawn from the above assessment:

i. The throughput reporting to the TSF in the revised schedule is similar to the permitting design, however the total tonnage is higher for the revised schedule. The duration of the processing schedule has also extended compared with the permitting design.
ii. The measured in-situ tailings dry density has improved which has assisted in lowering the final TSF embankment level.
iii. The measured beach slope has flattened which has assisted in lowering the final TSF embankment level.
iv. The Cell C and Cell D Stage 1 storage capacity is higher than the permitting design which has assisted in lowering the ultimate embankment level.
v. The forecast Thunderbox TSF levels are similar to the permitting designs submitted previously. The main differences are associated with updates to account for changes in the observed in-situ tailings density, beach slope, revised throughput and total tonnage.
vi. The Cell A and Cell B embankment levels are the same as the permitting design levels. A permitting design should be completed for Cell A and Cell B, and submitted to the regulator for approval to allow the construction of stages 12, 13 and 14.
vii. The revised estimate for the Stage 1 and Stage 2 Cell C and Cell D embankment levels are the same as the permitting design. Stage 3 and Stage 4 are slightly higher (+0.4 m) and Stage 5 is lower (-1.0 m) than the permitting design. Stage 6 is no longer required based on the revised estimates and the ultimate level is 1.8 m lower.

We trust that this is sufficient for your current requirements, should you require additional information or have questions please contact us.

[redacted]

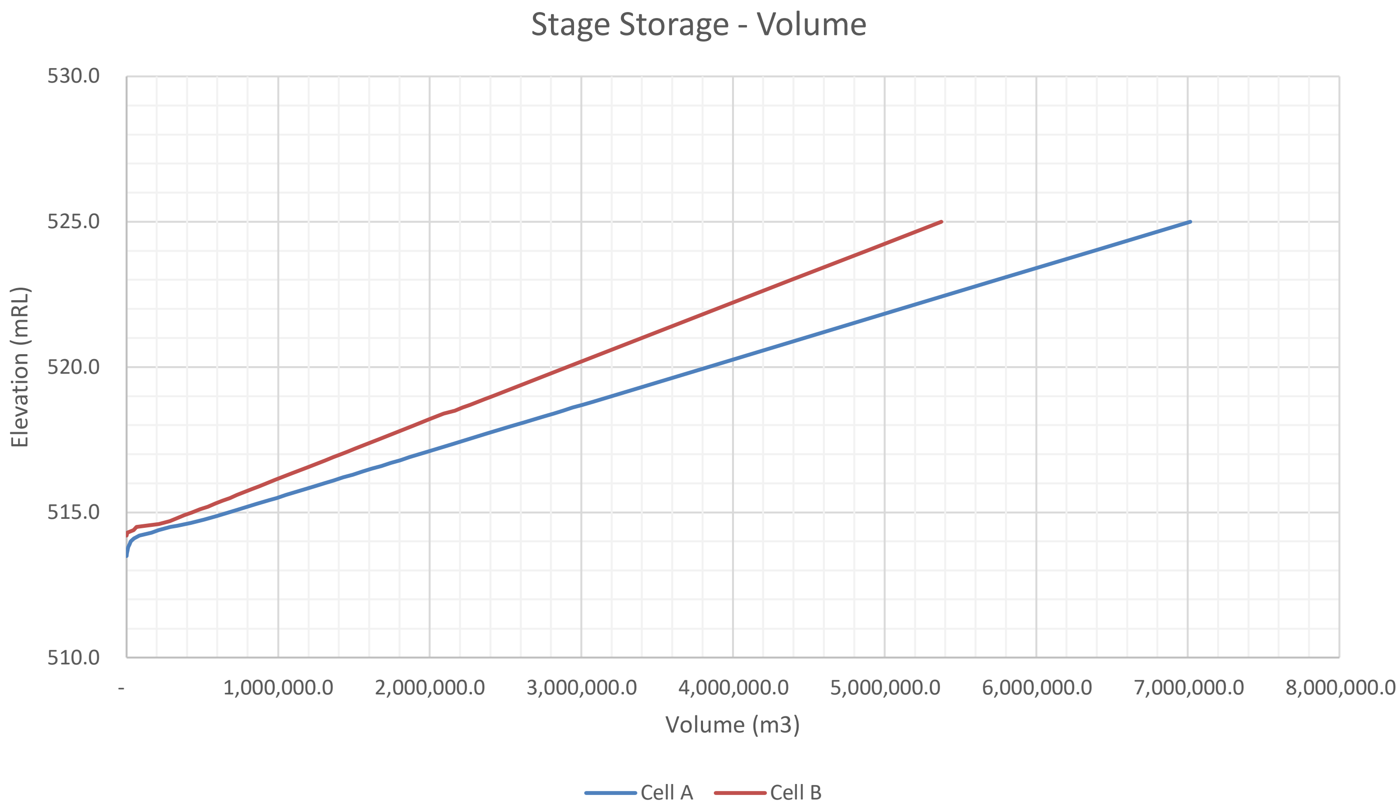
REFERENCES

1. Knight Piésold Report. Ref PE801-00296/22, "*Thunderbox Gold Mine – Tailings Storage Facility Expansion Cell A and Cell B Stages 10 and 11 Final Design*", Rev 0, October 2021.

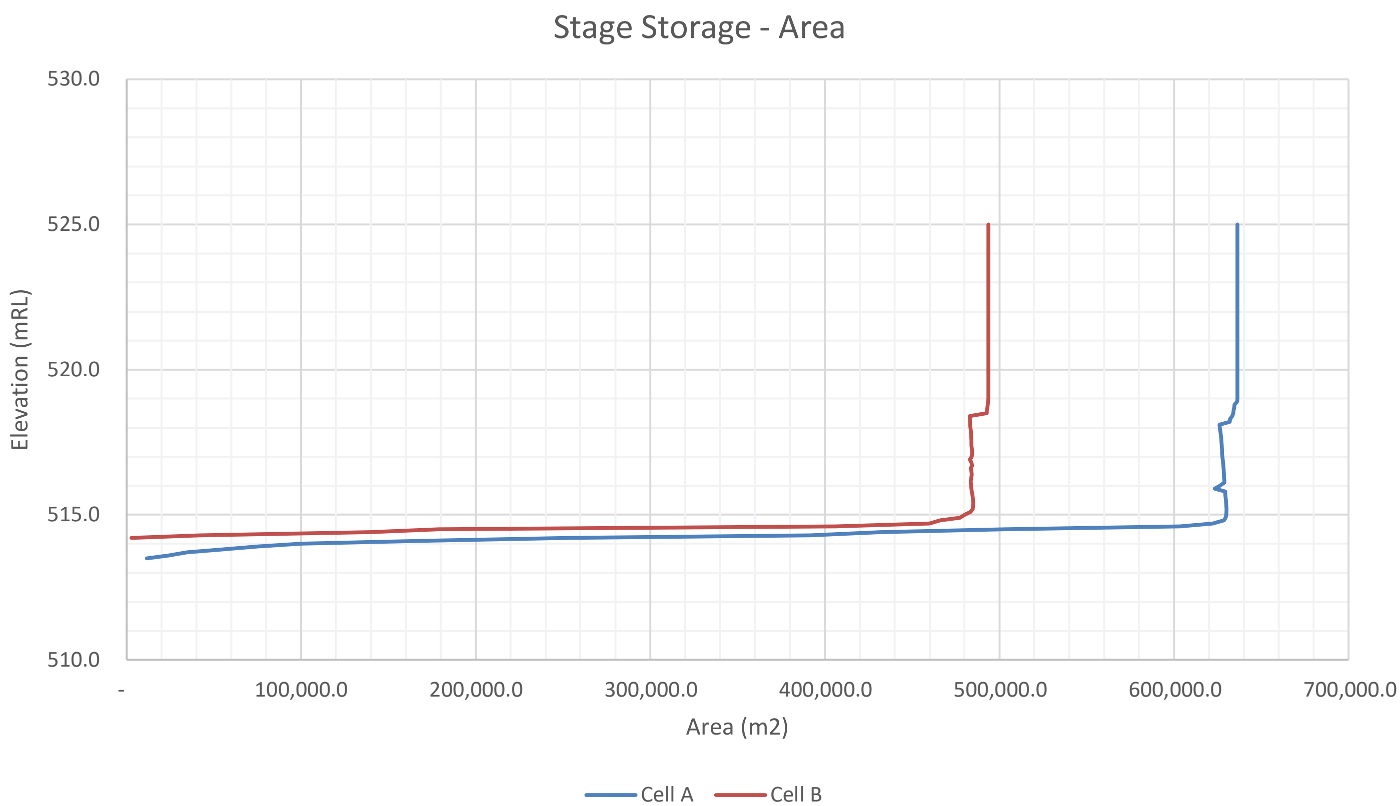
2. Knight Piésold Report. Ref PE801-00296/17, "*Thunderbox Gold Mine – Tailings Storage Facility Cell C and Cell D Permitting Design Report*", Rev 3, July 2021.

3. Knight Piésold Report. Ref PE801-00296/36, "*Thunderbox Gold Mine – Tailings Storage Facility Cell C and Cell D Stage 1 Construction Report*", Rev 1, April 2024.

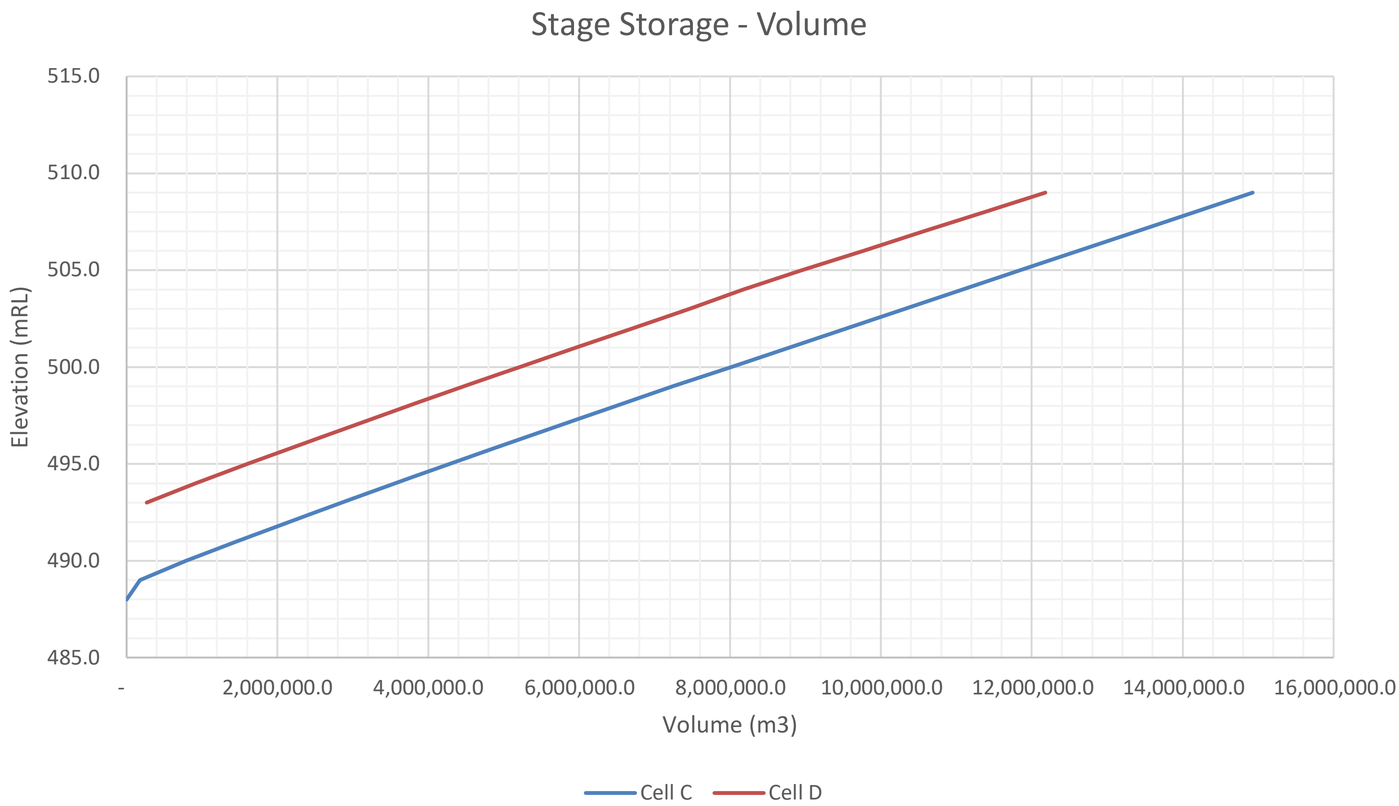
FIGURES

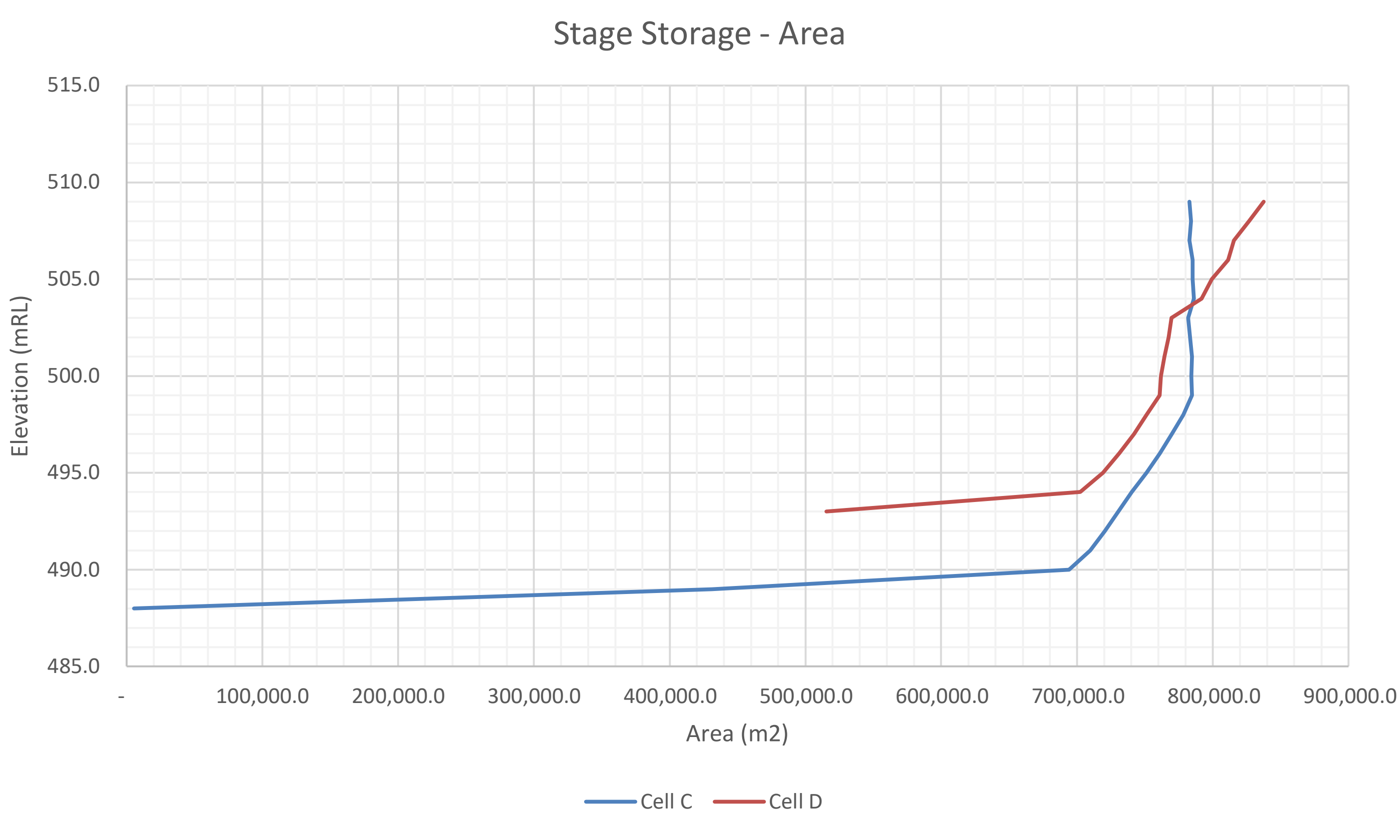


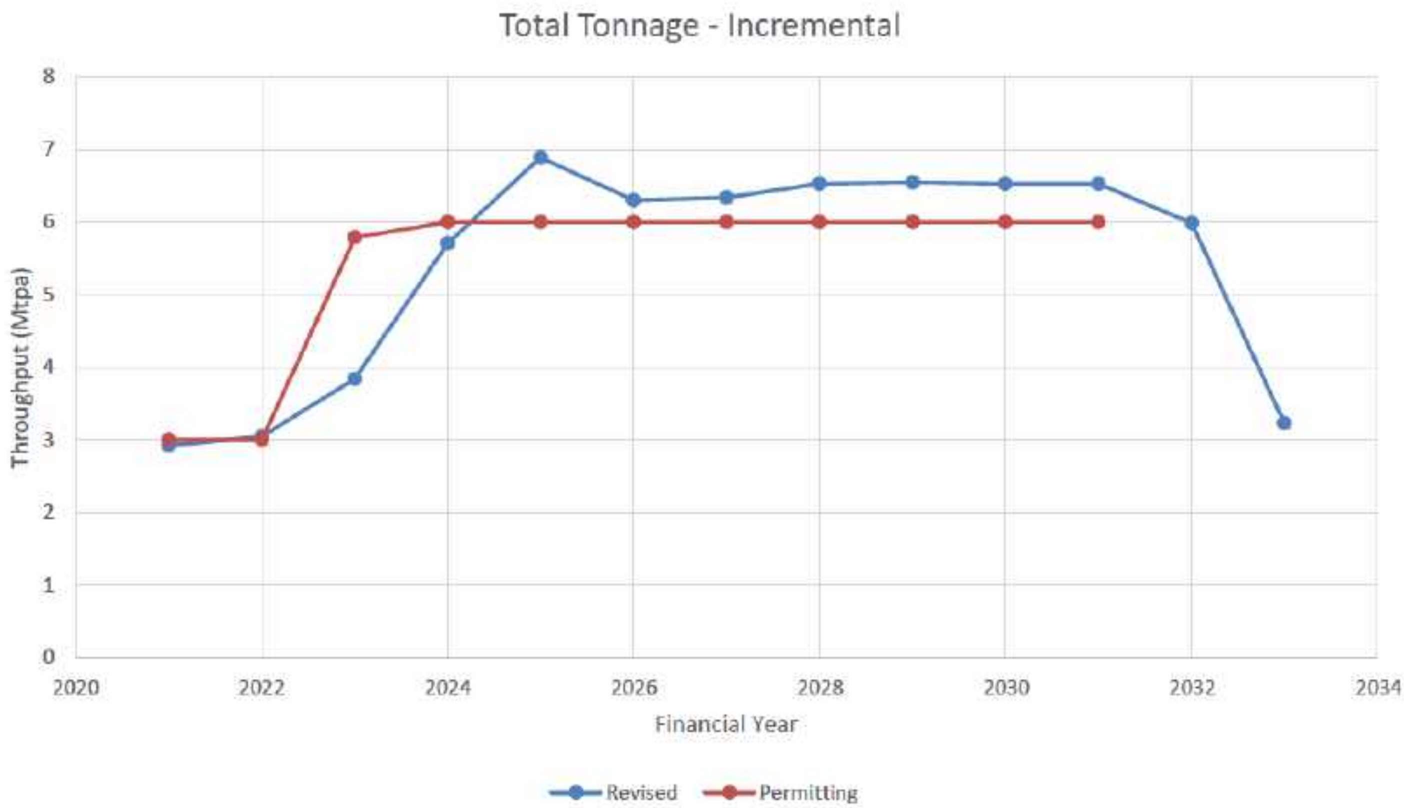
Stage Storage - Volume
530.0
525.0
520.0
515.0
510.0
Elevation (mRL)
-
1,000,000.0
2,000,000.0
3,000,000.0
4,000,000.0
5,000,000.0
6,000,000.0
7,000,000.0
8,000,000.0
Volume (m3)
Cell A
Cell B



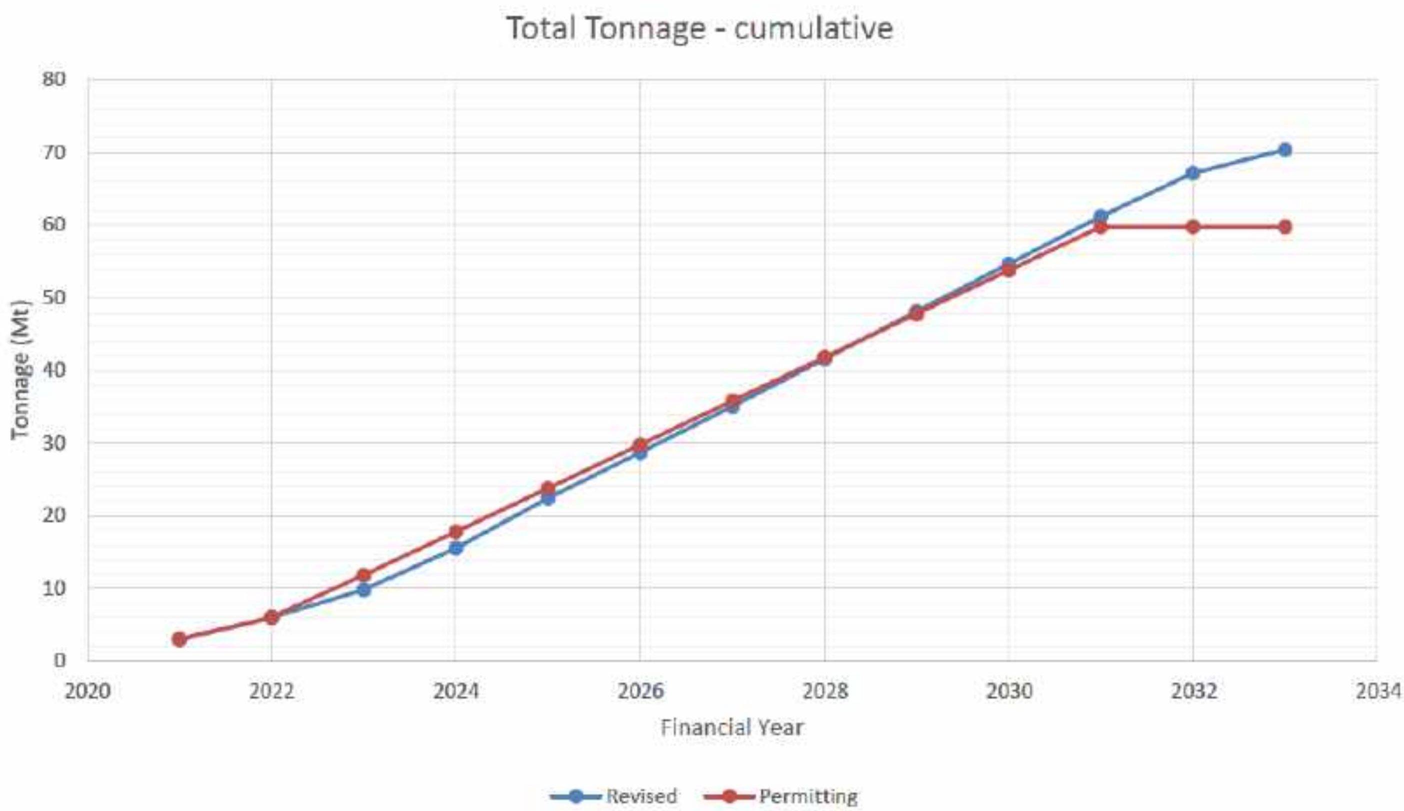
Stage Storage - Area
530.0
525.0
520.0
515.0
510.0
Elevation (mRL)
-
100,000.0
200,000.0
300,000.0
400,000.0
500,000.0
600,000.0
700,000.0
Area (m2)
Cell A
Cell B


Stage Storage - Volume
515.0
510.0
505.0
500.0
495.0
490.0
485.0
Elevation (mRL)
-
2,000,000.0
4,000,000.0
6,000,000.0
8,000,000.0
10,000,000.0
12,000,000.0
14,000,000.0
16,000,000.0
Volume (m3)
Cell C
Cell D

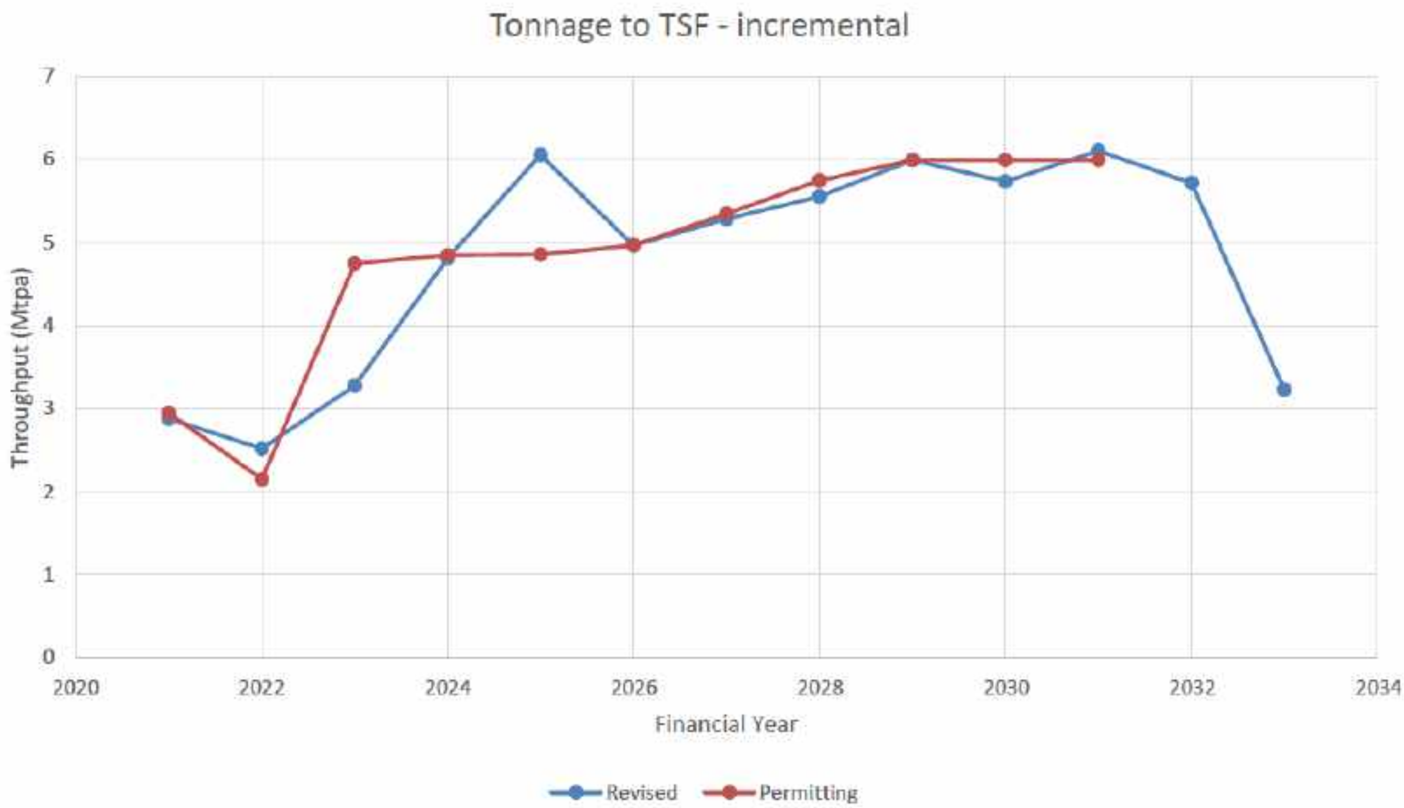

Stage Storage - Area
515.0
510.0
505.0
500.0
495.0
490.0
485.0
Elevation (mRL)
-
100,000.0
200,000.0
300,000.0
400,000.0
500,000.0
600,000.0
700,000.0
800,000.0
900,000.0
Area (m2)
Cell C
Cell D



Total Tonnage - Incremental
Throughput (Mtpa)
0
1
2
3
4
5
6
7
8
2020
2022
2024
2026
2028
2030
2032
2034
Financial Year
Revised
Permitting



Total Tonnage - cumulative
Tonnage (Mt)
0
10
20
30
40
50
60
70
80
2020
2022
2024
2026
2028
2030
2032
2034
Financial Year
Revised
Permitting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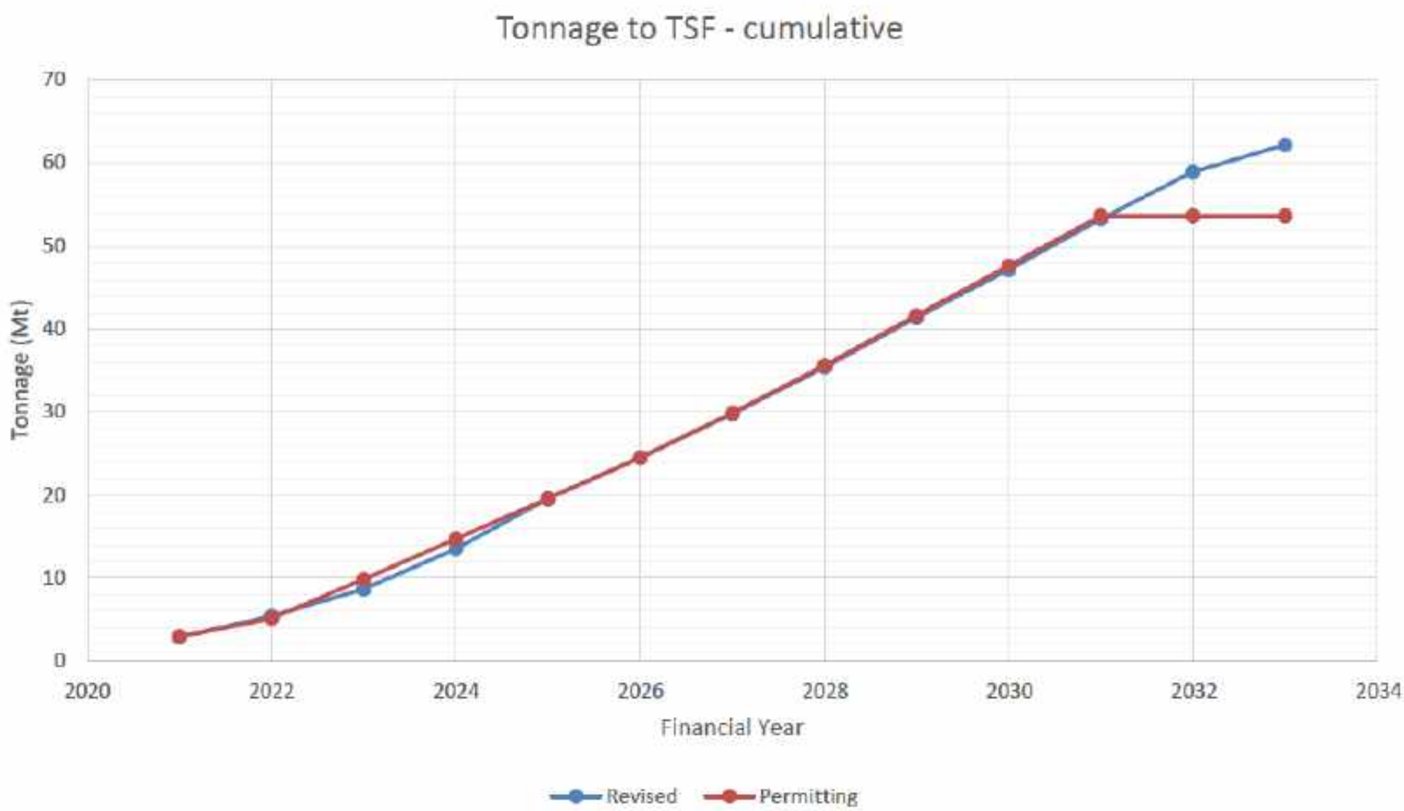
Throughput (Mtpa)
Financial Year
Revised
Permitting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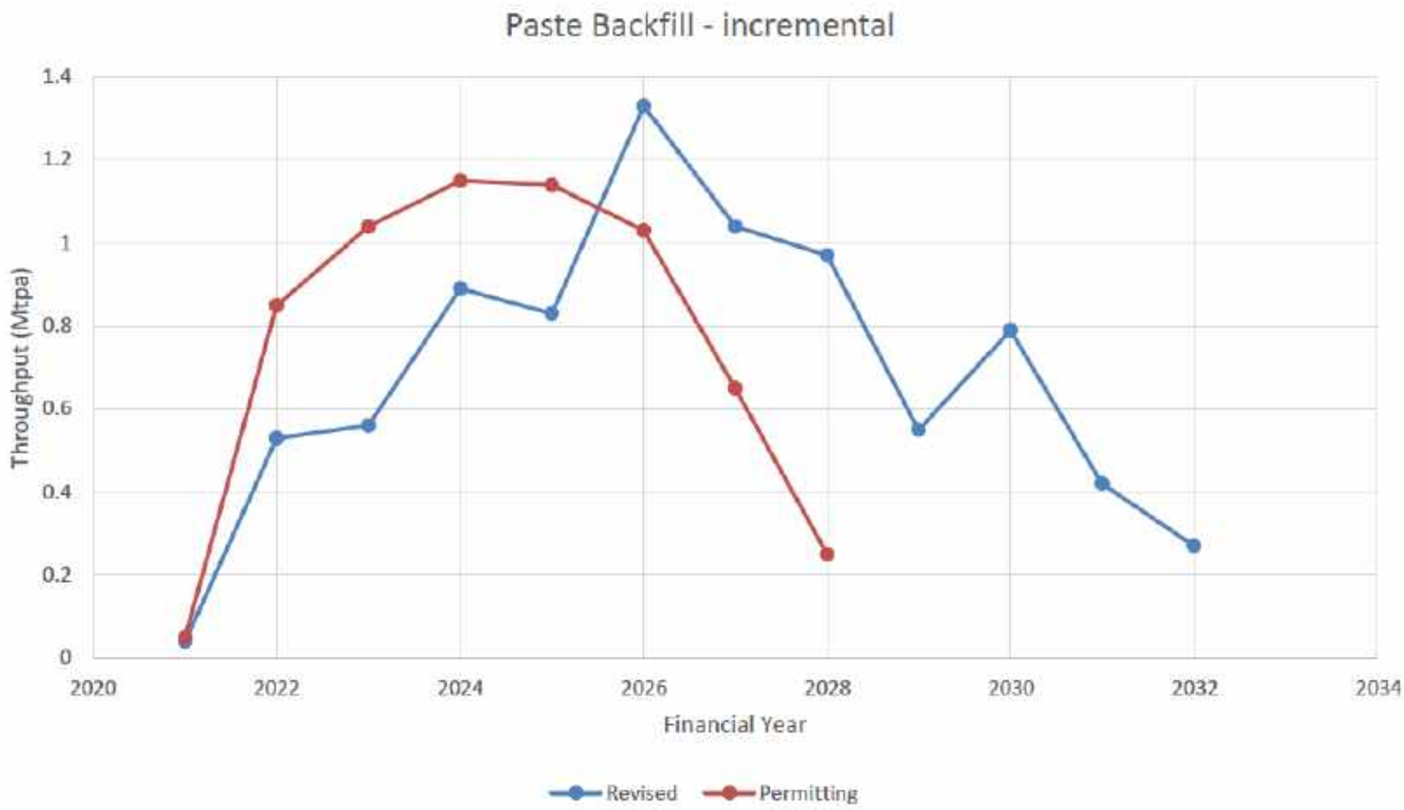
Tonnage (Mt)
Financial Year
Revised
Permitting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1.2
1
0.8
0.6
0.4
0.2
0
2020
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2030
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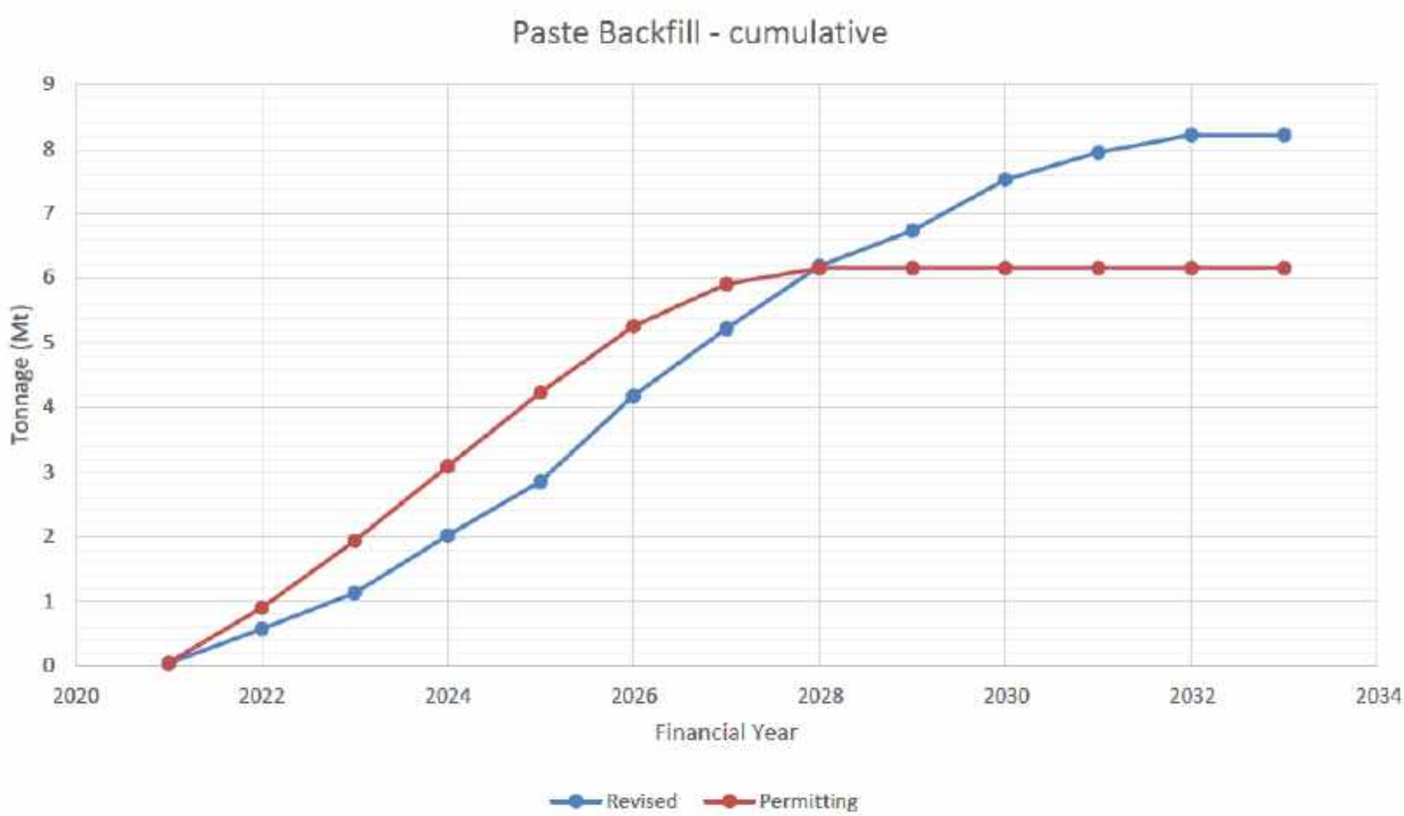
2034
Financial Year
Revised
Permitting


Paste Backfill - cumulative
Tonnage (Mt)
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8
7
6
5
4
3
2
1
0
2020
2022
2024
2026
2028
2030
2032
2034
Financial Year
Revised
Permitting

9 Thunderbox TSF Cell C & D Permitting Design (Attachment 8C)

NORTHERN STAR RESOURCES LIMITED
THUNDERBOX GOLD MINE



TAILINGS STORAGE FACILITY
CELL C AND CELL D PERMITTING DESIGN

PREPARED FOR:

Northern Star Resources Limited
Level 1/388 Hay St,
Subiaco, WA 6008

PREPARED BY:

Knight Piésold Pty Limited
[redacted]

PE801-00296/17
Rev 3
July, 2021

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NORTHERN STAR RESOURCES LIMITED

THUNDERBOX GOLD MINE

TAILINGS STORAGE FACILITY

CELL C AND CELL D PERMITTING DESIGN

REPORT

KP Job No. PE801-00296/31

KP Report No. PE801-00296/17

[redacted]

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1. INTRODUCTION

1.1 GENERAL

The Thunderbox Gold Mine south of the town of Leinster, Western Australia is currently being operated by Northern Star Resources Limited (NSRL). Knight Piésold (KP) was engaged to undertake the engineering design for an expansion of the existing the tailings storage facility (TSF) which involves horizontal expansion integrating the Eastern Waste Dump and the existing Cell A and Cell B to form two additional cells, namely Cell C and Cell D. The site general arrangement is shown on Drawing 801-296-D3000-100.

The project is owned by NSRL and was previously on care and maintenance (since August 2007). The redevelopment of the operation commenced in 2015 following the completion of a feasibility study. The plant was re-commissioned in February 2016 and has been in continuous operation since then. The current plant throughput is 3.0 Mtpa and is ramping up to 5.79 Mtpa in FY22 and FY23 then 6.0 Mtpa in FY24. The plant incorporates a single-stage crusher, a SAG mill and a ball mill as well as conventional CIL leaching and elution circuits.

TSF Cell A Stage 9 raise was completed in January 2021 and Cell B is being used for tailings storage. With the increased plant throughput and mine reserves, it is proposed that the existing TSF will expand vertically and horizontally, further integrating the Eastern Waste Dump and the existing TSF Cell A and Cell B, by forming two additional cells (Cell C and Cell D), to reduce the overall footprint cleared, ensure improved stability by constructing a waste rock buttress for cells A and B, and achieve construction material efficiencies. Vertical expansion (Cell A and Cell B) is reported in a separate study. This report presents the mining proposal and works approval design for the proposed horizontal tailings storage expansion (Cell C and Cell D) only.

The Eastern Waste Dump profile are combined with the existing TSF to form two cells C and D, and two central decants. Utilising the two cells:

- Provides sufficient tailings storage capacity for an additional 37.7 Mt of tailings from July 2022);
- Provides efficient deposition areas to increase densities and reduce embankment levels;
- Reduces construction earthwork quantities by utilising the existing cell walls and the Eastern Waste Dump;
- Reduces the overall land take area (compared with standalone new storages);
- Provides greater flexibility in the management of tailings; and

- Provides buttress requirement to the existing Cell A and Cell B.

1.2 PROJECT LOCATION AND DESCRIPTION

The Thunderbox Operations are centred on the Thunderbox Open Pit and CIL gold treatment plant, located 45 km south of the town of Leinster in Western Australia and immediately adjacent to the sealed Goldfields Highway.

The existing TSF (Cell A and Cell B) is located approximately 2 km southeast of the plant. The cells abut each other with Cell A located immediately north of Cell B. The Cell C and Cell D are proposed to be abutting the existing TSF Cell A, Cell B and the Eastern Waste Dump. The TSF (vertical expansion and horizontal expansion) is bounded to the east by the Goldfields Highway and to the immediate west by the Eastern Waste Dump. The site general arrangement is shown on Drawing 801-296-D3000-100.

The site slopes gently to the south-east at an overall slope of approximately 1%.

1.3 DESIGN OBJECTIVES

The design objectives for the TSF expansion are summarised as follows:

- Permanent and secure containment of all solid tailings materials generated over the life of the project;
- Continuous removal and reuse of free water from the facility;
- Improve the future stability of the existing cells, Cell A and Cell B;
- Provide excess storage capacity to retain design storm events;
- Incorporate safety into the design, construction and operation of the facility;
- Reduced environmental impact with rapid and effective rehabilitation; and
- Provide ease of operation.

A summary of the key policies and guidance documents used for the design of the tailing storage are summarised as follows:

- Guidelines on the Consequence Categories for Dams, ANCOLD, October 2012 (Ref. 1);
- Guidelines on Tailings Dams – Planning, Design, Construction, Operation and Closure, ANCOLD, July 2019 (Ref. 2);
- Guidelines for Design of Dams and Appurtenant Structures for Earthquake, ANCOLD, May 2019 (Ref. 3);
- Department of Mines Industry Regulation and Safety (DMIRS) “Code of Practice – Tailings Storage Facilities in Western Australia” 2013 (Ref. 4);

- Guide to Preparation of a Design Report for Tailings Storage Facilities (TSFs) - DMIRS, August 2015 (Ref. 5); and
- Guide to Departmental Requirements for the Management and Closure of Tailings Storage Facilities (TSFs) - DMIRS, August 2015 (Ref. 6).

1.4 TSF DESIGN PARAMETERS AND ASSUMPTIONS

The overall design criteria are maintained from the previous TSF permitting design (Ref.7) as summarised in Table 1.1. These design criteria are in accordance with the WA Department of Mines Industry Regulation and Safety (DMIRS) guidelines and the Australian National Committee on Large Dams (ANCOLD) guidelines.

Table 1.1: TSF design criteria

TSF Design	
Storage Capacity - Final Stage Freeboard	37.7 Mt of dry tails (from July 2022). Greater of: (i) 0.50 m above maximum tailings elevation, or (ii) 0.50 m above required stormwater capacity elevation.
Stormwater Capacity (containment) - Short duration - Long duration	1% Annual Exceedance Probability (AEP) 72 hour storm event superimposed over average rainfall sequence with no release, evaporation or decant. 1% AEP, 12 months wet rainfall sequence.
Earthquake Loading - Operating - Final -Closure	Operating Basis Earthquake (OBE) – 1 in 475 year. Safety Evaluation Earthquake (SEE) - 1 in 1,000 year. Maximum Credible Earthquake (MCE) – greater than 1 in 10,000 year.
Operations	
Production Throughput	3.0 Mtpa, increasing to 6.0 Mtpa. 0.07 Mtpa to 1.31 Mtpa to underground paste backfill. The remaining tailings reporting to TSF cell(s).
Production Days/Year	330 (90.4% availability).
Slurry Characteristics	62% solids by weight. SG solids = 2.7. SG liquor = 1.006. Slurry average settled density = 1.60 t/m^3. Permeability of 4 x 10^{-7} m/s.
Deposition	Deposition from perimeter embankments towards centre of basin. Supernatant pond maintained central to the facility.
Water Management	Vertical decant tower system for removal of supernatant solution. Return to the plant via submersible pump. Underdrainage system drains by gravity into underdrainage tower. Return to supernatant pond, via submersible pump.

Table 1.1 (cont.): TSF design criteria

Embankment construction	
General	Cell C and Cell D downstream construction for the first two stages and upstream construction in subsequent stages Downstream construction where buttressed against Eastern Waste Dump Divider embankment centreline construction
Construction Description -Cut off trench -Embankment -Underdrains	 Embankment upstream toe cut-off key and drain on embankment sections where upstream construction planned Compacted Oxide mine waste for Stage 1 and Stage 2, tailings will be utilised for Stage 3+ with upstream construction – Cell C and Cell D Zoned embankment constructed from selected mine waste/tailings comprising an upstream low permeability zone where buttressed against Eastern Waste Dump Slotted HDPE draincoil 160 mm diameter along toe of embankment and basin underdrainage system, reporting to an underdrainage tower
Construction Materials Low permeability fill (Zone A) Structural fill (Zone C/C1) - Filter material (Zone F) - Erosion protection (Zone E) - Clean rock (Zone G) - Crest wearing course	 Selected mine waste or tailings. Run of mine (ROM) waste, traffic compacted. Imported or screened sand. Select and/or screened from blasted rock mine waste. Select and screened from blasted rock mine waste. Select borrow material
TSF Rehabilitation	
Final Embankment Slopes	1V:3.5 H (overall) 15.9° slope
Capping	Mine waste subsoil capillary break followed by topsoil, re-vegetation.
Cover profile	Shaped to achieve a water harvesting structure towards decant towers.

1.5 PROJECT HISTORY

The existing TSF comprises two adjacent operating cells (Cell A and Cell B). Both of them are circular in shape and approximately 50 ha in area. The TSF was designed by DE Cooper and Associates Pty Ltd in 2001. The TSF had an operational life of 5 years and tailings deposition ceased in 2007. The mine was recommissioned in 2015, processing and tailings deposition recommenced in January 2016. Biennial audits were conducted by Coffey Mining Pty Ltd (Coffey) from 2007 to 2013 and subsequently by Knight Piésold. The development of tailings storage at Thunderbox is summarised in Table 1.2.

Table 1.2: TSF construction summary

Stage	Cell A		Cell B	
	Crest RL	Construction completed	Crest RL	Construction completed
1	RL497.0 m	October 2002	RL493.5 m	October 2002
2	RL499.5 m	July 2003	RL496.0 m	September 2003
3	RL502.0 m	October 2004	RL498.5 m	October 2005
4	RL504.5 m	November 2006	RL501.0 m	March 2007
5	RL507.0 m	March 2016	RL503.5 m	April 2017
6	RL509.7 m	April 2018		
6 Expansion	RL503.5 m North Void	December 2018	RL503.5 m South Void	January 2019
7 Expansion	RL506.0 m North Void	May 2019	RL506.0 m	May 2019
8 Expansion	RL508.8 m North Void	March 2020	RL508.8 m	August 2020
9 Expansion	RL511.4 m	January 2021	RL511.4	Ongoing

2. SITE CHARACTERISTICS

2.1 GEOLOGY

The Thunderbox deposit is located within the regional north-north-west trending Thunderbox shear zone.

In addition to the major north-north-west trending ductile shear system, there is a pervasive network of relatively late north-north-east trending brittle faults, one of which separates the mineralised zones of the Thunderbox gold deposit. The shear is vertical to steeply west dipping (Ref. 8).

2.2 FLORA AND FAUNA

One species of Significant Flora has been identified in the area. This is *CSauropus* sp. Woolgorong (M. Officer s.n. 10.8.94) (Ref.9). As most populations are located well away from the proposed areas of the mine pits and associated infrastructure, it is considered unlikely that they would be affected by any mine operations.

2.3 CLIMATE

The region is in a semi-arid environment and has a dry climate with hot summers and cool winters. The average annual rainfall is about 224 mm. February and March tend to be the wettest months, September and October are the driest months. The majority of the annual average evaporation of 2,865 mm occurs from October to March. The average rate in January is 13.0 mm per day, while on a hot, windy day the evaporation can be over 20.0 mm. During the winter the average daily evaporation decreases to 3.7 mm. The relative humidity averages less than 30% during summer while the winter figures are typically around 70 %.

A detailed baseline climatology assessment for the project is provided in Appendix A with design storms for the 1% Annual Exceedance Probability (AEP) 72-hour event of 201 mm and the Probable Maximum Precipitation (PMP) 24-hour event of 560 mm.

2.4 SEISMICITY

A seismic hazard assessment has been carried out for the site based on a technical publication by Geoscience Australia ‘Atlas of Seismic Hazard Maps of Australia’ (Ref. 10).

Based on the Hazard Rating of 'SIGNIFICANT' Category 1 facility, the Operating Basis Earthquake (1 in 475 year peak ground acceleration) was estimated as 0.02 g, implying a low seismic hazard. The Safety Evaluation Earthquake (1 in 1,000 year peak ground acceleration) was estimated as 0.03 g. The Maximum Credible Earthquake was calculated as 0.16 g in a deterministic analysis. This was updated for the recent ANCOLD 2019 seismic guidelines.

2.5 WATER CATCHMENTS

No well-defined drainage channels were identified at the TSF site. Rainfall runoff is likely to occur as sheet-flow across the site as the flatness of the ground is unlikely to promote significant channelling of surface water.

The TSF expansion is designed to be a paddock arrangement and the catchment areas will be limited to the surface areas of the facility. However, the waste dump on the west side will need to be shaped to ensure this.

2.6 GROUNDWATER

Groundwater within the project area is generally within 28m of the natural ground level and typically flows south east across the site. Existing monitoring bore data indicates that cyclic trend can be seen where ground water levels peak during the wet season before reduce over the subsequent dry season. Groundwater within the project area is saline, and will be suitable for livestock use.

3. RISK / HAZARD CLASSIFICATION

3.1 GENERAL

The hazard/consequence category for the Thunderbox TSF has been assessed on the basis of the following two guidelines:

- Guidelines on Tailings Dams – Planning, Design, Construction, Operation and Closure, ANCOLD, July 2019 (Ref. 2); and
- Department of Mines Industry Regulation and Safety (DMIRS) “Code of Practice – Tailings Storage Facilities in Western Australia” 2013 (Ref. 4).

3.2 POPULATION AT RISK (PAR) ASSESSMENT

3.2.1 General

As part of the calculation of the hazard/consequence category, an assessment of the Population at Risk (PAR) was undertaken. A dam break analysis was undertaken and is reported in Section 7.12. The impact was assessed to determine the relevant PAR. The PAR value then was incorporated into the hazard/consequence rating, as outlined in Section 3.5.

3.2.2 PAR Calculation

Tailings release from a dam break was modelled and the impact area was determined immediately downstream of the embankment. This impact area was used to calculate the PAR for this event.

There are a number of factors impacting the PAR calculation as follows:

- The tailings solids indicate low health risk thus dust from the facility does not pose a short term or long-term health risk;
- The tailings may have some residual cyanide in solution and supernatant is saline which may impact vegetation growth;
- The mine haul road to the TSF and traffic flow/supervision during construction or stockpiling activities;
- The Goldfield Highway public road downstream of the TSF;
- Once per shift inspections by Processing Department are conducted at the TSF which requires access along the pipeline access road; and
- No notable camps, tracks, permanent offices are located within the immediate downstream.

The PAR is restricted to potential loss of life due to the physical outcomes resulting from a facility failure (i.e. dam break events) and not health or environmental issues. The PAR is estimated to be 0.51, based on the calculation of number of vehicles and time within the impact zone (including a 5% contingency), as summarized in Table 3.1. On the basis of this estimation the PAR category is defined as '<1'.

Table 3.1: Calculation of overall PAR

Population Category	Duration in Impact Zone	Frequency of Event	Calculated PAR
	(minutes)	(No per year)	
Permanent Dwellings	No dwellings or Residential structures in Impact Area	Nil	
	0	0	0
Mine Buildings	Nil (refer to note)	Nil	
	0	0	0
Goldfield Highway	Length in Impact Zone = 3,200 m	Number of people in area = 2 per car / per trip / per day	
	Car Speed = 110 km/hr	Operating days per year = 365	
		Trips per day per car = 197 (based on Main road statistics)	
	Time passing Impact Zone = 1.74 min	Number of Persons passing Impact Zone per year = 143,810	0.48
TSF Inspection	Length in Impact Zone = 500 m	No of Persons per Car = 2	
	Car Speed = 20 km/hr	Operating days per year = 365	
		Trips per day = 4	
	1.50	2920	0.008
Parks	No parks in area	Nil	
	0.00	0	0.000
Campers	No recognised camping area in impact zone	Nil	
	0.00	0	0.000
Tourists to Mine Site	No recognised public roads in impact zone	Nil	
	0.00	0	0.000
Unclassified			
(5% contingency)			0.025
		TOTAL	0.51

Note: there are currently no proposed mine infrastructure, buildings or facilities within the impact zone.

3.3 DMIRS HAZARD RATING

The TSF horizontal expansion classification was assessed by the methods set out in the DMIRS guidelines 2013 (Ref. 4) to determine the category of the facility over the life. The hazard rating was determined by investigating the potential impact of either uncontrolled release, seepage of supernatant water, or complete embankment failure and its impact on humans, stock, and environment as well as the economic loss.

The hazard rating was selected as either high, significant or low, based on the effect on humans, stock, the environment and economic loss. This considered the scenarios of uncontrolled release and embankment failure but did not consider the likelihood of occurrence. The major aspects considered are summarized in Table 3.2 below.

Table 3.2: DMIRS guidelines on hazard rating

Type of impact or damage	Hazard Rating
Loss of Human Life or personal injury No habitable structures or recognised camping areas are located in the immediate vicinity downstream of the embankment. Section 3.2 calculated the PAR as being ‘<1’ for TSF failure events.	**Low**
Adverse human health due to direct physical impact or contamination of the environment (e.g. chemical or radiation denigration of water, soil, air) No groundwater production bores for human consumption in the downstream seepage zone of the TSF. Thus, loss of human life due to consumption of local ground water is not expected. Contamination of habitable areas is expected as the supernatant water quality from seepage or water release does not pass drinking water guidelines.	**Low**
Loss of assets due to direct physical impact or contamination of the environment (e.g. chemical or radioactive pollution of water, soil or air) Tailings geochemistry results indicated the sample had a moderate number of enrichments, with the level of enrichment varying from slight to high. Arsenic and Sulfur were found to be highly enriched, with antimony significantly enriched and silver, lead and selenium slightly enriched. Monitoring Bore data for the existing cells A and B have shown no significant elevations in heavy metals or cyanide, and are well below the DWER licence limit. It is noted that cells A and B comprise of recompacted in situ basin material and include similar seepage measures as proposed for cells C and D. Groundwater is saline and is suitable for livestock use. There may be potential for temporary loss of assets of mine infrastructure located downstream of the main embankment in the event of a dam break. Loss of TSF storage capacity is possible however with multiple cells and repair being practicable relatively quickly addressed at a cost for earthworks.	**Medium**
Damage to items of environmental, heritage or historical value due to direct physical impact or contamination of the environment (e.g. chemical or radioactive pollution of water, soil or air) The site does not contain any identified Threatened Ecological or Priority Ecological Communities. Temporary adverse effects on fauna and flora is possible. No known heritage or historical value is identified. Vegetation impacts of hypersaline water	**Low**

The TSF classification category is a function of the highest hazard identified above and the maximum embankment height for Cell C and D (approximately 22 m) using the matrix provided in Table 2 of DMIRS 2013. As a result, the facility is considered a "**Medium Category 1**" facility.

3.4 ANCOLD CONSEQUENCE CATEGORY

An assessment has been conducted to determine the severity level of impacts based on ANCOLD (Ref. 2). An assessment to determine the severity level of impacts from a large-scale failure of the facility "Dam Failure Severity Level" and a spillway flow or other water release "Environmental Spill Severity Level" was conducted. Similar to the DMIRS Hazard Rating, the likelihood of failure is not considered in the ANCOLD Consequence Category Assessment. The Population at Risk (PAR) as detailed in Section 3.2, being '<1' was the basis of this assessment.

Table 3.3: ANCOLD Guideline on Severity Level (Dam Failure)

Damage Type	Severity Level
Infrastructure (dam, houses, commerce, farms, community) Damage to the storage itself is expected to be repairable relatively quickly but at a cost for earthworks (<$10M). Site roads, pipework and power supply cables may be inundated but repairs are expected to be minor.	Minor
Business Importance Processing operations could continue as the second TSF cell would likely be operational. Significant costs in recovering/replacing equipment and re-establishing working areas. There would likely be severe reaction from the community and some loss of business credibility hence "crippling to business" was selected but bankruptcy unlikely.	Major
Public Health No contamination of habitable areas is expected as there are no structures or recognised camping areas located in the vicinity. Emergency management costs associated with response to inundation of explosives storage facility and clean-up.	Minor
Social Dislocation No social impact is expected as there are no structures or public facilities located in the vicinity (<100 person or <20 business months).	Minor
Impact Area The impact area would be expected to be contained within less than 20 km^2. Minor sediment may continue to flow downstream due to surface runoff however the site is semi-arid, therefore this is not considered to be an immediate impact area.	Major
Impact Duration Released tailings can be recovered and affected areas remediated in a short period of time with no long-term environmental damage. Impact not expected to exceed 1 year in duration.	Minor
Impact on Natural Environment Potential of tailings to inundate surface water features used by native fauna.	Medium

A secondary assessment of an Environmental Spill consequence has been assessed for the case of water spilling during flood events, extreme wet weather or operator error. As there is no spillway, the effect would be similar to a tailings breach due to erosion of the perimeter embankment. The severity level would be considered 'MAJOR' due to Business Importance.

Hence, based on a PAR of <1 and the 'MAJOR' Dam Failure Severity Level, the facility would be rated as **SIGNIFICANT** for the Dam Failure Consequence Category. Based on a PAR of <1 and the 'MAJOR' Environmental Spill Severity Level, the facility would be rated as **SIGNIFICANT** for the Dam Spill Consequence Category.

3.5 DESIGN CATEGORY AND DESIGN CRITERIA

On the basis of the assessment provided above in sections 3.3 and 3.4, the overall minimum design criteria for this study are summarised in Table 3.4. These design criteria are in accordance with the DMIRS Code of Practice (Ref. 4) and ANCOLD guidelines (Ref. 2) where criteria are given. Other parameters were adopted on the basis of industry best practice and client requirements.

Table 3.4: DMIRS and ANCOLD design criteria summary

HYDRAULICS	
Design Storm Storage Allowance (Appendix 5, DMIRS)	1% AEP, 72 hour duration storm with no release, evaporation or decant.
Freeboard (Appendix 5, DMIRS)	Total Freeboard of at least 0.5 m or wave plus 0.3 m; Operational Freeboard to be the greater of 0.3 m or the predicted crest deformation due to the maximum seismic event.
Operating Spillway	None.
Closure Spillway	None.
Diversion structures during operation	2% AEP storm
STABILITY	
Earthquake loading (Table 7 ANCOLD 2019)	OBE 475 Year SEE 1,000 Year Post Closure MCE
Minimum Factor of Safety (Table 8 ANCOLD 2019)	Long term drained 1.5 Short term undrained 1.3 Post Seismic 1.1
DAM SAFETY / INSPECTION FREQUENCY	
Inspection Frequency	• Comprehensive inspection by Dam Designer or equivalent qualified Engineer after first year and then every 2 years. • Annual intermediate inspections by Dam Engineer. • Routine daily by operations personnel.

The above parameters have been used for the design of the facility.

The TSF has been designed to manage direct rainfall and runoff from a total catchment of approximately 140 Ha partially made up of direct rainfall on the tailings and supernatant pond surfaces. The storm capacity freeboard in the facility is maintained significantly greater than the minimum requirement of a 1% AEP 72-hour event.

4. GEOTECHNICAL SITE INVESTIGATION

4.1 GEOTECHNICAL INVESTIGATION 2017

A geotechnical investigation was undertaken in July 2017 over the TSF expansion footprint in the vicinity of cell A and B to determine the sub-surface conditions, comprising the following scope:

- Drilling of two boreholes using diamond coring techniques including in situ SPT and permeability testing;
- Excavation of 20 test pits;
- Collecting 9 No. push tube samples;
- Conducting 14 No. DCP tests; and
- Laboratory testing of samples obtained from the boreholes and the test pits.

Detailed findings are presented in the TSF expansion permitting design (Ref. 7). The following conclusions were made:

- The areas investigated are partly disturbed and relatively flat;
- The near surface profile can be excavated with conventional earthmoving equipment. The sub-surface profile generally comprises:
  - Backfill, comprising Sandy Clay/Sandy Silt/Clayey Sand if present, overlying;
  - Sandy Clay/Clayey Sand; and
  - Silty Clay/Clayey Silt.
- The in situ sandy Clay within the basin areas are generally suitable for use as soil liner if compacted to 98% SMDD. Clayey Sand with less than 35% fines may be present at some places locally within the basin.

4.2 CPT INVESTIGATION 2020

A second investigation was undertaken in September 2020 to evaluate in situ tailings material properties and hydraulic conditions within the stored tailings. The geotechnical investigation comprised the following scope:

- Eight cone penetrometer tests with dissipation tests to assess excess pore pressures within the existing TSF cells A and B;
- Collection of undisturbed samples of soils and tailings material for subsequent laboratory testing including the following:
- Particle size distribution;
  - Atterberg limits;
  - Linear shrinkage;

- Compaction tests;
- Falling head permeability tests;
- Emerson tests;
- Consolidated Undrained (CU) Triaxial tests; and
- Uniaxial compressive strength.

Detailed findings are presented in the KP technical memorandum TSF expansion geotechnical investigation included in Appendix B and the CPT investigation interpretation results are summarised below:

- The CPT investigation provided indicative depths and thicknesses of the tailings material layers. The top 3 m to 6 m comprises dilative tailings overlying contractive tailings. Tailings are generally becoming weaker with depth. The lower part of the tailings is sensitive with relatively low residual strength;
- The tailings close to the embankments are generally dilative, possibly due to traffic compaction during construction;
- The friction angle for dilative materials range from 32° to 45°, with TSF Cell A having a slightly higher friction angle than TSF Cell B;
- The undrained shear strengths vary significantly with state parameter, a few peak undrained shear strength ratios appear to be high, possibly influenced by thin sand lenses in the clay like layers. The undrained shear strengths need to be capped at the drained shear strength for stability assessment; and
- The tailings have low permeability and as such will tend to hold moisture in the tailings for a significant amount of time prior to drainage, assuming natural drainage without the aid of any underdrainage system.

The following geotechnical design parameters for in situ tailings were determined and other undrained and post seismic parameters are discussed in the technical memorandum included in Appendix B.

Table 4.1: Undrained shear strengths for tailings

CPT Reference	Elevation from (m RL)	Elevation to (m RL)	Peak Undrained strength s_u/σ_v'	Residual Undrained strength s_u/σ_v'
CPT 05-1	503.30	499.40	Dilative	
	499.40	495.82	0.52	0.12
	495.82	489.12	0.33	0.04
CPT 06-1	504.20	500.80	Dilative	
	500.80	497.96	0.62	0.14
	497.96	490.56	0.40	0.06

4.3 CELL C INVESTIGATION 2020

A third geotechnical investigation was undertaken in October 2020 over the TSF expansion footprint Cell C (smaller footprint) to determine the sub-surface conditions, comprising the following scope:

- Drilling of two boreholes using diamond coring techniques including in situ SPT and permeability testing;
- Excavation of 34 test pits;
- Collecting 2 No. push tube samples;
- Conducting 34 No. DCP tests; and
- Laboratory testing of samples obtained from the boreholes and the test pits.

Detailed findings are presented in the TSF expansion permitting design (Ref. 7). The following conclusions were made:

- The areas investigated are partly disturbed and relatively flat. The site should generally be suitable for the proposed TSF expansion;
- Conventional earthmoving equipment, such as large dozers and excavators should be capable of excavating the near surface materials across the site. However, excavation difficulties will likely be encountered where Ferricrete hardpan exists at shallow depth. It is expected that the Ferricrete hardpan materials should be excavatable using a D9 dozer or equivalent equipped with a single-tyne ripper attachment;
- Due to the existence of Ferricrete hardpan at shallow depth, the cut-off trench will be likely very shallow, less than 1 m, typically 0.5 to 1 m depending on locations;
- The ground water level is approximately 30 m below the existing ground surface, it will unlikely have any impact on the TSF design and construction;
- The permeability of top layer materials based on lab tests appear to be higher than would normally be expected for similar materials compacted to 98%SMDD. However, the in situ test results appear to be reasonable and indicate that the in situ undisturbed materials have lower permeability than the re-compacted same materials after excavation or remoulding as the cementation bond between particles is likely to be destroyed after excavation and compaction;
- The Emersion tests indicate that the upper layer materials and mine waste are not dispersive; and
- The in situ near surface soils to be compacted as low permeability soil liner, achieved a permeability range of 5×10^{-6} m/s.

4.4 CELL C/D INVESTIGATION 2021

Due to the increasing throughput, the TSF original concept Cell C was expanded to occupy a larger footprint. A fourth investigation was conducted in March 2021, comprising the following scope:

- Drilling three boreholes within the proposed TSF Cells C and D area using diamond coring techniques to depths of 24.1m, 27.3 m and 9m respectively;
- Standard Penetration Tests (SPT);
- Fifty-one test pits within the proposed TSF Cells C and D area; and
- Collection of soil samples for laboratory testing.

Fieldwork was supervised by a Geotechnical Engineer from KP Perth. The site investigation was undertaken in accordance with Australian Standard AS1726–2017. Detailed findings are presented in the TSF expansion Site Investigation 2021 provided in Appendix C. The following conclusions were made:

- The areas investigated are partly disturbed and relatively flat. The site should be generally suitable for the proposed TSF expansion;
- Conventional earthmoving equipment, such as large dozers and excavators should be capable of excavating the near surface materials across the site. However, excavation difficulties will likely be encountered where Laterite/Ferricrete hardpan exists at shallow depth. It is expected that the Ferricrete hardpan materials should be excavatable using a D9 dozer or equivalent equipped with a single-tyne ripper attachment;
- Due to the existence of Laterite/Ferricrete hardpan at shallow depth, the cut-off trench will be likely shallow, typically about 1.0 m, which will vary with locations;
- The ground water level is approximately 30 m below the existing ground surface, it will unlikely have any impact on the TSF design and construction;
- The permeability of top layer materials based on lab tests appear to be higher than what would normally be expected for similar materials compacted to 98% SMDD. However, the in situ test results appear to be reasonably low and indicate that the in situ undisturbed materials have lower permeability than the re-compacted same materials after excavation or remoulding as the cementation bond between particles is likely to be destroyed after excavation and compaction. The materials in the cemented laterite layer and the underlying residual soil (extremely weathered rock) will have reasonably low permeability;
- The Emersion tests indicate that the upper layer materials are not dispersive;

- The in situ near surface soils in some areas are not suitable to be compacted as low permeability soil liner; and
- The tested mine waste samples may not be suitable to be used as low permeability zone (Zone A) due to the high gravel content and low fine contents. Additional samples shall be collected from the stockpiles for lab testing to identify and quantify suitable low permeability mine waste as Zone A materials.

5. TAILINGS CHARACTERISTICS

5.1 GENERAL

Tailings physical testing and geochemical analysis was conducted on tailings samples in 2017 (Appendix D) during the initial life of mine (LoM) expansion design. An operational tailings sample was provided in 2018, with testing undertaken to verify material properties for Stage 7 to Stage 9 designs (Ref.11). The following physical tests were carried out on the samples:

i. Classification tests to determine:
   - Particle size distribution of the tailings.
   - Supernatant liquor density.
   - Liquid and plastic limits of the tailings solids.
   - Tailings solids particle density.

ii. Undrained and drained sedimentation tests.

iii. Air drying tests.

iv. Permeability tests.

v. Consolidation tests.

vi. Geochemistry tests.

vii. Acid generation potential.

viii. Multi element analysis.

ix. Supernatant water quality.

Full details of the tests undertaken, the results and interpretation are provided in Appendix D. A summary of the design parameters and associated implications for design are provided in the following sections.

5.2 DESIGN PARAMETERS

The deposition design uses expected tailings material types and properties based on laboratory testing of the bench scale samples in 2017 for this expansion design. It is envisaged that the material properties will be similar but will vary daily and over the life of the project. Material properties which may affect the deposition methodology include particle size distribution, percent solids of discharge, slurry flow rate and specific gravity of solids and liquids. The tailings design parameters are summarised in Table 5.1.

Table 5.1: Tailings material properties

Parameter	Value
Maximum Air-Dried Density	1.62 t/m^3
Solids Particle Density	2.77 t/m^3
P_{80}	72 µm
Beach Slope	1V: 100H (latest beach survey)
Solids Content	62%
Supernatant Release	28 – 35%
Underdrainage Release	3-8%
Vertical Permeability	4x10^{-7} m/s
Coeff. of Consolidation (Cv)	73 m^2/yr
Coeff. of Volume Decrease (Mv)	0.014m^2/kN
Compression Index (Cc)	0.226

5.3 WATER BALANCE MODELLING PARAMETERS

5.3.1 General

The water management model requires a number of input parameters. The following sub-sections outline the selection of parameters used for the water management modelling.

A climatology assessment was completed as part of the original permitting design in the KP technical memorandum basic climatology included in Appendix A.

5.3.2 Rainfall and Evaporation

Daily historic climate data were obtained from the Scientific Information for Land Owners (SILO) database for use in deriving the basic climatology.

Table 5.2: Annual synthetic climate scenarios

Month	Annual Climate Scenarios (mm)			
	1% AEP Dry	Average	1% AEP Wet	Pan Evaporation
October	0.0	27.8	29.9	285
November	2.4	0.7	3.9	333
December	0.0	2.0	69.1	389
January	4.0	0.0	101.2	404
February	7.3	19.2	65.8	321
March	0.0	17.5	173.3	289
April	2.4	57.7	2.4	193
May	46.2	29.2	45.4	128
June	0.0	20.7	64.0	91
July	0.0	13.9	8.2	98
August	0.0	35.1	8.1	136
September	0.0	0.6	0.0	199
Total	62.3	224.4	571.3	2,866

Design storms for the 1% Annual Exceedance Probability (AEP) 72-hour event is 201 mm and the Probable Maximum Precipitation (PMP) 24-hour event is 560 mm.

5.3.3 Runoff Coefficients

Runoff coefficients for undisturbed areas, active and drying tailings beaches, and pond surfaces were based on expected values for similar projects in the region. The runoff coefficients used for water balance modelling are presented in Table 6.2.

Table 5.3: Adopted runoff coefficients

Condition	Runoff Coefficient
Undisturbed Area	0.2
Drying Tailings Beach	0.8
Active Tailings Beach (Supernatant Producing Areas)	1.0
Ponds	1.0

5.3.4 Additional Modelling Parameters

The tailings slurry design parameters are provided in Section 5. The additional TSF design parameters are summarised in Table 6.3.

Table 5.4: TSF design parameters

TSF design	Parameters
Storage Capacity	42 Mt (From August 2017)
Life of Mine	10 years (FY2021 to FY2031)
Ore Throughput	3.0 – 6.0 Mtpa
Design Beach slope	1V: 100H (latest beach survey dated 2nd September 2020)

5.4 IMPLICATIONS FOR DESIGN

Tailings geochemistry testing of a representative sample of tailings solids and supernatant water for the Thunderbox operation was completed in 2017 and 2018. The implications for tailings management are presented in the KP technical memorandum- Tailings Geochemical Assessment (Ref. 17). Results of the physical and geochemical testing of samples of tailings indicate the following:

- The tailings are Non-Acid Forming (NAF);
- The multi-element analyses of the solids indicate several metals to be present at elevated concentrations (namely arsenic, antimony, chromium, lead, sulfur and zinc). Arsenic and Sulfur were found to be highly enriched. As such, a cover system will be required on closure to isolate the tailings from the environment;
- The results of the supernatant testing have been compared to reference water quality standards for release of water from mining operations and livestock drinking water. The results indicate that the supernatant exceeds a number of reference guidelines. The laboratory was unable to determine the total cyanide concentration due to suspected interreference with thiocyanate in the sample. The concentrations of both free and WAD cyanide were high. Although the WAD cyanide level does not meet the release criteria, it is lower than the 50 mg/L target required under the International Cyanide Guideline for decant ponds. Measures are incorporated into the design to reduce seepage from the basin and release of supernatant to the environment. Monitoring bore data for the existing cells A and B show that no significant elevations of cyanide or arsenic have been registered and are well below the DWER licence conditions;
- The supernatant and seepage are saline due to the use of saline groundwater in the processing of ore. The groundwater in the vicinity of the TSF is stock water quality. As such it is not expected that seepage from the facility will result in a significant increase in groundwater salinity. Monitoring data for the existing cells A and B indicate that Total Dissolved Solids are well below the DWER licence limit

of 1,500 mg/L, fluctuating within a range of 290 mg/L to 750 mg/L during the most recent monitoring period;

- A cover system will need to be constructed on closure to reduce any dust generation and be resistant to erosion to prevent loss of tailings solids, also water ingress and resulting seepage. A modified store and release cover system is proposed over the tailings beach on closure to isolate the tailings solids from the environment. This cover system would limit infiltration of rainfall via a lower permeability layer and promote revegetation through provision of a water storage zone. A capillary break would also prevent the upward migration of salts; and
- In addition, the design should ensure the TSF has sufficient stormwater capacity.

6. WATER MANAGEMENT MODEL

6.1 GENERAL

The management of water within the TSF is a critical aspect of the design. In order to understand (and enable control) the flow of water around the site, a TSF water balance model was developed. The model uses the design tailings production together with estimated settled tailings densities to determine the tailings level at various stages in the facility life. The model then examined a range of extreme rainfall events to determine supernatant pond volumes and the required embankment stage crest levels. A range of extreme dry rainfall events was also analysed to determine the water shortfall that could potentially occur.

The primary objectives of the water balance modelling are summarised below:

- Estimate settled tailings densities;
- Establish the filling rate for tailings solids within the TSF;
- Determine net flows and average supernatant pond volumes within the TSF throughout operation;
- Determine supernatant pond volumes following design rainfall events and sequences;
- Determine staged embankment crest elevations, to ensure containment of tailings and prevent discharge of supernatant water for design rainfall events and sequences; and
- Determine the magnitude of recycle water shortfalls during design dry rainfall sequences.

For the water management model, the following inputs into the TSF were included:

- Water in the tailings slurry from the plant; and
- Rainfall runoff from the tailings and pond surface.

6.2 TSF WATER BALANCE

6.2.1 Model

The TSF water balance was modelled using specially developed computer software. The program is a computer model written in Visual Basic/Excel specifically for tailings storage facilities and incorporates a database of information derived from both laboratory and field data accumulated over the past 30 years by KP Australia. The program calculates tailings densities achieved in the storage, and determines the volume of water available for return to the process plant taking into account rainfall, evaporation, supernatant and underdrainage release from the tailings due to consolidation.

6.2.2 Modelling runs

The model was run with a repeating sequence of average conditions. In addition, the effects of 1% AEP wet and dry years were assessed. The effects of storm events on the TSF were also examined, as follows:

- Average climatic conditions;
- 1% AEP, 1 year wet sequence occurring in every year of the operation;
- Average climatic conditions with a 1% AEP 72 hour storm event on the TSF occurring in every year of the operation;
- Average climatic conditions with a Probable Maximum Precipitation (PMP) 24 hour storm event on the TSF occurring in every year of the operation;
- Average climatic conditions with a Probable Maximum Precipitation (PMP) 72 hour storm event on the TSF occurring in every year of the operation; and
- 1% AEP, 1 year dry sequence occurring in every year of the operation.

It should be noted that for all modelling runs the data were checked to ensure that no overlap of extreme events occurred. In these cases, the timing was adjusted to ensure each event considered was independent of any other event.

6.2.3 Results of modelling runs

The model was run on a monthly time-step for the duration of the operating life. Modelled flows do not represent the design duties for pumps and pipelines or peak flows for rainfall as they are averaged over the month and do not take into account efficiency and availability of the infrastructure. Six different climate scenarios were modelled, as described in the sections that follow and the results are presented in tables 6.4 to 6.9.

6.2.3.1 Average climatic conditions

The model was run with a repeating sequence of average conditions. The size of the supernatant pond is shown in Figure 6.1. Based on the modelling the following conclusions can be made:

- The TSF operates with a water deficit under average conditions. The supernatant pond remains at minimum pond size (specified in the modelling as 5,000 m^3). The make-up water required is approximately 38% - 83% of the water in the slurry, which ranges from 30,000 to 131,000 m^3/month;
- The TSF recycle to the process plant varies from 17% to 62% of water in slurry during the operation. The average recycle is 35% of the water in slurry for the two cells, which ranges from 13,000 to 83,000 m^3/month;

- The average settled dry density gradually increases as a result of exposed dry tailings beach and consolidation of the underlying tailings, achieving a final average density of approximately 1.60 t/m^3; and
- Over the life of the project, the water recycled from the TSF is not sufficient to supply the water required to satisfy the process plant outputs of tailings slurry water. The total make-up water required over the life of operation is approximately 14.5 Mm^3 with 7.3 Mm^3 for Cell C and 8.1 Mm^3 for Cell D.

6.2.3.2 1% AEP wet sequence

Effects of a 1% AEP wet year were analysed by inserting a wet year independently into each year of the model. As the pond reduces to the minimum volume during the dry season each year, the water balance impact is independent of the previous year's rainfall.

Given the prioritisation of water supply to process plant make-up, a wet year increased the TSF recycle average to as high as 85% of the water in slurry, consequently reducing the make-up requirement, which ranges from 19,000 to 127,000 m^3/month.

The size of the supernatant pond is shown in Figure 6.1.

6.2.3.3 1% AEP dry sequence

The model was also run for the 1% AEP dry year simulations, to determine the process water shortfall that could potentially occur. The tables summarise the results of multiple individual modelling runs for a single 1% AEP dry event. Each year is independent, as the pond level stays at its minimum, allowing multiple individual modelling runs for the dry event to be carried out without impacting on one another.

The 1% AEP dry year precipitation is 62.3 mm. Given that the supernatant pond stays at the minimum even under average climatic conditions, the modelled dry sequence results in even lower TSF recycle.

The average recycle under 1% AEP dry year conditions is 29% of the water in slurry, which yields 16.4 Mm^3 shortfall in total, ranging from 32,000 to 132,000 m^3/month. It was assumed that the additional water required can be sourced from groundwater bores.

6.3 DENSITY

Tailings physical characteristics from laboratory testing in Section 5.1 were adopted to assess the impact of the TSF size on the settled dry density. It should be noted that the tailings density increases as the effective deposition area increases thus reducing the embankment rate of rise.

The deposition plan was set up to deposit into the lower cell initially for a longer period of time, so that the rate of rise in the lower TSF Cell is higher. Over time, the tailings level between the two cells will become similar, which reduces the construction materials required to raise the divider embankment. Ultimately, the final TSF embankments will be the same with tailings at approximately the same elevation.

A plot of tailings density throughout the facility life is shown in Figure 6.2. The individual layer densities are controlled in part by the minimum pond size (assumed to be 5,000 m^3) and dry densities are in the range 1.49 t/m^3 to 1.60 t/m^3.

Table 6.1: Tailings density comparison

Nominal Throughput to TSF (Mtpa)	Cell A		Cell B	
	Layer Density Range (t/m^3)	Overall Density of Tailings Mass (t/m^3)	Layer Density Range (t/m^3)	Overall Density of Tailings Mass (t/m^3)
3.0 – 6.0	1.49 – 1.61	1.60	1.48 – 1.61	1.60

The modelled layer density reaches the maximum theoretical air-drying value in the summer months, which indicates that the facility area for TSF expansion is considered to be sufficient for a production rate in the range of 3.0 – 6.0 Mtpa, for the particular tailings characteristics (i.e. Hard Rock Tailings). Tailings densities are expected to improve due to the larger effective deposition areas and better supernatant pond control.

6.4 SUMMARY

The following conclusions can be made from the TSF water balance modelling:

- The water balance for the expansion is negative during the life of mine as expected. The supernatant pond stays at minimum size almost all the time, ponding of water against the embankment wall is unlikely to occur under any storm event provided the facility ponds are maintained as small as practical;
- Plant site make-up water is required throughout the operation but slightly varies between the wet and dry seasons. Due to the low rainfall the benefit of storing the wet season runoff, prior to expansion commissioning, is not significant;
- Under average climatic conditions, available water from the TSF is less than the required plant make-up. Decant returns range from 13,000 to 83,000 m3/month and the make-up requirement ranges from 30,000 to 131,000 m3/month. Consequently, the minimum operating pond volume is maintained throughout the year;

- Under dry climatic conditions, even less make-up water is available from the TSF. Decant returns range from 14,000 to 79,000 m^3/month. This results in an increase in the external water requirement, ranging from 32,000 to 132,000 m^3/month;
- Under wet climatic conditions, water available from the TSF increases and results in a temporary increase in TSF recycle to as high as 144,000 m3/month; and
- The TSF expansion footprint is considered to be sufficient for a tailings production rate of 6.0 Mtpa.

7. TAILINGS STORAGE FACILITY DESIGN

7.1 INTRODUCTION

The existing tailings storage facility (TSF) comprises of two cells, designated Cell A and Cell B, which were designed as a paddock type facility with basin underdrainage and a central pump out decant system. The TSF Cell A and Cell B Stage 1 were constructed in October 2002, utilising mine waste. Subsequent raises were constructed utilising the upstream construction technique with compacted tailings at 2.5 m per lift until April 2018. A TSF expansion integrating into the existing Eastern waste dump was designed and permitted in 2018 and the Stage 6 expansion construction was completed in December 2018, forming the north void and south void by construction of additional embankments connecting the waste dump and the existing embankment. Initial tailings deposition filled the voids. The south void deposition was completed in Q1 2019 and the north void deposition is expected to be completed in Q3 2021.

The development of tailings storage at Thunderbox is summarised in Table 7.1.

Table 7.1: TSF construction summary

Stage	Cell A		Cell B	
	Crest RL	Construction completed	Crest RL	Construction completed
1	RL497.0 m	October 2002	RL493.5 m	October 2002
2	RL499.5 m	July 2003	RL496.0 m	September 2003
3	RL502.0 m	October 2004	RL498.5 m	October 2005
4	RL504.5 m	November 2006	RL501.0 m	March 2007
5	RL507.0 m	March 2016	RL503.5 m	April 2017
6	RL509.7 m	April 2018		
6 Expansion	RL503.5 m North Void	December 2018	RL503.5 m South Void	January 2019
7 Expansion	RL506.0 m North Void	May 2019	RL506.0 m	May 2019
8 Expansion	RL508.8 m North Void	March 2020	RL508.8 m	August 2020
9 Expansion	RL511.4 m	January 2021	RL511.4 m	Ongoing

The existing operation discharges tailings into TSF Cell B and this is expected to reach full capacity in the next several months at which time deposition will re-commence in Cell A (completed in June 2021).

With the revised mine plan to increase plant throughput, the TSF horizontal expansion (Cell C and Cell D) will develop additional area in the east, integrating the Eastern Waste Dump and the existing TSF to form two cells and two central decants. The final combined storage (Cell A, Cell B, Cell C and Cell D) will provide approximately 267 Ha in final tailings inundation area which will operate for the next 10 years. Tailings will be discharged from the perimeter embankment into the facility by sub-aerial deposition methods, via spigots spaced at regular intervals. The active tailings beach will be regularly rotated so as to maximise tailings density and evaporation of water.

The general layout of the TSF is shown on Drg. No. 801-296-D3000-110 and discussed in the following sections.

7.2 EMBANKMENT CONSTRUCTION

The Cell C and Cell D embankment will form a paddock-type storage and existing Cell A and Cell B will be raised in subsequent stages to allow construction. The staged embankment construction schedule for cells C and D only is given in Table 7.2. Over the 10-year period the rate of rise for each cell is variable but averages in the range 2.5 metres per year.

Table 7.2: TSF expansion staged embankment

Cell C and D Stage	Storage Capacity			Embankment Levels		
	Cell C (Mt)	Cell D (Mt)	Total (Mt)	Cell C (RL m)	Divider (RL m)	Cell D (RL m)
1	6.7	2.8	9.5	494.1	494.1	494.1
2	11.5	7.4	19	498.2	498.2	498.2
3	14	9.9	23.9	500.2	500.2	500.2
4	17	12.7	29.7	502.6	502.6	502.6
5	20	15.7	35.7	505.0	505.0	505.0
6	21	16.7	37.7	505.8	505.8	505.8

The TSF embankment will be constructed with an upstream slope of 1V:2.0H, a downstream slope of 1V:2.75H (interim) and a crest width of 6 m. The initial two stages of embankment will be raised using downstream construction technique with Run of Mine (ROM) waste from the current pit cutback and upstream construction technique using tailings in subsequent stages. The divider embankment will be raised centrally with Run of Mine (ROM) waste from the current pit cutback until Stage 2 after which the divider will be raised with compacted dry tailings sourced from the exposed tailings beach. The embankments against the Eastern Waste Dump (of the existing Cell A and Cell B) will be raised using downstream technique with Run of Mine (ROM) in Stage 1 and compacted dry tailings from Stage 2 onwards. The typical embankment sections are shown on Drg. No. 801-296-D3000-301 and Drg. No. 801-296-D3000-302.

A waste rock buttress downstream of the external embankment of Cell A and Cell B is currently proposed to increase factors of safety. The detailed buttress requirement will be assessed in the detailed design phase for each raise based on tailings strength developed.

The TSF divider embankment will be constructed utilising Run of Mine (ROM) waste in Stage 1 and compacted dry tailings with a slope of 1V:2H for both upstream and downstream slopes. The typical embankment sections are shown on Drg. No. 801-296-D300-301.

The TSF embankment buttressed against the Eastern Waste dump will consist of 6 m compacted low permeability zone (selected mine waste in Stage 1 and tailings in subsequent stages) and will be raised using the downstream construction technique. The typical embankment sections are shown on Drg. No. 801-296-D3000-302.

The embankment against the Cell A and Cell B buttress will consist of a compacted low permeability zone (selected mine waste in Stage 1 and tailings in subsequent stages) and will be raised using the downstream construction technique. The typical embankment sections are shown on Drg. No. 801-296-D3000-303.

Tailings will be used as Zone A materials for all the subsequent upstream raises, which will be won from the previous stage tailings beach. This material will be scarified, moisture conditioned and compacted by an earthworks contractor.

7.3 CELL A AND CELL B BUTTRESS

A buttress downstream of cells A and B is currently undergoing construction in order to increase the embankment factor of safety on the east side. This buttress is being constructed utilising oxide mine waste material, won directly from the current pit cut back, placed and traffic compacted by the mining fleet. The current design intent is for Cells C and D to further buttress Cell A and Cell B during operation as the tailings level within the facility rises. It is noted that the buttressing has been taken into account in when determining the capacity of cells C and D.

7.4 CUT-OFF TRENCH AND LOW PERMEABILITY UPSTREAM MATERIAL

A cut-off trench is proposed around the entire facility including the east waste dump embankment, Cell A and Cell B embankment and the external embankment. It is proposed that low permeability Zone A material will be placed on the east waste dump, Cell A and Cell B downstream buttress face in addition to the external embankment to limit seepage from the facility.

7.5 GEOTEXTILE/FILTER ZONE

Based on available laboratory testing completed on samples taken from oxide mine waste and the eastern waste dump and no geotextile/filter zone will be required. It is noted that variations within the material may be encountered during construction and therefore a geotextile/filter zone may be required where materials are not considered compatible. This will be assessed in the field during construction.

7.6 SEEPAGE CONTROL

In order to reduce seepage losses through the TSF expansion basin and to increase the settled densities of deposited tailings, a number of seepage control and underdrainage collection features are integrated into the design. Monitoring bore data from the existing cells A and B have been reviewed to confirm the performance of the seepage control measures implemented. It is noted that groundwater quality with respect to pH, water level, total dissolved solids, WAD CN and Arsenic are all within the DWER licence requirements (Ref. 16). Therefore, the seepage control measures adopted for cells C and D have been based on the those utilised within cells A and B. A summary of the Monitoring Borehole water quality data from the 2018 Audit is provided below in Table 7.3.

Table 7.3: Summary of Monitoring Borehole water quality data - 2018

Parameter	DWER licence limit	Groundwater		
		Max	Min	Average
pH	6.0 - 9.0	7.9	7.5	7.7
Standing water level	> 4.0	24.6	12.8	16.6
Total dissolved solids	< 1,500 mg/L	750	290	521
Weak acid dissociable cyanide (WAD CN)	< 0.5 mg/L	0.096	0.005	0.014
Arsenic (As)	< 0.5 mg/L	0.063	0.001	0.017

The seepage control and underdrainage collection systems will consist of the components as listed below:

i. Low permeability basin liner;
ii. Basin underdrainage collection system;
iii. Underdrainage collection tower; and
iv. Embankment upstream toe drain.
v. Cut-off trench

Primary seepage control from the expanded TSF footprint Cell C and Cell D will comprise the construction of a cut-off trench excavated in the foundation soils, backfilled with low permeability fill to reduce seepage loss through the embankment foundations.

The cut-off trench will be located beneath the upstream toe of the embankments and will be cut to a depth of approximately 0.5 – 1 m. The cut-off trench will be constructed continuously along the upstream toe of the external embankment and the embankment section against the waste dump to the full deposition elevation to limit potential seepage at any level. If the cut material is suitable as fill, it may be replaced in the excavation in compacted layers; alternatively, suitable low permeability material will be won, conditioned, placed and compacted in the trench.

The details of the embankment cut-off trench are shown on Drg. No. 801-296-D3000-302.

i. Low permeability compacted soil liner (CSL)

A compacted soil liner (CSL) will be constructed within the entire expanded TSF basin area, comprising either reworked in situ material or imported Zone A material.

The construction methodology for the compacted soil liner will be as follows:

- The TSF basin area will be cleared, grubbed and topsoil stripped;
- Borrow areas within the TSF basin will be shaped to facilitate full gravity drainage into the TSF;
- Where in situ material is suitable (classified as Zone A material) - scarify, moisture condition and compact in situ material to achieve target density; and
- Where in situ material is unsuitable (too coarse for classification as Zone A material or low plasticity to non-plastic) – win suitable material from borrow, place, spread, moisture condition and compact to achieve target density.

The CSL surface shall drain positively and be finished with a smooth drum vibratory roller or other approved means. The low permeability liner properties (permeability, moisture content, dry density ratio and thickness) will be preserved after compaction. A trial pad will be constructed to assess the linear shrinkage during drying. If significant cracking of the CSL is observed then a protection layer will be constructed over the liner, to prevent cracking and erosion during operation prior to inundation of the CSL with tailings.

Monitoring bore data have been reviewed to confirm the performance of the seepage control measures implemented for existing cells A and B. It is noted that the existing cells A and B comprise a CSL located 300m radially around the decant towers with the remaining basin untreated. Additionally, no central underdrainage was installed within cells A or B. Groundwater quality with respect to pH, water level, total dissolved solids, WAD CN and Arsenic for cells A and B are all within the DWER licence requirements (Ref. 16). Therefore, it is proposed that reworked in situ material and imported material (where required) will be utilised to construct the CSL in cells C and D. Laboratory testing on the basin material indicated that a permeability in the range of 6 x 10^{-7} m/s would typically be achievable. Areas of unsuitable material will be removed and replaced with low permeability material won from borrow. It is noted that the Ferricrete / Laterite hardpan underlying the facility will work in conjunction with the CSL and other seepage control measures to provide adequate seepage control for the facility. The seepage control measures proposed for cells C and D generally exceed those utilised for cells A and B.

ii. Basin underdrainage collection system

The TSF underdrainage collection system is designed to reduce the phreatic surface on the tailings basin area under the decant pond. The underdrainage has several benefits:

- Reduces seepage through the basin which is beneficial to the environment; and
- Drains the tailings mass, thus increasing the density of the tailings and provides a more efficient facility in terms of storage.

The design of the underdrainage system takes advantage of the natural fall of the ground, and thus minimal reshaping of the basin will be required. The underdrainage system will be constructed over the CSL under the decant pond to reduce seepage further from the supernatant pond.

The underdrainage system will consist of finger and collector drains in both Cell C and Cell D. The finger drains will consist of 100 mm diameter drain coil pipe embedded within a 400 mm sand (zone F) layer wrapped in geotextile. The collector drains will consist of

160 mm diameter drain coil pipe embedded within a 400 mm sand (zone F) layer wrapped in geotextile. Erosion mitigation measures have been incorporated into the design to protect the underdrainage system for the period between end of construction and tailings deposition.

The branch drain pipes will feed directly into the underdrainage tower located at the upstream toe of the embankment. The extent of the underdrainage system is designed to cover the maximum pond volume resulting from a 1 in 50-year 24-hour storm event. The underdrainage system will be constructed in Stage 1 and will cover approximately 35% of the total basin area.

iii. Underdrainage tower

On the upstream face of the embankment, two underdrainage towers will be constructed. Each tower will collect solution from the toe drains and underdrainage system. The underdrainage tower will consist of the following components:

- A solid concrete pipe of 900 mm internal diameter, Class 3, reinforced concrete with spigot and socket joints;
- A submersible pump (designed by others); and
- A hoist and pulley to raise and lower the pump (designed by others).

The typical sections and details are shown on Drg. No. 801-296-D3000-452.

iv. Embankment upstream toe drain

In addition to the expanded basin drainage system, a toe drain will be constructed along the upstream toe of the embankment on sections where the embankment is designed to be raised upstream. The toe drain has two purposes. The main purpose is to increase the stability of the embankment during the initial and future stages by providing drainage of tailings at the embankment. The second purpose of the toe drain is to act as an underdrainage collection pipe.

The toe drain will comprise of two 160 mm drain coil pipes laid at the base of the external embankment toe within 300 mm of drainage material (Zone F) wrapped in geotextile. The toe drain will flow into the underdrainage collection tower for recycling back into the facility. Erosion mitigation measures have been incorporated into the design to protect the underdrainage system for the period between end of construction and tailings deposition.

Details of the embankment toe drain are shown in Drg. No. 801-296-D300-302.

All seepage control works will be completed as part of the Stage 1 construction. The underdrainage tower will be extended during future raises.

v. Cut-off Trench

One of the primary seepage controls from the TSF will comprise a cut-off trench excavated in the foundation soils and backfilled with low permeability fill (Zone A) to reduce seepage loss under the embankment foundations. The cut-off trench will be located beneath the upstream low permeability zone to a depth of 1 to 2 m (depending on ground conditions). The cut-off trench will be constructed continuously along the embankment to the full deposition elevation in order to reduce potential seepage at any level. Low permeability material (Zone A) will be used to backfill the cut-off trench. If the cut material is suitable as fill, it may be placed in the TSF embankment in compacted layers (or reused as cut-off trench backfill).

The location and details of the embankment cut-off trench are shown on Drg. Nos 801-296-D3000-201 to 801-296-D3000-303.

7.7 DECANT AND RETURN WATER POND SYSTEM

The deposition is to push the supernatant pond towards the centre of the TSF expansion Cell C and Cell D. The decant pump will be raised on a regular basis with successive embankment lifts to ensure that no tailings enters the pump intake. The decant system will comprise of the following components:

- An access causeway constructed of Zone D material;
- A decant tower, consisting of an 1,800 mm diameter slotted concrete pipe surrounded by clean waste rock (Zone G);
- A submersible pump and pipework (designed by others); and
- A hoist and pulley to raise and lower the pump (designed by others).

The location of the decant tower is shown on Drg. No. 801-296-D3000-500 with relevant sections and details on Drg. No. 801-296-D3000-551 and Drg. No. 801-296-D3000-552.

7.8 SEEPAGE MODELLING

Finite element seepage analyses, using GeoStudio (Ref. 12) Seep/W program, were conducted to evaluate seepage through the embankment and foundation under normal operating conditions and to approximate the phreatic surface and pore water pressures in the TSF embankment.

The seepage analysis results were used to estimate the total seepage losses from the TSF. The outputs from the Seep/W program were used to model the phreatic surface and pore water pressures for the final embankment configurations in a Slope/W slope stability assessment. A detailed seepage assessment was completed and is presented in Appendix E. The results summary is provided below:

- In the steady state condition, the effectiveness of the basin and toe drains appear not to have significant impact on the phreatic levels and seepage to the embankment due to the low ground water table and pond being far away from the embankment. However, these drains will be effective to lower the phreatic levels in the tailings during operation; and
- Based on the seepage modelling for the steady state condition, the estimated phreatic surfaces will be under the embankment, and there will be very little seepage into the embankment. During operation it is recommended to carry out the following further work:
  - Transient modelling to estimate the phreatic levels during operation after confirmation of the detailed schedules of construction and tailings deposition.
  - Geotechnical investigation including CPT tests to confirm the following:
    - Properties of the constructed embankment.
    - Tailings properties.
    - Phreatic levels.
  - Update of this seepage analysis after the geotechnical investigation.

7.9 STABILITY ASSESSMENT

GeoStudio Slope/W program was used to determine the factor of safety of the TSF in a slope stability assessment for the design of the TSF expansion and to confirm the validity of the existing facility design. "SLOPE/W", developed by GEO-SLOPE International Ltd. in Canada (Ref. 13), is a limit equilibrium program and was performed using the modified Morgenstern-Price method. The detailed stability assessment is included in Appendix F.

The results summary is provided below:

- The results of the stability analyses demonstrate an adequate factor of safety under the static loading condition. For the revised ANCOLD Guidelines (Ref. 2), it is recommended to assume that a flow liquefaction event can occur. For this post-liquefaction loading condition the factor of safety 1.48;
- KP recommends CPT testing should continue to be undertaken in the tailings before future raises are constructed to increase the tailings strength database, and to confirm the properties of the constructed materials, tailings properties and phreatic levels; and

- The modelled material parameters should be verified and confirmed during the construction and operation phases. It is also crucial that the facility be operated correctly and the supernatant pond be kept under control at all times to ensure maximum distance from the embankment to the operational pond is maintained.

7.10 FREEBOARD

The TSF is designed to operate without the need for a spillway. A minimum Total Freeboard (water) of 500 mm should be maintained on the facility after a storm event together with a minimum Operational Freeboard (solids) of 300 mm, as outlined in the DMIRS Code of Practice (Ref. 4).

Freeboard allowances are set such that a PMP event can be retained on the facility without breach of the perimeter embankments. Following high rainfall events, increased decant return to the Plant will be used to lower the pond level and increase available storm storage capacity.

Definitions for freeboard are provided below:

Operational Freeboard (for solids) is the vertical height between the lowest elevation of the perimeter embankment and the tailings beach immediately inside the embankment. The operational freeboard varies over the course of a deposition cycle as the storage is raised and fills with tailings. The operational freeboard becomes critically important at the end of a deposition cycle, particularly to reduce the potential for back flow and overtopping as a result of mounding of tailings at discharge points. The Operational Freeboard is 300 mm.

Total Freeboard (for water) is the vertical height between the lowest elevation of the perimeter embankment and the pond level **AFTER** a 1% AEP 72 hour storm event assuming no decant or evaporation. As a result, it is difficult to visualise operationally if the storm event hasn't taken place. Hence the maximum pond level before the design event is determined mathematically to account for the potential inflow. The Total Freeboard after the event is then 500 mm.

Beach Freeboard is the vertical height between the normal operating pond level and the point on the beach where the operational freeboard is measured i.e. the exposed beach extent. The Beach Freeboard can vary significantly during the life of the storage and depends upon beach length, slurry/tailings characteristics and deposition methodology.

7.11 DAM BREAK ASSESSMENT

A tailings inundation exercise was conducted for the dam break scenario of the TSF expansion. The modelled inundation was conducted to assist in determining the areas and Population at Risk (PAR) due to a dam break.

A significant failure of the embankment will result in a release of tailings and/or water depending on the location of the breach, its size and the cause. For the analysis, the end condition was assessed as a tailings discharge resulting from a final embankment height breach when the facility is at its maximum tailings storage volume in a relatively dry condition. For this case the failure was modelled at both Cell C and Cell D embankment of the facility.

An embankment breach resulting in a release of slurry/solids was analysed from the ultimate facility height. A number of methods of analysing the flow of slurry and run out from a breached tailings dam have been presented over the years. These have been based on reviews of past failures and attempts to predict the flow slides using analytical means and simple correlations with facility geometry. The correlations proposed by M. Rico et al. (Ref. 14) and more recently Larrauri & Lall (Ref. 15) were used to correlate outflow volume from stored volume followed by correlating runout estimates from the outflow volume. Then a tailings deposition model (Rift TD) was used to generate potential inundation maps.

Rico (2007) proposed a correlation between stored tailings volume at the time of failure with tailings outflow volume from a historical data set of 29 dam failures of varying embankment configurations, tailings consistency and stored volumes. An empirical relationship with a good correlation (r^2 = 0.86) was found that determined, on average, about one-third of the tailings and water are released. It is expected that downstream embankments would typically be below this regression line and upstream embankments or high-water retaining facilities would be above this regression line.

The outflow volume was then correlated against recorded run out distances of tailings dam failures. A regression line is provided by Rico (r^2 = 0.56) however records varied significantly based on tailings water content, tailings viscosity, downstream obstacles, topographic restrictions, barriers etc. Therefore, run out distance estimates can vary significantly.

Additional information about TSF failures since Rico is available. The original liner regressions by Rico were updated by Larrauri & Lall with the results using the updated dataset. A new model for the calculation of Dmax was proposed introducing the predictor (Hf). This variable was introduced to consider that the potential energy associated with the release volume may be better related to the fractional volume released as opposed to the total volume of the TSF.

In addition to the methodology above, another methodology developed by KP Australia was applied to the Thunderbox TSF. The logic behind the methodology is that the stronger the tailings mass, the steeper the resulting tailings breach will be. If the breach slope is very steep, then at a certain elevation the released tailings will block the outlet preventing further tailings from being released. An example of this concept is illustrated on Figure 7.1.

It is noted that both methodologies described above are considered to be compliant with the requirements of ANCOLD (Ref. 1 and Ref. 2) and are recognised as being appropriate by industry practitioners such as the Canadian Dam Association.

The calculation for the tailings/solids breach was based on the following assumptions:

- The dam breach could occur on either Cell D in the North or Cell C in the South. Therefore, both cases were considered in this analysis;
- Due to cells A and B upstream of cells C and D a cascading failure mechanism was considered:
  - Northern Failure solids release from Cell D and from Cell A.
  - Eastern Failure solids release from Cell C and Cell D only.
- Cells C and D, were assumed to have tailings storage volume at the final stage of approximately 23.6 Mm^3 (approximately 13.1 Mm^3 for Cell C and 10.5 Mm^3 for Cell D) with a final embankment height of 20 to 22 m;
- Cells A and B, were assumed to have tailings storage volume at the final stage of approximately 26 Mm^3 (for the purposes of this assessment this was assumed as approximately 13 Mm^3 for Cell A and 13 Mm^3 for Cell B) with a final embankment height of 23 to 29 m;
- An estimated outflow volume as a result of embankment failure of 3.8 Mm^3 for cells A and B, 3.8 Mm^3 for Cell C, 3.1 Mm^3 for Cell D based on the recent Larrauri & Lall regression;
- The localised detailed topography around the immediate vicinity of the TSF Expansion was assessed for the case of a dry condition embankment slump type failure. Inundation areas based on beach slopes of 1V:25H, 1V:50H, 1V:75H, 1V:100H, 1V:125H, 1V:150H and 1V:175H were overlayed on Figure 7.2 for the breach occurring on the northern embankment and Figure 7.3 for the breach occurring at the divider between Cell C and Cell D; and

- For the breach occurring on the northern embankment, the area of impact is approximately 524 ha and the runout distance is about 3.6 km. For the breach occurring on the divider embankment, the area of impact is approximately 596 ha and the runout distance is about 3.5 km.

8. MONITORING AND MAINTENANCE

8.1 MONITORING PROGRAMME

As part of the TSF operation, extensive monitoring of all aspects of the operation will be undertaken to ensure the TSF design intent is achieved. This monitoring will comprise three basic types. These are:

- Operation monitoring.

  This will include items such as spigot offtake location, whether pipe joints are leaking, etc. This level of monitoring is directed at ensuring that the facility is operating smoothly.

- Compliance monitoring.

  This includes items such as checking survey pins for movement, monitoring bores for contamination, etc. This monitoring is required to ensure that the project is meeting all its commitments in regard to a safe and secure operation.

- Performance monitoring.

  This will include items such as tailings level surveys and water flow measurements, etc. This monitoring is necessary to assess the performance of the facility and refine future embankment lift levels and final extents.

The monitoring requirements for the facilities are summarised in Table 8.1.

Table 8.1: Monitoring programme

Area	Monitoring Requirement	Frequency	Method
Section 1:	Operation monitoring		
Tailings Facility	Pipeline integrity, visual inspection of corridor	Daily	Manual
	Offtake location	Daily	Manual
	Blockage or damage of discharge	Daily	Manual
	Visual check on tailings and water levels versus embankment crest and marker guide posts	Daily	Manual
	Visual integrity assessment of facility	Daily	Manual
Decant	Size of decant pond	Daily	Manual
	Pond level and associated freeboard	Daily	Manual
	Location of decant pond	Daily	Manual
Section 2:	Compliance Monitoring		
Embankment	Survey pins	Monthly	Manual
	Water volume estimate within facility	Monthly	Manual
	Tailings level and volume	Monthly	Manual
	Aerial topographic survey	Annual	Manual
	General inspection by suitably qualified engineer	Annually	Manual
Monitoring Bores	Water level	Monthly	Manual
	Water quality – conductivity	Quarterly	Manual
	Water quality – major component analysis	Quarterly	Manual
Piezometers	Water level	Monthly	Manual
Section 3:	Performance Monitoring		
Climatic	Precipitation	Hourly	Automatic
Tailings	Tailings solids (tonnes)	Daily	Automatic
	Water in tailings (tonnes or m^3)	Daily	Automatic
	Average tailings flow (m^3/s)	Daily	Automatic
Decant and underdrainage	Outflow from decant (m^3)	Daily	Automatic
	Outflow from underdrainage (m^3)	Daily	Automatic
Water Balance	Assessment of all water within the TSF to determine the need for additional water management	Quarterly	Manual
Technical Audit	Independent geotechnical engineer.	Annually	Manual

A general layout of the required key monitoring locations is presented on Drg. No. 801-296-D3000-900 with recommended monitoring/verification sections presented. The technical specification for installation of complex monitoring equipment will be in accordance with the manufacturer's specifications, with supervision by the equipment supplier recommended in order to ensure long term function of the equipment. More generic monitoring equipment will be installed by an appropriate company with experience in drilling the required locations and providing the required materials.

8.2 MAINTENANCE PROGRAMME

Inspection and maintenance of the TSF is largely aimed at mitigating potential problems by dealing with them before they develop into major problems.

Some aspects of the maintenance programme such as inspections can be integrated into the monitoring programme. If problems are detected then the problem is either to be corrected immediately or is to be noted and a maintenance request form filled in. The form will allow for different levels of urgency depending on how quickly the maintenance is required. The assessment of urgency should be based on the potential for the problem to affect the operation or integrity of the facility. The maintenance will then be integrated with the overall site maintenance programme.

Table 8.2 outlines the maintenance requirements for each area of the TSF. Modifications to the maintenance programmes as a result of emergency situations or annual reviews should be conducted regularly. Checklists for the Production Service Technician will be provided in the operating manual so that all inspections and faults are documented.

Table 8.2: Maintenance programme

Area	Monitoring Requirement	Frequency
Pipeline	Inspect pipeline for pipe bursts, leaking joints.	Daily
	Inspect offtake(s) for blockages, failure etc. Repair and/or replace as necessary. Re-locate offtake(s) to new location and check that flow at new location is acceptable.	Daily
	Inspect the pipeline corridor for signs of potential leakage.	Daily
	Carry out maintenance on valves and fittings as recommended by suppliers.	As recommended
Tailings	Inspect level of tailings versus embankment crest level.	Daily
	Inspect tailings for general gradient.	Daily
	Inspect discharge location for erosion or damage. Repair as appropriate.	Daily
Decant	Inspect decant pond and location. Adjust discharge location to maintain pond around decant tower.	Daily
	Inspect decant for damage or debris.	Weekly or after significant rain events
Embankment	Check general structural integrity and visual signs of seepage through embankment.	Daily
	Visual inspection for slips, erosion problems including around survey pins, tension cracks etc. Problems to be referred to qualified geotechnical engineer for assessment.	Weekly
Underdrainage System	Covered by tailings.	N/A
Toe Drains	Covered by tailings.	N/A
Instrumentation	Inspect all instrumentation and repair / replace as required.	Frequency as per instrumentation instructions
General	General inspection of tailings facility and all structures.	Annually
	General assessment of dust emissions.	Daily
	Geotechnical audit and report.	Annually

8.3 GEOTECHNICAL AUDIT REPORTS

It is important that suitably qualified geotechnical advice is available during the operating life of the facility. NSRL should keep the Geotechnical Engineer informed of the operating performance of the facility and raise any questions immediately.

As the TSF expansion is currently in a normal operation phase, annual audits should be conducted, provided that the operation and performance of the facility continues to be satisfactory.

A comprehensive Geotechnical Audit Report should be prepared and submitted to NSRL and DMIRS following each annual audit site visit.

8.4 INCIDENTS AND REPORTING

In the operation of the TSF there are many potential incidents that should be recorded, the reporting of such incidents can be spilt into two categories:

- Reportable internally – these are incidents that may affect the day to day operations of the facility and are generally relatively minor. Knight Piésold would not normally be notified of these incidents unless specialist advice is sought; and
- Reportable externally – these are serious incidents that impact the environment and the health and safety of employees and the public. These are significant incidents and are reportable by law to the relevant government agency. Knight Piésold should be notified and specialist advice sought.

As externally reportable incidents are extremely wide ranging, reference should be made to suitable published documents to determine which incidents may be applicable to the facility. Additionally, it is considered that should the licensed conditions be breached then it is likely to be an incident that is externally reportable.

Regardless of the reportable status of an incident, the incident can be split into three general categories:

- Environmental;
- Structural; and
- Health and Safety (Personnel or Public).

Reporting of incidents is an extremely important task as part of the safe operation of a TSF. However, the procedure for reporting should not be one that is prescribed but one that is developed by NSRL within the organisation. NSRL has the following incident reporting procedures and a register managed via INX:

- If an incident occurs, an Incident Report Form is filled in, this is signed off by relevant managers and entered into INX (actions can be tracked until the incident is closed);
- If the incident is classified as major and requires follow-up (including externally reportable), an Investigation Report Form is completed, and this concludes with a Managers Review Meeting; and
- If it is a maintenance issue (i.e. no spill), a work order is raised on PRONTO and work assigned and conducted.

9. OPERATING AND EMERGENCY ACTION PLAN

9.1 GENERAL

A detailed emergency action plan will be developed as part of the operating manual for the TSF to manage emergency situations and unforeseen natural disasters. Potential consequences and remedial procedures will be presented in the operating manual for the following events:

- Power failure;
- Earthquake events;
- Extreme rainfall;
- Dam break/overtopping; and
- Excessive dust.

The consequences of the various situations and some remedial procedures are provided.

9.2 POWER FAILURE

The tailings pumps are connected to the process plant power distribution system and the decant return system is run utilising a genset located on the decant causeway. In the event of a total loss of power, all systems including all pumps and automatic valves not connected to standby generators will cease operations. Systems affected could include:

- Removal of water in the decant pond back to the plant;
- Underdrainage pumping system; and
- Tailings pumping system.

Shutdown of the decant pump will mean that the level of water in the decant pond will slowly begin to rise if tailings continue to be discharged. Visual inspection of the supernatant pond level will be required. The available storage volume is very large, however if power cannot be reinstated within 3 days, temporary power facilities should be installed.

Shutdown of the underdrainage pumps will mean that the head of water overlying the underdrainage system will increase, and consequently the potential for seepage will also increase. If the power outage is likely to be for more than two days then an emergency plan should be initiated to supply temporary power to the underdrainage pumps.

Upon loss of power, the tailings pumping system will shut down. It is expected that, regardless of the length of stoppage, the tailings will be re-mobilised readily on re-commencing pumping. However, in the event that the tailings cannot be re-mobilised, the pipeline(s) will need to be drained by manual valves into sumps constructed at the pipeline(s) low points.

Discontinuing tailings discharge will likely prevent decant water return from being required at the plant. A similar result to no water removal may occur.

9.3 EARTHQUAKE EVENTS

Recorded earthquake events have occurred in the Eastern-Goldfields region and accordingly the TSF has been designed to stringent stability criteria. However, the stability of the facility embankments should be checked annually as part of the review of the facility.

Contingency procedures to be adopted in the event of an earthquake are dependent on the intensity of the earthquake event at the site and are outlined below:

9.3.1 Major Earthquake Event (Modified Mercalli Intensity VI or greater)

Recognition: Difficulty standing, hanging objects quiver, masonry cracks, waves on ponds, some minor injuries (Ref. 3).

Response:

i. Immediately terminate deposition of tailings into the TSF and pumping from the decant;

ii. Immediate inspection of facility embankments and decants for obvious deformation or movement;

iii. Immediate inspection of all pipes including residue pipeline(s) for rupture or leakage;

iv. Arrange for immediate inspection and report of storage by a suitably qualified geotechnical engineer;

v. Deposition can be recommenced if no major damage to facility and pipelines has occurred;

vi. Survey pins and monitoring bores are to be read immediately after the event and all instrumentation to be read daily; and

vii. A detailed daily inspection of the facility is to be undertaken until completion of the geotechnical engineer's report.

9.3.2 Minor Earthquake Event (Modified Mercalli Intensity V or less)

Recognition: Felt outdoors as well as indoors, liquid disturbed, small objects displaced, doors swing open or closed, pictures move (Ref. 3).

Response:

i. Inspect pipelines for rupture or leakage. If required by damage to the lines, stop pumping until repairs are complete;

ii. Inspect embankments and decants for obvious deformation or movement;

iii. Monitor all instrumentation immediately after the event and weekly thereafter until readings return to normal; and

iv. If any damage or leakage is observed, immediately arrange for an inspection by a suitably qualified geotechnical engineer.

9.4 EXTREME RAINFALL EVENTS

The tailings storage facility has a minimum flood storage capacity equivalent to a 1% AEP storm event. For the most part, the flood storage capacity will be well in excess of the design capacity. On this basis it is not expected that overtopping of the embankment will occur.

Major storm events (typically cyclonic) can cause serious erosion problems as well as other damage. A system of inspections should be carried out to mitigate any potential adverse consequences of extreme rainfall.

9.5 DAM FAILURE / OVERTOPPING

9.5.1 General

The TSF embankments are designed for defined operating capacities and specific storm event return periods. The Production Service Technicians working within the facility area will be trained in the correct method and approach to be used for the deposition of tailings.

An assessment has been made, for the facility, of the potential consequences of a release of contaminants (either tailings or water). Typical emergency action plans are provided for each type of release with specific details provided.

The analysis is based on an assessment of potential failure mechanisms, the consequences of each type of failure, and remedial measures that should be undertaken for each situation.

9.5.2 Emergency Action Plan – Contaminated Seepage

All tailings facilities incur seepage to varying degrees. The quantity and quality of the seepage depends on many factors including:

The underdrainage system is expected to intercept a proportion of the seepage. However, good operating practices will assist in reducing seepage, including:

- Reducing the decant pond size at all times by optimising management of the process plant;
- Maximising drying time of successive tailings layers to improve densification and therefore reduce permeability of the tailings;
- Continual operation of the underdrainage system; and
- Maximising the percent solids and density of the tailings.

Seepage from the facility and detection in the monitoring system will be handled as part of the general maintenance and monitoring programme. Monitoring boreholes will be located around the perimeter of the facility and the levels and chemical constituents of the groundwater in the bores will be monitored on a regular basis in accordance with the lease operating conditions.

If unacceptable changes in the concentration of groundwater chemical constituents or groundwater level are detected in the monitoring bores, environmental protocols need to be initiated, which address these issues.

9.5.3 Emergency Action Plan – Embankment Overtopping

As discussed, the risk of embankment overtopping is very low. Regular inspections will ensure that the volume of material which may potentially escape will be small. However, in the event of this situation occurring, the following procedures should be initiated:

- The deposition point should be re-located so that the loss of tailings out of the facility stops;
- An inspection should be made of the extent of the release;
- The Department of Mines Industry Regulation and Safety (DMIRS), the Department of Water and Environment Regulation (DWER) and other relevant authorities should be contacted / notified;
- The tailings after drying should be picked up and stored in the facility;
- Any environmental or other damage should be made good; and
- The area of the crest at which the spill occurred should be flagged off to indicate to the Production Service Technicians that no further deposition is to occur from this area until after the next embankment lift.

9.5.4 Emergency Action Plan – Dam Failure

This is the most critical type of emergency situation with the greatest hazard potential for damage. If such a dam failure occurred the following steps should be taken:

- Shut down the plant and cease deposition into the facility;
- Immediately on determining that a dam break has occurred, check on the location and safety of any personnel known to be in the area. If it is possible that someone has been caught in the flow slide, inform the emergency services (police rescue, etc.) and follow their recommendations;
- Any available suitable earthmoving equipment shall immediately be mobilised to a designated assembly area adjacent to the facility;
- If safe and practical to do so, the flow of supernatant / water from the facility shall be controlled as far as possible, utilising earthmoving equipment to form bunds with the intent of minimising flow into natural watercourses;
- Report the incident to the DMIRS, DWER and other relevant authorities;
- Inform Knight Piésold of the failure as soon as practicable;
- Inspect the flow area, determine the extent of the flow slide and record the damage it has caused;
- Inspect the facility to determine the area of the embankment which has been damaged;
- If the tailings line has been buried or damaged, disassemble the line, remove or repair the damaged sections and re-lay the pipeline into another area of the facility (if practicable) to allow continuation of tailings deposition when safe to do so;
- Fix any damage to the decant structure, pipelines, access roads, etc. as quickly as practicable;
- The breach and the overall facility should be inspected by a competent geotechnical engineer and a repair plan developed;
- Affected areas outside the facility should be inspected and a plan developed to recover the tailings;
- After the tailings has dried and the breach is stable, the tailings should be picked up and placed into the facility;
- The breach should be repaired and all damage to the environment made good;
- The conditions before the failure should be determined and the operating procedure modified so that the same situation does not occur again; and
- Re-commence tailings deposition when safe to do so.

9.6 EXCESSIVE DUST

Dust is a hazard both to site personnel and the surrounding environment and therefore should be controlled throughout the life of the TSF.

There are a number of distinct operations and effects associated with the TSF that have the potential to create dust emissions. The potential sources of dust are:

- Wind blow;
- Movement of vehicles around the site;
- Material excavation, handling and tipping operations; and
- Restoration works.

The following dust measures are considered to be adequate for the control of dust emissions from the TSF. These are:

- Regular and adequate employment of water spraying on unsurfaced areas to control dust emissions. The need for this control will be assessed continually, based upon on-site observations, weather conditions and the potential for dust emission across the site. In particular, dry conditions with high wind speeds would be a cause for action; and
- Progressive restoration and establishment of vegetative cover on the site as soon as possible following construction.

If it is considered essential that operations susceptible to dust are undertaken and personnel are to be exposed to elevated levels of dust, appropriate precautions should be undertaken which can include but are not limited to the following:

- Small localised dust suppression, including mist spray;
- Supply and wearing of appropriate dust masks;
- Provision of change and wash down facility for personnel;
- Personnel dust monitors; and
- Restriction of working periods in elevated dust environments.

The Contractor and Superintendent shall make random audits of dust emissions, and the Superintendent shall have the authority to stop work if, in his opinion, dust emissions are excessive or have the potential to create a safety or environmental problem.

The Contractor has their own safety procedures for tailings pipeline management as part of their contract. The Contractor is responsible for the implementation of proper construction, mining practices and safety precautions.

10. SAFETY IN DESIGN

10.1 GENERAL

As part of the requirements for the design of the TSF facility it is the responsibility of everyone involved to reduce risks associated with the facility as much as practicable.

The TSF has gone through a number of phases in its life cycle for the existing cells as outlined below and these will be repeated for the Cell C and Cell D design:

Phase 1: Initial concept development and design.

Phase 2: Initial construction including installation of equipment, pipework etc.

Phase 3: Discharge of tailings into facility and operation of water recovery and control systems.

Phase 4: Review of operating data and design of Stage 2.

Phase 5: Construction of Stage 2.

Phase 6: Discharge of tailings.

Phases 7 to 21: Repeat of Phases 4 to 6 for subsequent stages.

Phase 22: Review of operating data and final design of facility closure.

Phase 23: Construction of closure components.

Phase 24: Monitoring and reporting on compliance with closure criteria requirements.

10.2 DELINEATION OF RESPONSIBILITY

Each phase has separate requirements and may be under the control of different stakeholders. Table 10.1 provides a list of responsible parties for each of the current phases and an outline of the technical requirements for the responsible parties for future phases.

Table 10.1: Designated responsible parties

Stage	Design	Construction	Operation
Cells C and D Expansion Stage 1	Designer: Knight Piésold Pty Ltd Owner: Northern Star Resources Limited	Clients Supervisor: Knight Piésold Pty Ltd Contractor: T.B.A Owner: Northern Star Resources Limited	Operator: Northern Star Resources Limited
Stages 2 to 6	To be designated (refer to Note 1)	To be designated (refer to Note 2)	Operator: (refer to Note 3)
Closure	To be designated (refer to Notes 2 and 4)	To be designated (refer to Note 2)	Operator: (refer to Note 3)

Note 1: Review of operating parameters and design of facility stages and closure requires selection of an appropriate engineering firm with experience in tailings management (tailings) and civil engineering fields.

Note 2: Client Supervisor responsibility requires selection of an appropriate engineering firm with experience in supervision of civil engineering/earthworks construction.

Contractor responsibility requires selection of an appropriate construction company with experience in construction of civil engineering facilities particularly construction of dams and interaction with mining fleet operations.

Note 3: The current operator of the mine is Northern Star Resources Limited, and it is assumed that their responsibility will be extended to include the operation of the TSF.

Note 4: The designer of the closure phase will also need to include experience in the design of TSF shutdown and closure / rehabilitation requirements.

It should be noted that as the current designer, KP will provide a design for all stages of the facility based on projected throughput and other data. This does not remove the need for design review and detailed construction documentation development for each future stage.

10.3 INCORPORATION OF SAFETY COMPONENTS IN DESIGN STAGE

10.3.1 General

There is a hierarchy of control measures to eliminate or reduce risks as follows:

i. Elimination;

ii. Substitution;

iii. Isolation;

iv. Engineering controls;

v. Administrative controls; and

vi. Personal protective equipment.

For the storage of tailings there are certain minimum requirements involving the need for a storage facility including embankment and methods for delivery of the tailings and removal of surplus water. As a result, many of the hazards associated with the facility cannot be eliminated and engineering and administrative control systems are required.

10.3.2 Engineering Controls

The design has incorporated a number of design aspects to reduce risks associated with the facility as follows:

- TSF Expansion integrating the development of the Eastern Waste Dump increases safety of the embankment for seismic loading and settlement;
- The embankment has been designed with zones to reduce seepage flow and improve stability by lowering the phreatic surface;
- A cut-off trench was constructed under the embankment to reduce seepage flows through the foundation material;
- Drains were constructed at the facility upstream toe to increase tailings densities near the embankment, reduce the phreatic surface and reduce seepage losses;
- Conservative parameters and safety factors have been used in the design;
- Design includes safety berms for all embankment crest areas; and
- The TSF Cell A and Cell B Expansion has been operated for several years and the initial TSF Cell C and Cell D Stage 1 is designed for an operating period of 2 years which will allow sufficient time to allow verification and confirmation of tailings beach slopes and achieved densities, well before construction of Stage 2 is required. The timing or height of Stage 2 can then be adjusted if required.

10.3.3 Knowledge Transfer to Downstream Responsible Parties

As the designer it is necessary to provide a clear understanding of the responsible parties for the construction and operational phases regarding the assumptions made for how the facility is to be constructed and operated. Primarily knowledge transfer is achieved by providing various documents outlining construction requirements and management procedures. These include:

Construction

- Provision of construction drawings for TSF Expansion Stages 2 to 6;
- A technical specification covering all aspects of construction of the facility including QA/QC requirements; and
- Specification for QA testing separate from the Contractor.

Operation

- An operating manual outlining deposition concepts and targets, minimum monitoring, maintenance requirements, required inspection levels and frequency.

10.3.4 Ongoing Review and Design Re-assessment

In order to ensure that the original design intent is met or alternatively that changes to the intent are backed up with detailed design work, the life cycle incorporates a series of regular checks on the operation and design. These include the following:

- Annual audits of the facility by a competent geotechnical engineer to comply with the requirements of the DMIRS guidelines (Ref.4);
- A design phase for each subsequent stage (stages at about 3 year frequency) involving review of operating parameters to date and any required modifications to the design based on forward projections for the next stage; and
- Testing of rehabilitation and closure requirements during the operating phase with ongoing monitoring after closure (as outlined in the closure documentation).

The ongoing review of the operation and design will ensure that the facility can be modified as required for any changes to the conditions and operation of the mine site.

11. CONSTRUCTION

Construction for each stage will be conducted by a dedicated earthworks contractor and will utilise mining operations for material source and delivery. A dedicated construction management team, technical supervision and quality assurance/quality control (QA/QC) is required for each stage of construction to ensure the facility is constructed to the design intent. At the completion of each subsequent embankment raise, an “as built” drawing set and construction report will be prepared. This will be completed so the report can be submitted to regulators within timeframes stipulated within the works approval. The report will collate the QA/QC records, document changes to the design to suit site conditions and reasons for the changes and verification of the material parameters actually used with an updated seepage and stability model if required.

11.1 SCOPE OF WORK

The scope of works for the contractor of each stage includes supply of all necessary personnel, equipment and materials, and undertaking of all works necessary to construct the embankment in accordance with the Drawings and Specifications. In summary, each stage construction works comprises the following elements:

- Mobilisation to site;
- Initial survey pickup for DTM;
- Construction of the TSF zoned embankment to the design levels and grades, including, erosion protection, wearing course and safety bunds;
- Construct concrete underdrainage tower base and towers with waste surround, access causeway and inlet excavation;
- Construct concrete decant base and slotted towers with rock surround, access causeway and inlet excavation;
- Supply and installation of monitoring boreholes and assist with the installation of piezometers and other instrumentation;
- Final and intermediate survey pickup for DTM; and
- Demobilisation from site.

11.2 TECHNICAL SPECIFICATION

11.2.1 Embankment Zones Placement

The embankment material shall be placed uniformly without abrupt changes in material type, quality or size for each zone. The following zones are required for the construction of the TSF.

Zone A

Zone A layer shall comprise low permeability fill meeting grading requirements outlined in Table 11.1. The material shall have a minimum plasticity index of 8.

Table 11.1: Zone A material grading requirements

Sieve Size (mm)	% Passing
19	100
9.5	50 – 100
2.36	30 - 100
0.075	30 - 90

Zone A material shall be material sourced from the tailings beach or Waste Dump. The Contractor shall condition the material to obtain moisture content suitable for placement and compaction. The method by which the contractor conditions the material shall be subject to the approval of the Engineer. The layer shall be compacted to density limits of at least 98% SMDD.

The material shall be placed and compacted in successive horizontal layers of loose material so that the maximum compacted layer depth is not greater than 300 mm.

Compaction of Zone A material shall be completed with vibratory pad foot compactor and sealed off using a smooth drum compactor in the case of wet weather. During the compaction process the embankment foundation shall be lightly watered or dried as required to maintain specified moisture content.

Zone C

Zone C is the structural fill zone. The material shall be sourced from borrow areas, existing stockpiles, excavations associated with the works, or other areas as directed by the Engineer.

The material shall have a Plasticity Index of at least 5% and shall have a grading conforming to the limits as given in the Table 11.2.

Table 11.2: Zone C gradation limits

Sieve Size (mm)	Percent Passing	
	Minimum	Maximum
300	100	100
37.5	70	100
19	30	100
4.75	10	100
0.425	0	70
0.075	0	30

Zone C1

Zone C1 construction shall be carried out in accordance with the following method specification:

i. Any areas where proof rolling results in excessive heaving or rutting (to the point where the foundation becomes un-trafficable), shall be removed and replaced with approved Zone C1 fill.

ii. The footprint area of each Zone C1 layer shall be proof rolled and nominally compacted by trafficking loaded haul trucks uniformly across the full bench width prior to commencing the next layer of filling. It is noted that clearing/stripping operations will effectively complete this task prior to placement of the first layer of Zone C1 fill.

iii. The compacted layer thickness for oxidised waste material in Zone C1 shall be 0.5 – 0.7 m (nominally 0.7 – 1.0 m layer uncompacted). This layer thickness should be confirmed (and may be modified) with the Engineer once the material properties and vehicle type performing traffic compaction are confirmed.

iv. The compacted layer thickness for fresh rock material in Zone C1 shall be 1.5 – 2.5 m.

v. Any boulders (greater than 1.3 m diameter) within the Zone C1 areas shall be pushed to the downstream batter of Zone C1 (away from any Zone B / Zone C1 interface).

vi. When paddock dumping waste during the wet season, piles of material shall be spread (and compacted) as soon as practicable, to reduce the risk of large volumes of uncompacted fill becoming saturated within the embankment profile. Saturated fill, caused by rainfall onto dumped piles left in place by the Contractor, shall be removed from the TSF embankment extents.

vii. The material shall be placed and spread in a manner that ensures even trafficking across the entire platform by the hauling fleet.

viii. Any completed fill areas that rut or significantly deform under haul truck trafficking, as designated by the Engineer, shall be excavated and the spoil hauled to a stockpile remote from the TSF embankment, as nominated by the Company.

ix. Each Zone C1 layer shall be constructed in a manner that remains free draining and so that water sheds away from the completed embankment/previous layer.

x. If required, trimming of the Zone C1 upstream face will be completed as part of the Zone A / Zone B raise construction. Zone C1 material shall be placed to ensure there is minimal surplus material requiring removal to achieve the final trimmed profile. This can be achieved by ensuring (via survey set out) the toe of each fill layer is located on the final Zone B / Zone C1 interface line.

Zone D

Zone D is random fill to be constructed from general fill material sourced from various locations around the site. Proposed materials may be sourced from borrow areas, excavations associated with the works, or other areas as directed by the Engineer.

Zone E

Zone E is a riprap erosion protection zone to be sourced from pit borrow or existing mine waste dumps by the Contractor. Proposed materials may also be sourced from any other excavation providing that the material is to the satisfaction of the Engineer.

The riprap shall be free of wood, steel, organics and other deleterious materials. Zone E material shall consist of hard, dense and durable rock and shall be well graded within the following limits, except as otherwise approved by the Engineer in writing:

i. Maximum rock size shall be not greater than that which can be encompassed in the layer thickness shown on the Drawings.
ii. Not less than 25 percent, by weight, of the material shall consist of rock having an average dimension greater than 200 mm.
iii. Not more than 15 percent, by weight, of the material shall consist of rock having an average dimension of less than 75 mm.
iv. A maximum fines content (<0.075 mm) of 5%.

The Zone E material need not be hand placed but may be dumped and spread by approved methods to a layer thickness as shown on the Drawings in such a manner as to ensure that the finer material is generally near the surface on which the rip rap is placed; that the larger rocks are generally near the outer surface; that the completed rip rap is stable without any tendency to slide and that there are no large unfilled voids. Hand working of the outer surface may be necessary to meet this requirement.

Zone G

Zone G decant surround material shall be obtained from waste dumps by the Contractor as directed by the Principal. Zone G material shall comprise sound, durable, clean, sub-angular to angular rock fragments and be free of wood, steel, organics and other deleterious material. Due to the intended purpose of the zone, the placed material shall comprise clean rock-fill and have a general particle size of between 100 mm and 300 mm and little or no fines (less than 5% passing 0.075 mm sieve).

Zone F

Zone F is classified as a free draining sand/gravel drainage medium. The drainage medium will be sourced from the nominated borrow as directed by the Principal. The target grading envelope for the material is given in Table 11.3. To achieve the specified grading requirements screening may be required.

Table 11.3: Zone F grading requirements

Sieve Size (mm)	% Passing
19	100
2.36	40 - 100
0.425	0 - 30
0.075	0 - 5

Wearing Course

The wearing course shall consist of durable, select laterite/gravel or other suitable material approved by the Engineer. Wearing course material shall be sourced from borrow areas, existing stockpiles, excavations associated with the works, or other areas as directed by the Engineer.

The wearing course shall be free from cobbles, stumps, roots, sticks, vegetable matter and other deleterious matter. It shall be placed to the lines and grades as indicated on the Drawings. Wearing course material shall have a gradation as specified in Table 11.4.

Table 11.4: Wearing course gradation limits

AS test sieve	Percentage by mass of total aggregate passing test sieve	
	Nominal maximum particle size	
	37.5 mm	20 mm
63.0	100	-
37.5	80 – 100	100
19.0	60 – 80	80 – 100
9.5	45 – 65	55 – 80
4.75	30 – 50	40 – 60
2.36	20 – 40	30 – 50
0.425	10 – 25	12 – 27
0.075	5 – 15	5 – 15

In addition, the wearing course material should have a plasticity index of between 0 and 10%, and a liquid limit of between 0 and 25%.

Topsoil

Topsoil is defined as soil of any gradation or degree of plasticity which contains significant quantities of visually identifiable vegetation, sod, roots or humus. Topsoil material will be won from stripping operations and kept in stockpile, until being utilised for rehabilitation of the site.

11.2.2 Quality Assurance

This section details all quality control and acceptance testing associated with earthworks items that is to be carried out by the Engineer. The extent of testing shall be at the discretion of the Company Representative and generally as detailed herein.

Tests shall be carried out as the work progresses to ensure that construction conforms to the requirements of this Specification. All tests shall be carried out in accordance with AS1289 (Methods of Testing Soils for Engineering Purposes) unless stated otherwise.

Testing frequencies for quality control shall be as advised by the Engineer. Table 11.5 summarises the minimum amount of testing required.

Table 11.5: Quality control and record testing

Type of Test	Frequency (Once per)
Zone A (Tailings)	
Atterberg Limits	5,000 m^3
Particle Size Distribution (PSD)	5,000 m^3
Moisture – Density Relationship	5,000 m^3
Field density and moisture content	500 m^3
Zone A (Mine waste)	
Atterberg Limits	2,500 m^3
Particle Size Distribution (PSD)	2,500 m^3
Moisture – Density Relationship	2,500 m^3
Field density and moisture content	500 m^3
Zones E & G	
Particle Size Distribution (PSD)	5,000 m^3
Thickness Verification	
Survey Instrument grid Point	100 m^2
Direct measurement via auger/excavation hole or other approved method	5,000 m^2

12. REHABILITATION

12.1 EMBANKMENT PROFILE

At the end of the TSF operation, the final stage downstream face of the TSF embankment will have an overall slope of 1V: 3.5 H (15.9°). The adopted downstream profile will be inherently stable under both normal and seismic loading conditions, will provide a stable drainage system, and will allow for re-vegetation.

With the proposed upstream construction, rehabilitation can commence a number of years before planned closure to allow the performance to be monitored and modified as necessary. The embankment downstream face will be rehabilitated with topsoil which has been stockpiled from construction activities.

12.2 CAPPING

Based on the geochemistry results available, the tailings are assessed to be enriched with metals, and high arsenic concentration. Closure of the facility will require a cover system including a capillary break to prevent upward migration of salinity, a low permeability layer to reduce ingress of water and oxygen and an erosion protection layer overlain. This will be reviewed in the detailed rehabilitation phase.

The main focus of the rehabilitation programme will be re-vegetation, erosion control and stormwater management. Establishing a surface cover of vegetation will reduce the potential for adverse environmental impact such as dust generation and rainfall erosion, as well as improving aesthetics.

Rehabilitation of the tailings surface will commence upon termination of tailings deposition. After removal of the pond around the decant area, drying of the tailings is expected to take several months. The underdrainage system will need to continue to operate for a number of years after completion of capping and re-vegetation to drain excess water from the tailings deposit.

The final profile of the tailings surface will form a water harvesting structure towards decant towers to collect rainfall for vegetation growth. A more detailed decommissioning/closure plan will be developed for the tailings storage facility during the final years of operation.

12.3 INFRASTRUCTURE CLOSURE

The removal of infrastructure at closure will be staged and will proceed through the following steps:

- The final supernatant pond will progressively evaporate after tailings deposition has ceased;

- The tailings surface will be allowed to dry until it has sufficient strength to provide access;
- The tailings distribution pipelines will be removed from the embankment;
- The decant pump and associated electrical and mechanical infrastructure will be removed;
- The decant tower will be backfilled with coarse rock to the surface of the causeway;
- The underdrainage system will continue to be operated intermittently until the quantity of water reduces. No set duration can be specified, but typically this will be in the order of 6 – 12 months. After the flow reduces, the underdrainage pump will be removed and the underdrainage tower will be backfilled with coarse rock;
- The embankment external faces will be rehabilitated if not already done so as part of the final embankment stage works earlier;
- The cover design will be placed over the tailings surface, with topsoil and revegetation; and
- The monitoring bores will continue to be monitored as set out by any permitting requirements.

13. REFERENCES

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10. The 2018 National Seismic Hazard Assessment for Australia, Geoscience Australia: Canberra.
11. Knight Piésold Pty Ltd: Thunderbox Operation, TSF Expansion Stage 7-9 permitting design Rev 0, Sep 2018, Ref: PE801-00296/11.
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TABLES

TABLE 6.4: TSF CELL C WATER BALANCE - AVERAGE CONDITIONS

Year	Month	Rainfall	Evaporation	Cumulative Tonnage	Tailings Level	Tailings density		Water in Slurry	Supernatant Runoff	Rainfall Runoff	Evaporation Losses	Pond Volume	Consolidation Volume	Available TSF		Discharge	Make Up Requirement
						Layers	Mass							Recycle			
		mm	mm	t	RL m	t/m3	t/m3	m³	m³	m³	m³	m³	m³	m³	%	m³	m³
	Aug-22	35.1	136	279,517	486.36	1.35	1.35	170,295	54,254	6,734	1,666	5,251	-	-	0.0%	-	170,295
	Sep-22	0.6	198.9	559,033	487.24	1.41	1.38	170,295	51,859	173	3,202	5,000	-	-	0.0%	-	170,295
	Oct-22	27.8	285.2	838,550	487.63	1.54	1.43	170,295	49,316	9,722	4,776	5,000	-	-	0.0%	-	170,295
	Nov-22	0.7	332.8	1,118,067	488.00	1.61	1.47	170,295	47,443	279	5,715	5,000	-	5,779	3.4%	-	164,516
1	Dec-22	2	388.8	1,397,584	488.36	1.61	1.51	170,295	45,998	887	6,883	5,000	-	2,689	1.6%	-	167,606
	Jan-23	0	404.1	1,677,100	488.72	1.61	1.53	170,295	45,468	-	7,204	5,000	1,529	1,926	1.1%	-	168,369
	Feb-23	19.2	320.8	1,956,617	489.06	1.61	1.55	170,295	46,935	10,192	5,462	5,000	798	1,020	0.6%	-	169,275
	Mar-23	17.5	288.7	2,236,134	489.31	1.61	1.56	170,295	48,975	9,616	4,817	5,000	493	3,375	2.0%	-	166,920
	Apr-23	57.7	192.9	2,515,651	489.57	1.61	1.57	170,295	51,737	31,877	3,036	5,000	340	-	0.0%	-	170,295
	May-23	29.2	128.3	2,795,167	489.84	1.50	1.56	170,295	53,932	16,205	1,923	5,000	207	882	0.5%	-	169,413
	Jun-23	20.7	90.5	3,074,684	490.13	1.44	1.55	170,295	55,007	11,555	1,317	5,000	178	-	0.0%	-	170,295
	Jul-23	13.9	98.4	3,354,201	490.41	1.46	1.54	170,295	54,856	7,796	1,439	5,000	164	-	0.0%	-	170,295
	Aug-23	35.1	136	3,633,718	490.67	1.53	1.54	170,295	53,692	19,788	2,051	5,000	144	-	0.0%	-	170,295
	Sep-23	0.6	198.9	3,913,234	490.92	1.61	1.55	170,295	51,539	340	3,127	5,000	595	-	0.0%	-	170,295
	Oct-23	27.8	285.2	4,192,751	491.16	1.61	1.56	170,295	49,072	15,810	4,751	5,000	1,849	-	0.0%	-	170,295
	Nov-23	0.7	332.8	4,472,268	491.41	1.61	1.57	170,295	47,254	399	5,693	5,000	2,157	5,779	3.4%	-	164,516
2	Dec-23	2	388.8	4,751,784	491.65	1.61	1.57	170,295	45,863	1,144	6,864	5,000	1,199	2,689	1.6%	-	167,606
	Jan-24	0	404.1	5,031,301	491.89	1.61	1.58	170,295	45,388	-	7,193	5,000	824	1,926	1.1%	-	168,369
	Feb-24	19.2	320.8	5,310,818	492.14	1.61	1.58	170,295	46,902	11,056	5,458	5,000	621	1,020	0.6%	-	169,275
	Mar-24	17.5	288.7	5,590,335	492.38	1.61	1.58	170,295	48,959	10,087	4,815	5,000	483	59,070	34.7%	-	111,225
	Apr-24	57.7	192.9	5,869,851	492.63	1.61	1.58	170,295	51,726	33,363	3,035	5,000	509	49,082	28.8%	-	121,213
	May-24	29.2	128.3	6,149,368	492.89	1.52	1.58	170,295	53,926	16,921	1,923	5,000	433	54,263	31.9%	-	116,032
	Jun-24	20.7	90.5	6,428,885	493.16	1.45	1.58	170,295	55,003	12,034	1,316	5,000	389	42,006	24.7%	-	128,289
	Jul-24	13.9	98.4	6,708,402	493.42	1.46	1.57	170,295	54,852	8,099	1,439	5,000	358	40,002	23.5%	-	130,293
	Aug-24	35.1	136	6,708,402	493.42	-	1.57	-	-	20,451	2,045	5,000	315	39,792	0.0%	-	-
	Sep-24	0.6	198.9	6,708,402	493.42	-	1.57	-	-	350	3,114	5,000	273	52,463	0.0%	-	-
	Oct-24	27.8	285.2	6,708,402	493.42	-	1.57	-	-	16,197	4,726	5,000	50	54,267	0.0%	-	-
	Nov-24	0.7	332.8	6,708,402	493.42	-	1.57	-	-	408	5,658	5,000	10	80,918	0.0%	-	-
3	Dec-24	2	388.8	6,708,402	493.42	-	1.57	-	-	1,165	6,820	5,000	2	68,421	0.0%	-	-
	Jan-25	0	404.1	6,708,402	493.42	-	1.57	-	-	-	7,145	5,000	0	65,423	0.0%	-	-
	Feb-25	19.2	320.8	6,909,587	493.59	1.61	1.57	122,572	33,754	11,177	5,449	5,000	0	61,377	50.1%	-	61,195
	Mar-25	17.5	288.7	7,110,773	493.76	1.61	1.58	122,572	35,236	10,192	4,808	5,000	0	71,573	58.4%	-	50,999
	Apr-25	57.7	192.9	7,311,959	493.93	1.61	1.58	122,572	37,229	33,672	3,032	5,000	947	49,347	40.3%	-	73,224
	May-25	29.2	128.3	7,513,144	494.10	1.61	1.58	122,572	38,813	17,062	1,921	5,000	1,948	61,979	50.6%	-	60,593
	Jun-25	20.7	90.5	7,714,330	494.28	1.52	1.58	122,572	39,588	12,121	1,316	5,000	1,282	44,118	36.0%	-	78,454
	Jul-25	13.9	98.4	7,915,516	494.45	1.55	1.58	122,572	39,479	8,150	1,438	5,000	959	41,341	33.7%	-	81,231
	Aug-25	35.1	136	8,116,701	494.62	1.61	1.58	122,572	38,641	20,616	2,049	5,000	784	39,019	31.8%	-	83,553
	Sep-25	0.6	198.9	8,317,887	494.79	1.61	1.58	122,572	37,089	353	3,123	5,000	625	53,120	43.3%	-	69,452
	Oct-25	27.8	285.2	8,519,073	494.96	1.61	1.59	122,572	35,311	16,382	4,743	5,000	499	54,714	44.6%	-	67,858
	Nov-25	0.7	332.8	8,720,259	495.13	1.61	1.59	122,572	34,001	413	5,682	5,000	452	82,563	67.4%	-	40,009
4	Dec-25	2	388.8	8,921,444	495.30	1.61	1.59	122,572	32,999	1,182	6,850	5,000	488	69,358	56.6%	-	53,214
	Jan-26	0	404.1	9,122,630	495.47	1.61	1.59	122,572	32,657	-	7,178	5,000	406	66,111	53.9%	-	56,461
	Feb-26	19.2	320.8	9,323,816	495.63	1.61	1.59	122,572	33,749	11,397	5,448	5,000	355	61,869	50.5%	-	60,703
	Mar-26	17.5	288.7	9,525,001	495.80	1.61	1.59	122,572	35,232	10,392	4,807	5,000	318	18,720	15.3%	-	103,852
	Apr-26	57.7	192.9	9,726,187	495.97	1.61	1.59	122,572	37,226	34,327	3,032	5,000	289	-	0.0%	-	122,572
	May-26	29.2	128.3	9,927,373	496.14	1.61	1.59	122,572	38,811	17,392	1,921	5,000	266	11,521	9.4%	-	111,050
	Jun-26	20.7	90.5	10,128,559	496.31	1.53	1.59	122,572	39,587	12,352	1,316	5,000	262	-	0.0%	-	122,572
	Jul-26	13.9	98.4	10,329,744	496.49	1.56	1.59	122,572	39,478	8,305	1,438	5,000	256	-	0.0%	-	122,572
	Aug-26	35.1	136	10,530,930	496.66	1.61	1.59	122,572	38,639	21,003	2,049	5,000	252	-	0.0%	-	122,572
	Sep-26	0.6	198.9	10,732,116	496.82	1.61	1.59	122,572	37,086	360	3,122	5,000	234	39,482	32.2%	-	83,090
	Oct-26	27.8	285.2	10,933,301	496.99	1.61	1.59	122,572	35,308	16,684	4,743	5,000	212	40,620	33.1%	-	81,951
	Nov-26	0.7	332.8	11,134,487	497.15	1.61	1.59	122,572	33,997	421	5,681	5,000	190	68,816	56.1%	-	53,756
5	Dec-26	2	388.8	11,335,673	497.31	1.61	1.59	122,572	32,995	1,201	6,850	5,000	158	55,902	45.6%	-	66,670
	Jan-27	0	404.1	11,536,858	497.47	1.61	1.59	122,572	32,653	-	7,178	5,000	153	51,676	42.2%	-	70,896
	Feb-27	19.2	320.8	11,536,858	497.47	-	1.60	-	-	11,528	5,424	5,000	211	47,150	0.0%	-	-
	Mar-27	17.5	288.7	11,536,858	497.47	-	1.60	-	-	10,507	4,790	5,000	174	57,991	0.0%	-	-
	Apr-27	57.7	192.9	11,536,858	497.47	-	1.60	-	-	34,644	3,023	5,000	46	34,944	0.0%	-	-
	May-27	29.2	128.3	11,536,858	497.47	-	1.60	-	-	17,532	1,917	5,000	19	47,450	0.0%	-	-
	Jun-27	20.7	90.5	11,536,858	497.47	-	1.60	-	-	12,429	1,314	5,000	9	29,185	0.0%	-	-
	Jul-27	13.9	98.4	11,536,858	497.47	-	1.60	-	-	8,346	1,436	5,000	5	27,819	0.0%	-	-
	Aug-27	35.1	136	11,744,967	497.64	1.61	1.60	126,790	39,968	21,079	2,049	5,000	2	25,885	20.4%	-	100,904
	Sep-27	0.6	198.9	11,953,076	497.81	1.61	1.60	126,790	38,362	360	3,123	5,000	1	40,053	31.6%	-	86,737
	Oct-27	27.8	285.2	12,161,184	497.98	1.61	1.60	126,790	36,523	16,689	4,743	5,000	136	41,134	32.4%	-	85,655
	Nov-27	0.7	332.8	12,369,293	498.15	1.61	1.60	126,790	35,167	420	5,682	5,000	144	68,810	54.3%	-	57,980
6	Dec-27	2	388.8	12,577,401	498.31	1.61	1.60	126,790	34,130	1,200	6,851	5,000	122	54,547	43.0%	-	72,243
	Jan-28	0	404.1	12,785,510	498.48	1.61	1.60	126,790	33,777	-	7,179	5,000	115	50,886	40.1%	-	75,903
	Feb-28	19.2	320.8	12,993,618	498.65	1.61	1.60	126,790	34,907	11,532	5,448	5,000	109	46,601	36.8%	-	80,189
	Mar-28	17.5	288.7	13,201,727	498.82	1.61	1.60	126,790	36,442	10,497	4,808	5,000	96	57,845	45.6%	-	68,945
	Apr-28	57.7	192.9	13,409,835	498.99	1.61	1.60	126,790	38,506	34,615	3,032	5,000	91	34,558	27.3%	-	92,232
	May-28	29.2	128.3	13,617,944	499.15	1.61	1.60	126,790	40,146	17,508	1,921	5,000	86	47,461	37.4%	-	79,329
	Jun-28	20.7	90.5	13,826,052	499.33	1.52	1.60	126,790	40,949	12,413	1,316	5,000	87	28,927	22.8%	-	97,863
	Jul-28	13.9	98.4	14,034,161	499.50	1.55	1.60	126,790	40,836	8,331	1,438	5,000	86	27,504	21.7%	-	99,286
	Aug-28	35.1	136	14,034,161	499.50	-	1.60	-	-	21,036	2,045	5,000	86	25,629	0.0%	-	-
	Sep-28	0.6	198.9	14,034,161	499.50	-	1.60	-	-	360	3,114	5,000	83	6,315	0.0%	-	-
	Oct-28	27.8	285.2	14,034,161	499.50	-	1.60	-	-	16,661	4,726	5,000	39	5,892	0.0%	-	-
	Nov-28	0.7	332.8	14,034,161	499.50	-	1.60	-	-	420	5,658	5,000	20	31,666	0.0%	-	-
7	Dec-28	2	388.8	14,034,161	499.50	-	1.60	-	-	1,199	6,820	5,000	11	15,634	0.0%	-	-
	Jan-29	0	404.1	14,034,161	499.50	-	1.60	-	-	-	7,145	5,000	6	11,124	0.0%	-	-
	Feb-29	19.2	320.8	14,278,335	499.69	1.61	1.60	148,763	40,957	11,541	5,453	5,000	3	6,914	4.6%	-	141,848
	Mar-29	17.5	288.7	14,522,509	499.88	1.61	1.60	148,763	42,758	10,502	4,811	5,000	2	59,000	39.7%	-	89,763
	Apr-29	57.7	192.9	14,766,683	500.08	1.61	1.60	148,763	45,179	34,634	3,033	5,000	42	35,601	23.9%	-	113,161
	May-29	29.2	128.3	15,010,858	500.27	1.58	1.60	148,763	47,103	17,515	1,922	5,000	167	48,605	32.7%	-	100,158
	Jun-29	20.7	90.5	15,255,032	500.48	1.48	1.60	148,763	48,046	12,418	1,316	5,000	250	30,050	20.2%	-	118,713
	Jul-29	13.9	98.4	15,499,206	500.69	1.50	1.60	148,763	47,913	8,333	1,439	5,000	205	28,602	19.2%	-	120,161
	Aug-29	35.1	136	15,743,380	500.89	1.60	1.60	148,763	46,895	21,037	2,050	5,000	179	26,713	18.0%	-	122,049
	Sep-29	0.6	198.9	15,987,555	501.08	1.61	1.60	148,763	45,011	360	3,124	5,000	155	41,099	27.6%	-	107,664
	Oct-29	27.8	285.2	16,231,729	501.27	1.61	1.60	148,763	42,853	16,653	4,746	5,000	1,012	42,227	28.4%	-	106,536
	Nov-29	0.7	332.8	16,475,903	501.46	1.61	1.60	148,763	41,263	419	5,686	5,000	1,228	70,180	47.2%	-	78,583
8	Dec-29	2	388.8	16,720,077	501.65	1.61	1.60	148,763	40,047	1,197	6,856	5,000	739	55,819	37.5%	-	92,944
	Jan-30	0	404.1	16,964,251	501.84	1.61	1.60	148,763	39,632	-	7,185	5,000	510	52,133	35.0%	-	96,629
	Feb-30	19.2	320.8	16,964,251	501.84	-	1.60	-	-	11,493	5,424	5,000	400	47,815	0.0%	-	-
	Mar-30	17.5	288.7	16,964,251	501.84	-	1.60	-	-	10,475	4,790	5,000	331	19,078	0.0%	-	-
	Apr-30	57.7	192.9	16,964,251	501.84	-	1.60	-	-	34,539	3,023	5,000	42	-	0.0%	-	-
	May-30	29.2	128.3	16,964,251	501.84	-	1.60	-	-	17,479	1,917	5,000	22	11,974	0.0%	-	-
	Jun-30	20.7	90.5	16,964,251	501.84	-	1.60	-	-	12,391	1,314	5,000	14	-	0.0%	-	-
	Jul-30	13.9	98.4	16,964,251	501.84	-	1.60	-	-	8,320	1,436	5,000	9	-	0.0%	-	-
	Aug-30	35.1	136	17,215,707	502.04	1.59	1.60	153,199	48,293	21,013	2,050	5,000	6	-	0.0%	-	153,199
	Sep-30	0.6	198.9	17,467,162	502.24	1.61	1.60	153,199	46,354	359	3,125	5,000	4	47,049	30.7%	-	106,150
	Oct-30	27.8	285.2	17,718,618	502.44	1.61	1.60	153,199	44,131	16,634	4,747	5,000	293	48,451	31.6%	-	104,747
	Nov-30	0.7	332.8	17,970,073	502.64	1.61	1.60	153,199	42,494	419	5,687	5,000	255	76,821	50.1%	-	76,378
9	Dec-30	2	388.8	18,221,528	502.84	1.61	1.60	153,199	41,241	1,196	6,857	5,000	215	62,864	41.0%	-	90,335

TABLE 6.4: TSF CELL C WATER BALANCE - AVERAGE CONDITIONS

Year	Month	Rainfall	Evaporation	Cumulative Tonnage	Tailings Level	Tailings density		Water in Slurry	Supernatant Runoff	Rainfall Runoff	Evaporation Losses	Pond Volume	Consolidation Volume	Available TSF Recycle		Discharge	Make Up Requirement
						Layers	Mass										
		mm	mm	t	RL m	t/m3	t/m3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	%	m^3	m^3
	Jan-31	0	404.1	18,472,984	503.04	1.61	1.60	153,199	40,815	-	7,186	5,000	189	59,398	38.8%	-	93,801
	Feb-31	19.2	320.8	18,724,439	503.24	1.61	1.60	153,199	42,180	11,492	5,454	5,000	171	55,013	35.9%	-	98,185
	Mar-31	17.5	288.7	18,975,894	503.44	1.61	1.60	153,199	44,034	10,457	4,811	5,000	152	66,061	43.1%	-	87,137
	Apr-31	57.7	192.9	19,227,350	503.65	1.61	1.60	153,199	46,527	34,485	3,034	5,000	143	42,401	27.7%	-	110,797
	May-31	29.2	128.3	19,478,805	503.85	1.57	1.60	153,199	48,509	17,439	1,922	5,000	136	55,772	36.4%	-	97,427
	Jun-31	20.7	90.5	19,730,260	504.07	1.47	1.60	153,199	49,479	12,365	1,316	5,000	121	37,224	24.3%	-	115,975
	Jul-31	13.9	98.4	19,981,716	504.29	1.49	1.60	153,199	49,343	8,297	1,439	5,000	119	35,127	22.9%	-	118,071
	Aug-31	35.1	136	19,981,716	504.29	-	1.60	-	-	20,951	2,045	5,000	106	32,958	0.0%	-	-
	Sep-31	0.6	198.9	19,981,716	504.29	-	1.60	-	-	358	3,114	5,000	99	6,469	0.0%	-	-
	Oct-31	27.8	285.2	19,981,716	504.29	-	1.60	-	-	16,594	4,726	5,000	35	6,017	0.0%	-	-
	Nov-31	0.7	332.8	19,981,716	504.29	-	1.60	-	-	418	5,658	5,000	14	31,558	0.0%	-	-
10	Dec-31	2	388.8	19,981,716	504.29	-	1.60	-	-	1,194	6,820	5,000	7	15,583	0.0%	-	-
	Jan-32	0	404.1	19,981,716	504.29	-	1.60	-	-	-	7,145	5,000	4	11,091	0.0%	-	-
	Feb-32	19.2	320.8	20,232,235	504.49	1.61	1.60	152,628	42,023	11,473	5,454	5,000	2	6,894	4.5%	-	145,734
	Mar-32	17.5	288.7	20,482,754	504.68	1.61	1.60	152,628	43,870	10,440	4,811	5,000	2	67,263	44.1%	-	85,366
	Apr-32	57.7	192.9	20,733,273	504.88	1.61	1.60	152,628	46,354	34,427	3,034	5,000	896	43,592	28.6%	-	109,036
11	May-32	29.2	128.3	20,983,791	505.08	1.57	1.60	152,628	48,328	17,410	1,922	5,000	1,452	56,311	36.9%	-	96,317

TABLE 6.5: TSF CELL D WATER BALANCE - AVERAGE CONDITIONS

Year	Month	Rainfall	Evaporation	Cumulative Tonnage	Tailings Level	Tailings density		Water in Slurry	Supernatant Runoff	Rainfall Runoff	Evaporation Losses	Pond Volume	Consolidation Volume	Available TSF Recycle		Discharge	Make Up Requirement
						Layers	Mass										
		mm	mm	t	RL m	t/m3	t/m3	m³	m³	m³	m³	m³	m³	m³	%	m³	m³
	Aug-22	35.1	136	124,355	488.27	1.35	1.35	75,763	24,445	5,488	1,728	5,194	-	28,011	37.0%	-	47,752
	Sep-22	0.6	198.9	248,710	489.18	1.42	1.39	75,763	23,272	125	3,185	5,000	-	20,406	26.9%	1	55,357
	Oct-22	27.8	285.2	373,065	489.55	1.58	1.44	75,763	22,140	6,653	4,769	5,000	-	24,024	31.7%	2	51,739
	Nov-22	0.7	332.8	497,420	489.91	1.59	1.48	75,763	21,310	184	5,708	5,000	-	15,786	20.8%	3	59,977
1	Dec-22	2	388.8	621,775	490.27	1.60	1.51	75,763	20,663	569	6,875	5,000	-	14,357	18.9%	4	61,406
	Jan-23	0	404.1	746,130	490.62	1.60	1.53	75,763	20,410	-	7,197	5,000	617	13,829	18.3%	5	61,934
	Feb-23	19.2	320.8	870,485	490.97	1.60	1.54	75,763	21,022	6,319	5,458	5,000	343	22,227	29.3%	6	53,536
	Mar-23	17.5	288.7	994,840	491.15	1.60	1.55	75,763	21,888	6,099	4,812	5,000	212	23,387	30.9%	7	52,376
	Apr-23	57.7	192.9	1,119,195	491.32	1.60	1.56	75,763	23,076	21,123	3,033	5,000	154	41,320	54.5%	8	34,443
	May-23	29.2	128.3	1,243,550	491.49	1.60	1.57	75,763	24,026	11,188	1,922	5,000	71	33,364	44.0%	9	42,399
	Jun-23	20.7	90.5	1,367,906	491.67	1.51	1.56	75,763	24,492	8,301	1,316	5,000	55	31,533	41.6%	10	44,230
	Jul-23	13.9	98.4	1,492,261	491.85	1.56	1.56	75,763	24,422	5,823	1,438	5,000	50	28,857	38.1%	11	46,906
	Aug-23	35.1	136	1,616,616	492.02	1.61	1.57	75,763	23,907	15,315	2,049	5,000	47	37,221	49.1%	12	38,542
	Sep-23	0.6	198.9	1,740,971	492.18	1.61	1.57	75,763	22,955	272	3,121	5,000	42	20,147	26.6%	13	55,616
	Oct-23	27.8	285.2	1,865,326	492.35	1.61	1.58	75,763	21,860	13,073	4,740	5,000	67	30,260	39.9%	14	45,503
	Nov-23	0.7	332.8	1,989,681	492.52	1.61	1.58	75,763	21,050	341	5,677	5,000	201	15,916	21.0%	15	59,847
2	Dec-23	2	388.8	2,114,036	492.69	1.61	1.58	75,763	20,427	1,009	6,843	5,000	132	14,725	19.4%	16	61,038
	Jan-24	0	404.1	2,238,391	492.85	1.61	1.58	75,763	20,210	-	7,169	5,000	102	13,142	17.3%	17	62,621
	Feb-24	19.2	320.8	2,362,746	493.01	1.61	1.59	75,763	20,876	10,330	5,441	5,000	83	25,848	34.1%	18	49,915
	Mar-24	17.5	288.7	2,487,101	493.13	1.61	1.59	75,763	21,788	9,558	4,802	5,000	71	26,615	35.1%	19	49,149
	Apr-24	57.7	192.9	2,611,456	493.24	1.61	1.59	75,763	23,017	31,630	3,029	5,000	59	51,677	68.2%	20	24,086
	May-24	29.2	128.3	2,735,811	493.35	1.61	1.59	75,763	23,994	16,058	1,920	5,000	40	38,173	50.4%	21	37,591
	Jun-24	20.7	90.5	2,860,166	493.47	1.61	1.59	75,763	24,472	11,426	1,315	5,000	36	34,619	45.7%	22	41,144
	Jul-24	13.9	98.4	2,984,521	493.58	1.61	1.59	75,763	24,405	7,697	1,437	5,000	35	30,699	40.5%	23	45,064
	Aug-24	35.1	136	2,984,521	493.58	-	1.59	-	-	19,435	2,045	5,000	34	17,425	0.0%	24	-
	Sep-24	0.6	198.9	2,984,521	493.58	-	1.59	-	-	332	3,114	5,000	32	-	0.0%	25	-
	Oct-24	27.8	285.2	2,984,521	493.58	-	1.59	-	-	15,393	4,726	5,000	7	10,674	0.0%	26	-
	Nov-24	0.7	332.8	2,984,521	493.58	-	1.59	-	-	388	5,658	5,000	2	-	0.0%	27	-
3	Dec-24	2	388.8	2,984,521	493.58	-	1.59	-	-	1,107	6,820	5,000	1	-	0.0%	28	-
	Jan-25	0	404.1	2,984,521	493.58	-	1.59	-	-	-	7,145	5,000	0	-	0.0%	29	-
	Feb-25	19.2	320.8	3,176,291	493.76	1.61	1.59	116,835	32,184	10,729	5,449	5,000	0	37,465	32.1%	30	79,370
	Mar-25	17.5	288.7	3,368,060	493.93	1.61	1.60	116,835	33,594	9,819	4,808	5,000	0	38,605	33.0%	31	78,230
	Apr-25	57.7	192.9	3,559,829	494.11	1.61	1.60	116,835	35,491	32,555	3,032	5,000	21	65,035	55.7%	32	51,800
	May-25	29.2	128.3	3,751,599	494.28	1.61	1.60	116,835	36,999	16,554	1,921	5,000	20	51,652	44.2%	33	65,183
	Jun-25	20.7	90.5	3,943,368	494.47	1.53	1.59	116,835	37,737	11,801	1,316	5,000	20	48,243	41.3%	34	68,592
	Jul-25	13.9	98.4	4,135,138	494.65	1.55	1.59	116,835	37,633	7,964	1,438	5,000	19	44,178	37.8%	35	72,657
	Aug-25	35.1	136	4,326,907	494.82	1.61	1.59	116,835	36,834	20,215	2,049	5,000	18	55,018	47.1%	36	61,817
	Sep-25	0.6	198.9	4,518,677	495.00	1.61	1.60	116,835	35,355	347	3,122	5,000	17	32,597	27.9%	37	84,238
	Oct-25	27.8	285.2	4,710,446	495.16	1.61	1.60	116,835	33,661	16,148	4,742	5,000	15	45,081	38.6%	38	71,754
	Nov-25	0.7	332.8	4,902,216	495.33	1.61	1.60	116,835	32,413	408	5,681	5,000	13	27,152	23.2%	39	89,683
4	Dec-25	2	388.8	5,093,985	495.50	1.61	1.60	116,835	31,457	1,167	6,849	5,000	11	25,785	22.1%	40	91,050
	Jan-26	0	404.1	5,285,755	495.67	1.61	1.60	116,835	31,131	-	7,177	5,000	86	24,040	20.6%	41	92,795
	Feb-26	19.2	320.8	5,477,524	495.84	1.61	1.60	116,835	32,171	11,257	5,447	5,000	84	38,065	32.6%	42	78,770
	Mar-26	17.5	288.7	5,669,293	496.00	1.61	1.60	116,835	33,584	10,270	4,807	5,000	70	39,118	33.5%	43	77,717
	Apr-26	57.7	192.9	5,861,063	496.17	1.61	1.60	116,835	35,485	33,944	3,031	5,000	60	66,457	56.9%	44	50,378
	May-26	29.2	128.3	6,052,832	496.34	1.61	1.60	116,835	36,995	17,207	1,921	5,000	52	52,333	44.8%	45	64,502
	Jun-26	20.7	90.5	6,244,602	496.52	1.54	1.60	116,835	37,735	12,228	1,316	5,000	49	48,696	41.7%	46	68,139
	Jul-26	13.9	98.4	6,436,371	496.69	1.57	1.60	116,835	37,631	8,226	1,438	5,000	46	44,464	38.1%	47	72,371
	Aug-26	35.1	136	6,628,141	496.86	1.61	1.60	116,835	36,831	20,814	2,049	5,000	44	55,639	47.6%	48	61,196
	Sep-26	0.6	198.9	6,819,910	497.02	1.61	1.60	116,835	35,351	357	3,122	5,000	38	32,624	27.9%	49	84,211
	Oct-26	27.8	285.2	7,011,680	497.18	1.61	1.60	116,835	33,656	16,518	4,742	5,000	33	45,466	38.9%	50	71,369
	Nov-26	0.7	332.8	7,203,449	497.34	1.61	1.60	116,835	32,408	416	5,680	5,000	29	27,172	23.3%	51	89,663
5	Dec-26	2	388.8	7,395,219	497.50	1.61	1.60	116,835	31,453	1,186	6,849	5,000	24	25,814	22.1%	52	91,021
	Jan-27	0	404.1	7,586,988	497.66	1.61	1.60	116,835	31,128	-	7,176	5,000	22	23,974	20.5%	53	92,862
	Feb-27	19.2	320.8	7,586,988	497.66	-	1.60	-	-	11,370	5,424	5,000	21	5,967	0.0%	54	-
	Mar-27	17.5	288.7	7,586,988	497.66	-	1.60	-	-	10,363	4,790	5,000	20	5,593	0.0%	55	-
	Apr-27	57.7	192.9	7,586,988	497.66	-	1.60	-	-	34,170	3,023	5,000	6	31,152	0.0%	56	-
	May-27	29.2	128.3	7,586,988	497.66	-	1.60	-	-	17,292	1,917	5,000	2	15,377	0.0%	57	-
	Jun-27	20.7	90.5	7,586,988	497.66	-	1.60	-	-	12,258	1,314	5,000	1	10,946	0.0%	58	-
	Jul-27	13.9	98.4	7,586,988	497.66	-	1.60	-	-	8,231	1,436	5,000	0	6,796	0.0%	59	-
	Aug-27	35.1	136	7,790,120	497.83	1.61	1.60	123,758	39,013	20,774	2,049	5,000	0	57,738	46.7%	60	66,019
	Sep-27	0.6	198.9	7,993,252	498.00	1.61	1.61	123,758	37,447	355	3,123	5,000	0	34,679	28.0%	61	89,079
	Oct-27	27.8	285.2	8,196,384	498.17	1.61	1.61	123,758	35,652	16,414	4,743	5,000	16	47,339	38.3%	62	76,419
	Nov-27	0.7	332.8	8,399,517	498.34	1.61	1.61	123,758	34,330	413	5,682	5,000	18	29,079	23.5%	63	94,679
6	Dec-27	2	388.8	8,602,649	498.51	1.61	1.61	123,758	33,318	1,178	6,851	5,000	17	27,663	22.4%	64	96,095
	Jan-28	0	404.1	8,805,781	498.68	1.61	1.61	123,758	32,974	-	7,179	5,000	16	25,812	20.9%	65	97,946
	Feb-28	19.2	320.8	9,008,913	498.85	1.61	1.61	123,758	34,077	11,295	5,448	5,000	12	39,935	32.3%	66	83,823
	Mar-28	17.5	288.7	9,212,045	499.02	1.61	1.61	123,758	35,574	10,272	4,808	5,000	11	41,049	33.2%	67	82,709
	Apr-28	57.7	192.9	9,415,177	499.18	1.61	1.61	123,758	37,588	33,862	3,032	5,000	10	68,428	55.3%	68	55,330
	May-28	29.2	128.3	9,618,310	499.35	1.61	1.61	123,758	39,188	17,131	1,921	5,000	10	54,407	44.0%	69	69,350
	Jun-28	20.7	90.5	9,821,442	499.52	1.52	1.61	123,758	39,971	12,149	1,316	5,000	10	50,815	41.1%	70	72,943
	Jul-28	13.9	98.4	10,024,574	499.69	1.55	1.60	123,758	39,861	8,156	1,438	5,000	10	46,589	37.6%	71	77,169
	Aug-28	35.1	136	10,024,574	499.69	-	1.60	-	-	20,595	2,045	5,000	10	18,560	0.0%	72	-
	Sep-28	0.6	198.9	10,024,574	499.69	-	1.60	-	-	352	3,114	5,000	10	-	0.0%	73	-
	Oct-28	27.8	285.2	10,024,574	499.69	-	1.60	-	-	16,312	4,726	5,000	5	11,591	0.0%	74	-
	Nov-28	0.7	332.8	10,024,574	499.69	-	1.60	-	-	411	5,658	5,000	2	-	0.0%	75	-
7	Dec-28	2	388.8	10,024,574	499.69	-	1.60	-	-	1,174	6,820	5,000	1	-	0.0%	76	-
	Jan-29	0	404.1	10,024,574	499.69	-	1.60	-	-	-	7,145	5,000	0	-	0.0%	77	-
	Feb-29	19.2	320.8	10,264,393	499.89	1.61	1.60	146,109	40,232	11,303	5,453	5,000	0	46,082	31.5%	78	100,027
	Mar-29	17.5	288.7	10,504,212	500.08	1.61	1.61	146,109	41,999	10,289	4,811	5,000	0	47,478	32.5%	79	98,631
	Apr-29	57.7	192.9	10,744,032	500.27	1.61	1.61	146,109	44,376	33,942	3,033	5,000	5	75,289	51.5%	80	70,820
	May-29	29.2	128.3	10,983,851	500.47	1.58	1.61	146,109	46,265	17,171	1,922	5,000	105	61,619	42.2%	81	84,490
	Jun-29	20.7	90.5	11,223,670	500.68	1.48	1.60	146,109	47,190	12,178	1,316	5,000	190	58,242	39.9%	82	87,867
	Jul-29	13.9	98.4	11,463,489	500.89	1.49	1.60	146,109	47,060	8,175	1,439	5,000	153	53,949	36.9%	83	92,160
	Aug-29	35.1	136	11,703,308	501.09	1.60	1.60	146,109	46,060	20,645	2,050	5,000	124	64,779	44.3%	84	81,330
	Sep-29	0.6	198.9	11,943,128	501.28	1.61	1.60	146,109	44,211	353	3,124	5,000	100	41,540	28.4%	85	104,569
	Oct-29	27.8	285.2	12,182,947	501.47	1.61	1.60	146,109	42,092	16,353	4,746	5,000	947	54,646	37.4%	86	91,464
	Nov-29	0.7	332.8	12,422,766	501.66	1.61	1.60	146,109	40,531	412	5,686	5,000	1,180	36,437	24.9%	87	109,672
8	Dec-29	2	388.8	12,662,585	501.85	1.61	1.60	146,109	39,337	1,177	6,856	5,000	684	34,341	23.5%	88	111,768
	Jan-30	0	404.1	12,902,405	502.04	1.61	1.60	146,109	38,930	-	7,185	5,000	461	32,207	22.0%	89	113,902
	Feb-30	19.2	320.8	12,902,405	502.04	-	1.61	-	-	11,297	5,424	5,000	355	6,227	0.0%	90	-
	Mar-30	17.5	288.7	12,902,405	502.04	-	1.61	-	-	10,296	4,790	5,000	289	5,795	0.0%	91	-
	Apr-30	57.7	192.9	12,902,405	502.04	-	1.61	-	-	33,948	3,023	5,000	17	30,942	0.0%	92	-
	May-30	29.2	128.3	12,902,405	502.04	-	1.61	-	-	17,180	1,917	5,000	5	15,267	0.0%	93	-
	Jun-30	20.7	90.5	12,902,405	502.04	-	1.61	-	-	12,179	1,314	5,000	2	10,868	0.0%	94	-
	Jul-30	13.9	98.4	12,902,405	502.04	-	1.61	-	-	8,178	1,436	5,000	1	6,744	0.0%	95	-
	Aug-30	35.1	136	13,150,680	502.25	1.59	1.60	151,261	47,684	20,662	2,050	5,000	1	66,297	43.8%	96	84,964
	Sep-30	0.6	198.9	13,398,956	502.45	1.61	1.61	151,261	45,770	353	3,125	5,000	1	42,999	28.4%	97	108,262
	Oct-30	27.8	285.2	13,647,232	502.65	1.61	1.61	151,261	43,576	16,367	4,747	5,000	273	55,470	36.7%	98	95,792
	Nov-30	0.7	332.8	13,895,508	502.85	1.61	1.61	151,261	41,960	412	5,687	5,000	228	36,914	24.4%	99	114,348
9	Dec-30	2	388.8	14,143,784	503.05	1.61	1.61	151,261	40,724	1,178	6,858	5,000	186	35,230	23.3%	100	116,031

TABLE 6.5: TSF CELL D WATER BALANCE - AVERAGE CONDITIONS

Year	Month	Rainfall	Evaporation	Cumulative Tonnage	Tailings Level	Tailings density		Water in Slurry	Supernatant Runoff	Rainfall Runoff	Evaporation Losses	Pond Volume	Consolidation Volume	Available TSF Recycle		Discharge	Make Up Requirement
						Layers	Mass										
		mm	mm	t	RL m	t/m3	t/m3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	%	m^3	m^3
	Jan-31	0	404.1	14,392,060	503.25	1.61	1.61	151,261	40,303	-	7,186	5,000	158	33,275	22.0%	101	117,987
	Feb-31	19.2	320.8	14,640,335	503.45	1.61	1.61	151,261	41,650	11,323	5,454	5,000	140	47,659	31.5%	102	103,603
	Mar-31	17.5	288.7	14,888,611	503.65	1.61	1.61	151,261	43,480	10,307	4,811	5,000	127	49,102	32.5%	103	102,159
	Apr-31	57.7	192.9	15,136,887	503.85	1.61	1.61	151,261	45,941	33,999	3,034	5,000	118	77,024	50.9%	104	74,237
	May-31	29.2	128.3	15,385,163	504.06	1.57	1.61	151,261	47,896	17,200	1,922	5,000	110	63,284	41.8%	105	87,977
	Jun-31	20.7	90.5	15,633,439	504.28	1.47	1.60	151,261	48,854	12,199	1,316	5,000	108	59,845	39.6%	106	91,416
	Jul-31	13.9	98.4	15,881,714	504.50	1.49	1.60	151,261	48,720	8,189	1,439	5,000	105	55,575	36.7%	107	95,686
	Aug-31	35.1	136	15,881,714	504.49	-	1.60	-	-	20,678	2,045	5,000	97	18,731	0.0%	108	-
	Sep-31	0.6	198.9	15,881,714	504.49	-	1.60	-	-	353	3,114	5,000	91	-	0.0%	109	-
	Oct-31	27.8	285.2	15,881,714	504.49	-	1.60	-	-	16,378	4,726	5,000	30	11,681	0.0%	110	-
	Nov-31	0.7	332.8	15,881,714	504.49	-	1.60	-	-	412	5,658	5,000	11	-	0.0%	111	-
10	Dec-31	2	388.8	15,881,714	504.49	-	1.60	-	-	1,178	6,820	5,000	4	-	0.0%	112	-
	Jan-32	0	404.1	15,881,714	504.49	-	1.60	-	-	-	7,145	5,000	2	-	0.0%	113	-
	Feb-32	19.2	320.8	16,129,989	504.70	1.61	1.60	151,260	41,649	11,328	5,454	5,000	1	47,525	31.4%	114	103,736
	Mar-32	17.5	288.7	16,378,263	504.89	1.61	1.60	151,260	43,480	10,311	4,811	5,000	1	48,980	32.4%	115	102,281
	Apr-32	57.7	192.9	16,626,537	505.09	1.61	1.60	151,260	45,940	34,014	3,034	5,000	886	77,807	51.4%	116	73,454
11	May-32	29.2	128.3	16,874,811	505.29	1.57	1.60	151,260	47,896	17,207	1,922	5,000	1,431	64,612	42.7%	117	86,649

TABLE 6.6: TSF CELL C WATER BALANCE - DRY CONDITIONS

Year	Month	Rainfall	Evaporation	Cumulative Tonnage	Tailings Level	Tailings density		Water in Slurry	Supernatant Runoff	Rainfall Runoff	Evaporation Losses	Pond Volume	Consolidation Volume	Available TSF		Discharge	Make Up Requirement
						Layers	Mass							Recycle			
		mm	mm	t	RL m	t/m3	t/m3	m³	m³	m³	m³	m³	m³	m³	%	m³	m³
	Aug-22	35.1	136	279,517	486.36	1.35	1.35	170,295	54,252	-	1,662	5,215	-	28,011	16.4%	-	142,284
	Sep-22	0.6	198.9	559,033	487.24	1.41	1.38	170,295	51,858	-	3,195	5,000	-	20,406	12.0%	1	149,889
	Oct-22	27.8	285.2	838,550	487.63	1.54	1.43	170,295	49,316	-	4,766	5,000	-	24,024	14.1%	2	146,271
	Nov-22	0.7	332.8	1,118,067	488.00	1.61	1.47	170,295	47,443	955	5,716	5,000	-	15,786	9.3%	3	154,509
1	Dec-22	2	388.8	1,397,584	488.36	1.61	1.51	170,295	45,998	-	6,882	5,000	-	14,357	8.4%	4	155,938
	Jan-23	0	404.1	1,677,100	488.72	1.61	1.53	170,295	45,468	1,956	7,206	5,000	1,529	13,829	8.1%	5	156,465
	Feb-23	19.2	320.8	1,956,617	489.06	1.61	1.55	170,295	46,935	3,875	5,457	5,000	798	22,227	13.1%	6	148,068
	Mar-23	17.5	288.7	2,236,134	489.31	1.61	1.56	170,295	48,975	-	4,810	5,000	493	23,387	13.7%	7	146,908
	Apr-23	57.7	192.9	2,515,651	489.57	1.61	1.57	170,295	51,737	1,326	3,021	5,000	340	41,320	24.3%	8	128,975
	May-23	29.2	128.3	2,795,167	489.84	1.50	1.56	170,295	53,932	25,639	1,926	5,000	207	33,364	19.6%	9	136,931
	Jun-23	20.7	90.5	3,074,684	490.13	1.44	1.55	170,295	55,007	-	1,314	5,000	178	31,533	18.5%	10	138,762
	Jul-23	13.9	98.4	3,354,201	490.41	1.46	1.54	170,295	54,856	-	1,437	5,000	164	28,857	16.9%	11	141,438
	Aug-23	35.1	136	3,633,718	490.67	1.53	1.54	170,295	53,692	-	2,044	5,000	144	37,221	21.9%	12	133,074
	Sep-23	0.6	198.9	3,913,234	490.92	1.61	1.55	170,295	51,539	-	3,127	5,000	595	20,147	11.8%	13	150,148
	Oct-23	27.8	285.2	4,192,751	491.16	1.61	1.56	170,295	49,072	-	4,740	5,000	1,849	30,260	17.8%	14	140,035
	Nov-23	0.7	332.8	4,472,268	491.41	1.61	1.57	170,295	47,254	1,370	5,693	5,000	2,157	15,916	9.3%	15	154,379
2	Dec-23	2	388.8	4,751,784	491.65	1.61	1.57	170,295	45,863	-	6,863	5,000	1,199	14,725	8.6%	16	155,570
	Jan-24	0	404.1	5,031,301	491.89	1.61	1.58	170,295	45,388	2,294	7,195	5,000	824	13,142	7.7%	17	157,153
	Feb-24	19.2	320.8	5,310,818	492.14	1.61	1.58	170,295	46,902	4,203	5,454	5,000	621	25,848	15.2%	18	144,447
	Mar-24	17.5	288.7	5,590,335	492.38	1.61	1.58	170,295	48,959	-	4,808	5,000	483	26,615	15.6%	19	143,680
	Apr-24	57.7	192.9	5,869,851	492.63	1.61	1.58	170,295	51,726	1,388	3,020	5,000	509	51,677	30.3%	20	118,618
	May-24	29.2	128.3	6,149,368	492.89	1.52	1.58	170,295	53,926	26,772	1,926	5,000	433	38,173	22.4%	21	132,122
	Jun-24	20.7	90.5	6,428,885	493.16	1.45	1.58	170,295	55,003	-	1,314	5,000	389	34,619	20.3%	22	135,676
	Jul-24	13.9	98.4	6,708,402	493.42	1.46	1.57	170,295	54,852	-	1,437	5,000	358	30,699	18.0%	23	139,596
	Aug-24	35.1	136	6,708,402	493.42	-	1.57	-	-	-	2,038	5,000	315	17,425	0.0%	24	-
	Sep-24	0.6	198.9	6,708,402	493.42	-	1.57	-	-	-	3,113	5,000	273	-	0.0%	25	-
	Oct-24	27.8	285.2	6,708,402	493.42	-	1.57	-	-	-	4,715	5,000	50	10,674	0.0%	26	-
	Nov-24	0.7	332.8	6,708,402	493.42	-	1.57	-	-	1,398	5,659	5,000	10	-	0.0%	27	-
3	Dec-24	2	388.8	6,708,402	493.42	-	1.57	-	-	-	6,819	5,000	2	-	0.0%	28	-
	Jan-25	0	404.1	6,708,402	493.42	-	1.57	-	-	2,331	7,147	5,000	0	-	0.0%	29	-
	Feb-25	19.2	320.8	6,909,587	493.59	1.61	1.57	122,572	33,754	4,249	5,444	5,000	0	37,465	30.6%	30	85,107
	Mar-25	17.5	288.7	7,110,773	493.76	1.61	1.58	122,572	35,236	-	4,801	5,000	0	38,605	31.5%	31	83,966
	Apr-25	57.7	192.9	7,311,959	493.93	1.61	1.58	122,572	37,229	1,401	3,017	5,000	947	65,035	53.1%	32	57,537
	May-25	29.2	128.3	7,513,144	494.10	1.61	1.58	122,572	38,813	26,996	1,924	5,000	1,948	51,652	42.1%	33	70,920
	Jun-25	20.7	90.5	7,714,330	494.28	1.52	1.58	122,572	39,588	-	1,313	5,000	1,282	48,243	39.4%	34	74,329
	Jul-25	13.9	98.4	7,915,516	494.45	1.55	1.58	122,572	39,479	-	1,436	5,000	959	44,178	36.0%	35	78,394
	Aug-25	35.1	136	8,116,701	494.62	1.61	1.58	122,572	38,641	-	2,042	5,000	784	55,018	44.9%	36	67,554
	Sep-25	0.6	198.9	8,317,887	494.79	1.61	1.58	122,572	37,089	-	3,123	5,000	625	32,597	26.6%	37	89,975
	Oct-25	27.8	285.2	8,519,073	494.96	1.61	1.59	122,572	35,311	-	4,732	5,000	499	45,081	36.8%	38	77,491
	Nov-25	0.7	332.8	8,720,259	495.13	1.61	1.59	122,572	34,001	1,417	5,683	5,000	452	27,152	22.2%	39	95,420
4	Dec-25	2	388.8	8,921,444	495.30	1.61	1.59	122,572	32,999	-	6,849	5,000	488	25,785	21.0%	40	96,787
	Jan-26	0	404.1	9,122,630	495.47	1.61	1.59	122,572	32,657	2,368	7,180	5,000	406	24,040	19.6%	41	98,532
	Feb-26	19.2	320.8	9,323,816	495.63	1.61	1.59	122,572	33,749	4,333	5,443	5,000	355	38,065	31.1%	42	84,507
	Mar-26	17.5	288.7	9,525,001	495.80	1.61	1.59	122,572	35,232	-	4,800	5,000	318	39,118	31.9%	43	83,454
	Apr-26	57.7	192.9	9,726,187	495.97	1.61	1.59	122,572	37,226	1,428	3,017	5,000	289	66,457	54.2%	44	56,115
	May-26	29.2	128.3	9,927,373	496.14	1.61	1.59	122,572	38,811	27,517	1,924	5,000	266	52,333	42.7%	45	70,239
	Jun-26	20.7	90.5	10,128,559	496.31	1.53	1.59	122,572	39,587	-	1,313	5,000	262	48,696	39.7%	46	73,876
	Jul-26	13.9	98.4	10,329,744	496.49	1.56	1.59	122,572	39,478	-	1,436	5,000	256	44,464	36.3%	47	78,108
	Aug-26	35.1	136	10,530,930	496.66	1.61	1.59	122,572	38,639	-	2,042	5,000	252	55,639	45.4%	48	66,933
	Sep-26	0.6	198.9	10,732,116	496.82	1.61	1.59	122,572	37,086	-	3,122	5,000	234	32,624	26.6%	49	89,948
	Oct-26	27.8	285.2	10,933,301	496.99	1.61	1.59	122,572	35,308	-	4,732	5,000	212	45,466	37.1%	50	77,106
	Nov-26	0.7	332.8	11,134,487	497.15	1.61	1.59	122,572	33,997	1,442	5,682	5,000	190	27,172	22.2%	51	95,400
5	Dec-26	2	388.8	11,335,673	497.31	1.61	1.59	122,572	32,995	-	6,849	5,000	158	25,814	21.1%	52	96,758
	Jan-27	0	404.1	11,536,858	497.47	1.61	1.59	122,572	32,653	2,402	7,180	5,000	153	23,974	19.6%	53	98,598
	Feb-27	19.2	320.8	11,536,858	497.47	-	1.60	-	-	4,383	5,419	5,000	211	5,967	0.0%	54	-
	Mar-27	17.5	288.7	11,536,858	497.47	-	1.60	-	-	-	4,783	5,000	174	5,593	0.0%	55	-
	Apr-27	57.7	192.9	11,536,858	497.47	-	1.60	-	-	1,441	3,008	5,000	46	31,152	0.0%	56	-
	May-27	29.2	128.3	11,536,858	497.47	-	1.60	-	-	27,739	1,921	5,000	19	15,377	0.0%	57	-
	Jun-27	20.7	90.5	11,536,858	497.47	-	1.60	-	-	-	1,311	5,000	9	10,946	0.0%	58	-
	Jul-27	13.9	98.4	11,536,858	497.47	-	1.60	-	-	-	1,434	5,000	5	6,796	0.0%	59	-
	Aug-27	35.1	136	11,744,967	497.64	1.61	1.60	126,790	39,968	-	2,042	5,000	2	57,738	45.5%	60	69,051
	Sep-27	0.6	198.9	11,953,076	497.81	1.61	1.60	126,790	38,362	-	3,123	5,000	1	34,679	27.4%	61	92,111
	Oct-27	27.8	285.2	12,161,184	497.98	1.61	1.60	126,790	36,523	-	4,732	5,000	136	47,339	37.3%	62	79,450
	Nov-27	0.7	332.8	12,369,293	498.15	1.61	1.60	126,790	35,167	1,441	5,683	5,000	144	29,079	22.9%	63	97,711
6	Dec-27	2	388.8	12,577,401	498.31	1.61	1.60	126,790	34,130	-	6,850	5,000	122	27,663	21.8%	64	99,127
	Jan-28	0	404.1	12,785,510	498.48	1.61	1.60	126,790	33,777	2,400	7,181	5,000	115	25,812	20.4%	65	100,978
	Feb-28	19.2	320.8	12,993,618	498.65	1.61	1.60	126,790	34,907	4,384	5,443	5,000	109	39,935	31.5%	66	86,855
	Mar-28	17.5	288.7	13,201,727	498.82	1.61	1.60	126,790	36,442	-	4,801	5,000	96	41,049	32.4%	67	85,740
	Apr-28	57.7	192.9	13,409,835	498.99	1.61	1.60	126,790	38,506	1,440	3,017	5,000	91	68,428	54.0%	68	58,362
	May-28	29.2	128.3	13,617,944	499.15	1.61	1.60	126,790	40,146	27,701	1,924	5,000	86	54,407	42.9%	69	72,382
	Jun-28	20.7	90.5	13,826,052	499.33	1.52	1.60	126,790	40,949	-	1,313	5,000	87	50,815	40.1%	70	75,975
	Jul-28	13.9	98.4	14,034,161	499.50	1.55	1.60	126,790	40,836	-	1,436	5,000	86	46,589	36.7%	71	80,201
	Aug-28	35.1	136	14,034,161	499.50	-	1.60	-	-	-	2,038	5,000	86	18,560	0.0%	72	-
	Sep-28	0.6	198.9	14,034,161	499.50	-	1.60	-	-	-	3,113	5,000	83	-	0.0%	73	-
	Oct-28	27.8	285.2	14,034,161	499.50	-	1.60	-	-	-	4,715	5,000	39	11,591	0.0%	74	-
	Nov-28	0.7	332.8	14,034,161	499.50	-	1.60	-	-	1,438	5,659	5,000	20	-	0.0%	75	-
7	Dec-28	2	388.8	14,034,161	499.50	-	1.60	-	-	-	6,819	5,000	11	-	0.0%	76	-
	Jan-29	0	404.1	14,034,161	499.50	-	1.60	-	-	2,397	7,148	5,000	6	-	0.0%	77	-
	Feb-29	19.2	320.8	14,278,335	499.69	1.61	1.60	148,763	40,957	4,388	5,448	5,000	3	46,082	31.0%	78	102,680
	Mar-29	17.5	288.7	14,522,509	499.88	1.61	1.60	148,763	42,758	-	4,804	5,000	2	47,478	31.9%	79	101,285
	Apr-29	57.7	192.9	14,766,683	500.08	1.61	1.60	148,763	45,179	1,441	3,018	5,000	42	75,289	50.6%	80	73,473
	May-29	29.2	128.3	15,010,858	500.27	1.58	1.60	148,763	47,103	27,712	1,925	5,000	167	61,619	41.4%	81	87,143
	Jun-29	20.7	90.5	15,255,032	500.48	1.48	1.60	148,763	48,046	-	1,313	5,000	250	58,242	39.2%	82	90,521
	Jul-29	13.9	98.4	15,499,206	500.69	1.50	1.60	148,763	47,913	-	1,437	5,000	205	53,949	36.3%	83	94,813
	Aug-29	35.1	136	15,743,380	500.89	1.60	1.60	148,763	46,895	-	2,043	5,000	179	64,779	43.5%	84	83,983
	Sep-29	0.6	198.9	15,987,555	501.08	1.61	1.60	148,763	45,011	-	3,124	5,000	155	41,540	27.9%	85	107,223
	Oct-29	27.8	285.2	16,231,729	501.27	1.61	1.60	148,763	42,853	-	4,736	5,000	1,012	54,646	36.7%	86	94,117
	Nov-29	0.7	332.8	16,475,903	501.46	1.61	1.60	148,763	41,263	1,438	5,687	5,000	1,228	36,437	24.5%	87	112,326
8	Dec-29	2	388.8	16,720,077	501.65	1.61	1.60	148,763	40,047	-	6,855	5,000	739	34,341	23.1%	88	114,421
	Jan-30	0	404.1	16,964,251	501.84	1.61	1.60	148,763	39,632	2,394	7,187	5,000	510	32,207	21.6%	89	116,556
	Feb-30	19.2	320.8	16,964,251	501.84	-	1.60	-	-	4,370	5,419	5,000	400	6,227	0.0%	90	-
	Mar-30	17.5	288.7	16,964,251	501.84	-	1.60	-	-	-	4,783	5,000	331	5,795	0.0%	91	-
	Apr-30	57.7	192.9	16,964,251	501.84	-	1.60	-	-	1,437	3,008	5,000	42	30,942	0.0%	92	-
	May-30	29.2	128.3	16,964,251	501.84	-	1.60	-	-	27,655	1,920	5,000	22	15,267	0.0%	93	-
	Jun-30	20.7	90.5	16,964,251	501.84	-	1.60	-	-	-	1,311	5,000	14	10,868	0.0%	94	-
	Jul-30	13.9	98.4	16,964,251	501.84	-	1.60	-	-	-	1,434	5,000	9	6,744	0.0%	95	-
	Aug-30	35.1	136	17,215,707	502.04	1.59	1.60	153,199	48,293	-	2,043	5,000	6	66,297	43.3%	96	86,901
	Sep-30	0.6	198.9	17,467,162	502.24	1.61	1.60	153,199	46,354	-	3,125	5,000	4	42,999	28.1%	97	110,200
	Oct-30	27.8	285.2	17,718,618	502.44	1.61	1.60	153,199	44,131	-	4,736	5,000	293	55,470	36.2%	98	97,729
	Nov-30	0.7	332.8	17,970,073	502.64	1.61	1.60	153,199	42,494	1,436	5,688	5,000	255	36,914	24.1%	99	116,285
9	Dec-30	2	388.8	18,221,528	502.84	1.61	1.60	153,199	41,241	-	6,856	5,000	215	35,230	23.0%	100	117,968

TABLE 6.6: TSF CELL C WATER BALANCE - DRY CONDITIONS

Year	Month	Rainfall	Evaporation	Cumulative Tonnage	Tailings Level	Tailings density		Water in Slurry	Supernatant Runoff	Rainfall Runoff	Evaporation Losses	Pond Volume	Consolidation Volume	Available TSF Recycle		Discharge	Make Up Requirement
						Layers	Mass										
		mm	mm	t	RL m	t/m3	t/m3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	%	m^3	m^3
	Jan-31	0	404.1	18,472,984	503.04	1.61	1.60	153,199	40,815	2,391	7,188	5,000	189	33,275	21.7%	101	119,924
	Feb-31	19.2	320.8	18,724,439	503.24	1.61	1.60	153,199	42,180	4,369	5,449	5,000	171	47,659	31.1%	102	105,540
	Mar-31	17.5	288.7	18,975,894	503.44	1.61	1.60	153,199	44,034	-	4,805	5,000	152	49,102	32.1%	103	104,097
	Apr-31	57.7	192.9	19,227,350	503.65	1.61	1.60	153,199	46,527	1,434	3,019	5,000	143	77,024	50.3%	104	76,174
	May-31	29.2	128.3	19,478,805	503.85	1.57	1.60	153,199	48,509	27,592	1,925	5,000	136	63,284	41.3%	105	89,914
	Jun-31	20.7	90.5	19,730,260	504.07	1.47	1.60	153,199	49,479	-	1,313	5,000	121	59,845	39.1%	106	93,354
	Jul-31	13.9	98.4	19,981,716	504.29	1.49	1.60	153,199	49,343	-	1,437	5,000	119	55,575	36.3%	107	97,623
	Aug-31	35.1	136	19,981,716	504.29	-	1.60	-	-	-	2,038	5,000	106	18,731	0.0%	108	-
	Sep-31	0.6	198.9	19,981,716	504.29	-	1.60	-	-	-	3,113	5,000	99	-	0.0%	109	-
	Oct-31	27.8	285.2	19,981,716	504.29	-	1.60	-	-	-	4,715	5,000	35	11,681	0.0%	110	-
	Nov-31	0.7	332.8	19,981,716	504.29	-	1.60	-	-	1,433	5,659	5,000	14	-	0.0%	111	-
10	Dec-31	2	388.8	19,981,716	504.29	-	1.60	-	-	-	6,819	5,000	7	-	0.0%	112	-
	Jan-32	0	404.1	19,981,716	504.29	-	1.60	-	-	2,388	7,147	5,000	4	-	0.0%	113	-
	Feb-32	19.2	320.8	20,232,235	504.49	1.61	1.60	152,628	42,023	4,362	5,449	5,000	2	47,525	31.1%	114	105,104
	Mar-32	17.5	288.7	20,482,754	504.68	1.61	1.60	152,628	43,870	-	4,805	5,000	2	48,980	32.1%	115	103,648
	Apr-32	57.7	192.9	20,733,273	504.88	1.61	1.60	152,628	46,354	1,432	3,019	5,000	896	77,807	51.0%	116	74,822
11	May-32	29.2	128.3	20,983,791	505.08	1.57	1.60	152,628	48,328	27,546	1,925	5,000	1,452	64,612	42.3%	117	88,016

TABLE 6.7: TSF CELL D WATER BALANCE - DRY CONDITIONS

Year	Month	Rainfall	Evaporation	Cumulative Tonnage	Tailings Level	Tailings density		Water in Slurry	Supernatant Runoff	Rainfall Runoff	Evaporation Losses	Pond Volume	Consolidation Volume	Available TSF Recycle		Discharge	Make Up Requirement
						Layers	Mass										
		mm	mm	t	RL m	t/m3	t/m3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	%	m^3	m^3
	Aug-22	35.1	136	124,355	488.27	1.35	1.35	75,763	24,442	-	1,723	5,155	-	22,565	29.8%	-	53,198
	Sep-22	0.6	198.9	248,710	489.18	1.42	1.39	75,763	23,271	-	3,177	5,000	-	20,249	26.7%	1	55,514
	Oct-22	27.8	285.2	373,065	489.55	1.58	1.44	75,763	22,140	-	4,759	5,000	-	17,381	22.9%	2	58,382
	Nov-22	0.7	332.8	497,420	489.91	1.59	1.48	75,763	21,310	630	5,709	5,000	-	16,231	21.4%	3	59,532
1	Dec-22	2	388.8	621,775	490.27	1.60	1.51	75,763	20,663	-	6,874	5,000	-	13,789	18.2%	4	61,974
	Jan-23	0	404.1	746,130	490.62	1.60	1.53	75,763	20,410	1,226	7,199	5,000	616	15,054	19.9%	5	60,709
	Feb-23	19.2	320.8	870,485	490.97	1.60	1.54	75,763	21,022	2,403	5,453	5,000	342	18,315	24.2%	6	57,448
	Mar-23	17.5	288.7	994,840	491.15	1.60	1.55	75,763	21,888	-	4,805	5,000	212	17,295	22.8%	7	58,468
	Apr-23	57.7	192.9	1,119,195	491.32	1.60	1.56	75,763	23,076	879	3,018	5,000	154	21,091	27.8%	8	54,672
	May-23	29.2	128.3	1,243,550	491.49	1.60	1.57	75,763	24,026	17,702	1,925	5,000	71	39,874	52.6%	9	35,889
	Jun-23	20.7	90.5	1,367,906	491.67	1.51	1.56	75,763	24,492	-	1,313	5,000	55	23,234	30.7%	10	52,529
	Jul-23	13.9	98.4	1,492,261	491.85	1.56	1.56	75,763	24,422	-	1,436	5,000	50	23,036	30.4%	11	52,727
	Aug-23	35.1	136	1,616,616	492.02	1.61	1.57	75,763	23,907	-	2,042	5,000	47	21,913	28.9%	12	53,850
	Sep-23	0.6	198.9	1,740,971	492.18	1.61	1.57	75,763	22,955	-	3,121	5,000	42	19,875	26.2%	13	55,888
	Oct-23	27.8	285.2	1,865,326	492.35	1.61	1.58	75,763	21,860	-	4,729	5,000	67	17,198	22.7%	14	58,565
	Nov-23	0.7	332.8	1,989,681	492.52	1.61	1.58	75,763	21,050	1,170	5,677	5,000	201	16,744	22.1%	15	59,020
2	Dec-23	2	388.8	2,114,036	492.69	1.61	1.58	75,763	20,427	-	6,842	5,000	132	13,717	18.1%	16	62,046
	Jan-24	0	404.1	2,238,391	492.85	1.61	1.58	75,763	20,210	2,086	7,171	5,000	102	15,226	20.1%	17	60,537
	Feb-24	19.2	320.8	2,362,746	493.01	1.61	1.59	75,763	20,876	3,928	5,436	5,000	83	19,451	25.7%	18	56,312
	Mar-24	17.5	288.7	2,487,101	493.13	1.61	1.59	75,763	21,788	-	4,795	5,000	71	17,063	22.5%	19	58,700
	Apr-24	57.7	192.9	2,611,456	493.24	1.61	1.59	75,763	23,017	1,316	3,014	5,000	59	21,378	28.2%	20	54,385
	May-24	29.2	128.3	2,735,811	493.35	1.61	1.59	75,763	23,994	25,407	1,923	5,000	40	47,518	62.7%	21	28,245
	Jun-24	20.7	90.5	2,860,166	493.47	1.61	1.59	75,763	24,472	-	1,312	5,000	36	23,196	30.6%	22	52,567
	Jul-24	13.9	98.4	2,984,521	493.58	1.61	1.59	75,763	24,405	-	1,435	5,000	35	23,005	30.4%	23	52,758
	Aug-24	35.1	136	2,984,521	493.58	-	1.59	-	-	-	2,038	5,000	34	-	0.0%	24	-
	Sep-24	0.6	198.9	2,984,521	493.58	-	1.59	-	-	-	3,113	5,000	32	-	0.0%	25	-
	Oct-24	27.8	285.2	2,984,521	493.58	-	1.59	-	-	-	4,715	5,000	7	-	0.0%	26	-
	Nov-24	0.7	332.8	2,984,521	493.58	-	1.59	-	-	1,329	5,659	5,000	2	-	0.0%	27	-
3	Dec-24	2	388.8	2,984,521	493.58	-	1.59	-	-	-	6,819	5,000	1	-	0.0%	28	-
	Jan-25	0	404.1	2,984,521	493.58	-	1.59	-	-	2,215	7,148	5,000	0	-	0.0%	29	-
	Feb-25	19.2	320.8	3,176,291	493.76	1.61	1.59	116,835	32,184	4,079	5,443	5,000	0	30,820	26.4%	30	86,015
	Mar-25	17.5	288.7	3,368,060	493.93	1.61	1.60	116,835	33,594	-	4,801	5,000	0	28,793	24.6%	31	88,042
	Apr-25	57.7	192.9	3,559,829	494.11	1.61	1.60	116,835	35,491	1,354	3,017	5,000	21	33,850	29.0%	32	82,986
	May-25	29.2	128.3	3,751,599	494.28	1.61	1.60	116,835	36,999	26,192	1,924	5,000	20	61,286	52.5%	33	55,549
	Jun-25	20.7	90.5	3,943,368	494.47	1.53	1.59	116,835	37,737	-	1,313	5,000	20	36,444	31.2%	34	80,391
	Jul-25	13.9	98.4	4,135,138	494.65	1.55	1.59	116,835	37,633	-	1,436	5,000	19	36,216	31.0%	35	80,619
	Aug-25	35.1	136	4,326,907	494.82	1.61	1.59	116,835	36,834	-	2,042	5,000	18	34,810	29.8%	36	82,025
	Sep-25	0.6	198.9	4,518,677	495.00	1.61	1.60	116,835	35,355	-	3,122	5,000	17	32,249	27.6%	37	84,586
	Oct-25	27.8	285.2	4,710,446	495.16	1.61	1.60	116,835	33,661	-	4,732	5,000	15	28,944	24.8%	38	87,891
	Nov-25	0.7	332.8	4,902,216	495.33	1.61	1.60	116,835	32,413	1,397	5,682	5,000	13	28,141	24.1%	39	88,694
4	Dec-25	2	388.8	5,093,985	495.50	1.61	1.60	116,835	31,457	-	6,848	5,000	11	24,620	21.1%	40	92,215
	Jan-26	0	404.1	5,285,755	495.67	1.61	1.60	116,835	31,131	2,338	7,179	5,000	86	26,376	22.6%	41	90,459
	Feb-26	19.2	320.8	5,477,524	495.84	1.61	1.60	116,835	32,171	4,280	5,442	5,000	84	31,093	26.6%	42	85,742
	Mar-26	17.5	288.7	5,669,293	496.00	1.61	1.60	116,835	33,584	-	4,800	5,000	70	28,854	24.7%	43	87,981
	Apr-26	57.7	192.9	5,861,063	496.17	1.61	1.60	116,835	35,485	1,412	3,016	5,000	60	33,940	29.0%	44	82,895
	May-26	29.2	128.3	6,052,832	496.34	1.61	1.60	116,835	36,995	27,225	1,924	5,000	52	62,348	53.4%	45	54,487
	Jun-26	20.7	90.5	6,244,602	496.52	1.54	1.60	116,835	37,735	-	1,313	5,000	49	36,471	31.2%	46	80,364
	Jul-26	13.9	98.4	6,436,371	496.69	1.57	1.60	116,835	37,631	-	1,436	5,000	46	36,241	31.0%	47	80,594
	Aug-26	35.1	136	6,628,141	496.86	1.61	1.60	116,835	36,831	-	2,042	5,000	44	34,832	29.8%	48	82,003
	Sep-26	0.6	198.9	6,819,910	497.02	1.61	1.60	116,835	35,351	-	3,122	5,000	38	32,268	27.6%	49	84,567
	Oct-26	27.8	285.2	7,011,680	497.18	1.61	1.60	116,835	33,656	-	4,731	5,000	33	28,959	24.8%	50	87,877
	Nov-26	0.7	332.8	7,203,449	497.34	1.61	1.60	116,835	32,408	1,425	5,681	5,000	29	28,181	24.1%	51	88,654
5	Dec-26	2	388.8	7,395,219	497.50	1.61	1.60	116,835	31,453	-	6,848	5,000	24	24,630	21.1%	52	92,206
	Jan-27	0	404.1	7,586,988	497.66	1.61	1.60	116,835	31,128	2,369	7,179	5,000	22	26,340	22.5%	53	90,495
	Feb-27	19.2	320.8	7,586,988	497.66	-	1.60	-	-	4,323	5,419	5,000	21	-	0.0%	54	-
	Mar-27	17.5	288.7	7,586,988	497.66	-	1.60	-	-	-	4,783	5,000	20	-	0.0%	55	-
	Apr-27	57.7	192.9	7,586,988	497.66	-	1.60	-	-	1,421	3,008	5,000	6	-	0.0%	56	-
	May-27	29.2	128.3	7,586,988	497.66	-	1.60	-	-	27,359	1,921	5,000	2	25,441	0.0%	57	-
	Jun-27	20.7	90.5	7,586,988	497.66	-	1.60	-	-	-	1,311	5,000	1	-	0.0%	58	-
	Jul-27	13.9	98.4	7,586,988	497.66	-	1.60	-	-	-	1,434	5,000	0	-	0.0%	59	-
	Aug-27	35.1	136	7,790,120	497.83	1.61	1.60	123,758	39,013	-	2,042	5,000	0	36,971	29.9%	60	86,786
	Sep-27	0.6	198.9	7,993,252	498.00	1.61	1.61	123,758	37,447	-	3,123	5,000	0	34,324	27.7%	61	89,433
	Oct-27	27.8	285.2	8,196,384	498.17	1.61	1.61	123,758	35,652	-	4,732	5,000	16	30,936	25.0%	62	92,822
	Nov-27	0.7	332.8	8,399,517	498.34	1.61	1.61	123,758	34,330	1,416	5,683	5,000	18	30,081	24.3%	63	93,677
6	Dec-27	2	388.8	8,602,649	498.51	1.61	1.61	123,758	33,318	-	6,850	5,000	17	26,486	21.4%	64	97,272
	Jan-28	0	404.1	8,805,781	498.68	1.61	1.61	123,758	32,974	2,353	7,181	5,000	16	28,163	22.8%	65	95,595
	Feb-28	19.2	320.8	9,008,913	498.85	1.61	1.61	123,758	34,077	4,295	5,443	5,000	12	32,939	26.6%	66	90,818
	Mar-28	17.5	288.7	9,212,045	499.02	1.61	1.61	123,758	35,574	-	4,801	5,000	11	30,784	24.9%	67	92,973
	Apr-28	57.7	192.9	9,415,177	499.18	1.61	1.61	123,758	37,588	1,408	3,017	5,000	10	35,990	29.1%	68	87,768
	May-28	29.2	128.3	9,618,310	499.35	1.61	1.61	123,758	39,188	27,105	1,924	5,000	10	64,378	52.0%	69	59,380
	Jun-28	20.7	90.5	9,821,442	499.52	1.52	1.61	123,758	39,971	-	1,313	5,000	10	38,668	31.2%	70	85,090
	Jul-28	13.9	98.4	10,024,574	499.69	1.55	1.60	123,758	39,861	-	1,436	5,000	10	38,435	31.1%	71	85,323
	Aug-28	35.1	136	10,024,574	499.69	-	1.60	-	-	-	2,038	5,000	10	-	0.0%	72	-
	Sep-28	0.6	198.9	10,024,574	499.69	-	1.60	-	-	-	3,113	5,000	10	-	0.0%	73	-
	Oct-28	27.8	285.2	10,024,574	499.69	-	1.60	-	-	-	4,715	5,000	5	-	0.0%	74	-
	Nov-28	0.7	332.8	10,024,574	499.69	-	1.60	-	-	1,408	5,659	5,000	2	-	0.0%	75	-
7	Dec-28	2	388.8	10,024,574	499.69	-	1.60	-	-	-	6,819	5,000	1	-	0.0%	76	-
	Jan-29	0	404.1	10,024,574	499.69	-	1.60	-	-	2,347	7,148	5,000	0	-	0.0%	77	-
	Feb-29	19.2	320.8	10,264,393	499.89	1.61	1.60	146,109	40,232	4,298	5,448	5,000	0	39,082	26.7%	78	107,028
	Mar-29	17.5	288.7	10,504,212	500.08	1.61	1.61	146,109	41,999	-	4,804	5,000	0	37,195	25.5%	79	108,914
	Apr-29	57.7	192.9	10,744,032	500.27	1.61	1.61	146,109	44,376	1,412	3,018	5,000	5	42,774	29.3%	80	103,335
	May-29	29.2	128.3	10,983,851	500.47	1.58	1.61	146,109	46,265	27,167	1,925	5,000	105	71,613	49.0%	81	74,497
	Jun-29	20.7	90.5	11,223,670	500.68	1.48	1.60	146,109	47,190	-	1,313	5,000	190	46,066	31.5%	82	100,043
	Jul-29	13.9	98.4	11,463,489	500.89	1.49	1.60	146,109	47,060	-	1,437	5,000	153	45,776	31.3%	83	100,333
	Aug-29	35.1	136	11,703,308	501.09	1.60	1.60	146,109	46,060	-	2,043	5,000	124	44,142	30.2%	84	101,968
	Sep-29	0.6	198.9	11,943,128	501.28	1.61	1.60	146,109	44,211	-	3,124	5,000	100	41,187	28.2%	85	104,922
	Oct-29	27.8	285.2	12,182,947	501.47	1.61	1.60	146,109	42,092	-	4,736	5,000	947	38,303	26.2%	86	107,806
	Nov-29	0.7	332.8	12,422,766	501.66	1.61	1.60	146,109	40,531	1,412	5,687	5,000	1,180	37,437	25.6%	87	108,673
8	Dec-29	2	388.8	12,662,585	501.85	1.61	1.60	146,109	39,337	-	6,855	5,000	684	33,166	22.7%	88	112,944
	Jan-30	0	404.1	12,902,405	502.04	1.61	1.60	146,109	38,930	2,353	7,187	5,000	461	34,558	23.7%	89	111,551
	Feb-30	19.2	320.8	12,902,405	502.04	-	1.61	-	-	4,295	5,419	5,000	355	-	0.0%	90	-
	Mar-30	17.5	288.7	12,902,405	502.04	-	1.61	-	-	-	4,783	5,000	289	-	0.0%	91	-
	Apr-30	57.7	192.9	12,902,405	502.04	-	1.61	-	-	1,412	3,008	5,000	17	-	0.0%	92	-
	May-30	29.2	128.3	12,902,405	502.04	-	1.61	-	-	27,182	1,920	5,000	5	25,266	0.0%	93	-
	Jun-30	20.7	90.5	12,902,405	502.04	-	1.61	-	-	-	1,311	5,000	2	-	0.0%	94	-
	Jul-30	13.9	98.4	12,902,405	502.04	-	1.61	-	-	-	1,434	5,000	1	-	0.0%	95	-
	Aug-30	35.1	136	13,150,680	502.25	1.59	1.60	151,261	47,684	-	2,043	5,000	1	45,642	30.2%	96	105,619
	Sep-30	0.6	198.9	13,398,956	502.45	1.61	1.61	151,261	45,770	-	3,125	5,000	1	42,646	28.2%	97	108,616
	Oct-30	27.8	285.2	13,647,232	502.65	1.61	1.61	151,261	43,576	-	4,736	5,000	273	39,114	25.9%	98	112,148
	Nov-30	0.7	332.8	13,895,508	502.85	1.61	1.61	151,261	41,960	1,414	5,688	5,000	228	37,914	25.1%	99	113,347
9	Dec-30	2	388.8	14,143,784	503.05	1.61	1.61	151,261	40,724	-	6,857	5,000	186	34,054	22.5%	100	117,208

TABLE 6.7: TSF CELL D WATER BALANCE - DRY CONDITIONS

Year	Month	Rainfall	Evaporation	Cumulative Tonnage	Tailings Level	Tailings density		Water in Slurry	Supernatant Runoff	Rainfall Runoff	Evaporation Losses	Pond Volume	Consolidation Volume	Available TSF		Discharge	Make Up Requirement
						Layers	Mass							Recycle			
		mm	mm	t	RL m	t/m3	t/m3	m³	m³	m³	m³	m³	m³	m³	%	m³	m³
	Jan-31	0	404.1	14,392,060	503.25	1.61	1.61	151,261	40,303	2,355	7,188	5,000	158	35,628	23.6%	101	115,633
	Feb-31	19.2	320.8	14,640,335	503.45	1.61	1.61	151,261	41,650	4,305	5,449	5,000	140	40,646	26.9%	102	110,615
	Mar-31	17.5	288.7	14,888,611	503.65	1.61	1.61	151,261	43,480	-	4,805	5,000	127	38,802	25.7%	103	112,459
	Apr-31	57.7	192.9	15,136,887	503.85	1.61	1.61	151,261	45,941	1,414	3,019	5,000	118	44,454	29.4%	104	106,808
	May-31	29.2	128.3	15,385,163	504.06	1.57	1.61	151,261	47,896	27,213	1,925	5,000	110	73,295	48.5%	105	77,967
	Jun-31	20.7	90.5	15,633,439	504.28	1.47	1.60	151,261	48,854	-	1,313	5,000	108	47,649	31.5%	106	103,613
	Jul-31	13.9	98.4	15,881,714	504.50	1.49	1.60	151,261	48,720	-	1,437	5,000	105	47,388	31.3%	107	103,873
	Aug-31	35.1	136	15,881,714	504.49	-	1.60	-	-	-	2,038	5,000	97	-	0.0%	108	-
	Sep-31	0.6	198.9	15,881,714	504.49	-	1.60	-	-	-	3,113	5,000	91	-	0.0%	109	-
	Oct-31	27.8	285.2	15,881,714	504.49	-	1.60	-	-	-	4,715	5,000	30	-	0.0%	110	-
	Nov-31	0.7	332.8	15,881,714	504.49	-	1.60	-	-	1,414	5,659	5,000	11	-	0.0%	111	-
10	Dec-31	2	388.8	15,881,714	504.49	-	1.60	-	-	-	6,819	5,000	4	-	0.0%	112	-
	Jan-32	0	404.1	15,881,714	504.49	-	1.60	-	-	2,356	7,147	5,000	2	-	0.0%	113	-
	Feb-32	19.2	320.8	16,129,989	504.70	1.61	1.60	151,260	41,649	4,307	5,449	5,000	1	40,509	26.8%	114	110,752
	Mar-32	17.5	288.7	16,378,263	504.89	1.61	1.60	151,260	43,480	-	4,805	5,000	1	38,676	25.6%	115	112,585
	Apr-32	57.7	192.9	16,626,537	505.09	1.61	1.60	151,260	45,940	1,415	3,019	5,000	886	45,222	29.9%	116	106,038
11	May-32	29.2	128.3	16,874,811	505.29	1.57	1.60	151,260	47,896	27,225	1,925	5,000	1,431	74,627	49.3%	117	76,634

TABLE 6.8: TSF CELL C WATER BALANCE - WET CONDITIONS

Year	Month	Rainfall	Evaporation	Cumulative Tonnage	Tailings Level	Tailings density		Water in Slurry	Supernatant Runoff	Rainfall Runoff	Evaporation Losses	Pond Volume	Consolidation Volume	Available TSF		Discharge	Make Up Requirement
						Layers	Mass							Recycle			
		mm	mm	t	RL m	t/m3	t/m3	m³	m³	m³	m³	m³	m³	m³	%	m³	m³
	Aug-22	35.1	136	279,517	486.36	1.35	1.35	170,295	54,252	1,554	1,663	5,224	-	53,920	31.7%	-	116,375
	Sep-22	0.6	198.9	559,033	487.24	1.41	1.38	170,295	51,858	-	3,196	5,000	-	48,886	28.7%	1	121,409
	Oct-22	27.8	285.2	838,550	487.63	1.54	1.43	170,295	49,316	10,457	4,776	5,000	-	54,996	32.3%	2	115,299
	Nov-22	0.7	332.8	1,118,067	488.00	1.61	1.47	170,295	47,443	1,552	5,717	5,000	-	43,279	25.4%	3	127,016
1	Dec-22	2	388.8	1,397,584	488.36	1.61	1.51	170,295	45,998	30,632	6,915	5,000	-	69,715	40.9%	4	100,580
	Jan-23	0	404.1	1,677,100	488.72	1.61	1.53	170,295	45,468	49,492	7,255	5,000	1,529	89,234	52.4%	5	81,061
	Feb-23	19.2	320.8	1,956,617	489.06	1.61	1.55	170,295	46,935	34,928	5,481	5,000	798	77,179	45.3%	6	93,115
	Mar-23	17.5	288.7	2,236,134	489.31	1.61	1.56	170,295	48,975	95,226	4,876	5,000	493	139,819	82.1%	7	30,476
	Apr-23	57.7	192.9	2,515,651	489.57	1.61	1.57	170,295	51,737	1,326	3,021	5,000	340	50,381	29.6%	8	119,913
	May-23	29.2	128.3	2,795,167	489.84	1.50	1.56	170,295	53,932	25,195	1,926	5,000	207	77,408	45.5%	9	92,887
	Jun-23	20.7	90.5	3,074,684	490.13	1.44	1.55	170,295	55,008	35,725	1,322	5,050	178	89,538	52.6%	10	80,757
	Jul-23	13.9	98.4	3,354,201	490.41	1.46	1.54	170,295	54,856	4,599	1,443	5,000	164	58,226	34.2%	11	112,069
	Aug-23	35.1	136	3,633,718	490.67	1.53	1.54	170,295	53,692	4,567	2,046	5,000	144	56,356	33.1%	12	113,939
	Sep-23	0.6	198.9	3,913,234	490.92	1.61	1.55	170,295	51,539	-	3,127	5,000	595	49,008	28.8%	13	121,287
	Oct-23	27.8	285.2	4,192,751	491.16	1.61	1.56	170,295	49,072	17,004	4,752	5,000	1,849	63,173	37.1%	14	107,122
	Nov-23	0.7	332.8	4,472,268	491.41	1.61	1.57	170,295	47,254	2,226	5,694	5,000	2,157	45,943	27.0%	15	124,352
2	Dec-23	2	388.8	4,751,784	491.65	1.61	1.57	170,295	45,863	39,516	6,897	5,000	1,199	79,681	46.8%	16	90,614
	Jan-24	0	404.1	5,031,301	491.89	1.61	1.58	170,295	45,388	58,026	7,244	5,000	824	96,993	57.0%	17	73,302
	Feb-24	19.2	320.8	5,310,818	492.14	1.61	1.58	170,295	46,902	37,889	5,478	5,000	621	79,934	46.9%	18	90,361
	Mar-24	17.5	288.7	5,590,335	492.38	1.61	1.58	170,295	48,963	99,900	5,076	5,209	483	144,060	84.6%	19	26,234
	Apr-24	57.7	192.9	5,869,851	492.63	1.61	1.58	170,295	51,729	1,388	3,062	5,000	509	50,773	29.8%	20	119,522
	May-24	29.2	128.3	6,149,368	492.89	1.52	1.58	170,295	53,926	26,309	1,926	5,000	433	78,742	46.2%	21	91,553
	Jun-24	20.7	90.5	6,428,885	493.16	1.45	1.58	170,295	55,004	37,209	1,322	5,048	390	91,231	53.6%	22	79,063
	Jul-24	13.9	98.4	6,708,402	493.42	1.46	1.57	170,295	54,852	4,778	1,443	5,000	358	58,593	34.4%	23	111,702
	Aug-24	35.1	136	6,708,402	493.42	-	1.57	-	-	4,719	2,039	5,000	315	2,995	0.0%	24	-
	Sep-24	0.6	198.9	6,708,402	493.42	-	1.57	-	-	-	3,113	5,000	273	-	0.0%	25	-
	Oct-24	27.8	285.2	6,708,402	493.42	-	1.57	-	-	17,421	4,726	5,000	50	12,744	0.0%	26	-
	Nov-24	0.7	332.8	6,708,402	493.42	-	1.57	-	-	2,272	5,659	5,000	10	-	0.0%	27	-
3	Dec-24	2	388.8	6,708,402	493.42	-	1.57	-	-	40,260	6,853	5,000	2	33,409	0.0%	28	-
	Jan-25	0	404.1	6,708,402	493.42	-	1.57	-	-	58,963	7,197	5,000	0	51,766	0.0%	29	-
	Feb-25	19.2	320.8	6,909,587	493.59	1.61	1.57	122,572	33,754	38,303	5,468	5,000	0	66,589	54.3%	30	55,983
	Mar-25	17.5	288.7	7,110,773	493.76	1.61	1.58	122,572	35,421	101,630	9,417	28,447	0	104,186	85.0%	31	18,386
	Apr-25	57.7	192.9	7,311,959	493.93	1.59	1.58	122,572	37,356	1,410	6,253	5,000	947	56,907	46.4%	32	65,665
	May-25	29.2	128.3	7,513,144	494.10	1.61	1.58	122,572	38,813	26,529	1,924	5,000	1,852	65,270	53.3%	33	57,302
	Jun-25	20.7	90.5	7,714,330	494.28	1.52	1.58	122,572	39,589	37,476	1,322	5,040	1,384	77,087	62.9%	34	45,485
	Jul-25	13.9	98.4	7,915,516	494.46	1.55	1.58	122,572	39,480	4,808	1,441	5,000	960	43,846	35.8%	35	78,726
	Aug-25	35.1	136	8,116,701	494.63	1.61	1.58	122,572	38,641	4,758	2,044	5,000	782	42,137	34.4%	36	80,435
	Sep-25	0.6	198.9	8,317,887	494.80	1.61	1.58	122,572	37,089	-	3,123	5,000	624	34,590	28.2%	37	87,982
	Oct-25	27.8	285.2	8,519,073	494.97	1.61	1.58	122,572	35,311	17,620	4,744	5,000	499	48,686	39.7%	38	73,886
	Nov-25	0.7	332.8	8,720,259	495.13	1.61	1.59	122,572	34,001	2,303	5,683	5,000	451	31,072	25.4%	39	91,500
4	Dec-25	2	388.8	8,921,444	495.30	1.61	1.59	122,572	32,999	40,848	6,884	5,000	487	67,450	55.0%	40	55,122
	Jan-26	0	404.1	9,122,630	495.47	1.61	1.59	122,572	32,657	59,914	7,231	5,000	406	85,746	70.0%	41	36,826
	Feb-26	19.2	320.8	9,323,816	495.63	1.61	1.59	122,572	33,749	39,058	5,468	5,000	355	67,694	55.2%	42	54,878
	Mar-26	17.5	288.7	9,525,001	495.80	1.61	1.59	122,572	35,424	103,655	9,723	30,488	318	104,186	85.0%	43	18,386
	Apr-26	57.7	192.9	9,726,187	495.97	1.59	1.59	122,572	37,359	1,438	6,474	5,000	289	58,099	47.4%	44	64,473
	May-26	29.2	128.3	9,927,373	496.14	1.61	1.59	122,572	38,811	27,041	1,924	5,000	249	64,177	52.4%	45	58,395
	Jun-26	20.7	90.5	10,128,559	496.32	1.53	1.59	122,572	39,587	38,193	1,322	5,039	278	76,697	62.6%	46	45,875
	Jul-26	13.9	98.4	10,329,744	496.49	1.56	1.59	122,572	39,478	4,899	1,441	5,000	259	43,234	35.3%	47	79,338
	Aug-26	35.1	136	10,530,930	496.66	1.61	1.59	122,572	38,639	4,847	2,044	5,000	253	41,695	34.0%	48	80,877
	Sep-26	0.6	198.9	10,732,116	496.83	1.61	1.59	122,572	37,086	-	3,122	5,000	234	34,198	27.9%	49	88,373
	Oct-26	27.8	285.2	10,933,301	496.99	1.61	1.59	122,572	35,308	17,945	4,743	5,000	212	48,720	39.7%	50	73,852
	Nov-26	0.7	332.8	11,134,487	497.15	1.61	1.59	122,572	33,997	2,343	5,683	5,000	190	30,848	25.2%	51	91,724
5	Dec-26	2	388.8	11,335,673	497.31	1.61	1.59	122,572	32,995	41,495	6,883	5,000	157	67,764	55.3%	52	54,808
	Jan-27	0	404.1	11,536,858	497.48	1.61	1.59	122,572	32,653	60,762	7,230	5,000	152	86,337	70.4%	53	36,234
	Feb-27	19.2	320.8	11,536,858	497.48	-	1.59	-	-	39,507	5,444	5,000	211	34,274	0.0%	54	-
	Mar-27	17.5	288.7	11,536,858	497.47	-	1.59	-	-	104,052	4,851	5,000	174	99,375	0.0%	55	-
	Apr-27	57.7	192.9	11,536,858	497.47	-	1.59	-	-	1,441	3,008	5,000	46	-	0.0%	56	-
	May-27	29.2	128.3	11,536,858	497.47	-	1.59	-	-	27,259	1,920	5,000	19	25,357	0.0%	57	-
	Jun-27	20.7	90.5	11,536,858	497.47	-	1.59	-	-	38,427	1,320	5,014	9	37,102	0.0%	58	-
	Jul-27	13.9	98.4	11,536,858	497.47	-	1.59	-	-	4,923	1,436	5,000	5	3,506	0.0%	59	-
	Aug-27	35.1	136	11,744,967	497.64	1.61	1.60	126,790	39,968	4,864	2,044	5,000	2	42,791	33.7%	60	83,999
	Sep-27	0.6	198.9	11,953,076	497.81	1.61	1.60	126,790	38,362	-	3,123	5,000	1	35,241	27.8%	61	91,549
	Oct-27	27.8	285.2	12,161,184	497.98	1.61	1.60	126,790	36,523	17,950	4,744	5,000	136	49,864	39.3%	62	76,925
	Nov-27	0.7	332.8	12,369,293	498.15	1.61	1.60	126,790	35,167	2,342	5,683	5,000	144	31,969	25.2%	63	94,820
6	Dec-27	2	388.8	12,577,401	498.32	1.61	1.60	126,790	34,130	41,468	6,884	5,000	122	68,836	54.3%	64	57,954
	Jan-28	0	404.1	12,785,510	498.48	1.61	1.60	126,790	33,777	60,721	7,231	5,000	115	87,382	68.9%	65	39,407
	Feb-28	19.2	320.8	12,993,618	498.65	1.61	1.60	126,790	34,907	39,519	5,468	5,000	109	69,067	54.5%	66	57,723
	Mar-28	17.5	288.7	13,201,727	498.82	1.61	1.60	126,790	36,630	104,659	9,516	29,098	96	107,771	85.0%	67	19,018
	Apr-28	57.7	192.9	13,409,835	498.99	1.59	1.60	126,790	38,636	1,450	6,324	5,000	91	57,950	45.7%	68	68,840
	May-28	29.2	128.3	13,617,944	499.15	1.61	1.60	126,790	40,146	27,221	1,924	5,000	81	65,524	51.7%	69	61,266
	Jun-28	20.7	90.5	13,826,052	499.33	1.52	1.60	126,790	40,949	38,379	1,322	5,040	90	78,057	61.6%	70	48,732
	Jul-28	13.9	98.4	14,034,161	499.50	1.55	1.60	126,790	40,836	4,914	1,441	5,000	87	44,437	35.0%	71	82,353
	Aug-28	35.1	136	14,034,161	499.50	-	1.60	-	-	4,854	2,039	5,000	87	2,902	0.0%	72	-
	Sep-28	0.6	198.9	14,034,161	499.50	-	1.60	-	-	-	3,113	5,000	83	-	0.0%	73	-
	Oct-28	27.8	285.2	14,034,161	499.50	-	1.60	-	-	17,920	4,727	5,000	39	13,232	0.0%	74	-
	Nov-28	0.7	332.8	14,034,161	499.50	-	1.60	-	-	2,337	5,659	5,000	20	-	0.0%	75	-
7	Dec-28	2	388.8	14,034,161	499.50	-	1.60	-	-	41,413	6,853	5,000	11	34,570	0.0%	76	-
	Jan-29	0	404.1	14,034,161	499.50	-	1.60	-	-	60,651	7,198	5,000	6	53,459	0.0%	77	-
	Feb-29	19.2	320.8	14,278,335	499.69	1.61	1.60	148,763	40,957	39,552	5,472	5,000	3	75,040	50.4%	78	73,723
	Mar-29	17.5	288.7	14,522,509	499.89	1.61	1.60	148,763	42,892	104,433	7,742	18,138	2	126,448	85.0%	79	22,314
	Apr-29	57.7	192.9	14,766,683	500.08	1.60	1.60	148,763	45,272	1,447	5,037	5,000	42	54,861	36.9%	80	93,901
	May-29	29.2	128.3	15,010,858	500.28	1.58	1.60	148,763	47,103	27,232	1,925	5,000	155	72,566	48.8%	81	76,196
	Jun-29	20.7	90.5	15,255,032	500.49	1.48	1.60	148,763	48,046	38,395	1,322	5,043	261	85,337	57.4%	82	63,426
	Jul-29	13.9	98.4	15,499,206	500.70	1.50	1.60	148,763	47,914	4,916	1,442	5,000	206	51,637	34.7%	83	97,126
	Aug-29	35.1	136	15,743,380	500.89	1.60	1.60	148,763	46,895	4,855	2,045	5,000	179	49,884	33.5%	84	98,878
	Sep-29	0.6	198.9	15,987,555	501.08	1.61	1.60	148,763	45,011	-	3,124	5,000	155	42,042	28.3%	85	106,721
	Oct-29	27.8	285.2	16,231,729	501.27	1.61	1.60	148,763	42,853	17,911	4,747	5,000	1,012	57,029	38.3%	86	91,734
	Nov-29	0.7	332.8	16,475,903	501.46	1.61	1.60	148,763	41,263	2,337	5,688	5,000	1,228	39,140	26.3%	87	109,623
8	Dec-29	2	388.8	16,720,077	501.65	1.61	1.60	148,763	40,047	41,373	6,890	5,000	740	75,269	50.6%	88	73,493
	Jan-30	0	404.1	16,964,251	501.85	1.61	1.60	148,763	39,632	60,577	7,237	5,000	510	93,483	62.8%	89	55,280
	Feb-30	19.2	320.8	16,964,251	501.84	-	1.60	-	-	39,387	5,444	5,000	400	34,343	0.0%	90	-
	Mar-30	17.5	288.7	16,964,251	501.84	-	1.60	-	-	103,735	4,850	5,000	331	99,216	0.0%	91	-
	Apr-30	57.7	192.9	16,964,251	501.84	-	1.60	-	-	1,437	3,008	5,000	42	-	0.0%	92	-
	May-30	29.2	128.3	16,964,251	501.84	-	1.60	-	-	27,176	1,920	5,000	22	25,277	0.0%	93	-
	Jun-30	20.7	90.5	16,964,251	501.84	-	1.60	-	-	38,310	1,320	5,013	14	36,991	0.0%	94	-
	Jul-30	13.9	98.4	16,964,251	501.84	-	1.60	-	-	4,908	1,436	5,000	9	3,495	0.0%	95	-
	Aug-30	35.1	136	17,215,707	502.05	1.59	1.60	153,199	48,293	4,849	2,045	5,000	6	51,104	33.4%	96	102,095
	Sep-30	0.6	198.9	17,467,162	502.25	1.61	1.60	153,199	46,354	-	3,125	5,000	4	43,233	28.2%	97	109,965
	Oct-30	27.8	285.2	17,718,618	502.45	1.61	1.60	153,199	44,131	17,890	4,748	5,000	293	57,567	37.6%	98	95,632
	Nov-30	0.7	332.8	17,970,073	502.65	1.61	1.60	153,199	42,494	2,334	5,689	5,000	255	39,394	25.7%	99	113,805
9	Dec-30	2	388.8	18,221,528	502.85	1.61	1.60	153,199	41,241	41,324	6,891	5,000	215	75,889	49.5%	100	77,309

TABLE 6.8: TSF CELL C WATER BALANCE - WET CONDITIONS

Year	Month	Rainfall	Evaporation	Cumulative Tonnage	Tailings Level	Tailings density		Water in Slurry	Supernatant Runoff	Rainfall Runoff	Evaporation Losses	Pond Volume	Consolidation Volume	Available TSF Recycle		Discharge	Make Up Requirement
						Layers	Mass										
		mm	mm	t	RL m	t/m3	t/m3	m³	m³	m³	m³	m³	m³	m³	%	m³	m³
	Jan-31	0	404.1	18,472,984	503.05	1.61	1.60	153,199	40,815	60,504	7,238	5,000	189	94,270	61.5%	101	58,929
	Feb-31	19.2	320.8	18,724,439	503.25	1.61	1.60	153,199	42,180	39,384	5,473	5,000	171	76,261	49.8%	102	76,937
	Mar-31	17.5	288.7	18,975,894	503.45	1.61	1.60	153,199	44,151	103,916	7,303	15,698	152	130,219	85.0%	103	22,980
	Apr-31	57.7	192.9	19,227,350	503.65	1.60	1.60	153,199	46,608	1,439	4,717	5,000	143	54,172	35.4%	104	99,027
	May-31	29.2	128.3	19,478,805	503.86	1.57	1.60	153,199	48,509	27,114	1,925	5,000	132	73,829	48.2%	105	79,369
	Jun-31	20.7	90.5	19,730,260	504.08	1.47	1.60	153,199	49,479	38,229	1,322	5,044	124	86,466	56.4%	106	66,732
	Jul-31	13.9	98.4	19,981,716	504.29	1.49	1.60	153,199	49,343	4,895	1,442	5,000	120	52,959	34.6%	107	100,239
	Aug-31	35.1	136	19,981,716	504.29	-	1.60	-	-	4,835	2,039	5,000	106	2,901	0.0%	108	-
	Sep-31	0.6	198.9	19,981,716	504.29	-	1.60	-	-	-	3,113	5,000	99	-	0.0%	109	-
	Oct-31	27.8	285.2	19,981,716	504.29	-	1.60	-	-	17,847	4,726	5,000	35	13,155	0.0%	110	-
	Nov-31	0.7	332.8	19,981,716	504.29	-	1.60	-	-	2,328	5,659	5,000	14	-	0.0%	111	-
10	Dec-31	2	388.8	19,981,716	504.29	-	1.60	-	-	41,245	6,853	5,000	7	34,399	0.0%	112	-
	Jan-32	0	404.1	19,981,716	504.29	-	1.60	-	-	60,405	7,197	5,000	4	53,212	0.0%	113	-
	Feb-32	19.2	320.8	20,232,235	504.49	1.61	1.60	152,628	42,023	39,317	5,473	5,000	2	75,869	49.7%	114	76,759
	Mar-32	17.5	288.7	20,482,754	504.69	1.61	1.60	152,628	43,987	103,742	7,302	15,694	2	129,734	85.0%	115	22,894
	Apr-32	57.7	192.9	20,733,273	504.88	1.60	1.60	152,628	46,435	1,437	4,716	5,000	896	54,746	35.9%	116	97,882
11	May-32	29.2	128.3	20,983,791	505.09	1.57	1.60	152,628	48,328	27,069	1,925	5,000	1,417	74,889	49.1%	117	77,740

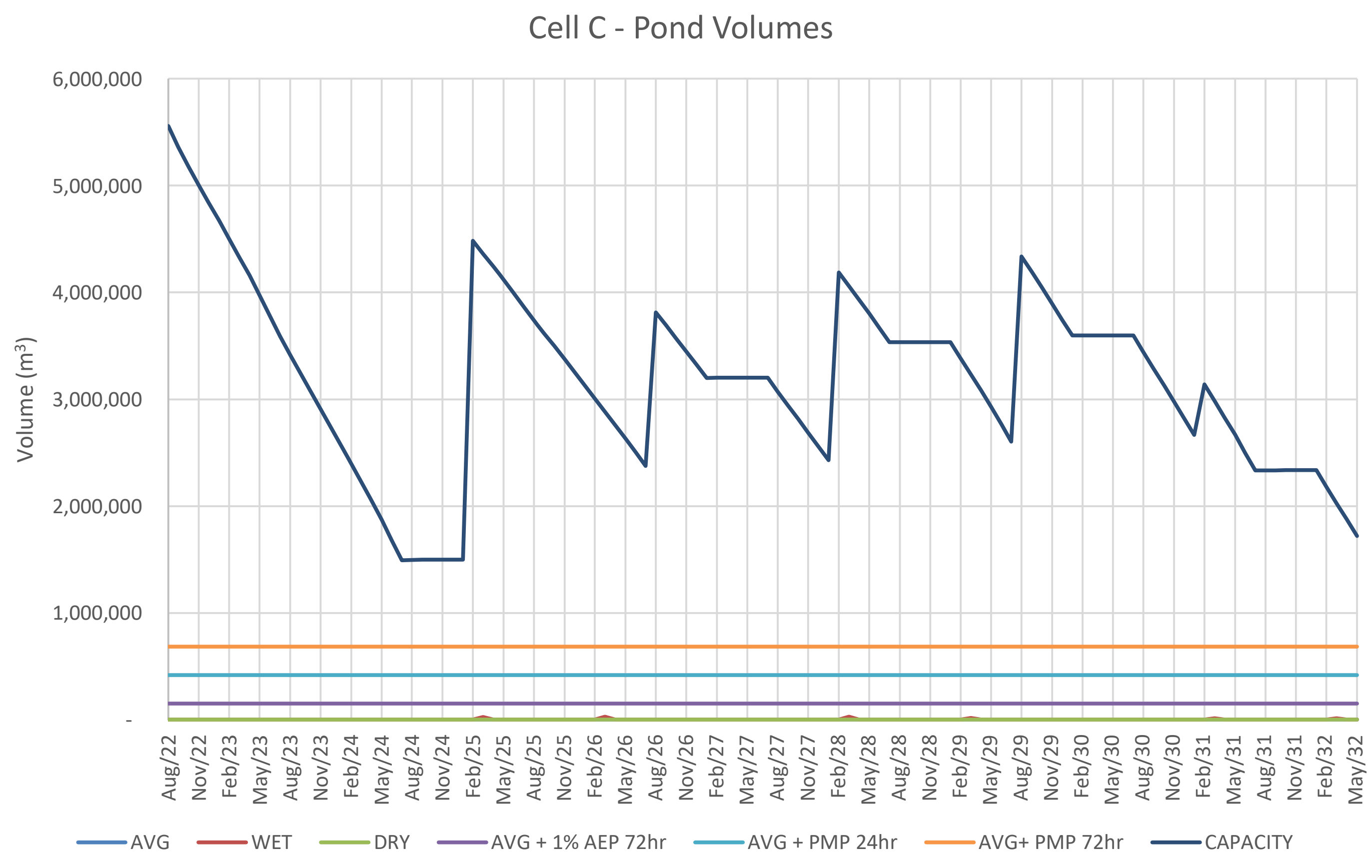
TABLE 6.9: TSF CELL D WATER BALANCE - WET CONDITIONS

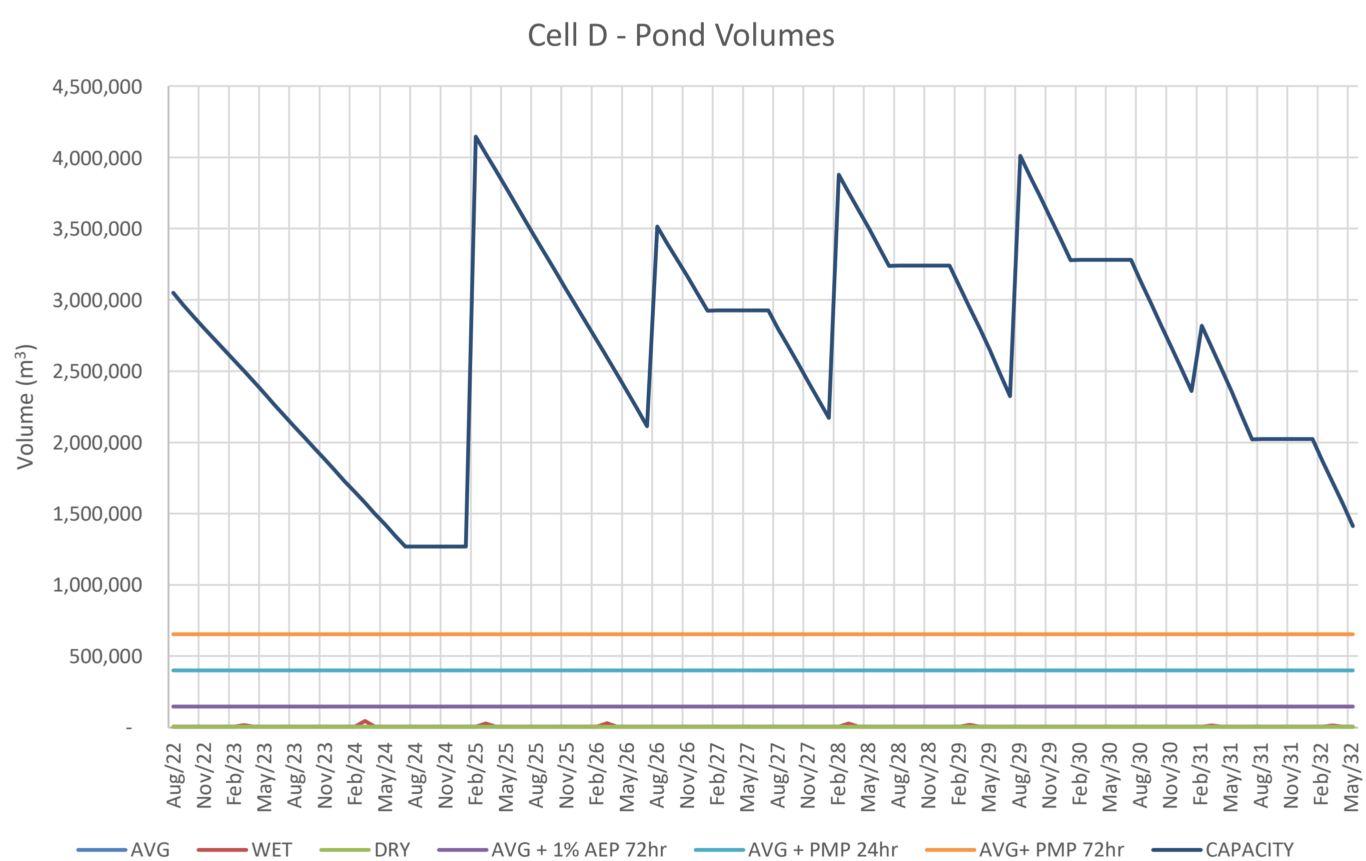
Year	Month	Rainfall	Evaporation	Cumulative Tonnage	Tailings Level	Tailings density		Water in Slurry	Supernatant Runoff	Rainfall Runoff	Evaporation Losses	Pond Volume	Consolidation Volume	Available TSF Recycle		Discharge	Make Up Requirement
						Layers	Mass										
		mm	mm	t	RL m	t/m3	t/m3	m³	m³	m³	m³	m³	m³	m³	%	m³	m³
	Aug-22	35.1	136	124,355	488.27	1.35	1.35	75,763	24,443	1,266	1,724	5,164	-	23,822	31.4%	-	51,941
	Sep-22	0.6	198.9	248,710	489.18	1.42	1.39	75,763	23,271	-	3,179	5,000	-	20,256	26.7%	1	55,507
	Oct-22	27.8	285.2	373,065	489.55	1.58	1.44	75,763	22,140	7,156	4,769	5,000	-	24,526	32.4%	2	51,237
	Nov-22	0.7	332.8	497,420	489.91	1.59	1.48	75,763	21,310	1,023	5,709	5,000	-	16,624	21.9%	3	59,139
1	Dec-22	2	388.8	621,775	490.27	1.60	1.51	75,763	20,663	19,655	6,907	5,000	-	33,411	44.1%	4	42,352
	Jan-23	0	404.1	746,130	490.62	1.60	1.53	75,763	20,410	31,028	7,248	5,000	616	44,807	59.1%	5	30,956
	Feb-23	19.2	320.8	870,485	490.97	1.60	1.54	75,763	21,022	21,657	5,477	5,000	342	37,545	49.6%	6	38,218
	Mar-23	17.5	288.7	994,840	491.15	1.60	1.55	75,763	22,015	60,777	7,397	16,208	212	64,399	85.0%	7	11,364
	Apr-23	57.7	192.9	1,119,195	491.33	1.59	1.56	75,763	23,157	884	4,785	5,000	154	30,619	40.4%	8	45,144
	May-23	29.2	128.3	1,243,550	491.49	1.60	1.56	75,763	24,026	17,404	1,925	5,000	61	39,567	52.2%	9	36,196
	Jun-23	20.7	90.5	1,367,906	491.67	1.51	1.56	75,763	24,492	25,678	1,322	5,040	64	48,873	64.5%	10	26,890
	Jul-23	13.9	98.4	1,492,261	491.85	1.56	1.56	75,763	24,423	3,436	1,441	5,000	51	26,509	35.0%	11	49,255
	Aug-23	35.1	136	1,616,616	492.02	1.61	1.57	75,763	23,907	3,535	2,043	5,000	47	25,447	33.6%	12	50,316
	Sep-23	0.6	198.9	1,740,971	492.18	1.61	1.57	75,763	22,955	-	3,121	5,000	42	19,875	26.2%	13	55,888
	Oct-23	27.8	285.2	1,865,326	492.35	1.61	1.58	75,763	21,860	14,064	4,741	5,000	63	31,246	41.2%	14	44,517
	Nov-23	0.7	332.8	1,989,681	492.52	1.61	1.58	75,763	21,050	1,901	5,678	5,000	201	17,474	23.1%	15	58,289
2	Dec-23	2	388.8	2,114,036	492.69	1.61	1.58	75,763	20,427	34,861	6,877	5,000	132	48,543	64.1%	16	27,220
	Jan-24	0	404.1	2,238,391	492.85	1.61	1.58	75,763	20,217	52,803	8,035	5,688	101	64,399	85.0%	17	11,364
	Feb-24	19.2	320.8	2,362,746	493.02	1.61	1.59	75,763	20,882	35,417	5,699	5,000	83	51,371	67.8%	18	24,392
	Mar-24	17.5	288.7	2,487,101	493.13	1.61	1.59	75,763	21,980	95,760	11,923	46,488	70	64,399	85.0%	19	11,364
	Apr-24	57.7	192.9	2,611,456	493.24	1.58	1.59	75,763	23,149	1,331	8,094	5,000	60	57,933	76.5%	20	17,830
	May-24	29.2	128.3	2,735,811	493.36	1.61	1.59	75,763	23,994	24,970	1,923	5,000	30	47,071	62.1%	21	28,692
	Jun-24	20.7	90.5	2,860,166	493.47	1.61	1.59	75,763	24,472	35,329	1,321	5,033	44	58,491	77.2%	22	17,272
	Jul-24	13.9	98.4	2,984,521	493.58	1.61	1.59	75,763	24,405	4,541	1,440	5,000	37	27,576	36.4%	23	48,187
	Aug-24	35.1	136	2,984,521	493.58	-	1.59	-	-	4,485	2,040	5,000	35	2,481	0.0%	24	-
	Sep-24	0.6	198.9	2,984,521	493.58	-	1.59	-	-	-	3,113	5,000	32	-	0.0%	25	-
	Oct-24	27.8	285.2	2,984,521	493.58	-	1.59	-	-	16,557	4,727	5,000	7	11,837	0.0%	26	-
	Nov-24	0.7	332.8	2,984,521	493.58	-	1.59	-	-	2,160	5,659	5,000	3	-	0.0%	27	-
3	Dec-24	2	388.8	2,984,521	493.58	-	1.59	-	-	38,264	6,854	5,000	1	31,411	0.0%	28	-
	Jan-25	0	404.1	2,984,521	493.58	-	1.59	-	-	56,040	7,199	5,000	0	48,842	0.0%	29	-
	Feb-25	19.2	320.8	3,176,291	493.76	1.61	1.59	116,835	32,184	36,773	5,468	5,000	0	63,488	54.3%	30	53,347
	Mar-25	17.5	288.7	3,368,060	493.93	1.61	1.60	116,835	33,775	97,931	9,356	28,041	0	99,310	85.0%	31	17,525
	Apr-25	57.7	192.9	3,559,829	494.11	1.59	1.60	116,835	35,615	1,364	6,208	5,000	21	53,833	46.1%	32	63,002
	May-25	29.2	128.3	3,751,599	494.29	1.61	1.60	116,835	36,999	25,741	1,924	5,000	18	60,834	52.1%	33	56,001
	Jun-25	20.7	90.5	3,943,368	494.47	1.53	1.59	116,835	37,737	36,492	1,322	5,039	22	72,890	62.4%	34	43,945
	Jul-25	13.9	98.4	4,135,138	494.65	1.55	1.59	116,835	37,633	4,699	1,441	5,000	19	40,949	35.0%	35	75,886
	Aug-25	35.1	136	4,326,907	494.83	1.61	1.59	116,835	36,834	4,665	2,044	5,000	18	39,474	33.8%	36	77,362
	Sep-25	0.6	198.9	4,518,677	495.00	1.61	1.59	116,835	35,355	-	3,122	5,000	17	32,249	27.6%	37	84,586
	Oct-25	27.8	285.2	4,710,446	495.17	1.61	1.60	116,835	33,661	17,369	4,743	5,000	14	46,301	39.6%	38	70,535
	Nov-25	0.7	332.8	4,902,216	495.33	1.61	1.60	116,835	32,413	2,271	5,682	5,000	13	29,014	24.8%	39	87,821
4	Dec-25	2	388.8	5,093,985	495.50	1.61	1.60	116,835	31,457	40,306	6,883	5,000	11	64,891	55.5%	40	51,944
	Jan-26	0	404.1	5,285,755	495.67	1.61	1.60	116,835	31,131	59,151	7,229	5,000	84	83,137	71.2%	41	33,698
	Feb-26	19.2	320.8	5,477,524	495.84	1.61	1.60	116,835	32,171	38,581	5,467	5,000	84	65,369	55.9%	42	51,467
	Mar-26	17.5	288.7	5,669,293	496.01	1.61	1.60	116,835	33,779	102,493	9,957	32,075	70	99,310	85.0%	43	17,525
	Apr-26	57.7	192.9	5,861,063	496.18	1.59	1.60	116,835	35,619	1,423	6,642	5,000	59	57,534	49.2%	44	59,301
	May-26	29.2	128.3	6,052,832	496.34	1.61	1.60	116,835	36,995	26,755	1,924	5,000	48	61,874	53.0%	45	54,961
	Jun-26	20.7	90.5	6,244,602	496.52	1.54	1.60	116,835	37,735	37,808	1,322	5,038	53	74,236	63.5%	46	42,599
	Jul-26	13.9	98.4	6,436,371	496.69	1.57	1.60	116,835	37,631	4,853	1,441	5,000	46	41,127	35.2%	47	75,708
	Aug-26	35.1	136	6,628,141	496.86	1.61	1.60	116,835	36,831	4,803	2,044	5,000	44	39,634	33.9%	48	77,201
	Sep-26	0.6	198.9	6,819,910	497.03	1.61	1.60	116,835	35,351	-	3,122	5,000	38	32,268	27.6%	49	84,567
	Oct-26	27.8	285.2	7,011,680	497.18	1.61	1.60	116,835	33,656	17,766	4,743	5,000	33	46,713	40.0%	50	70,122
	Nov-26	0.7	332.8	7,203,449	497.34	1.61	1.60	116,835	32,408	2,315	5,682	5,000	29	29,070	24.9%	51	87,765
5	Dec-26	2	388.8	7,395,219	497.50	1.61	1.60	116,835	31,453	40,966	6,882	5,000	24	65,560	56.1%	52	51,275
	Jan-27	0	404.1	7,586,988	497.66	1.61	1.60	116,835	31,128	59,929	7,229	5,000	22	83,850	71.8%	53	32,986
	Feb-27	19.2	320.8	7,586,988	497.66	-	1.60	-	-	38,965	5,444	5,000	21	33,542	0.0%	54	-
	Mar-27	17.5	288.7	7,586,988	497.66	-	1.60	-	-	102,625	4,851	5,000	20	97,794	0.0%	55	-
	Apr-27	57.7	192.9	7,586,988	497.66	-	1.60	-	-	1,421	3,008	5,000	6	-	0.0%	56	-
	May-27	29.2	128.3	7,586,988	497.66	-	1.60	-	-	26,885	1,920	5,000	2	24,967	0.0%	57	-
	Jun-27	20.7	90.5	7,586,988	497.66	-	1.60	-	-	37,900	1,320	5,014	1	36,567	0.0%	58	-
	Jul-27	13.9	98.4	7,586,988	497.66	-	1.60	-	-	4,856	1,436	5,000	0	3,434	0.0%	59	-
	Aug-27	35.1	136	7,790,120	497.83	1.61	1.60	123,758	39,013	4,794	2,044	5,000	0	41,764	33.7%	60	81,994
	Sep-27	0.6	198.9	7,993,252	498.00	1.61	1.60	123,758	37,447	-	3,123	5,000	0	34,324	27.7%	61	89,433
	Oct-27	27.8	285.2	8,196,384	498.17	1.61	1.60	123,758	35,652	17,654	4,744	5,000	16	48,578	39.3%	62	75,180
	Nov-27	0.7	332.8	8,399,517	498.34	1.61	1.61	123,758	34,330	2,301	5,683	5,000	18	30,965	25.0%	63	92,793
6	Dec-27	2	388.8	8,602,649	498.51	1.61	1.61	123,758	33,318	40,701	6,884	5,000	17	67,153	54.3%	64	56,605
	Jan-28	0	404.1	8,805,781	498.68	1.61	1.61	123,758	32,974	59,538	7,231	5,000	16	85,297	68.9%	65	38,461
	Feb-28	19.2	320.8	9,008,913	498.85	1.61	1.61	123,758	34,077	38,709	5,468	5,000	11	67,329	54.4%	66	56,429
	Mar-28	17.5	288.7	9,212,045	499.02	1.61	1.61	123,758	35,759	102,417	9,434	28,558	11	105,194	85.0%	67	18,564
	Apr-28	57.7	192.9	9,415,177	499.19	1.59	1.61	123,758	37,715	1,418	6,265	5,000	10	56,437	45.6%	68	67,321
	May-28	29.2	128.3	9,618,310	499.35	1.61	1.61	123,758	39,188	26,635	1,924	5,000	9	63,908	51.6%	69	59,850
	Jun-28	20.7	90.5	9,821,442	499.53	1.52	1.60	123,758	39,971	37,564	1,322	5,040	10	76,184	61.6%	70	47,574
	Jul-28	13.9	98.4	10,024,574	499.70	1.55	1.60	123,758	39,861	4,811	1,441	5,000	10	43,281	35.0%	71	80,477
	Aug-28	35.1	136	10,024,574	499.70	-	1.60	-	-	4,753	2,039	5,000	10	2,723	0.0%	72	-
	Sep-28	0.6	198.9	10,024,574	499.70	-	1.60	-	-	-	3,113	5,000	10	-	0.0%	73	-
	Oct-28	27.8	285.2	10,024,574	499.70	-	1.60	-	-	17,544	4,727	5,000	5	12,822	0.0%	74	-
	Nov-28	0.7	332.8	10,024,574	499.70	-	1.60	-	-	2,288	5,659	5,000	2	-	0.0%	75	-
7	Dec-28	2	388.8	10,024,574	499.70	-	1.60	-	-	40,545	6,853	5,000	1	33,692	0.0%	76	-
	Jan-29	0	404.1	10,024,574	499.70	-	1.60	-	-	59,380	7,198	5,000	0	52,182	0.0%	77	-
	Feb-29	19.2	320.8	10,264,393	499.89	1.61	1.60	146,109	40,232	38,737	5,472	5,000	0	73,497	50.3%	78	72,612
	Mar-29	17.5	288.7	10,504,212	500.08	1.61	1.60	146,109	42,130	102,309	7,647	17,599	0	124,193	85.0%	79	21,916
	Apr-29	57.7	192.9	10,744,032	500.28	1.60	1.61	146,109	44,466	1,418	4,967	5,000	5	53,520	36.6%	80	92,589
	May-29	29.2	128.3	10,983,851	500.48	1.58	1.60	146,109	46,265	26,697	1,925	5,000	96	71,133	48.7%	81	74,976
	Jun-29	20.7	90.5	11,223,670	500.69	1.48	1.60	146,109	47,190	37,654	1,322	5,043	198	83,677	57.3%	82	62,432
	Jul-29	13.9	98.4	11,463,489	500.90	1.49	1.60	146,109	47,060	4,823	1,442	5,000	153	50,637	34.7%	83	95,472
	Aug-29	35.1	136	11,703,308	501.09	1.60	1.60	146,109	46,060	4,764	2,045	5,000	124	48,904	33.5%	84	97,205
	Sep-29	0.6	198.9	11,943,128	501.28	1.61	1.60	146,109	44,211	-	3,124	5,000	100	41,187	28.2%	85	104,922
	Oct-29	27.8	285.2	12,182,947	501.47	1.61	1.60	146,109	42,092	17,589	4,747	5,000	946	55,880	38.2%	86	90,229
	Nov-29	0.7	332.8	12,422,766	501.66	1.61	1.60	146,109	40,531	2,295	5,688	5,000	1,180	38,319	26.2%	87	107,790
8	Dec-29	2	388.8	12,662,585	501.85	1.61	1.60	146,109	39,337	40,653	6,890	5,000	684	73,784	50.5%	88	72,325
	Jan-30	0	404.1	12,902,405	502.05	1.61	1.60	146,109	38,930	59,542	7,237	5,000	461	91,697	62.8%	89	54,412
	Feb-30	19.2	320.8	12,902,405	502.05	-	1.60	-	-	38,714	5,444	5,000	355	33,625	0.0%	90	-
	Mar-30	17.5	288.7	12,902,405	502.05	-	1.60	-	-	101,963	4,850	5,000	289	97,402	0.0%	91	-
	Apr-30	57.7	192.9	12,902,405	502.05	-	1.60	-	-	1,412	3,008	5,000	17	-	0.0%	92	-
	May-30	29.2	128.3	12,902,405	502.05	-	1.60	-	-	26,712	1,920	5,000	5	24,796	0.0%	93	-
	Jun-30	20.7	90.5	12,902,405	502.05	-	1.60	-	-	37,655	1,320	5,013	2	36,325	0.0%	94	-
	Jul-30	13.9	98.4	12,902,405	502.05	-	1.60	-	-	4,825	1,436	5,000	1	3,403	0.0%	95	-
	Aug-30	35.1	136	13,150,680	502.25	1.59	1.60	151,261	47,684	4,768	2,045	5,000	1	50,409	33.3%	96	100,853
	Sep-30	0.6	198.9	13,398,956	502.45	1.61	1.60	151,261	45,770	-	3,125	5,000	1	42,646	28.2%	97	108,616
	Oct-30	27.8	285.2	13,647,232	502.65	1.61	1.61	151,261	43,576	17,603	4,748	5,000	273	56,706	37.5%	98	94,556
	Nov-30	0.7	332.8	13,895,508	502.85	1.61	1.61	151,261	41,960	2,297	5,689	5,000	228	38,797	25.6%	99	112,464
9	Dec-30	2	388.8	14,143,784	503.05	1.61	1.61	151,261	40,724	40,688	6,891	5,000	186	74,707	49.4%	100	76,554

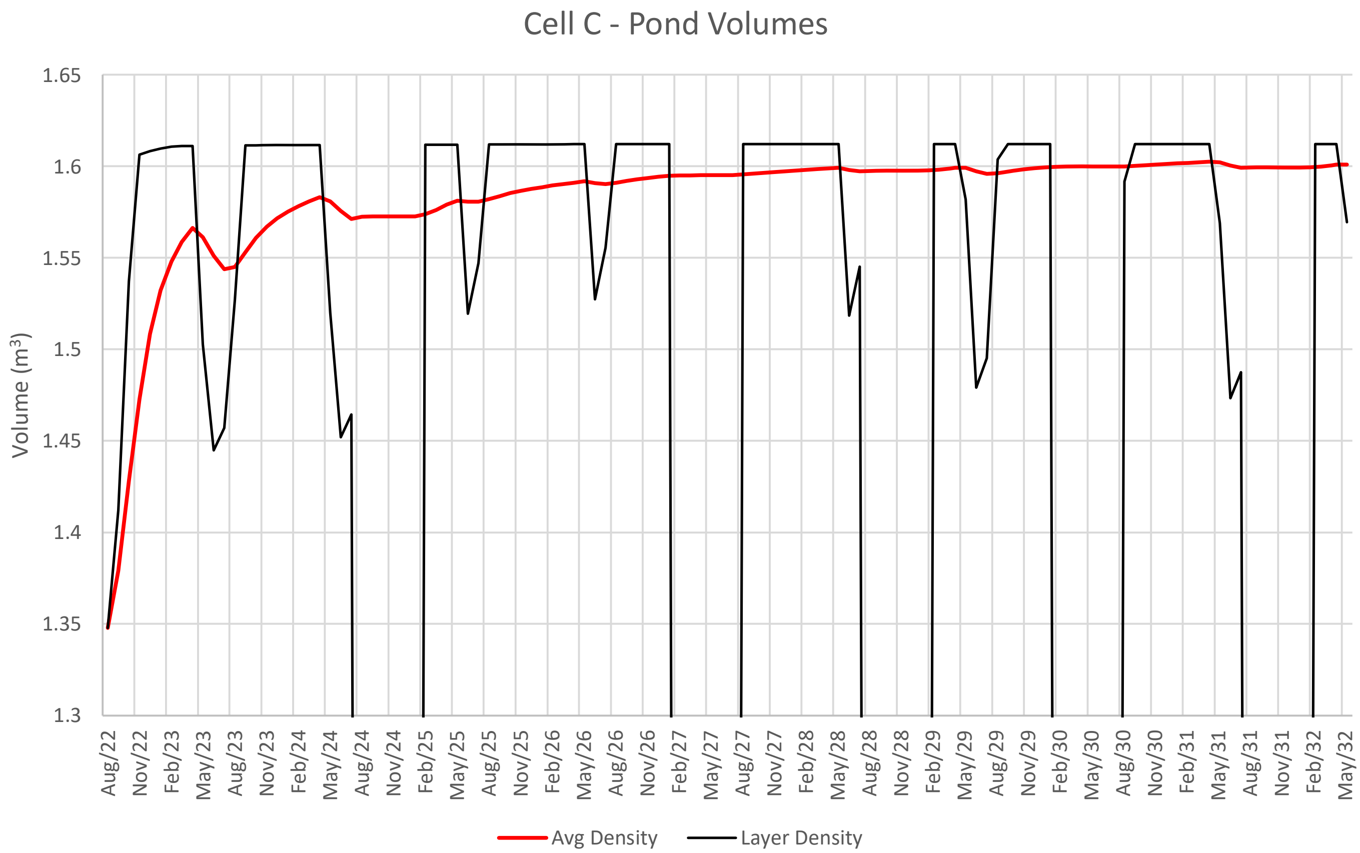
TABLE 6.9: TSF CELL D WATER BALANCE - WET CONDITIONS

Year	Month	Rainfall	Evaporation	Cumulative Tonnage	Tailings Level	Tailings density		Water in Slurry	Supernatant Runoff	Rainfall Runoff	Evaporation Losses	Pond Volume	Consolidation Volume	Available TSF Recycle		Discharge	Make Up Requirement
						Layers	Mass										
		mm	mm	t	RL m	t/m3	t/m3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	%	m^3	m^3
	Jan-31	0	404.1	14,392,060	503.25	1.61	1.61	151,261	40,303	59,593	7,238	5,000	158	92,816	61.4%	101	58,445
	Feb-31	19.2	320.8	14,640,335	503.45	1.61	1.61	151,261	41,650	38,804	5,473	5,000	140	75,121	49.7%	102	76,141
	Mar-31	17.5	288.7	14,888,611	503.65	1.61	1.61	151,261	43,594	102,415	7,235	15,329	127	128,572	85.0%	103	22,689
	Apr-31	57.7	192.9	15,136,887	503.86	1.60	1.61	151,261	46,019	1,419	4,667	5,000	118	53,218	35.2%	104	98,043
	May-31	29.2	128.3	15,385,163	504.06	1.57	1.61	151,261	47,896	26,742	1,925	5,000	107	72,820	48.1%	105	78,441
	Jun-31	20.7	90.5	15,633,439	504.28	1.47	1.60	151,261	48,854	37,718	1,322	5,044	111	85,317	56.4%	106	65,945
	Jul-31	13.9	98.4	15,881,714	504.50	1.49	1.60	151,261	48,720	4,831	1,442	5,000	106	52,259	34.5%	107	99,003
	Aug-31	35.1	136	15,881,714	504.50	-	1.60	-	-	4,772	2,039	5,000	98	2,830	0.0%	108	-
	Sep-31	0.6	198.9	15,881,714	504.50	-	1.60	-	-	-	3,113	5,000	91	-	0.0%	109	-
	Oct-31	27.8	285.2	15,881,714	504.50	-	1.60	-	-	17,615	4,726	5,000	30	12,918	0.0%	110	-
	Nov-31	0.7	332.8	15,881,714	504.50	-	1.60	-	-	2,298	5,659	5,000	11	-	0.0%	111	-
10	Dec-31	2	388.8	15,881,714	504.50	-	1.60	-	-	40,708	6,853	5,000	4	33,860	0.0%	112	-
	Jan-32	0	404.1	15,881,714	504.50	-	1.60	-	-	59,619	7,197	5,000	2	52,424	0.0%	113	-
	Feb-32	19.2	320.8	16,129,989	504.70	1.61	1.60	151,260	41,649	38,821	5,473	5,000	1	74,998	49.6%	114	76,262
	Mar-32	17.5	288.7	16,378,263	504.90	1.61	1.60	151,260	43,593	102,457	7,222	15,258	1	128,571	85.0%	115	22,689
	Apr-32	57.7	192.9	16,626,537	505.09	1.60	1.60	151,260	46,018	1,420	4,657	5,000	886	53,925	35.7%	116	97,336
11	May-32	29.2	128.3	16,874,811	505.30	1.57	1.60	151,260	47,896	26,754	1,925	5,000	1,397	74,122	49.0%	117	77,139

FIGURES


Cell C - Pond Volumes
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
-
Volume (m³)
Aug/22 Nov/22 Feb/23 May/23 Aug/23 Nov/23 Feb/24 May/24 Aug/24 Nov/24 Feb/25 May/25 Aug/25 Nov/25 Feb/26 May/26 Aug/26 Nov/26 Feb/27 May/27 Aug/27 Nov/27 Feb/28 May/28 Aug/28 Nov/28 Feb/29 May/29 Aug/29 Nov/29 Feb/30 May/30 Aug/30 Nov/30 Feb/31 May/31 Aug/31 Nov/31 Feb/32 May/32
AVG
WET
DRY
AVG + 1% AEP 72hr
AVG + PMP 24hr
AVG+ PMP 72hr
CAPACITY


Cell D - Pond Volumes
4,500,000
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
-
Volume (m³)
Aug/22 Nov/22 Feb/23 May/23 Aug/23 Nov/23 Feb/24 May/24 Aug/24 Nov/24 Feb/25 May/25 Aug/25 Nov/25 Feb/26 May/26 Aug/26 Nov/26 Feb/27 May/27 Aug/27 Nov/27 Feb/28 May/28 Aug/28 Nov/28 Feb/29 May/29 Aug/29 Nov/29 Feb/30 May/30 Aug/30 Nov/30 Feb/31 May/31 Aug/31 Nov/31 Feb/32 May/32
AVG
WET
DRY
AVG + 1% AEP 72hr
AVG + PMP 24hr
AVG+ PMP 72hr
CAPACITY



Cell C - Pond Volumes
Volume (m³)
1.65
1.6
1.55
1.5
1.45
1.4
1.35
1.3
Aug/22
Nov/22
Feb/23
May/23
Aug/23
Nov/23
Feb/24
May/24
Aug/24
Nov/24
Feb/25
May/25
Aug/25
Nov/25
Feb/26
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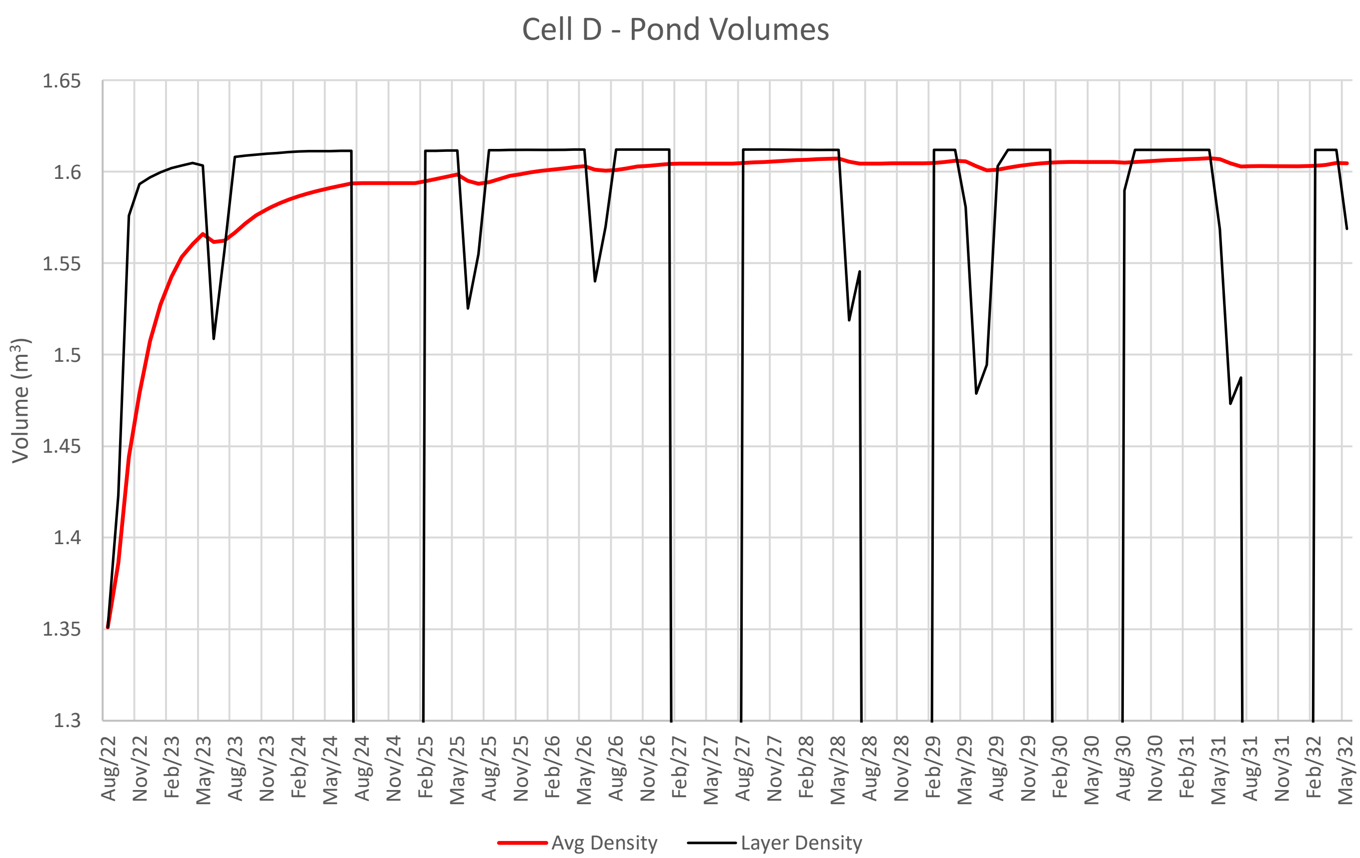
Feb/30
May/30
Aug/30
Nov/30
Feb/31
May/31
Aug/31
Nov/31
Feb/32
May/32
Avg Density
Layer Density



Cell D - Pond Volumes
Volume (m³)
1.65
1.6
1.55
1.5
1.45
1.4
1.35
1.3
Aug/22
Nov/22
Feb/23
May/23
Aug/23
Nov/23
Feb/24
May/24
Aug/24
Nov/24
Feb/25
May/25
Aug/25
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Aug/29
Nov/29
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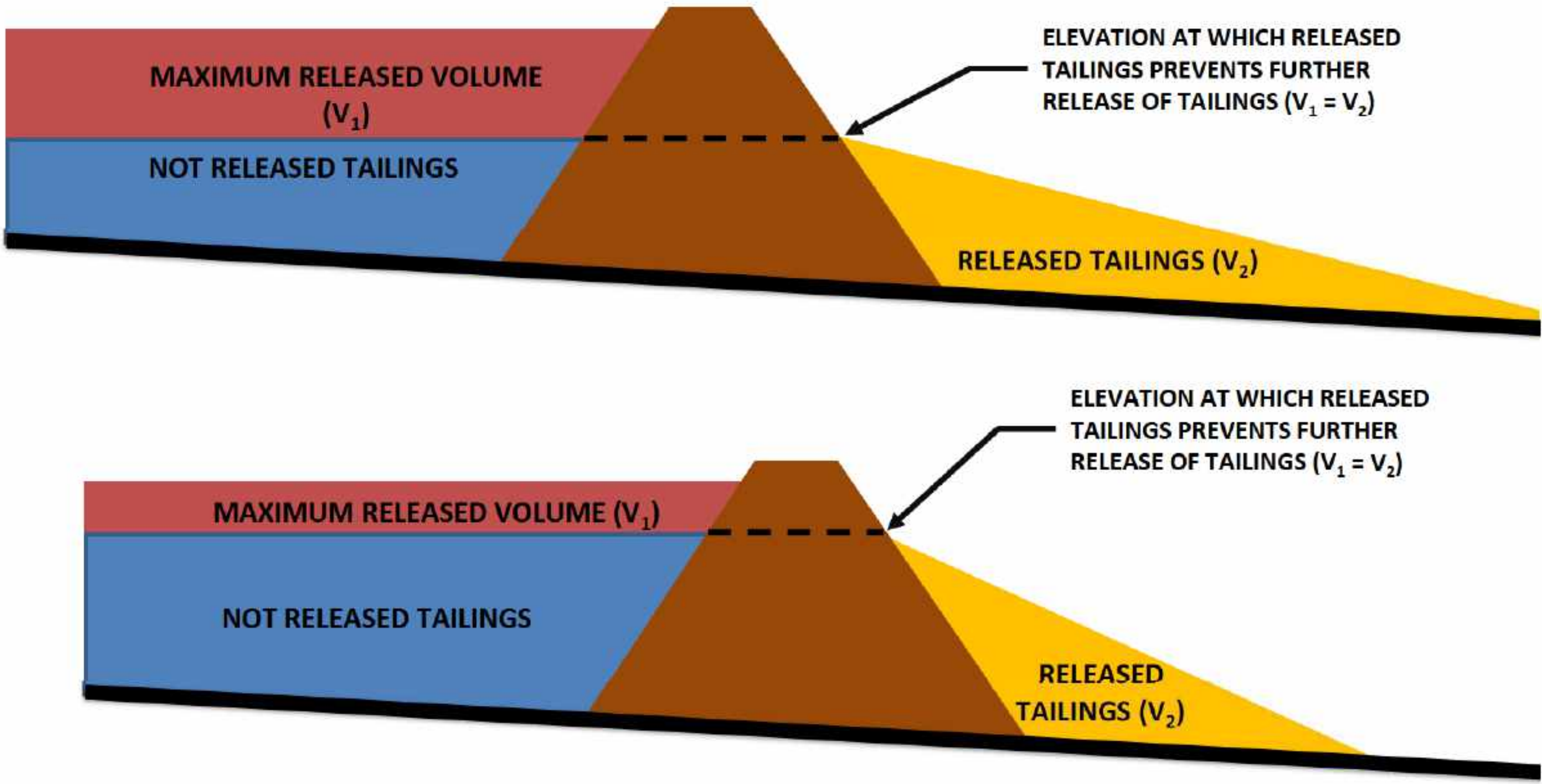
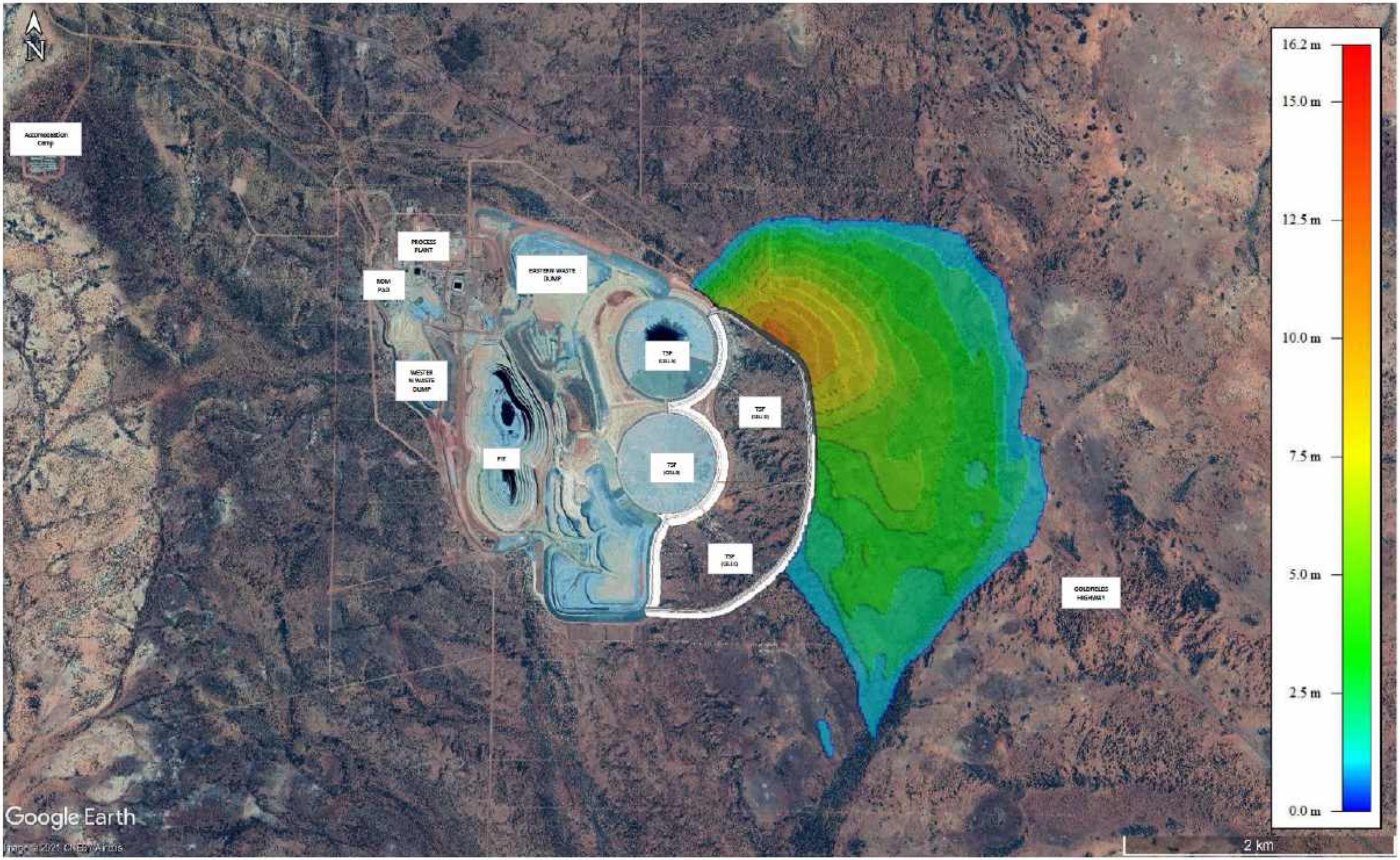
Nov/31
Feb/32
May/32
Avg Density
Layer Density



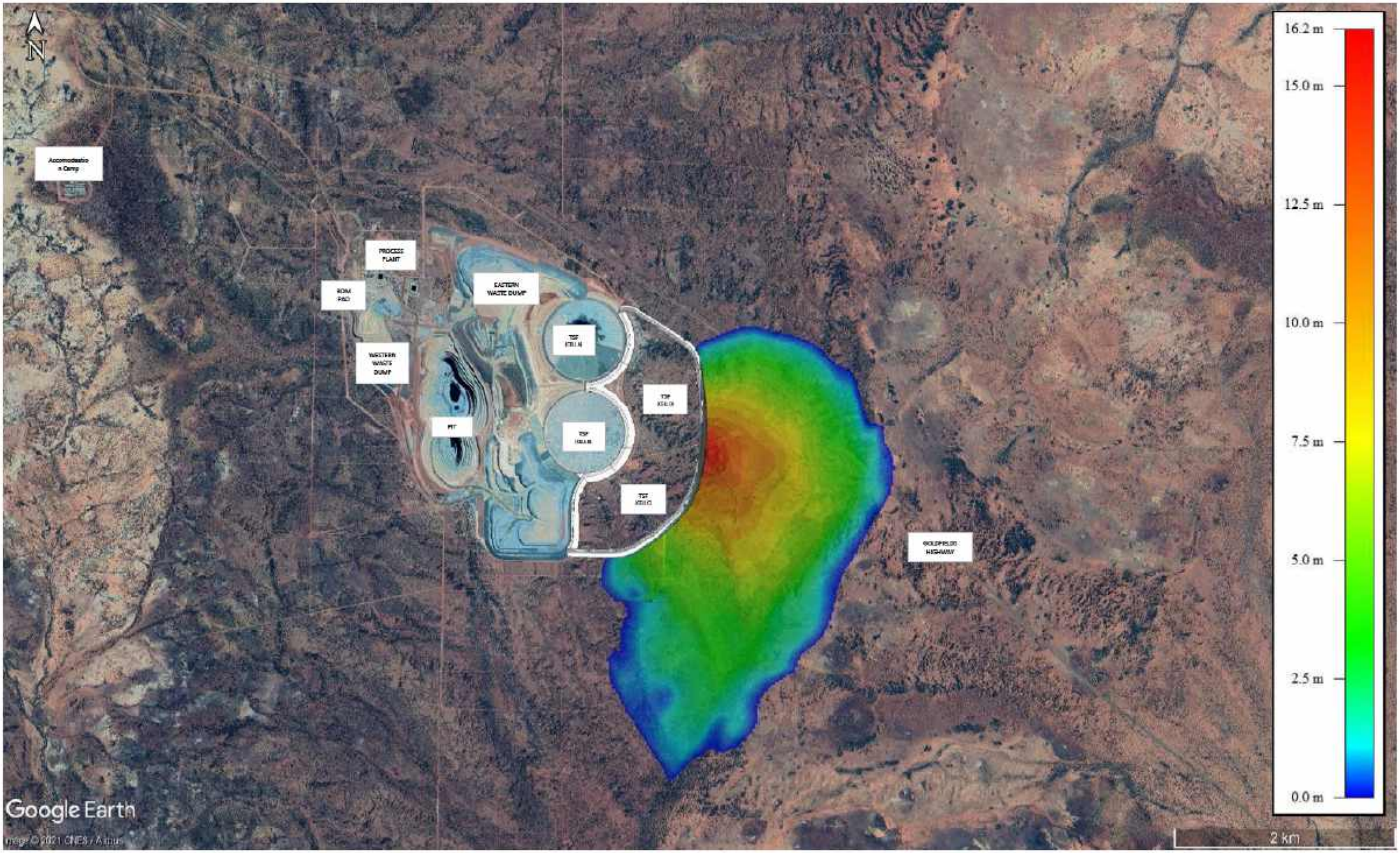
THUNDERBOX PROJECT
TSF WATER BALANCE
KP SOLIDS BREACH METHODOLOGY

Figure 7.1



THUNDERBOX PROJECT
TSF WATER BALANCE
NORTHERN FAILURE - SOLIDS INUNDATION EXTENTS

PE801-00296/17
Figure 7.2



THUNDERBOX PROJECT
TSF WATER BALANCE
EASTERN FAILURE - SOLIDS INUNDATION EXTENTS

PE801-00296/17
Figure 7.3

DRAWINGS

THUNDERBOX OPERATIONS

TAILINGS STORAGE FACILITY CELL C/D EXPANSION

PERMITTING DESIGN
JULY, 2021

Prepared for:

NORTHERN STAR RESOURCES LIMITED

Prepared by:

Knight Piésold CONSULTING

A.B.N. 67 001 040 419
A.C.N. 001 040 419

Knight Piésold Pty. Ltd.
Level 1, 184 Adelaide Terrace
EAST PERTH, WA 6004
AUSTRALIA

SHEET SIZE A3

REFERENCES

DRAWING No.	DRAWING TITLE

REVISIONS

REV	DATE	DESCRIPTION	DRN	DESIGN	CKD	APP	CLIENT APP
A	04/06/2021	ISSUED FOR CLIENT REVIEW	SGM	AMM	AMM	DJTM	
B	09/07/2021	ISSUED FOR PERMITTING DESIGN	UT	AMM	AMM	BAS	

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DATE	DESIGNED	CHECKED	APPROVED	CLIENT APP'D

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CONSULT AUSTRALIA Member Firm

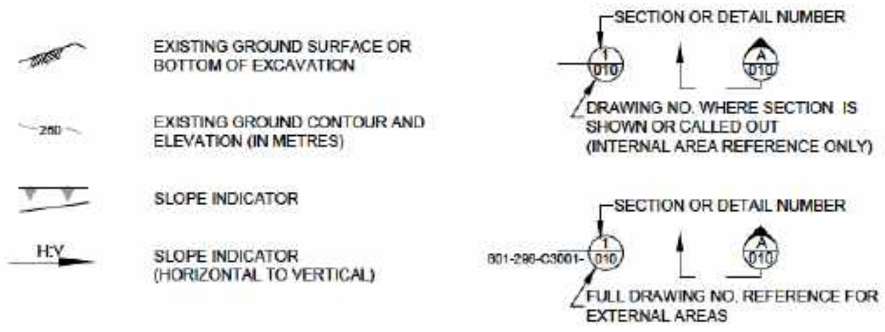
NORTHERN STAR RESOURCES LIMITED
THUNDERBOX OPERATIONS
TAILINGS STORAGE FACILITY CELL C/D EXPANSION
TITLE PAGE

SCALE N.T.S.

STATUS: PERMITTING

DRAWING NUMBER: **801-296-D3000-001** REV: **B**

COMMON LEGEND



ABBREVIATIONS

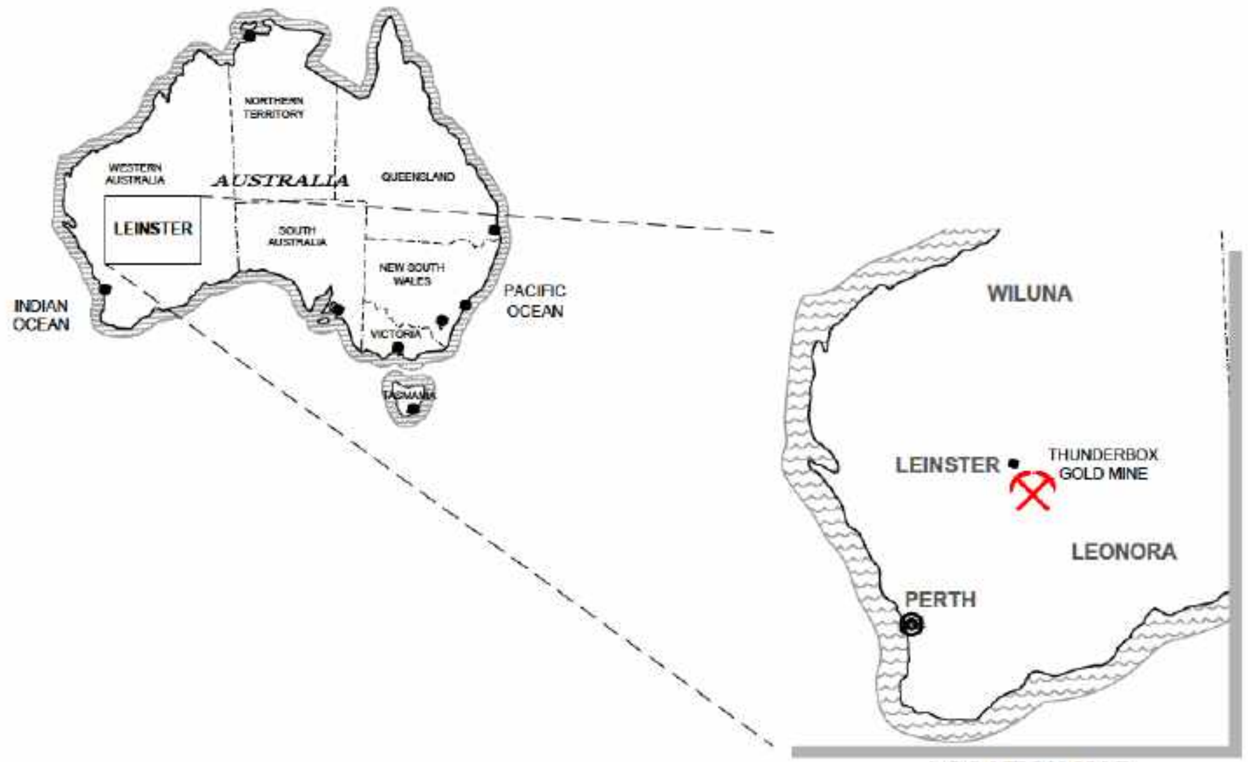
C.M.	CONSTRUCTION MANAGER	MMDD	MAXIMUM MODIFIED DRY DENSITY
N.T.S.	NOT TO SCALE	NOM	NOMINAL
APPROX. ~	APPROXIMATELY	OD	OUTSIDE DIAMETER
BOP	BOTTOM OF PIPE	OMC	OPTIMUM MOISTURE CONTENT
℄	CENTRELINE	PC	POINT OF CURVATURE
CPT	CORRUGATED POLYETHYLENE TUBING	PI	POINT OF INTERSECTION
		PT	POINT OF TANGENT
DIA. Ø	DIAMETER	PVC	POLYVINYL CHLORIDE
ELEV	ELEVATION	RC	REINFORCED CONCRETE
HLF	HEAP LEACH FACILITY	RCP	REINFORCED CONCRETE PIPE
HDPE	HIGH DENSITY POLYETHYLENE	REQ'D	REQUIRED
ID	INSIDE DIAMETER	R.L.	REDUCED LEVEL
IL	INVERT LEVEL	SDR	STANDARD DIMENSIONAL RATIO
LCRS	LEACHATE COLLECTION & REMOVAL SYSTEM	SCH	SCHEDULE
LLDPE	LINEAR LOW DENSITY POLYETHYLENE	SMDD	STANDARD MAXIMUM DRY DENSITY
		SOL	SETTING OUT LINE
MH	MANHOLE	SOP	SETTING OUT POINT
MAX	MAXIMUM	IWL	INTEGRATED WASTE LANDFORM
MIN	MINIMUM	TYP	TYPICAL

GENERAL NOTES

1. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE NOTED.
2. ALL COORDINATES STATED IN GRID PROJECTION: MGA (GDA94) ZONE 51.
3. ALL ELEVATIONS IN METRES, RELATIVE TO MEAN SEA LEVEL.
4. DRAWINGS ARE NOT TO BE SCALED.
5. DRAWINGS TO BE READ IN CONJUNCTION WITH THE TECHNICAL SPECIFICATIONS.

INDEX OF DRAWINGS

DRAWING TITLE	REV.	DRAWING No.
TITLE PAGE	B	801-296-D3000-001
INDEX, COMMON LEGEND AND ABBREVIATIONS	B	801-296-D3000-002
SITE GENERAL ARRANGEMENT PLAN	B	801-296-D3000-100
GENERAL ARRANGEMENT PLAN - STAGE 1	B	801-296-D3000-110
GENERAL ARRANGEMENT PLAN - STAGE FINAL	B	801-296-D3000-115
TYPICAL EMBANKMENT SECTIONS AND DETAILS - SHEET 1	B	801-296-D3000-301
TYPICAL EMBANKMENT SECTIONS AND DETAILS - SHEET 2	B	801-296-D3000-302
TYPICAL EMBANKMENT SECTIONS AND DETAILS - SHEET 3	B	801-296-D3000-303
UNDERDRAINAGE LAYOUT	B	801-296-D3000-400
UNDERDRAINAGE SECTIONS AND DETAILS - SHEET 1	B	801-296-D3000-451
UNDERDRAINAGE SECTIONS AND DETAILS - SHEET 2	B	801-296-D3000-452
DECANT SYSTEM LAYOUT	B	801-296-D3000-500
DECANT SYSTEM SECTIONS AND DETAILS - SHEET 1	B	801-296-D3000-551
DECANT SYSTEM SECTIONS AND DETAILS - SHEET 2	B	801-296-D3000-552
SPIGOT PIPEWORK DETAIL	B	801-296-D3000-810
SPIGOT CLAMP DETAILS	B	801-296-D3000-812
MONITORING INSTRUMENTATION LAYOUT	B	801-296-D3000-900
MONITORING INSTRUMENTATION DETAILS	B	801-296-D3000-905



LOCATION MAP
SCALE : N.T.S.

REV	DATE	DESCRIPTION	DRN	DESIGN	CKD	APP	CLIENT APP
A	04/06/2021	ISSUED FOR CLIENT REVIEW	SGM	AMM	AMM	DJTM	
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REVISIONS

DRAWING No.	DRAWING TITLE

REFERENCES

SHEET SIZE A3

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DATE	DESIGNED	CHECKED	APPROVED	CLIENT APP'D

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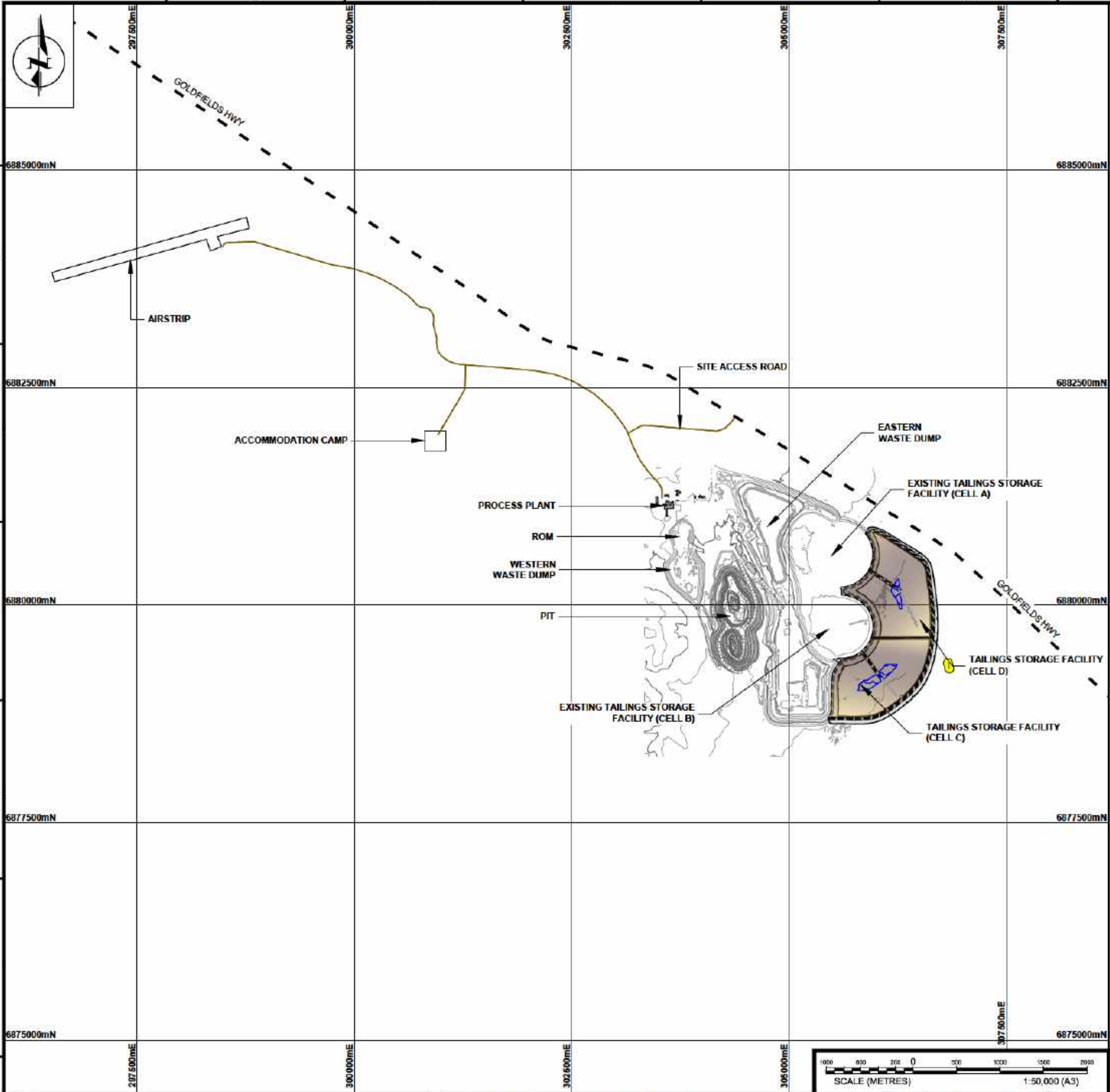
NORTHERN STAR RESOURCES LIMITED
THUNDERBOX OPERATIONS
TAILINGS STORAGE FACILITY CELL C/D EXPANSION
INDEX, COMMON LEGEND AND ABBREVIATIONS

SCALE N.T.S.
STATUS: PERMITTING
DRAWING NUMBER 801-296-D3000-002
REV B



LEGEND:

- EXISTING SEALED ROAD
- EXISTING SITE ROAD

NOTES:

1. 5m CONTOUR INTERVALS SHOWN. TOPOGRAPHIC DATA WEST OF CELLS C AND D PROVIDED BY SARACEN SEPTEMBER 2020. TOPOGRAPHIC DATA TO THE EAST PROVIDED BY NORTHERN STAR MINERALS LIMITED, FEBRUARY 2021.
2. FINAL TAILINGS STORAGE FACILITY SHOWN.
3. MINE AND SITE INFRASTRUCTURE PROVIDED BY SARACEN, SEPTEMBER 2020.

SHEET SIZE A3

REFERENCES

DRAWING No.	DRAWING TITLE

REVISIONS

REV	DATE	DESCRIPTION	DRN	DESIGN	CKD	APP	CLIENT APP
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ORIGINAL STAMPED IN RED

	DATE	DESIGNED	CHECKED	APPROVED	CLIENT APP'D

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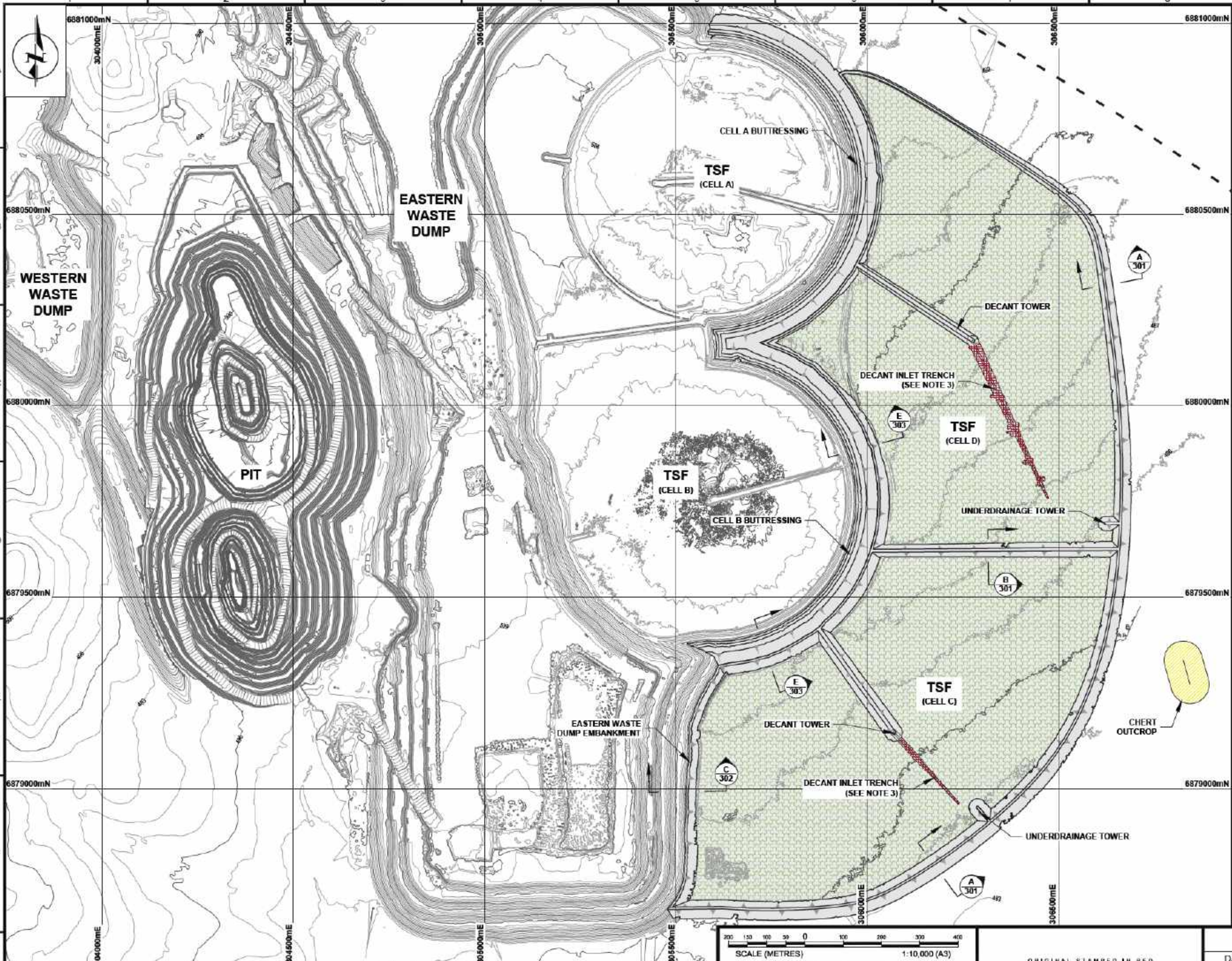
THUNDERBOX OPERATIONS
TAILINGS STORAGE FACILITY CELL C/D EXPANSION
SITE GENERAL ARRANGEMENT PLAN

SCALE 1:50 000

STATUS: PERMITTING

DRAWING NUMBER: 801-296-D3000-100

REV: B



LEGEND:

- EXISTING SEALED ROAD
- SMOOTH HDPE GEOMEMBRANE LINER
- COMPACTED SOIL LINER

NOTES:

1. 1m CONTOUR INTERVALS SHOWN. TOPOGRAPHIC DATA WEST OF CELLS C AND D PROVIDED BY SARACEN SEPTEMBER 2020. TOPOGRAPHIC DATA TO THE EAST PROVIDED BY NORTHERN STAR MINERALS LIMITED, FEBRUARY 2021.
2. STAGE 1 TAILINGS STORAGE FACILITY SHOWN.
3. DECANT INLET TRENCH DEPTH TO BE CHECKED ON SITE FOR SUITABILITY TO BE EXCAVATED.

SCALE (METRES) 1:10,000 (A3)

REFERENCES

DRAWING No.	DRAWING TITLE
801-296-D3000-301	EMBANKMENT SECTIONS & DETAILS - SHEET 1
801-296-D3000-302	EMBANKMENT SECTIONS & DETAILS - SHEET 2
801-296-D3000-303	EMBANKMENT SECTIONS & DETAILS - SHEET 3

REVISIONS

REV	DATE	DESCRIPTION	DRN	DESIGN	CKD	APP	CLIENT APP
A	04/06/2021	ISSUED FOR CLIENT REVIEW	SGM	AMM	AMM	DJTM	
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SHEET SIZE A3

ORIGINAL STAMPED IN RED

DATE	DESIGNED	CHECKED	APPROVED	CLIENT APP'D

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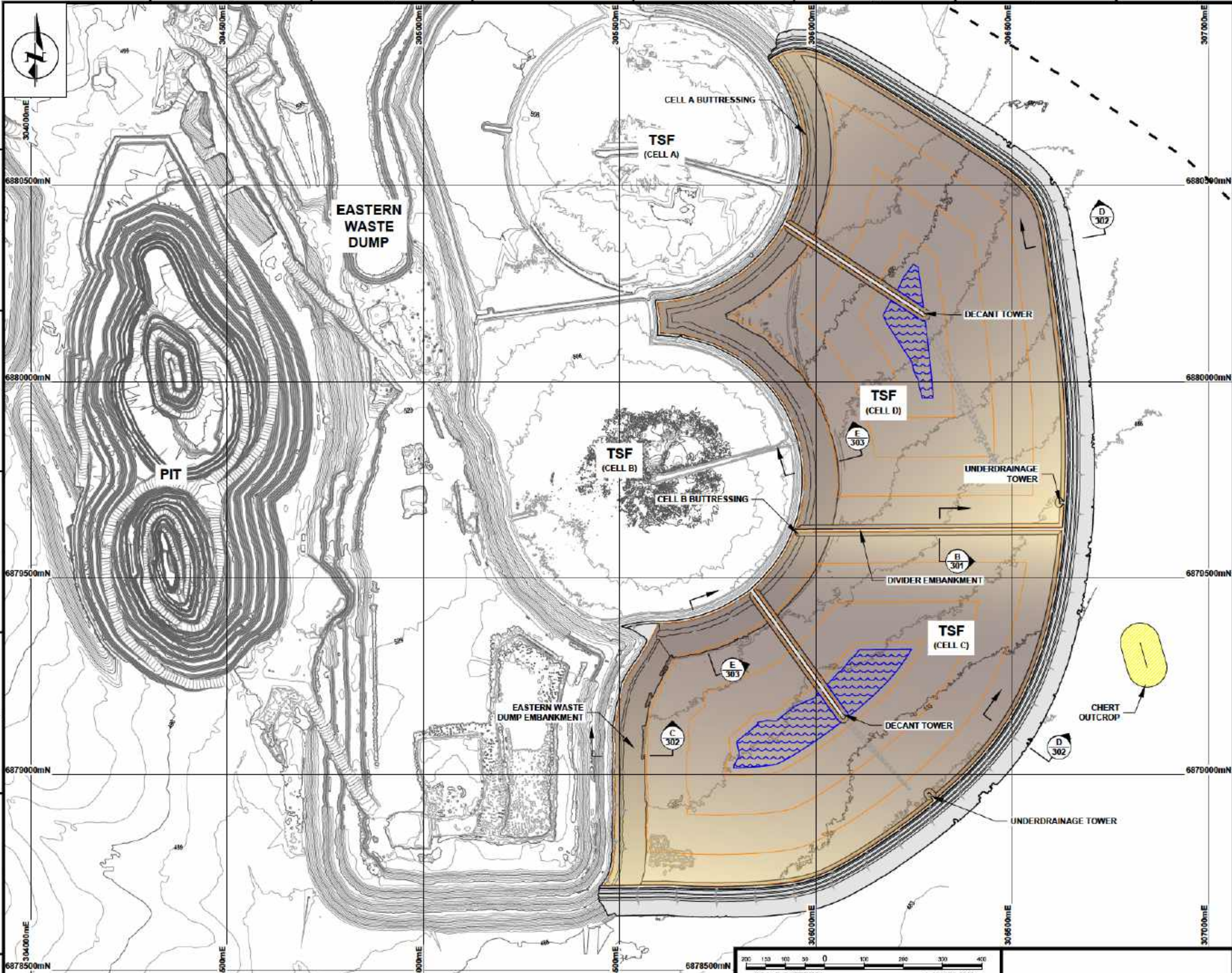
THUNDERBOX OPERATIONS
TAILINGS STORAGE FACILITY CELL C/D EXPANSION
GENERAL ARRANGEMENT PLAN - STAGE 1

SCALE 1:10,000

STATUS: PERMITTING

DRAWING NUMBER 801-296-D3000-110 REV B



LEGEND:

- EXISTING SEALED ROAD
- TAILINGS BEACH
- SUPERNATANT POND

NOTES:

1. 1m CONTOUR INTERVALS SHOWN. TOPOGRAPHIC DATA WEST OF CELLS C AND D PROVIDED BY SARACEN SEPTEMBER 2020. TOPOGRAPHIC DATA TO THE EAST PROVIDED BY NORTHERN STAR MINERALS LIMITED, FEBRUARY 2021.
2. STAGE FINAL TAILINGS STORAGE FACILITY SHOWN.

SHEET SIZE A3

REFERENCES

DRAWING No.	DRAWING TITLE
801-296-D3000-301	EMBANKMENT SECTIONS & DETAILS - SHEET 1
801-296-D3000-302	EMBANKMENT SECTIONS & DETAILS - SHEET 2
801-296-D3000-303	EMBANKMENT SECTIONS & DETAILS - SHEET 3

REVISIONS

REV	DATE	DESCRIPTION	DRN	DESIGN	CKD	APP	CLIENT APP
A	04/06/2021	ISSUED FOR CLIENT REVIEW	SGM	AMM	AMM	DJTM	
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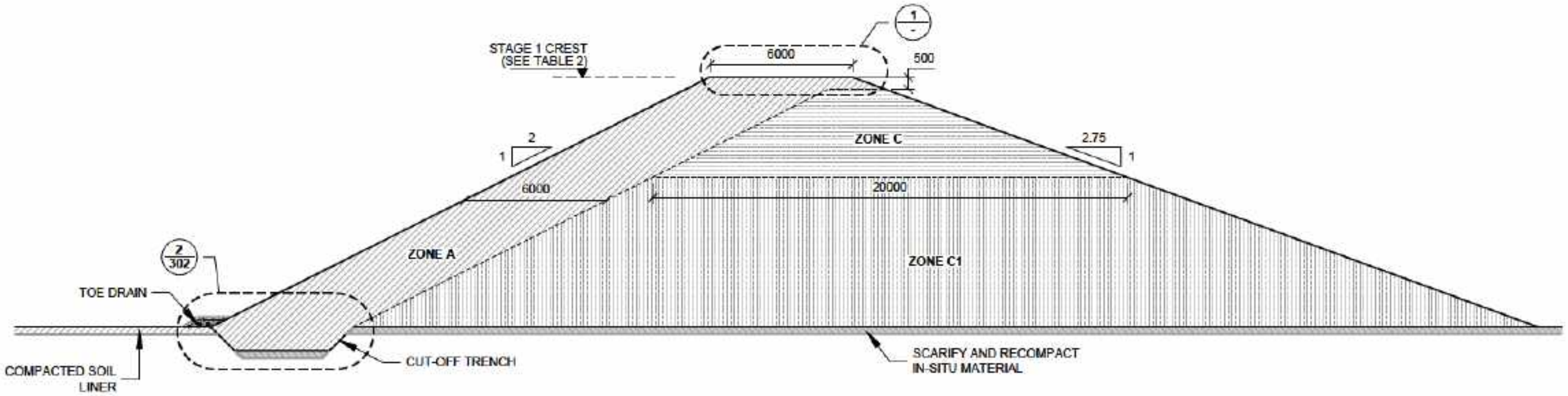
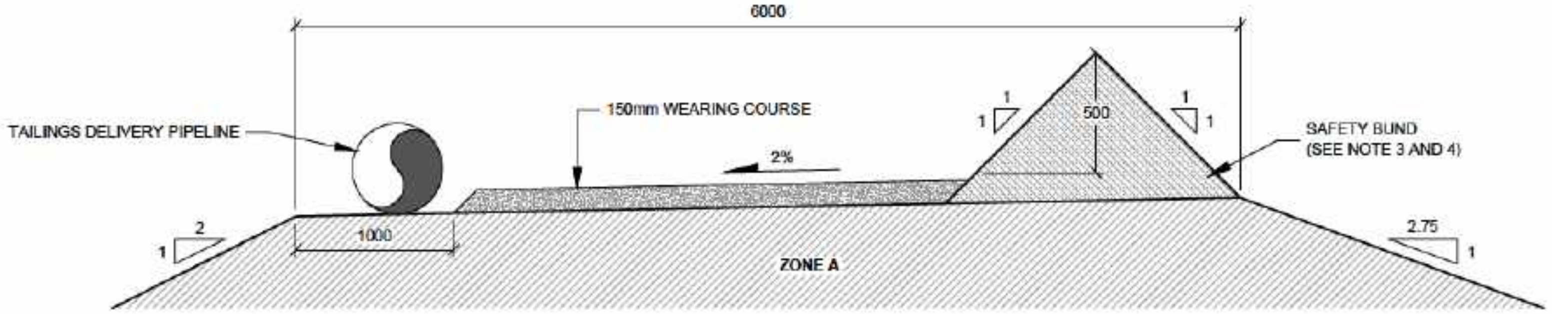
NORTHERN STAR RESOURCES LIMITED
THUNDERBOX OPERATIONS
TAILINGS STORAGE FACILITY CELL C/D EXPANSION
GENERAL ARRANGEMENT PLAN - STAGE FINAL

SCALE 1:10,000
STATUS: PERMITTING
DRAWING NUMBER 801-296-D3000-115
REV B



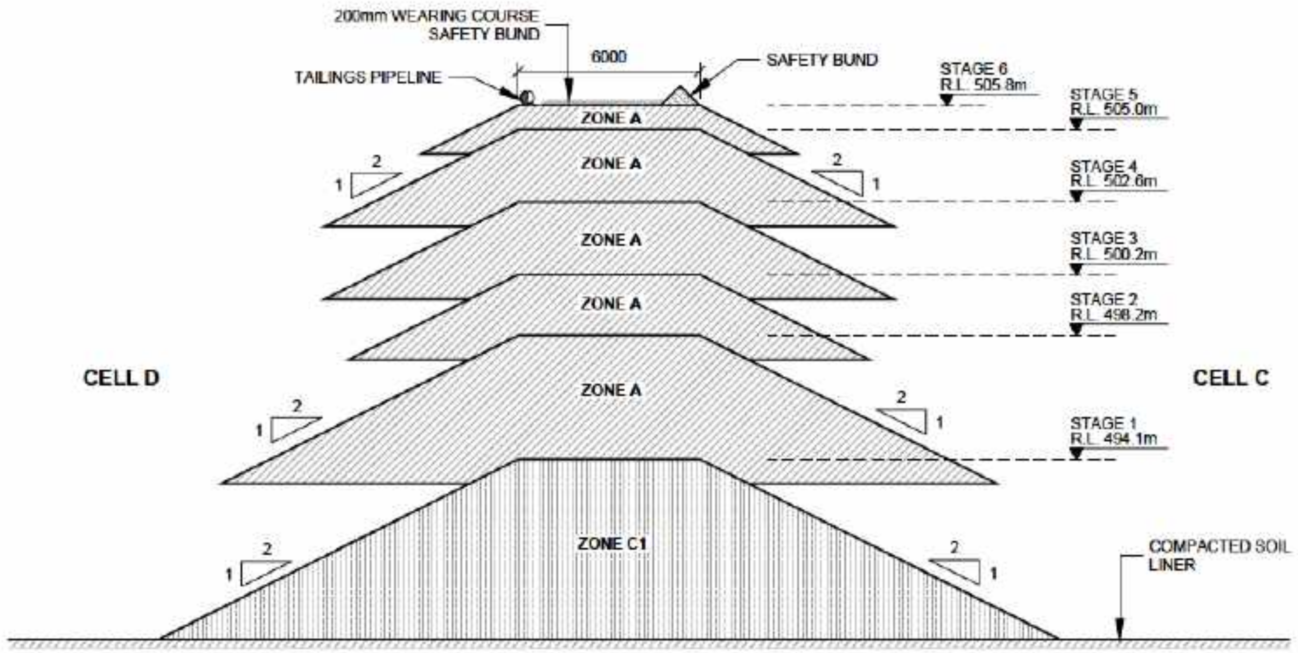
A/110 TYPICAL CELL C AND D DOWNSTREAM EMBANKMENT RAISE (STAGE 1) SECTION

1:250



1/303 1/- TYPICAL DOWNSTREAM EMBANKMENT RAISE, CREST DETAIL

1:50



B/115 B/110 TYPICAL DIVIDER EMBANKMENT DETAIL

1:250

NOTES:

1. EMBANKMENT FOUNDATION PREPARATION SHALL EXTEND 5000mm BEYOND THE TOE OF THE EMBANKMENT.
2. EMBANKMENT FOUNDATION IN THE VALLEY FLOOR WHICH IS DEEMED UNSUITABLE BY THE ENGINEER ON SITE IS TO BE REMOVED AND REPLACED BY ZONE A OR ZONE C MATERIAL.
3. SAFETY BUND MATERIAL TO BE PLACED, TRIMMED AND BUCKET TAMPED.
4. SAFETY BUNDS ARE TO BE INSTALLED (500mm HIGH MIN.) ON THE UPSTREAM CREST WHERE NO PIPELINE EXISTS. BREAKS IN UPSTREAM SAFETY BUNDS AT 50m INTERVALS TO ALLOW FOR DRAINAGE OF RAINFALL RUNOFF.
5. COMPACTED SOIL LINER IN TSF AS FOLLOWS:
   - WHERE IN-SITU MATERIAL IS UNSUITABLE AS COMPACTED SOIL LINER - 300mm IMPORTED SOIL ZONE A MATERIAL.
   - WHERE IN-SITU MATERIAL IS SUITABLE AS COMPACTED SOIL LINER - SCARIFY, MOISTURE CONDITION AND COMPACT IN-SITU MATERIAL (300mm).

TABLE No.1: ZONE SPECIFICATION SUMMARY

ZONE KEY	ZONE TYPE	ZONE DESCRIPTION	COMPACTION SPECIFICATION	MAXIMUM LAYER THICKNESS	GRADING
	ZONE A	LOW PERMEABILITY FILL	98% SMDD -2% <OMC < +3%	300mm	DMAX=150 %FINES>20 PI>8
	ZONE C	STRUCTURAL FILL BY CONTRACTOR	95%SMDD -3%<OMC<3%	500mm	DMAX=250 %FINES>5 PI>8
	ZONE C1	STRUCTURAL FILL PLACED BY MINING FLEET	UNIFORM DENSITY FREE FROM LARGE CAVITIES	1000mm	DMAX=500
	ZONE D	GENERAL FILL	95%SMDD -3%<OMC< +3%	500mm	N/A
	ZONE E	EROSION PROTECTION	UNIFORM DENSITY FREE FROM CAVITIES	300mm	DMAX=300 %FINES<5
	ZONE F	DRAINAGE MEDIUM	UNIFORM FREE OF CAVITIES	N/A	DMAX<19 %FINE<5
	ZONE G	SELECTED ROCKFILL	5mm < PARTICLE SIZE < 300mm	N/A	DMAX=500 %FINES<5
	EMBANKMENT FOUNDATION	IN-SITU MATERIALS AS APPROVED BY ENGINEER	98% SMDD -2% <OMC < +3%	N/A	N/A
	WEARING COURSE	GRAVEL	UNIFORM DENSITY FREE OF CAVITIES	200mm	DMAX=37.5 %FINES 5-15%
	COMPACTED SOIL LINER	COMPACTED OXIDE MINE WASTE	95%SMDD -3%<OMC<3%	300mm	DMAX=250 %FINES>5 PI>8

TABLE No.2: EMBANKMENT RAISE STAGING DETAILS

STAGES	EMBANKMENT LEVELS (R.L m)	RAISE HEIGHT (m)
1	494.1	10.1
2	498.2	4.1
3	500.2	2.0
4	502.6	2.4
5	505.0	2.4
6	505.8	0.8

REFERENCES

DRAWING No.	DRAWING TITLE
801-296-D3000-110	GENERAL ARRANGEMENT PLAN-STAGE 1
801-296-D3000-115	GENERAL ARRANGEMENT PLAN-STAGE FINAL
801-296-D3000-302	EMBANKMENT SECTIONS & DETAILS - SHEET 2

REVISIONS

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SHEET SIZE A3

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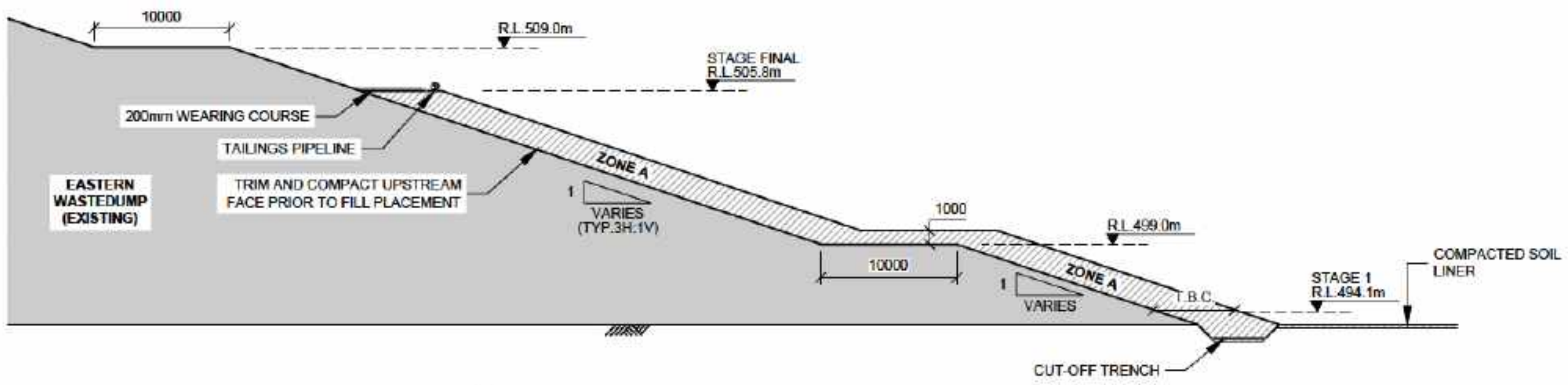
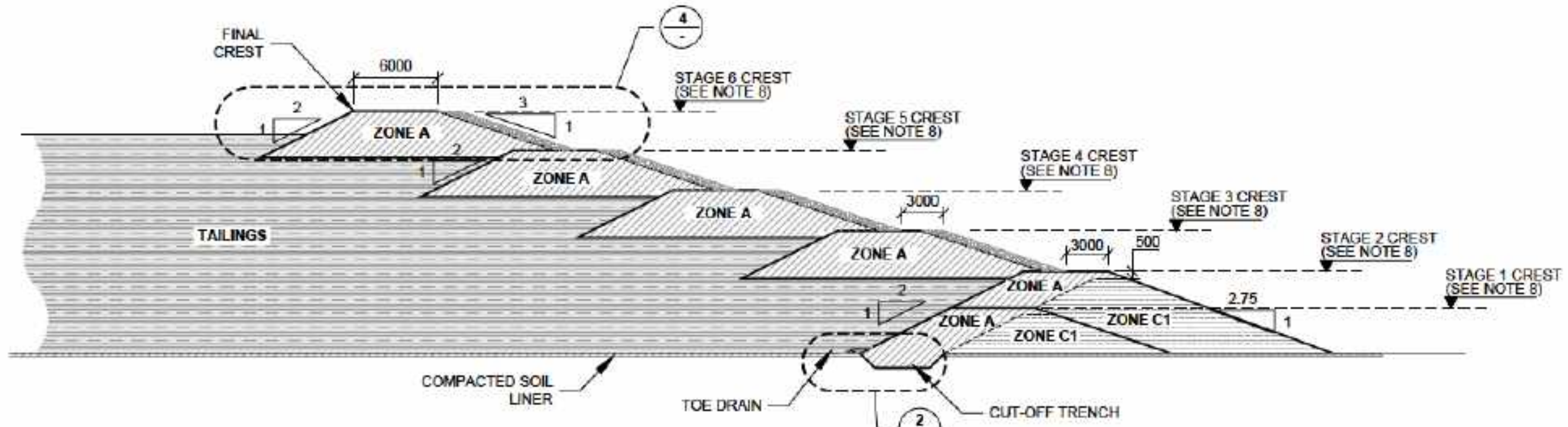
NORTHERN STAR RESOURCES LIMITED
THUNDERBOX OPERATIONS
TAILINGS STORAGE FACILITY CELL C/D EXPANSION
EMBANKMENT SECTIONS AND DETAILS - SHEET 1

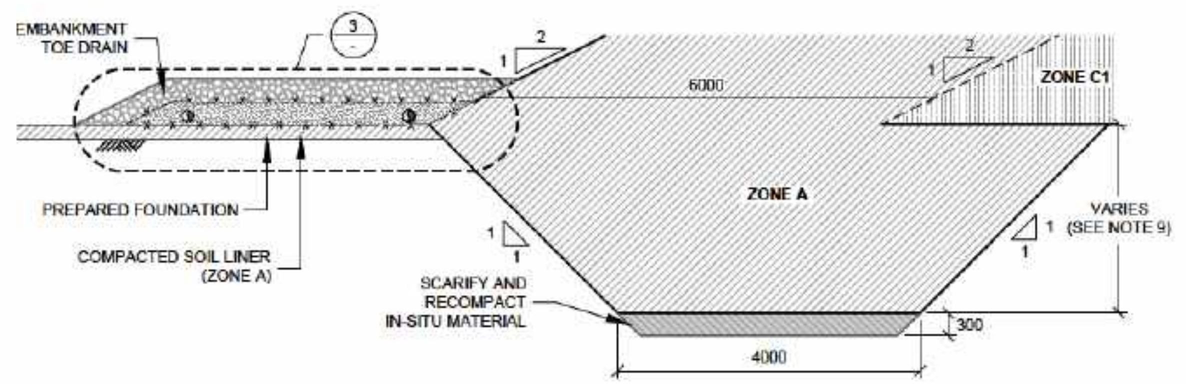
SCALE: AS SHOWN
STATUS: PERMITTING
DRAWING NUMBER: 801-296-D3000-301
REV: B



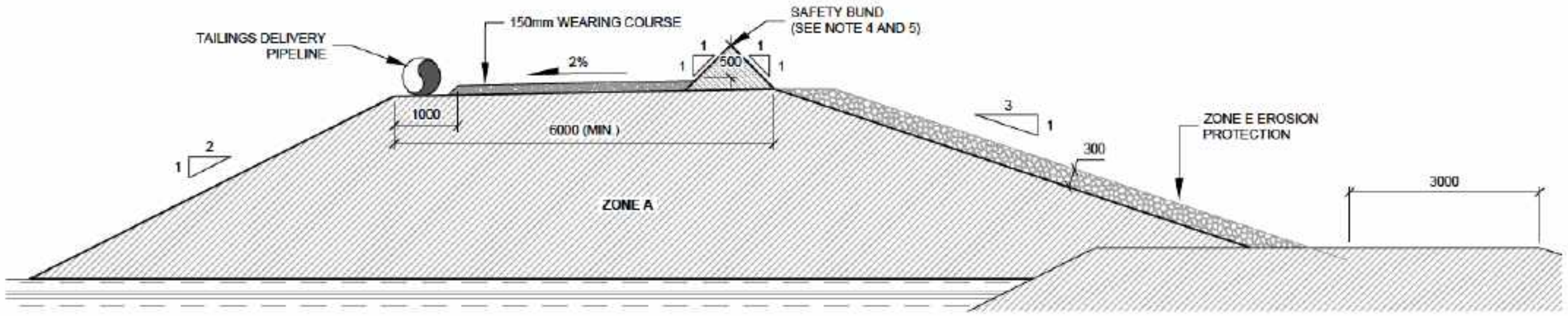
C/110 C/115 TYPICAL WASTE DUMP SECTION
1:500



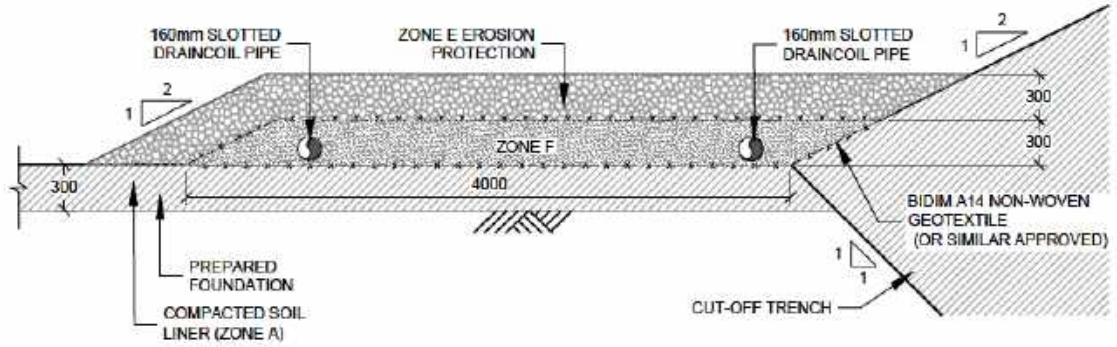
D/115 TYPICAL CELL C AND D UPSTREAM EMBANKMENT RAISE SECTION
1:500



2/301 TYPICAL EMBANKMENT CUT-OFF TRENCH DETAIL
1:100



4/301 TYPICAL UPSTREAM EMBANKMENT RAISE CREST DETAIL
1:100



3/- TYPICAL TOE DRAIN DETAIL
1:50

NOTES:

1. TAILINGS BORROW AREA WITHIN THE TSF BASIN EXCAVATED AND SHAPED TO FACILITATE DRAINAGE TO THE SUPERNATANT POND.
2. EMBANKMENT FOUNDATION PREPARATION SHALL EXTEND 5000mm BEYOND THE TOE OF THE EMBANKMENT.
3. EMBANKMENT FOUNDATION IN THE VALLEY FLOOR WHICH IS DEEMED UNSUITABLE BY THE ENGINEER ON SITE IS TO BE REMOVED AND REPLACED BY ZONE A OR ZONE C MATERIAL.
4. SAFETY BUND MATERIAL TO BE PLACED, TRIMMED AND BUCKET TAMPED.
5. SAFETY BUNDS ARE TO BE INSTALLED (500mm HIGH MIN.) ON THE UPSTREAM CREST WHERE NO PIPELINE EXISTS. BREAKS IN UPSTREAM SAFETY BUNDS AT 50m INTERVALS TO ALLOW FOR DRAINAGE OF RAINFALL RUNOFF.
6. COMPACTED SOIL LINER IN TSF AS FOLLOWS:
   - WHERE IN-SITU MATERIAL IS UNSUITABLE AS COMPACTED SOIL LINER - BLEND IMPORTED SOIL ZONE A MATERIAL.
   - WHERE IN-SITU MATERIAL IS SUITABLE AS COMPACTED SOIL LINER - SCARIFY, MOISTURE CONDITION AND COMPACT IN-SITU MATERIAL AS A SINGLE LAYER (300mm).
7. FOR EMBANKMENT ZONE SPECIFICATIONS REFER TABLE 1 ON DRAWING 801-296-D3000-301.
8. FOR EMBANKMENT CREST ELEVATION, REFER TABLE 2 ON DRAWING 801-296-D3000-301.
9. CUT OFF TRENCH TO BE EXCAVATED INTO SUITABLE MATERIAL AS DETERMINED BY SITE ENGINEER.

SHEET SIZE A3

REFERENCES

DRAWING No.	DRAWING TITLE
801-296-D3000-115	GENERAL ARRANGEMENT PLAN-STAGE 15
801-296-D3000-301	EMBANKMENT SECTIONS & DETAILS - SHEET 1

REVISIONS

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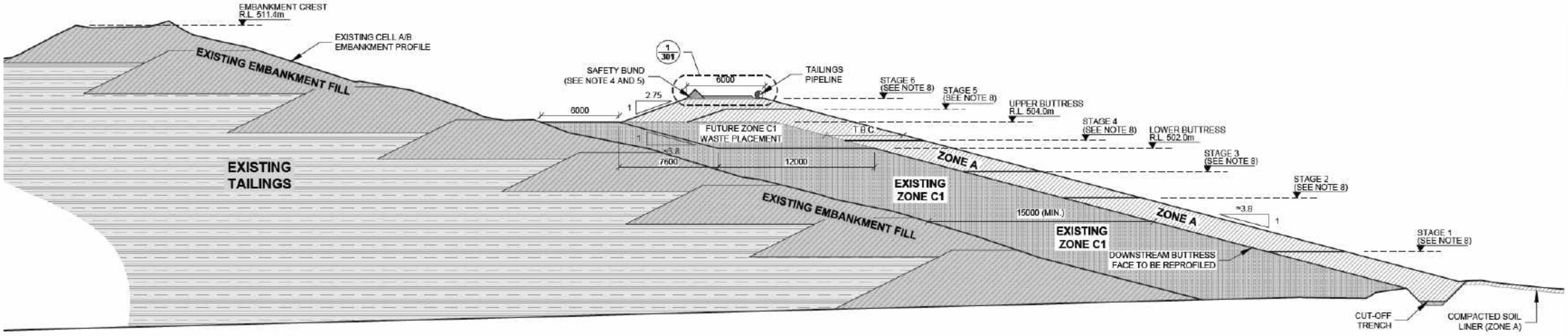
THUNDERBOX OPERATIONS
TAILINGS STORAGE FACILITY CELL C/D EXPANSION
EMBANKMENT SECTIONS AND DETAILS - SHEET 2

SCALE AS SHOWN
STATUS: PERMITTING
DRAWING NUMBER 801-296-D3000-302
REV B

287
410

NOTES:

1. TAILINGS BORROW AREA WITHIN THE TSF BASIN EXCAVATED AND SHAPED TO FACILITATE DRAINAGE TO THE SUPERNATANT POND.
2. EMBANKMENT FOUNDATION PREPARATION SHALL EXTEND 5000mm BEYOND THE TOE OF THE EMBANKMENT.
3. EMBANKMENT FOUNDATION IN THE VALLEY FLOOR WHICH IS DEEMED UNSUITABLE BY THE ENGINEER ON SITE IS TO BE REMOVED AND REPLACED BY ZONE A OR ZONE C MATERIAL.
4. SAFETY BUND MATERIAL TO BE PLACED, TRIMMED AND BUCKET TAMPED.
5. SAFETY BUNDS ARE TO BE INSTALLED (500mm HIGH MIN.) ON THE UPSTREAM CREST WHERE NO PIPELINE EXISTS. BREAKS IN UPSTREAM SAFETY BUNDS AT 50m INTERVALS TO ALLOW FOR DRAINAGE OF RAINFALL RUNOFF.
6. COMPACTED SOIL LINER IN TSF AS FOLLOWS:
   - WHERE IN-SITU MATERIAL IS UNSUITABLE AS COMPACTED SOIL LINER - BLEND IMPORTED SOIL ZONE A MATERIAL.
   - WHERE IN-SITU MATERIAL IS SUITABLE AS COMPACTED SOIL LINER - SCARIFY, MOISTURE CONDITION AND COMPACT IN-SITU MATERIAL AS A SINGLE LAYER (300mm).
7. FOR EMBANKMENT ZONE SPECIFICATIONS REFER TABLE 1 ON DRAWING 801-296-D3000-301.
8. FOR EMBANKMENT CREST ELEVATION, REFER TABLE 2 ON DRAWING 801-296-D3000-301.
9. CUT OFF TRENCH TO BE EXCAVATED INTO SUITABLE MATERIAL AS DETERMINED BY SITE ENGINEER.



E 110 E 115 **TYPICAL CELL A/B BUTTRESS SECTION**

1:200

REFERENCES	
801-296-D3000-115	GENERAL ARRANGEMENT PLAN-STAGE FINAL
801-296-D3000-301	EMBANKMENT SECTIONS AND DETAILS - SHEET 1
DRAWING No.	DRAWING TITLE

SHEET SIZE A3

REV	DATE	DESCRIPTION	DRN	DESIGN	CKD	APP	CLIENT APP
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NORTHERN STAR RESOURCES LIMITED
THUNDERBOX OPERATIONS
TAILINGS STORAGE FACILITY CELL C/D EXPANSION
EMBANKMENT SECTIONS AND DETAILS - SHEET 3

SCALE AS SHOWN
STATUS: PERMITTING
DRAWING NUMBER 801-296-D3000-303
REV B

LEGEND:

- PERIMETER BUND
- EMBANKMENT TOE DRAIN
- PRIMARY (COLLECTOR) DRAIN
- FINGER DRAIN
- SMOOTH HDPE GEOMEMBRANE LINER
- COMPACTED SOIL LINER

NOTES:

1. 1m CONTOUR INTERVALS SHOWN. TOPOGRAPHIC DATA WEST OF CELLS C AND D PROVIDED BY SARACEN SEPTEMBER 2020. TOPOGRAPHIC DATA TO THE EAST PROVIDED BY NORTHERN STAR MINERALS LIMITED, FEBRUARY 2021.
2. STAGE 1 TAILINGS STORAGE FACILITY.
3. FOR TYPICAL TOE DRAIN DETAIL REFER TO DETAIL 3 ON DRAWING 801-296-D3000-302.

REFERENCES

DRAWING No.	DRAWING TITLE
801-296-D3000-451	UNDERDRAINAGE SECTIONS & DETAILS - SHEET 1
801-296-D3000-452	UNDERDRAINAGE SECTIONS & DETAILS - SHEET 2

REVISIONS

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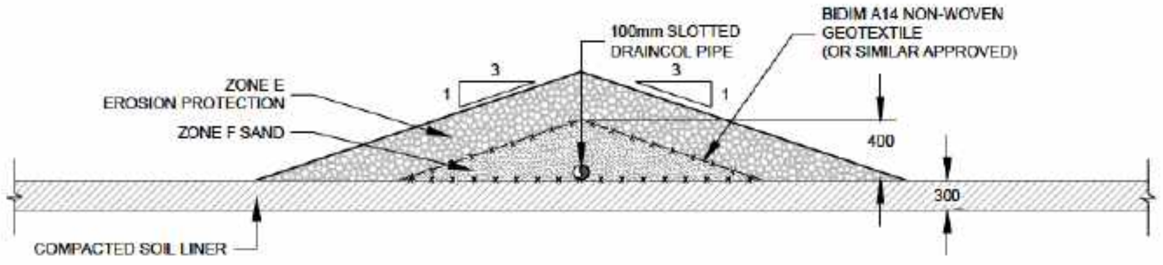
NORTHERN STAR RESOURCES LIMITED
THUNDERBOX OPERATIONS
TAILINGS STORAGE FACILITY CELL C/D EXPANSION
UNDERDRAINAGE LAYOUT

SCALE 1:10,000
STATUS: PERMITTING
DRAWING NUMBER **801-296-D3000-400** REV **B**

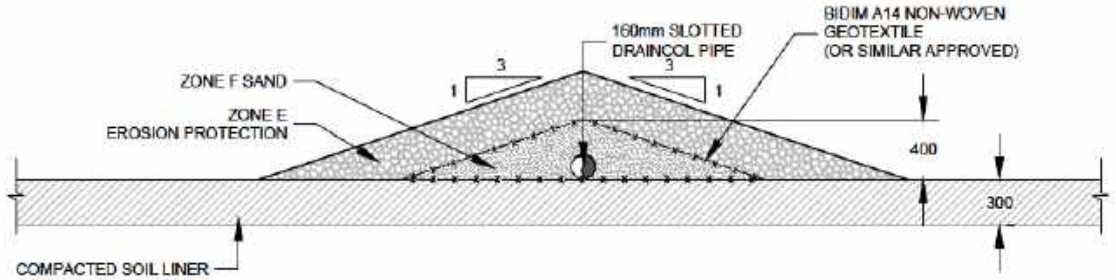
NOTES:

1. FOR ZONE SPECIFICATION DETAILS REFER TABLE 1 ON DRAWING PE801-296-D3000-301.
2. FINGER DRAINS TO BE SPACED AT 30m CENTRES.
3. ALL SLOTTED DRAINAGE PIPES TO BE FITTED WITH FILTER SOCK.
4. MINIMUM FALL GRADE ON UNDERDRAINAGE PIPES TO BE 1V:500H.
5. PROTECTION BUND MATERIAL TO BE PLACED, TRIMMED AND BUCKET TAMPED.



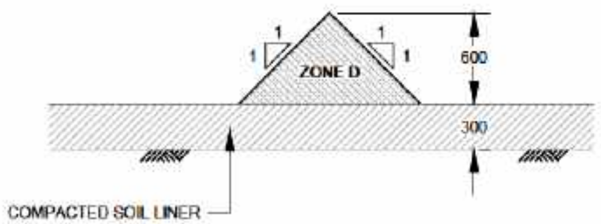
F 400 **TYPICAL FINGER DRAIN SECTION**

1:50



G 400 **TYPICAL COLLECTOR DRAIN SECTION**

1:50



H 400 **PERIMETER BUND SECTION**

1:50

REFERENCES	
801-296-D3000-301	EMBANKMENT SECTIONS & DETAILS - SHEET 1
801-296-D3000-400	UNDERDRAINAGE LAYOUT
DRAWING No.	DRAWING TITLE

SHEET SIZE A3

REV	DATE	DESCRIPTION	DRN	DESIGN	CKD	APP	CLIENT APP
A	04/06/2021	ISSUED FOR CLIENT REVIEW	SGM	AMM	AMM	DJTM	
B	09/07/2021	ISSUED FOR PERMITTING DESIGN	UT	AMM	AMM	BAS	

REVISIONS

ORIGINAL STAMPED IN RED

DATE	DESIGNED	CHECKED	APPROVED	CLIENT APP'D

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NORTHERN STAR RESOURCES LIMITED
THUNDERBOX OPERATIONS
TAILINGS STORAGE FACILITY CELL C/D EXPANSION
UNDERDRAINAGE SECTIONS AND DETAILS - SHEET 1

SCALE AS SHOWN

STATUS: PERMITTING

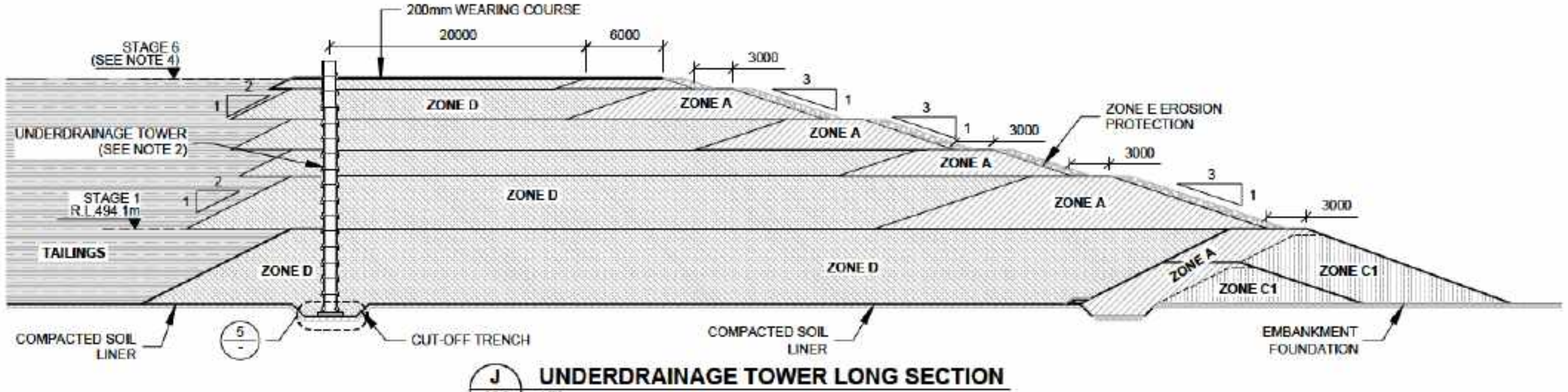
DRAWING NUMBER: **801-296-D3000-451**

REV: **B**

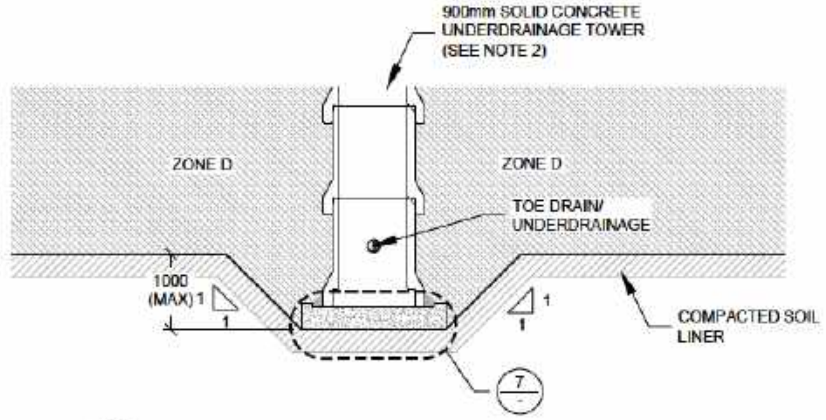
287 410

NOTES:

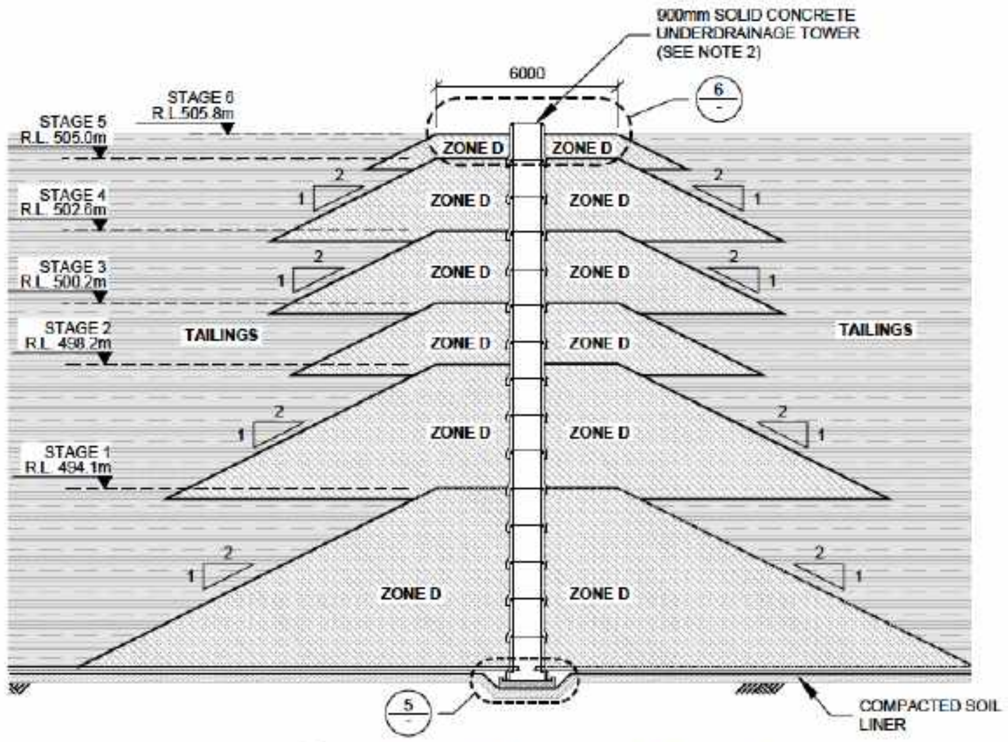
1. FOR ZONE SPECIFICATION DETAILS REFER TABLE 1 ON DRAWING PE801-296-D3000-301.
2. UNDERDRAINAGE TOWER IS TO BE CONSTRUCTED USING SOLID CONCRETE PIPE SECTIONS. PIPE SECTIONS OF 900mmØ ID, CLASS 3 BELL/SOCKET JOINT, REINFORCED CONCRETE.
3. MINIMUM FALL GRADE ON UNDERDRAINAGE PIPES TO BE 1V:500H.
4. FOR EMBANKMENT CREST ELEVATION, REFER TABLE 2 ON DRAWING 801-296-D3000-301.



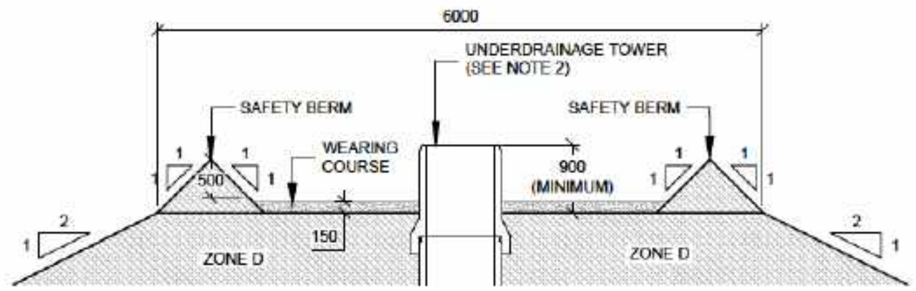
J 400 UNDERDRAINAGE TOWER LONG SECTION
1:500



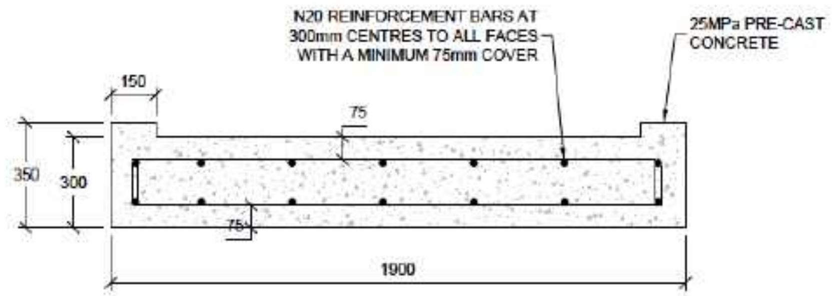
5 - UNDERDRAINAGE TOWER BASE DETAIL
1:100



K 400 UNDERDRAINAGE TOWER SECTION
1:250



6 - UNDERDRAINAGE ACCESS CAUSEWAY CREST DETAIL
1:200



7 - UNDERDRAINAGE TOWER BASE SLAB DETAIL
1:25

DRAWING No.	DRAWING TITLE
801-296-D3000-301	EMBANKMENT SECTIONS & DETAILS - SHEET 1
801-296-D3000-400	UMDERDRAINAGE LAYOUT

REV	DATE	DESCRIPTION	DRN	DESIGN	CKD	APP	CLIENT APP
A	04/06/2021	ISSUED FOR CLIENT REVIEW	SGM	AMM	AMM	DJTM	
B	09/07/2021	ISSUED FOR PERMITTING DESIGN	UT	AMM	AMM	BAS	

ORIGINAL STAMPED IN RED

DATE	DESIGNED	CHECKED	APPROVED	CLIENT APP'D

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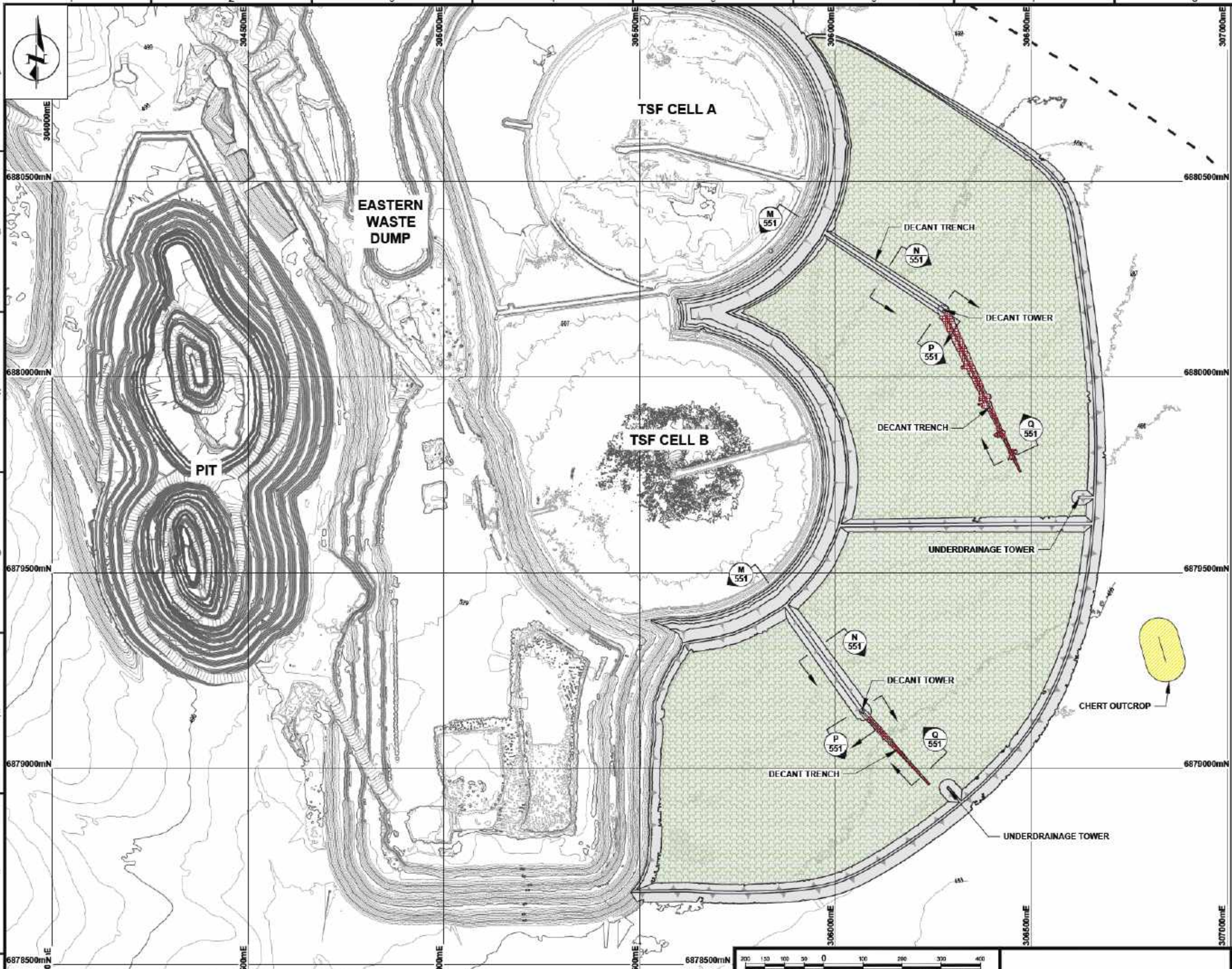
NORTHERN STAR RESOURCES LIMITED
THUNDERBOX OPERATIONS
TSF CELL C/D PERMITTING DESIGN
UNDERDRAINAGE SECTIONS AND DETAILS - SHEET 2

SCALE AS SHOWN
STATUS: PERMITTING
DRAWING NUMBER 801-296-D3000-452
REV B

SHEET SIZE A3



LEGEND:

- EXISTING SEALED ROAD
- SMOOTH HDPE GEOMEMBRANE LINER
- COMPACTED SOIL LINER

NOTES:

1. 1m CONTOUR INTERVALS SHOWN. TOPOGRAPHIC DATA WEST OF CELLS C AND D PROVIDED BY SARACEN SEPTEMBER 2020. TOPOGRAPHIC DATA TO THE EAST PROVIDED BY NORTHERN STAR MINERALS LIMITED, FEBRUARY 2021.
2. STAGE 1 TAILINGS STORAGE FACILITY SHOWN.

SHEET SIZE A3

REFERENCES

DRAWING No.	DRAWING TITLE
801-296-D3000-551	DECANT SYSTEM SECTIONS & DETAILS - SHEET 1
801-296-D3000-552	DECANT SYSTEM SECTIONS & DETAILS - SHEET 2

REVISIONS

REV	DATE	DESCRIPTION	DRN	DESIGN	CKD	APP	CLIENT APP
A	04/06/2021	ISSUED FOR CLIENT REVIEW	SGM	AMM	AMM	DJTM	
B	09/07/2021	ISSUED FOR PERMITTING DESIGN	UT	AMM	AMM	BAS	

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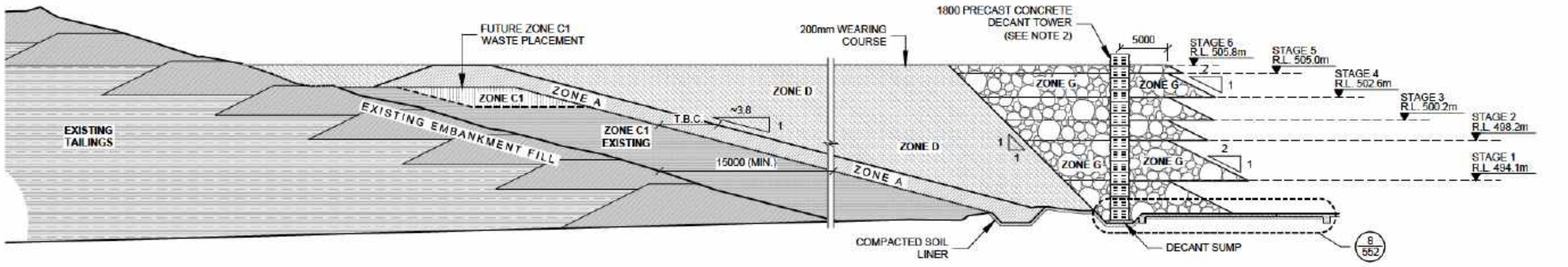
NORTHERN STAR RESOURCES LIMITED
THUNDERBOX OPERATIONS
TAILINGS STORAGE FACILITY CELL C/D EXPANSION
DECANT SYSTEM LAYOUT

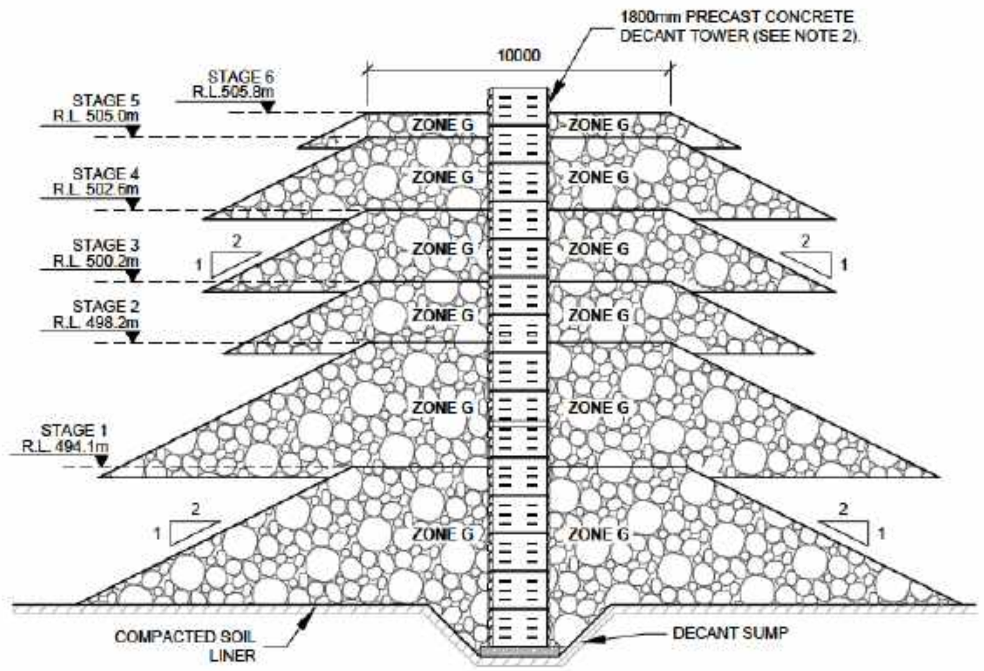
SCALE 1:10 000
STATUS: PERMITTING
DRAWING NUMBER 801-296-D3000-500
REV B



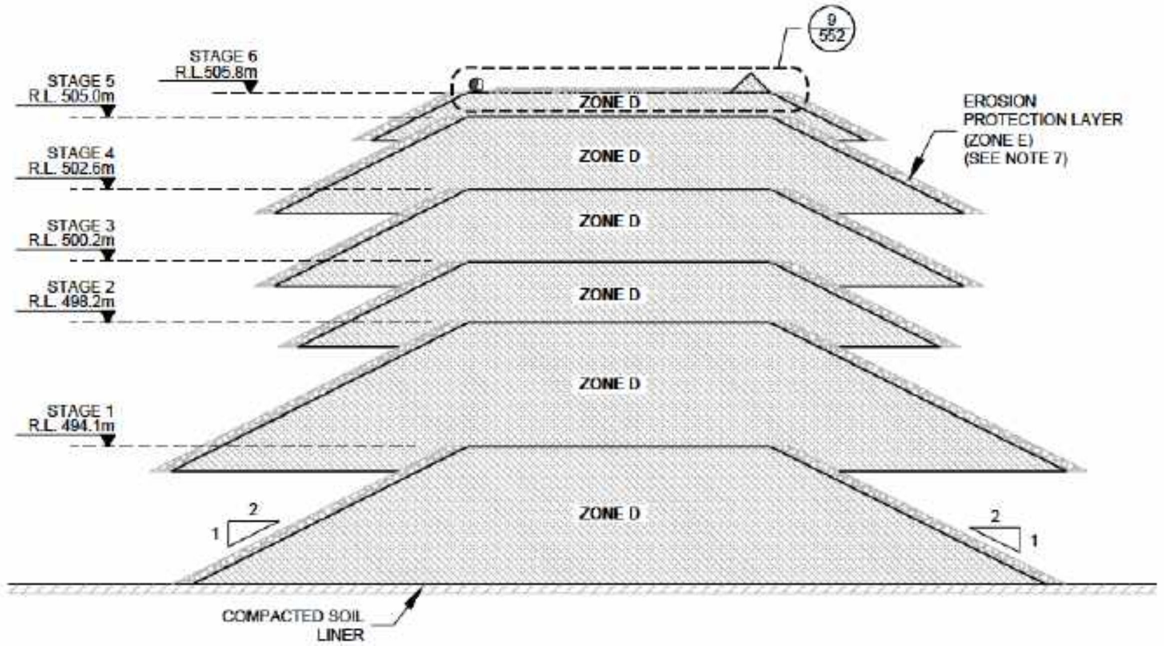
M / 500 DECANT TOWER LONG SECTION
1:500

NOTES:

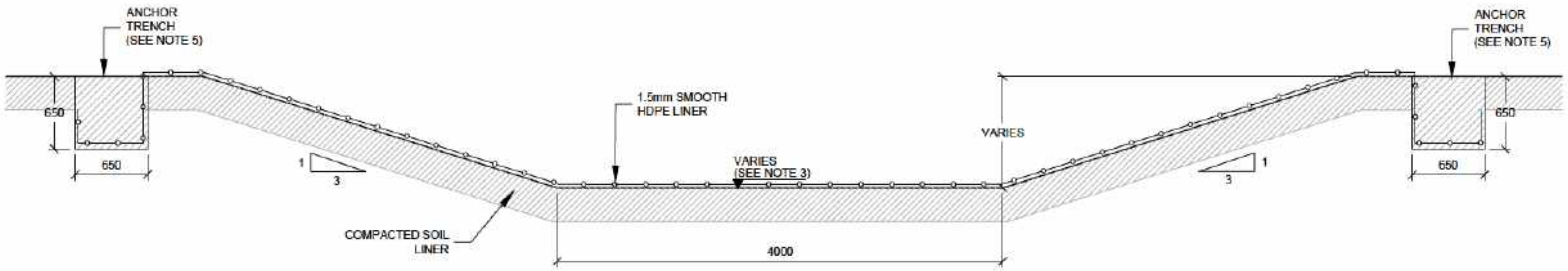
1. FOR ZONE SPECIFICATION DETAILS REFER TABLE 1 ON DRAWING PE801-296-D3000-301.
2. DECANT TOWER TO BE CONSTRUCTED USING SLOTTED CONCRETE PIPE SECTIONS. PIPE SECTIONS OF1800mm ID, CLASS 3 REINFORCED CONCRETE.
3. DECANT TRENCH TO BE EXCAVATED INTO THE MINIMAL GRADIENT OF 300(H):1(V)
4. FOR EMBANKMENT CREST ELEVATION, REFER TABLE 2 ON DRAWING 801-296-D3000-301.
5. ANCHOR TRENCH TO BE BACKFILLED AND COMPACTED IN TWO LAYERS.
6. PUMPS, CONTROL AND PIPEWORK DESIGNED AND SPECIFIED BY OTHERS.
7. ZONE E EROSION PROTECTION ONLY REQUIRED WITHIN THE FINAL 75m OF THE CAUSEWAY, WITHIN THE AVERAGE POND EXTENTS.



P / 500 DECANT TOWER SECTION
1:250



N / 500 DECANT TOWER CAUSEWAY SECTION
1:500



Q / 500 DECANT TRENCH SECTION
1:50

DRAWING No.	DRAWING TITLE
801-296-D3000-301	EMBANKMENT SECTIONS & DETAILS - SHEET 1
801-296-D3000-500	DECANT SYSTEM LAYOUT
801-296-D3000-552	DECANT SECTIONS AND DETAILS - SHEET 2

SHEET SIZE A3 — REFERENCES

REV	DATE	DESCRIPTION	DRN	DESIGN	CKD	APP	CLIENT APP
A	04/06/2021	ISSUED FOR CLIENT REVIEW	SGM	AMM	AMM	DJTM	
B	09/07/2021	ISSUED FOR PERMITTING DESIGN	UT	AMM	AMM	BAS	

REVISIONS

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DATE	DESIGNED	CHECKED	APPROVED	CLIENT APP'D

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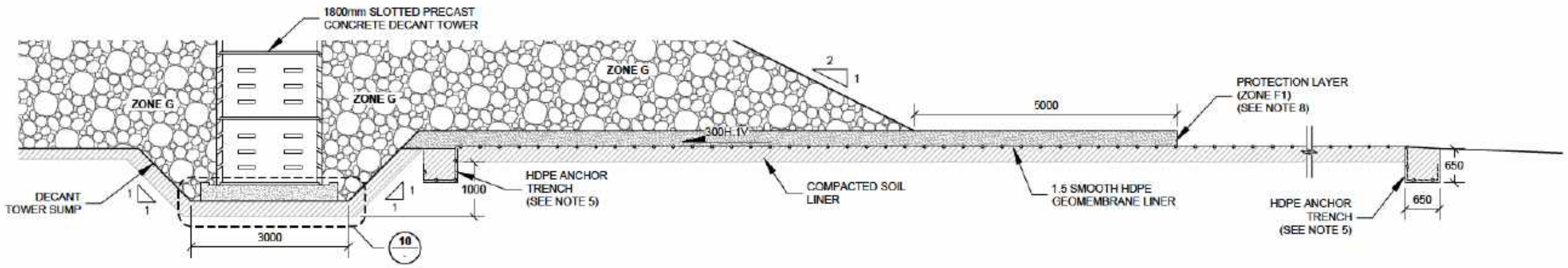
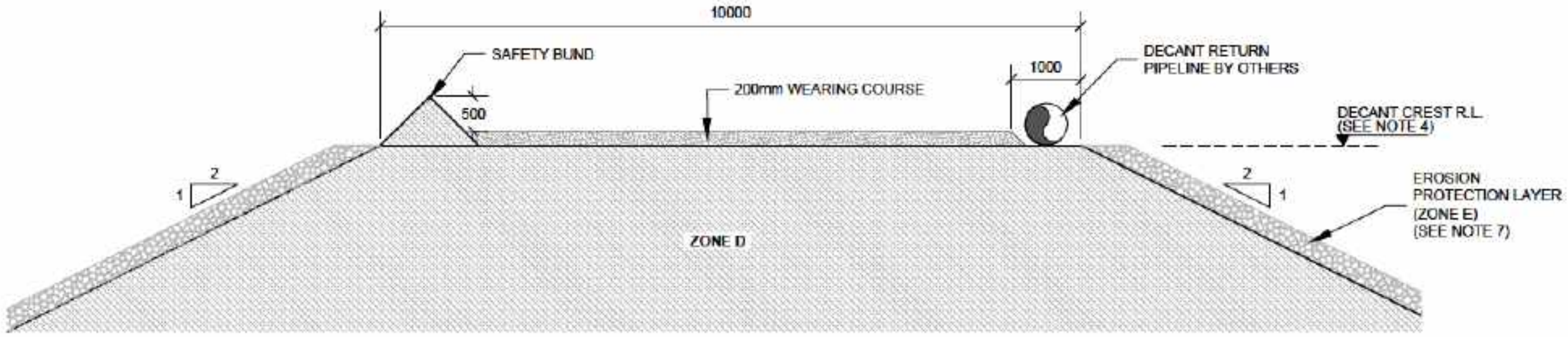
NORTHERN STAR RESOURCES LIMITED
THUNDERBOX OPERATIONS
TAILINGS STORAGE FACILITY CELL C/D EXPANSION
DECANT SECTIONS AND DETAILS - SHEET 1

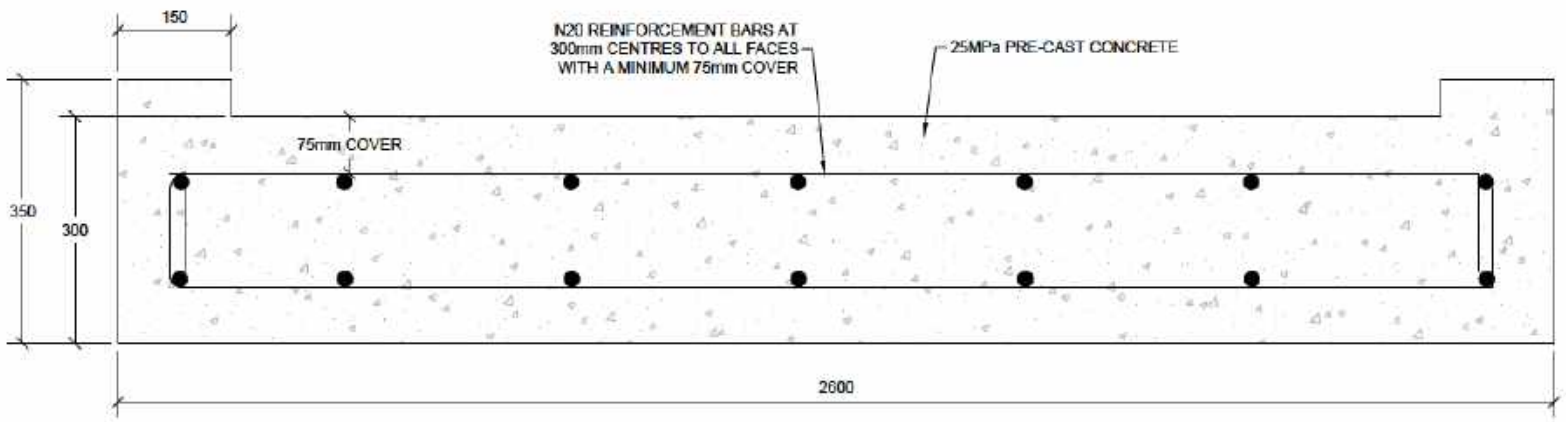
SCALE AS SHOWN
STATUS: PERMITTING
DRAWING NUMBER: 801-296-D3000-551
REV: B



8 / 551 **DECANT TOWER BASE DETAIL** 1:100



9 / 551 **DECANT ACCESS CAUSEWAY CREST DETAIL** 1:100



10 / - **DECANT TOWER BASE SLAB DETAIL** 1:10

NOTES:

1. FOR ZONE SPECIFICATION DETAILS REFER TABLE 1 ON DRAWING PE801-296-301.
2. DECANT TOWER TO BE CONSTRUCTED USING SLOTTED CONCRETE PIPE SECTIONS. PIPE SECTIONS OF1800mm ID, CLASS 3 REINFORCED CONCRETE.
3. DECANT TRENCH TO BE EXCAVATED INTO THE MINIMAL GRADIENT OF 300(H):1(V).
4. FOR EMBANKMENT CREST ELEVATION, REFER TABLE 2 ON DRAWING 801-296-D3000-301.
5. ANCHOR TRENCH TO BE BACKFILLED AND COMPACTED IN TWO LAYERS.
6. PUMPS, CONTROL AND PIPEWORK DESIGNED AND SPECIFIED BY OTHERS.
7. ZONE E EROSION PROTECTION ONLY REQUIRED WITHIN THE FINAL 75m OF THE CAUSEWAY, WITHIN THE AVERAGE AREA POND EXTENTS.
8. ZONE F MATERIAL REQUIRED WITHIN HDPE LINER EXTENT ONLY.

REFERENCES

DRAWING No.	DRAWING TITLE
801-296-D3000-301	EMBANKMENT SECTIONS & DETAILS - SHEET 1
801-296-D3000-551	DECANT SYSTEM SECTIONS & DETAILS - SHEET 1

REVISIONS

REV	DATE	DESCRIPTION	DRN	DESIGN	CKD	APP	CLIENT APP
A	04/06/2021	ISSUED FOR CLIENT REVIEW	SGM	AMM	AMM	DJTM	
B	09/07/2021	ISSUED FOR PERMITTING DESIGN	UT	AMM	AMM	BAS	

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DATE	DESIGNED	CHECKED	APPROVED	CLIENT APP'D

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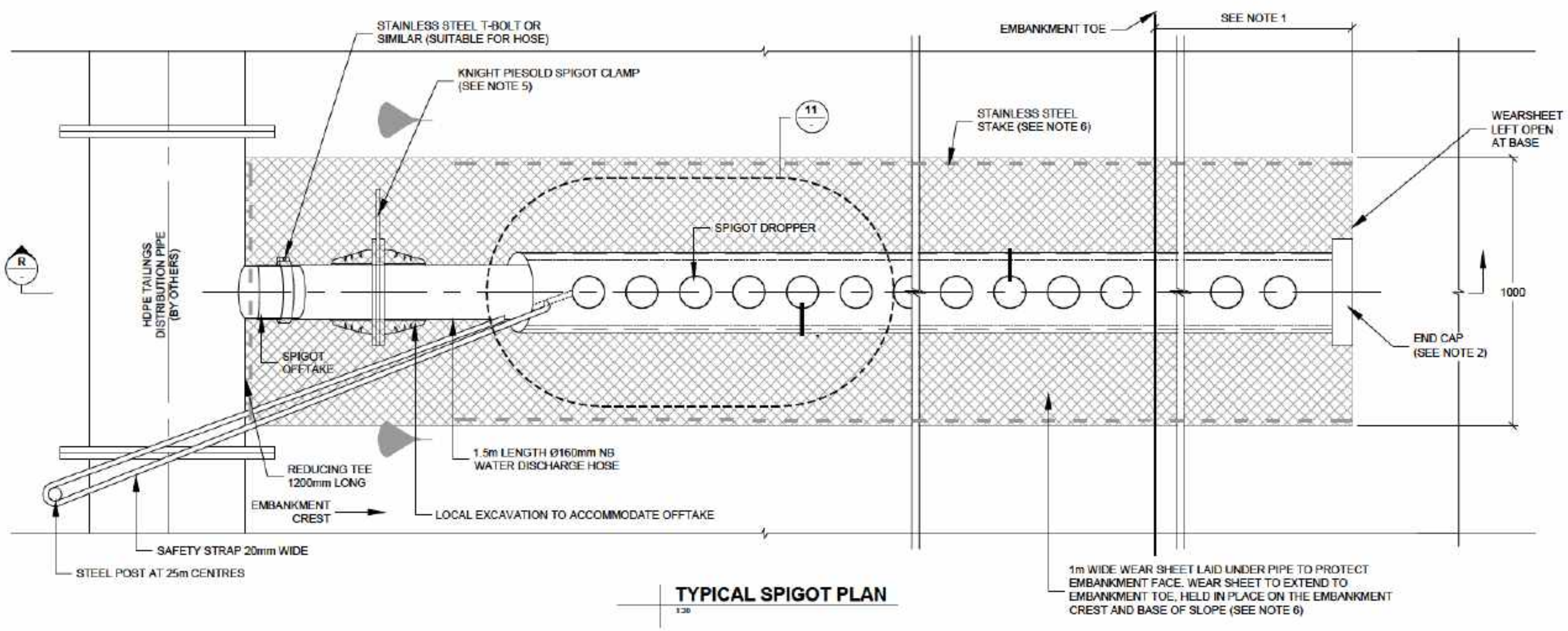
NORTHERN STAR RESOURCES LIMITED
THUNDERBOX OPERATIONS
TAILINGS STORAGE FACILITY CELL C/D EXPANSION
DECANT SECTIONS AND DETAILS - SHEET 2

SCALE AS SHOWN
STATUS: PERMITTING
DRAWING NUMBER 801-296-D3000-552
REV B

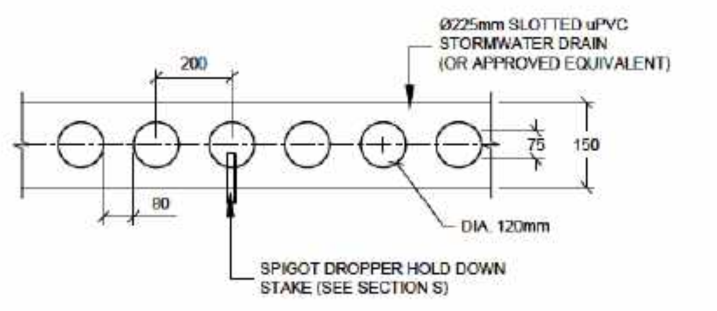
SHEET SIZE A3



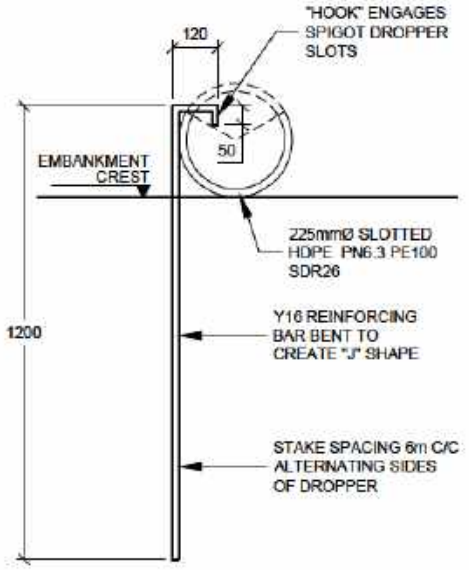
TYPICAL SPIGOT PLAN
1:20

NOTES:

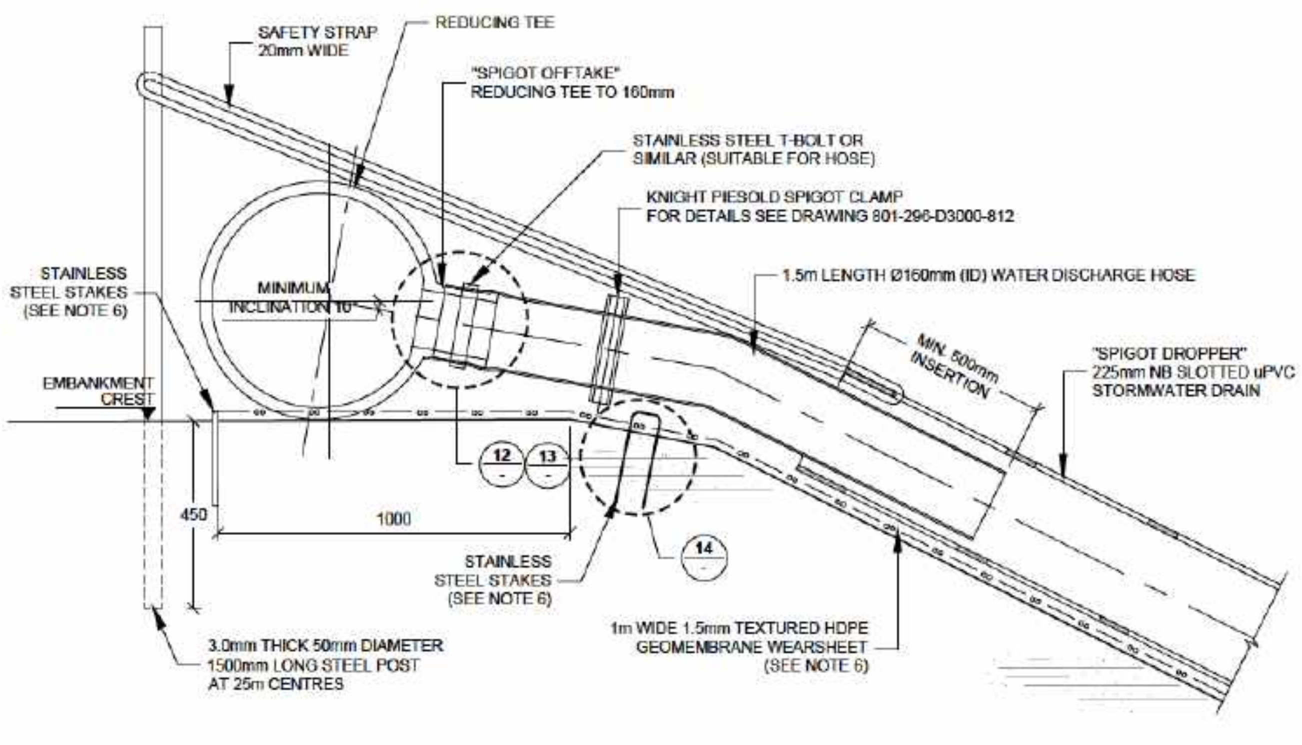
1. SPIGOT DROPPER TO EXTEND 2m BEYOND EMBANKMENT TOE DRAINS.
2. BOTTOM END OF SPIGOT DROPPER TO BE CAPPED, GLUED IN PLACE AND 6 NO. SELF TAPPING SCREWS 6mm DIAMETER.
3. TYPICAL OFFTAKE SPACING NOMINALLY 25m c/c.
4. TAILINGS DISTRIBUTION PIPELINE DESIGN BY OTHERS.
5. FOR SPIGOT CLAMP DETAILS, REFER TO DRG 801-296-D3000-812.
6. WEARSHEET STAKES TO BE MINIMUM 200mm INTERVALS BOTH SIDES.



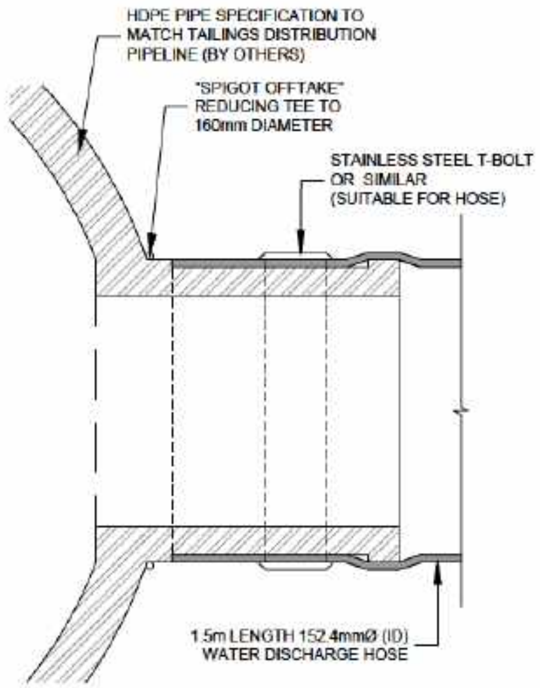
11 SPIGOT DROPPER DETAIL
1:20



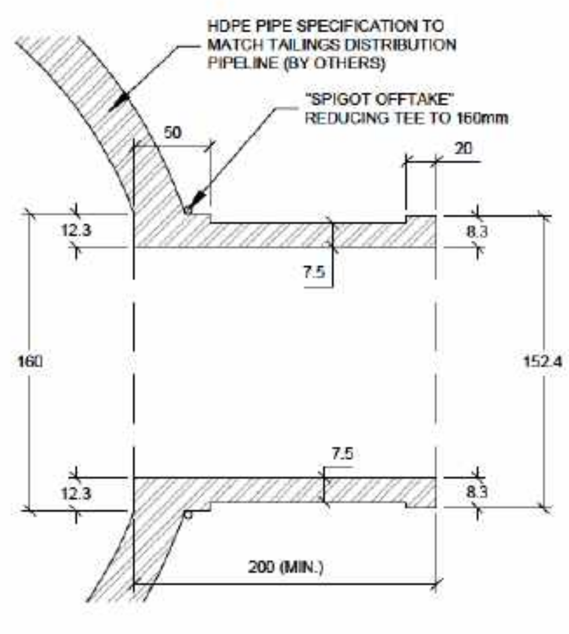
S SPIGOT DROPPER HOLD DOWN STAKE SECTION
1:20



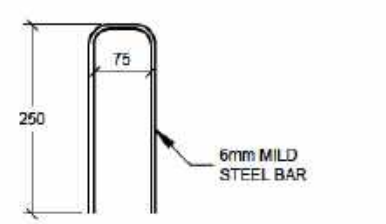
R TYPICAL SPIGOT PIPEWORK SECTION
1:20



12 SPIGOT OFFTAKE AND DISCHARGE HOSE DETAIL
1:5



13 SPIGOT OFFTAKE DETAIL
1:5



14 STEEL STAKES FOR GEOTEXTILE DETAIL
1:10

REFERENCES	
DRAWING No.	DRAWING TITLE
801-296-D3000-812	SPIGOT CLAMP DETAILS

REV	DATE	DESCRIPTION	DRN	DESIGN	CKD	APP	CLIENT APP
A	04/06/2021	ISSUED FOR CLIENT REVIEW	SGM	AMM	AMM	DJTM	
B	09/07/2021	ISSUED FOR PERMITTING DESIGN	UT	AMM	AMM	BAS	

ORIGINAL STAMPED IN RED

DATE	DESIGNED	CHECKED	APPROVED	CLIENT APP'D

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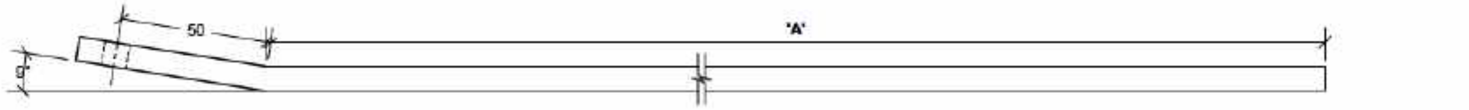
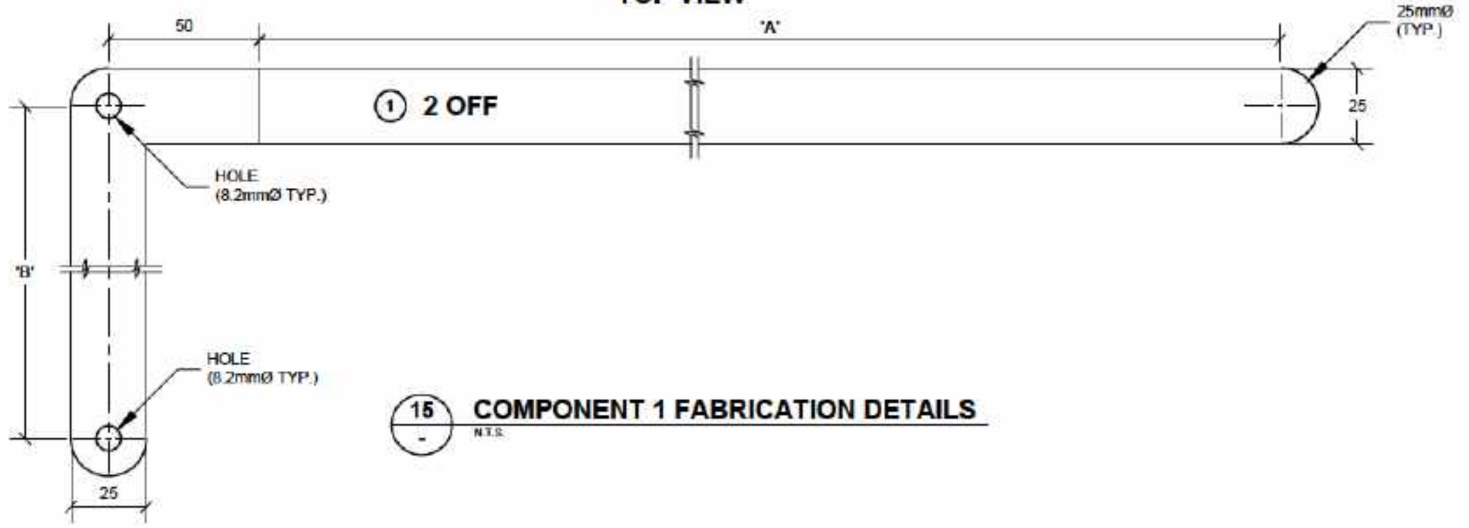
NORTHERN STAR RESOURCES LIMITED
THUNDERBOX OPERATIONS
TAILINGS STORAGE FACILITY CELL C/D EXPANSION
SPIGOT PIPEWORK DETAILS

SCALE AS SHOWN
STATUS: PERMITTING
DRAWING NUMBER: 801-296-D3000-810
REV: B

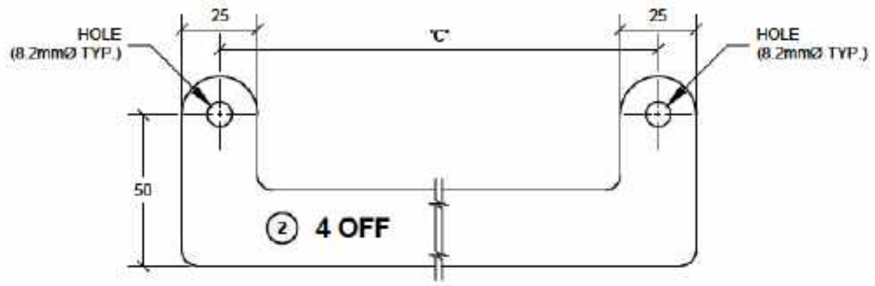
SHEET SIZE A3



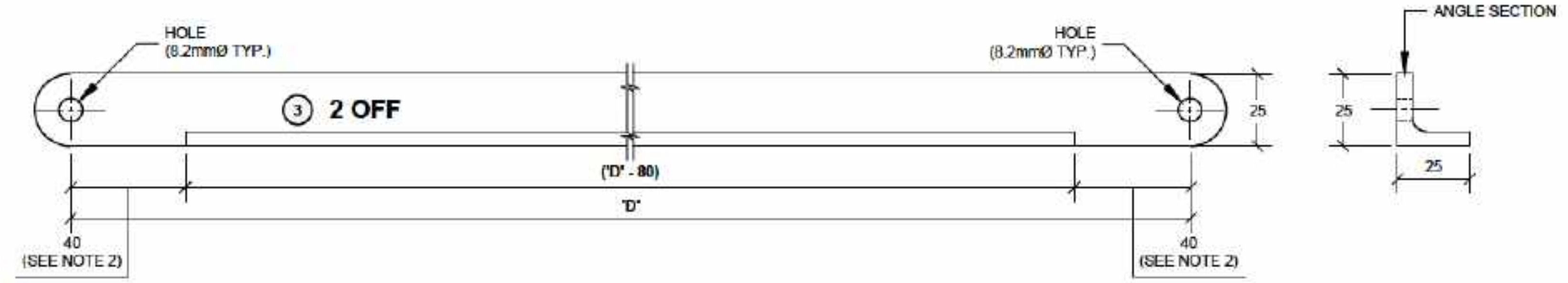
TOP VIEW



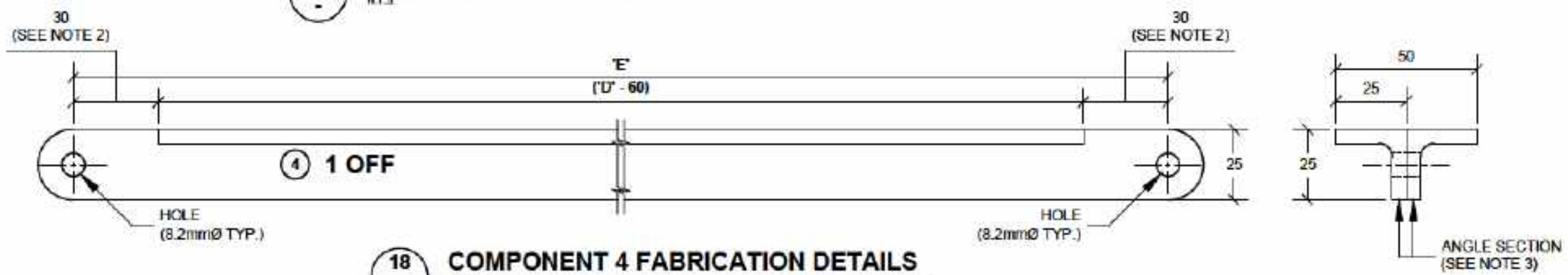
15 COMPONENT 1 FABRICATION DETAILS
N.T.S.



16 COMPONENT 2 FABRICATION DETAILS
N.T.S.



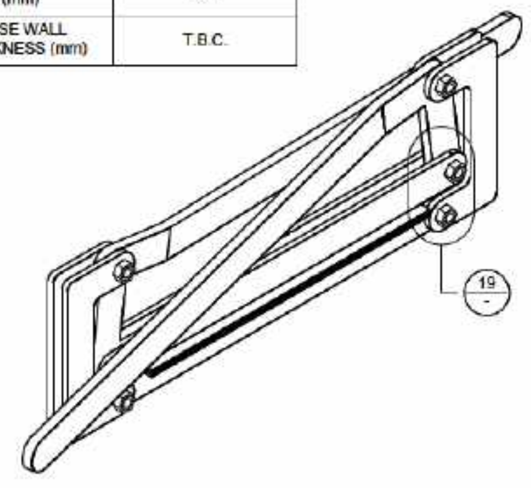
17 COMPONENT 3 FABRICATION DETAILS
N.T.S.



18 COMPONENT 4 FABRICATION DETAILS
N.T.S.

TABLE 3: COMPONENT SIZING

LENGTH I.D.	LENGTH (mm)
'A'	375
'B'	73
'C'	109
'D'	265
'E'	255
SUITABLE PIPE SIZE	
INTERNAL PIPE Ø (mm)	160
HOSE WALL THICKNESS (mm)	T.B.C.



SPIGOT CLAMP - ASSEMBLED VIEW
N.T.S.

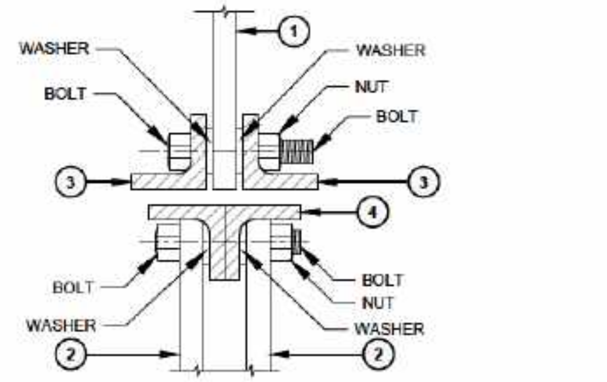
LEGEND:

1 2 25mm x 8mm STEEL PLATE

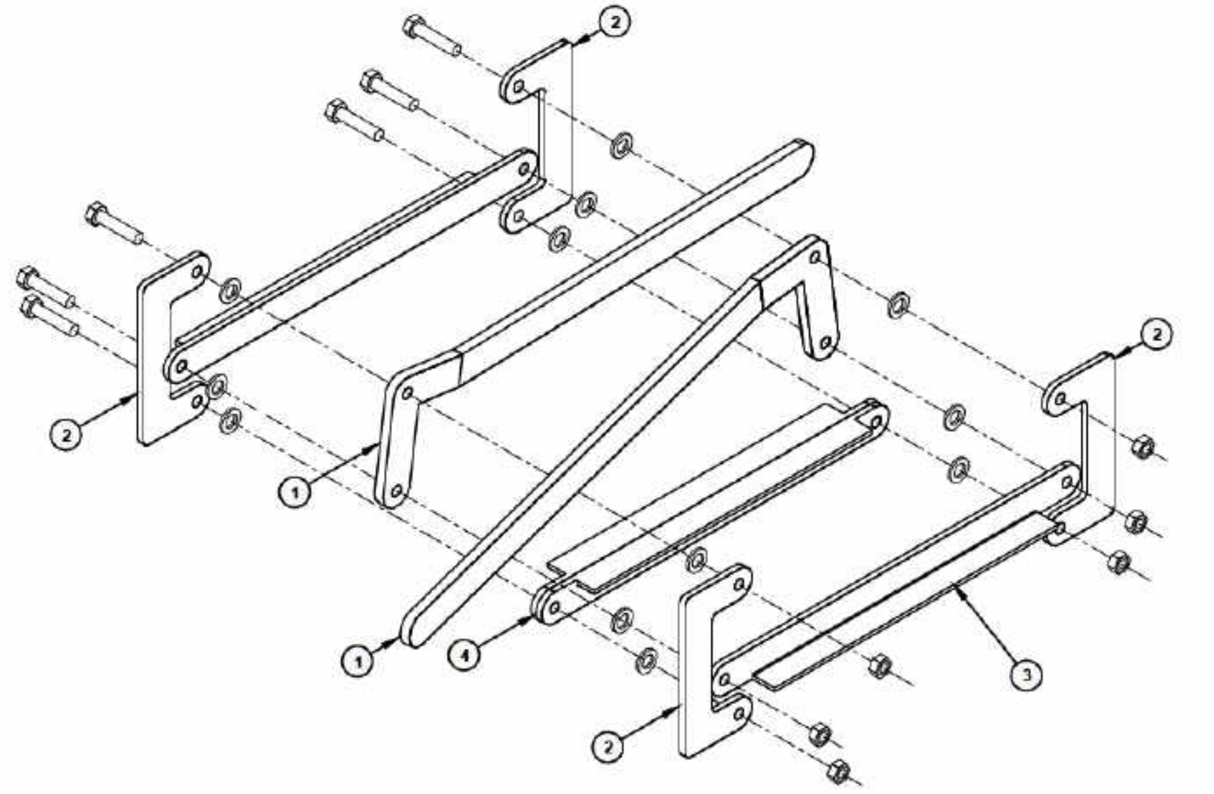
3 4 25mm x 5mm STEEL PLATE

NOTES:

1. ASSEMBLE WITH 6 No. 8mmØ x 40mm LONG BOLTS EACH WITH 2 No. NYLON WASHERS AND ONE "LOCK ON" NUT
2. INDICATED AREAS OF THE ANGLE SECTIONS TO BE REMOVED TO ALLOW HANDLE OPERATION.
3. ANGLE SECTIONS ARE TO BE CONTINUOUSLY WELDED TOGETHER. TOP SURFACE TO BE GROUND FLAT.



19 CLAMP ASSEMBLY DETAIL
N.T.S.



SPIGOT CLAMP ASSEMBLY - EXPLODED VIEW
N.T.S.

SHEET SIZE A3 / REFERENCES	DRAWING No.	DRAWING TITLE
	801-296-D3000-810	SPIGOT PIPEWORK DETAILS

REV	DATE	DESCRIPTION	DRN	DESIGN	CKD	APP	CLIENT APP
A	04/06/2021	ISSUED FOR CLIENT REVIEW	SGM	AMM	AMM	DJTM	
B	09/07/2021	ISSUED FOR PERMITTING DESIGN	UT	AMM	AMM	BAS	

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DATE	DESIGNED	CHECKED	APPROVED	CLIENT APP'D

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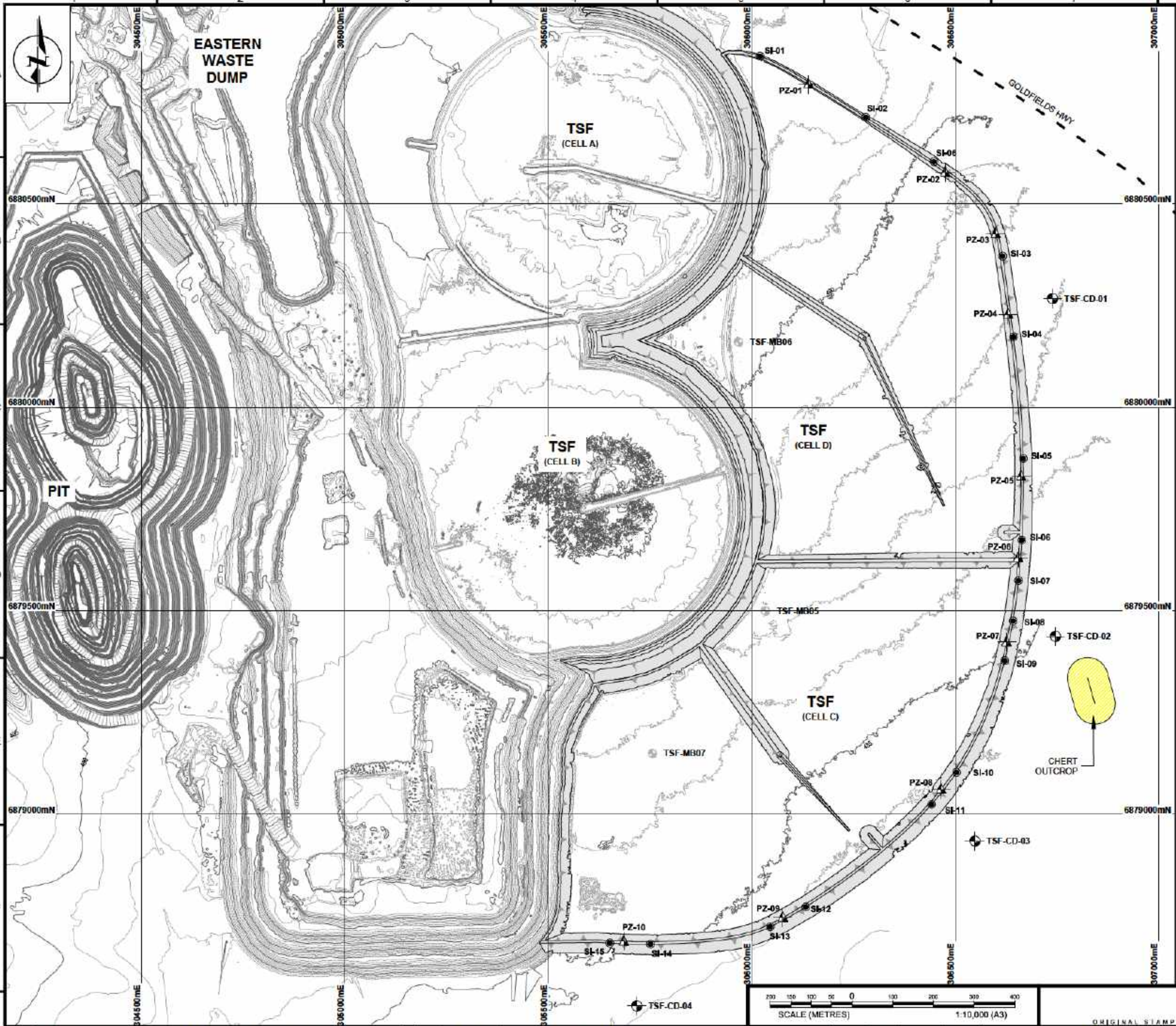
NORTHERN STAR RESOURCES LIMITED
THUNDERBOX OPERATIONS
TAILINGS STORAGE FACILITY CELL C/D EXPANSION
SPIGOT CLAMP DETAILS

SCALE AS SHOWN
STATUS: PERMITTING
DRAWING NUMBER: 801-296-D3000-812 | REV: B

287 410



LEGEND:

- EXISTING SEALED ROAD
- EXISTING SITE ROAD
- EXISTING MONITORING BORE LOCATION
- PROPOSED PIEZOMETER LOCATION
- PROPOSED SETTLEMENT PIN LOCATION
- PROPOSED MONITORING BORE LOCATION

NOTES:

1. 1m CONTOUR INTERVALS SHOWN.
2. FOR MONITORING INSTRUMENTATION DETAILS REFER DRAWING 801-296-D3000-905.
3. PIEZOMETERS AND SETTLEMENT PINS INSTALLED AT DOWNSTREAM CREST.
4. STAGE 1 TAILINGS STORAGE FACILITY SHOWN.
5. EXISTING MONITORING BORES TO BE DECOMMISSIONED AND GROUTED.

PROPOSED MONITORING BORE LOCATION

BORE I.D.	EASTING	NORTHING
TSF-CD-01	306738.6	6880267.1
TSF-CD-02	306745.8	6879437.3
TSF-CD-03	306548.0	6878934.4
TSF-CD-04	305716.8	6878529.5

PROPOSED PIEZOMETER LOCATIONS

PIEZOMETER I.D.	EASTING	NORTHING
PZ-01	306138.7	6880793.3
PZ-02	306475.1	6880576.9
PZ-03	306598.8	6880426.2
PZ-04	306629.5	6880228.7
PZ-05	306661.3	6879830.3
PZ-06	306654.4	6879630.5
PZ-07	306625.6	6879423.7
PZ-08	306464.5	6879061.6
PZ-09	306075.4	6878746.5
PZ-10	305684.9	6878688.4

PROPOSED SETTLEMENT PIN LOCATIONS

PIN I.D.	EASTING	NORTHING
SI-01	306020.2	6880862.4
SI-02	306279.7	6880712.7
SI-03	306615.9	6880371.2
SI-04	306642.6	6880173.0
SI-05	306666.7	6879874.1
SI-06	306663.3	6879674.2
SI-06	306447.2	6880603.4
SI-07	306655.2	6879574.5
SI-08	306641.5	6879475.5
SI-09	306621.0	6879377.7
SI-10	306502.7	6879103.6
SI-11	306441.3	6879024.8
SI-12	306132.2	6878772.8
SI-13	306044.9	6878724.3
SI-14	305750.3	6878681.4
SI-15	305650.4	6878684.2

EXISTING MONITORING BORE LOCATIONS (GROUT & SEAL)

BORE I.D.	EASTING	NORTHING
TSF-MB05	306033.0	6879500.0
TSF-MB06	305967.0	6880160.0
TSF-MB07	305755.0	6879150.0

SHEET SIZE A3

REFERENCES

DRAWING No.	DRAWING TITLE
801-296-D3000-905	MONITORING INSTRUMENTATION DETAILS

REVISIONS

REV	DATE	DESCRIPTION	DRN	DESIGN	CKD	APP	CLIENT APP
A	04/06/2021	ISSUED FOR CLIENT REVIEW	SGM	AMM	AMM	DJTM	
B	09/07/2021	ISSUED FOR PERMITTING DESIGN	UT	AMM	AMM	BAS	

ORIGINAL STAMPED IN RED

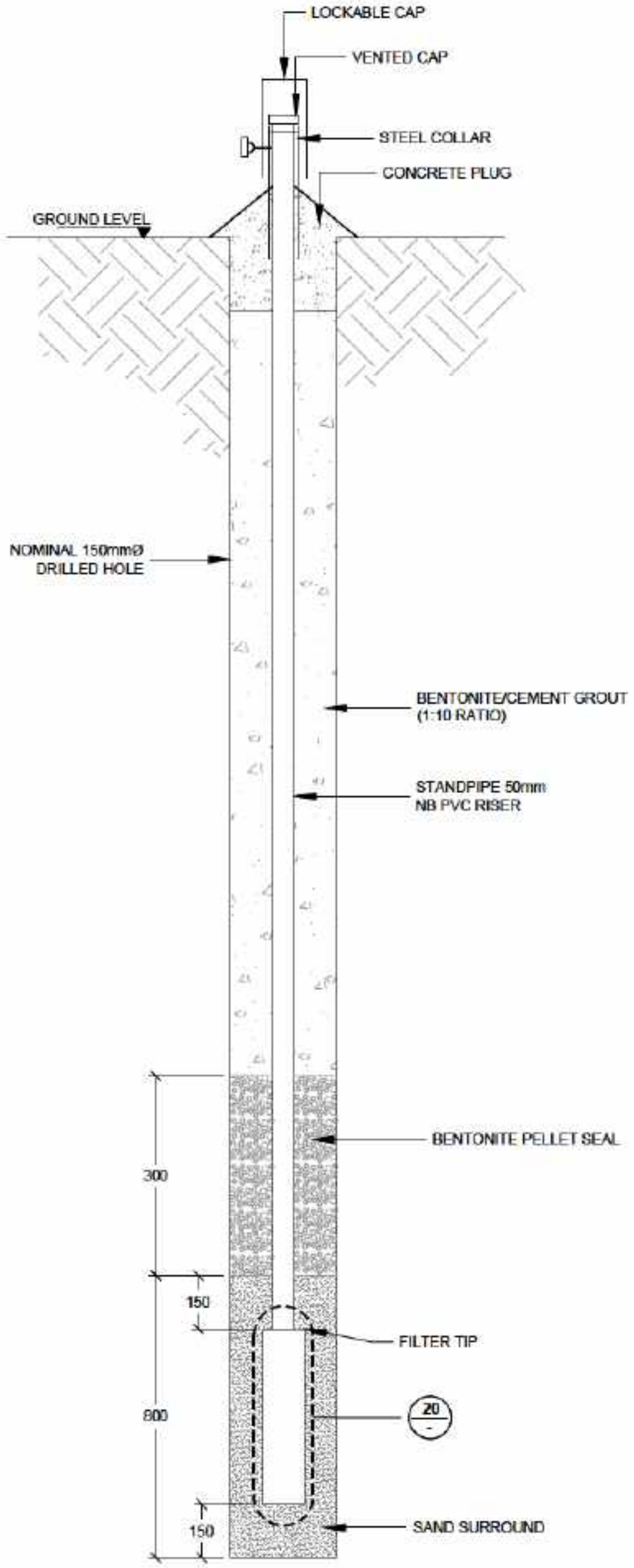
DATE	DESIGNED	CHECKED	APPROVED	CLIENT APP'D

Knight Piésold CONSULTING

CONSULT AUSTRALIA Member Firm

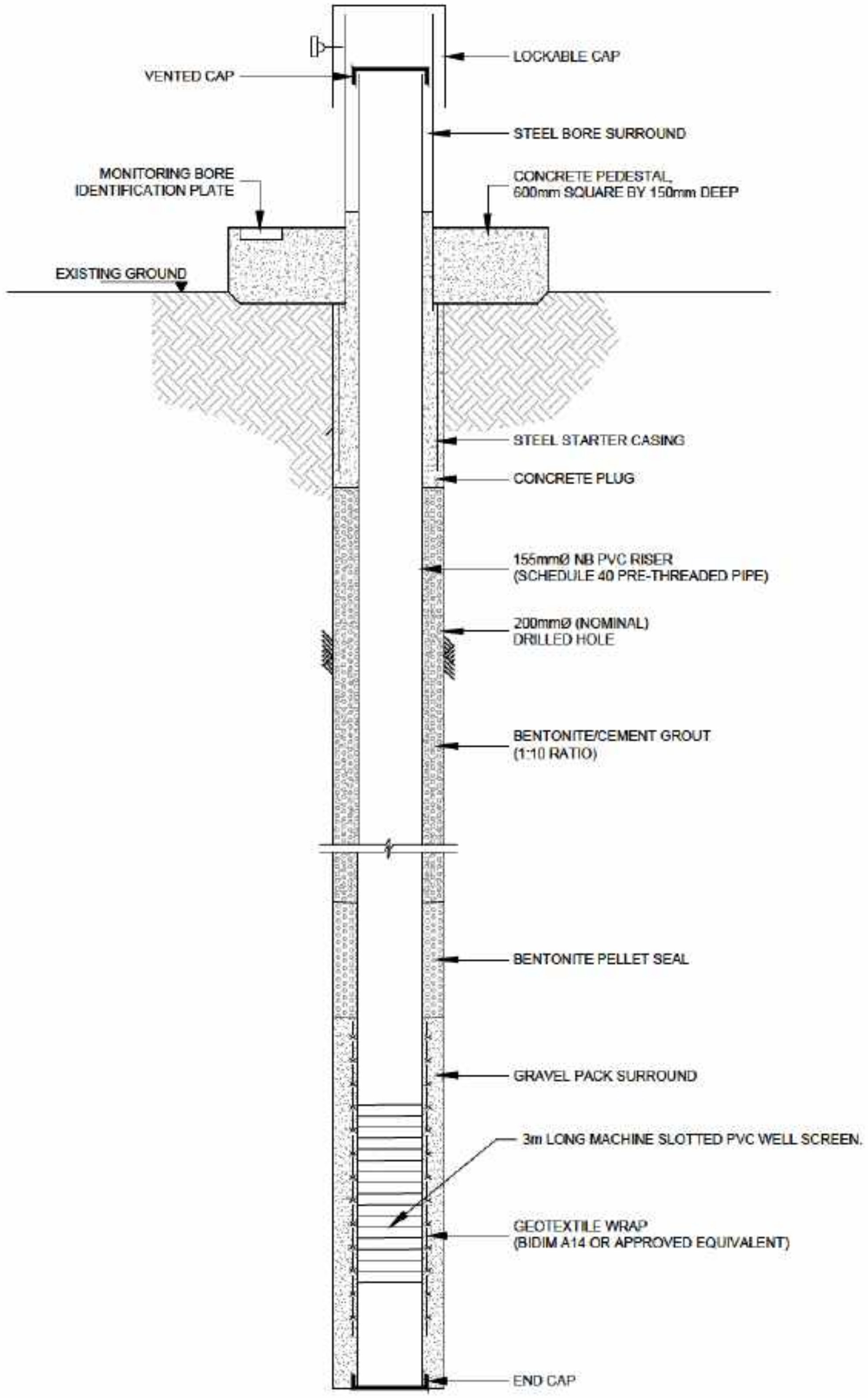
NORTHERN STAR RESOURCES LIMITED
THUNDERBOX OPERATIONS
TAILINGS STORAGE FACILITY CELL C/D EXPANSION
MONITORING INSTRUMENTATION LAYOUT

SCALE 1:10,000
STATUS: PERMITTING
DRAWING NUMBER 801-296-D3000-900
REV B



TYPICAL STANDPIPE PIEZOMETER SECTION

N.T.S.

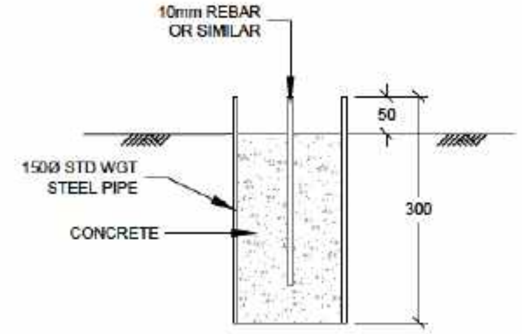


MONITORING BORE INSTALLATION DETAIL

N.T.S.

NOTES:

1. FOR INSTRUMENTATION LOCATIONS REFER DRAWING 801-296-D3000-900. FINAL LOCATIONS DETERMINED BY THE ENGINEER ON SITE.



TYPICAL SURVEY STATION PIN SECTION

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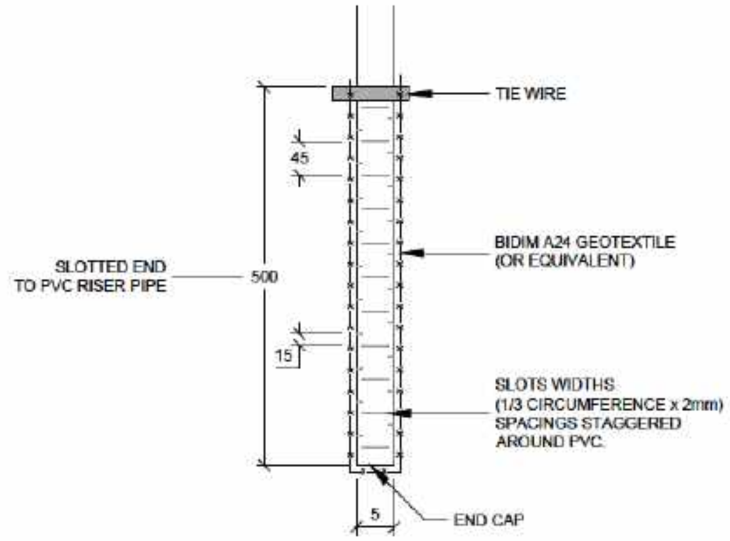

20 TYPICAL FILTER TIP DETAIL

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REFERENCES	
DRAWING No.	DRAWING TITLE
801-296-D3000-900	MONITORING INSTRUMENTATION LAYOUT

SHEET SIZE A3

REV	DATE	DESCRIPTION	DRN	DESIGN	CKD	APP	CLIENT APP
A	04/06/2021	ISSUED FOR CLIENT REVIEW	SGM	AMM	AMM	DJTM	
B	09/07/2021	ISSUED FOR PERMITTING DESIGN	UT	AMM	AMM	BAS	

REVISIONS

ORIGINAL STAMPED IN RED

DATE	DESIGNED	CHECKED	APPROVED	CLIENT APP'D

Knight Piésold CONSULTING

CONSULT AUSTRALIA Member Firm

NORTHERN STAR RESOURCES LIMITED
THUNDERBOX OPERATIONS
TAILINGS STORAGE FACILITY CELL C/D EXPANSION
MONITORING INSTRUMENTATION DETAILS

SCALE AS SHOWN
STATUS: PERMITTING
DRAWING NUMBER: 801-296-D3000-905
REV: B

APPENDIX A

Basic Climatology

MEMORANDUM

To:	Saracen Metals Pty Ltd	**Date:**	10 October 2017
[redacted]		**Our Ref:**	PE17-00920
		KP File Ref.:	**PE801-00296/10-A djtm M17011**
		From:	[redacted]

RE: THUNDERBOX PROJECT – BASIC CLIMATOLOGY

Knight Piésold (KP) is pleased to provide the following memorandum regarding basic climatology that has been developed for the Tailings Storage(TSF) Expansion Permitting for the Thunderbox Project site, 290 km North of Kalgoorlie in Western Australia.

1. DATA SOURCE / SUMMARY

Daily historic climate data was obtained from the Scientific Information for Land Owners (SILO) database for use in deriving the basic climatology.

Historic daily climate data from SILO, extracted as a data drill down, spanning the period January 1889 – September 2017 were analysed to obtain desired design inputs for water balance modelling, namely:

- Typical variability of annual precipitation and evaporation;
- Typical variability of monthly precipitation and evaporation; and
- Synthetic monthly precipitation sequences for three climate scenarios:
  - 100 year Annual Recurrence Interval (ARI) Wet precipitation, 1 year duration;
  - Average precipitation, 1 year duration;
  - 100 year ARI Dry precipitation, 1 year duration;

Design storms were developed using the BOM's 2016 IFD generating tool. Probable Maximum Precipitation (PMP) was estimated using the methods developed by the BOM.

2. WATER BALANCE PRECIPITATION ANALYSES

Precipitation data from the SILO dataset were reduced into a standardised format and then analysed on annual and monthly time scales to develop inputs for water balance modelling. The following sections detail the various analyses conducted and the results achieved. It is noted that as the wetter period of the year runs from January through to June, the annual data were analysed as Water Years, spanning October through to September.

2.1 ANNUAL ANALYSES

Daily precipitation records from the SILO dataset were summed to produce annual totals for the 129 years of record available. KP notes that water years were excluded from the analysis if greater than 15% of the daily data were missing. This was done to prevent missing records from introducing bias into computed climate statistics. Of the 129 water years of data, 1 year was excluded from the annual analysis. Sampling statistics were computed from the annual sums to provide a broad overview of the variability of annual climate at the project site, as given in Table 2.1.

Table 2.1: Annual precipitation statistics

Selected Statistic	Precipitation Value (mm)
Average	224
Median	211
Std. Deviation	106
Minimum	44
Maximum	617
25th Percentile	142
75th Percentile	288

2.2 MONTHLY ANALYSES

Daily precipitation data from SILO dataset were summed in a manner similar to that described in Section 2.1 to produce monthly totals. Monthly totals were excluded from the analyses if greater than 25% of the daily data from that month were missing (approximately 1 week); for the same reason as given in Section 2.1. Sampling statistics were computed on the monthly sums to provide a broad overview of the variability of monthly climate at the project site, as given in Table 2.2.

Table 2.2: Monthly precipitation statistics (mm)

Month	Average	Median	Std. Dev.	Min.	Max.	25th Pct.	75th Pct.
Oct	8	3	12	0	58	0	9
Nov	11	5	16	0	88	1	14
Dec	16	10	18	0	81	2	24
Jan	25	11	35	0	177	2	34
Feb	27	10	41	0	290	3	32
Mar	33	14	46	0	235	3	49
Apr	21	12	27	0	178	2	32
May	23	16	24	0	165	6	32
Jun	23	17	21	0	110	6	32
Jul	17	12	16	0	72	5	22
Aug	13	9	15	0	68	3	18
Sep	7	2	12	0	94	0	8

The sample statistics for monthly precipitation were also depicted as “box and whisker” plots to illustrate the variability of monthly values at the project site, as shown on Figure 2.1. For each month shown on these figures, the “box and whisker” plots are read as follows:

- Top of each “box” indicates the 75th percentile of the monthly values;
- Central line within each “box” indicates the median (or 50th percentile) of the monthly values;
- Bottom of each “box” indicates the 25th percentile of the monthly values;
- Red diamond inside each “box” indicates the average of the monthly values;

- The "whiskers", each of length 1.5 times the inter-quartile range (which is the 75th minus the 25th percentile values) indicate the range of expected readings above and below each "box". Values above and below the "whiskers" are considered to be outliers; and
- Individual monthly outlier values are indicated as blue crosses with monthly readings adjacent.

As is clearly shown on Figure 2.1, March is typically the wettest month of the year at the Thunderbox Project, with measureable precipitation occurring throughout the year. It is noted that the monthly precipitation is quite variable.

2.3 SYNTHETIC WATER BALANCE SCENARIOS

KP performed frequency analysis on annual duration values (from SILO climate dataset) to estimate the statistical likelihood of experiencing extremely "Wet" or "Dry" periods of weather at the project site. Exceedance and non-exceedance probabilities were assigned to various duration totals of daily precipitation values, by sorting the values in descending (for the "Wet" series) and ascending (for the "Dry" series) order.

A number (64) of different probability distributions, e.g.: Log-Pearson 3, Generalised Extreme Value, Wakeby, Inverse Gaussian, etc. were fitted to the various sums of daily precipitation data using EasyFit 5.4 Professional software. Three of the best fits were selected for comparison in each case, as shown on the following figures:

- Wet precipitation series, 1 year duration – Figure 2.2; and
- Dry precipitation series, 1 year duration – Figure 2.3.

Ideally, the distributions having the best weighted Kolmogorov-Smirnov and Anderson-Darling goodness-of-fit test ranking results will match across all scenarios, thereby providing consistent results. In this case, the goodness-of-fit test results indicated the following on a case-by-case basis:

- 1 year duration Wet scenarios = Log-Pearson 3 (KP Fit) distribution; and
- 1 year duration Dry scenarios = Johnson SB distribution.

The Log-Pearson 3 distribution was fit to the data for the Wet precipitation series for the data points with ARIs ≥10 years using least-squares regression analysis. This was done as this fit provides a more reasonable fit to the larger wet events than the other fits. This fit was then selected for estimating the extreme wet precipitation series depths. For the Dry precipitation series the Johnson SB distribution, as fit by EasyFit 5.4, was selected as it was the best statistical fit. The resulting estimated extreme wet and dry annual precipitation depths are shown in Table 2.3.

Table 2.3: Design precipitation, various duration Wet and Dry totals

ARI (yr)	1 Year Wet / Dry Precipitation Totals (mm)	
	Wet	Dry
100	571	52
50	506	62
20	422	82
10	359	102

In order to apportion the statistically-computed climate series precipitation totals to monthly time series for use in water balance modelling, the following observed rainfall patterns were used:

- 1 year duration Wet scenarios = (October 1941 – September 1942), the wettest observed water year of record;
- 1 year duration Average scenario = (October 1940 – September 1941), the median observed water year of record;
- 1 year duration Dry scenarios = (October 1968 – September 1969), the driest observed water year of record;

Ratios of observed monthly to observed total precipitation were computed for each scenario. These ratios were then multiplied by the computed statistical totals (at the selected design frequency, 100 years ARI) to form the desired synthetic climate scenarios for water balance modelling. The resulting climate scenarios are summarized (in monthly format) in Table 2.4.

Table 2.4: Annual synthetic climate scenarios

Month	Annual Climate Scenarios (mm)		
	100 year Dry	Average	100 year Wet
Oct	0.0	27.8	29.9
Nov	2.4	0.7	3.9
Dec	0.0	2.0	69.1
Jan	4.0	0.0	101.2
Feb	7.3	19.2	65.8
Mar	0.0	17.5	173.3
Apr	2.4	57.7	2.4
May	46.2	29.2	45.4
Jun	0.0	20.7	64.0
Jul	0.0	13.9	8.2
Aug	0.0	35.1	8.1
Sep	0.0	0.6	0.0

It is noted that the 100 year Wet year may have months where the precipitation is less than the average or the 100 year dry year. Similarly the 100 year Dry may have months where the precipitation is greater than the average or the 100 year wet year. This not an error and is due to the rainfall pattern within the specific year selected to develop the rainfall patterns.

3. DESIGN STORMS

Aside from climate scenarios for water balance modelling, design storms were derived for site water conveyance / handling design.

3.1 PROBABLE MAXIMUM PRECIPITATION

The Thunderbox Project site lies in the GSAM-GTSMR Transition Zone. As such the Generalised Tropical Storm Method, Revised (GTSMR) procedures (Ref. 1) and the Generalised Southeast Australia Method (GSAM) (Ref. 2) were evaluated to determine the governing method for deriving PMP for storm durations ≥24 hours. The results for the Thunderbox Project site are summarised in Table 3.1.

Table 3.1: PMP Depths

Duration (h)	GTSMR IAZ Depth (mm)	GSAM IAZ Depth (mm)
24	560	540
30	620	560
36	660	580
48	760	610
60	840	630
72	920	660
96	1,040	670

As the GTSMR IAZ produced the more conservative results, it was selected for use at the Thunderbox Project.

3.2 INTENSITY / FREQUENCY / DURATION

Intensity / Frequency / Duration (IFD) and corresponding Depth / Frequency / Duration (DFD) relationships for design storms (10 years ≤ ARI ≤ 2000 years) were sourced from the BOM 2016 IFD tool for the grid cell (28.19°S, 1 21.02°E). It is noted that for storms greater than the 100 year ARI, only the 24 hour to 168 hour durations are available. The design storm information sourced is summarised as storm depths in Table 3.2.

Table 3.2: Design storm depths

Duration (h)	Precipitation Depth (mm) for a given ARI (yr)							
	10	20	50	100	200	500	1000	2000
0.25	17.6	21.7	27.8	33.0	-	-	-	-
0.50	23.4	29.1	37.4	44.6	-	-	-	-
1	29.6	36.9	47.8	57.3	-	-	-	-
2	36.7	45.8	59.4	71.4	-	-	-	-
3	41.6	51.8	67.2	80.4	-	-	-	-
6	52.0	64.5	82.8	98.4	-	-	-	-
12	65.4	80.8	103.0	121.0	-	-	-	-
24	81.3	100.0	127.0	149.0	169.0	201.0	227.0	255.0
48	97.0	121.0	154.0	182.0	212.0	257.0	294.0	335.0
72	104.0	131.0	169.0	201.0	238.0	293.0	340.0	392.0
96	108.0	136.0	177.0	212.0	253.0	315.0	368.0	429.0
120	110.0	139.0	181.0	218.0	262.0	327.0	384.0	450.0
144	111.0	140.0	183.0	221.0	266.0	332.0	391.0	460.0
168	111.0	140.0	184.0	222.0	266.0	333.0	391.0	461.0

4. EVAPORATION

Daily evaporation data from SILO dataset were summed in a manner similar to that described in Section 2.1 to produce monthly totals. Monthly totals were excluded from the analyses if greater than 25% of the daily data from that month were missing (approximately 1 week); for the same reason as given in Section 2.1. Average monthly pan evaporation values for the site were calculated from the SILO dataset for 1970 onwards and are summarised in Table 4.1 below.

Table 4.1: Average monthly pan evaporation.

Month	Pan Evap. (mm)
Oct	285
Nov	333
Dec	389
Jan	404
Feb	321
Mar	289
Apr	193
May	128
Jun	91
Jul	98
Aug	136
Sep	199

As per "Evaporation Data for Western Australia" (Ref. 3), the pan factor for the Thunderbox Project is estimated as 0.66.

[redacted]

REFERENCES

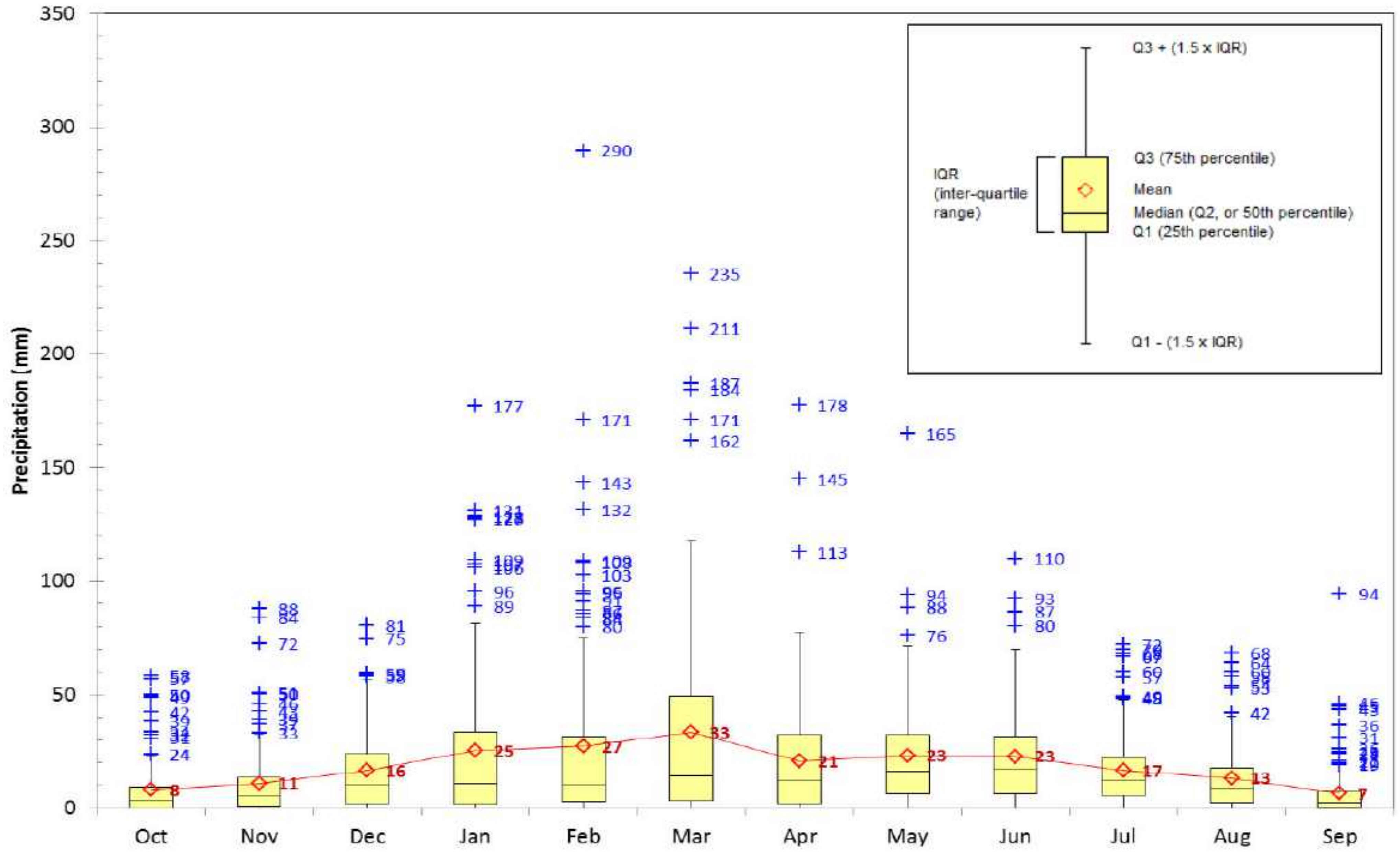
1. Australian Bureau of Meteorology. "*Revision of the Generalised Tropical Storm Method for Estimation Probable Maximum Precipitation, HRS Report No. 8*", 2003. Melbourne, VIC. Australia

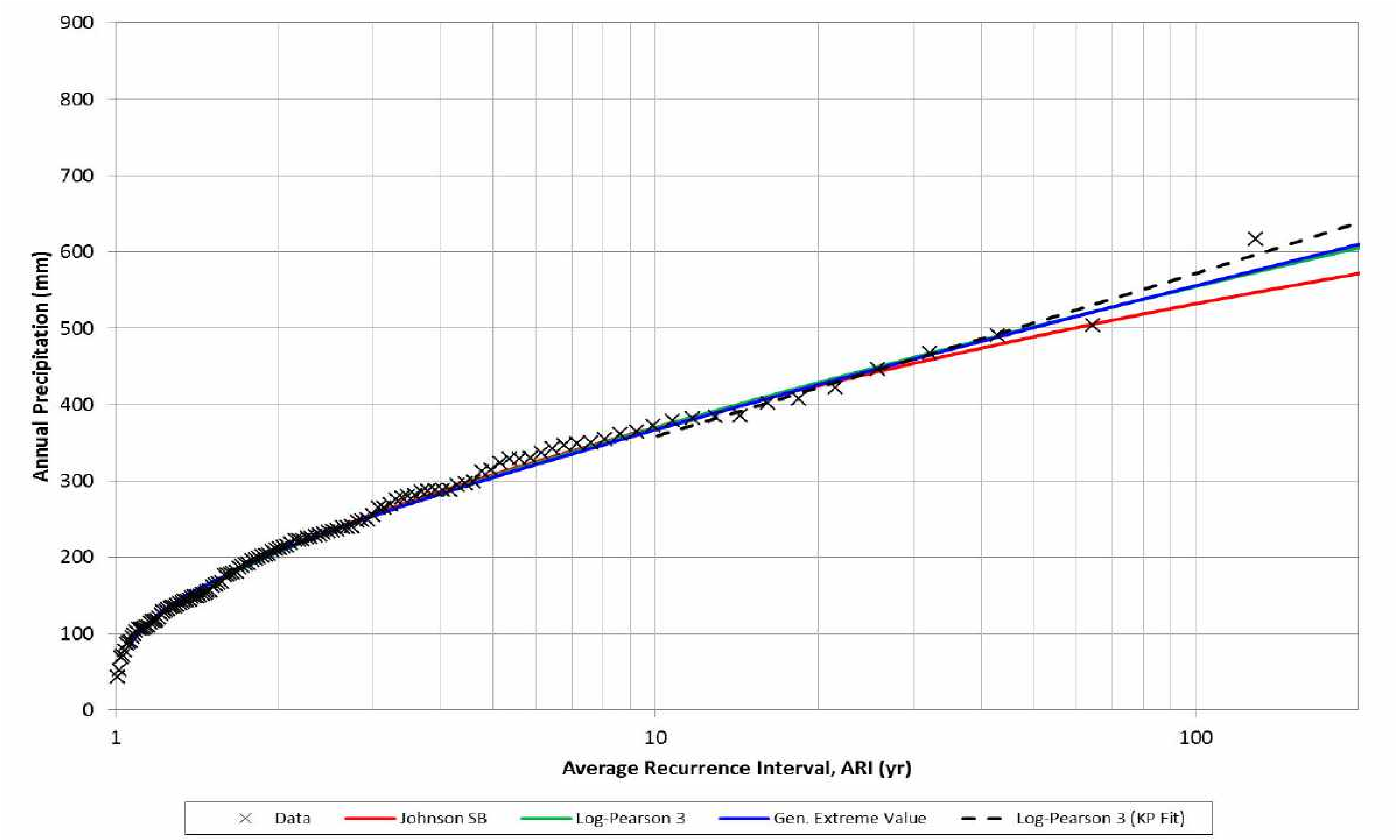
2. Australian Bureau of Meteorology. "Development of the *Generalised Southeast Australia Method for Estimating Probable Maximum Precipitation, HRS Report No. 4'*"', 1996. Melbourne, VIC. Australia

3. Luke G.J., Burke K.L., O'Brien T.M. (1987), "*Evaporation Data for Western Australia*". Department of Agriculture and Food, Western Australia. Report 65.

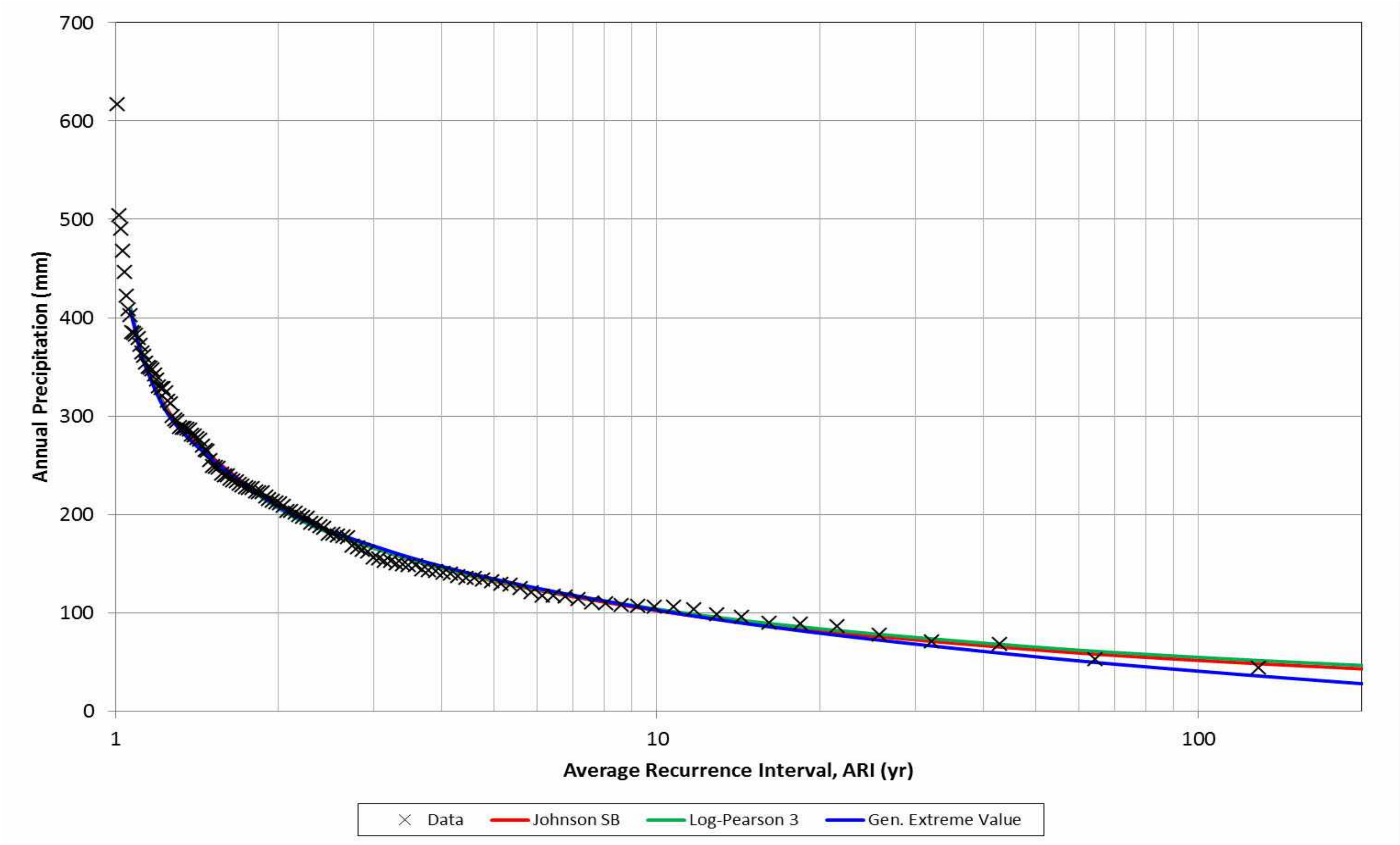
FIGURES

Excel Figures M17011.xlsm Figure 2.1





900
800
700
600
500
400
300
200
100
0
Annual Precipitation (mm)
1
10
100
Average Recurrence Interval, ARI (yr)
Data
Johnson SB
Log-Pearson 3
Gen. Extreme Value
Log-Pearson 3 (KP Fit)



700
600
500
400
300
200
100
0
Annual Precipitation (mm)
1
10
100
Average Recurrence Interval, ARI (yr)
Data
Johnson SB
Log-Pearson 3
Gen. Extreme Value

APPENDIX B

TSF Expansion CPT Investigation - 2020

Knight Piésold CONSULTING

MEMORANDUM

To:	Saracen Minerals Holdings Ltd	**Date:**	27 November 2020
[redacted]		**Our Ref:**	PE20-01517
		KP File Ref.:	PE801-00296/25-A LL M20005
		From:	[redacted]

RE: THUNDERBOX GOLD PROJECT – 2020 TSF CELLS A AND B EXPANSION GEOTECHNICAL INVESTIGATION

Knight Piésold Pty Limited (KP) was requested by Saracen Minerals Holdings Ltd (Saracen) to undertake a geotechnical site investigation of proposed TSF Cells A and B at the Thunderbox Gold Mine, Western Australia.

The site investigation was undertaken from the 2nd to the 8th of September 2020. This memorandum presents the factual data obtained from the geotechnical investigation and the associated interpretation of the ground conditions at the TSF Cells A and B.

1. SITE CHARACTERISTICS

1.1 INTRODUCTION

The Thunderbox Gold Mine is located 45 km south of the town of Leinster in Western Australia and immediately adjacent to the sealed Goldfields Highway.

1.2 TOPOGRAPHY AND SETTING

The existing TSF cells are bounded to the east by the Goldfields Highway and to the immediate west by the Eastern Waste Dump.

The surface of the tailings at TSF Cells A and B are generally flat, with the ground surface tapering up to the embankment level around the edges of the TSFs. The tailings surface is generally quite dry and no sludge/ tailings slurry is present. It was noted that the more recent deposits of the tailings slurry were deposited at the west side of TSF Cell A.

1.3 CLIMATE

The region is in a semi-arid environment and has a dry climate with hot summers and cool winters. The average annual rainfall is about 224 mm. February and March tend to be the wettest months, September and October are the driest months (Ref. 1).

1.4 GEOLOGY

The 1:250,000 geological map of Leonora (Ref. 2) indicates that the site is founded on igneous rock which is overlain by colluvial (Cza) and possibly alluvial (Qa) deposits:

- Qa: alluvial clay, silt, sand and gravel. The site is located at the uppermost reach of the drainage line and alluvial material is expected to be limited or absent.
- Cza: colluvial clay, silt and sand (pebbly in places).

Figures 1.1 and 1.2 present the geological map and map key.

1.5 SITE COORDINATE SYSTEM

The coordinates used in this memorandum are to UTM WGS84 Zone 51J (north) grid whereas Thunderbox uses a site grid. As the horizontal difference between the two grid systems is less than 1 m, the CPT locations were set out using a hand held GPS to approximately +/- 5 m accuracy, no grid conversion has been used.

2. SITE INVESTIGATION

2.1 INTRODUCTION

A geotechnical investigation was undertaken to assess strength of the existing tailings to provide design parameters for foundation and earthwork design. The scope of work focussed on conducting cone penetrometer tests (CPTs) at the existing TSF Cells A and B to assess the tailings strengths and behaviour.

The scope of work was carried out during September 2020 and comprised:

- Eight cone penetrometer tests with dissipation tests to assess excess pore pressures within the existing TSF cells.
- Collection of undisturbed samples of soils and tailings material for subsequent laboratory testing.

Fieldwork was supervised by a geotechnical engineer from KP Perth. The test locations were pre-determined and set out on site by a Saracen surveyor and verified by the geotechnical engineer, prior to fieldwork.

The site investigation was undertaken in accordance with Australian Standard AS1726–2017 (Ref. 3), where practicable.

Figure 2.1 shows the site investigation plan.

2.2 CONE PENETROMETER TESTING

Eight cone penetrometer tests (CPTu) were conducted to depths between 13.7 m and 18.5 m using a Morooka mounted CPT rig supplied and operated by Hagstrom Drilling.

The CPT tip was fitted with a pore pressure sensor (piezocone) to measure the water pressure with depth, in addition to tip resistance and friction.

The CPTu were conducted at the surveyed locations with the exception of KP CPT05 and KP CPT07 which were not located on the access track on the top of the embankment at TSF Cell B. Both locations were subsequently moved further away from the embankment wall and their new positions were closer to the centre of the TSF than KP CPT06 and KP CPT08 respectively.

A summary of the CPTu investigation is presented in Table 2.3.

CPT traces and photographs are presented in Appendices C and D respectively. The CPTu locations are shown in Figure 2.1.

Table 2.3: Summary of cone penetrometer tests

CPT ID	Location	Elevation (m RL)	Final Depth (m)
KP-CPT01	TSF Cell A	509.2	16.9
KP-CPT02	TSF Cell A	508.7	16.3
KP-CPT03	TSF Cell A	509.2	18.4
KP-CPT04	TSF Cell A	508.7	18.0
KP-CPT05A	TSF Cell B	503.3	14.1
KP-CPT06	TSF Cell B	504.2	13.7
KP-CPT07A	TSF Cell B	503.3	15.7
KP-CPT08	TSF Cell B	504.2	17.5

Twelve dissipation tests were carried out to assess the rate of dissipation of the excess pore pressures generated from the CPTu. The dissipation tests are summarised in Table 2.4.

Table 2.4: Summary of dissipation tests

CPT ID	Test Depth(s) (m)
KP-CPT01	12.0
KP-CPT02	9.1, 12.0, 15.0
KP-CPT03	None
KP-CPT04	10.5, 13.5, 16.5
KP-CPT05A	7.0, 12.0
KP-CPT06	None
KP-CPT07A	6.2, 11.5
KP-CPT08	None

Seven undisturbed push tube/piston tube samples and five disturbed Mostap samples were taken for laboratory testing to estimate in situ strength and classification for the tailings materials encountered during the CPTu investigation. The piston and Mostap sample test details are summarised in Table 2.5.

Table 2.5: Summary of cone penetrometer samples

CPT ID	Sample type	Final Depth (m)
KP-CPT02	Piston	3.5 - 4.0
KP-CPT02	Piston	10.5 - 11.0
KP-CPT02	Piston	14.5 - 15.0
KP-CPT04	Piston	6.0 - 6.5
KP-CPT04	Piston	13.0 - 13.5
KP-CPT05A	Piston	10.0 - 10.5
KP-CPT05A	Mostap	10.0 - 10.5
KP-CPT06	Mostap	8.5 - 9.0
KP-CPT07A	Piston	12.0 - 12.5
KP-CPT07A	Mostap	5.5 - 6.0
KP-CPT08	Mostap	4.0 - 4.5
KP-CPT08	Mostap	13.0 - 13.5

3. INTERPRETATION OF CPT TEST RESULTS

Three parameters were measured during cone penetration testing:

- Cone tip resistance.
- Cone sleeve friction resistance.
- Pore-water pressure.

In addition, pore-water pressure dissipation tests were undertaken at various locations.

Interpretation of test results was performed using the GeoLogismiki CPT bundle (CPeT-IT and Cliq, Ref. 4), which was primarily based on Robertson's CPT interpretation method (Ref. 5). The methodology and interpretation details are discussed below and include:

- Phreatic surface level and pore water pressure.
- Material classification.
- Soil parameters including friction angles (for dilative/drained material), undrained shear strengths (for contractive material), permeability, soil modulus and state parameter/ flow liquefaction etc.
- Liquefaction potential.

Cut sections based on the contractive and dilative behaviours (Table 3.1) of each of the cells are presented in figures 3.1 to 3.4.

Table 3.1: Interpreted Dilative and Contractive Behaviour Horizon

Cell	CPT ID	Dilative/Contractive Behaviour Horizon Depth* (m)
A	KP-CPT01	6.5
	KP-CPT02	6.0
	KP-CPT03	4.6
	KP-CPT04	3.5
B	KP-CPT05A	4.0
	KP-CPT06	3.0
	KP-CPT07A	2.7
	KP-CPT08	2.0

*Tailings above the depth is generally dilative and below it contractive.

3.1 PHREATIC LEVEL

Dynamic pore-water pressure measurements are recorded during site CPT in-situ probing. Positive pore-water pressure readings throughout the tailings indicate layers at, or near, saturation. Negative pore-water pressure readings indicate interbedded unsaturated layers (possibly capillary head).

Pore-water pressure dissipation tests (PPDTs) were performed at various depths during the probing programme to provide a better understanding of phreatic surface conditions. Under hydrostatic conditions the pore pressure during each PPDT will tend to stabilise, thereby providing a measurement of hydrostatic pressure at the test depth, and hence an approximation of the phreatic surface. The phreatic surface depths derived from the PPDTs are presented in Table 3.2.

Table 3.2: Interpreted Phreatic Surface Depth

Cell	CPT ID	Pore Pressure Dissipation Test Depth (m)	Interpreted Phreatic Depth (m)
A	KP-CPT01	12.0	10.2
	KP-CPT02	9.1, 12.0, 15.0	10.2
	KP-CPT03	None	10.2
	KP-CPT04	10.5, 13.5, 16.5	8.8
B	KP-CPT05A	7.0, 12.0	7.6
	KP-CPT06	None	5.8
	KP-CPT07A	6.2, 11.5	7.9
	KP-CPT08	None	9.3

The pore-water pressure dissipation tests indicate a variable phreatic level of between 5.8 m and 10.5 m below tailings surface. The phreatic surface depths are generally consistent across each TSF cell.

3.2 MATERIAL CLASSIFICATION

The material classification was based on the soil behaviour types (SBT - non-normalised or SBTn - normalised) recommended by Robertson (1986, Ref. 6; 1990, Ref. 7; 2009, Ref. 5) and Schneider et.al.(2008, Ref. 8), as presented in Table 3.3. The classification plots (Normalised SBTn and Schneider method) are included in Appendix B.

In the normalised SBTn assessment, the approximate boundary of soil behaviour types is given in terms of the SBTn index, I_c. The approximate boundary between sand-like and clay-like behaviour is about I_c = 2.6. This value was adopted to define sand-like and clay-like behaviour.

Table 3.3: Material Classification (Robertson 1986, 1990 and 2009)

Soil Type	Description	Ic (SBTn index)
1	Sensitive, fine grained	N/A
2	Organic soils, peats	>3.6
3	Clay - Clay to silty clay	2.95 – 3.6
4	Silt mixtures - Clayey silt to silty clay	2.6 – 2.96
5	Sand mixture - Silty sand to sandy silt	2.05 – 2.6
6	Sand – Clean sand to silty sand	1.31 – 2.05
7	Gravelly sand to dense sand	<1.31
8	Very stiff sand to clayey sand	N/A
9	Very stiff fine grained	N/A

Table 3.4 lists the interpreted depths of sand-like tailings and clay-like tailings throughout each probing. From the investigation it is apparent that the tailings in TSF Cell A is more sand-like, in comparison to TSF Cell B which is more clay-like in behaviour.

From the normalised friction ratio (R_f) and the normalised cone resistance (Q_t) chart by Robertson (2009) the tailings are interpreted to mainly comprise:

- “Sand – Clean sand to silty sand” (6).
- “Sand mixture - Silty sand to sandy silt” (5).
- “Silt mixtures - clay silt to silty clay” (4).

Horizons that were identified as “Clay - Clay to Silty Clay” (3) were also encountered at depth.

Table 3.4: Subsurface Conditions

TSF Cell	CPT ID	Depth Range (m)	Material Behaviour
A	KP-CPT01	0.0 – 9.0	Sand like
		9.0 – 16.9	Clay/Silt like
	KP-CPT02	0.0 – 8.7	Sand like
		8.7 – 16.3	Clay/Silt like
	KP-CPT03	0.0 – 5.6	Sand like
		5.6 – 18.4	Clay/Silt like
	KP-CPT04	0.0 – 8.0	Sand like
		8.0 – 18.0	Clay/Silt like
B	KP-CPT05A	0.0 – 3.8	Sand like
		3.8 – 14.1	Clay/Silt like
	KP-CPT06	0.0 – 3.8	Sand like
		3.8 – 13.7	Clay/Silt like
	KP-CPT07A	0.0 – 3.1	Sand like
		3.1 – 15.7	Clay/Silt like
	KP-CPT08	0.0 – 4.0	Sand like
		4.0 – 17.5	Clay/Silt like

3.3 MATERIAL PARAMETERS

3.3.1 State Parameters

Fine grained soils that develop high pore-water pressure at low strain, and loose sand-like materials that contract during shear, are most prone to strain softening and flow liquefaction. Flow liquefaction occurs when materials exhibiting brittle behaviour are subjected to rapid large loads i.e. there is insufficient time for pore pressure to dissipate. This may occur during upstream embankment construction if construction rates are excessive, or during deposition if rates of rise are too high.

Flow liquefaction is, broadly speaking, the cause of failure for both the Samarco (2015) and Brumadinho (2019) tailings dam failures in Brazil. Following these two failures ANCOLD published revised guidelines (July, 2019) addressing, amongst other things, flow liquefaction assessments for upstream constructed tailings storages.

The state parameter, which is defined as the difference between the in situ void ratio and the void ratio at critical state, at the same mean effective stress, is used to infer the susceptibility of materials to strain softening behaviour and flow liquefaction. Material with a state parameter of less than -0.05 ($\Psi < -0.05$) are dilative and will strain harden during undrained shear (i.e. Dilative material is not prone to flow liquefaction, which is good). Conversely, materials with a state parameter greater than -0.05 ($\Psi > -0.05$) are contractive and will strain soften during undrained shear, and may be susceptible to flow liquefaction (i.e. Contractive material is prone to flow liquefaction, which is bad).

The interpretations of the state parameters are based on the following method:

- Robertson and Cabal (2015) (Ref. 9).

The results indicate that the profiles typically comprise:

- A top tailings layer with typical dilative behaviour (Ψ < -0.05), in the unsaturated zone above the phreatic surface.
- A contractive tailings layer with Ψ > -0.05.

The profiles of dilative and contractive layers are shown in figures 3.1 to 3.4.

The peak friction angles (φ') were estimated for the sand-like primary tailings, according to (Ref. 9):

$$\varphi' = \varphi'_{\text{cv}} + 15.84\left[\log Q_{tn,cs}\right] - 26.88 \qquad (3.1)$$

Where φ'_{cv} is the constant volume (or critical state) friction angle:

$Q_{tn,cs}$ is the clean sand equivalent normalized cone resistance.

The assumed value of φ'_{cv} = 33° (for the tailings) was used in Equation 3.1.

Coffey Mining conducted a geotechnical investigation in 2014 (Coffey Report Ref. No. MINEWPER01227AA, Ref 10) and found that the friction angles for the deposited tailings ranged between 30 to 45°. The interpreted peak friction angle ranges for the sand-like tailings layer for each of the CPT are listed in Table 3.5. The friction angle is higher for the CPTs located in TSF Cell A, which is more sand-like than the CPTs located in TSF Cell B.

Table 3.5: Interpreted Peak Friction Angles for Sand-like Primary Tailings

TSF Cell	CPT ID	Depth Range (m)	Friction Angle φ' (°)
A	KP-CPT01	0.0 – 9.0	32 – 45
	KP-CPT02	0.0 – 8.7	32 – 40
	KP-CPT03	0.0 – 5.6	32 – 44
	KP-CPT04	0.0 – 8.0	32 – 40
B	KP-CPT05A	0.0 – 3.8	32 – 40
	KP-CPT06	0.0 – 3.8	32 – 42
	KP-CPT07A	0.0 – 3.1	32 – 38
	KP-CPT08	0.0 – 4.0	32 – 39

3.3.2 State Parameters and Tailings Undrained Shear Strength

Layering for each material was determined based on the 80$^{\text{th}}$ percentile values of state parameters. Material with a state parameter less than -0.05 was deemed to be dilative and material greater than -0.05 was deemed to be contractive. The undrained shear strength ratio was estimated using the total cone resistance (q_t) and a cone factor (N_{kt}). The cone factor, N_{kt}, typically varies between 10 and 18, with an average of 14. A cone factor of 14 was applied in this assessment.

In deriving the residual shear strength ratio, two methods were used:

- Method 1 – Based on CPTe-IT interpretation
- Method 2 – Robertson 2020 updated method.

Method 1 evaluates the residual shear strengths using the embedded method in the CPTe-IT 3.0.1.17 programme. Method 2 is an evaluation method updated by Robertson 2020 (Ref. 11).

The mean and 80th percentile values of state parameters and undrained shear strength ratios are listed in Table 3.6.

Table 3.6: Interpreted State Parameters and Undrained Shear Strength Ratios for Clay-like Tailings

CPT Location	Depth Range (m)		State Parameter - I_C Cutoff		Undrained Shear Strength Ratio - Peak		Method 1 - Residual, Remoulded/Sensitivity		Method 2 - Residual, Robertson 2020	
	From	**To**	**Mean**	**80th**	**Mean**	**80th**	**Mean**	**80th**	**Mean**	**80th**
KP CPT01	0.0	5.8	-0.20	-0.06	Dilative					
	5.8	7.7	-0.02	0.00	0.94	0.86	0.15	0.12	0.17	0.09
	7.7	8.0	-0.09	-0.07	Dilative					
	8.0	16.9	0.00	0.02	0.52	0.32	0.14	0.09	0.18	0.07
KP CPT02	0.0	6.6	-0.08	-0.05	Dilative					
	6.6	10.4	-0.03	-0.02	0.99	0.83	0.23	0.21	0.24	0.13
	10.4	16.2	0.02	0.03	0.36	0.29	0.12	0.09	0.12	0.09
KP CPT03	0.0	6.0	-0.17	-0.06	Dilative					
	6.0	10.4	-0.02	-0.01	0.98	0.66	0.22	0.15	0.17	0.10
	10.4	18.4	0.03	0.04	0.39	0.30	0.09	0.07	0.09	0.06
KP CPT04	0.0	5.8	-0.08	-0.05	Dilative					
	5.8	6.7	-0.03	-0.02	1.18	0.84	0.29	0.24	0.33	0.18
	6.7	8.1	-0.06	-0.05	Dilative					
	8.1	18.0	0.01	0.02	0.45	0.30	0.13	0.10	0.13	0.09
KP CPT05	0.0	3.9	-0.13	-0.04	Dilative					
	3.9	7.5	-0.03	-0.01	0.84	0.52	0.24	0.16	0.26	0.12
	7.5	14.2	0.03	0.04	0.43	0.33	0.09	0.06	0.08	0.04
KP CPT06	0.0	3.4	-0.13	-0.06	Dilative					
	3.4	6.2	-0.03	0.00	0.83	0.62	0.22	0.14	0.49	0.14
	6.2	13.6	0.01	0.03	0.52	0.40	0.13	0.08	0.12	0.06
KP CPT07	0.0	3.4	-0.11	-0.06	Dilative					
	3.4	6.4	-0.03	-0.01	0.87	0.46	0.29	0.15	0.51	0.14
	6.4	7.4	-0.09	-0.07	Dilative					
	7.4	15.7	0.00	0.02	0.59	0.42	0.13	0.09	0.12	0.07
KP CPT08	0.0	9.3	-0.08	-0.04	Dilative					
	9.3	17.5	0.00	0.02	0.50	0.36	0.14	0.10	0.14	0.09

The undrained shear strength varies with the state parameters significantly. A few peak undrained shear strength ratios appear to be too high, possibly influenced by thin sand lenses in the claylike layers, which will be capped at the drained shear strengths for the stability assessment.

The tailings appear to be brittle, the residual shear strengths are relatively low.

3.3.3 Permeability

Permeability was interpreted from the dissipation tests using coefficient of consolidation values calculated using Houlsby and Teh's (1988, Ref. 12) theory:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

$$k_h = \frac{c_h \times \gamma_w}{M}$$

Where:

- T: time factor given by Houlsby and Teh (1988).
- r: piezocone radius.
- Ir: stiffness index, shear modulus G divided by the undrained strength of clay.
- t_{50}: time corresponding to 50% consolidation.
- M: 1-D constrained modulus.
- γ_w is the unit weight of water.

The dissipation results of the Coffey investigation (Ref. 10), indicated that the typical permeability coefficients for Cell A range from 2.5 x 10^{-8} to 8.1 x 10^{-8} m/s and for Cell B 9.5 x 10^{-9} to 2.1 x 10^{-8} m/s. Table 3.7 provides the estimated permeability with results indicating values ranging between 1.03 × 10^{-8} m/s and 1.66 × 10^{-7} m/s for TSF Cell A, and 3.93 × 10^{-9} m/s to 1.36 × 10^{-7} m/s for Cell B. Thus, the results are consistent with the Coffey investigation in 2014.

Table 3.7: Interpreted Permeability

TSF Cell	CPT ID	Dissipation Depth (m)	Permeability (m/s)
A	KP-CPT01	12.0	2.86 x 10^{-8}
	KP-CPT02	9.1	1.03 x 10^{-8}
		12.0	3.53 x 10^{-8}
		15.0	1.66 x 10^{-7}
	KP-CPT04	10.5	7.48 x 10^{-8}
		13.5	1.16 x 10^{-7}
		16.5	8.81 x 10^{-8}
B	KP-CPT05A	7.0	3.93 x 10^{-9}
		12.0	1.36 x 10^{-7}
	KP-CPT07A	6.2	6.18 x 10^{-8}
		11.5	4.09 x 10^{-8}

1. LABORATORY TESTING

Representative samples of the in-situ soils in the tailings were taken from the boreholes for laboratory testing. The purpose of the laboratory testing was to classify and characterise the in situ materials so as to assess their behavioural characteristics under embankment loading.

The laboratory testing was undertaken by E-Precision soil lab and comprised:

- Particle size distribution.
- Atterberg limits.
- Linear shrinkage.
- Compaction tests.
- Falling head permeability tests.
- Emerson tests.
- Consolidated Undrained (CU) Triaxial tests.
- Uniaxial compressive strength.

The laboratory test reports are presented in Appendix B and the test results are summarised in Table 4.1.

Table 4.1: Summary of laboratory testing results

Sample	Location	Depth (m)	Description	USCS symbol	A-line	Particle size distribution (%)				Atterberg Limits (%)			Consolidated Undrained Test	
						Gravel	Sand	Silt	Clay	LL	PL	PI	c' (kPa)	φ' (deg)
Disturbed	KP-CPT06	8.5 - 9.0	SILT with sand, trace clay	ML	CL	0	22	73	5	28	22	6	-	-
	KP-CPT05A	10.0 - 10.5	SILT with sand, trace clay	ML	-	0	25	72	3	-	-	-	3.63	36.73
	KP-CPT08	4.0 - 4.5	SILT trace sand and clay	ML	ML	0	13	80	7	35	28	7	-	-
	KP-CPT08	13.0 - 13.5	SILT with sand, trace clay	ML	-	0	21	72	7	-	-	-	-	-
	KP-CPT07A	5.5 - 6.0	SILT trace sand and clay	ML	ML	0	5	86	9	45	34	11	-	-
Undisturbed	KP-CPT02	3.5 - 4.0	SILT trace sand and clay	ML	ML	0	15	80	5	33	26	7	-	-
	KP-CPT02	10.5 - 11.0	-	-	-	-	-	-	-	-	-	-	1.66	38.32
	KP-CPT02	14.5 - 15.0	SILT trace sand and clay	ML	ML	0	14	77	9	38	31	7	-	-
	KP-CPT04	6.0 - 6.5	SILT with sand, trace clay	ML	ML	0	24	68	8	31	24	7	-	-
	KP-CPT04	13.0 - 13.5	-	-	ML	-	-	-	-	31	23	8	8.85	26.81
	KP-CPT05A	10.0 - 10.5	-	-	CL	-	-	-	-	28	22	6	-	-
	KP-CPT07A	12.0 - 12.5	-	-	-	-	-	-	-	-	-	-	10.98	36.73

Abbreviations:

a. LL – liquid limit
b. PL – plastic limit
c. PI – plasticity index
d. c' – effective cohesion
e. φ' – effective stress friction angle

2. INVESTIGATION FINDINGS

The behaviour of the tailings materials in both TSF Cells A and B typically comprised:

- Sandy silt to depths of 2.5 to 6.0 m in Cell A and 1.0 to 3.0 m in Cell A.
- Clay like/Silty Clay likely to the maximum depth of investigation.

The general profile of the tailings in both Cells A and B are generally consistent in terms of the underlying stratigraphy. However, the CPTs for Cell A (CPT01 and CPT03), close to the embankment indicate a very dense layer (approximately 4 m) of sand like material, which may be the result of compaction during the construction of the embankment.

3. CONCLUSIONS AND RECOMMENDATIONS

Based on the site geotechnical investigation and laboratory test results, the following conclusions can be drawn:

- The site investigation provided the indicative depths and thickness of the tailings material layers at TSF Cell A and Cell B.
- The top 3 to 6 m dilative tailings overlies contractive tailings. Tailings are generally becoming weaker with depth. The lower part of the tailings is sensitive with relatively low residual strength.
- The tailings close to the embankments are generally dilative possibly due to traffic compaction during construction.
- The friction angle for the dilative materials ranges from 32° to 45°, with TSF Cell A having a slightly higher friction angle than TSF Cell B.
- The undrained shear strengths vary significantly with state parameters, a few peak undrained shear strength ratios appear to be too high, possibly influenced by thin sand lenses in the clay like layers. The undrained shear strengths need to be capped at the drained shear strengths for stability assessment.
- The tailings have low permeability and as such will tend to hold moisture in the tailings for a significant amount of time prior to drainage, assuming natural drainage without the aid of any underdrainage system.

The results of this investigation are being utilised in the embankment stability assessments currently being undertaken.

We trust the information provided is sufficient at this stage and will be pleased to provide any additional advice as required.

[redacted]

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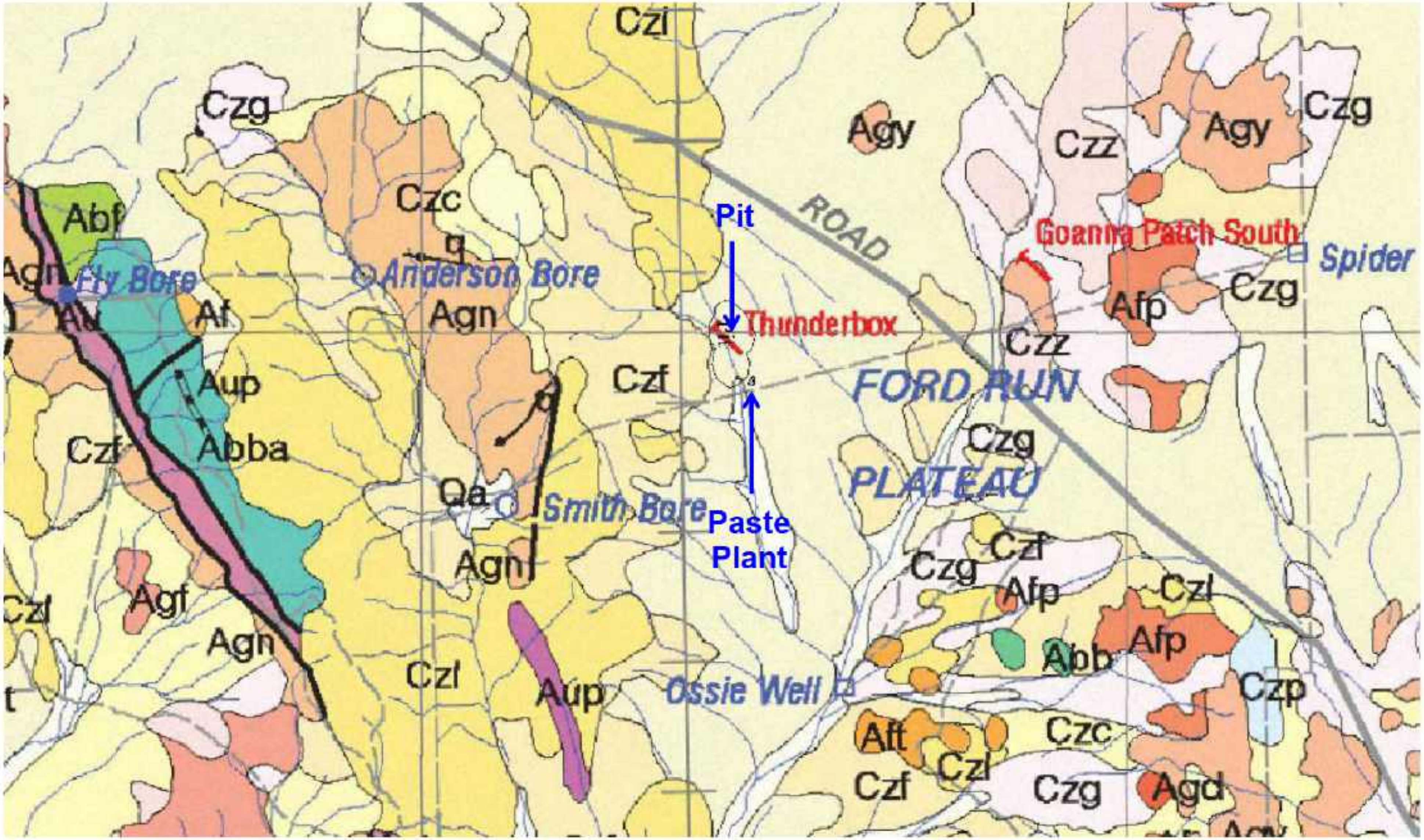
FIGURES



Extract of: Stewart, A.J., 2001, "*Leonora Second Edition, 1:250,000 scale geological map*", AGSO, Geoscience Australia, Canberra, Catalogue No. 36953.

Qa	Qac

Qa	*Clay, silt, sand and gravel in and near active stream channels; alluvial*
Qac	*Clay in claypens*

Cza	Czb	Czc	Czcl	Czd	Czl	Czg	Czh	Czl	Czk
Czl	Czp	Czq	Czs	Czu	Czz	Czzg			

Cza	*Clay, silt and sand; pebbly in places; colluvial, distal*
Czb	*Clay and dune sand, adjacent to playas (clay dominant)*
Czc	*Gravel, talus, sand; colluvial, proximal*
Czcl	*Sandy colluvium with limonitic pisoliths on low plateaus on weathered granitoid*
Czd	*Quartz and gypsum dunes with minor silt and clay adjacent to playas (dunes dominant)*
Czl	*Pebbly colluvium and alluvium derived from laterite*
Czg	*Colluvial sand and gravel derived from quartzofeldspathic rock*
Czh	*Silt, sand and gravel in halophyte flats adjacent to playas*
Czl	*Detritus and talus, derived from banded iron-formation*
Czk	*Calcrete*
Czl	*Lateritic duricrust, massive and rubbly*
Czp	*Evaporites, sand and clay in playas*
Czq	*Talus and quartz-rich detritus derived from quartz veins*
Czs	*Sand plain*
Czu	*Silcrete on or derived from ultramafic rock*
Czz	*Silcrete over granitoid*
Czzg	*Silcrete and/or kaolinised granite*

Cainozoic

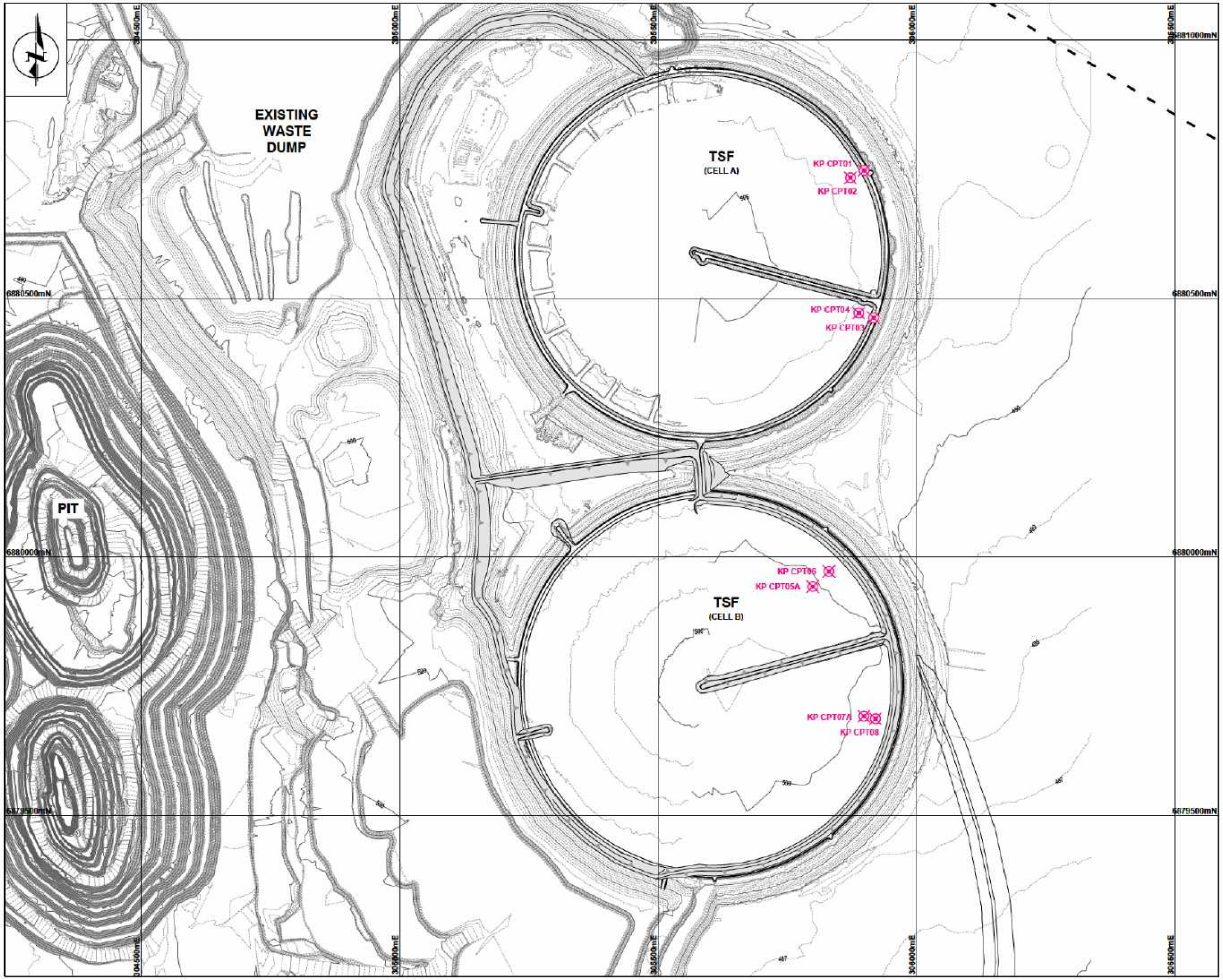
Ag	Agb	Agc	Agd	Age	Agf	Agfo	Agg	Agl	Agm
Agmc	Agmf	Agmm	Agmp	Agn	Agq	Ags	Agt	Agtp	Agy

Ag	*Granite, undivided*
Agb	*Foliated granitoid rock with mafic lenses; local gneissic banding*
Agc	*Coarse-grained granitoid, undivided*
Agd	*Diorite to monzodiorite*
Age	*Medium-grained granitoid, undivided*
Agf	*Fine-grained granitoid, undivided*
Agfo	*Foliated granitoid*
Agg	*Granodiorite*
Agl	*Leucogranite and microgranite*
Agm	*Biotite monzogranite*
Agmc	*Coarse-grained biotite monzogranite*
Agmf	*Fine-grained biotite monzogranite*
Agmm	*Biotite monzogranite, medium-grained*
Agmp	*Porphyritic monzogranite*
Agn	*Strongly foliated granitoid with local weak and/or incipient layering (banding) +/- mafic lenses*
Agq	*Quartz-rich granitoids*
Ags	*Syenite to alkali-feldspar syenite*
Agt	*Tonalite*
Agtp	*Porphyritic tonalite*
Agy	*Syenogranite to alkali-feldspar granite*

Ab	Abam	Abb	Abba	Abc	Abd	Abf	Abg	Abm	Abp
Abs	Aby								

Ab	*Metamorphosed fine-grained mafic igneous rocks, undivided*
Abam	*Amphibolite derived from mafic igneous rock*
Abb	*Metabasalt +/- metadolerite*
Abba	*Metabasalt, aphyric*
Abc	*Carbonated metabasalt*
Abd	*Metabasalt and metadolerite*
Abf	*Mafic schist, low-grade*
Abg	*Mafic and subordinate felsic volcanic rocks intercalated with minor foliated granitoid rock; metamorphosed; gneissic banding locally developed*
Abm	*High-magnesium metabasalt with spinifex texture*
Abp	*Metabasalt +/- metadolerite, porphyritic*
Abs	*Schistose metabasalt*
Aby	*Metabasalt, vesicular or amygdaloidal*

Archaean



LEGEND:

CPT PROBE LOCATIONS

NOTES:

1. 1m CONTOUR INTERVALS SHOWN.

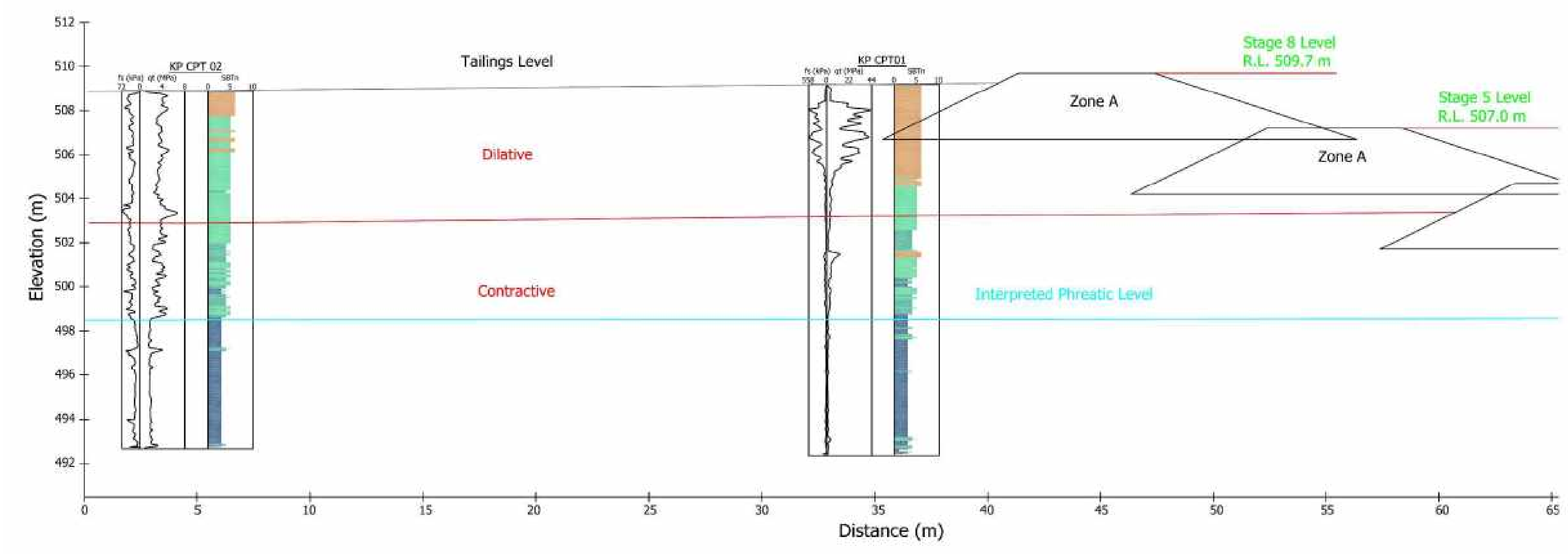
CPT LOCATIONS		
CPT I.D No.	EASTING	NORTHING
KP CPT01	305898.4	6880747.5
KP CPT02	305871.8	6880733.7
KP CPT03	305916.6	6880462.7
KP CPT04	305888.1	6880472.1
KP CPT05A	305799.0	6879943.0
KP CPT06	305830.3	6879972.3
KP CPT07A	305898.1	6879692.3
KP CPT08	305920.4	6879687.6

SCALE (METRES) 1:7,500 (A3)

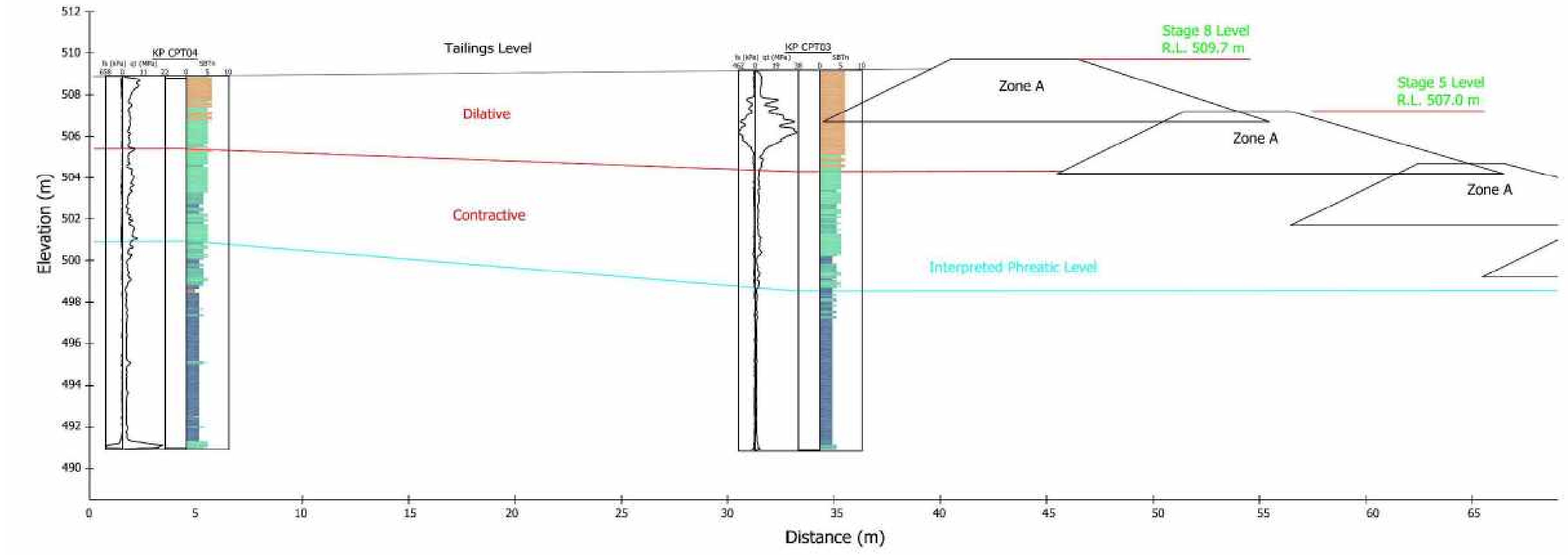
Knight Piésold CONSULTING

THUNDERBOX GOLD PROJECT
GENERAL ARRANGENENT
TSF CELLS A AND B EXPANSION

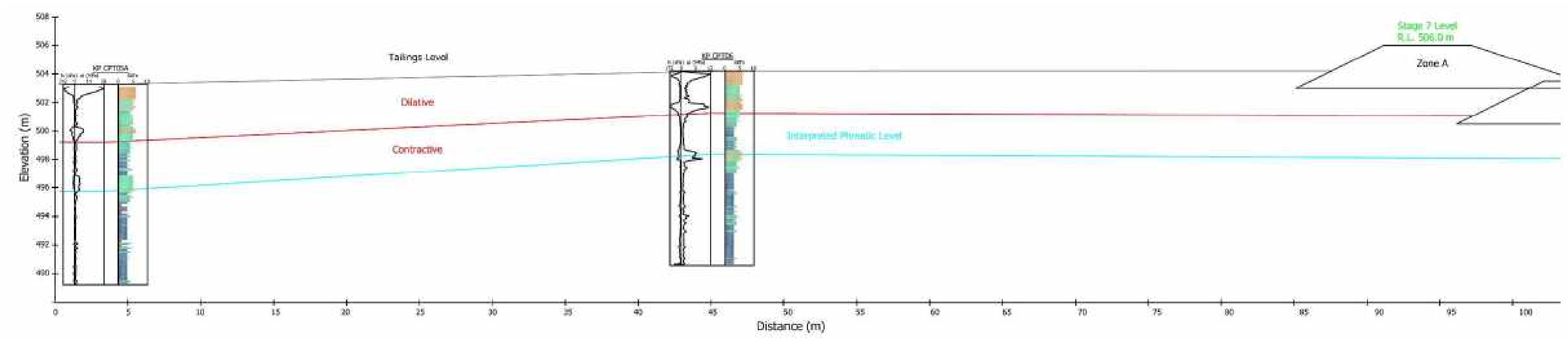
PE801-00296 M20005
Figure 2.1



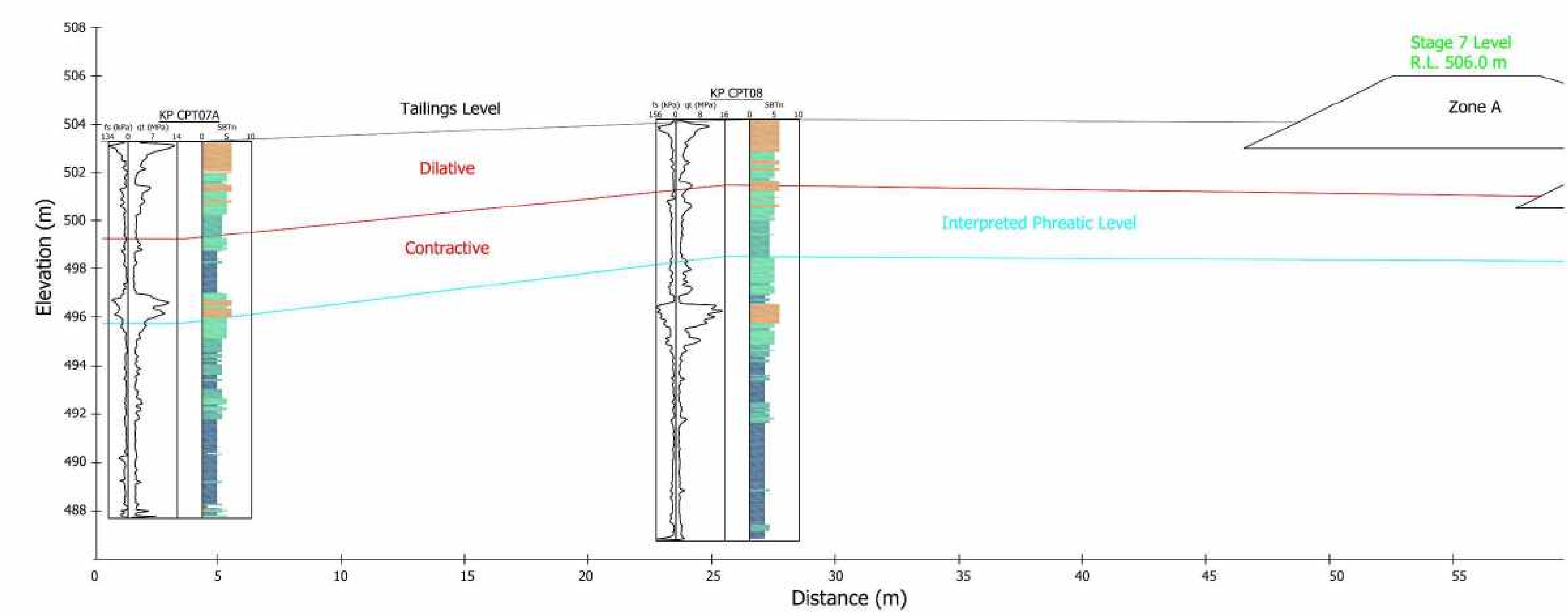
KP CPT 02
KP CPT01
Tailings Level
Stage 8 Level
R.L. 509.7 m
Stage 5 Level
R.L. 507.0 m
Zone A
Zone A
Dilative
Contractive
Interpreted Phreatic Level
Elevation (m)
Distance (m)



Tailings Level
KP CPT04
KP CPT03
Stage 8 Level
R.L. 509.7 m
Stage 5 Level
R.L. 507.0 m
Zone A
Zone A
Zone A
Dilative
Contractive
Interpreted Phreatic Level
Elevation (m)
Distance (m)



Stage 7 Level
R.L. 506.0 m
Tailings Level
KP CPT05A
KP CPT06
Zone A
Dilative
Contractive
Interpreted Phreatic Level
Elevation (m)
Distance (m)

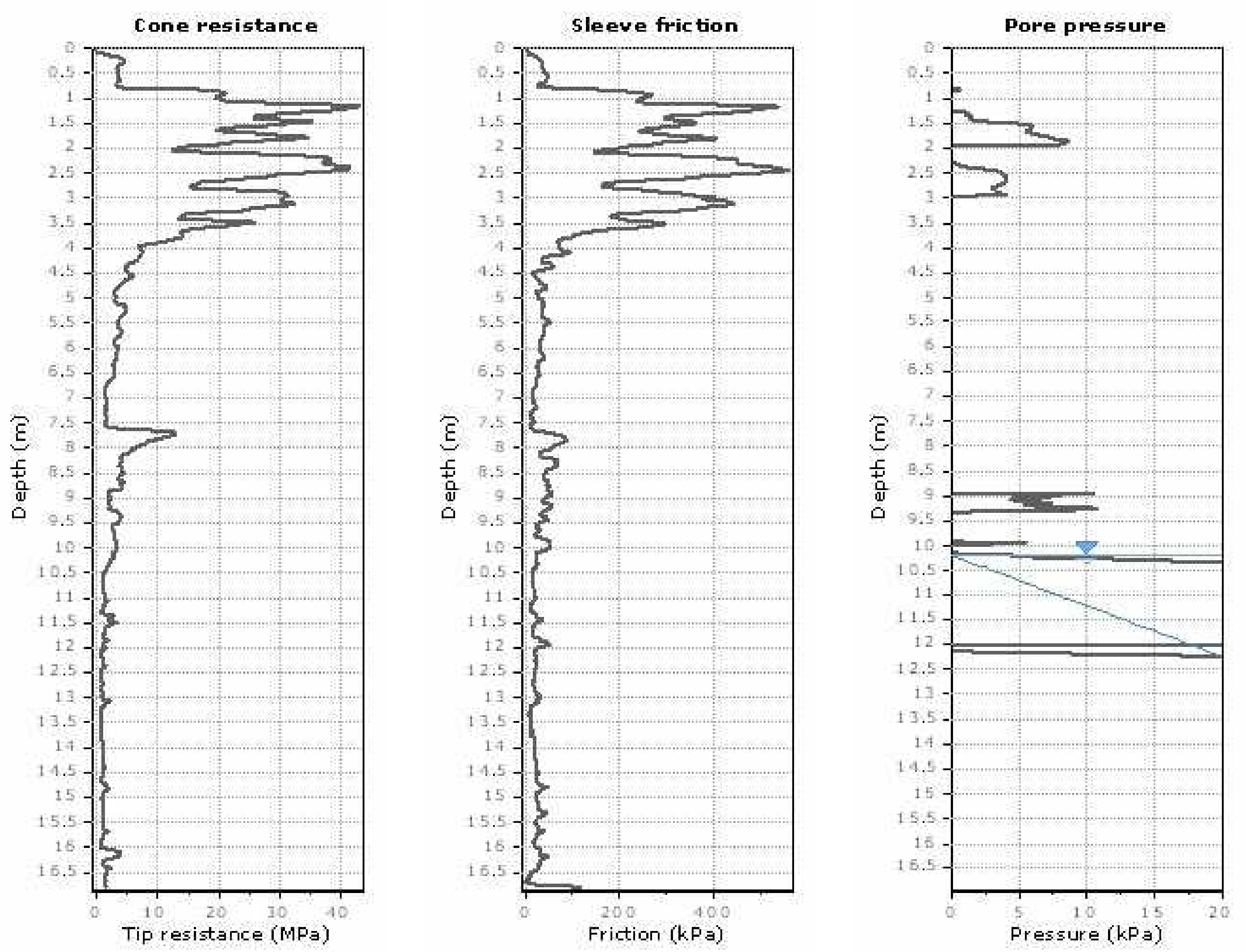

Stage 7 Level
R.L. 506.0 m
Zone A
Tailings Level
KP CPT07A
KP CPT08
Dilative
Contractive
Interpreted Phreatic Level
Elevation (m)
Distance (m)

APPENDIX A
CPT Results

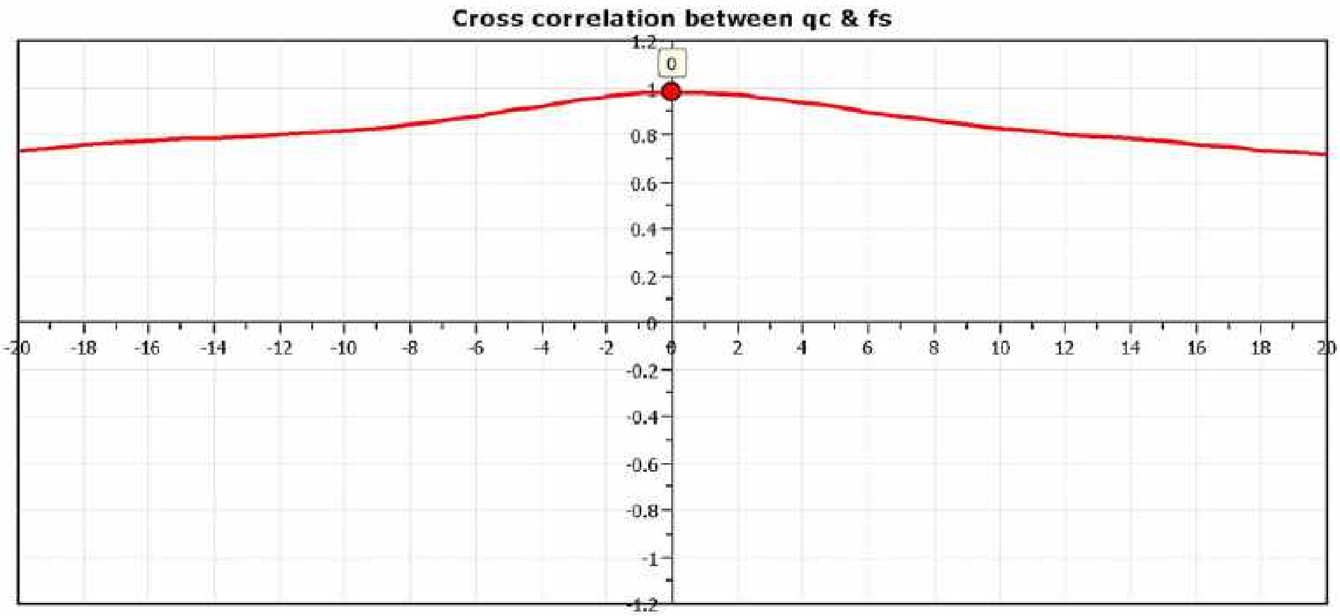
Knight Piésold Consulting
Level 1, 184 Adelaide Terrace
Perth WA 6004, Australia
http://www.knightpiesold.com/

CPT: KP CPT01
Total depth: 16.88 m, Date: 3/09/2020
Coords: lat 305898.4° lon 6880747.5°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

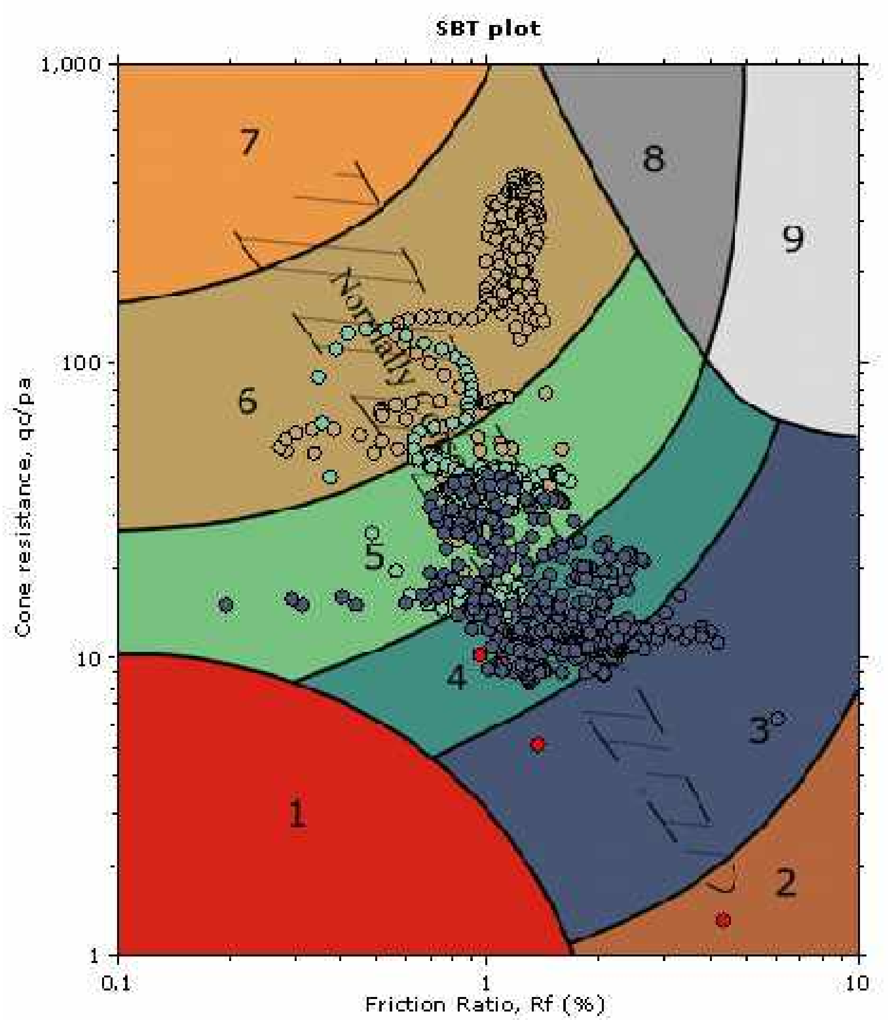
Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**

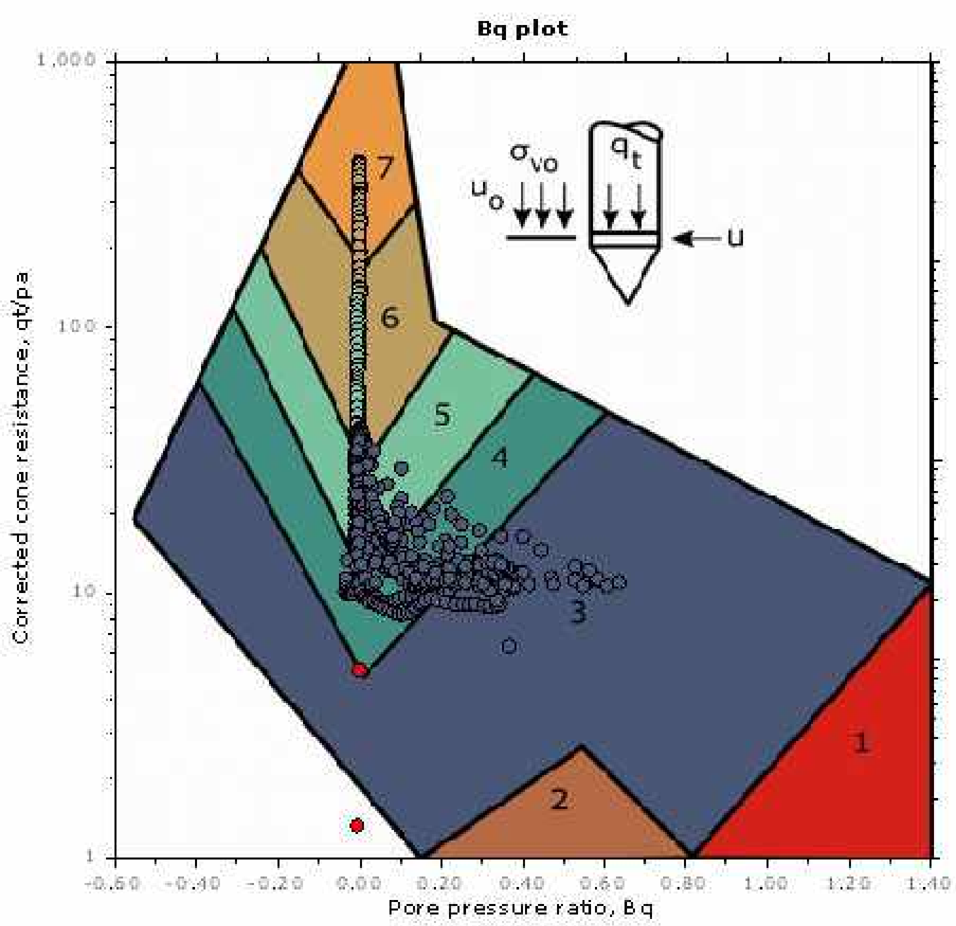


The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



SBT - Bq plots





SBT legend

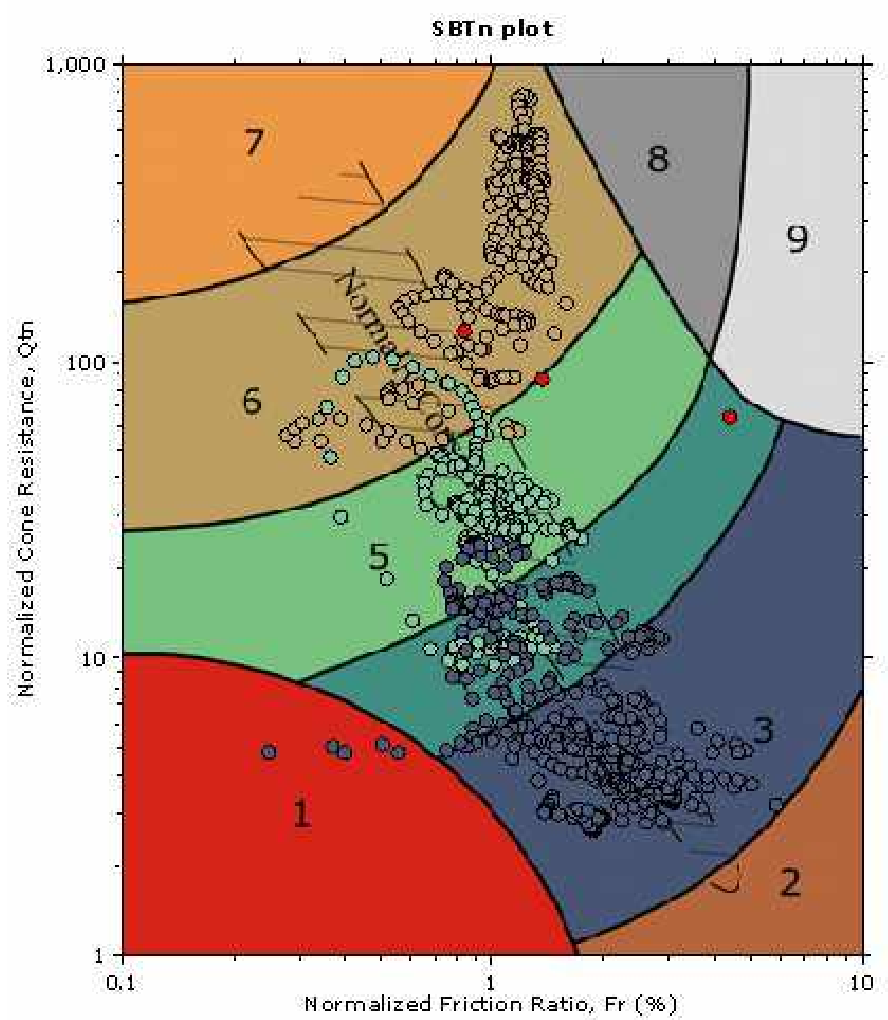
1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravelly sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

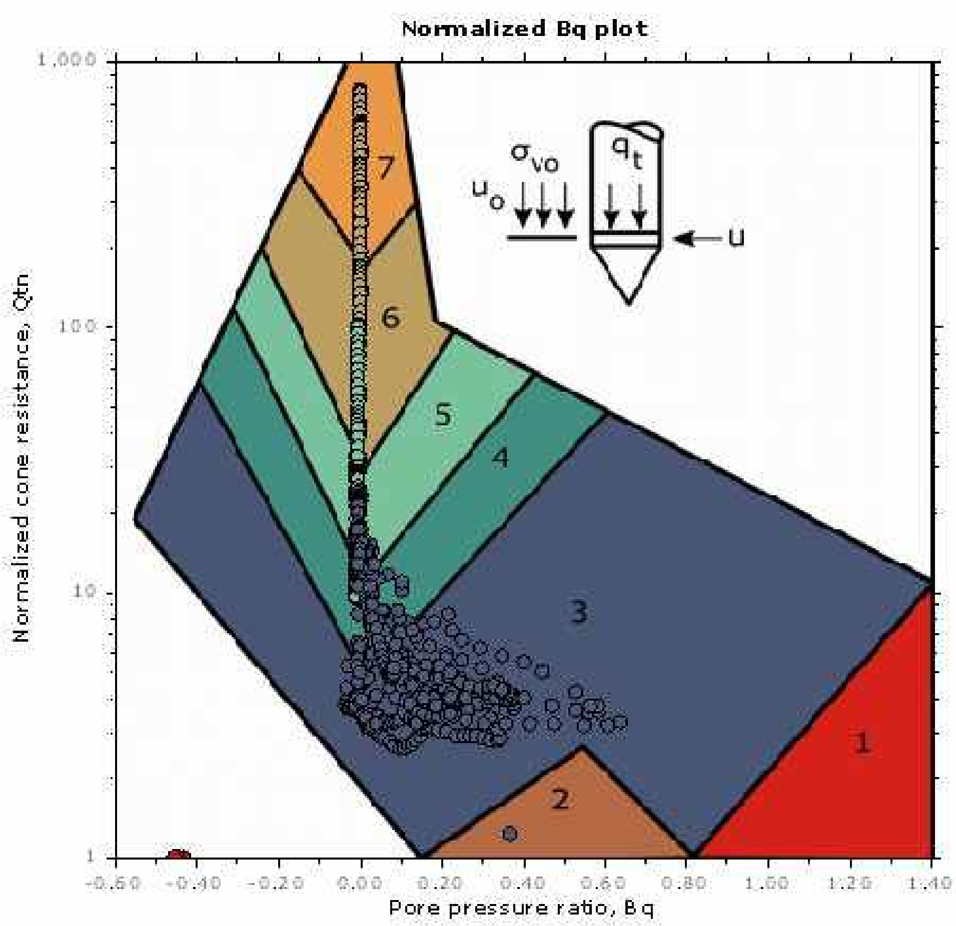
Knight Piésold Consulting
Level 1, 184 Adelaide Terrace
Perth WA 6004, Australia
http://www.knightpiesold.com/

Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**

CPT: KP CPT01
Total depth: 16.88 m, Date: 3/09/2020
Coords: lat 305898.4° lon 6880747.5°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

SBT - Bq plots (normalized)





SBTn legend

- 1. Sensitive fine grained
- 2. Organic material
- 3. Clay to silty clay
- 4. Clayey silt to silty clay
- 5. Silty sand to sandy silt
- 6. Clean sand to silty sand
- 7. Gravelly sand to sand
- 8. Very stiff sand to clayey sand
- 9. Very stiff fine grained

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CPT: KP CPT01
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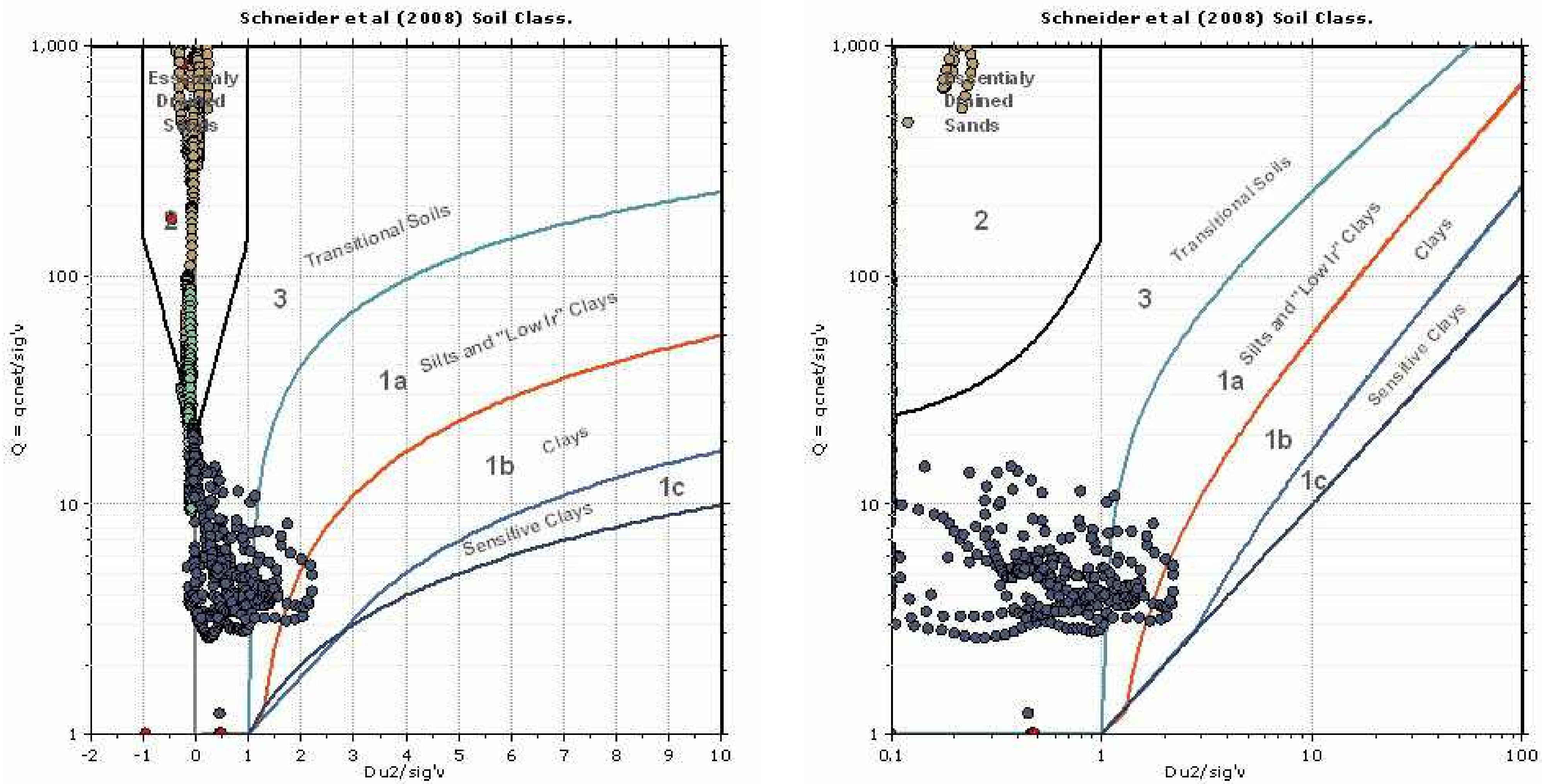
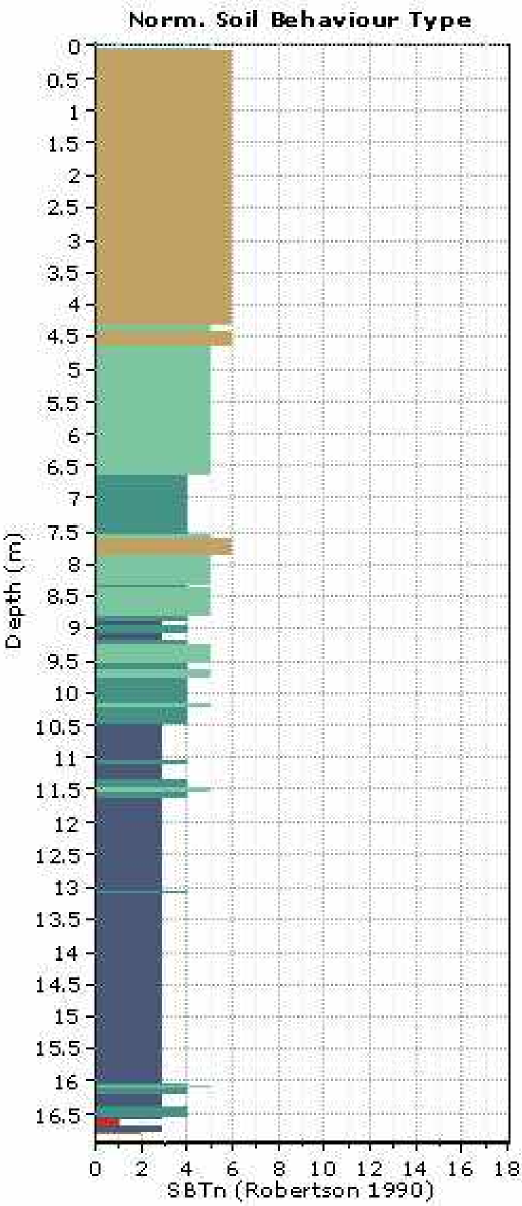
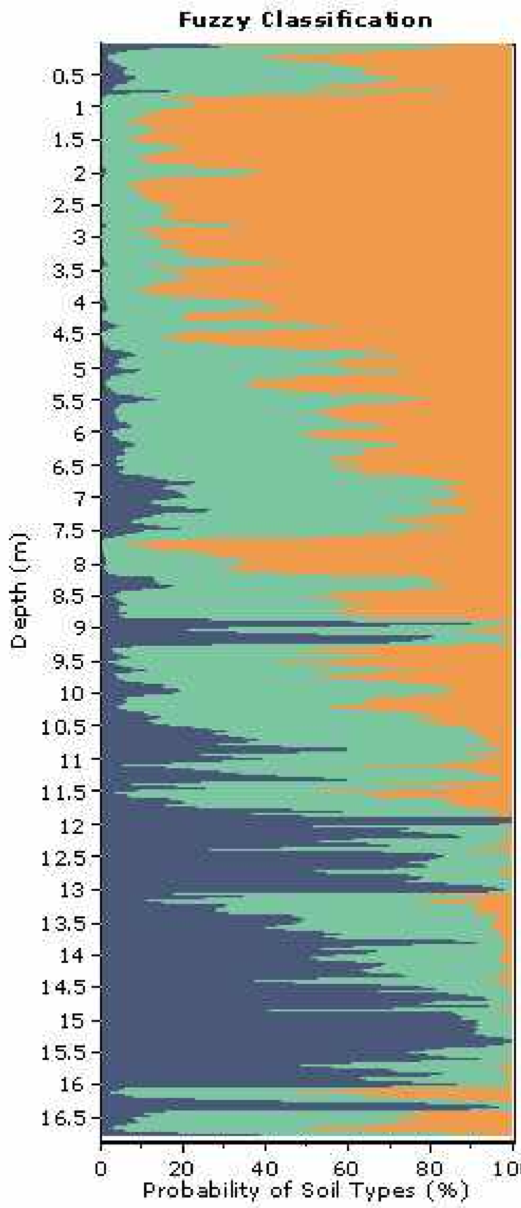
Cone Type: 180911
Cone Operator: Hagstrom Drilling

Bq plots (Schneider)




Norm. Soil Behaviour Type
Depth (m)
SBTn (Robertson 1990)


Fuzzy Classification
Depth (m)
Probability of Soil Types (%)

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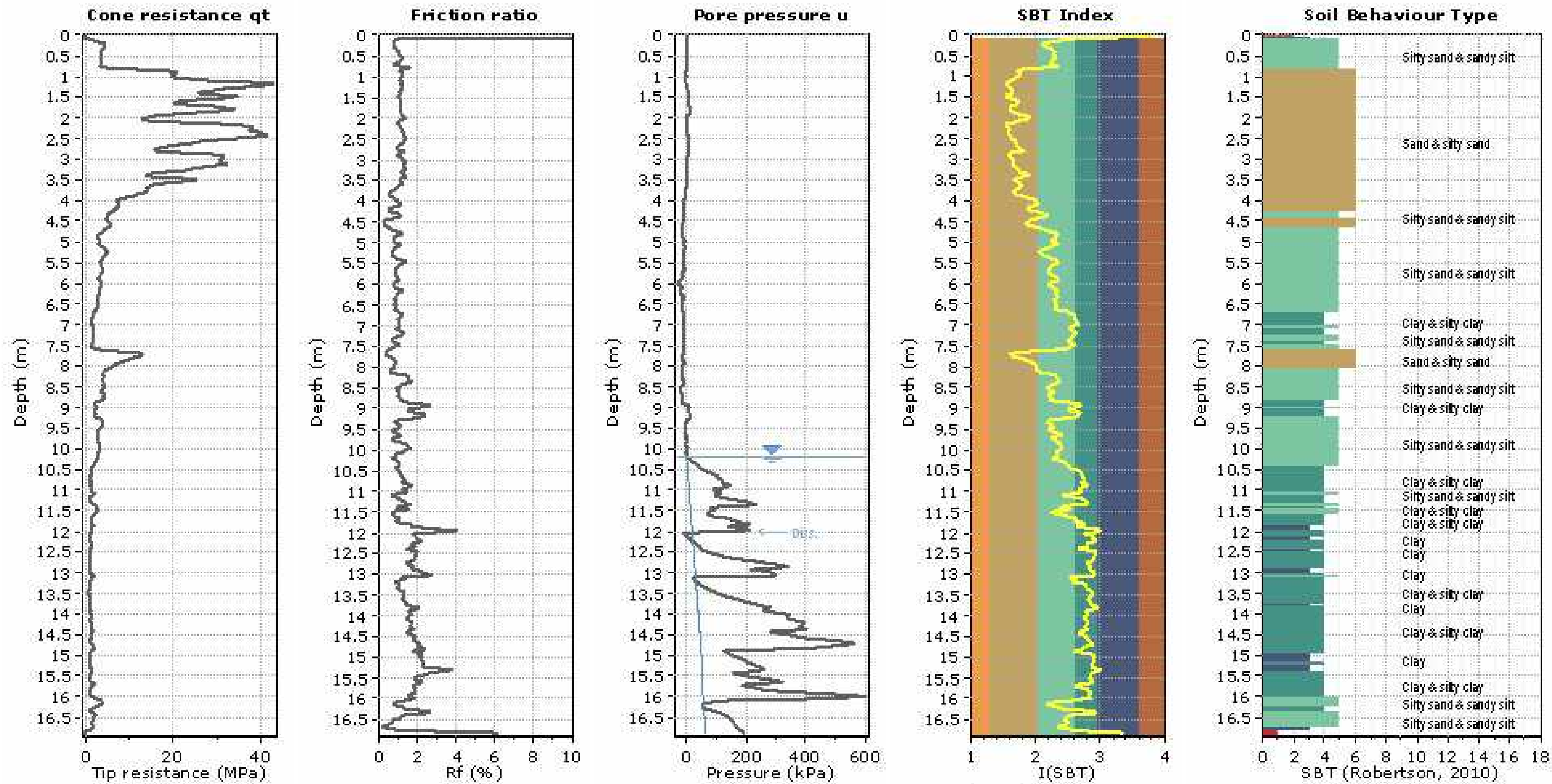
Cone Operator: Hagstrom Drilling

Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**



SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

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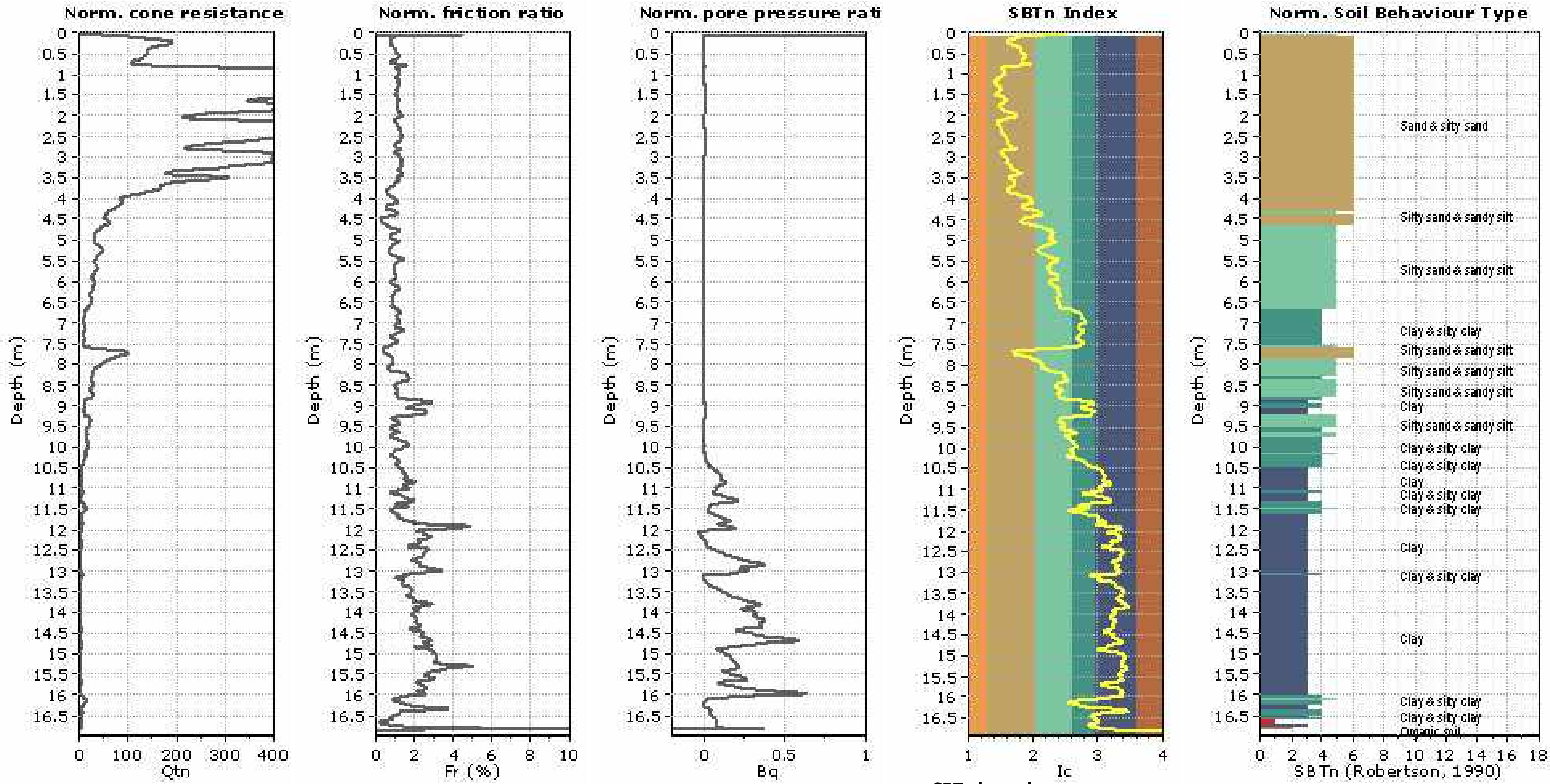
Cone Type: 180911
Cone Operator: Hagstrom Drilling

Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**



SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

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CPT: KP CPT01
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Cone Operator: Hagstrom Drilling

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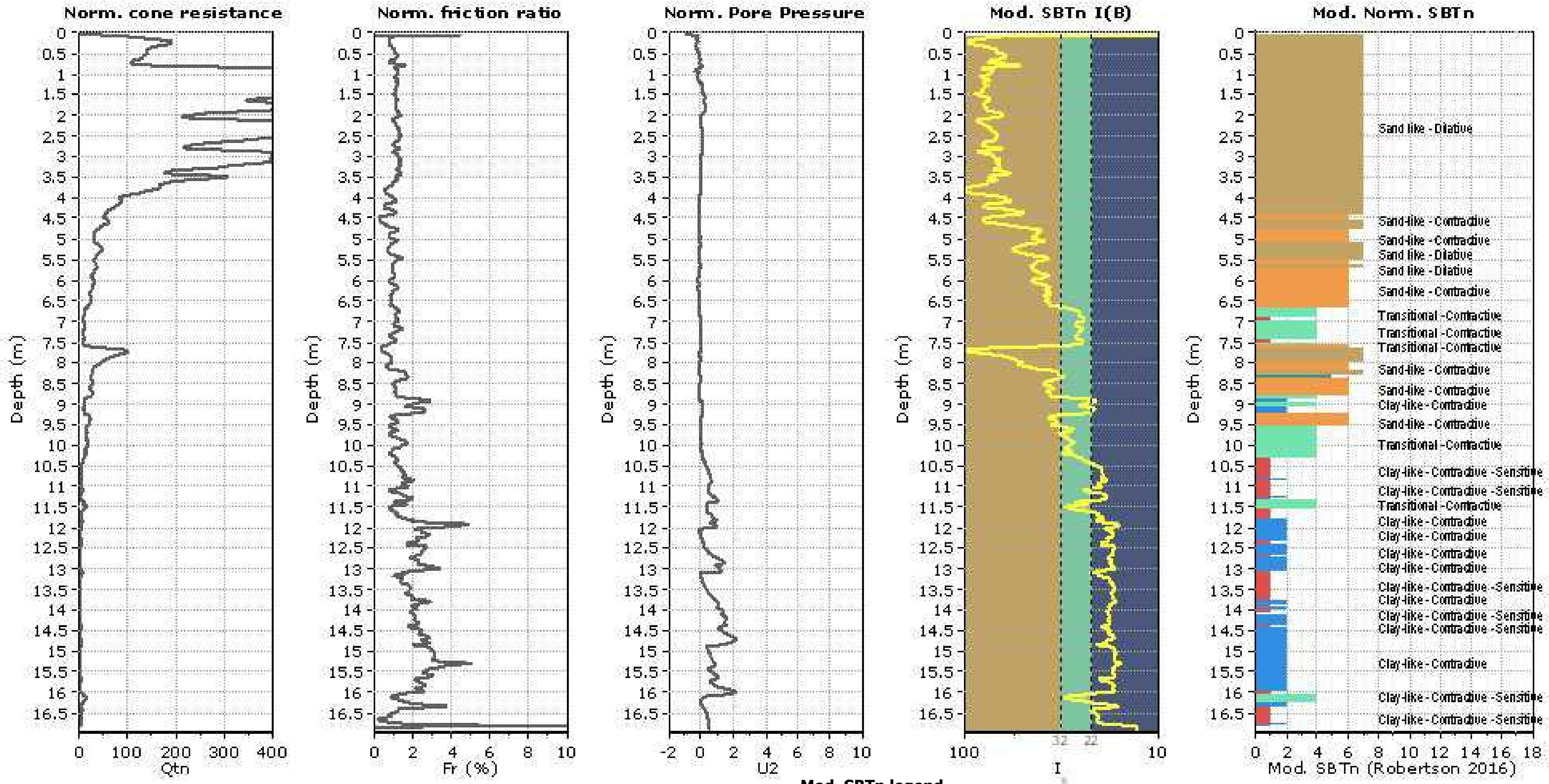
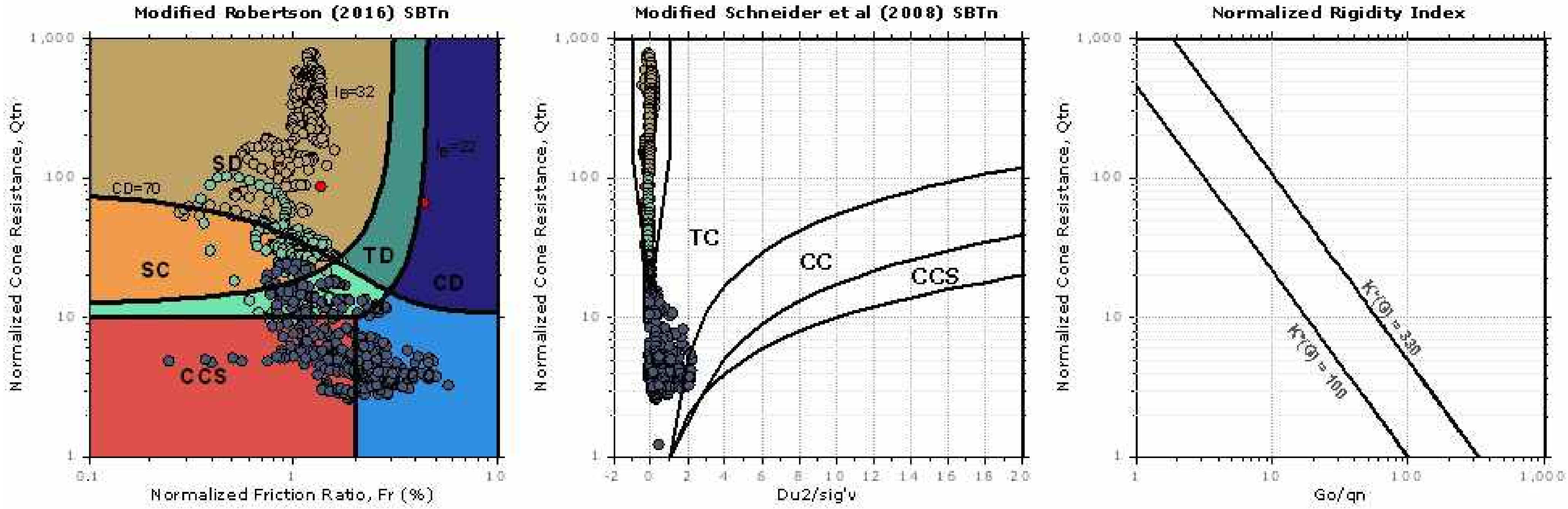


Mod. SBTn legend

- 1. CCS: ClayLike - Contractive, Sensitive
- 2. CC: Clay-like - Contractive
- 3. CD: Clay-Like: Dilative
- 4. TC: Transitional - Contractive
- 5. TD: Transitional - Dilative
- 6. SC: Sand-like - Contractive
- 7. SD: Sand-like - Dilative

Updated SBTn plots



CCS: Clay-like - Contractive - Sensitive
CC: Clay-like - Contractive
CD: Clay-like - Dilative
TC: Transitional - Contractive
TD: Transitional - Dilative
SC: Sand-like - Contractive
SD: Sand-like - Dilative

K(G) > 330: Soils with significant microstructure (e.g. age/cementation)

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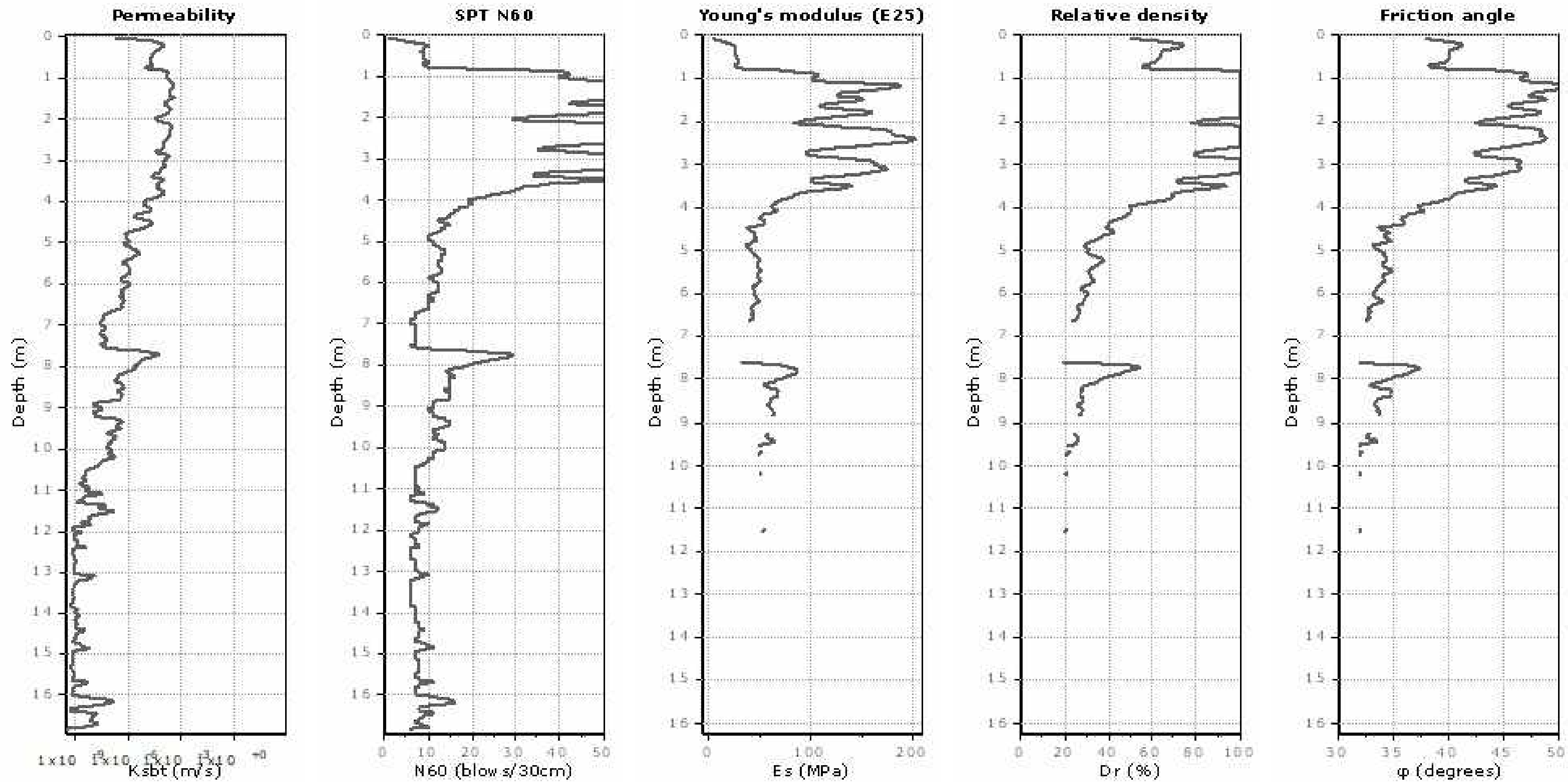
CPT: KP CPT01
Total depth: 16.88 m, Date: 3/09/2020
Coords: lat 305898.4° lon 6880747.5°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**



Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative density constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

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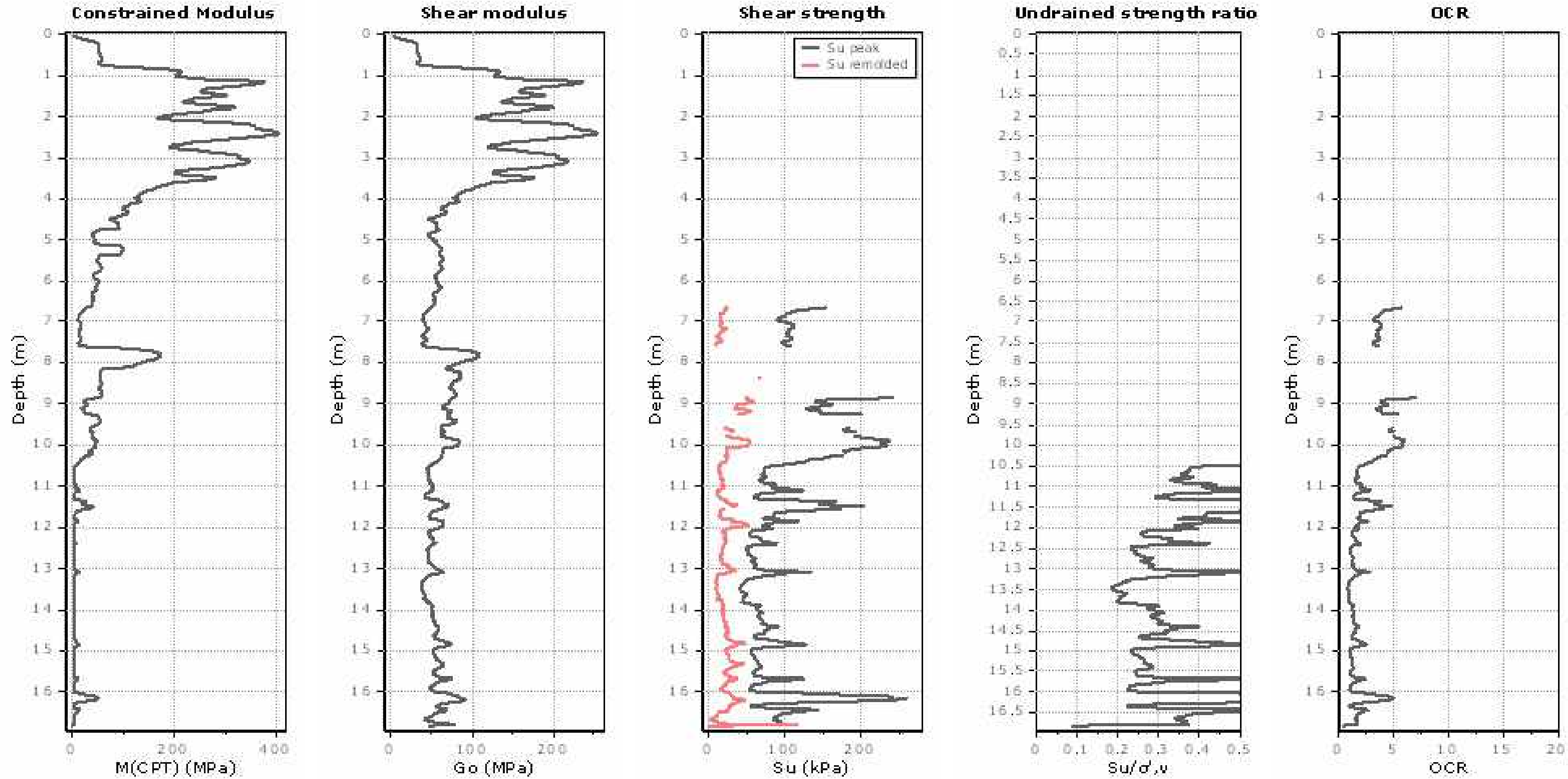
CPT: KP CPT01
Total depth: 16.88 m, Date: 3/09/2020
Coords: lat 305898.4° lon 6880747.5°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**



Calculation parameters
Constrained modulus: Based on variable alpha using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable alpha using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14

OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

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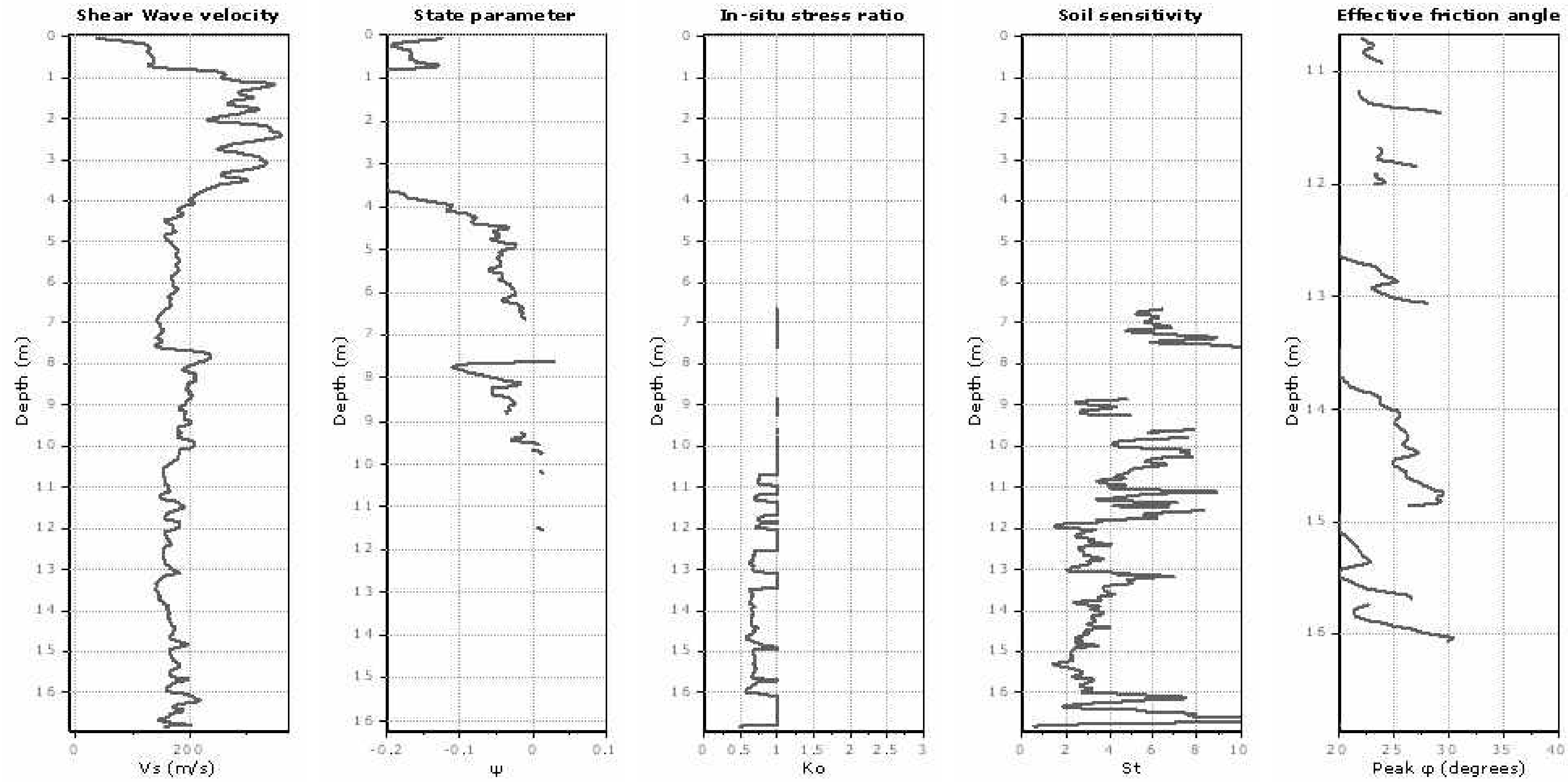
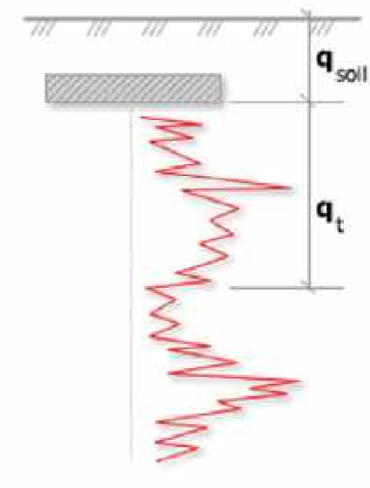
CPT: KP CPT01
Total depth: 16.88 m, Date: 3/09/2020
Coords: lat 305898.4° lon 6880747.5°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**



Calculation parameters

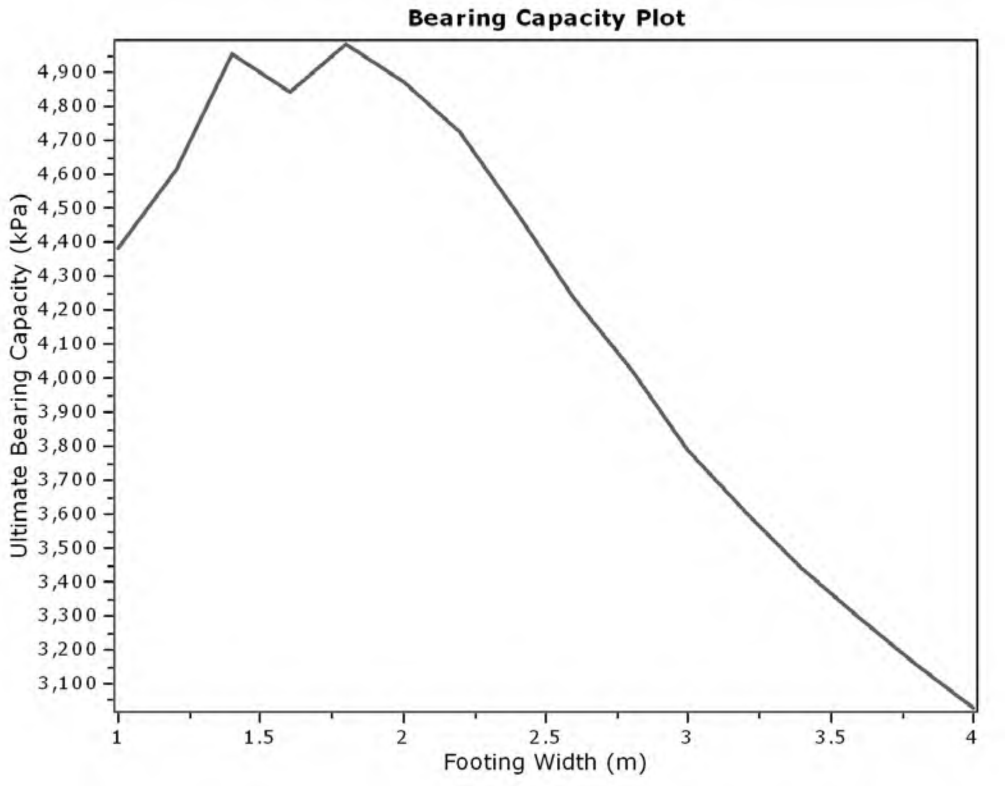
Soil Sensitivity factor, N_S: 7.00
User defined estimation data



Bearing Capacity calculation is perfromed based on the formula:

$$Q_{ult} = R_k \times q_t + q_{soil}$$

where:
R_k: Bearing capacity factor
q_t: Average corrected cone resistance over calculation depth
q_{soil}: Pressure applied by soil above footing



:: Tabular results ::

No	B (m)	Start Depth (m)	End Depth (m)	Ave. q_t (MPa)	R_k	Soil Press. (kPa)	Ult. bearing cap. (kPa)
1	1.00	0.50	2.00	21.88	0.20	9.50	4386.02
2	1.20	0.50	2.30	23.03	0.20	9.50	4616.32
3	1.40	0.50	2.60	24.73	0.20	9.50	4955.07
4	1.60	0.50	2.90	24.18	0.20	9.50	4844.71
5	1.80	0.50	3.20	24.88	0.20	9.50	4985.03
6	2.00	0.50	3.50	24.31	0.20	9.50	4871.27
7	2.20	0.50	3.80	23.59	0.20	9.50	4727.81
8	2.40	0.50	4.10	22.38	0.20	9.50	4485.75
9	2.60	0.50	4.40	21.15	0.20	9.50	4238.73
10	2.80	0.50	4.70	20.09	0.20	9.50	4026.81
11	3.00	0.50	5.00	18.91	0.20	9.50	3790.74
12	3.20	0.50	5.30	17.99	0.20	9.50	3608.11
13	3.40	0.50	5.60	17.17	0.20	9.50	3443.10
14	3.60	0.50	5.90	16.42	0.20	9.50	3294.20
15	3.80	0.50	6.20	15.75	0.20	9.50	3158.75
16	4.00	0.50	6.50	15.11	0.20	9.50	3032.04

Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

The porepressures are plotted as a function of square root of (t). The graphical technique suggested by Robertson and Campanella (1989), yields a value for t_{50}, which corresponds to the time for 50% consolidation.

The value of the coefficient of consolidation in the radial or horizontal direction c_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).
t_{50}: time corresponding to 50% consolidation

Permeability estimates based on dissipation test

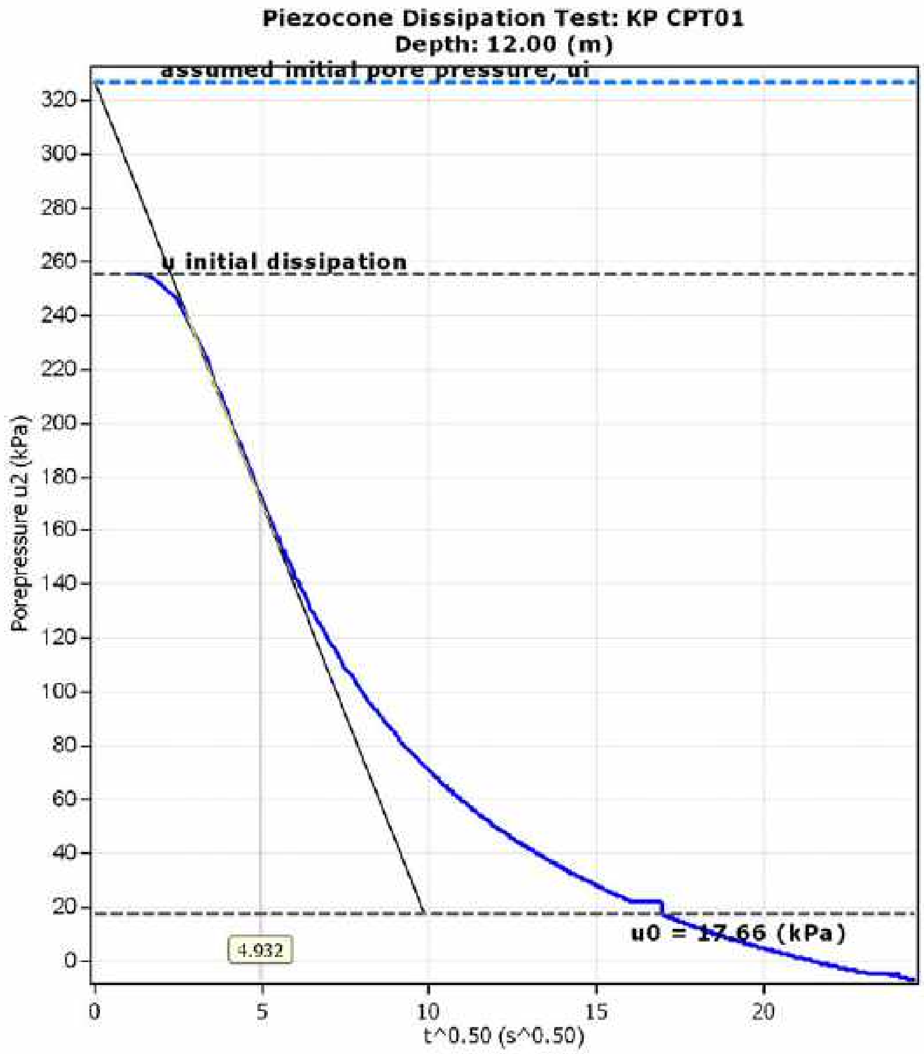
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

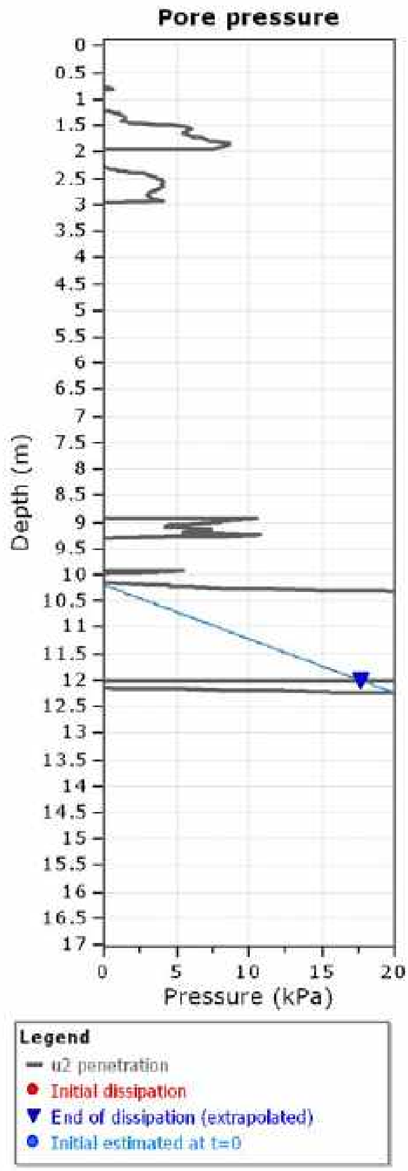
$$k_h = c_h \times \gamma_w / M$$

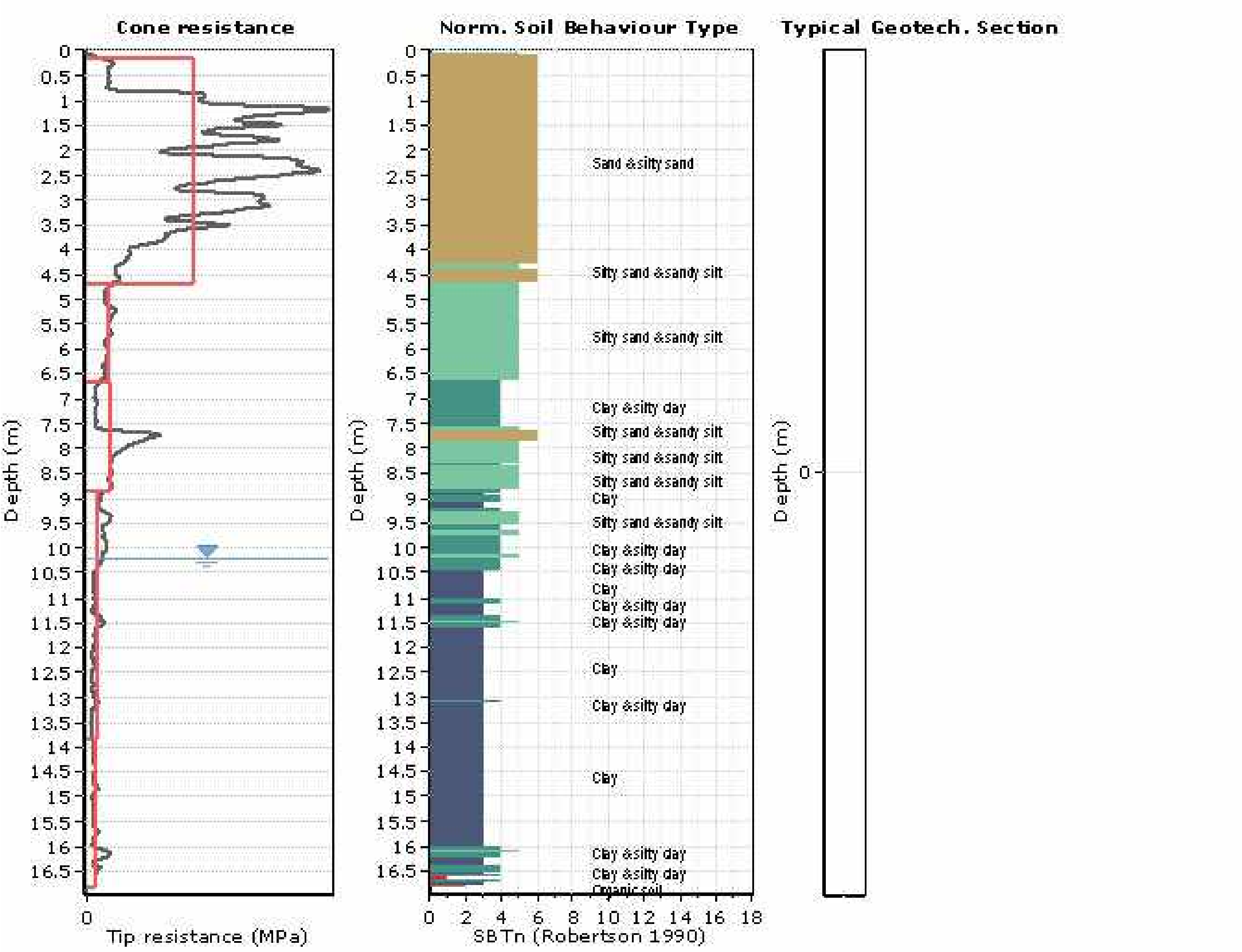
where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

Tabular results

CPTU Borehole	Depth (m)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/S_u	c_h (m^2/s)	c_h (m^2/year)	M (MPa)	k_h (m/s)
KP CPT01	12.00	4.9	24	7.71E-007	100.00	3.19E-005	1006	10.94	2.86E-008


Piezocone Dissipation Test: KP CPT01
Depth: 12.00 (m)
assumed initial pore pressure, ui
u initial dissipation
u0 = 17.66 (kPa)
4.932
Porepressure u2 (kPa)
t^0.50 (s^0.50)


Pore pressure
Depth (m)
Pressure (kPa)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0



Tabular results

.:: Layer No: 1 ::.

Code: Layer_1 **Start depth:** 0.12 (m), **End depth:** 4.70 (m)

Description: Sand & silty sand

Basic results

Total cone resistance: 18.67 ±11.80 MPa

Sleeve friction: 215.29 ±155.62 kPa

Ic: 1.68 ±0.17

SBT_n: 6

SBTn description: Sand & silty sand

Estimation results

Permeability: 1.19E-04 ±1.04E-04 m/s

N_{60}: 38.75 ±22.04 blows

Es: 101.67 ±51.87 MPa

Dr (%): 79.89 ±21.42

φ (degrees): 43.03 ±4.57 °

Unit weight: 19.00 ±0.00 kN/m³

Constrained Mod.: 203.33 ±103.75 MPa

Go: 127.42 ±65.02 MPa

Su: 0.00 ±0.00 kPa

Su ratio: 0.00 ±0.00

O.C.R.: 0.00 ±0.00

.:: Layer No: 2 ::.

Code: Layer_2 **Start depth:** 4.70 (m), **End depth:** 6.66 (m)

Description: Silty sand & sandy silt

Basic results	Estimation results	
Total cone resistance: 3.56 ±0.60 MPa	Permeability: 1.12E-06 ±9.28E-07 m/s	Constrained Mod.: 53.01 ±18.39 MPa
Sleeve friction: 33.65 ±6.97 kPa	N_{60}: 11.63 ±1.30 blows	Go: 57.03 ±4.38 MPa
Ic: 2.31 ±0.10	Es: 45.56 ±3.46 MPa	Su: 0.00 ±0.00 kPa
SBT_n: 5	Dr (%): 30.52 ±3.31	Su ratio: 0.00 ±0.00
SBTn description: Silty sand & sandy silt	φ (degrees): 33.69 ±0.65 °	O.C.R.: 0.00 ±0.00
	Unit weight: 19.00 ±0.00 kN/m³	

.:: Layer No: 3 ::.

Code: Layer_3 **Start depth:** 6.66 (m), **End depth:** 8.84 (m)

Description: Silty sand & sandy silt

Basic results	Estimation results	
Total cone resistance: 4.08 ±2.98 MPa	Permeability: 3.65E-06 ±1.07E-05 m/s	Constrained Mod.: 59.48 ±51.08 MPa
Sleeve friction: 37.24 ±22.21 kPa	N_{60}: 13.13 ±6.50 blows	Go: 65.63 ±22.23 MPa
Ic: 2.46 ±0.30	Es: 65.55 ±11.13 MPa	Su: 0.00 ±0.00 kPa
SBT_n: 5	Dr (%): 33.50 ±8.88	Su ratio: 0.00 ±0.00
SBTn description: Silty sand & sandy silt	φ (degrees): 34.33 ±1.36 °	O.C.R.: 0.00 ±0.00
	Unit weight: 19.00 ±0.00 kN/m³	

.:: Layer No: 4 ::.

Code: Layer_4 **Start depth:** 8.84 (m), **End depth:** 13.86 (m)

Description: Clay

Basic results	Estimation results	
Total cone resistance: 1.81 ±0.91 MPa	Permeability: 4.36E-08 ±8.45E-08 m/s	Constrained Mod.: 15.95 ±16.24 MPa
Sleeve friction: 24.64 ±12.55 kPa	N_{60}: 8.72 ±2.60 blows	Go: 56.06 ±11.89 MPa
Ic: 3.00 ±0.30	Es: 0.00 ±0.00 MPa	Su: 100.60 ±54.26 kPa
SBT_n: 3	Dr (%): 0.00 ±0.00	Su ratio: 0.52 ±0.32
SBTn description: Clay	φ (degrees): 0.00 ±0.00 °	O.C.R.: 2.38 ±1.48
	Unit weight: 19.00 ±0.00 kN/m³	

.:: Layer No: 5 ::.

Code: Layer_5 **Start depth:** 13.86 (m), **End depth:** 16.82 (m)

Description: Clay

Basic results	Estimation results	
Total cone resistance: 1.49 ±0.61 MPa	Permeability: 7.26E-09 ±2.09E-08 m/s	Constrained Mod.: 7.39 ±9.73 MPa
Sleeve friction: 25.45 ±11.46 kPa	N_{60}: 8.47 ±2.01 blows	Go: 58.81 ±9.91 MPa
Ic: 3.21 ±0.22	Es: 0.00 ±0.00 MPa	Su: 84.60 ±41.26 kPa
SBT_n: 3	Dr (%): 0.00 ±0.00	Su ratio: 0.35 ±0.17
SBTn description: Clay	φ (degrees): 0.00 ±0.00 °	O.C.R.: 1.62 ±0.77
	Unit weight: 19.00 ±0.00 kN/m³	

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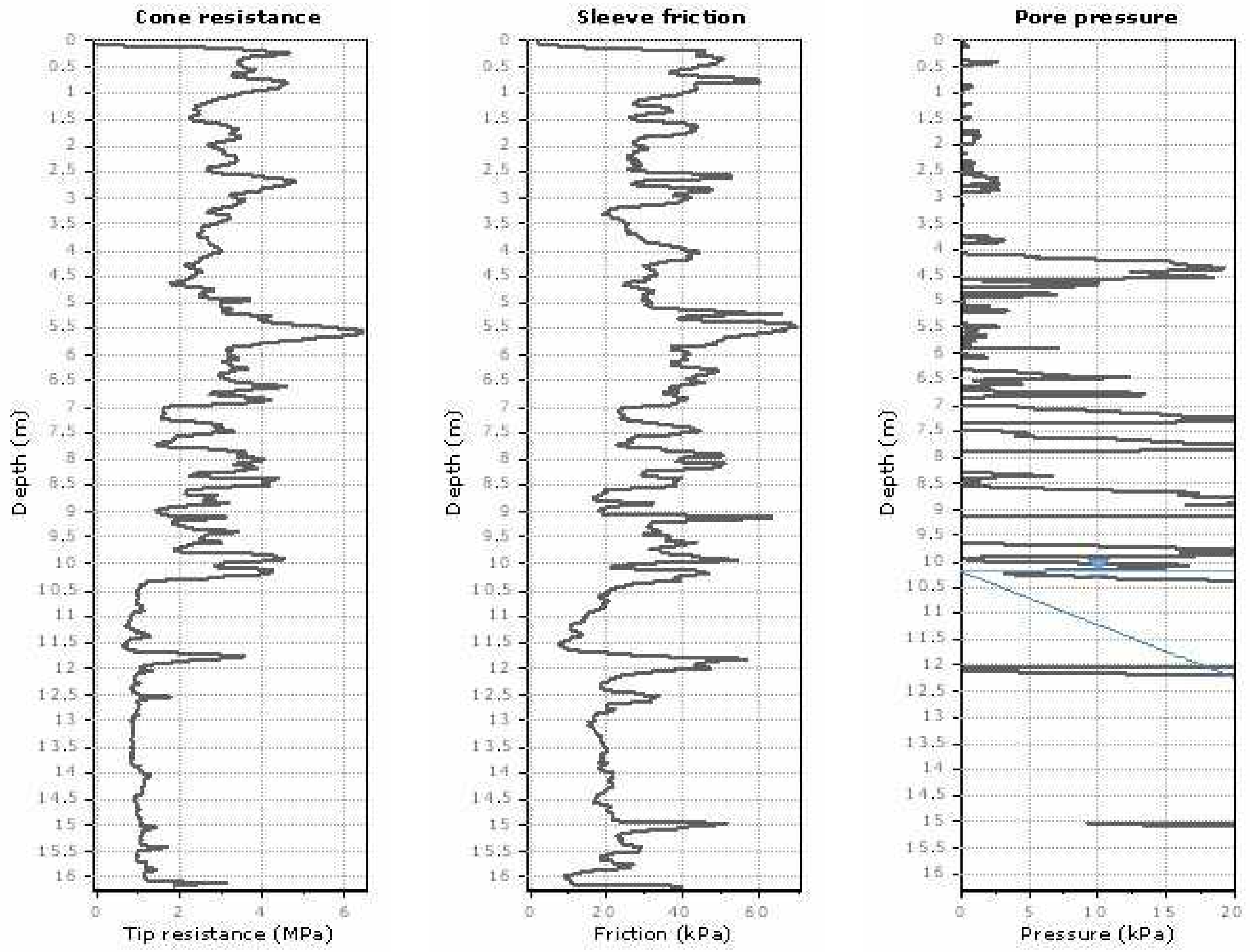
CPT: KP CPT01
Total depth: 16.88 m, Date: 3/09/2020
Coords: lat 305898.4° lon 6880747.5°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**

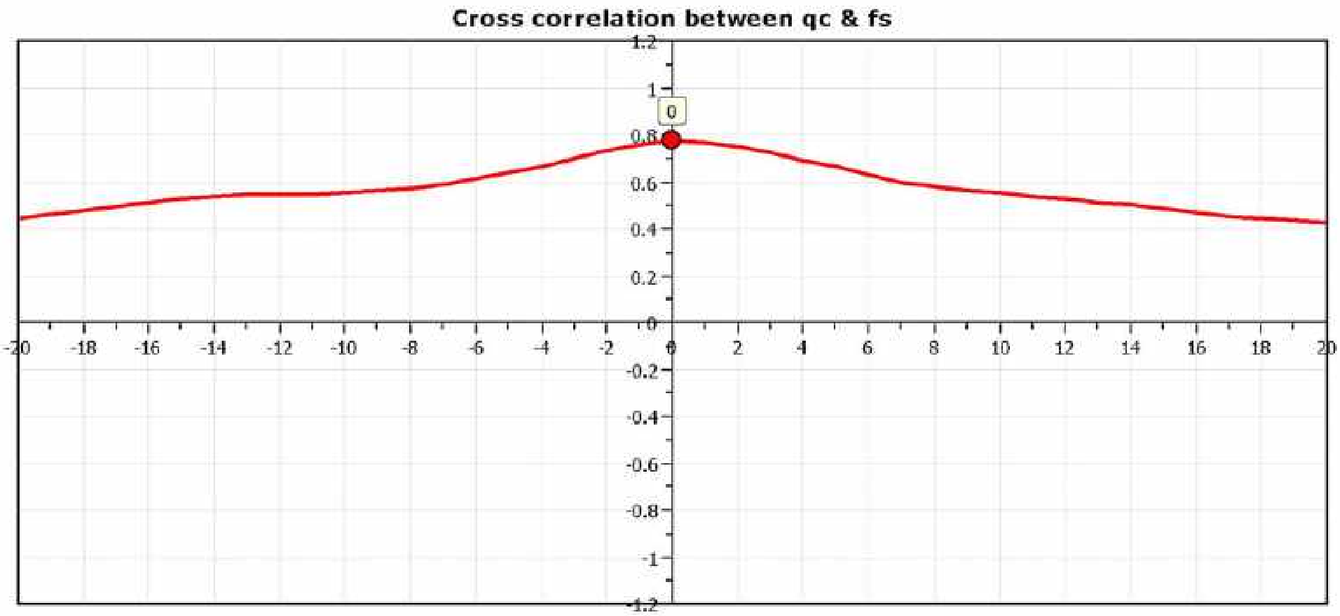
Summary table of mean values

From depth To depth (m)	Thickness (m)	Permeability (m/s)	SPT_{N60} (blows/30cm)	E_s (MPa)	D_r (%)	Friction angle	Constrained modulus, M (MPa)	Shear modulus, G_O (MPa)	Undrained strength, S_U (kPa)	Undrained strength ratio	OCR	Unit weight (kN/m³)
0.12	4.58	1.19E-04	38.8	101.7	79.9	43.0	203.3	127.4	0.0	0.0	0.0	19.0
4.70		(±1.04E-04)	(±22.0)	(±51.9)	(±21.4)	(±4.6)	(±103.7)	(±65.0)	(±0.0)	(±0.0)	(±0.0)	(±0.0)
4.70	1.96	1.12E-06	11.6	45.6	30.5	33.7	53.0	57.0	0.0	0.0	0.0	19.0
6.66		(±9.28E-07)	(±1.3)	(±3.5)	(±3.3)	(±0.7)	(±18.4)	(±4.4)	(±0.0)	(±0.0)	(±0.0)	(±0.0)
6.66	2.18	3.65E-06	13.1	65.6	33.5	34.3	59.5	65.6	0.0	0.0	0.0	19.0
8.84		(±1.07E-05)	(±6.5)	(±11.1)	(±8.9)	(±1.4)	(±51.1)	(±22.2)	(±0.0)	(±0.0)	(±0.0)	(±0.0)
8.84	5.02	4.36E-08	8.7	0.0	0.0	0.0	16.0	56.1	100.6	0.5	2.4	19.0
13.86		(±8.45E-08)	(±2.6)	(±0.0)	(±0.0)	(±0.0)	(±16.2)	(±11.9)	(±54.3)	(±0.3)	(±1.5)	(±0.0)
13.86	2.96	7.26E-09	8.5	0.0	0.0	0.0	7.4	58.8	84.6	0.4	1.6	19.0
16.82		(±2.09E-08)	(±2.0)	(±0.0)	(±0.0)	(±0.0)	(±9.7)	(±9.9)	(±41.3)	(±0.2)	(±0.8)	(±0.0)

Depth values presented in this table are measured from free ground surface



The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



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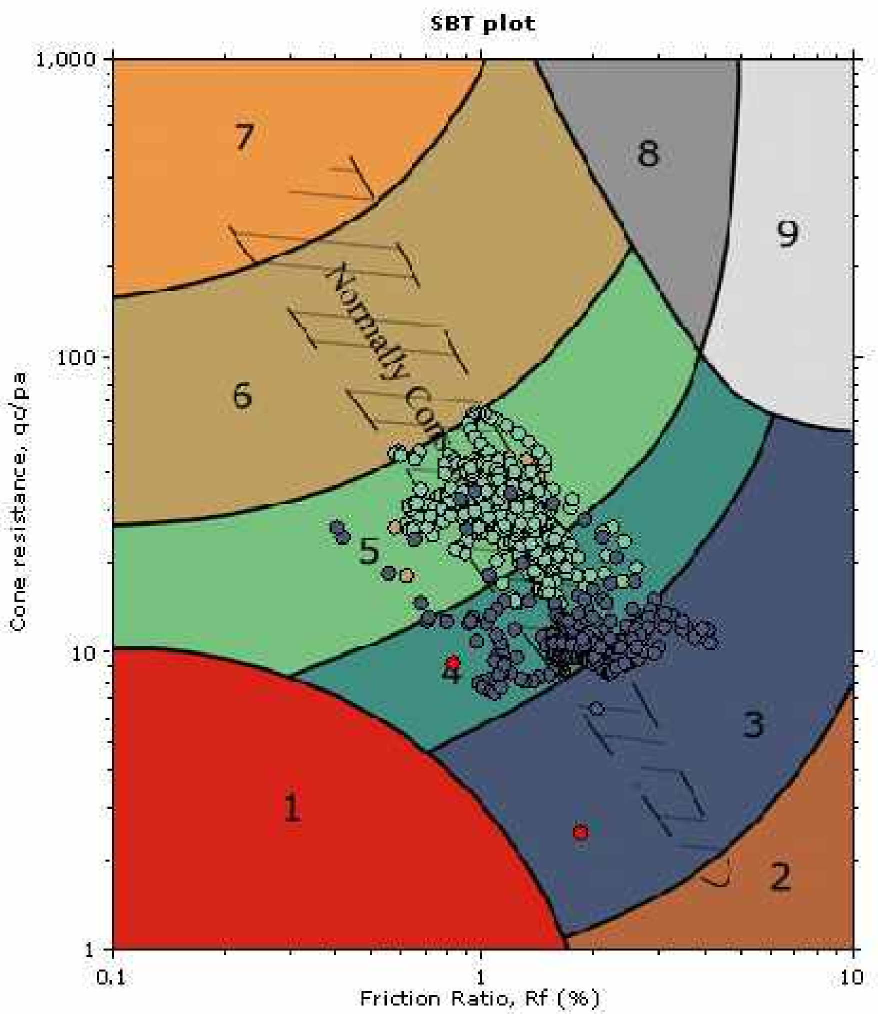
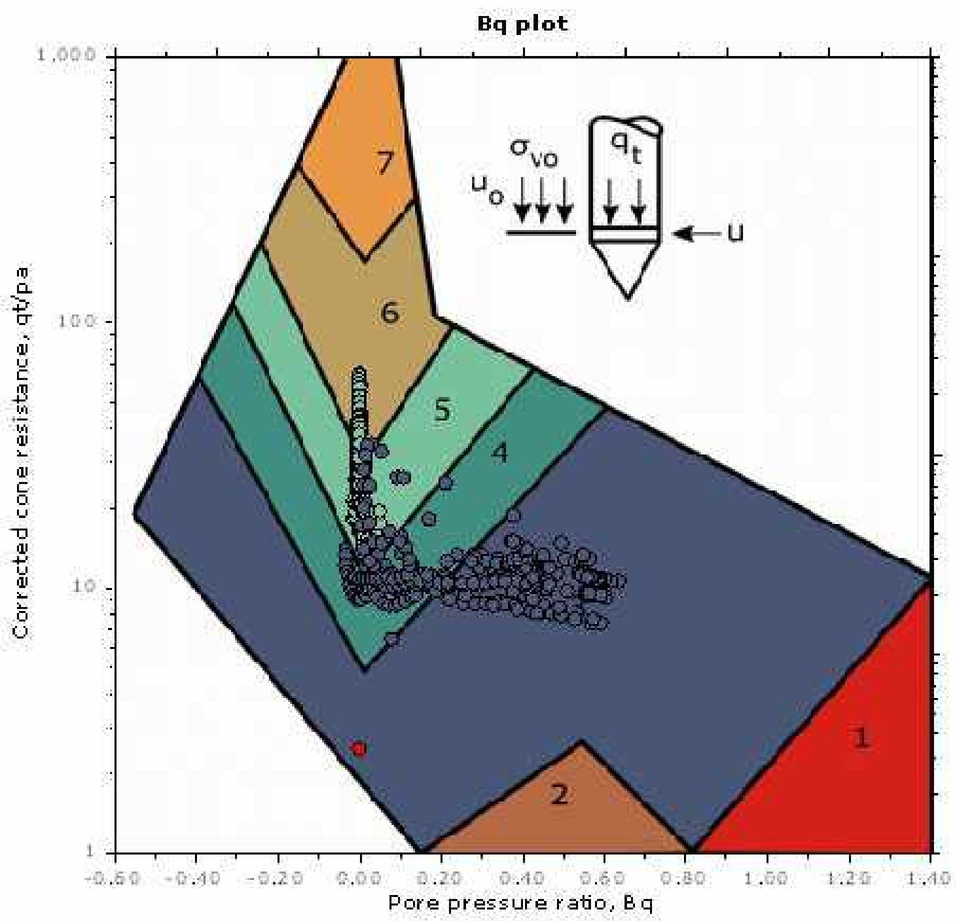
CPT: KP CPT 02
Total depth: 16.24 m, Date: 3/09/2020
Coords: lat 305871.8° lon 6880733.7°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**

SBT - Bq plots

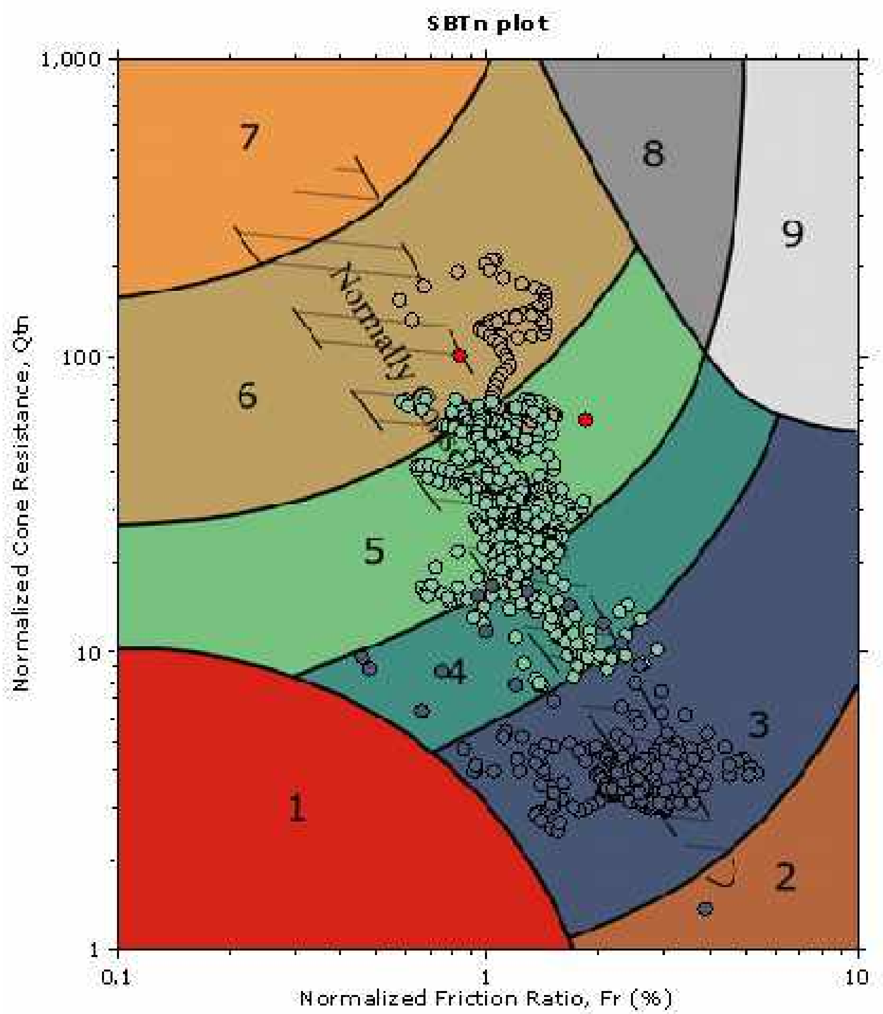


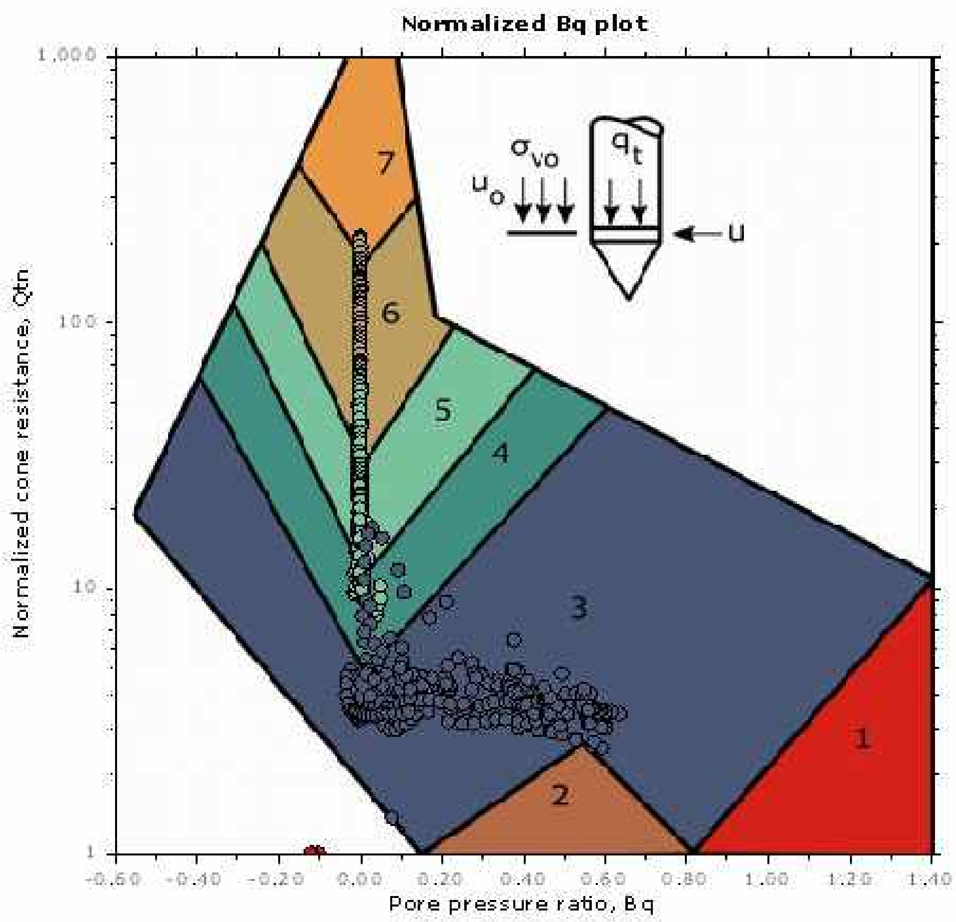


SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravelly sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

SBT - Bq plots (normalized)

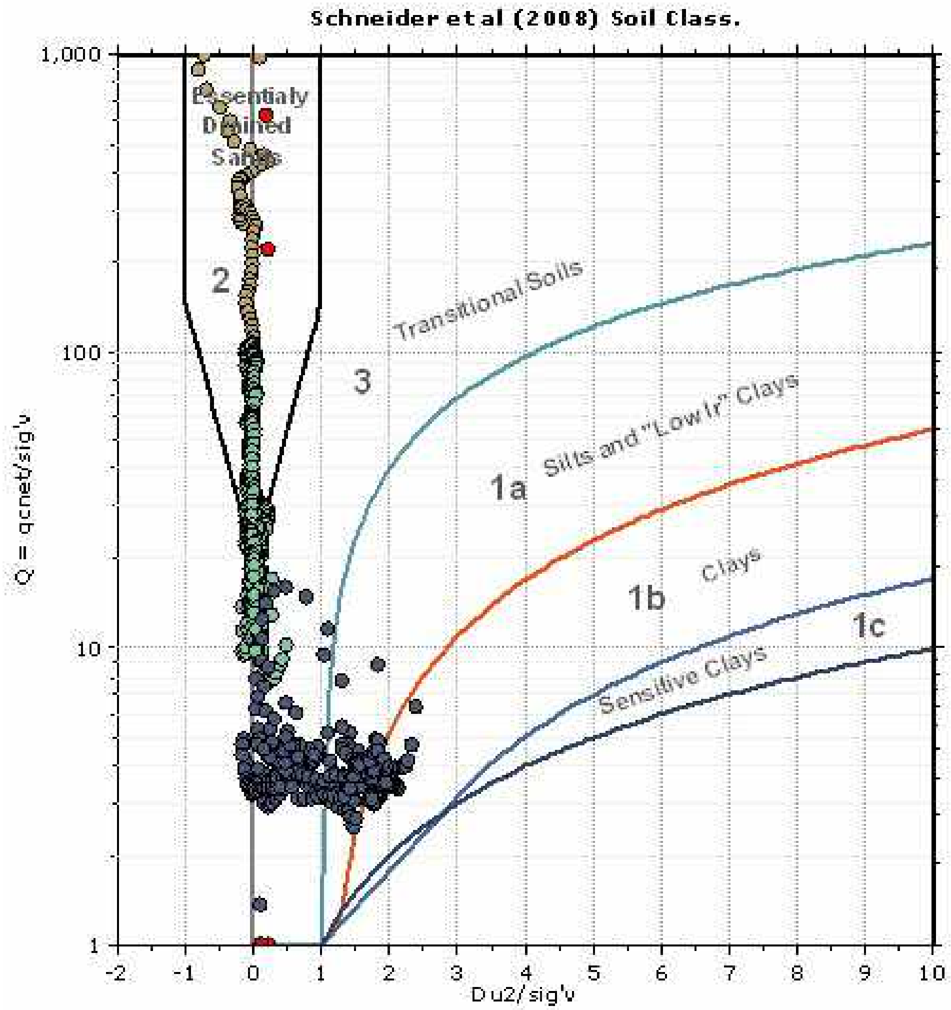


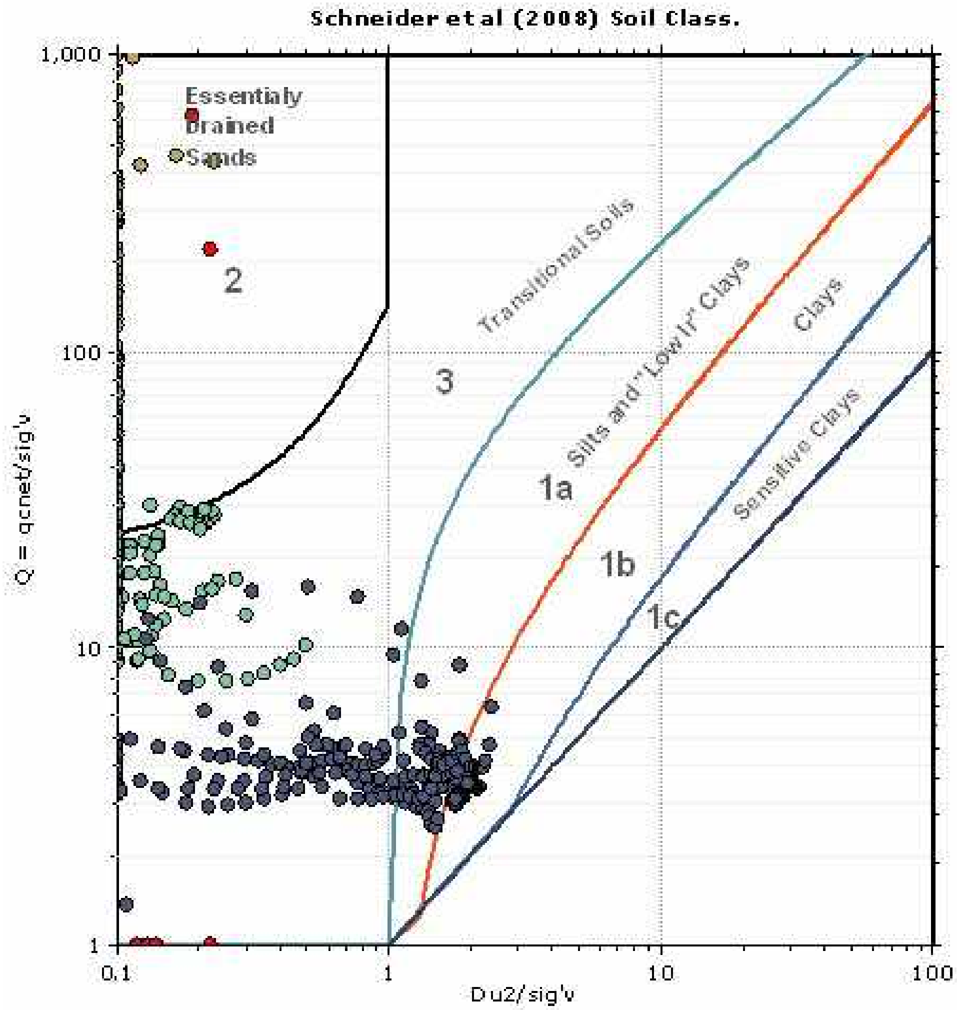


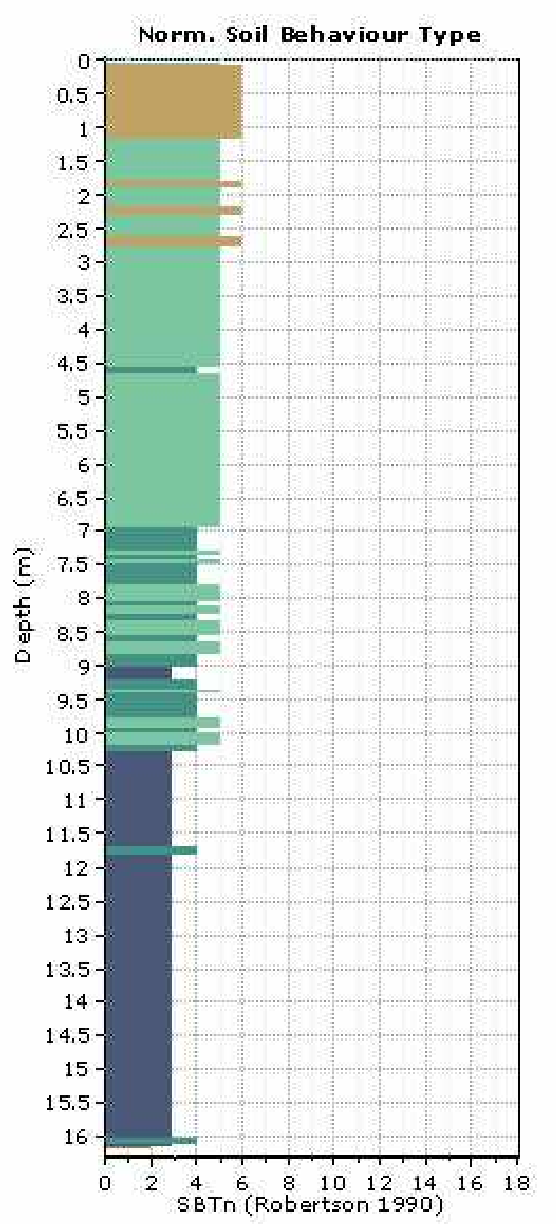
SBTn legend

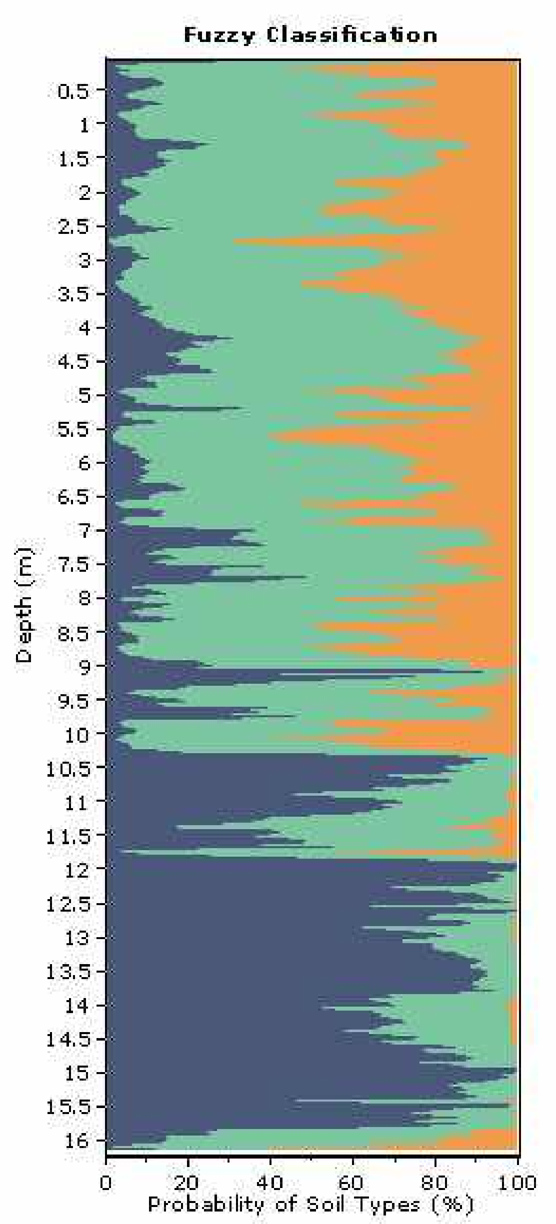
- 1. Sensitive fine grained
- 2. Organic material
- 3. Clay to silty clay
- 4. Clayey silt to silty clay
- 5. Silty sand to sandy silt
- 6. Clean sand to silty sand
- 7. Gravelly sand to sand
- 8. Very stiff sand to clayey sand
- 9. Very stiff fine grained

Bq plots (Schneider)





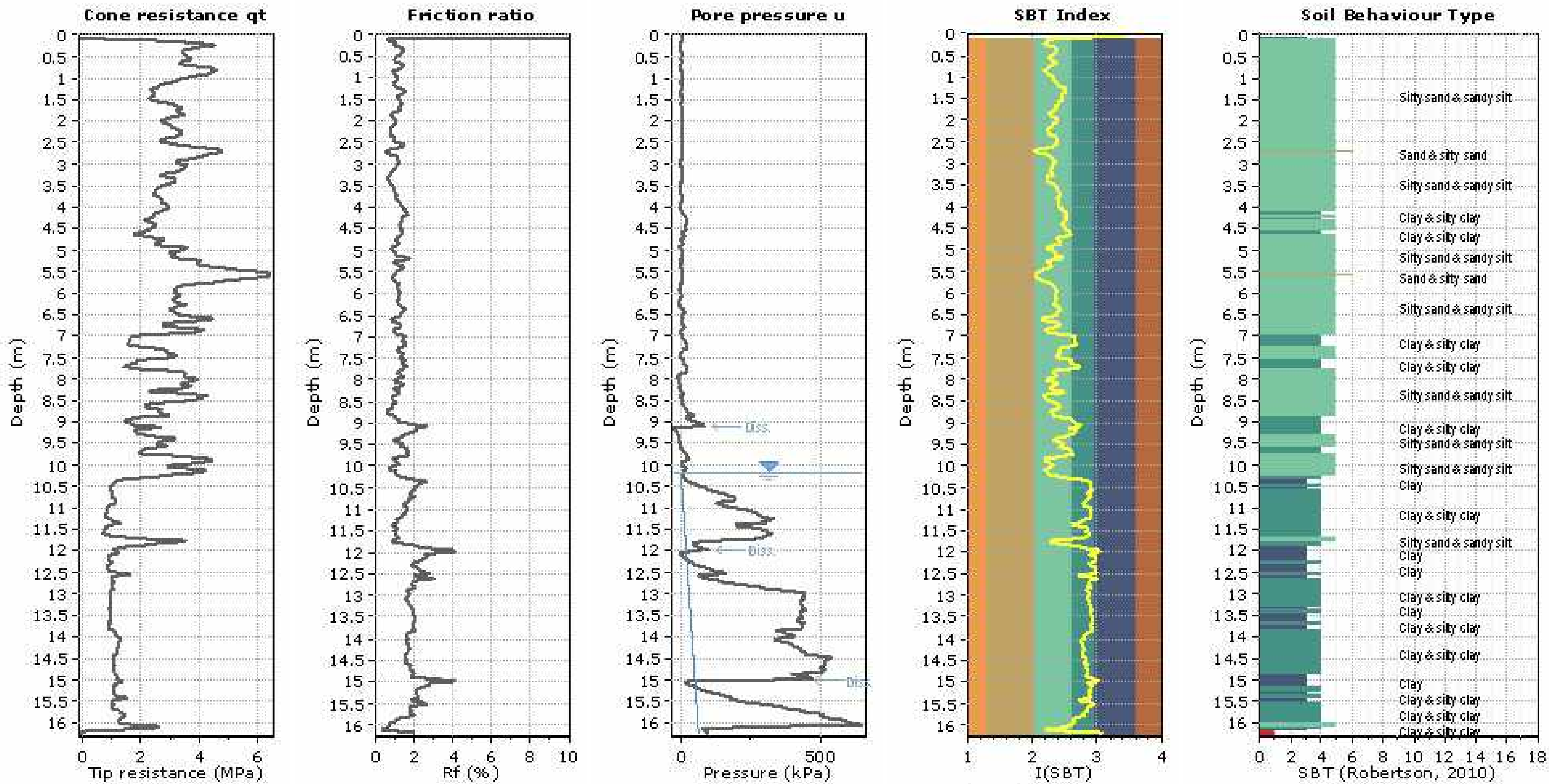

Norm. Soil Behaviour Type
Depth (m)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
10
10.5
11
11.5
12
12.5
13
13.5
14
14.5
15
15.5
16
0 2 4 6 8 10 12 14 16 18
SBTn (Robertson 1990)


Fuzzy Classification
Depth (m)
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
10
10.5
11
11.5
12
12.5
13
13.5
14
14.5
15
15.5
16
0 20 40 60 80 100
Probability of Soil Types (%)

Knight Piésold Consulting
Level 1, 184 Adelaide Terrace
Perth WA 6004, Australia
http://www.knightpiesold.com/

Project: Thunderbox Gold Mine
Location: Leinster, Western Australia, Australia

CPT: KP CPT 02
Total depth: 16.24 m, Date: 3/09/2020
Coords: lat 305871.8° lon 6880733.7°
Cone Type: 180911
Cone Operator: Hagstrom Drilling



SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

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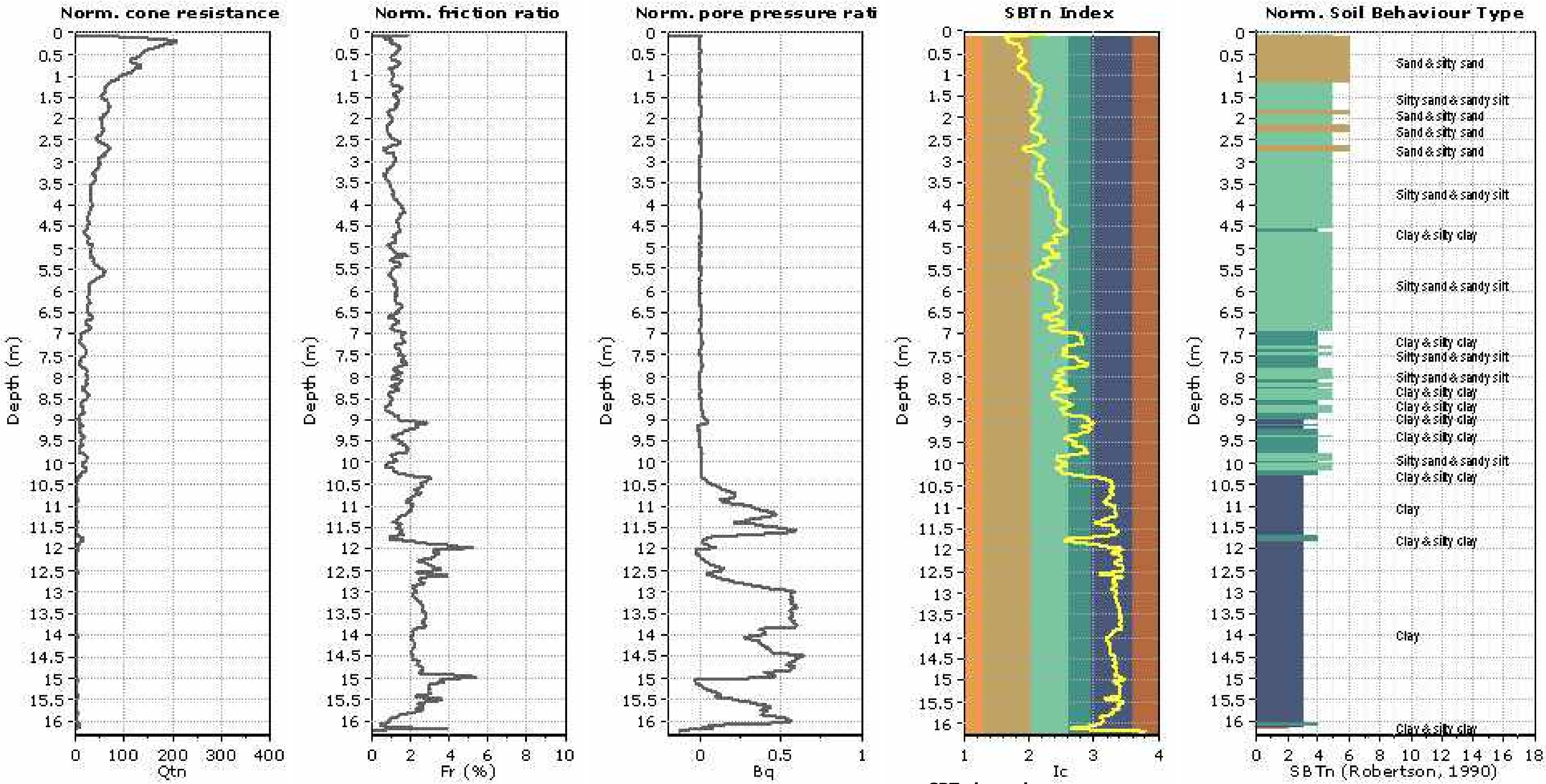
CPT: KP CPT 02
Total depth: 16.24 m, Date: 3/09/2020
Coords: lat 305871.8° lon 6880733.7°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**



SBTn legend

- 1. Sensitive fine grained
- 2. Organic material
- 3. Clay to silty clay
- 4. Clayey silt to silty clay
- 5. Silty sand to sandy silt
- 6. Clean sand to silty sand
- 7. Gravely sand to sand
- 8. Very stiff sand to clayey sand
- 9. Very stiff fine grained

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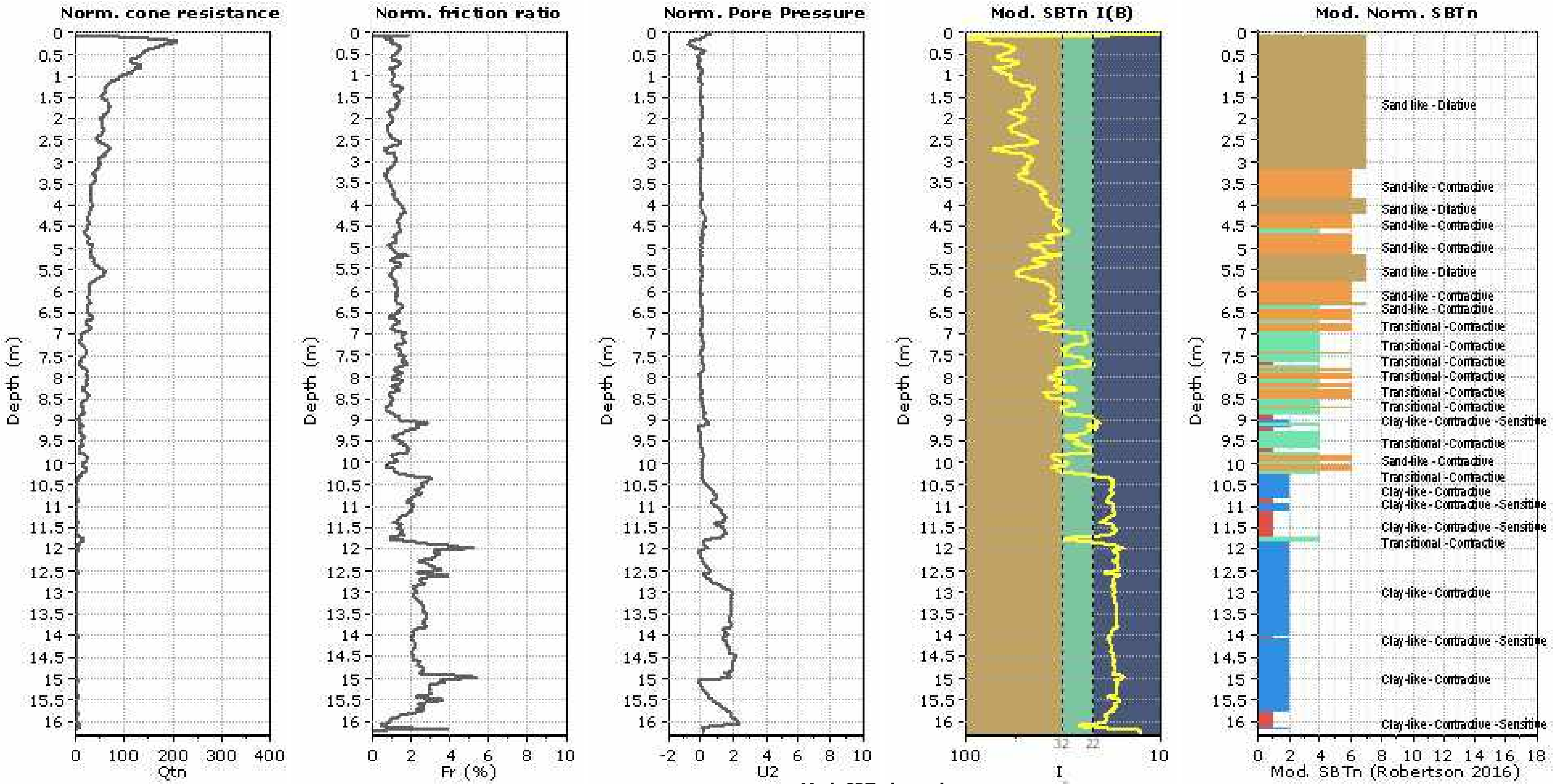
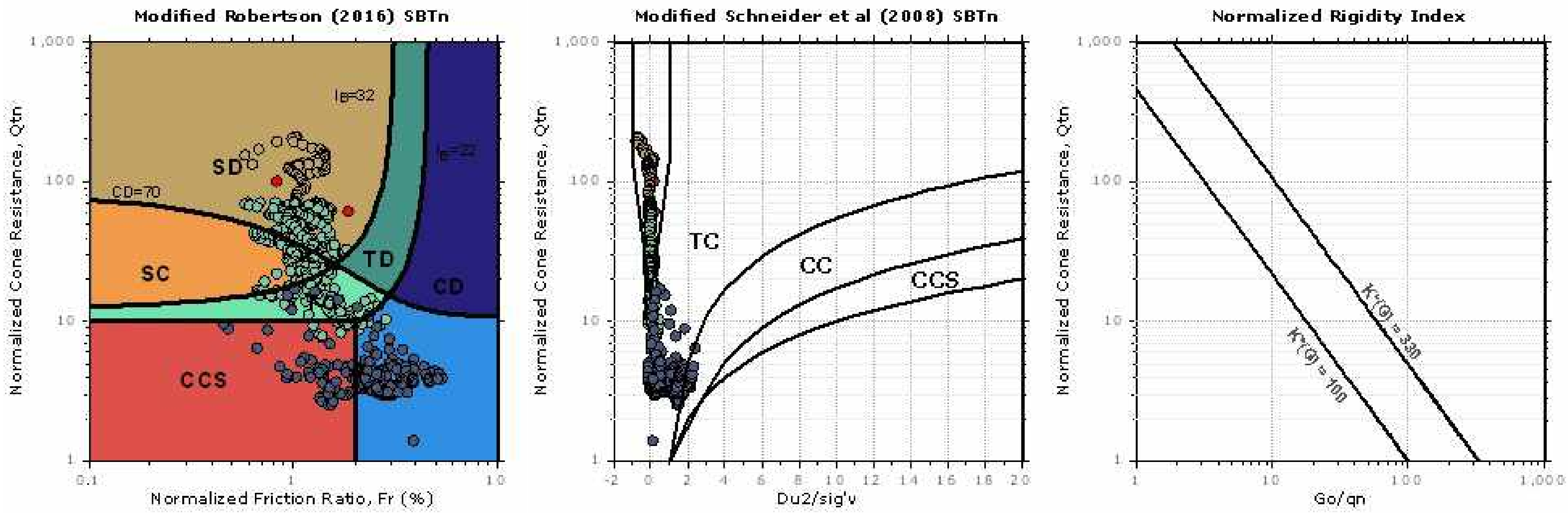
CPT: KP CPT 02
Total depth: 16.24 m, Date: 3/09/2020
Coords: lat 305871.8° lon 6880733.7°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**



Mod. SBTn legend
- 1. CCS: ClayLike - Contractive, Sensitive
- 2. CC: Clay-like - Contractive
- 3. CD: Clay-Like: Dilative
- 4. TC: Transitional - Contractive
- 5. TD: Transitional - Dilative
- 6. SC: Sand-like - Contractive
- 7. SD: Sand-like - Dilative

Updated SBTn plots



CCS: Clay-like - Contractive - Sensitive
CC: Clay-like - Contractive
CD: Clay-like - Dilative
TC: Transitional - Contractive
TD: Transitional - Dilative
SC: Sand-like - Contractive
SD: Sand-like - Dilative

K(G) > 330: Soils with significant microstructure (e.g. age/cementation)

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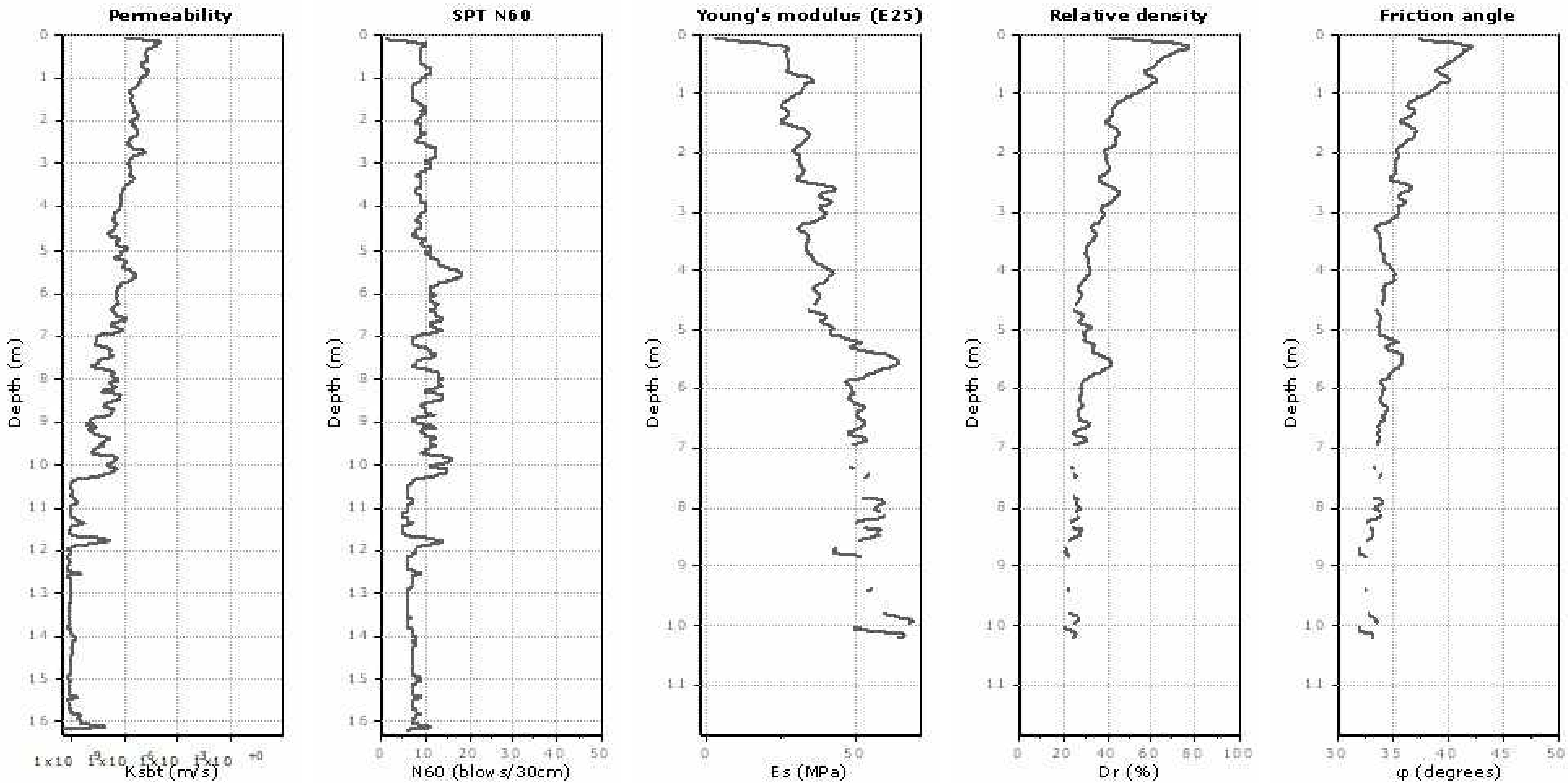
CPT: KP CPT 02
Total depth: 16.24 m, Date: 3/09/2020
Coords: lat 305871.8° lon 6880733.7°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**



Calculation parameters
Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative density constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

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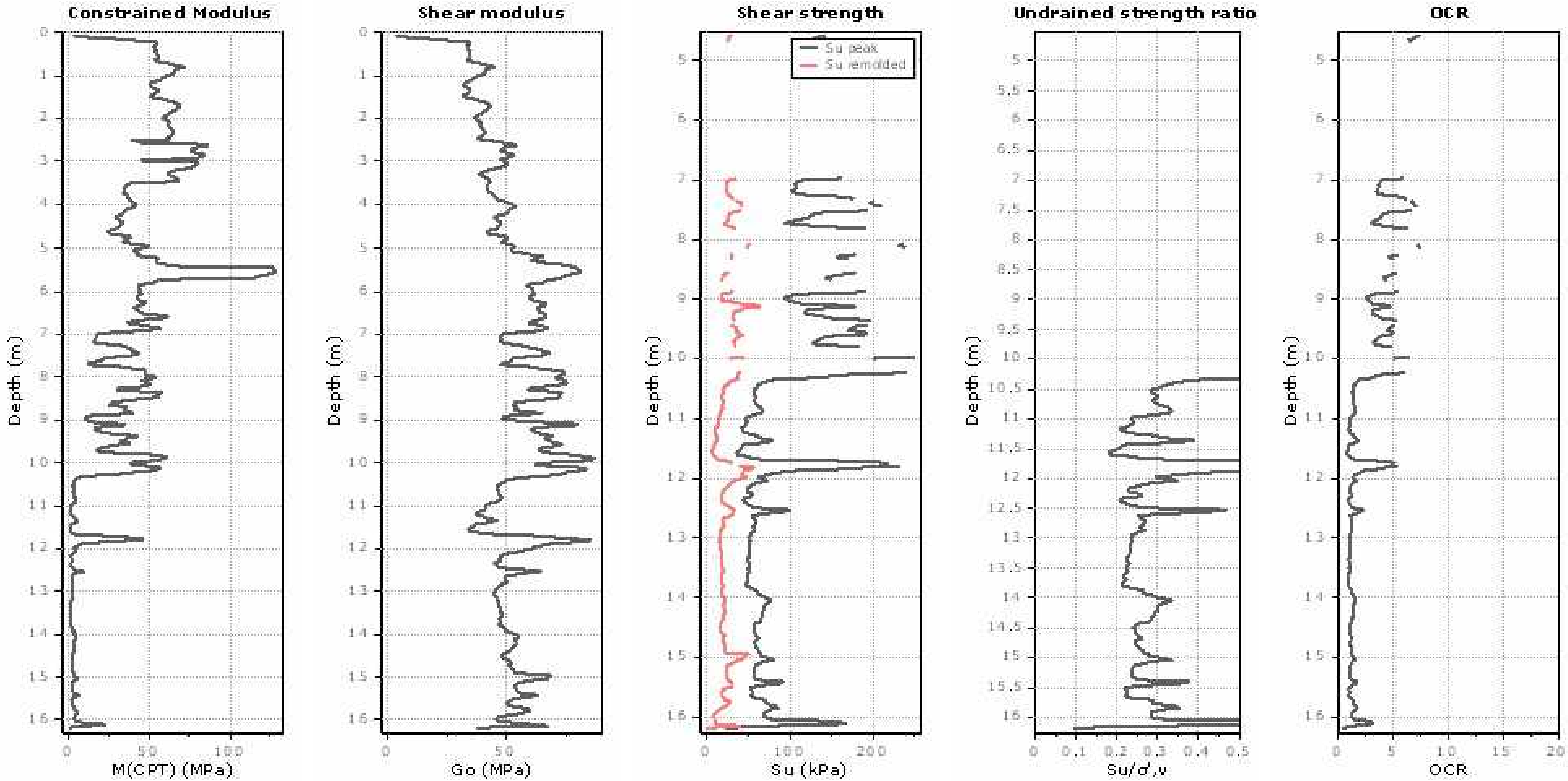
CPT: KP CPT 02
Total depth: 16.24 m, Date: 3/09/2020
Coords: lat 305871.8° lon 6880733.7°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**



Calculation parameters
Constrained modulus: Based on variable alpha using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable alpha using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14

OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

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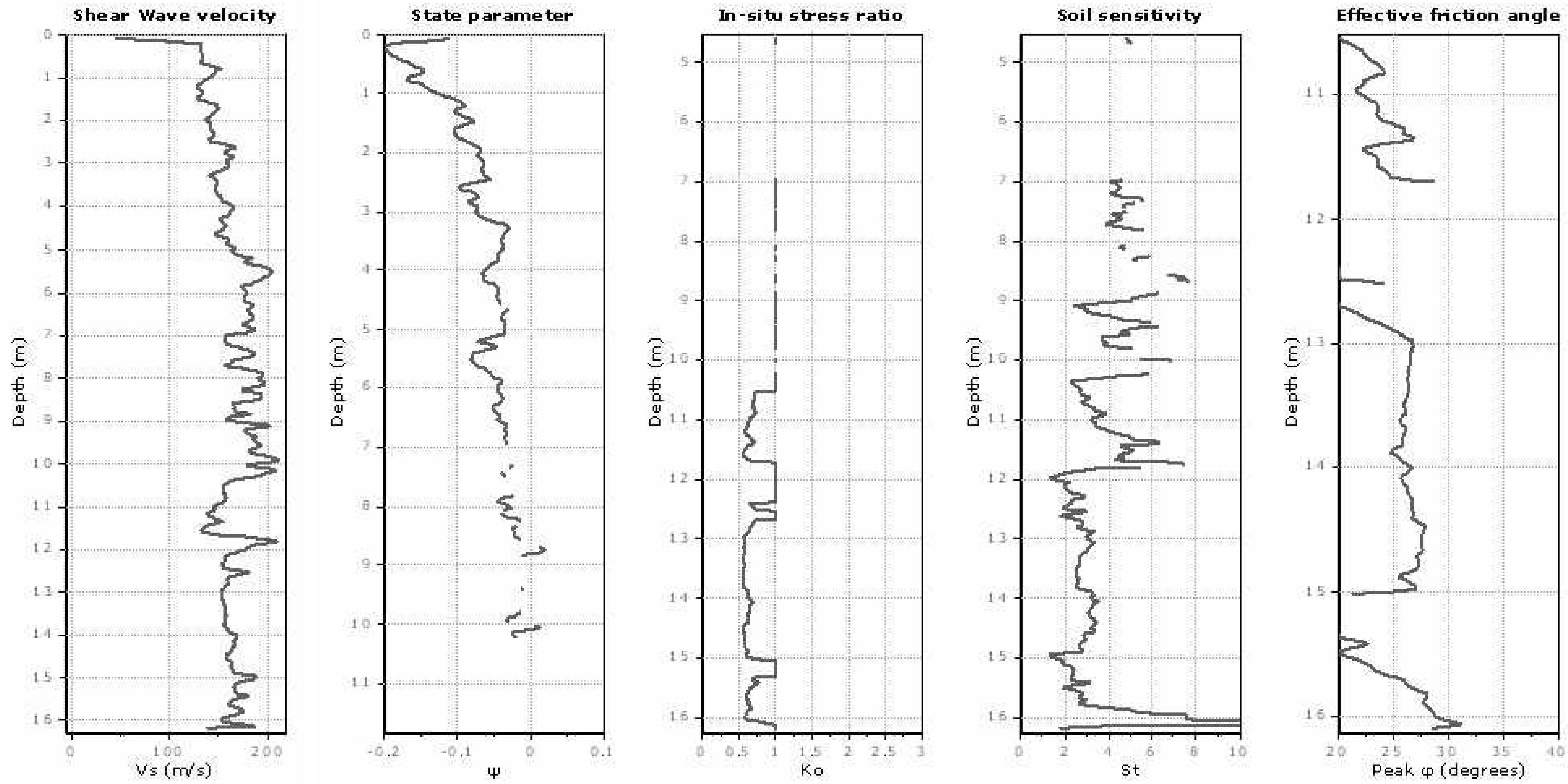
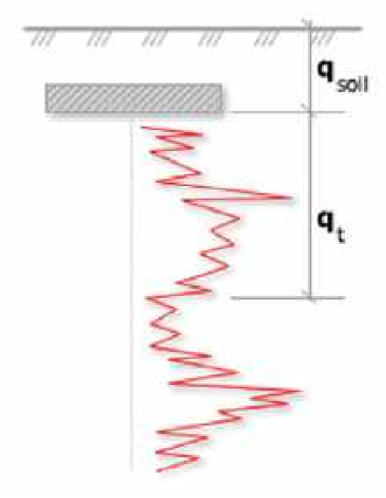
Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**

CPT: KP CPT 02
Total depth: 16.24 m, Date: 3/09/2020
Coords: lat 305871.8° lon 6880733.7°
Cone Type: 180911
Cone Operator: Hagstrom Drilling



Calculation parameters

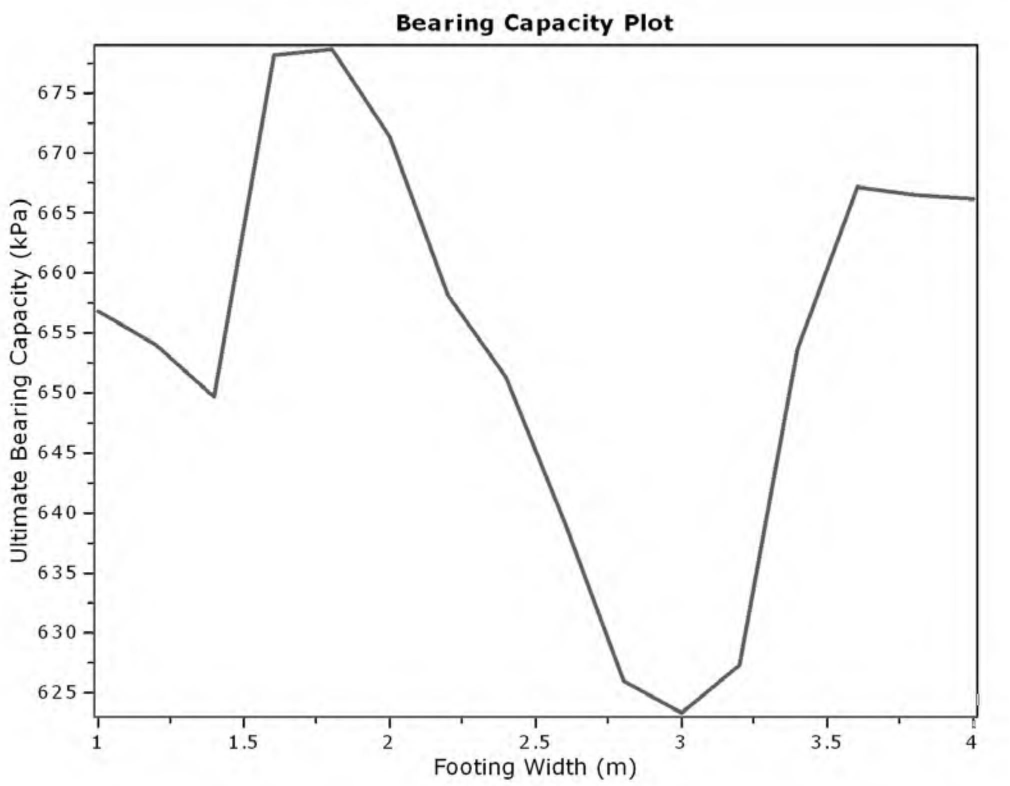
Soil Sensitivity factor, N_S: 7.00
User defined estimation data



Bearing Capacity calculation is perfromed based on the formula:

$$Q_{ult} = R_k \times q_t + q_{soil}$$

where:
R_k: Bearing capacity factor
q_t: Average corrected cone resistance over calculation depth
q_{soil}: Pressure applied by soil above footing



:: Tabular results ::

No	B (m)	Start Depth (m)	End Depth (m)	Ave. q_t (MPa)	R_k	Soil Press. (kPa)	Ult. bearing cap. (kPa)
1	1.00	0.50	2.00	3.24	0.20	9.50	656.79
2	1.20	0.50	2.30	3.22	0.20	9.50	653.96
3	1.40	0.50	2.60	3.20	0.20	9.50	649.63
4	1.60	0.50	2.90	3.34	0.20	9.50	678.14
5	1.80	0.50	3.20	3.35	0.20	9.50	678.60
6	2.00	0.50	3.50	3.31	0.20	9.50	671.20
7	2.20	0.50	3.80	3.24	0.20	9.50	658.05
8	2.40	0.50	4.10	3.21	0.20	9.50	651.32
9	2.60	0.50	4.40	3.15	0.20	9.50	638.90
10	2.80	0.50	4.70	3.08	0.20	9.50	625.88
11	3.00	0.50	5.00	3.07	0.20	9.50	623.26
12	3.20	0.50	5.30	3.09	0.20	9.50	627.28
13	3.40	0.50	5.60	3.22	0.20	9.50	653.66
14	3.60	0.50	5.90	3.29	0.20	9.50	667.05
15	3.80	0.50	6.20	3.28	0.20	9.50	666.42
16	4.00	0.50	6.50	3.28	0.20	9.50	666.05

Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

The porepressures are plotted as a function of square root of (t). The graphical technique suggested by Robertson and Campanella (1989), yields a value for t_{50}, which corresponds to the time for 50% consolidation.

The value of the coefficient of consolidation in the radial or horizontal direction c_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).
t_{50}: time corresponding to 50% consolidation

Permeability estimates based on dissipation test

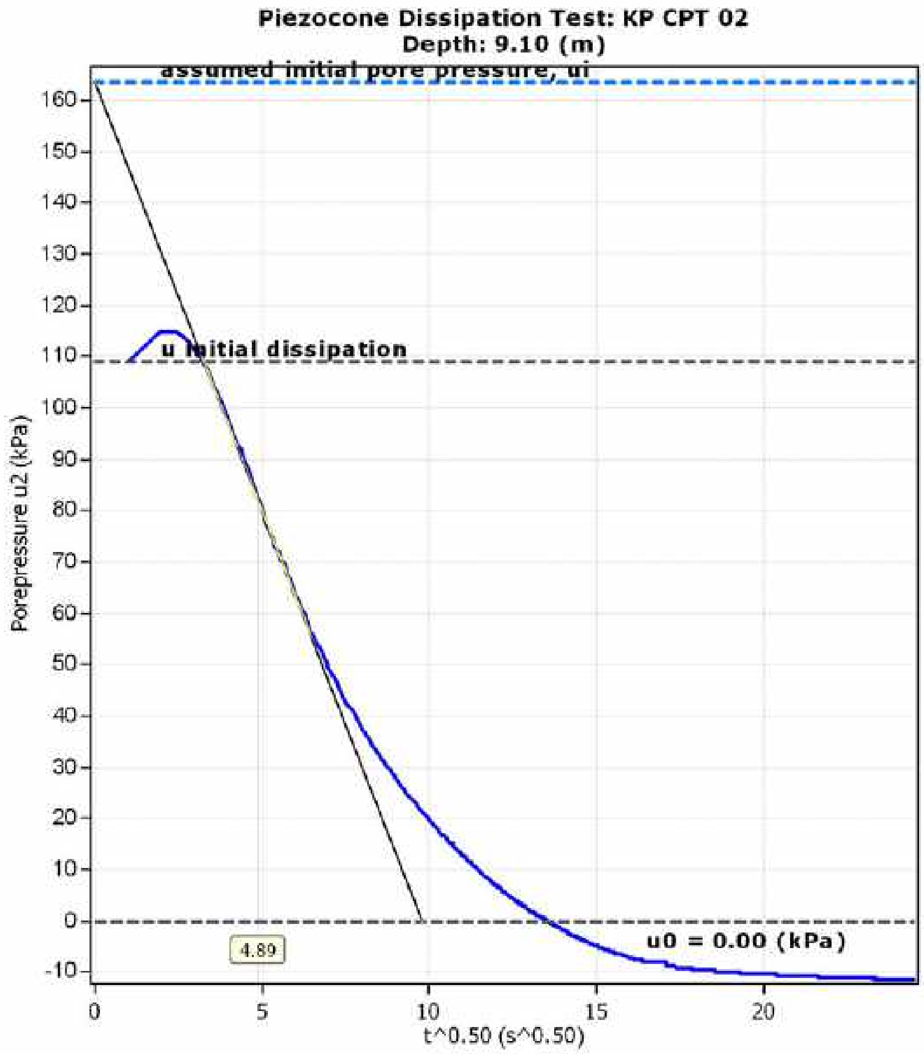
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

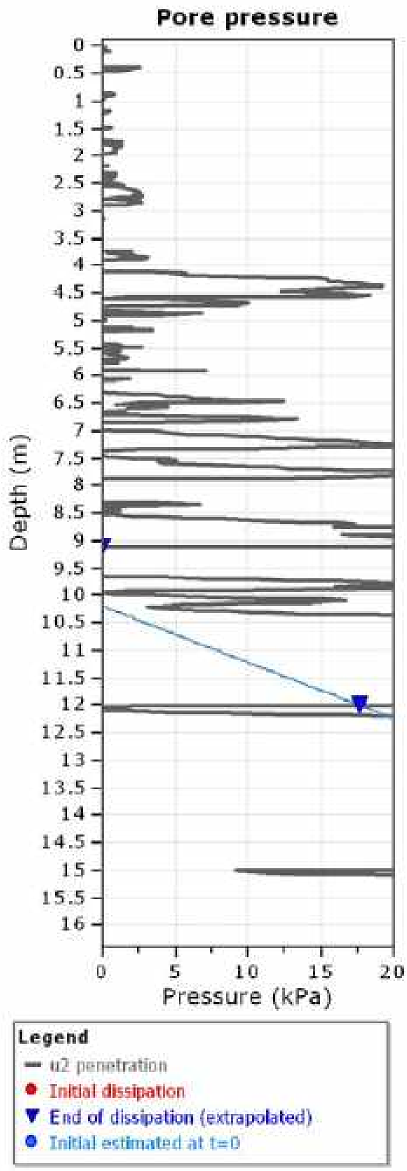
$$k_h = c_h \times \gamma_w / M$$

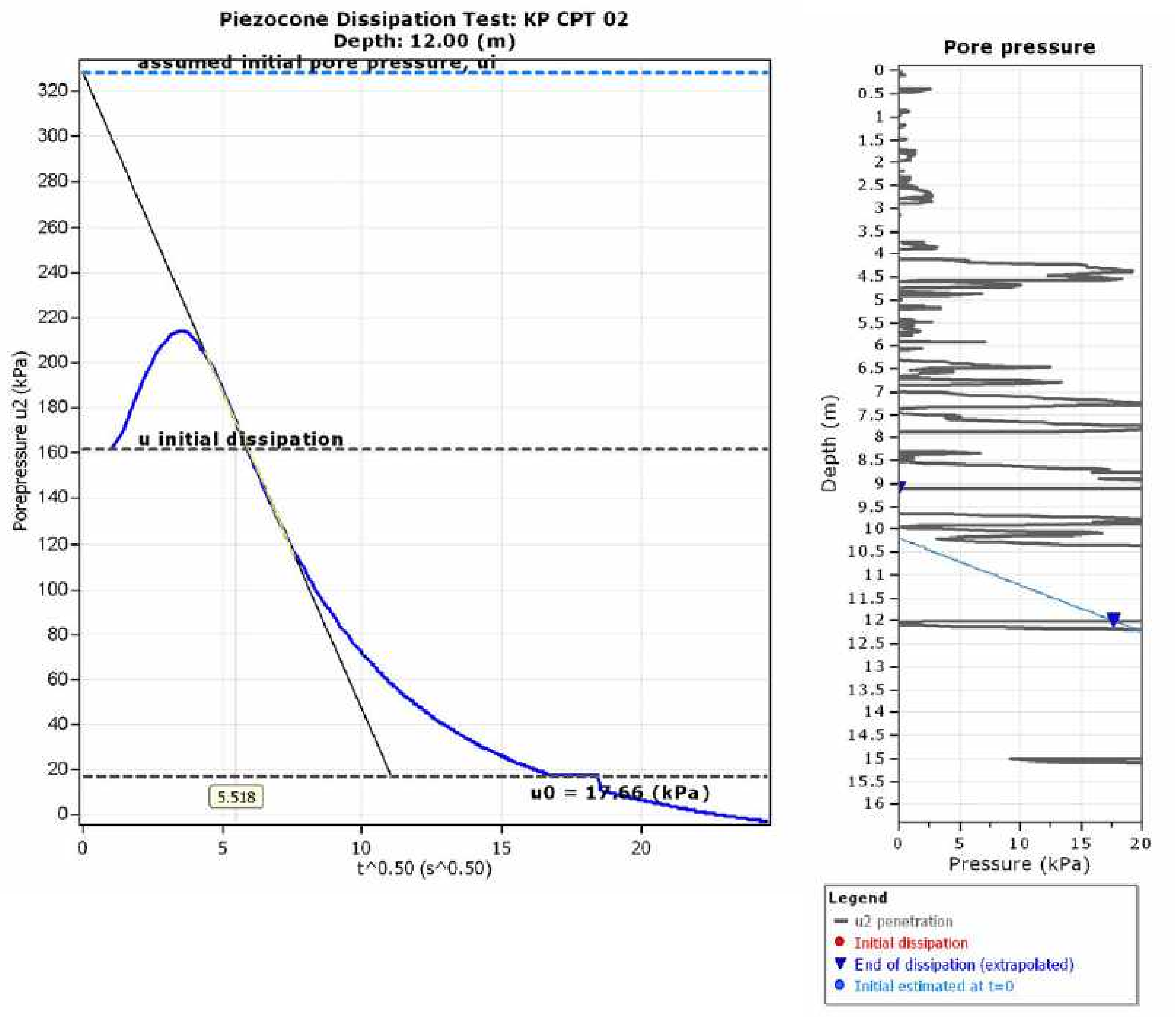
where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

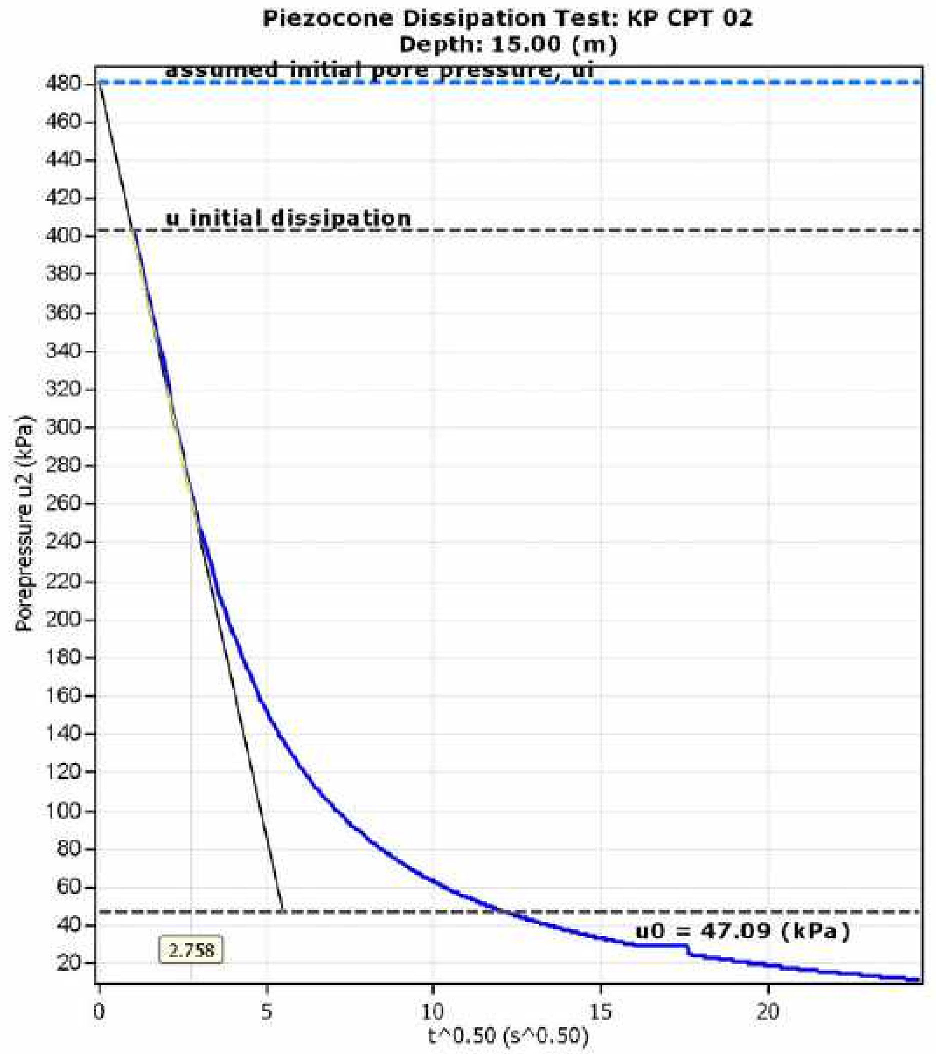
Tabular results

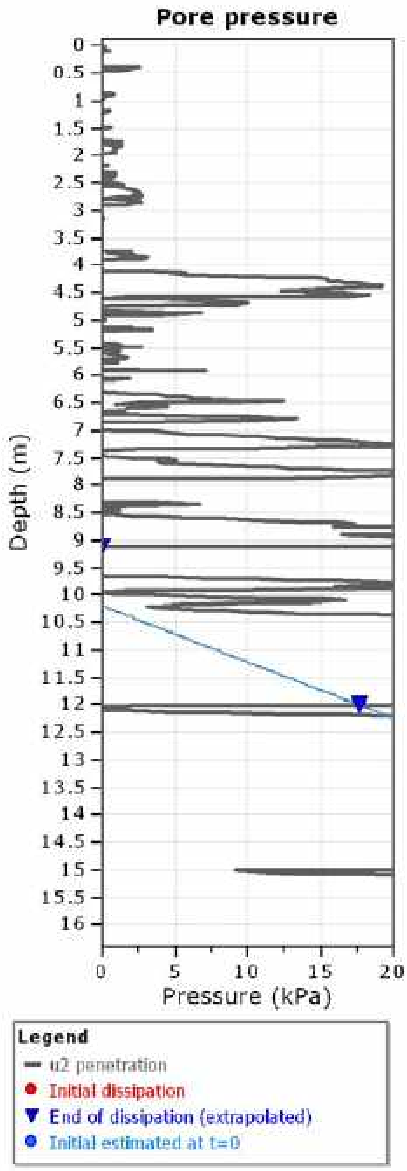
CPTU Borehole	Depth (m)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/S_u	c_h (m^2/s)	c_h ($m^2/year$)	M (MPa)	k_h (m/s)
KP CPT 02	9.10	4.9	24	7.58E-007	100.00	3.25E-005	1024	30.96	1.03E-008
KP CPT 02	12.00	5.5	30	9.65E-007	100.00	2.55E-005	804	7.08	3.53E-008
KP CPT 02	15.00	2.8	8	2.41E-007	100.00	1.02E-004	3218	6.03	1.66E-007

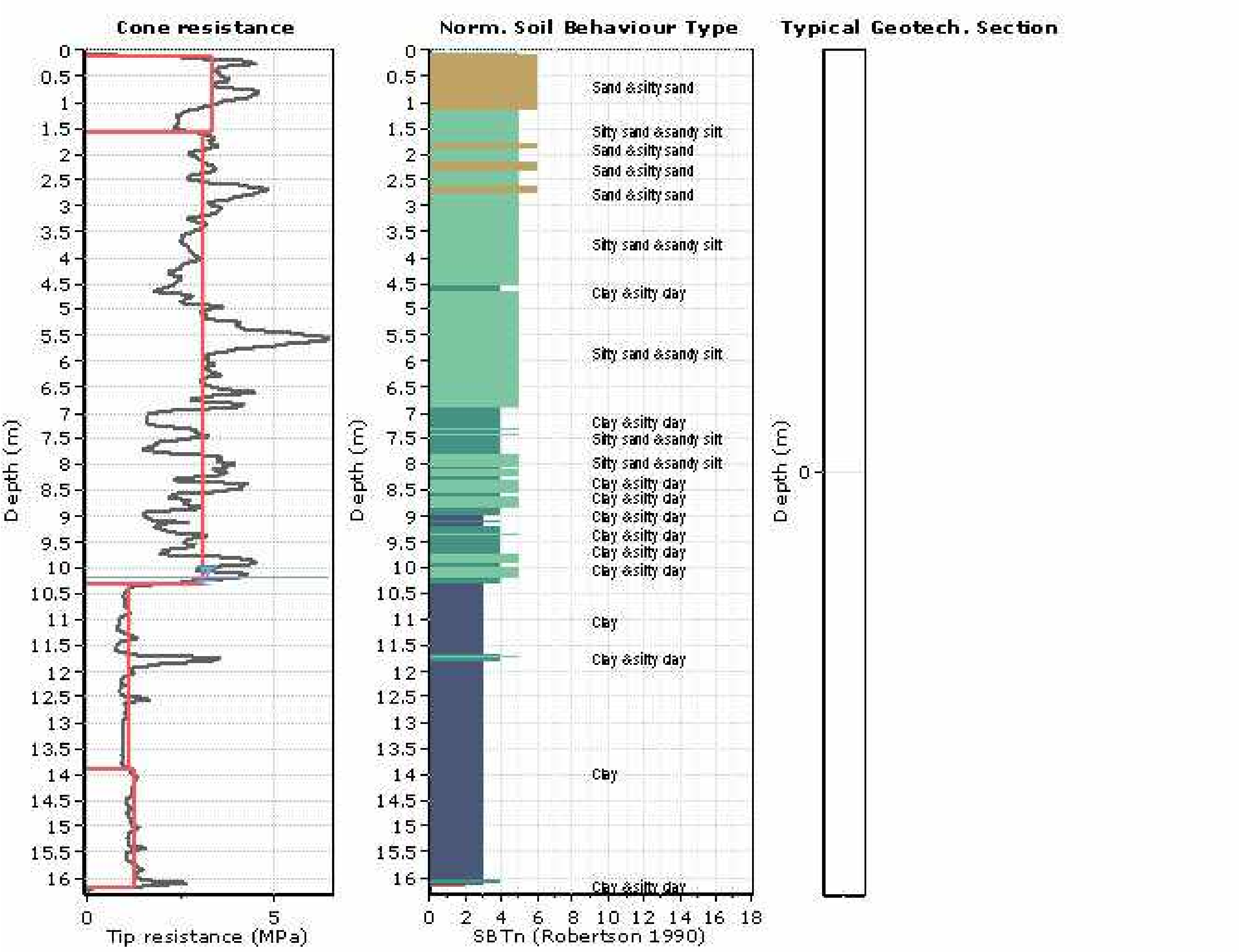

Piezocone Dissipation Test: KP CPT 02
Depth: 9.10 (m)
assumed initial pore pressure, ui
u initial dissipation
u0 = 0.00 (kPa)
4.89
Porepressure u2 (kPa)
t^0.50 (s^0.50)


Pore pressure
Depth (m)
Pressure (kPa)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: KP CPT 02
Depth: 12.00 (m)
assumed initial pore pressure, ui
u initial dissipation
5.518
u0 = 17.66 (kPa)
Porepressure u2 (kPa)
t^0.50 (s^0.50)
Pore pressure
Depth (m)
Pressure (kPa)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: KP CPT 02
Depth: 15.00 (m)
assumed initial pore pressure, ui
u initial dissipation
u0 = 47.09 (kPa)
2.758
Porepressure u2 (kPa)
t^0.50 (s^0.50)


Pore pressure
Depth (m)
Pressure (kPa)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0



Tabular results

.:: Layer No: 1 ::.

Code: Layer_1 **Start depth:** 0.10 (m), **End depth:** 1.56 (m)

Description: Sand & silty sand

Basic results

Total cone resistance: 3.35 ±0.73 MPa
Sleeve friction: 39.16 ±9.99 kPa
Ic: 1.94 ±0.16
SBT_n: 6
SBTn description: Sand & silty sand

Estimation results

Permeability: 1.99E-05 ±2.34E-05 m/s
N_{60}: 8.61 ±1.46 blows
Es: 27.60 ±3.99 MPa
Dr (%): 55.86 ±11.20
φ (degrees): 38.71 ±1.89 °
Unit weight: 19.00 ±0.00 kN/m³

Constrained Mod.: 55.21 ±7.98 MPa
Go: 34.60 ±5.00 MPa
Su: 0.00 ±0.00 kPa
Su ratio: 0.00 ±0.00
O.C.R.: 0.00 ±0.00

.:: Layer No: 2 ::.

Code: Layer_2 **Start depth:** 1.56 (m), **End depth:** 10.30 (m)

Description: Silty sand & sandy silt

Basic results

Total cone resistance: 3.09 ±0.89 MPa
Sleeve friction: 35.79 ±10.28 kPa
Ic: 2.42 ±0.24
SBT_n: 5
SBTn description: Silty sand & sandy silt

Estimation results

Permeability: 1.20E-06 ±1.92E-06 m/s
N_{60}: 10.72 ±2.33 blows
Es: 44.23 ±10.11 MPa
Dr (%): 31.94 ±6.29
φ (degrees): 34.37 ±1.09 °
Unit weight: 19.00 ±0.00 kN/m³

Constrained Mod.: 46.69 ±21.24 MPa
Go: 56.40 ±12.10 MPa
Su: 0.00 ±0.00 kPa
Su ratio: 0.00 ±0.00
O.C.R.: 0.00 ±0.00

.:: Layer No: 3 ::.

Code: Layer_3 **Start depth:** 10.30 (m), **End depth:** 13.88 (m)

Description: Clay

Basic results

Total cone resistance: 1.12 ±0.45 MPa
Sleeve friction: 20.94 ±9.31 kPa
Ic: 3.29 ±0.16
SBT_n: 3
SBTn description: Clay

Estimation results

Permeability: 4.04E-09 ±1.69E-08 m/s
N_{60}: 6.69 ±1.62 blows
Es: 0.00 ±0.00 MPa
Dr (%): 0.00 ±0.00
φ (degrees): 0.00 ±0.00 °
Unit weight: 19.00 ±0.00 kN/m³

Constrained Mod.: 4.65 ±7.15 MPa
Go: 48.59 ±9.15 MPa
Su: 62.32 ±29.48 kPa
Su ratio: 0.30 ±0.15
O.C.R.: 1.37 ±0.68

.:: Layer No: 4 ::.

Code: 13.88 **Start depth:** 13.88 (m), **End depth:** 16.18 (m)

Description: Clay

Basic results

Total cone resistance: 1.24 ±0.27 MPa
Sleeve friction: 22.01 ±8.03 kPa
Ic: 3.28 ±0.15
SBT_n: 3
SBTn description: Clay

Estimation results

Permeability: 2.89E-09 ±1.02E-08 m/s
N_{60}: 7.53 ±0.87 blows
Es: 0.00 ±0.00 MPa
Dr (%): 0.00 ±0.00
φ (degrees): 0.00 ±0.00 °
Unit weight: 19.00 ±0.00 kN/m³

Constrained Mod.: 4.09 ±2.94 MPa
Go: 53.68 ±5.30 MPa
Su: 68.11 ±18.64 kPa
Su ratio: 0.29 ±0.07
O.C.R.: 1.32 ±0.34

Summary table of mean values

From depth To depth (m)	Thickness (m)	Permeability (m/s)	SPT_{N60} (blows/30cm)	E_s (MPa)	D_r (%)	Friction angle	Constrained modulus, M (MPa)	Shear modulus, G_O (MPa)	Undrained strength, S_U (kPa)	Undrained strength ratio	OCR	Unit weight (kN/m³)
0.10 1.56	1.46	1.99E-05 (±2.34E-05)	8.6 (±1.5)	27.6 (±4.0)	55.9 (±11.2)	38.7 (±1.9)	55.2 (±8.0)	34.6 (±5.0)	0.0 (±0.0)	0.0 (±0.0)	0.0 (±0.0)	19.0 (±0.0)
1.56 10.30	8.74	1.20E-06 (±1.92E-06)	10.7 (±2.3)	44.2 (±10.1)	31.9 (±6.3)	34.4 (±1.1)	46.7 (±21.2)	56.4 (±12.1)	0.0 (±0.0)	0.0 (±0.0)	0.0 (±0.0)	19.0 (±0.0)
10.30 13.88	3.58	4.04E-09 (±1.69E-08)	6.7 (±1.6)	0.0 (±0.0)	0.0 (±0.0)	0.0 (±0.0)	4.6 (±7.1)	48.6 (±9.2)	62.3 (±29.5)	0.3 (±0.1)	1.4 (±0.7)	19.0 (±0.0)
13.88 16.18	2.30	2.89E-09 (±1.02E-08)	7.5 (±0.9)	0.0 (±0.0)	0.0 (±0.0)	0.0 (±0.0)	4.1 (±2.9)	53.7 (±5.3)	68.1 (±18.6)	0.3 (±0.1)	1.3 (±0.3)	19.0 (±0.0)

Depth values presented in this table are measured from free ground surface

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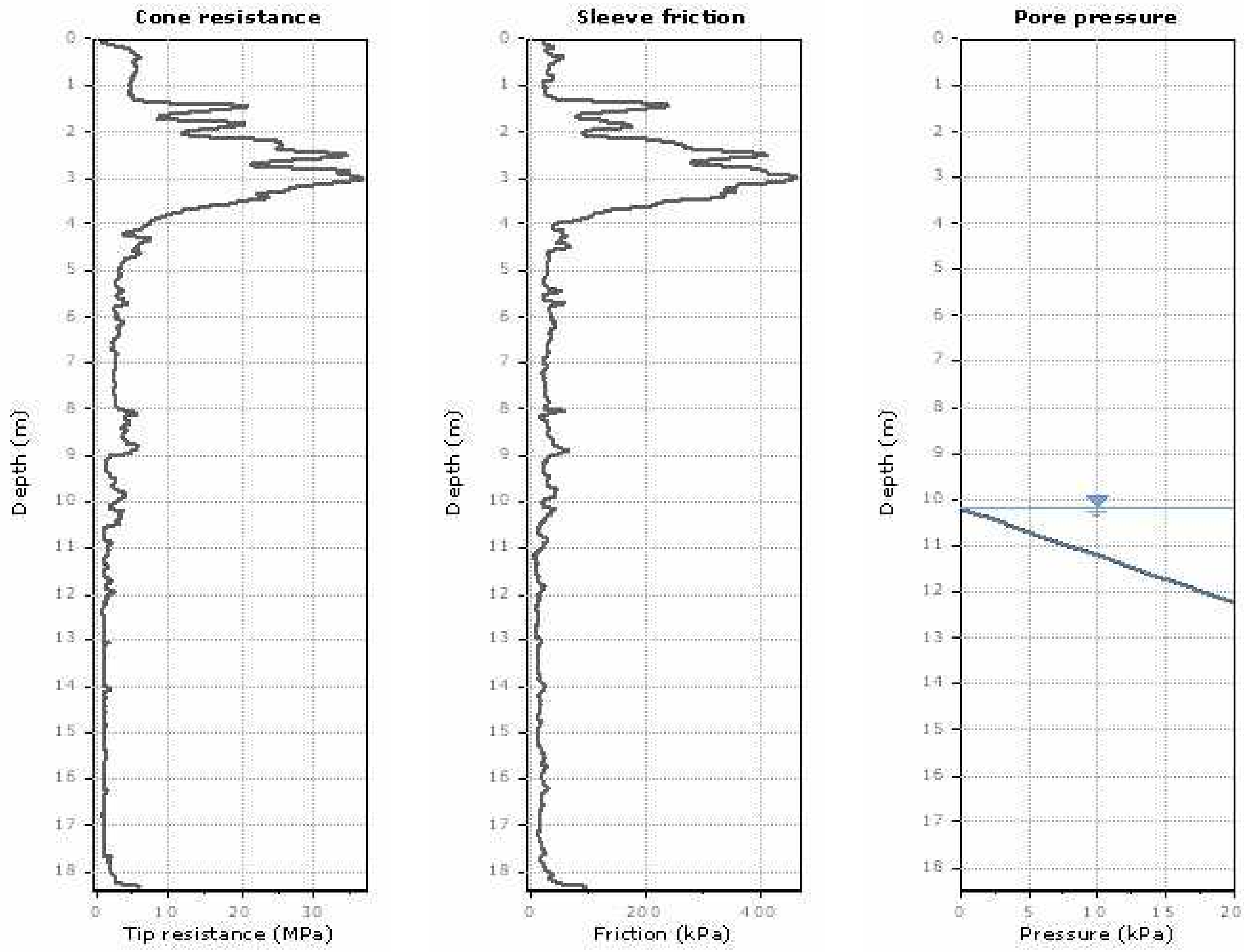
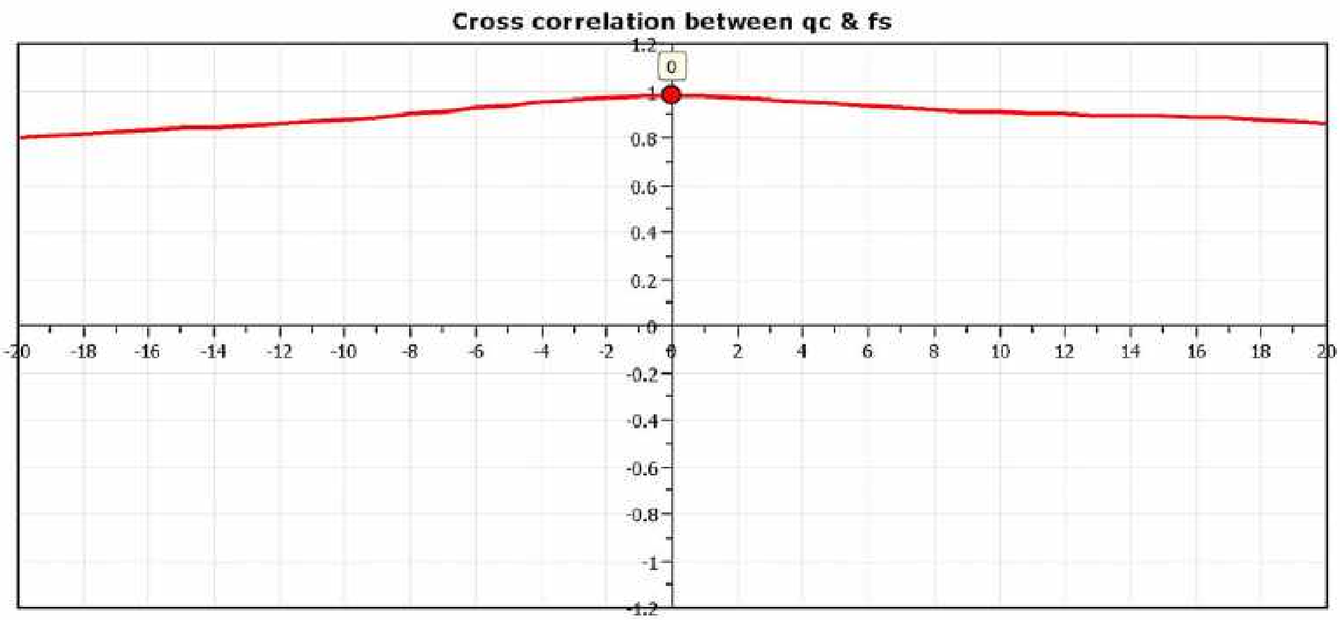
Perth WA 6004, Australia
http://www.knightpiesold.com/

CPT: KP CPT03
Total depth: 18.40 m, Date: 3/09/2020
Coords: lat 305916.6° lon 6880462.7°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

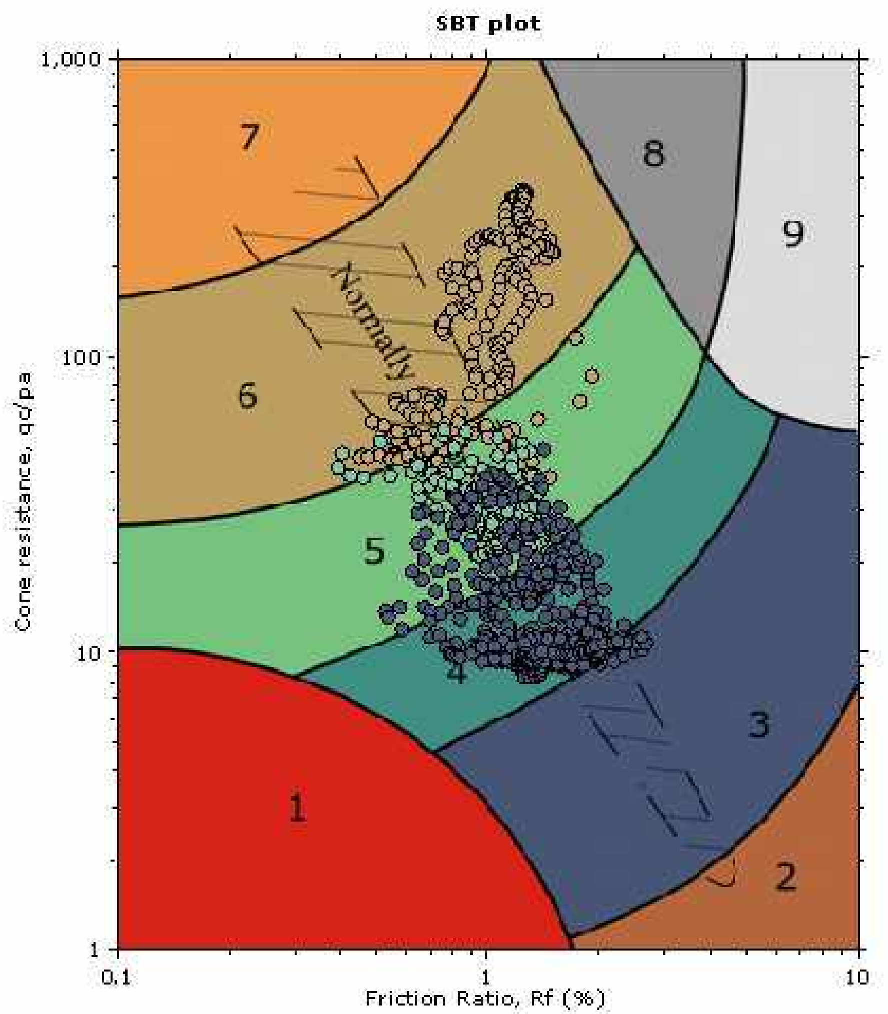
Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**

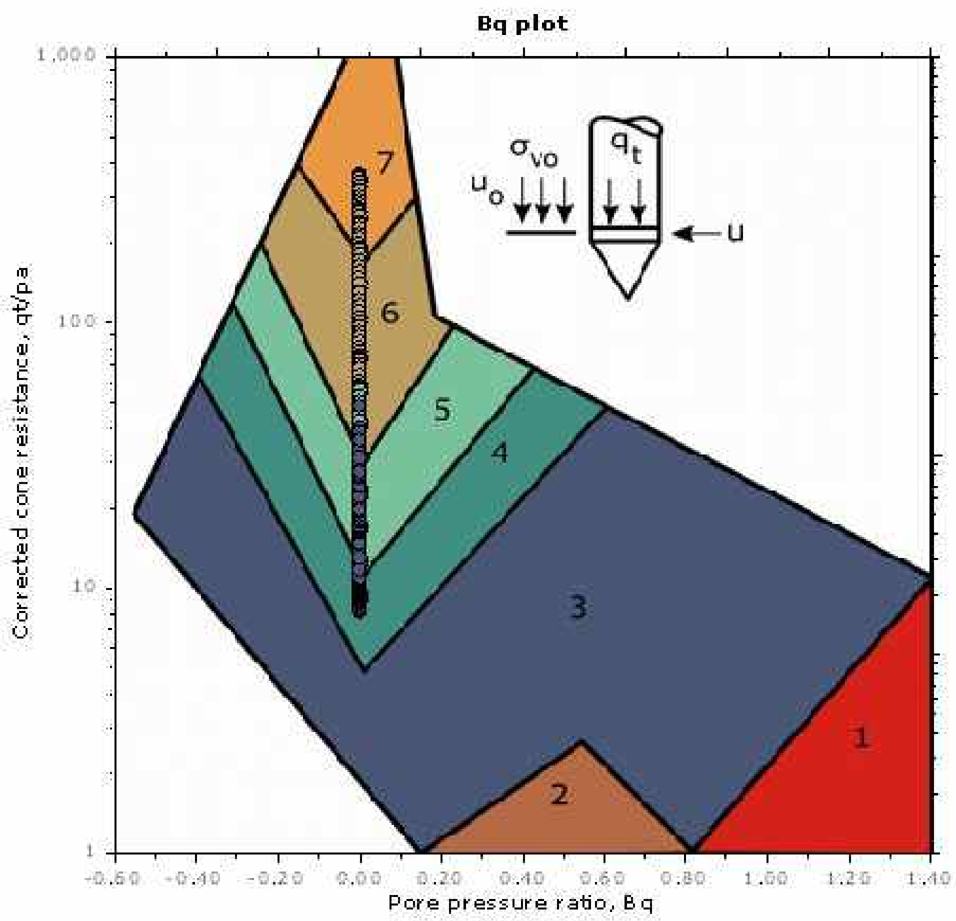


The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



SBT - Bq plots

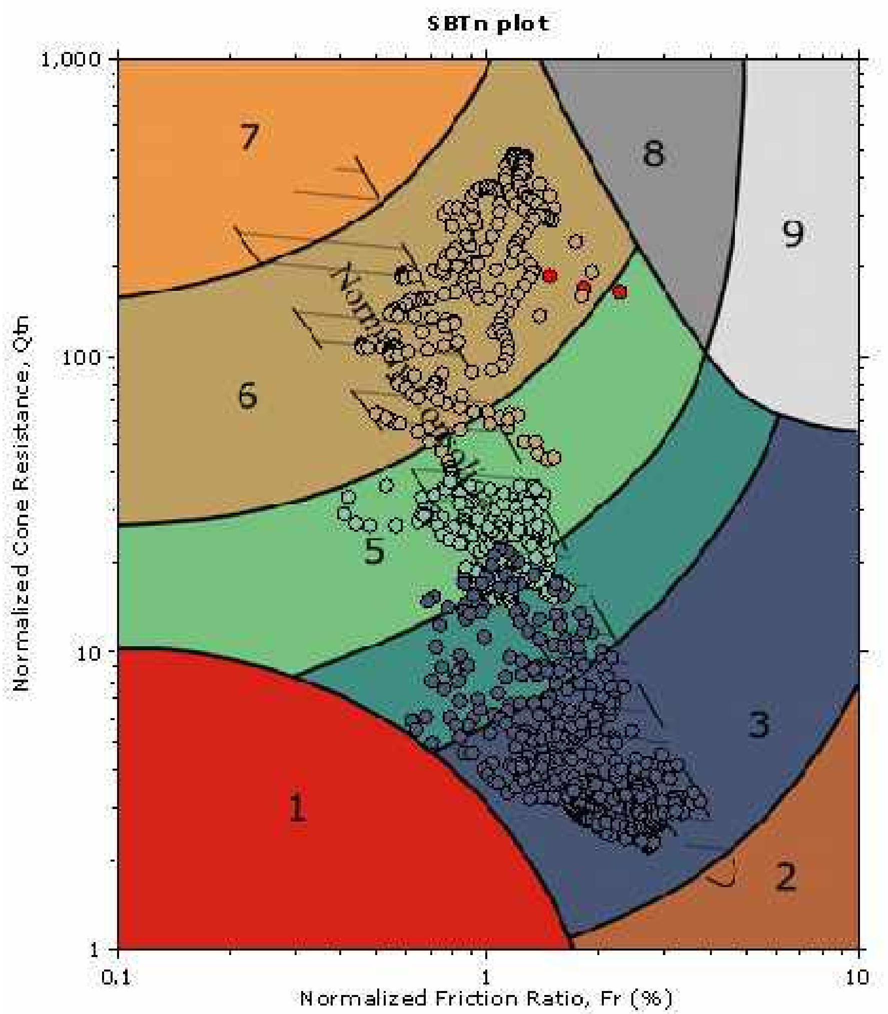


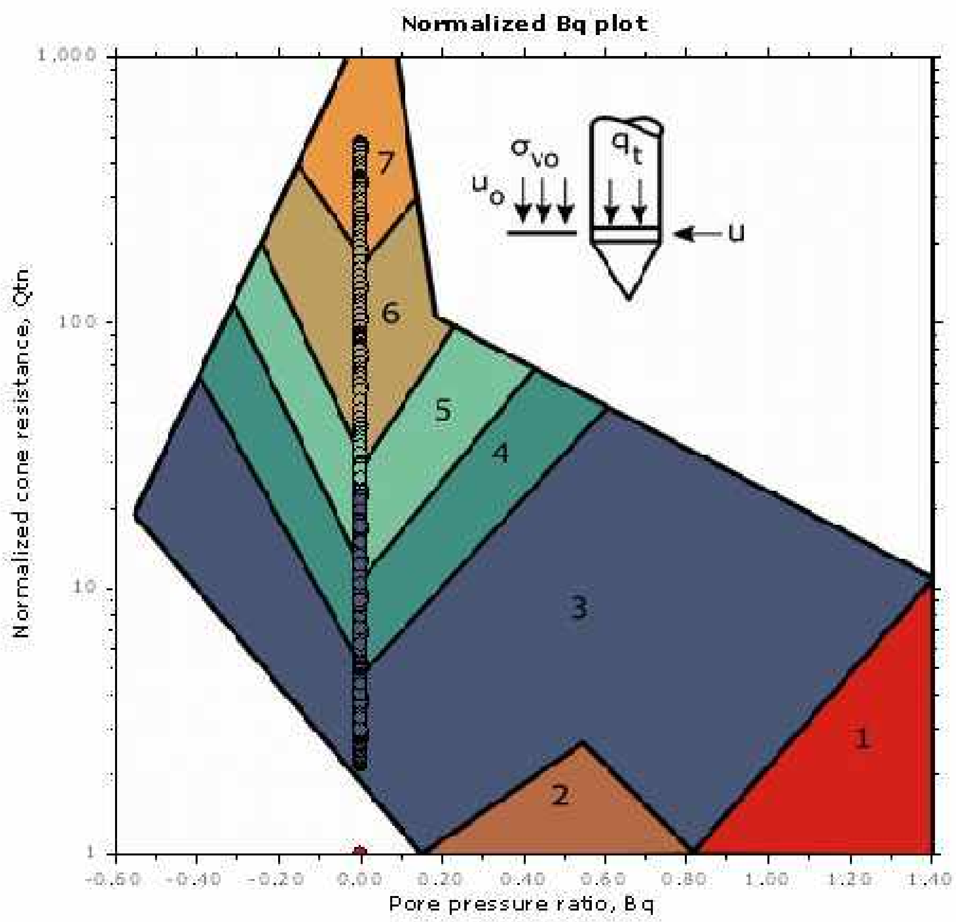


SBT legend

- 1. Sensitive fine grained
- 2. Organic material
- 3. Clay to silty clay
- 4. Clayey silt to silty clay
- 5. Silty sand to sandy silt
- 6. Clean sand to silty sand
- 7. Gravelly sand to sand
- 8. Very stiff sand to clayey sand
- 9. Very stiff fine grained

SBT - Bq plots (normalized)

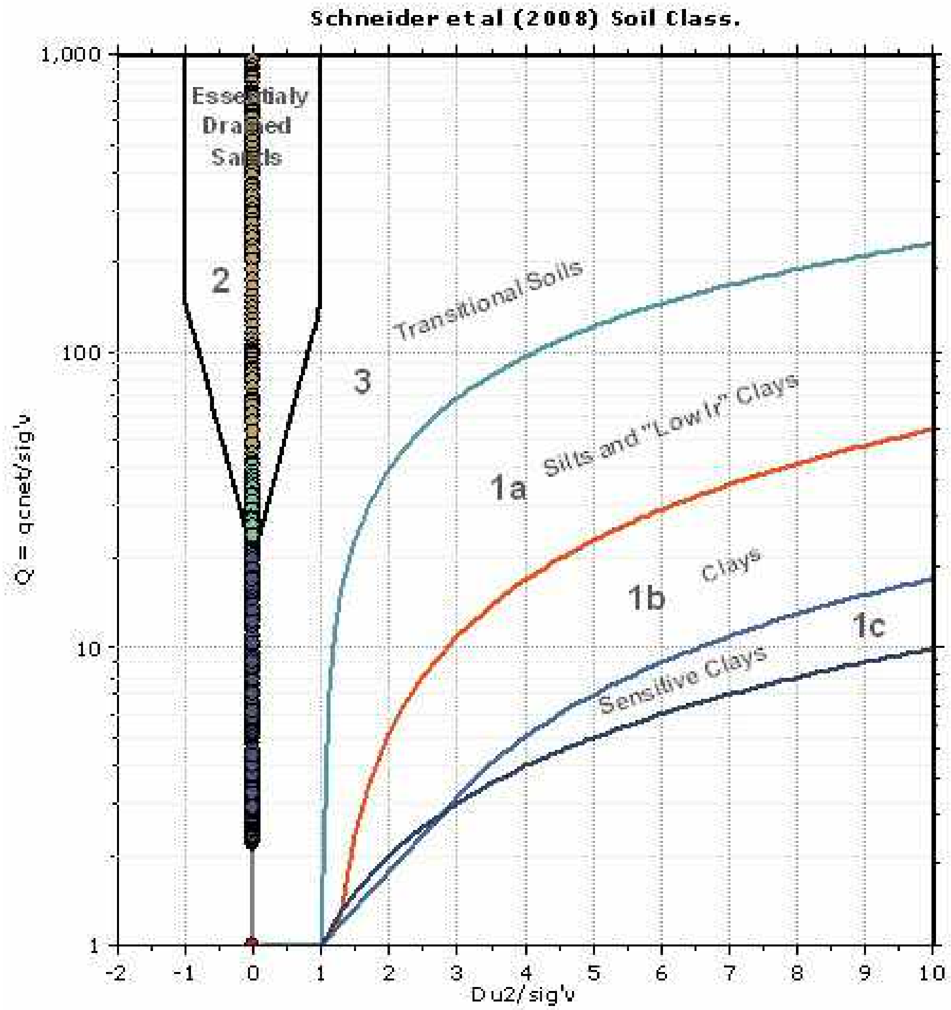


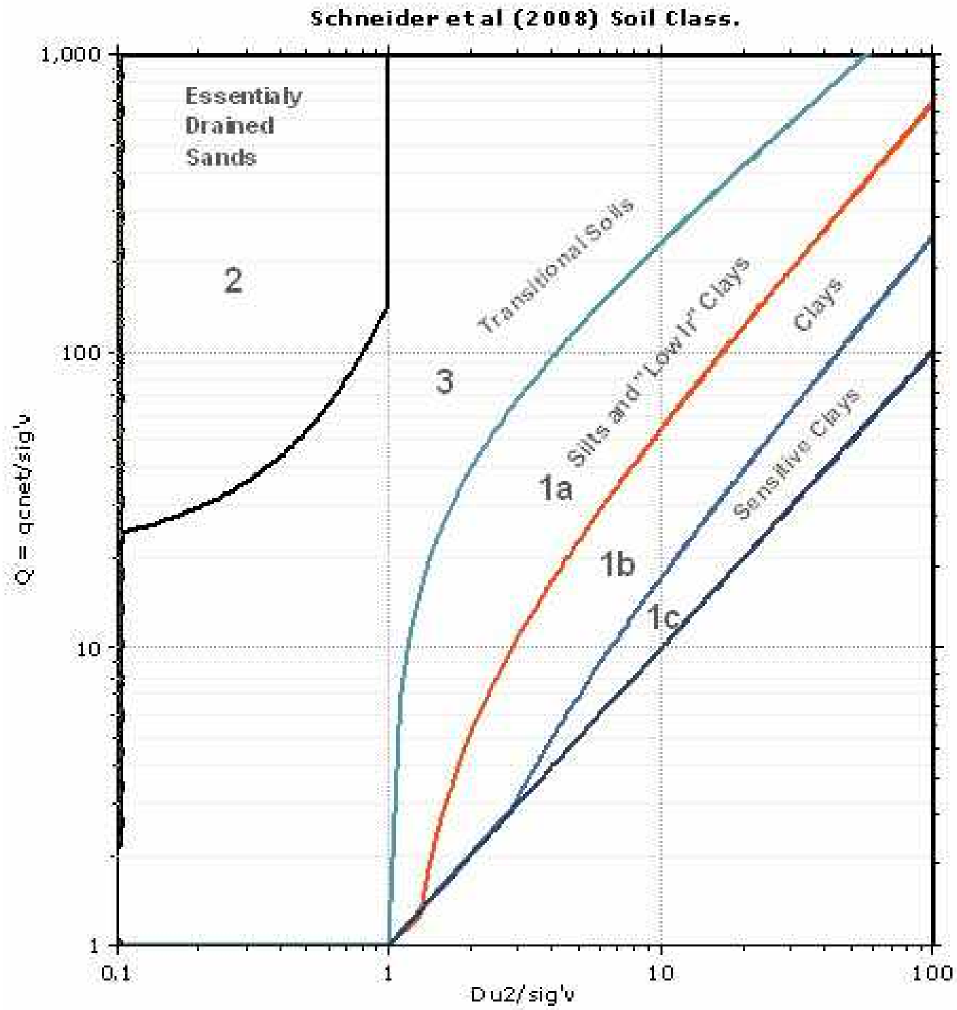


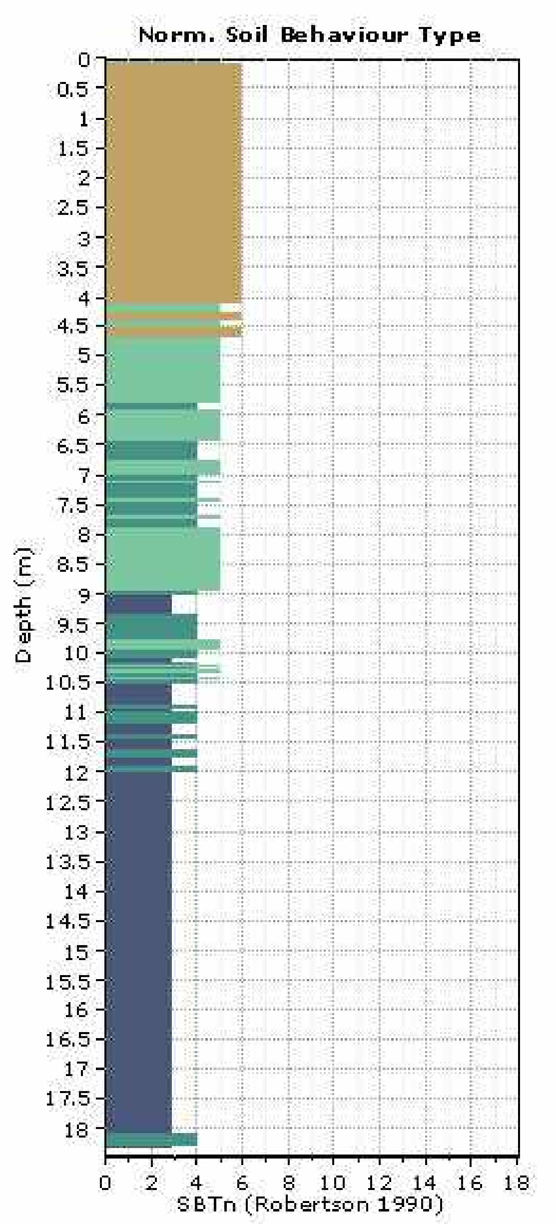
SBTn legend

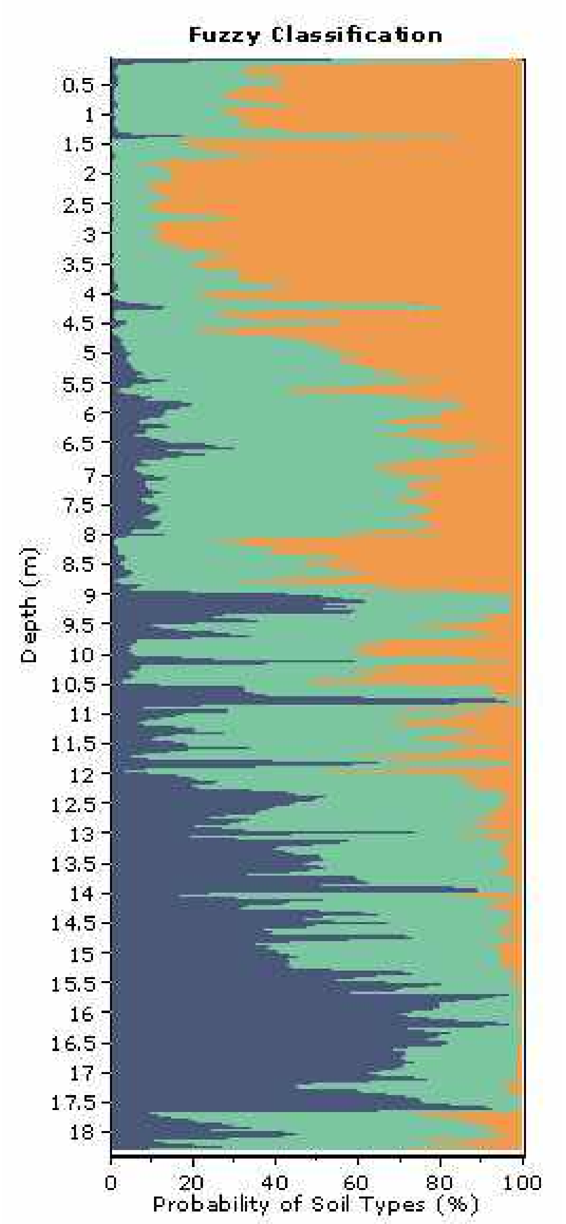
1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravelly sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

Bq plots (Schneider)





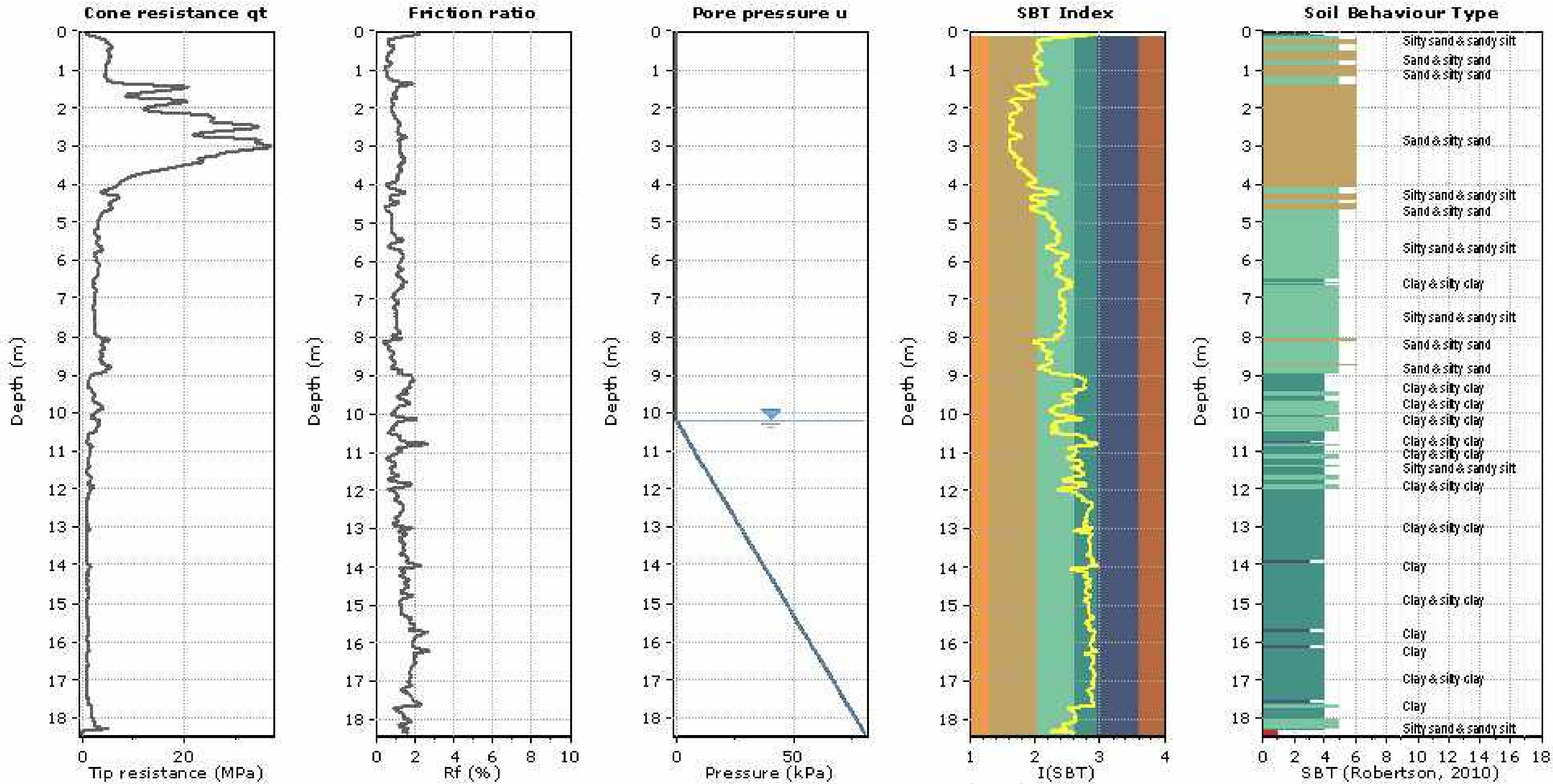

Norm. Soil Behaviour Type
Depth (m)
SBTn (Robertson 1990)


Fuzzy Classification
Depth (m)
Probability of Soil Types (%)

Knight Piésold Consulting
Level 1, 184 Adelaide Terrace
Perth WA 6004, Australia
http://www.knightpiesold.com/

CPT: KP CPT03
Total depth: 18.40 m, Date: 3/09/2020
Coords: lat 305916.6° lon 6880462.7°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**



SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

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Project: **Thunderbox Gold Mine**
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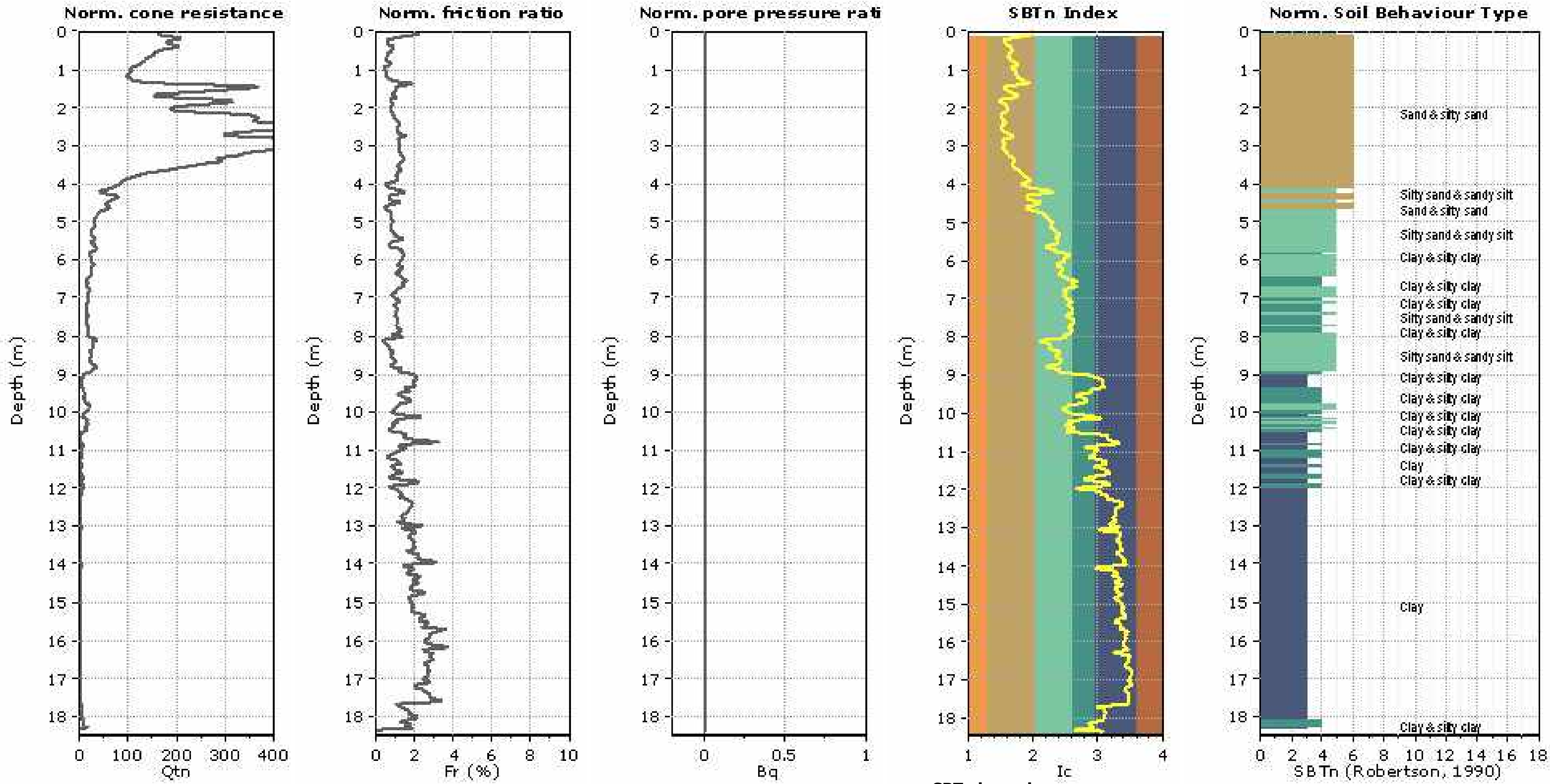

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
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Project: **Thunderbox Gold Mine**
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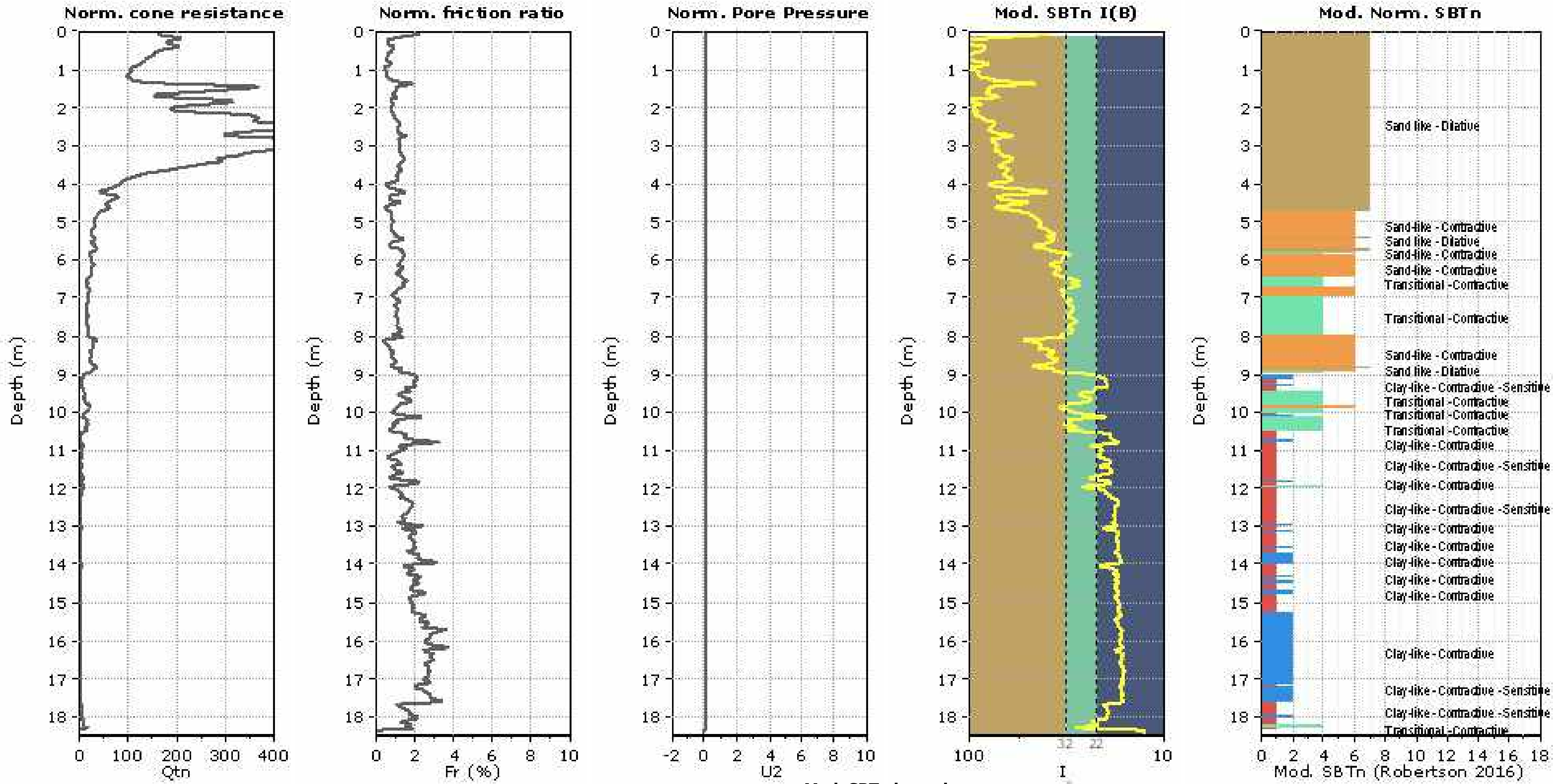

Mod. SBTn legend
1. CCS: ClayLike - Contractive, Sensitive
2. CC: Clay-like - Contractive
3. CD: Clay-Like: Dilative
4. TC: Transitional - Contractive
5. TD: Transitional - Dilative
6. SC: Sand-like - Contractive
7. SD: Sand-like - Dilative

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CPT: KP CPT03
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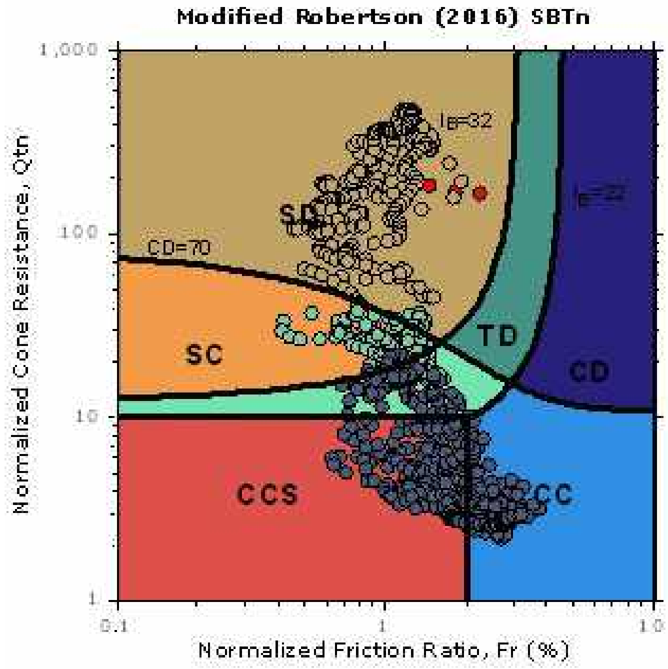
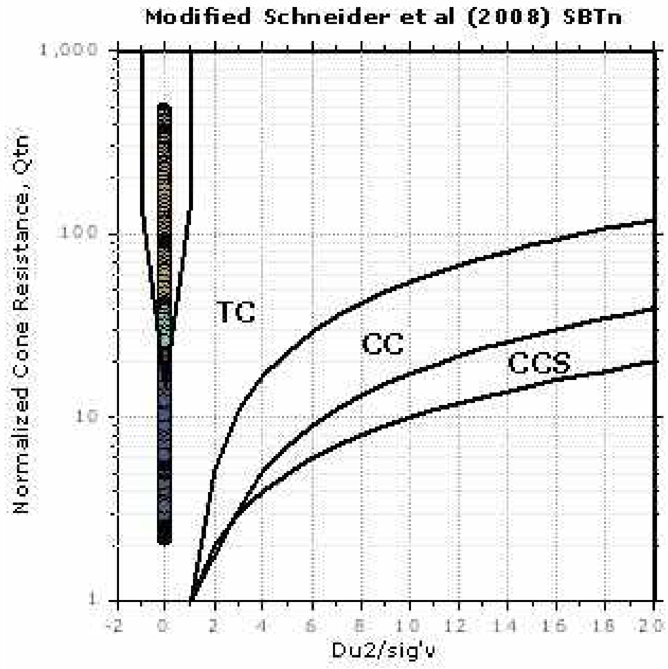
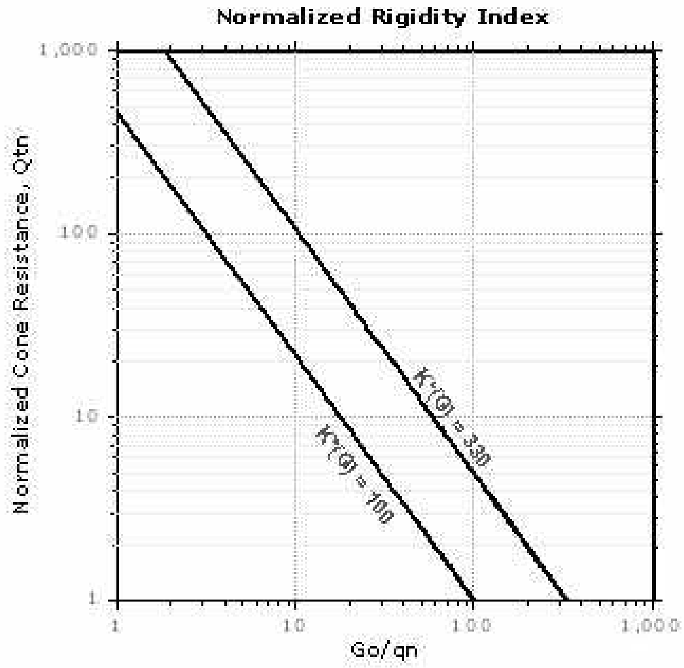
Coords: lat 305916.6° lon 6880462.7°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**

Updated SBTn plots







CCS: Clay-like - Contractive - Sensitive
CC: Clay-like - Contractive
CD: Clay-like - Dilative
TC: Transitional - Contractive
TD: Transitional - Dilative
SC: Sand-like - Contractive
SD: Sand-like - Dilative

K(G) > 330: Soils with significant microstructure (e.g. age/cementation)

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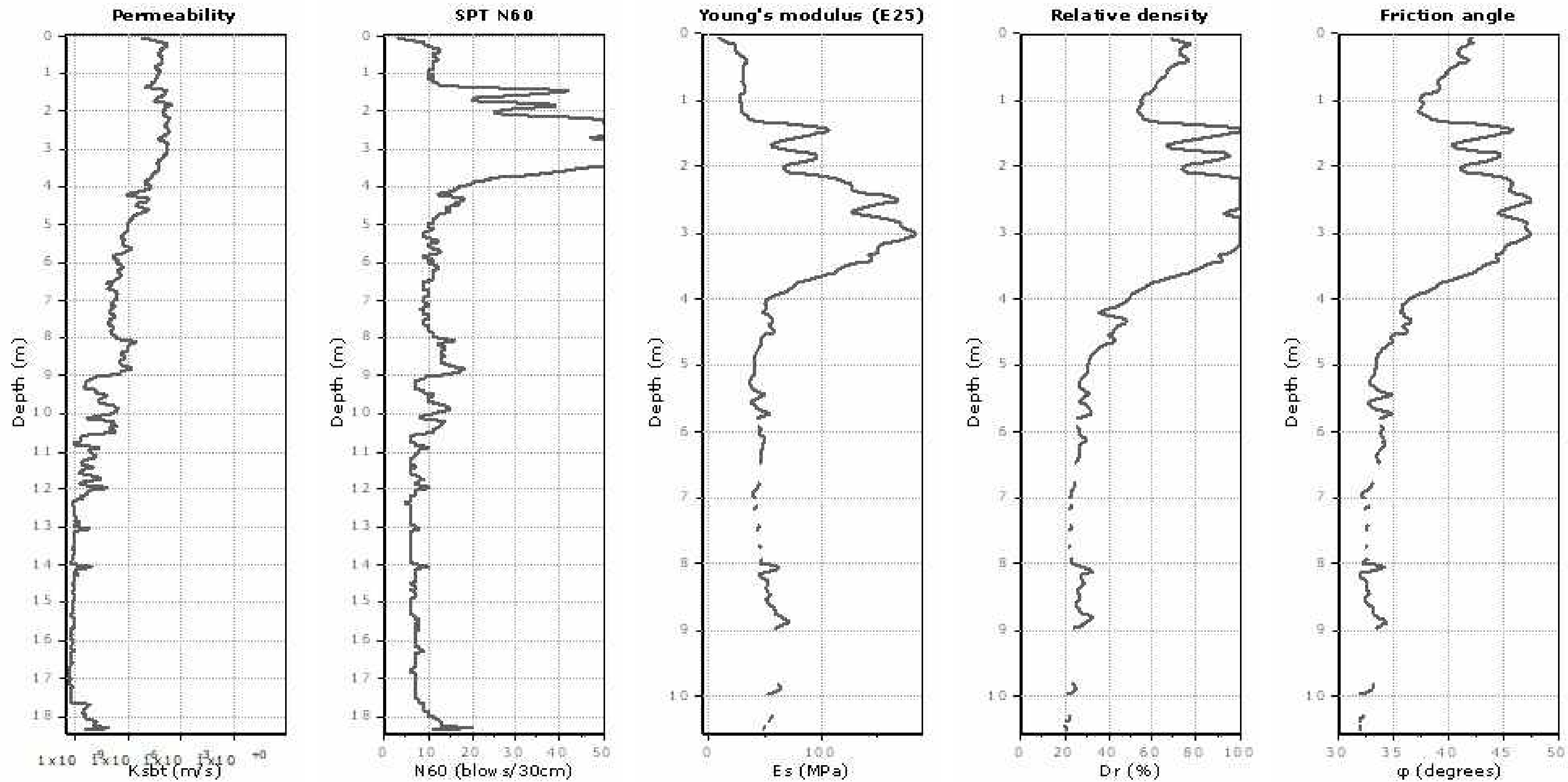
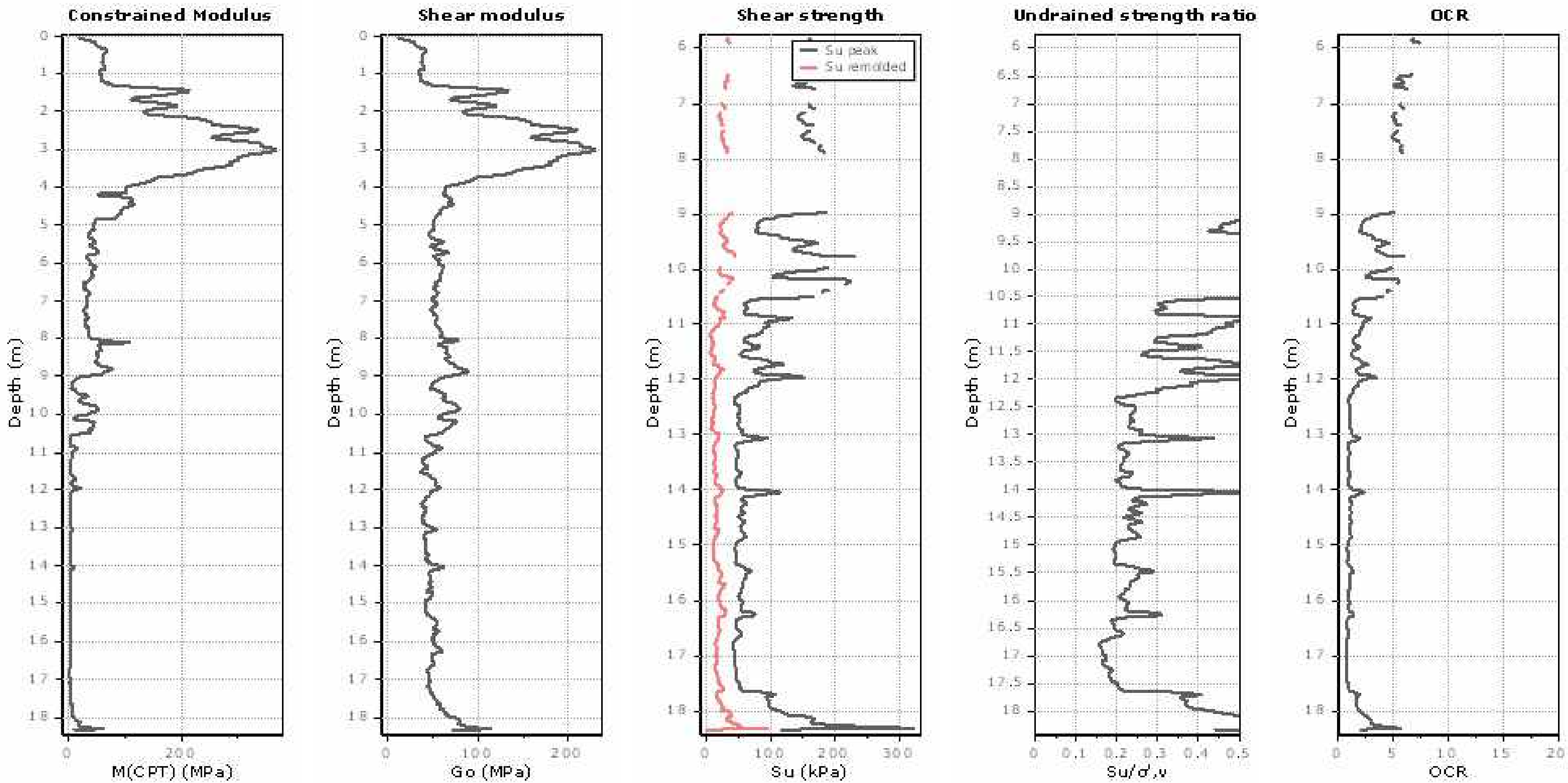
CPT: KP CPT03
Total depth: 18.40 m, Date: 3/09/2020
Coords: lat 305916.6° lon 6880462.7°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**



Calculation parameters
Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative density constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data



Calculation parameters

Constrained modulus: Based on variable alpha using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable alpha using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14

OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

Knight Piésold Consulting
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Perth WA 6004, Australia
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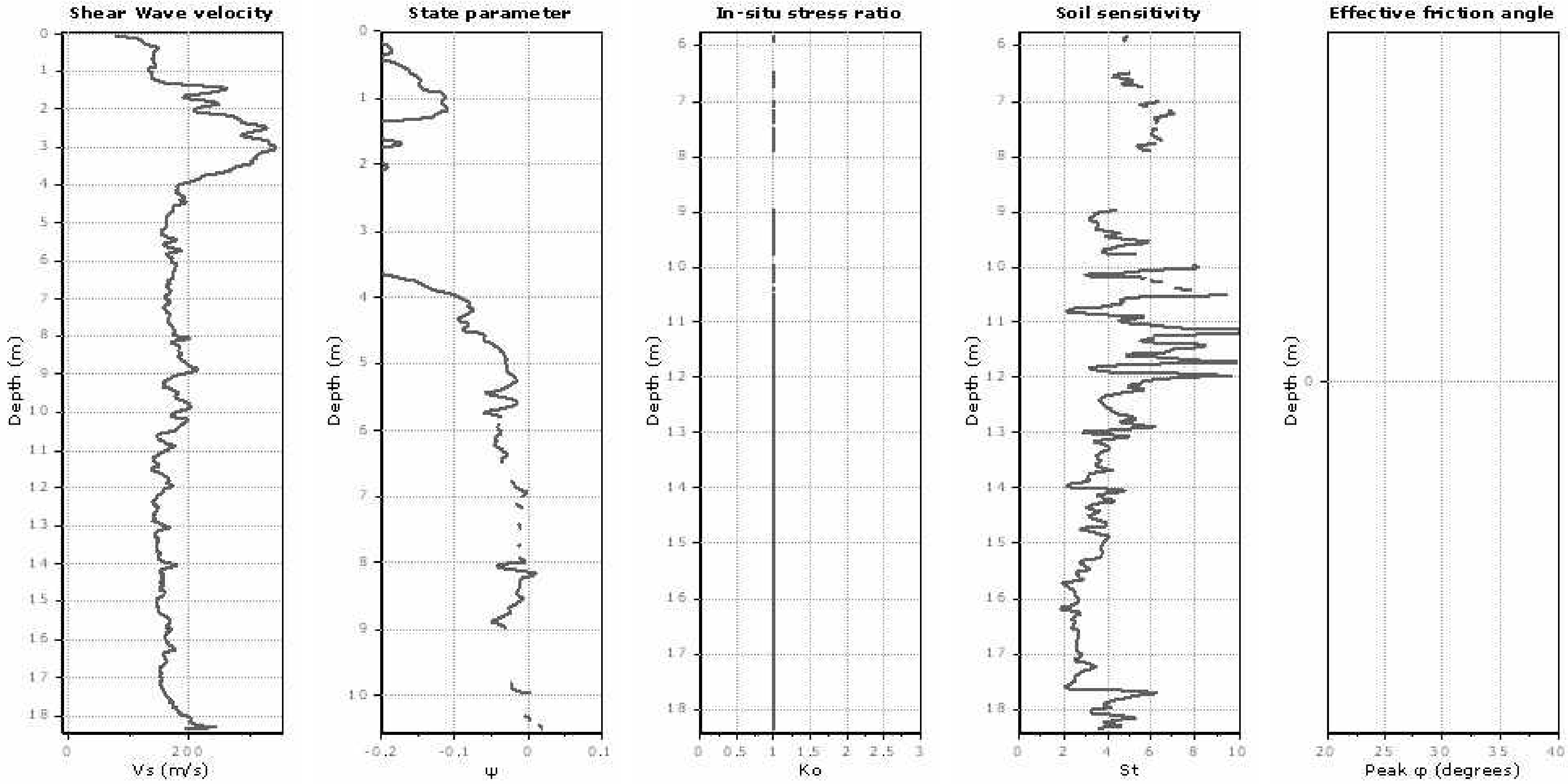
CPT: KP CPT03
Total depth: 18.40 m, Date: 3/09/2020
Coords: lat 305916.6° lon 6880462.7°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

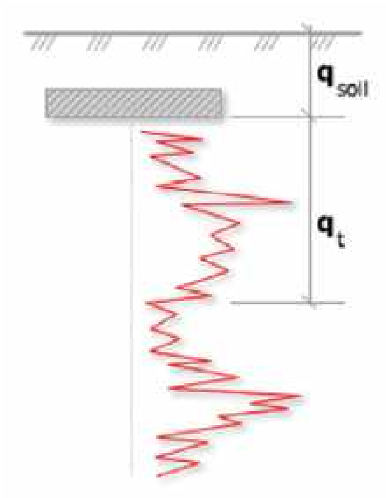
Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**



Calculation parameters

Soil Sensitivity factor, N_S: 7.00

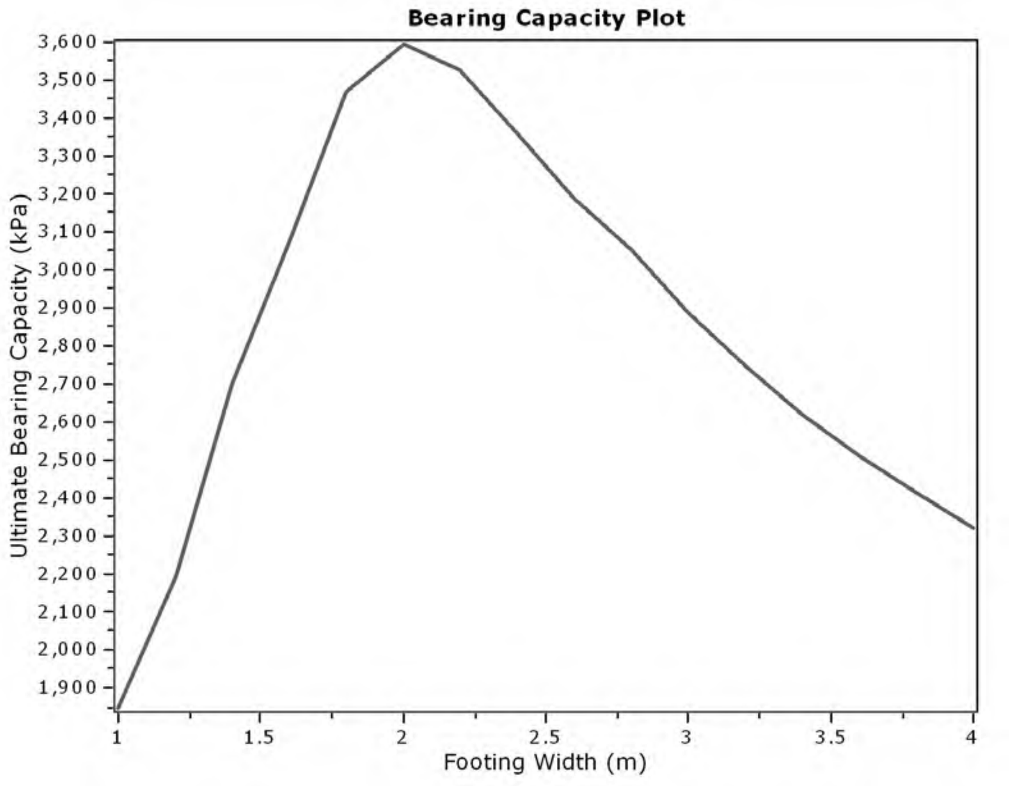
User defined estimation data



Bearing Capacity calculation is perfromed based on the formula:

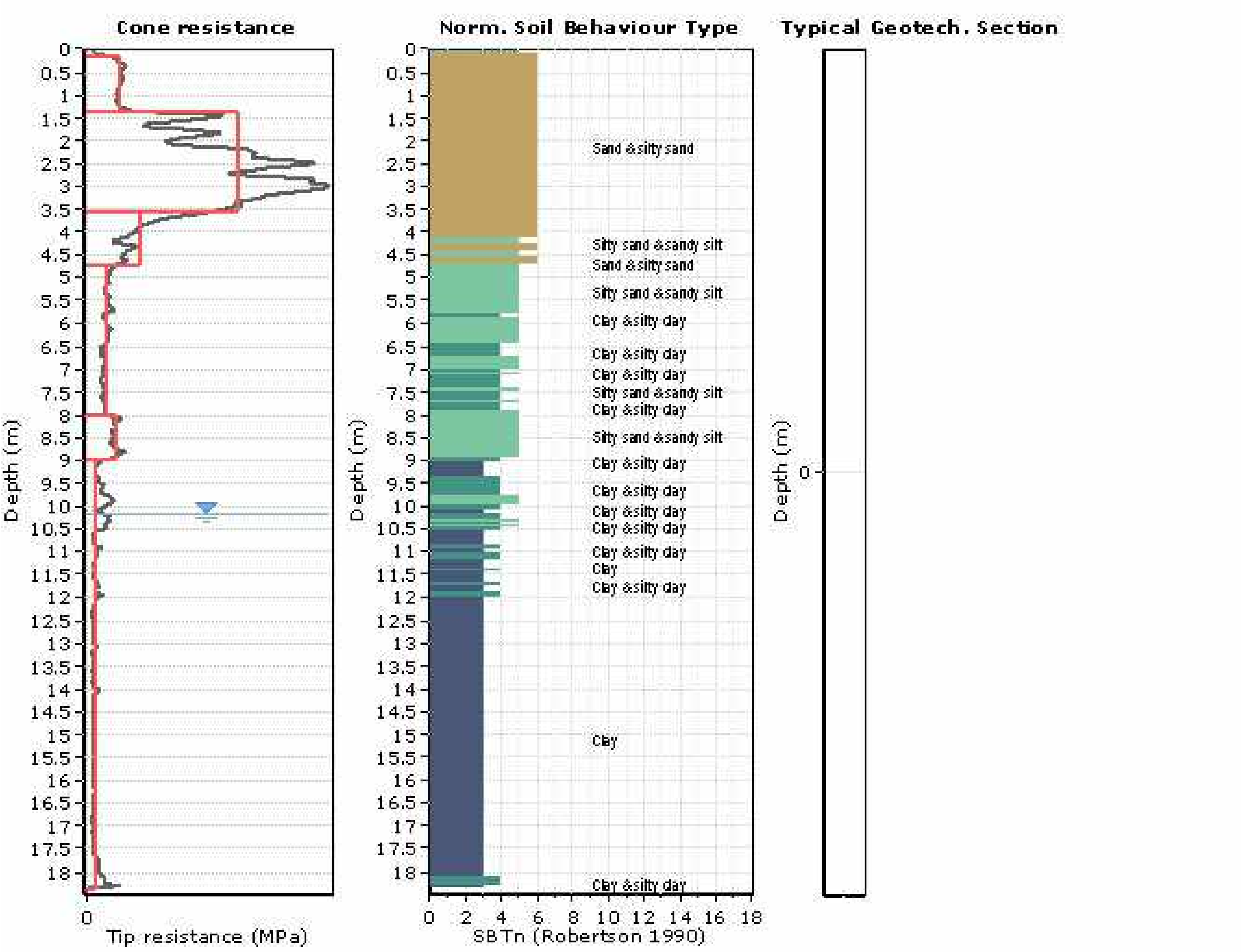
$$Q_{ult} = R_k \times q_t + q_{soil}$$

where:
R_k: Bearing capacity factor
q_t: Average corrected cone resistance over calculation depth
q_{soil}: Pressure applied by soil above footing



:: Tabular results ::

No	B (m)	Start Depth (m)	End Depth (m)	Ave. q_t (MPa)	R_k	Soil Press. (kPa)	Ult. bearing cap. (kPa)
1	1.00	0.50	2.00	9.20	0.20	9.50	1849.53
2	1.20	0.50	2.30	10.94	0.20	9.50	2197.03
3	1.40	0.50	2.60	13.45	0.20	9.50	2700.30
4	1.60	0.50	2.90	15.34	0.20	9.50	3076.58
5	1.80	0.50	3.20	17.30	0.20	9.50	3470.19
6	2.00	0.50	3.50	17.92	0.20	9.50	3593.73
7	2.20	0.50	3.80	17.59	0.20	9.50	3527.00
8	2.40	0.50	4.10	16.75	0.20	9.50	3359.22
9	2.60	0.50	4.40	15.90	0.20	9.50	3189.42
10	2.80	0.50	4.70	15.22	0.20	9.50	3052.56
11	3.00	0.50	5.00	14.40	0.20	9.50	2889.34
12	3.20	0.50	5.30	13.69	0.20	9.50	2747.15
13	3.40	0.50	5.60	13.07	0.20	9.50	2623.06
14	3.60	0.50	5.90	12.52	0.20	9.50	2513.83
15	3.80	0.50	6.20	12.03	0.20	9.50	2415.16
16	4.00	0.50	6.50	11.58	0.20	9.50	2324.94



Tabular results

.:: Layer No: 1 ::.

Code: Layer_1 **Start depth:** 0.14 (m), **End depth:** 1.36 (m)

Description: Sand & silty sand

Basic results	Estimation results	
Total cone resistance: 5.06 ±0.73 MPa	Permeability: 7.14E-05 ±3.95E-05 m/s	Constrained Mod.: 63.13 ±14.99 MPa
Sleeve friction: 37.94 ±22.99 kPa	N_{60}: 11.21 ±2.07 blows	Go: 39.56 ±9.40 MPa
Ic: 1.70 ±0.09	Es: 31.57 ±7.50 MPa	Su: 0.00 ±0.00 kPa
SBT_n: 6	Dr (%): 63.95 ±7.83	Su ratio: 0.00 ±0.00
SBTn description: Sand & silty sand	φ (degrees): 39.47 ±1.57 °	O.C.R.: 0.00 ±0.00
	Unit weight: 19.00 ±0.00 kN/m³	

.:: Layer No: 2 ::.

Code: Layer_2 **Start depth:** 1.36 (m), **End depth:** 3.54 (m)

Description: Sand & silty sand

Basic results	Estimation results	
Total cone resistance: 22.99 ±7.89 MPa	Permeability: 1.35E-04 ±6.14E-05 m/s	Constrained Mod.: 247.69 ±75.48 MPa
Sleeve friction: 268.59 ±114.24 kPa	N_{60}: 47.55 ±15.26 blows	Go: 155.22 ±47.30 MPa
Ic: 1.61 ±0.08	Es: 123.84 ±37.74 MPa	Su: 0.00 ±0.00 kPa
SBT_n: 6	Dr (%): 92.09 ±9.93	Su ratio: 0.00 ±0.00
SBTn description: Sand & silty sand	φ (degrees): 44.74 ±1.95 °	O.C.R.: 0.00 ±0.00
	Unit weight: 19.00 ±0.00 kN/m³	

.:: Layer No: 3 ::.

Code: Layer_3 **Start depth:** 3.54 (m), **End depth:** 4.74 (m)

Description: Sand & silty sand

Basic results	Estimation results	
Total cone resistance: 7.92 ±3.75 MPa	Permeability: 1.45E-05 ±1.22E-05 m/s	Constrained Mod.: 124.35 ±44.34 MPa
Sleeve friction: 78.97 ±55.10 kPa	N_{60}: 20.20 ±7.87 blows	Go: 80.17 ±25.20 MPa
Ic: 1.96 ±0.14	Es: 63.97 ±20.11 MPa	Su: 0.00 ±0.00 kPa
SBT_n: 6	Dr (%): 49.94 ±12.06	Su ratio: 0.00 ±0.00
SBTn description: Sand & silty sand	φ (degrees): 37.18 ±2.37 °	O.C.R.: 0.00 ±0.00
	Unit weight: 19.00 ±0.00 kN/m³	

.:: Layer No: 4 ::.

Code: Layer_4 **Start depth:** 4.74 (m), **End depth:** 8.00 (m)

Description: Silty sand & sandy silt

Basic results	Estimation results	
Total cone resistance: 2.83 ±0.49 MPa	Permeability: 4.54E-07 ±4.98E-07 m/s	Constrained Mod.: 38.89 ±10.55 MPa
Sleeve friction: 30.10 ±6.92 kPa	N_{60}: 10.20 ±1.07 blows	Go: 54.55 ±4.41 MPa
Ic: 2.47 ±0.13	Es: 43.85 ±3.95 MPa	Su: 0.00 ±0.00 kPa
SBT_n: 5	Dr (%): 27.59 ±3.27	Su ratio: 0.00 ±0.00
SBTn description: Silty sand & sandy silt	φ (degrees): 33.37 ±0.67 °	O.C.R.: 0.00 ±0.00
	Unit weight: 19.00 ±0.00 kN/m³	

.:: Layer No: 5 ::.

Code: Layer_5 **Start depth:** 8.00 (m), **End depth:** 8.96 (m)

Description: Silty sand & sandy silt

Basic results	Estimation results	
Total cone resistance: 4.22 ±0.61 MPa	Permeability: 8.51E-07 ±6.69E-07 m/s	Constrained Mod.: 58.89 ±13.25 MPa
Sleeve friction: 36.18 ±12.36 kPa	N_{60}: 14.24 ±1.65 blows	Go: 70.76 ±8.37 MPa
Ic: 2.34 ±0.10	Es: 56.46 ±6.68 MPa	Su: 0.00 ±0.00 kPa
SBT_n: 5	Dr (%): 27.87 ±2.17	Su ratio: 0.00 ±0.00
SBTn description: Silty sand & sandy silt	φ (degrees): 32.97 ±0.67 °	O.C.R.: 0.00 ±0.00
	Unit weight: 19.00 ±0.00 kN/m³	

.:: Layer No: 6 ::.

Code: Layer_6 **Start depth:** 8.96 (m), **End depth:** 18.36 (m)

Description: Clay

Basic results

Total cone resistance: 1.41 ±0.70 MPa
Sleeve friction: 19.58 ±9.26 kPa
Ic: 3.17 ±0.30
SBT_n: 3
SBTn description: Clay

Estimation results

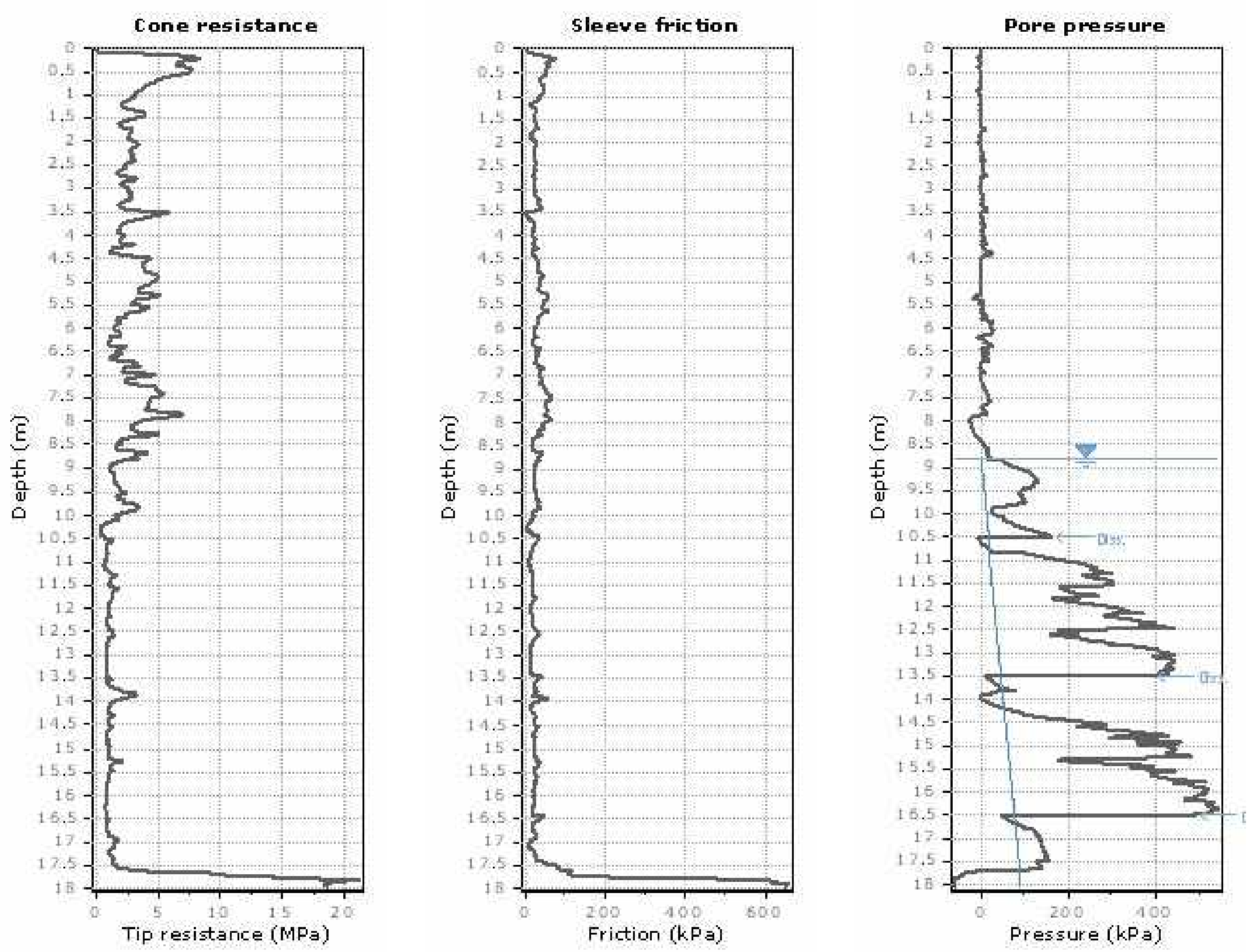
Permeability: 1.52E-08 ±4.13E-08 m/s
N_{60}: 7.75 ±2.19 blows
Es: 0.00 ±0.00 MPa
Dr (%): 0.00 ±0.00
φ (degrees): 0.00 ±0.00 °
Unit weight: 19.00 ±0.00 kN/m³

Constrained Mod.: 8.33 ±11.65 MPa
Go: 51.76 ±11.13 MPa
Su: 76.39 ±41.72 kPa
Su ratio: 0.35 ±0.22
O.C.R.: 1.63 ±1.02

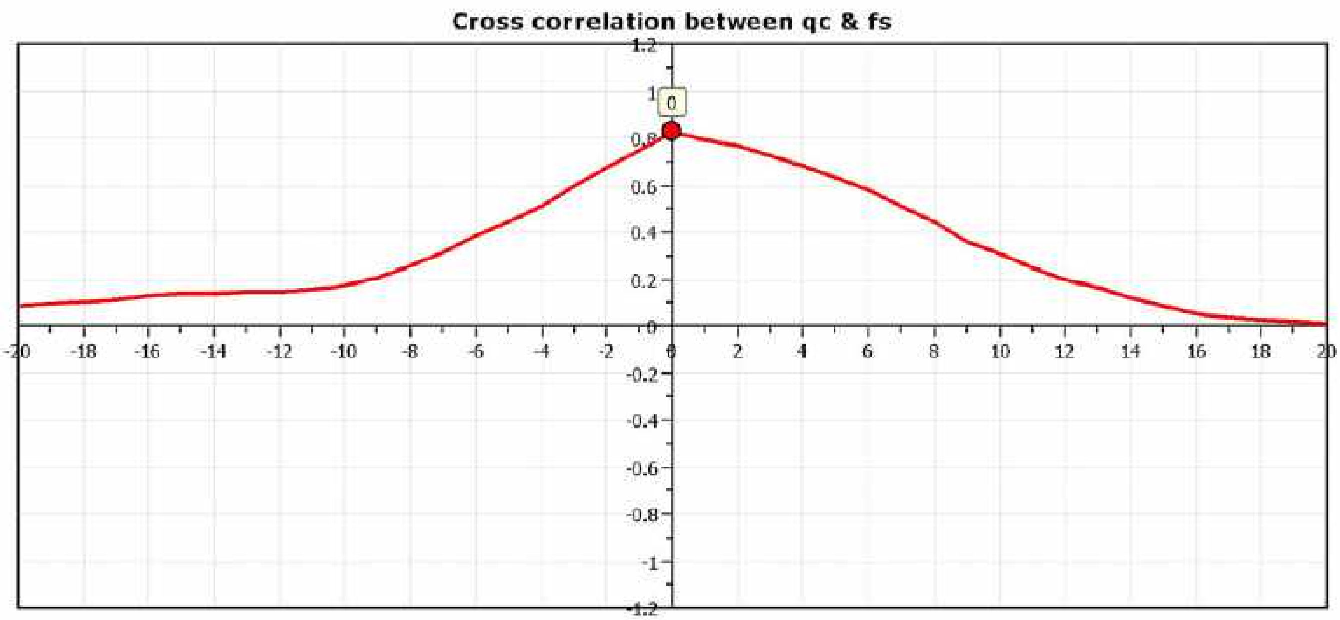
Summary table of mean values

From depth To depth (m)	Thickness (m)	Permeability (m/s)	SPT_{N60} (blows/30cm)	E_s (MPa)	D_r (%)	Friction angle	Constrained modulus, M (MPa)	Shear modulus, G_O (MPa)	Undrained strength, S_U (kPa)	Undrained strength ratio	OCR	Unit weight (kN/m³)
0.14	1.22	7.14E-05	11.2	31.6	63.9	39.5	63.1	39.6	0.0	0.0	0.0	19.0
1.36		(±3.95E-05)	(±2.1)	(±7.5)	(±7.8)	(±1.6)	(±15.0)	(±9.4)	(±0.0)	(±0.0)	(±0.0)	(±0.0)
1.36	2.18	1.35E-04	47.5	123.8	92.1	44.7	247.7	155.2	0.0	0.0	0.0	19.0
3.54		(±6.14E-05)	(±15.3)	(±37.7)	(±9.9)	(±1.9)	(±75.5)	(±47.3)	(±0.0)	(±0.0)	(±0.0)	(±0.0)
3.54	1.20	1.45E-05	20.2	64.0	49.9	37.2	124.3	80.2	0.0	0.0	0.0	19.0
4.74		(±1.22E-05)	(±7.9)	(±20.1)	(±12.1)	(±2.4)	(±44.3)	(±25.2)	(±0.0)	(±0.0)	(±0.0)	(±0.0)
4.74	3.26	4.54E-07	10.2	43.8	27.6	33.4	38.9	54.6	0.0	0.0	0.0	19.0
8.00		(±4.98E-07)	(±1.1)	(±3.9)	(±3.3)	(±0.7)	(±10.6)	(±4.4)	(±0.0)	(±0.0)	(±0.0)	(±0.0)
8.00	0.96	8.51E-07	14.2	56.5	27.9	33.0	58.9	70.8	0.0	0.0	0.0	19.0
8.96		(±6.69E-07)	(±1.7)	(±6.7)	(±2.2)	(±0.7)	(±13.3)	(±8.4)	(±0.0)	(±0.0)	(±0.0)	(±0.0)
8.96	9.40	1.52E-08	7.8	0.0	0.0	0.0	8.3	51.8	76.4	0.4	1.6	19.0
18.36		(±4.13E-08)	(±2.2)	(±0.0)	(±0.0)	(±0.0)	(±11.6)	(±11.1)	(±41.7)	(±0.2)	(±1.0)	(±0.0)

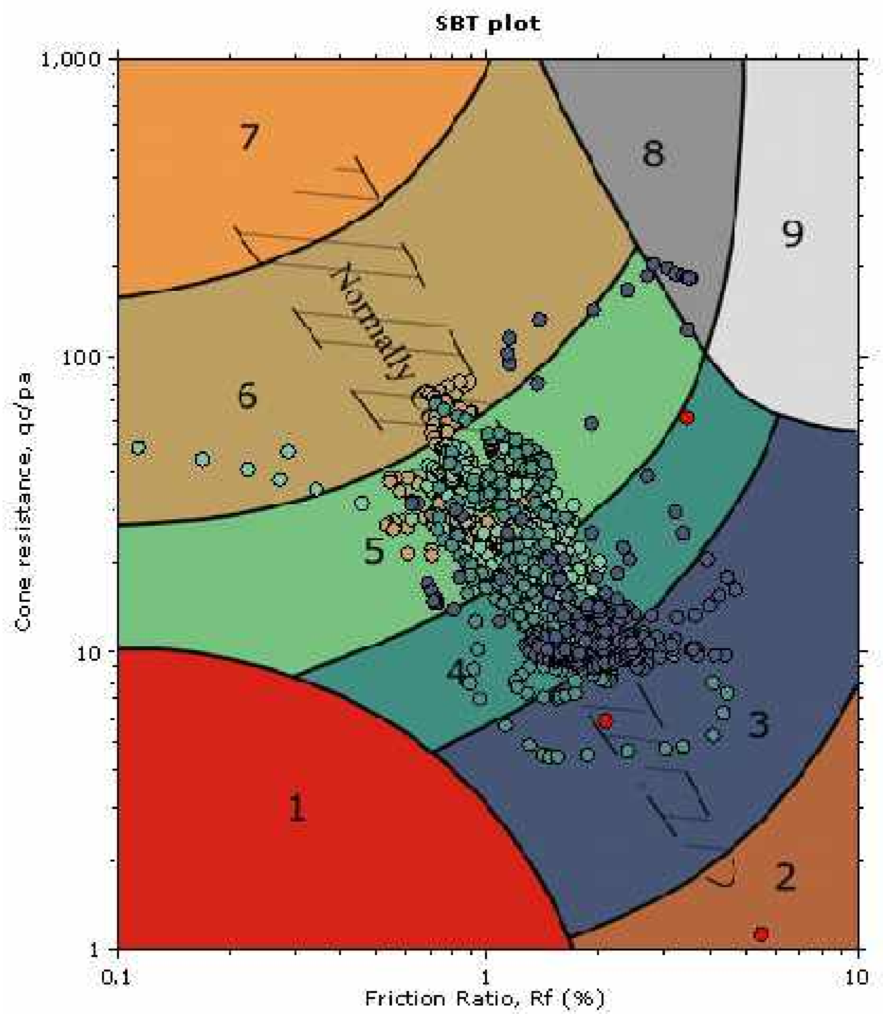
Depth values presented in this table are measured from free ground surface

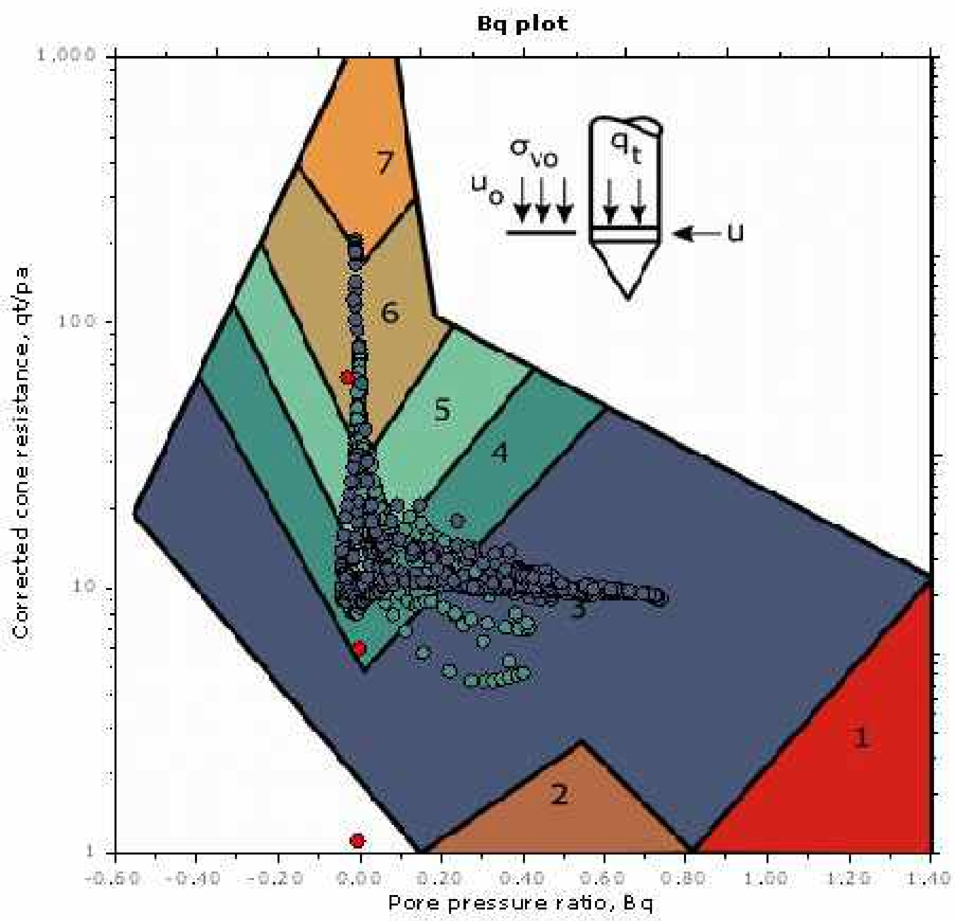


The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



SBT - Bq plots

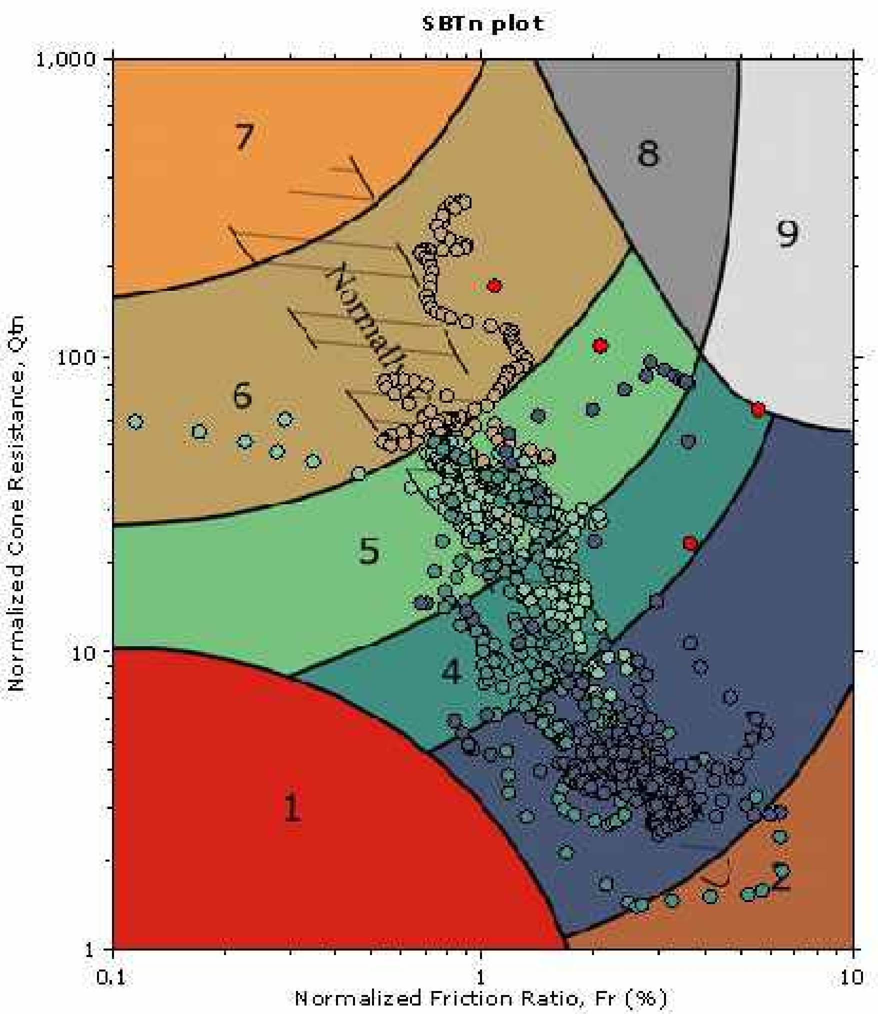


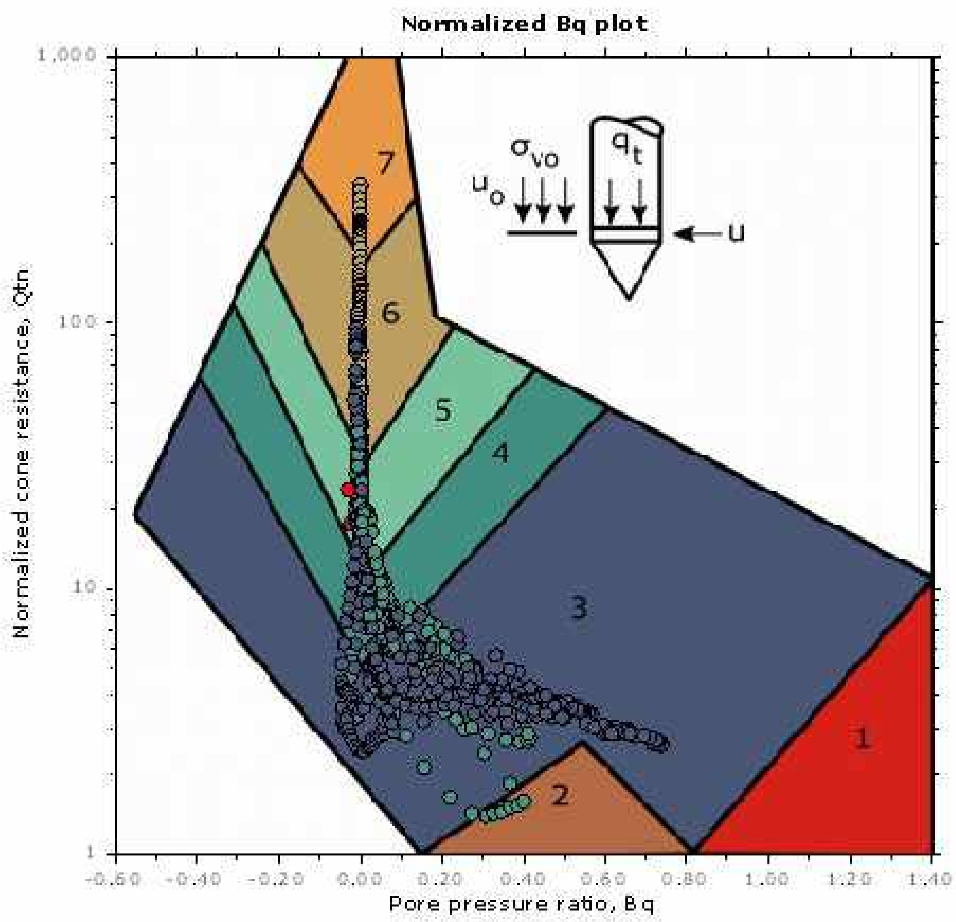


SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravelly sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

SBT - Bq plots (normalized)

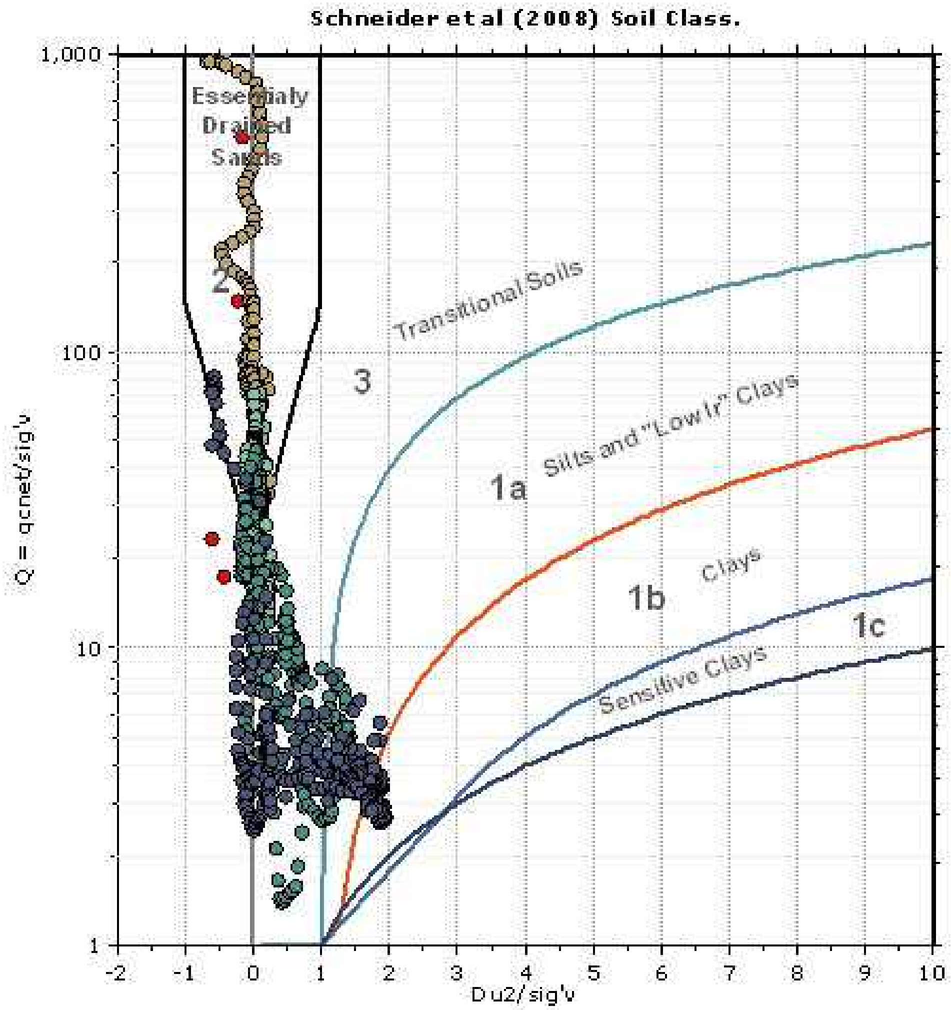


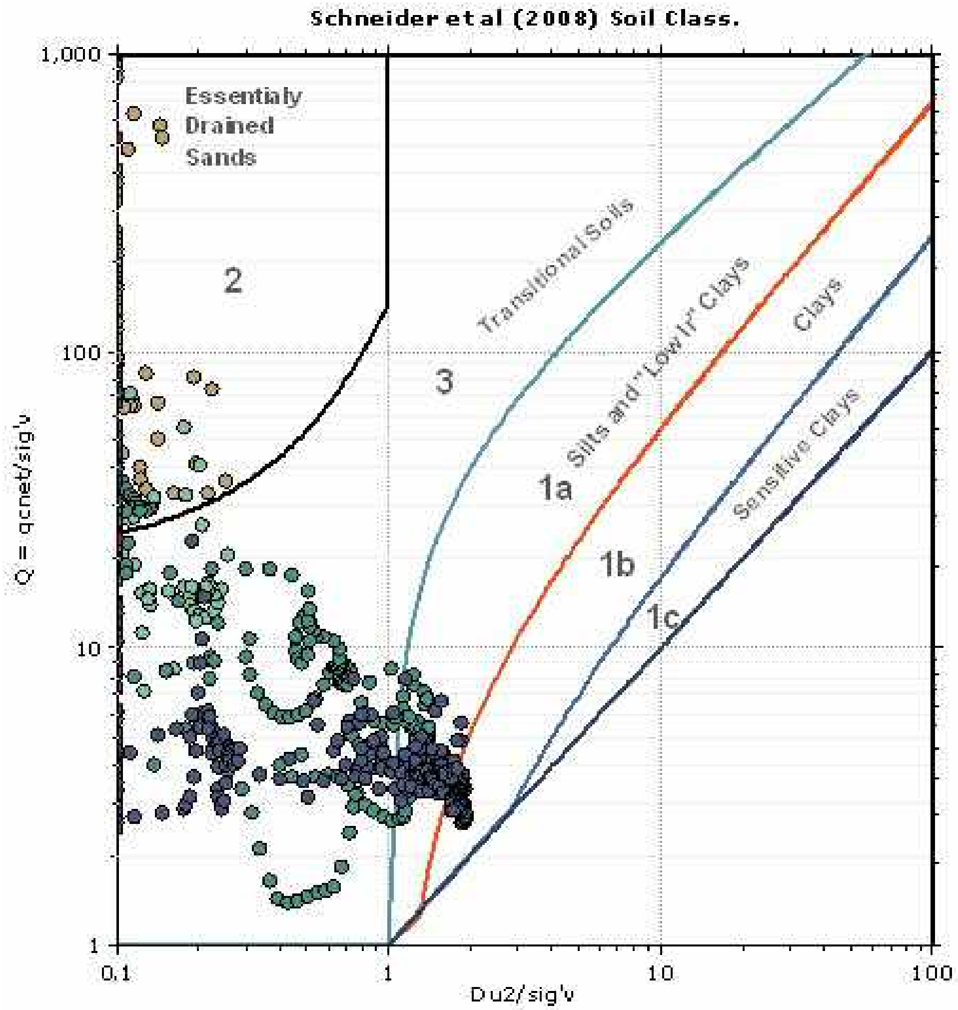


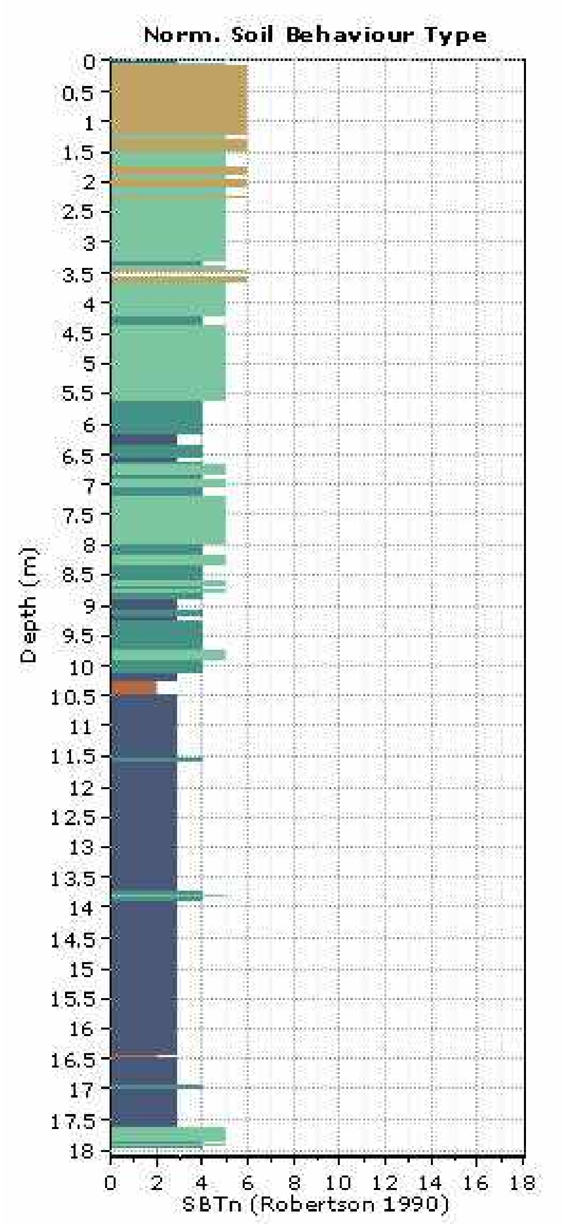
SBTn legend

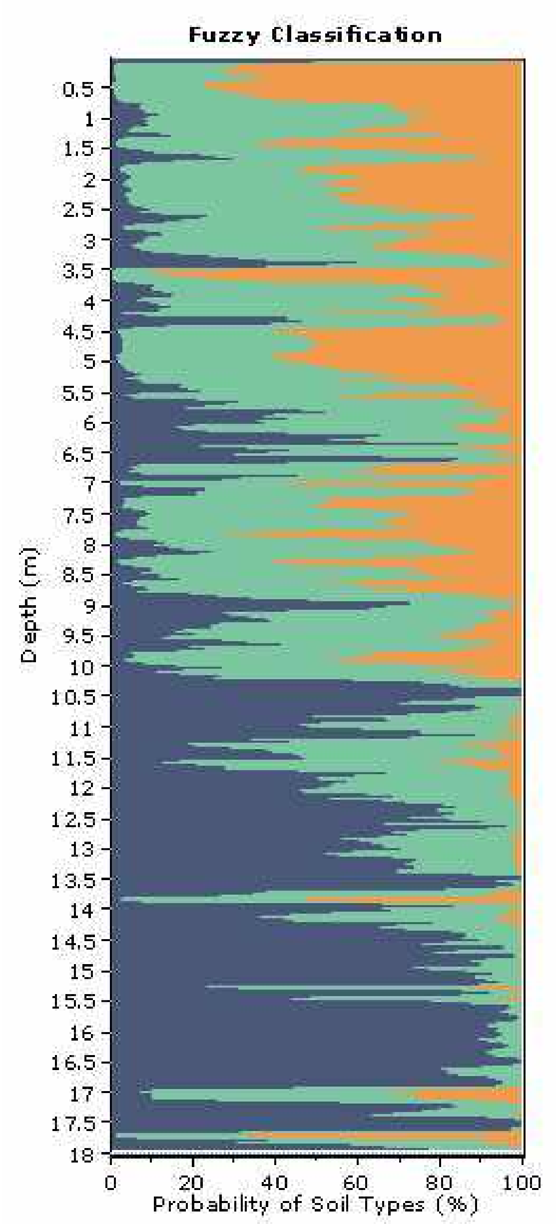
- 1. Sensitive fine grained
- 2. Organic material
- 3. Clay to silty clay
- 4. Clayey silt to silty clay
- 5. Silty sand to sandy silt
- 6. Clean sand to silty sand
- 7. Gravelly sand to sand
- 8. Very stiff sand to clayey sand
- 9. Very stiff fine grained

Bq plots (Schneider)





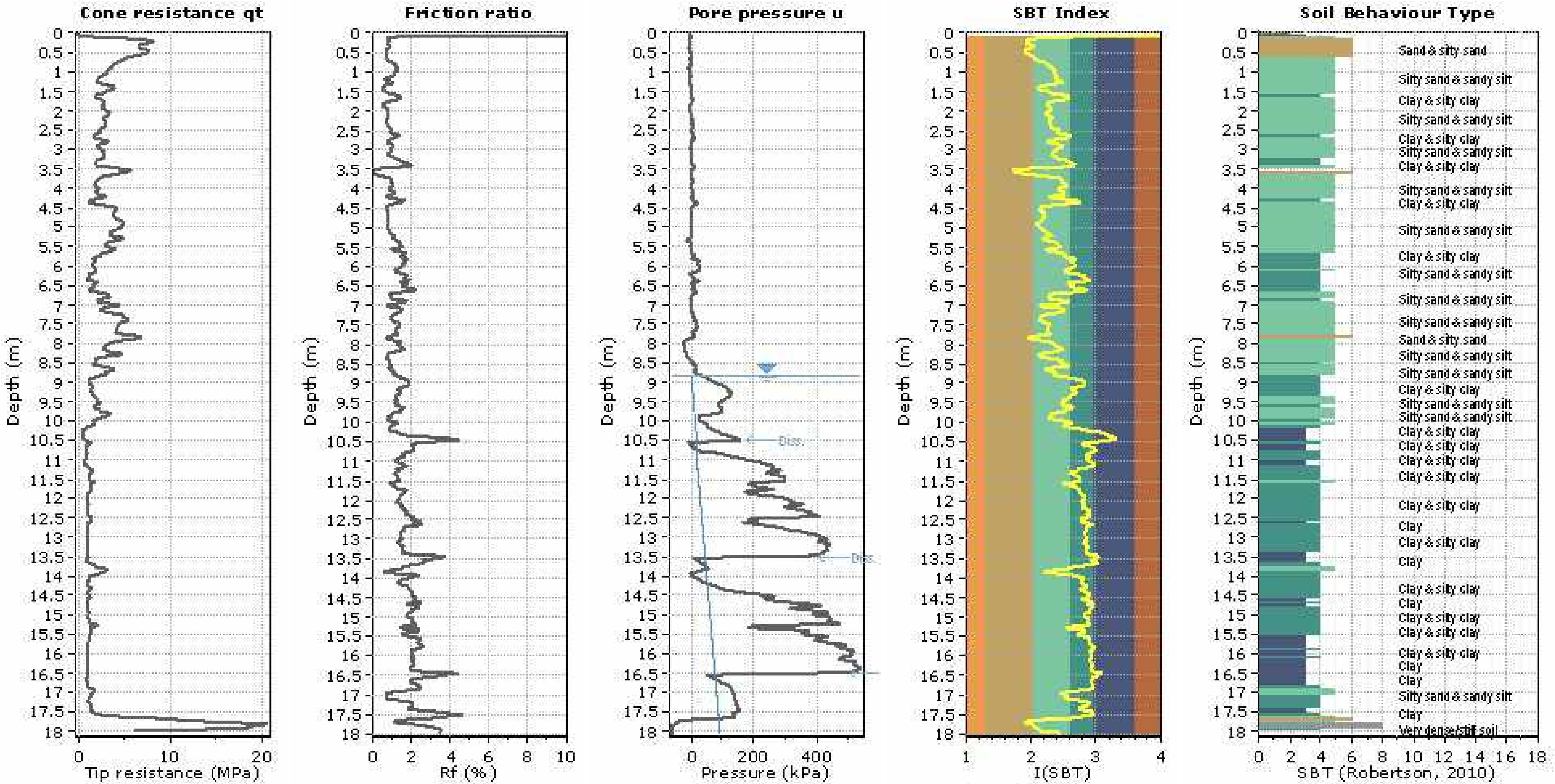

Norm. Soil Behaviour Type
Depth (m)
SBTn (Robertson 1990)


Fuzzy Classification
Depth (m)
Probability of Soil Types (%)

Knight Piésold Consulting
Level 1, 184 Adelaide Terrace
Perth WA 6004, Australia
http://www.knightpiesold.com/

CPT: KP CPT04
Total depth: 18.04 m, Date: 3/09/2020
Coords: lat 305888.1° lon 6880472.1°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**



SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

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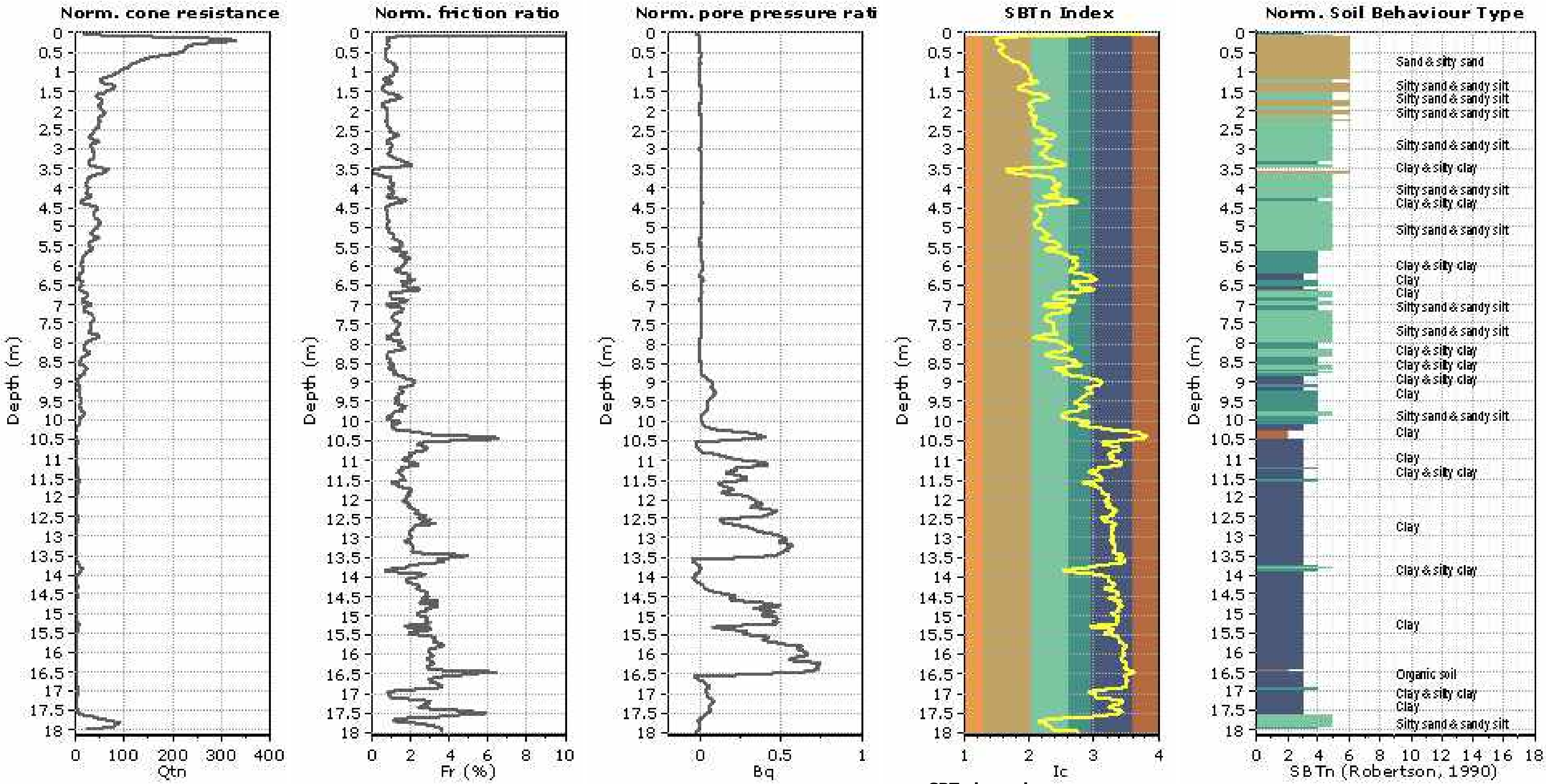
Perth WA 6004, Australia
http://www.knightpiesold.com/

CPT: KP CPT04
Total depth: 18.04 m, Date: 3/09/2020
Coords: lat 305888.1° lon 6880472.1°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**



SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

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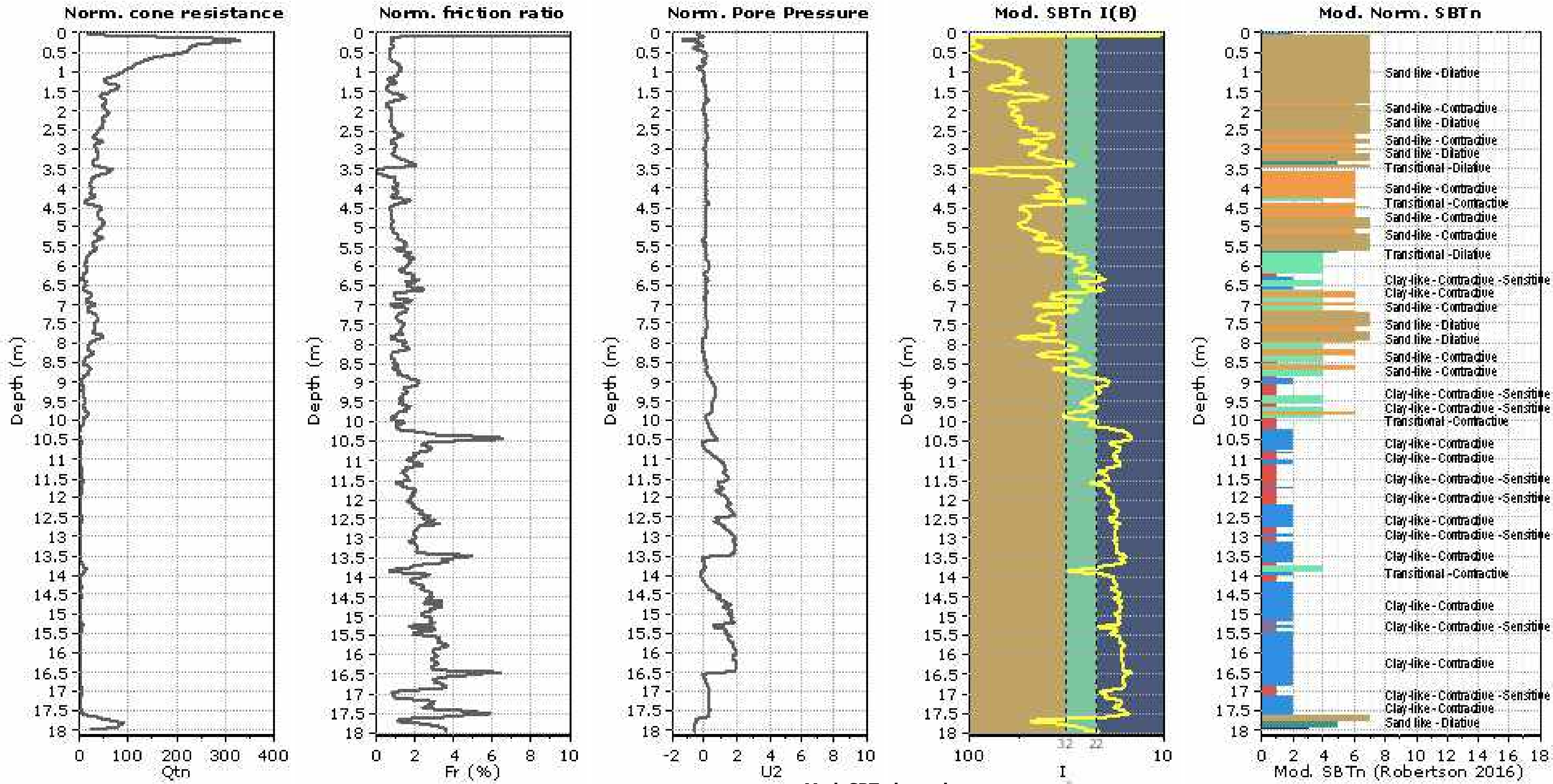

Mod. SBTn legend

- 1. CCS: ClayLike - Contractive, Sensitive
- 2. CC: Clay-like - Contractive
- 3. CD: Clay-Like: Dilative
- 4. TC: Transitional - Contractive
- 5. TD: Transitional - Dilative
- 6. SC: Sand-like - Contractive
- 7. SD: Sand-like - Dilative

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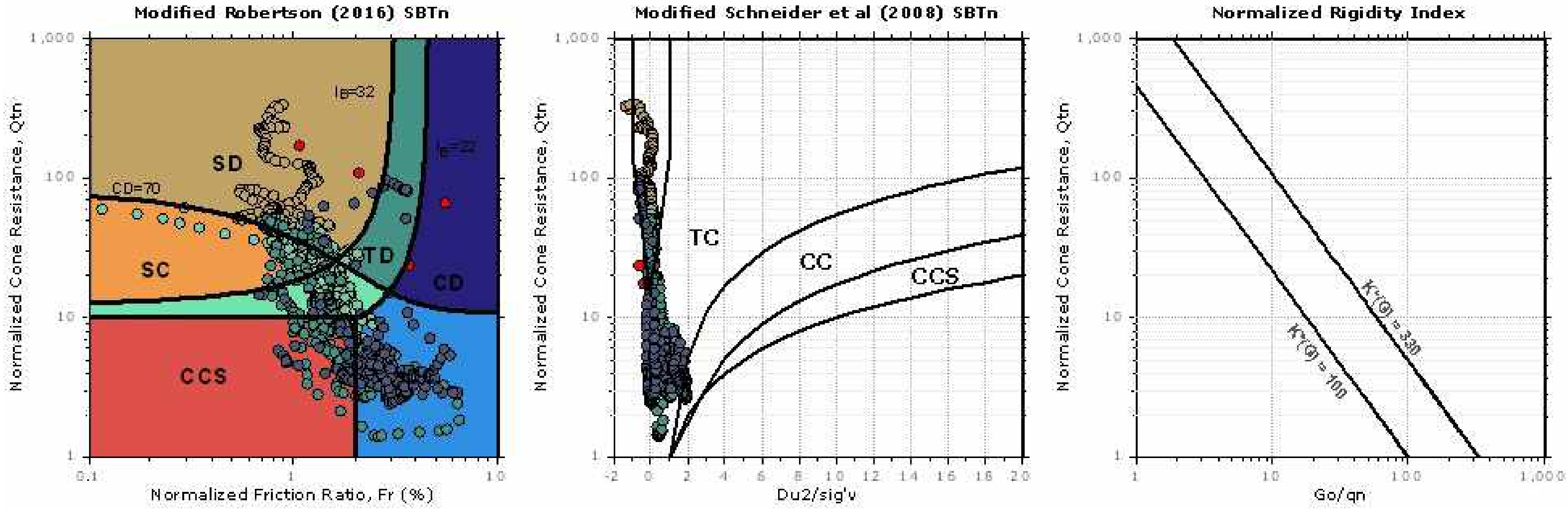
Cone Operator: Hagstrom Drilling

Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**

Updated SBTn plots



CCS: Clay-like - Contractive - Sensitive
CC: Clay-like - Contractive
CD: Clay-like - Dilative
TC: Transitional - Contractive
TD: Transitional - Dilative
SC: Sand-like - Contractive
SD: Sand-like - Dilative

K(G) > 330: Soils with significant microstructure (e.g. age/cementation)

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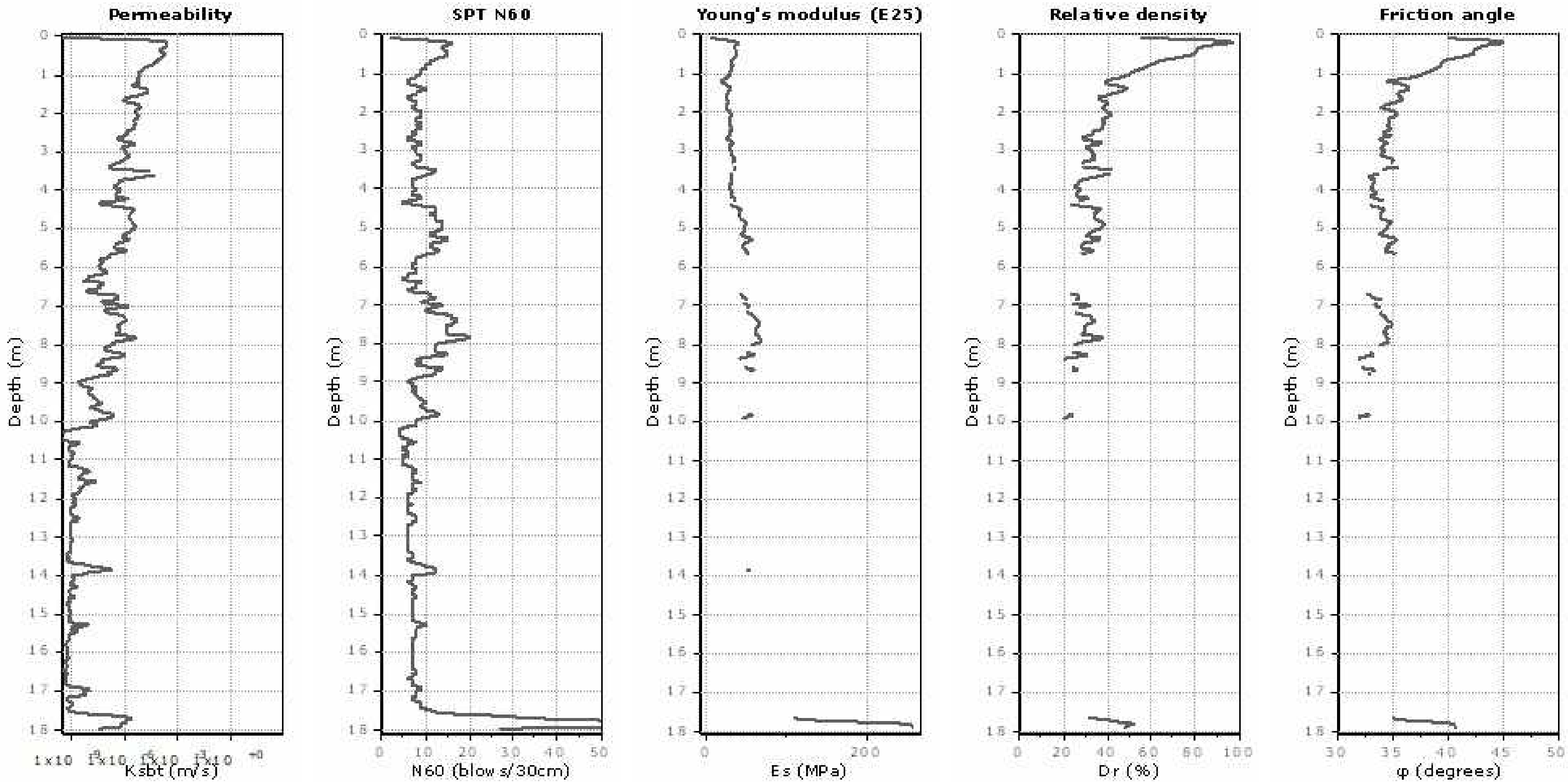
Cone Operator: Hagstrom Drilling

Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**



Calculation parameters
Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative density constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

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Cone Type: 180911
Cone Operator: Hagstrom Drilling

Project: **Thunderbox Gold Mine**
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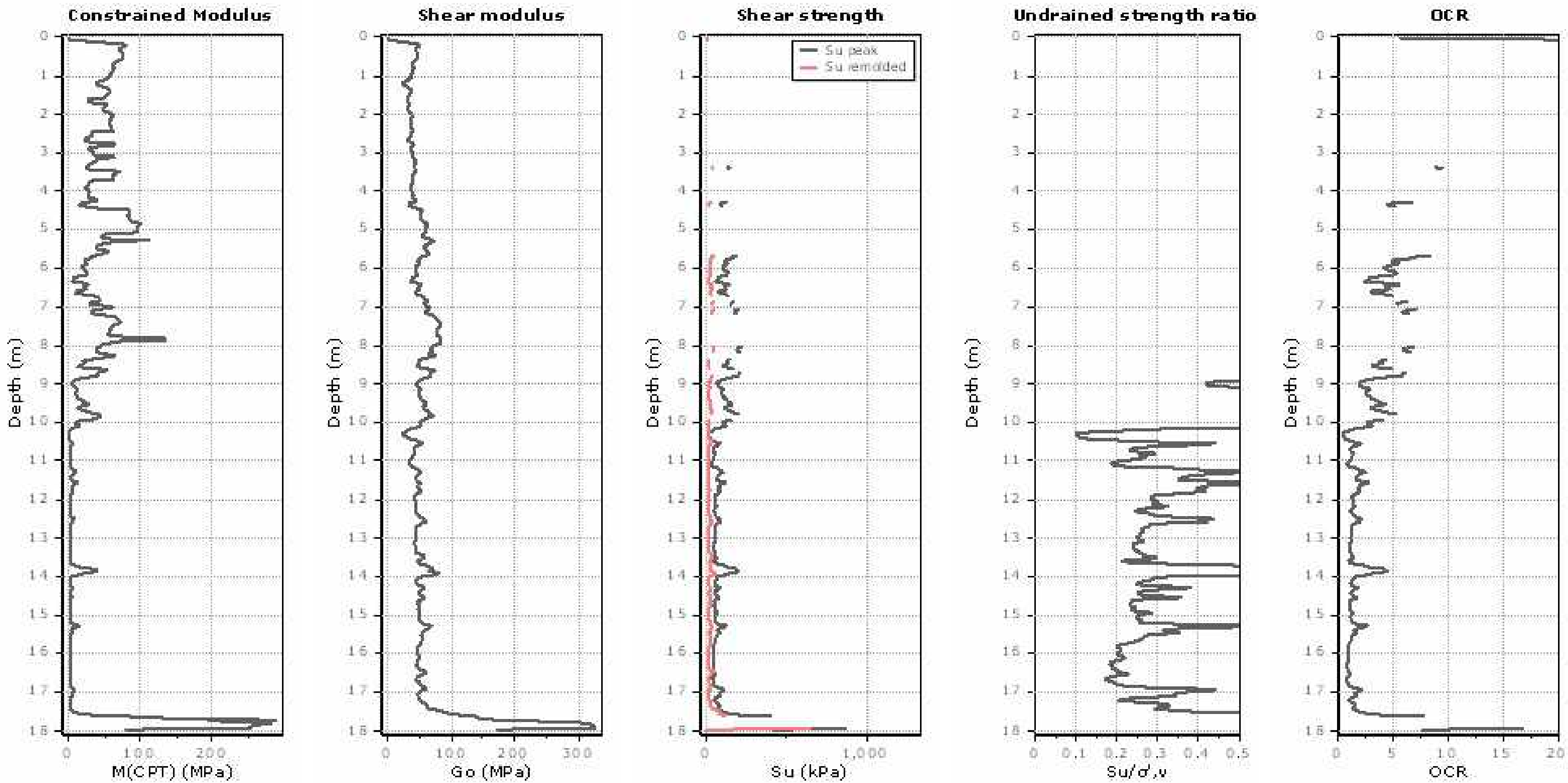
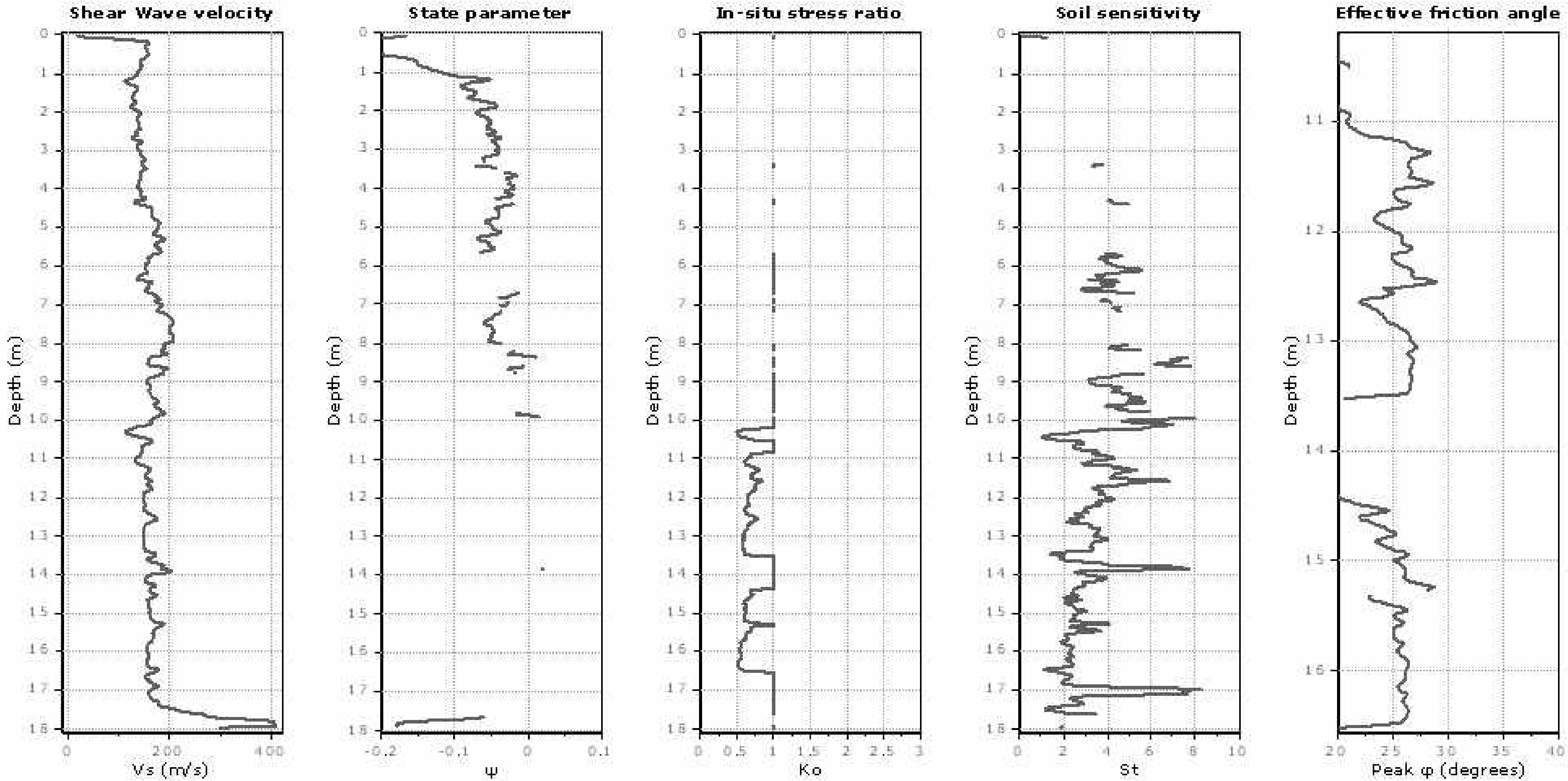


Calculation parameters

Constrained modulus: Based on variable alpha using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable alpha using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14

OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data



Calculation parameters

Soil Sensitivity factor, N_S: 7.00

User defined estimation data

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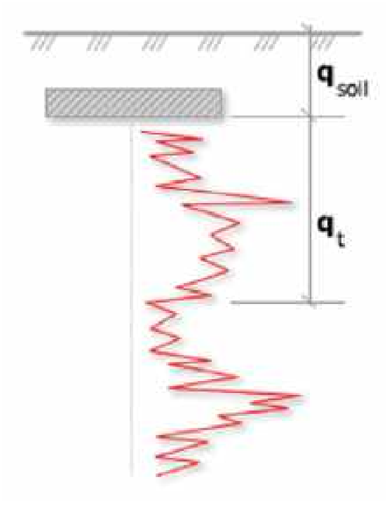
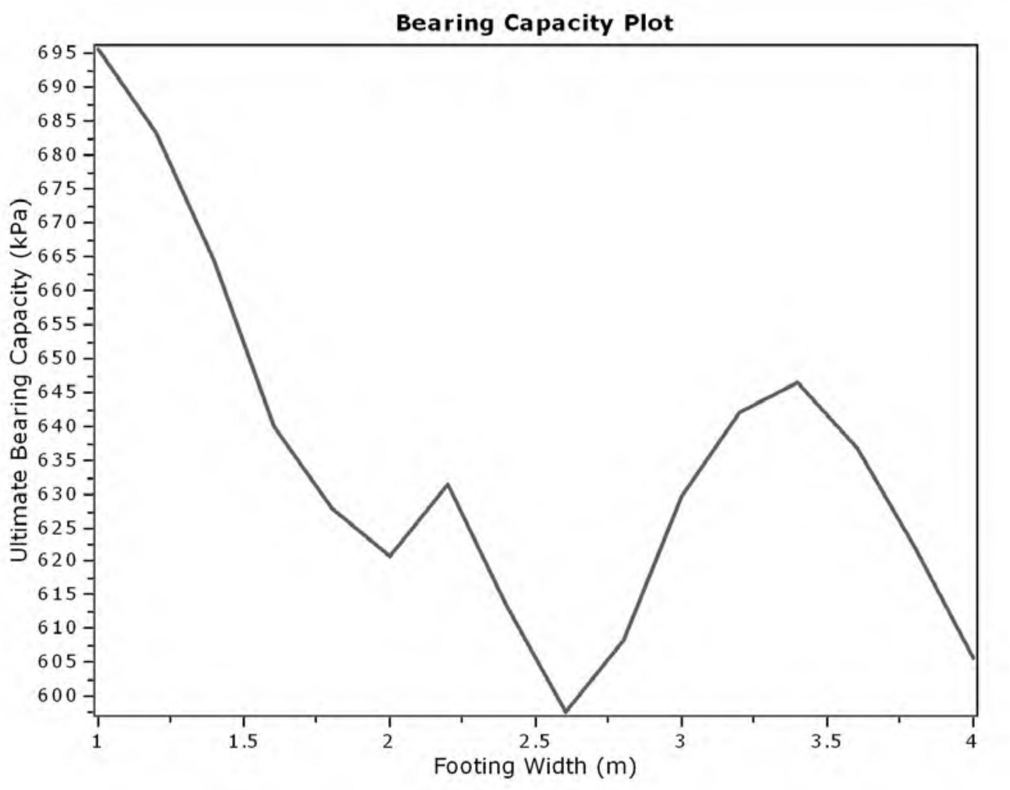


Bearing Capacity calculation is perfromed based on the formula:

$$Q_{ult} = R_k \times q_t + q_{soil}$$

where:
R_k: Bearing capacity factor
q_t: Average corrected cone resistance over calculation depth
q_{soil}: Pressure applied by soil above footing



:: Tabular results ::

No	B (m)	Start Depth (m)	End Depth (m)	Ave. q_t (MPa)	R_k	Soil Press. (kPa)	Ult. bearing cap. (kPa)
1	1.00	0.50	2.00	3.43	0.20	9.50	695.72
2	1.20	0.50	2.30	3.37	0.20	9.50	683.28
3	1.40	0.50	2.60	3.27	0.20	9.50	664.49
4	1.60	0.50	2.90	3.15	0.20	9.50	639.97
5	1.80	0.50	3.20	3.09	0.20	9.50	627.94
6	2.00	0.50	3.50	3.06	0.20	9.50	620.64
7	2.20	0.50	3.80	3.11	0.20	9.50	631.47
8	2.40	0.50	4.10	3.02	0.20	9.50	613.64
9	2.60	0.50	4.40	2.94	0.20	9.50	597.71
10	2.80	0.50	4.70	2.99	0.20	9.50	608.19
11	3.00	0.50	5.00	3.10	0.20	9.50	629.70
12	3.20	0.50	5.30	3.16	0.20	9.50	641.92
13	3.40	0.50	5.60	3.18	0.20	9.50	646.41
14	3.60	0.50	5.90	3.14	0.20	9.50	636.59
15	3.80	0.50	6.20	3.06	0.20	9.50	621.82
16	4.00	0.50	6.50	2.98	0.20	9.50	605.71

Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

The porepressures are plotted as a function of square root of (t). The graphical technique suggested by Robertson and Campanella (1989), yields a value for t_{50}, which corresponds to the time for 50% consolidation.

The value of the coefficient of consolidation in the radial or horizontal direction c_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).
t_{50}: time corresponding to 50% consolidation

Permeability estimates based on dissipation test

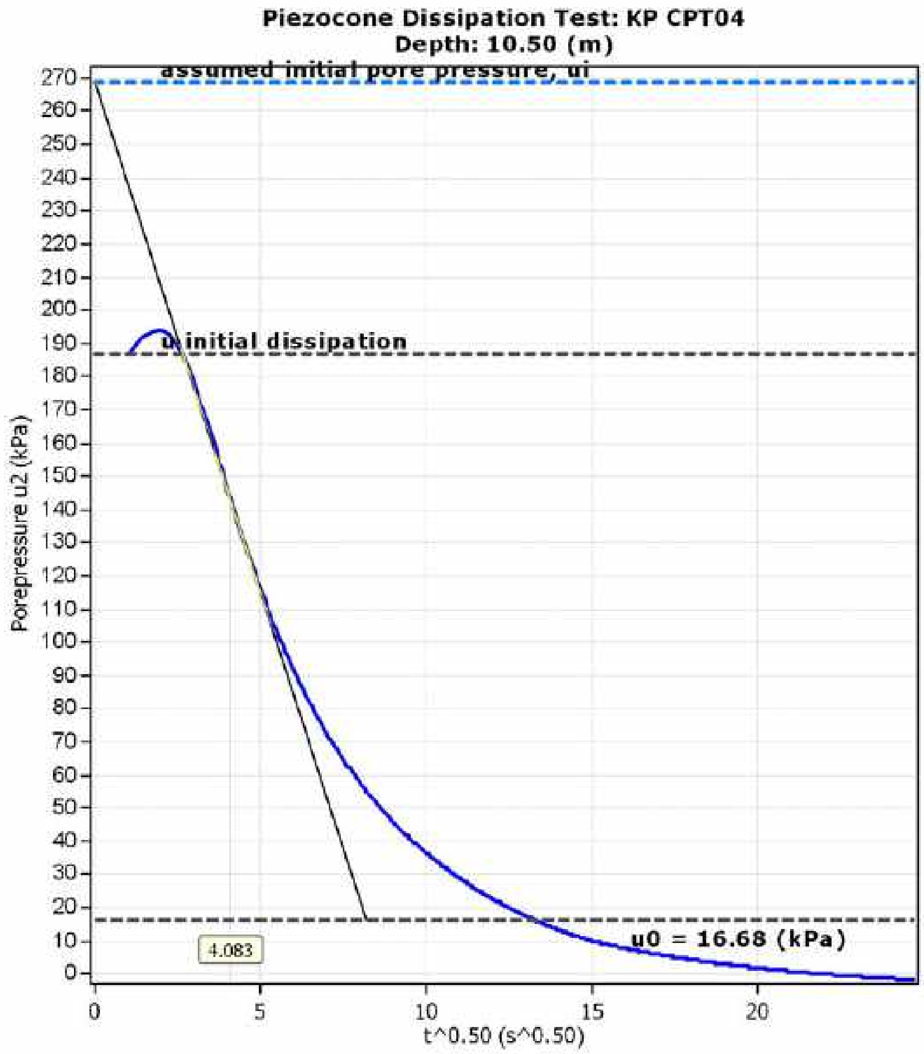
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

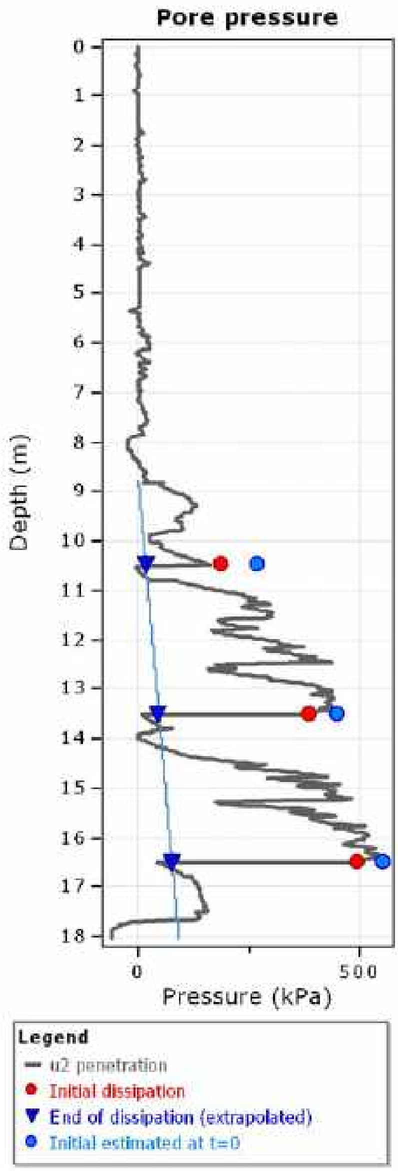
$$k_h = c_h \times \gamma_w / M$$

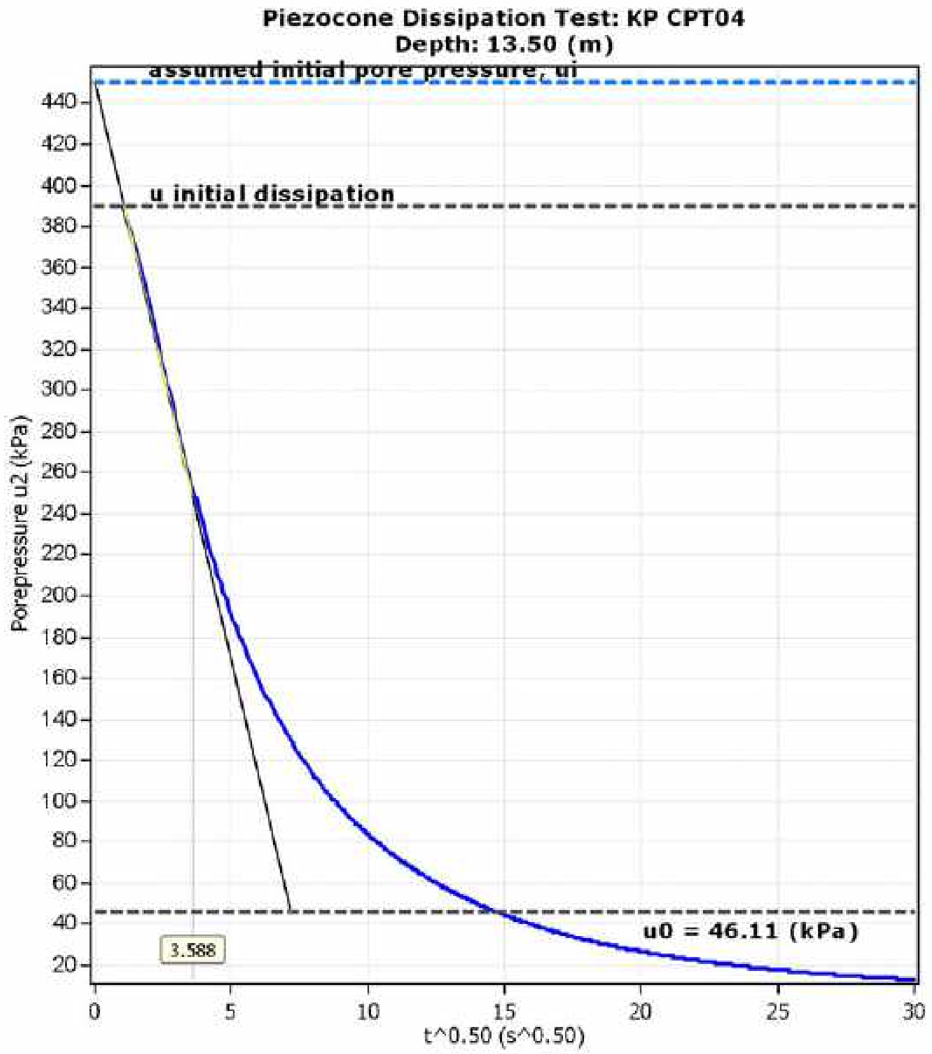
where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

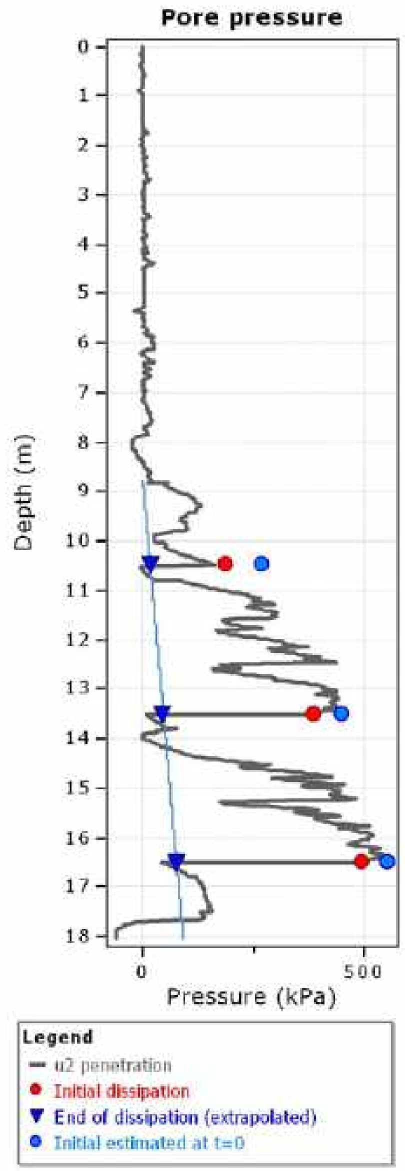
Tabular results

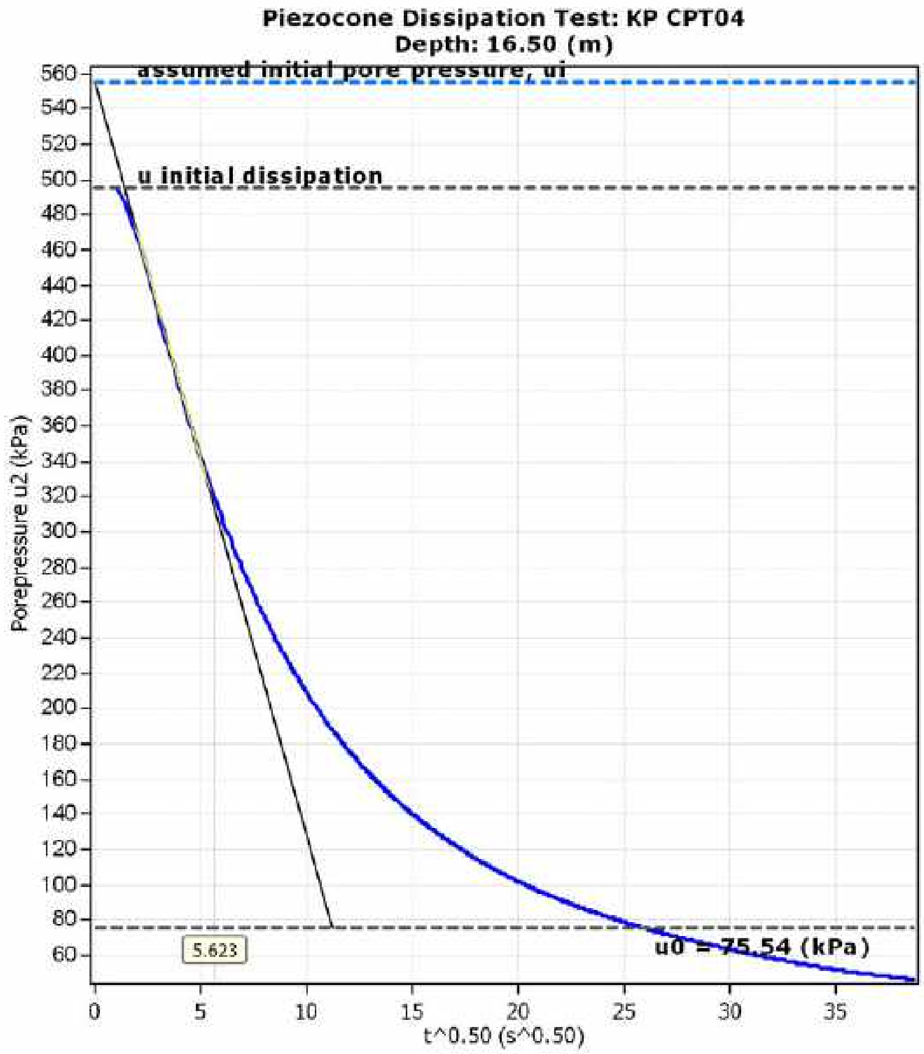
CPTU Borehole	Depth (m)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/S_u	c_h (m^2/s)	c_h (m^2/year)	M (MPa)	k_h (m/s)
KP CPT04	10.50	4.1	17	5.29E-007	100.00	4.66E-005	1468	6.11	7.48E-008
KP CPT04	13.50	3.6	13	4.08E-007	100.00	6.03E-005	1902	5.06	1.17E-007
KP CPT04	16.50	5.6	32	1.00E-006	100.00	2.45E-005	774	2.73	8.81E-008

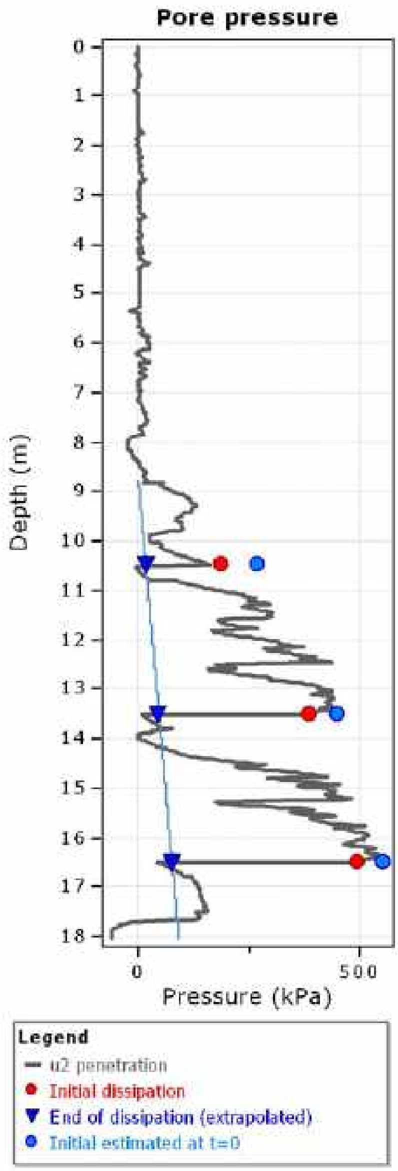

Piezocone Dissipation Test: KP CPT04
Depth: 10.50 (m)
assumed initial pore pressure, ui
ui initial dissipation
u0 = 16.68 (kPa)
4.083
Porepressure u2 (kPa)
t^0.50 (s^0.50)

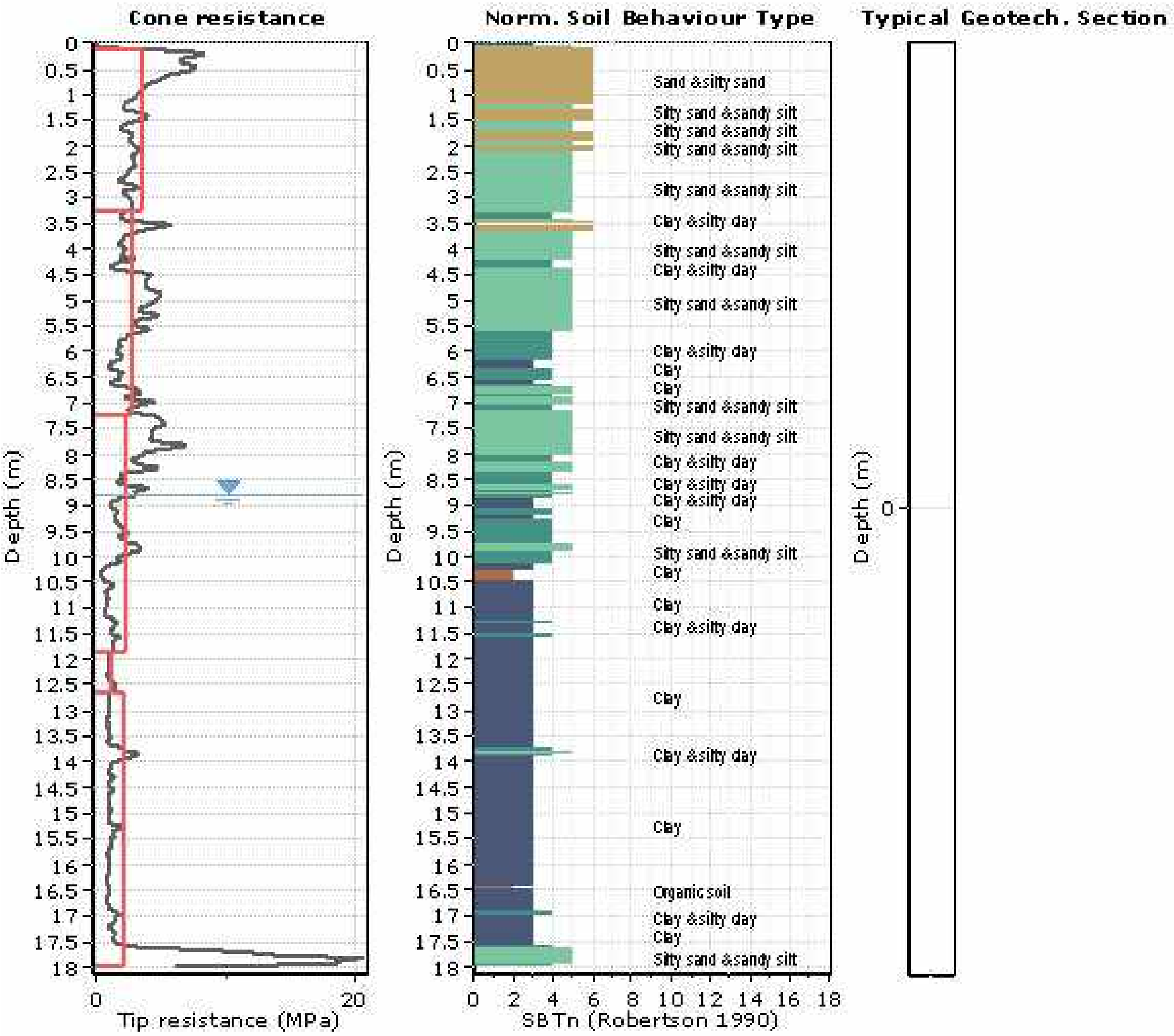

Pore pressure
Depth (m)
Pressure (kPa)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: KP CPT04
Depth: 13.50 (m)
assumed initial pore pressure, ui
u initial dissipation
u0 = 46.11 (kPa)
3.588
Porepressure u2 (kPa)
t^0.50 (s^0.50)


Pore pressure
Depth (m)
Pressure (kPa)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: KP CPT04
Depth: 16.50 (m)
assumed initial pore pressure, ui
u initial dissipation
5.623
u0 = 75.54 (kPa)
Porepressure u2 (kPa)
t^0.50 (s^0.50)


Pore pressure
Depth (m)
Pressure (kPa)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0



Tabular results

.:: Layer No: 1 ::.

Code: Layer_1 **Start depth:** 0.10 (m), **End depth:** 3.26 (m)

Description: Sand & silty sand

Basic results

Total cone resistance: 3.59 ±1.71 MPa

Sleeve friction: 31.35 ±13.41 kPa

Ic: 2.01 ±0.25

SBT_n: 6

SBTn description: Sand & silty sand

Estimation results

Permeability: 3.46E-05 ±6.60E-05 m/s

N_{60}: 9.18 ±2.63 blows

Es: 29.81 ±4.36 MPa

Dr (%): 47.80 ±17.99

φ (degrees): 36.72 ±3.16 °

Unit weight: 19.00 ±0.00 kN/m³

Constrained Mod.: 53.07 ±14.90 MPa

Go: 37.36 ±5.46 MPa

Su: 0.00 ±0.00 kPa

Su ratio: 0.00 ±0.00

O.C.R.: 0.00 ±0.00

.:: Layer No: 2 ::.

Code: Layer_2 **Start depth:** 3.26 (m), **End depth:** 7.22 (m)

Description: Silty sand & sandy silt

Basic results	Estimation results	
Total cone resistance: 2.85 ±1.16 MPa	Permeability: 1.58E-06 ±5.06E-06 m/s	Constrained Mod.: 43.49 ±25.53 MPa
Sleeve friction: 30.45 ±10.82 kPa	N_{60}: 9.70 ±2.58 blows	Go: 50.19 ±9.82 MPa
Ic: 2.43 ±0.28	Es: 41.61 ±8.41 MPa	Su: 0.00 ±0.00 kPa
SBT_n: 5	Dr (%): 31.36 ±4.30	Su ratio: 0.00 ±0.00
SBTn description: Silty sand & sandy silt	φ (degrees): 33.91 ±0.71 °	O.C.R.: 0.00 ±0.00
	Unit weight: 19.00 ±0.00 kN/m³	

.:: Layer No: 3 ::.

Code: Layer_3 **Start depth:** 7.22 (m), **End depth:** 11.86 (m)

Description: Clay & silty clay

Basic results	Estimation results	
Total cone resistance: 2.28 ±1.48 MPa	Permeability: 2.30E-07 ±5.66E-07 m/s	Constrained Mod.: 25.67 ±27.29 MPa
Sleeve friction: 27.95 ±15.23 kPa	N_{60}: 9.48 ±3.89 blows	Go: 55.86 ±15.02 MPa
Ic: 2.86 ±0.39	Es: 0.00 ±0.00 MPa	Su: 92.70 ±47.12 kPa
SBT_n: 4	Dr (%): 0.00 ±0.00	Su ratio: 0.54 ±0.31
SBTn description: Clay & silty clay	φ (degrees): 0.00 ±0.00 °	O.C.R.: 2.48 ±1.44
	Unit weight: 19.00 ±0.00 kN/m³	

.:: Layer No: 4 ::.

Code: Layer_4 **Start depth:** 11.86 (m), **End depth:** 12.62 (m)

Description: Clay

Basic results	Estimation results	
Total cone resistance: 1.11 ±0.16 MPa	Permeability: 1.47E-09 ±5.12E-10 m/s	Constrained Mod.: 4.01 ±1.51 MPa
Sleeve friction: 19.70 ±6.68 kPa	N_{60}: 6.59 ±0.82 blows	Go: 47.08 ±6.13 MPa
Ic: 3.23 ±0.06	Es: 0.00 ±0.00 MPa	Su: 62.88 ±11.42 kPa
SBT_n: 3	Dr (%): 0.00 ±0.00	Su ratio: 0.32 ±0.06
SBTn description: Clay	φ (degrees): 0.00 ±0.00 °	O.C.R.: 1.46 ±0.25
	Unit weight: 19.00 ±0.00 kN/m³	

.:: Layer No: 5 ::.

Code: Layer_5 **Start depth:** 12.62 (m), **End depth:** 17.96 (m)

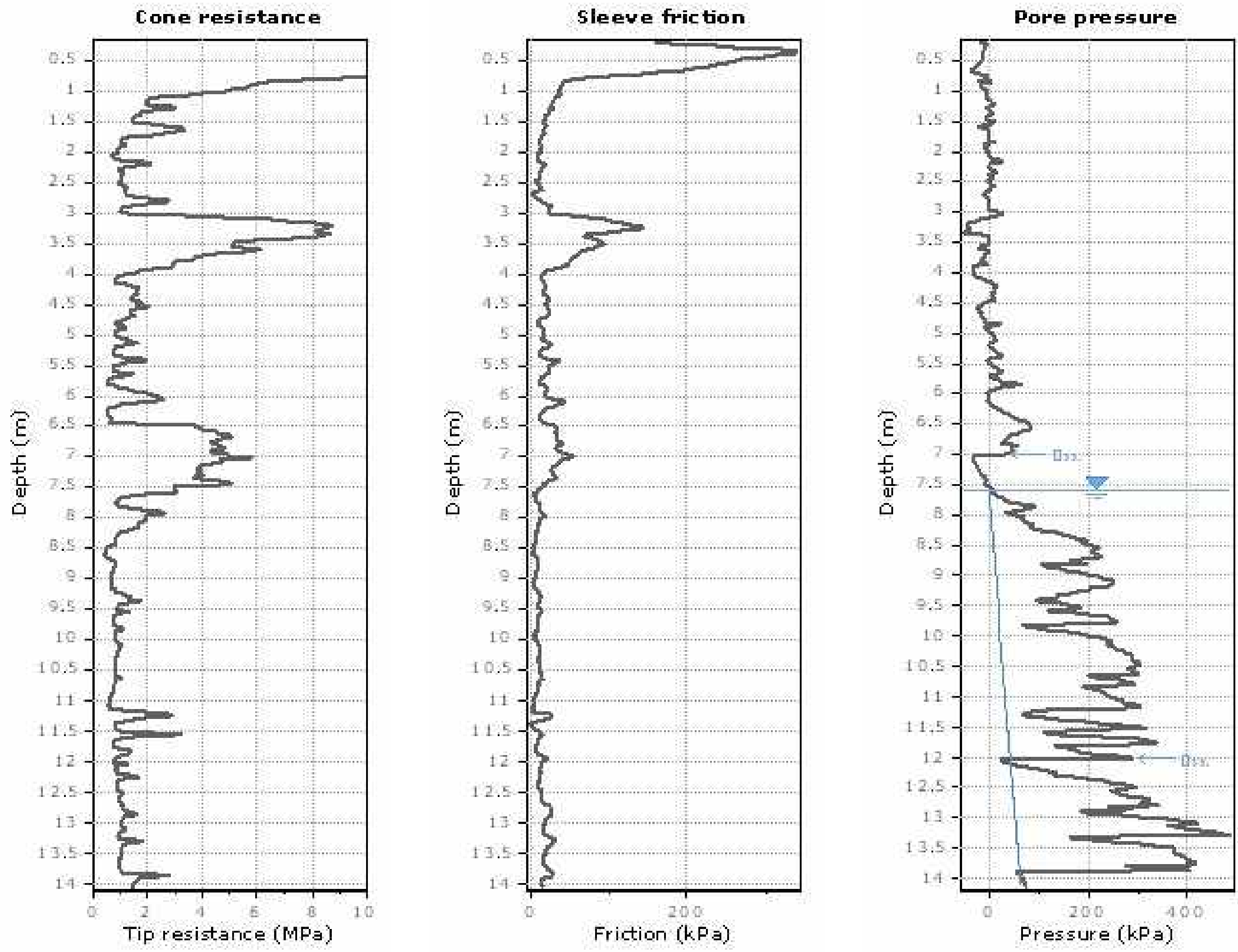
Description: Clay

Basic results	Estimation results	
Total cone resistance: 2.10 ±3.57 MPa	Permeability: 7.01E-08 ±3.00E-07 m/s	Constrained Mod.: 18.30 ±54.72 MPa
Sleeve friction: 49.37 ±112.24 kPa	N_{60}: 10.24 ±10.99 blows	Go: 65.50 ±51.92 MPa
Ic: 3.25 ±0.30	Es: 0.00 ±0.00 MPa	Su: 75.47 ±98.42 kPa
SBT_n: 3	Dr (%): 0.00 ±0.00	Su ratio: 0.33 ±0.43
SBTn description: Clay	φ (degrees): 0.00 ±0.00 °	O.C.R.: 1.55 ±1.99
	Unit weight: 19.00 ±0.00 kN/m³	

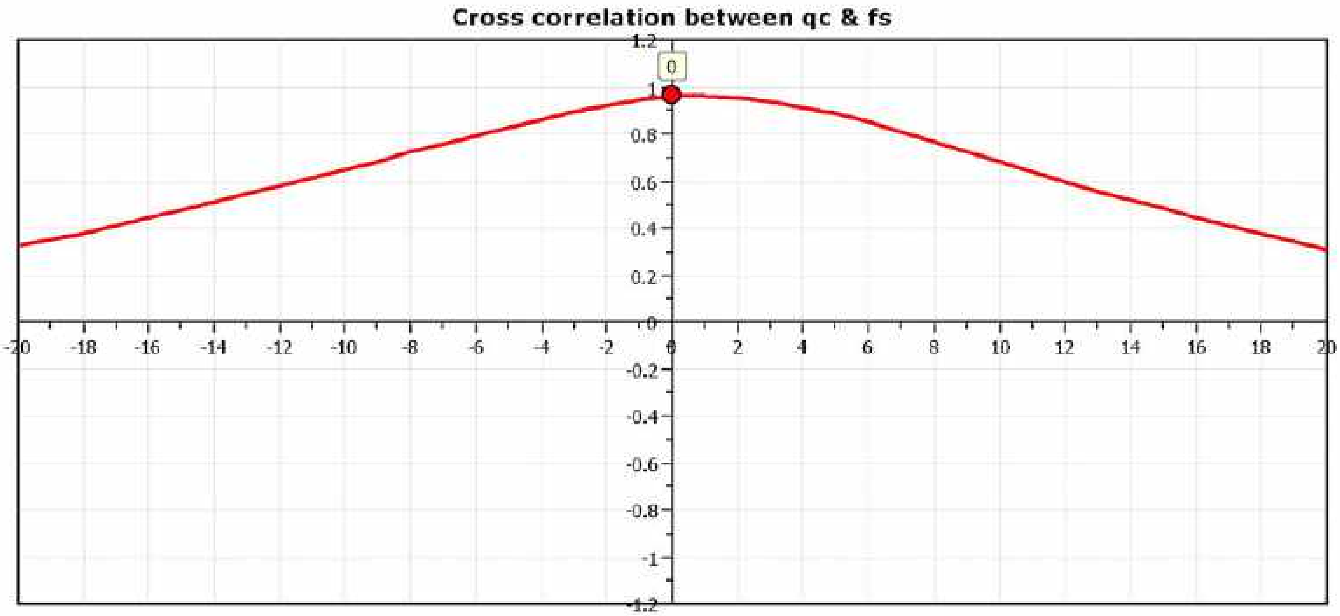
Summary table of mean values

From depth To depth (m)	Thickness (m)	Permeability (m/s)	SPT_{N60} (blows/30cm)	E_s (MPa)	D_r (%)	Friction angle	Constrained modulus, M (MPa)	Shear modulus, G_O (MPa)	Undrained strength, S_U (kPa)	Undrained strength ratio	OCR	Unit weight (kN/m³)
0.10	3.16	3.46E-05	9.2	29.8	47.8	36.7	53.1	37.4	0.0	0.0	0.0	19.0
3.26		(±6.60E-05)	(±2.6)	(±4.4)	(±18.0)	(±3.2)	(±14.9)	(±5.5)	(±0.0)	(±0.0)	(±0.0)	(±0.0)
3.26	3.96	1.58E-06	9.7	41.6	31.4	33.9	43.5	50.2	0.0	0.0	0.0	19.0
7.22		(±5.06E-06)	(±2.6)	(±8.4)	(±4.3)	(±0.7)	(±25.5)	(±9.8)	(±0.0)	(±0.0)	(±0.0)	(±0.0)
7.22	4.64	2.30E-07	9.5	0.0	0.0	0.0	25.7	55.9	92.7	0.5	2.5	19.0
11.86		(±5.66E-07)	(±3.9)	(±0.0)	(±0.0)	(±0.0)	(±27.3)	(±15.0)	(±47.1)	(±0.3)	(±1.4)	(±0.0)
11.86	0.76	1.47E-09	6.6	0.0	0.0	0.0	4.0	47.1	62.9	0.3	1.5	19.0
12.62		(±5.12E-10)	(±0.8)	(±0.0)	(±0.0)	(±0.0)	(±1.5)	(±6.1)	(±11.4)	(±0.1)	(±0.3)	(±0.0)
12.62	5.34	7.01E-08	10.2	0.0	0.0	0.0	18.3	65.5	75.5	0.3	1.5	19.0
17.96		(±3.00E-07)	(±11.0)	(±0.0)	(±0.0)	(±0.0)	(±54.7)	(±51.9)	(±98.4)	(±0.4)	(±2.0)	(±0.0)

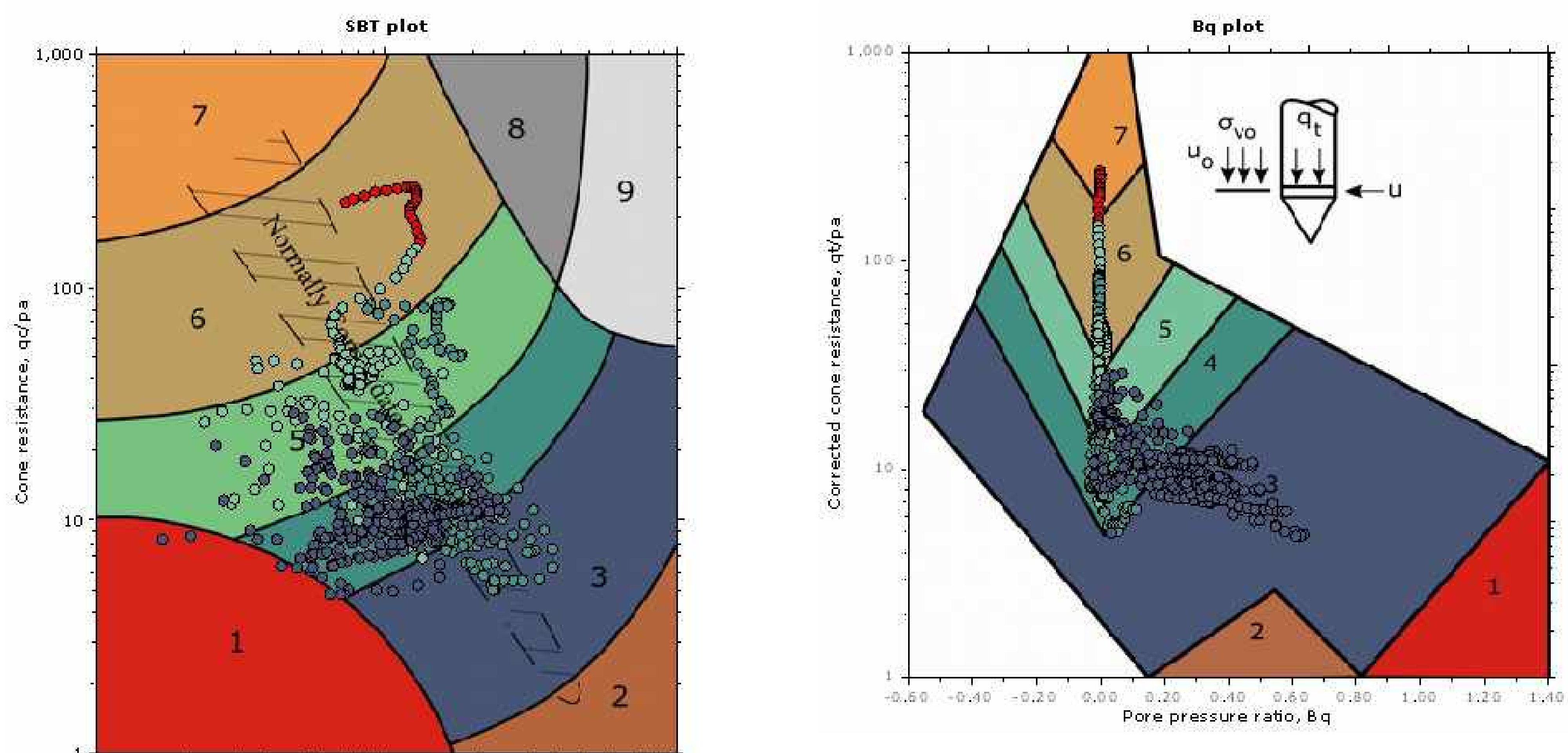
Depth values presented in this table are measured from free ground surface



The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



SBT - Bq plots



SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravelly sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

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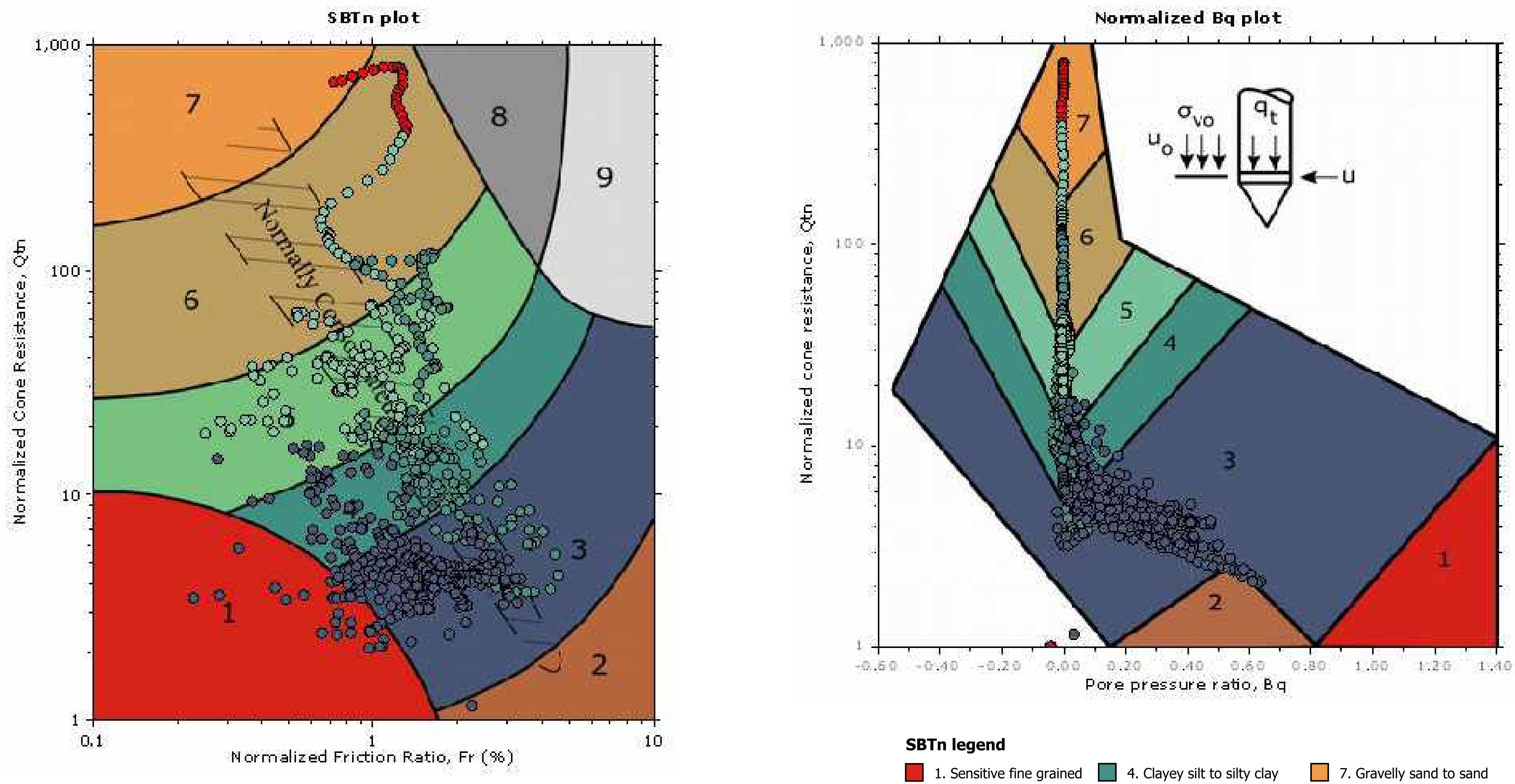
CPT: KP CPT05A
Total depth: 14.12 m, Date: 4/09/2020
Coords: lat 305799° lon 6879943°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**

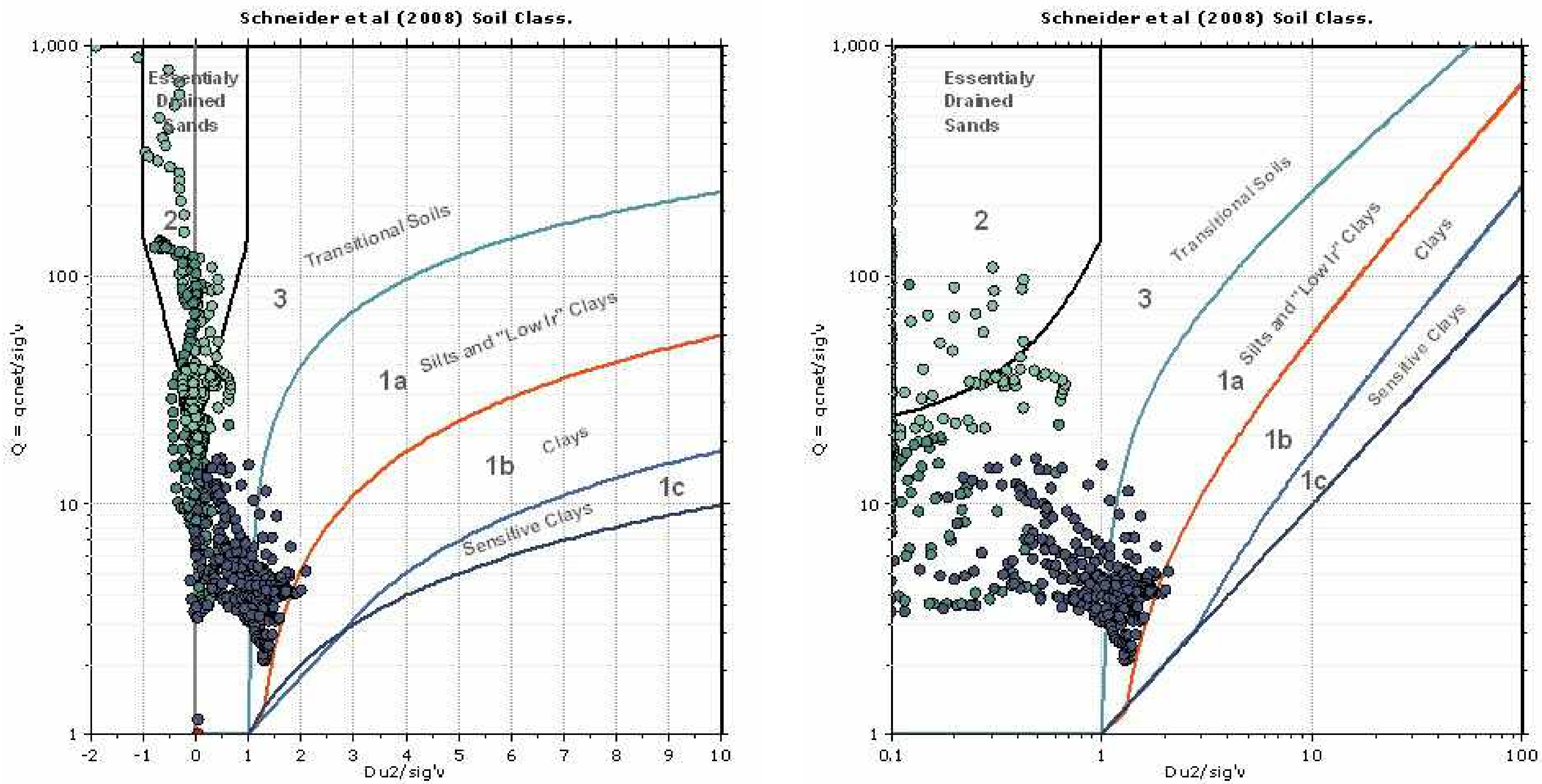
SBT - Bq plots (normalized)



SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravelly sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

Bq plots (Schneider)



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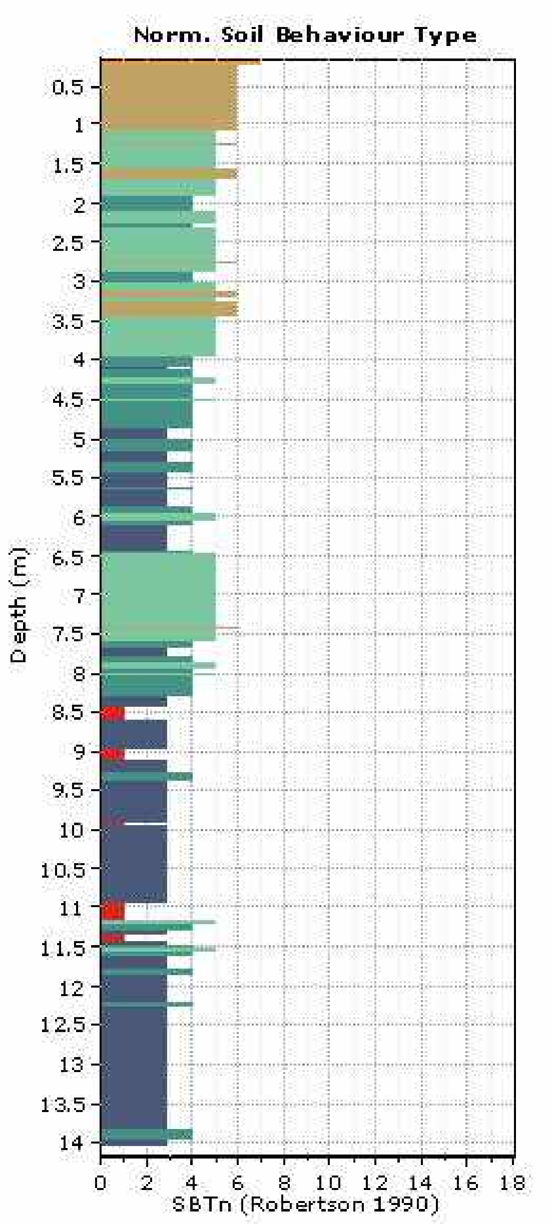

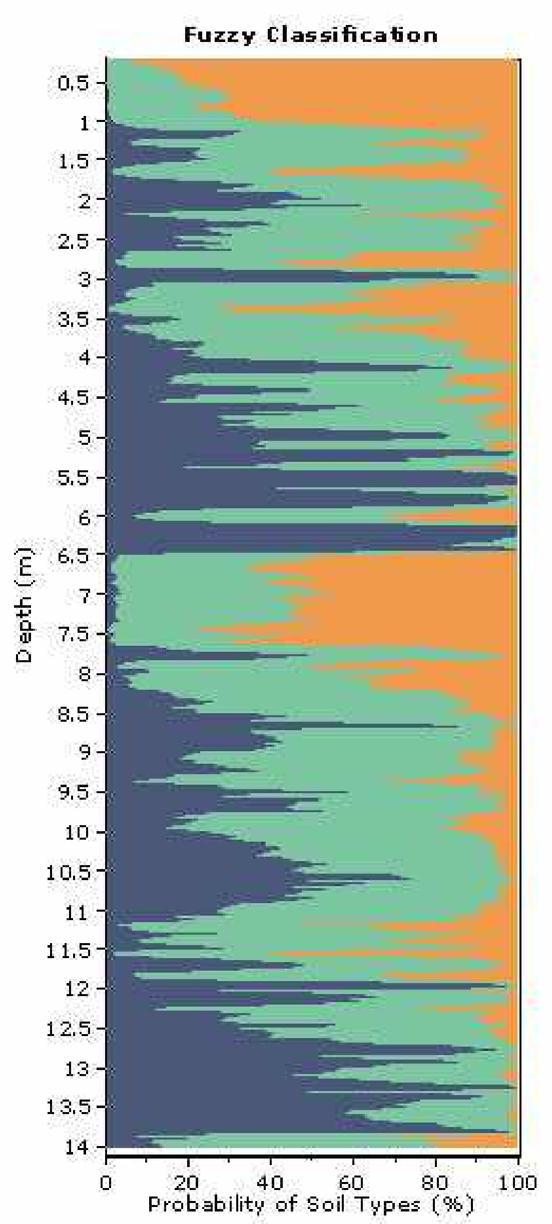

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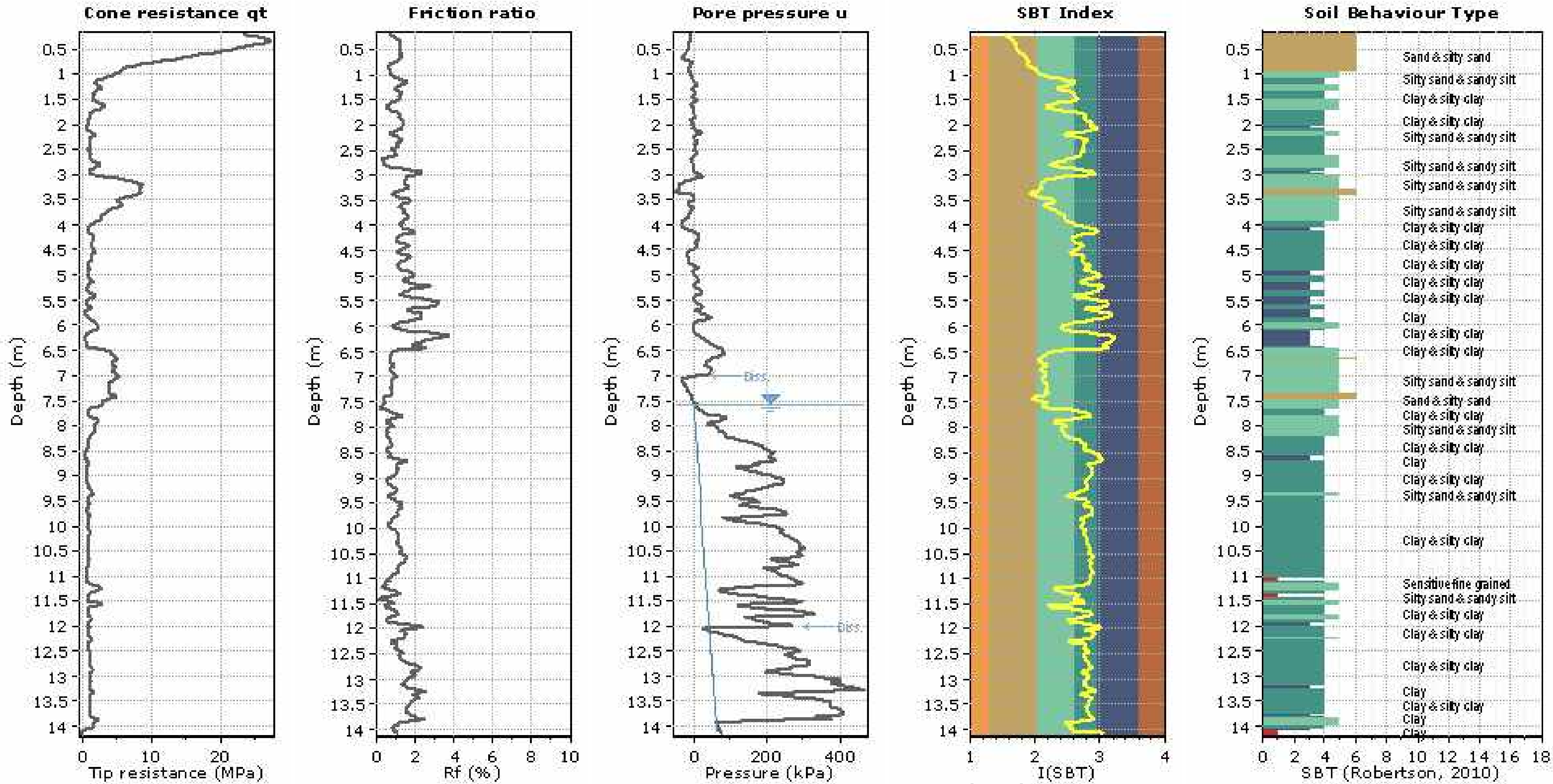
CPT: KP CPT05A
Total depth: 14.12 m, Date: 4/09/2020
Coords: lat 305799° lon 6879943°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**



SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

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CPT: KP CPT05A
Total depth: 14.12 m, Date: 4/09/2020
Coords: lat 305799° lon 6879943°
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Project: **Thunderbox Gold Mine**
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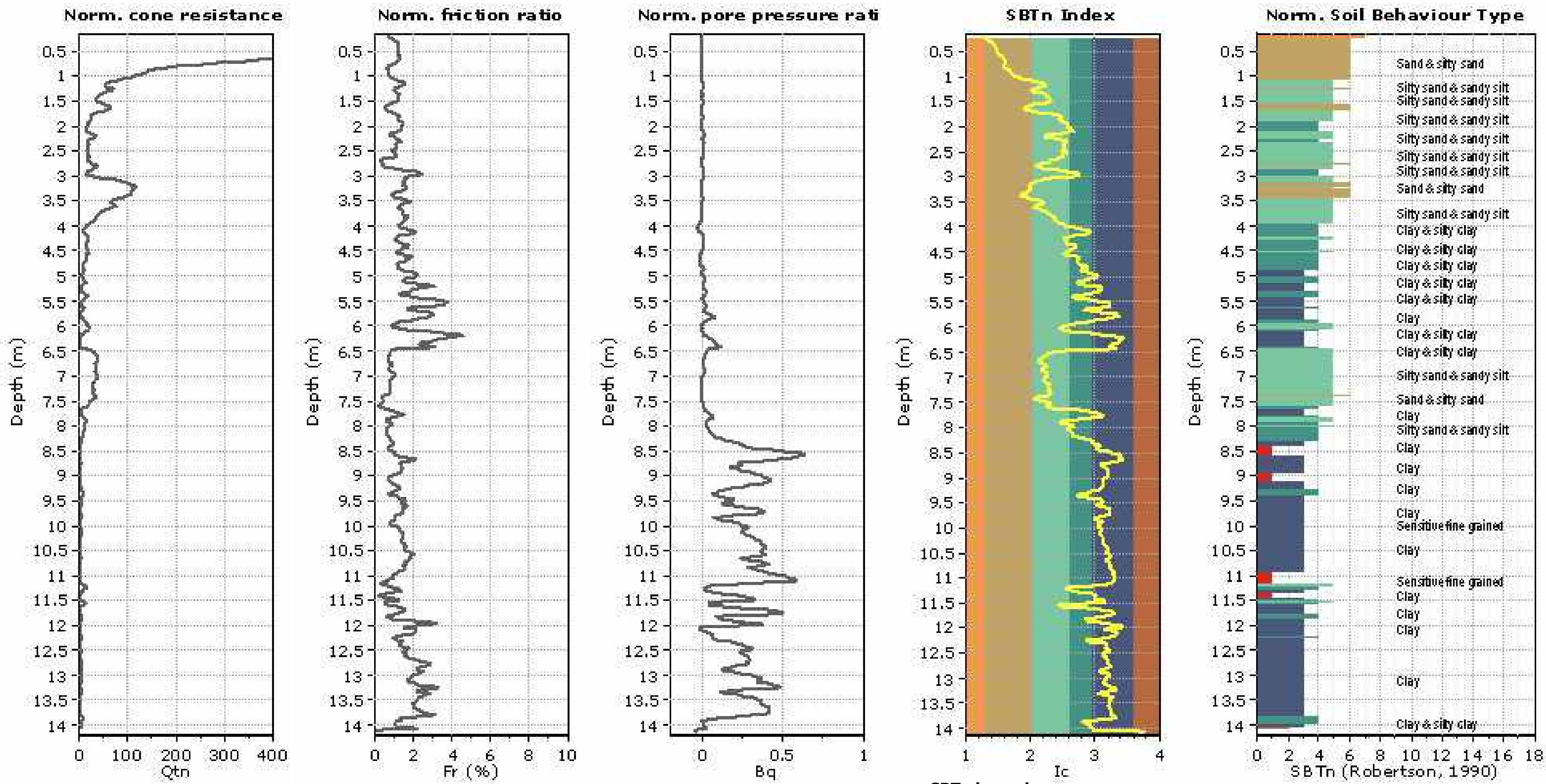

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

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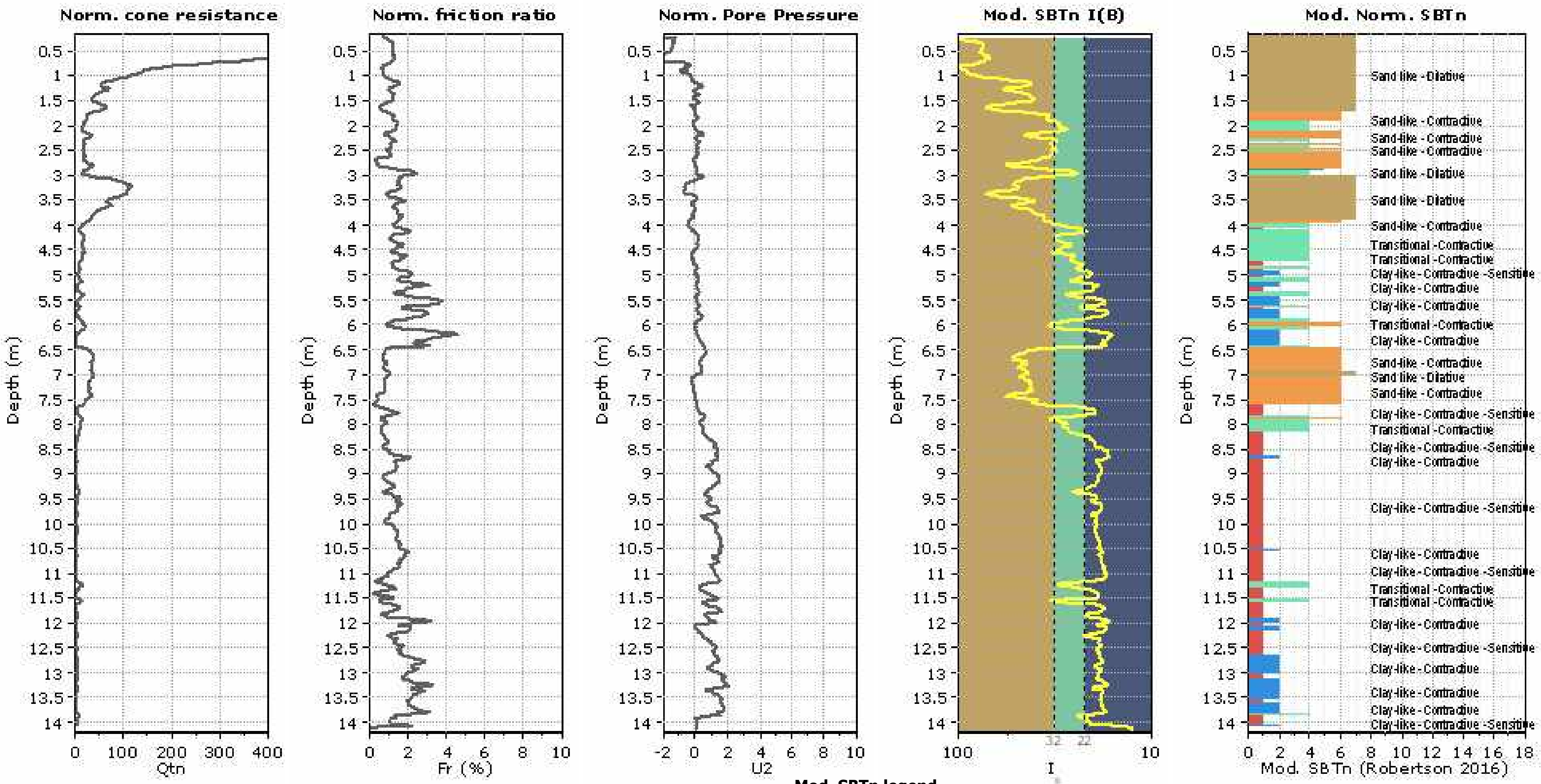
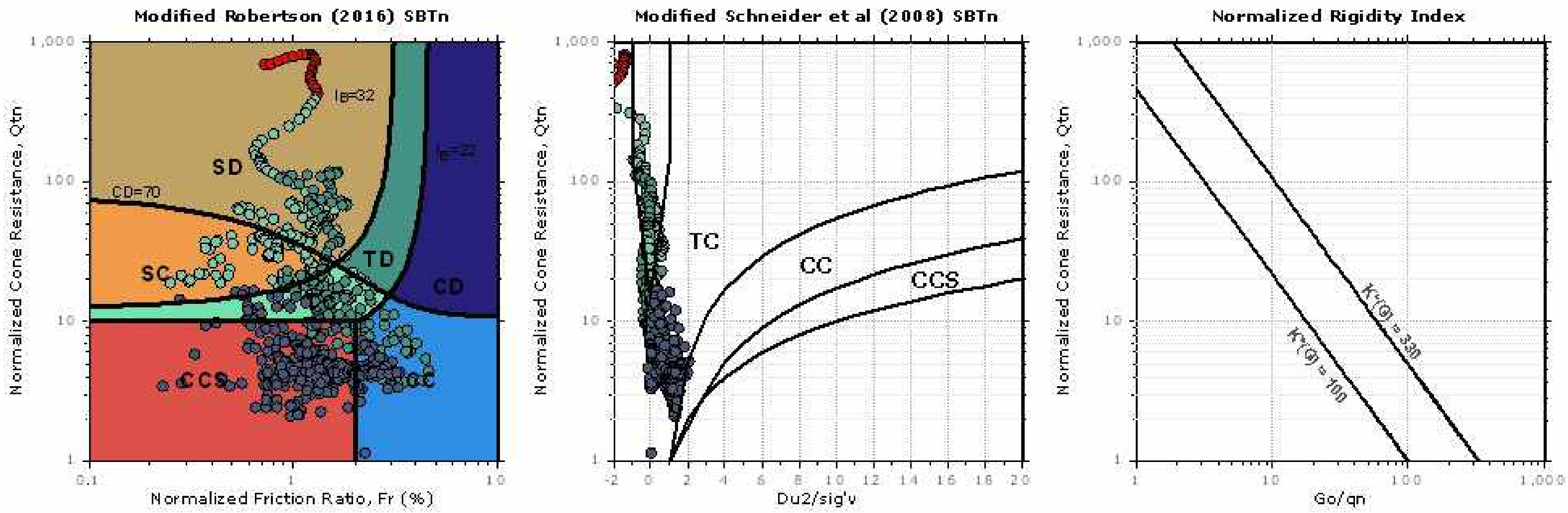


Mod. SBTn legend

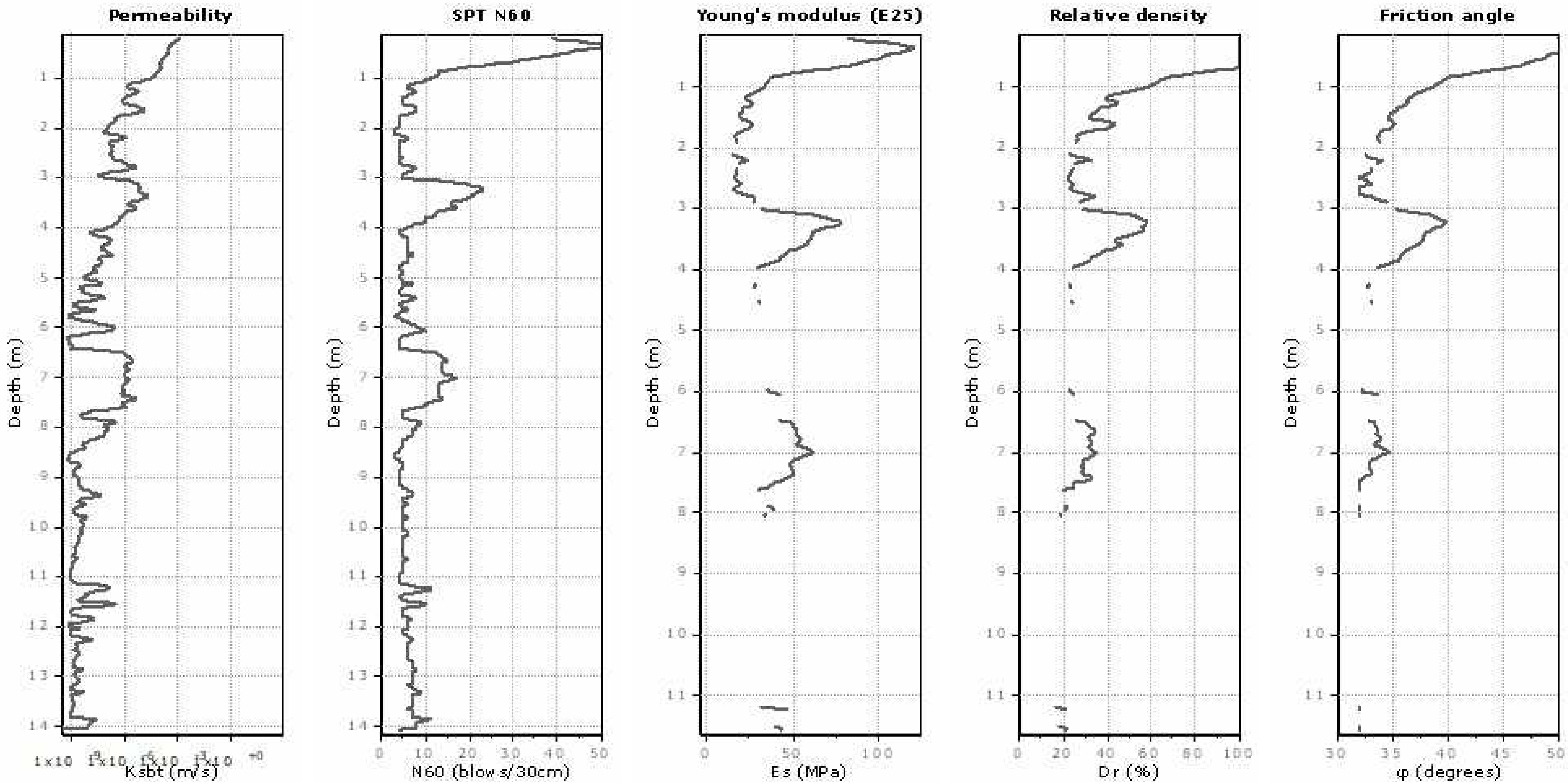
- 1. CCS: ClayLike - Contractive, Sensitive
- 2. CC: Clay-like - Contractive
- 3. CD: Clay-Like: Dilative
- 4. TC: Transitional - Contractive
- 5. TD: Transitional - Dilative
- 6. SC: Sand-like - Contractive
- 7. SD: Sand-like - Dilative

Updated SBTn plots



CCS: Clay-like - Contractive - Sensitive
CC: Clay-like - Contractive
CD: Clay-like - Dilative
TC: Transitional - Contractive
TD: Transitional - Dilative
SC: Sand-like - Contractive
SD: Sand-like - Dilative

K(G) > 330: Soils with significant microstructure (e.g. age/cementation)



Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative density constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

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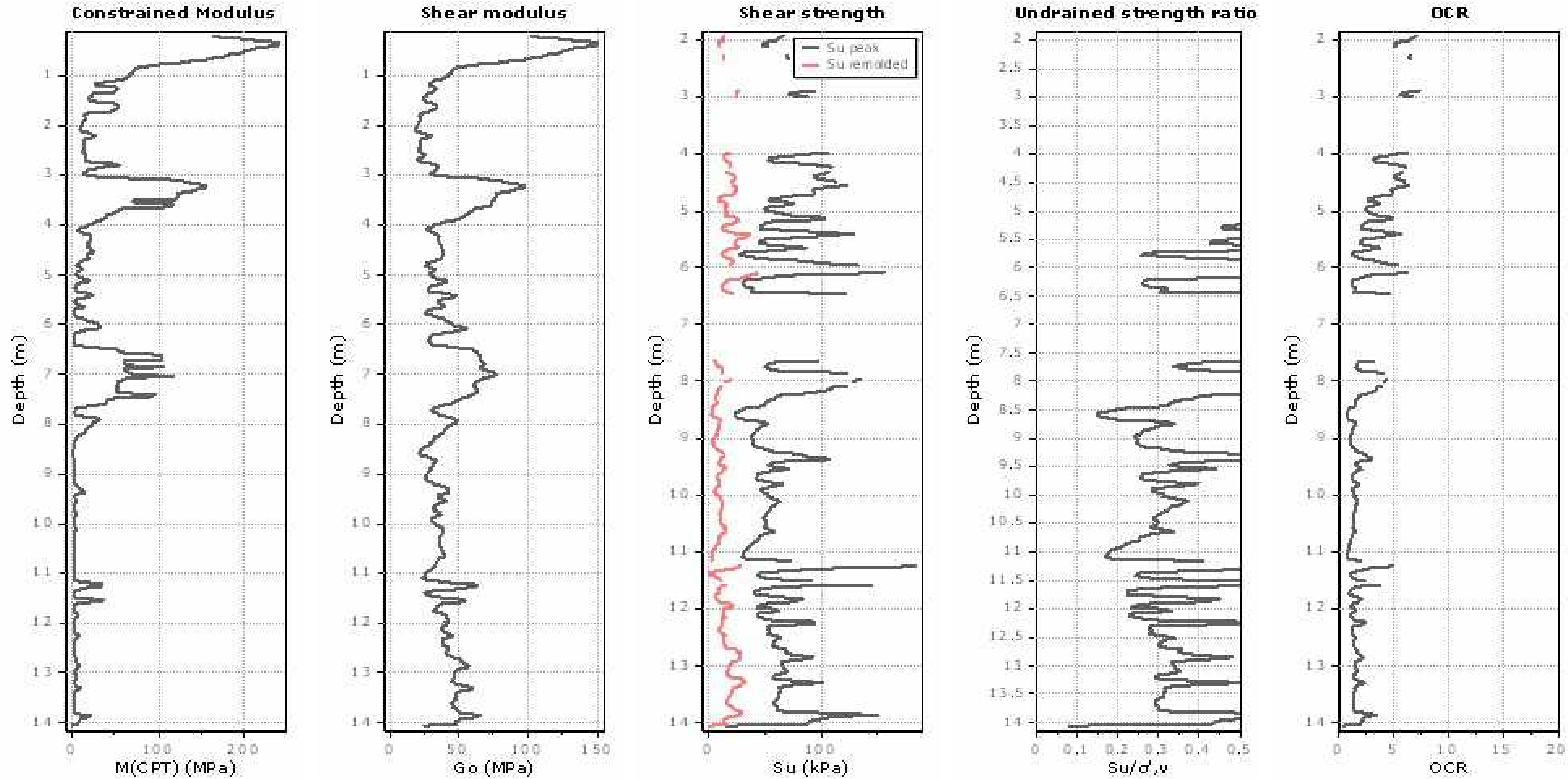
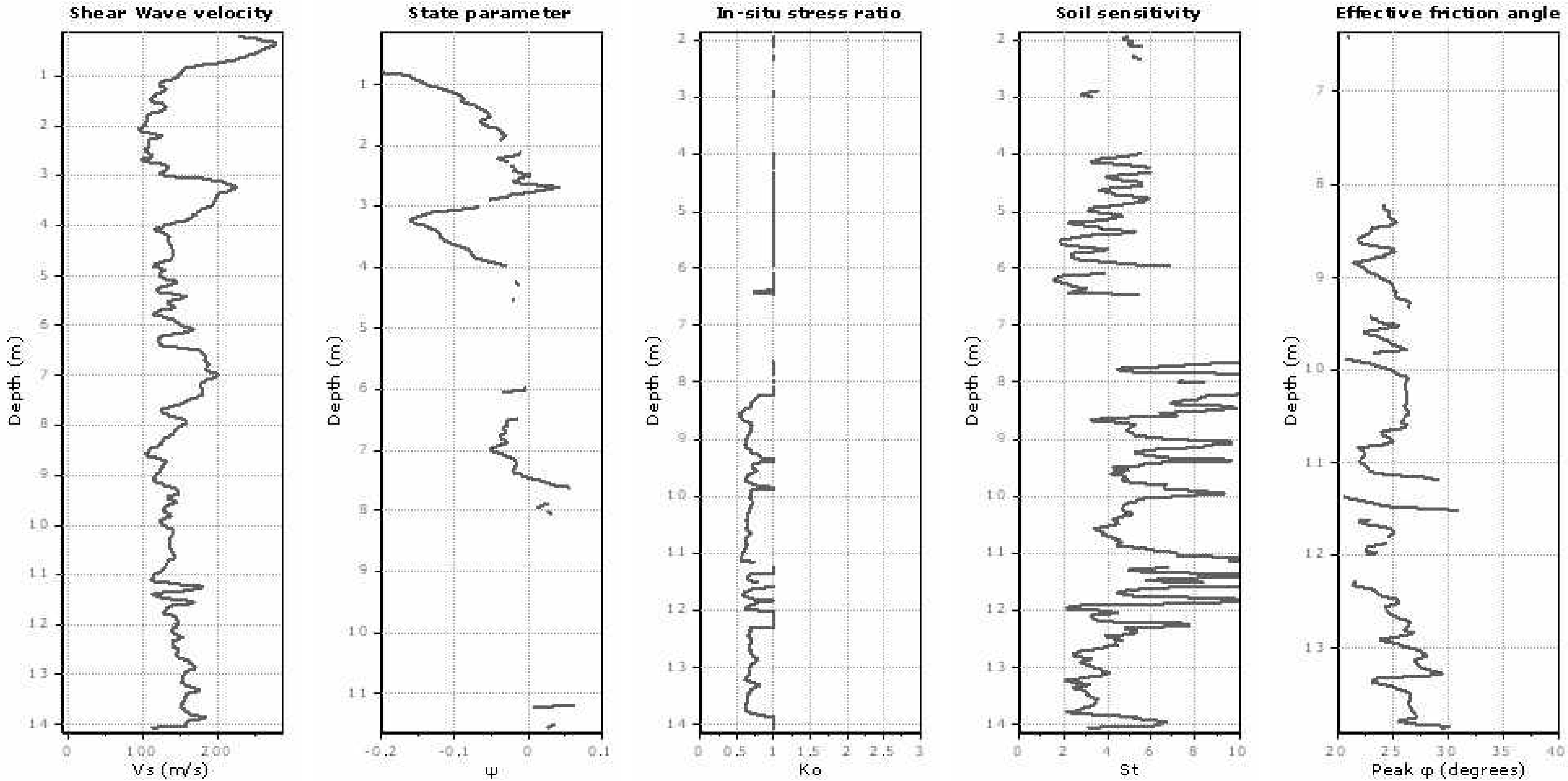


Calculation parameters
Constrained modulus: Based on variable alpha using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable alpha using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14

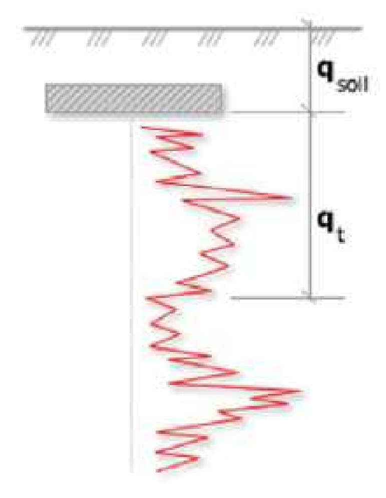
OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data



Calculation parameters

Soil Sensitivity factor, N_S: 7.00

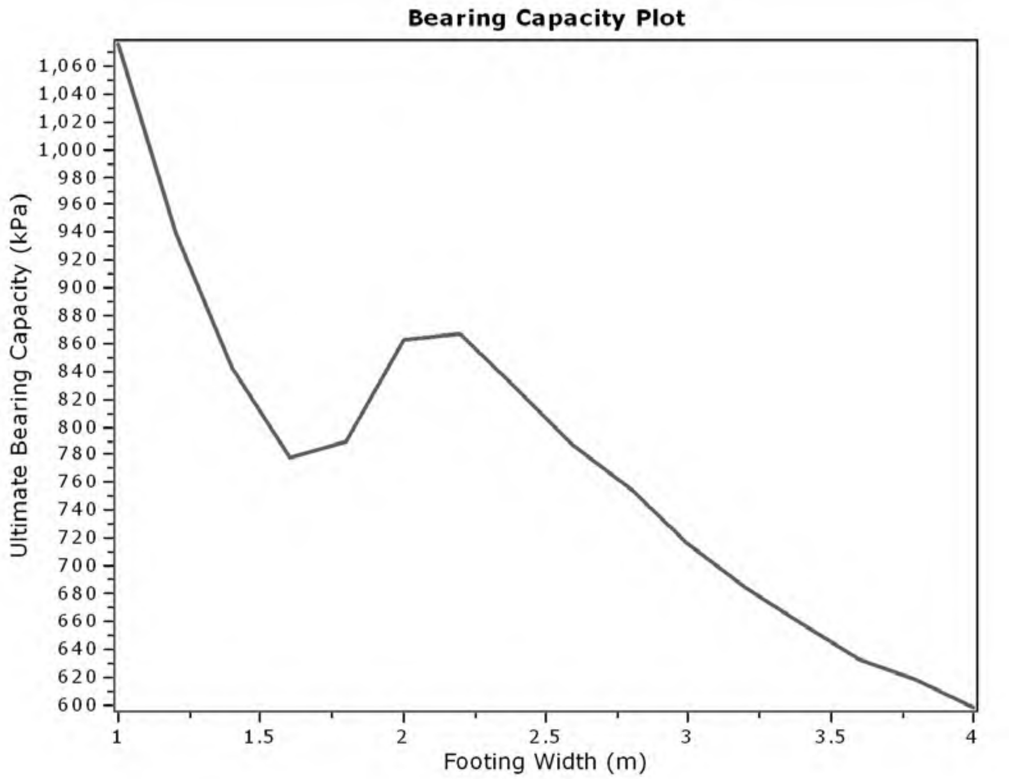
User defined estimation data



Bearing Capacity calculation is perfromed based on the formula:

$$Q_{ult} = R_k \times q_t + q_{soil}$$

where:
R_k: Bearing capacity factor
q_t: Average corrected cone resistance over calculation depth
q_{soil}: Pressure applied by soil above footing



:: Tabular results ::

No	B (m)	Start Depth (m)	End Depth (m)	Ave. q_t (MPa)	R_k	Soil Press. (kPa)	Ult. bearing cap. (kPa)
1	1.00	0.50	2.00	5.33	0.20	9.50	1075.72
2	1.20	0.50	2.30	4.65	0.20	9.50	938.68
3	1.40	0.50	2.60	4.17	0.20	9.50	842.83
4	1.60	0.50	2.90	3.84	0.20	9.50	777.97
5	1.80	0.50	3.20	3.90	0.20	9.50	788.94
6	2.00	0.50	3.50	4.26	0.20	9.50	862.05
7	2.20	0.50	3.80	4.29	0.20	9.50	867.64
8	2.40	0.50	4.10	4.09	0.20	9.50	826.92
9	2.60	0.50	4.40	3.88	0.20	9.50	785.75
10	2.80	0.50	4.70	3.73	0.20	9.50	754.82
11	3.00	0.50	5.00	3.53	0.20	9.50	715.87
12	3.20	0.50	5.30	3.38	0.20	9.50	684.77
13	3.40	0.50	5.60	3.24	0.20	9.50	658.33
14	3.60	0.50	5.90	3.11	0.20	9.50	632.14
15	3.80	0.50	6.20	3.04	0.20	9.50	617.64
16	4.00	0.50	6.50	2.94	0.20	9.50	597.87

Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

The porepressures are plotted as a function of square root of (t). The graphical technique suggested by Robertson and Campanella (1989), yields a value for t_{50}, which corresponds to the time for 50% consolidation.

The value of the coefficient of consolidation in the radial or horizontal direction c_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).
t_{50}: time corresponding to 50% consolidation

Permeability estimates based on dissipation test

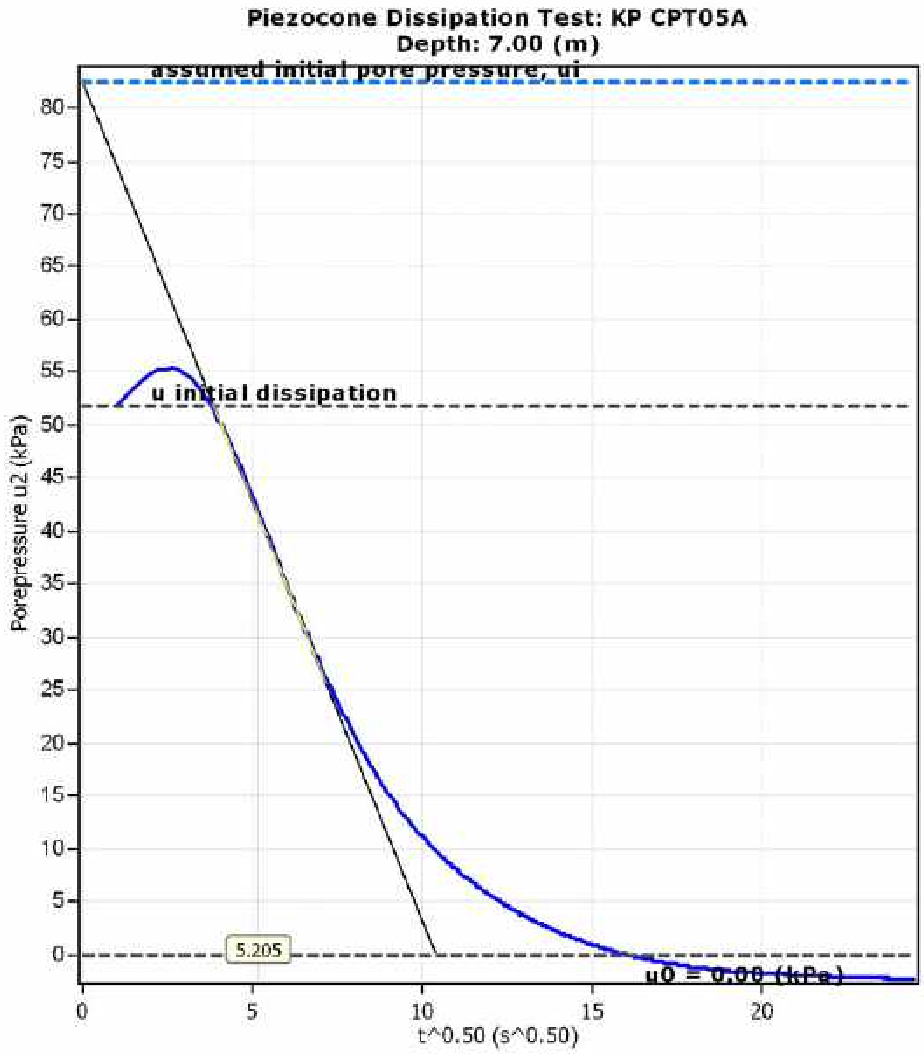
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

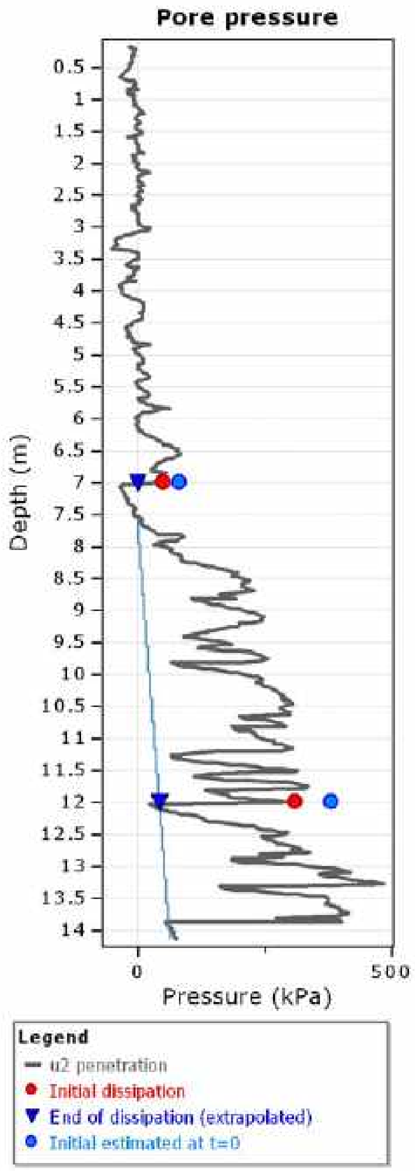
$$k_h = c_h \times \gamma_w / M$$

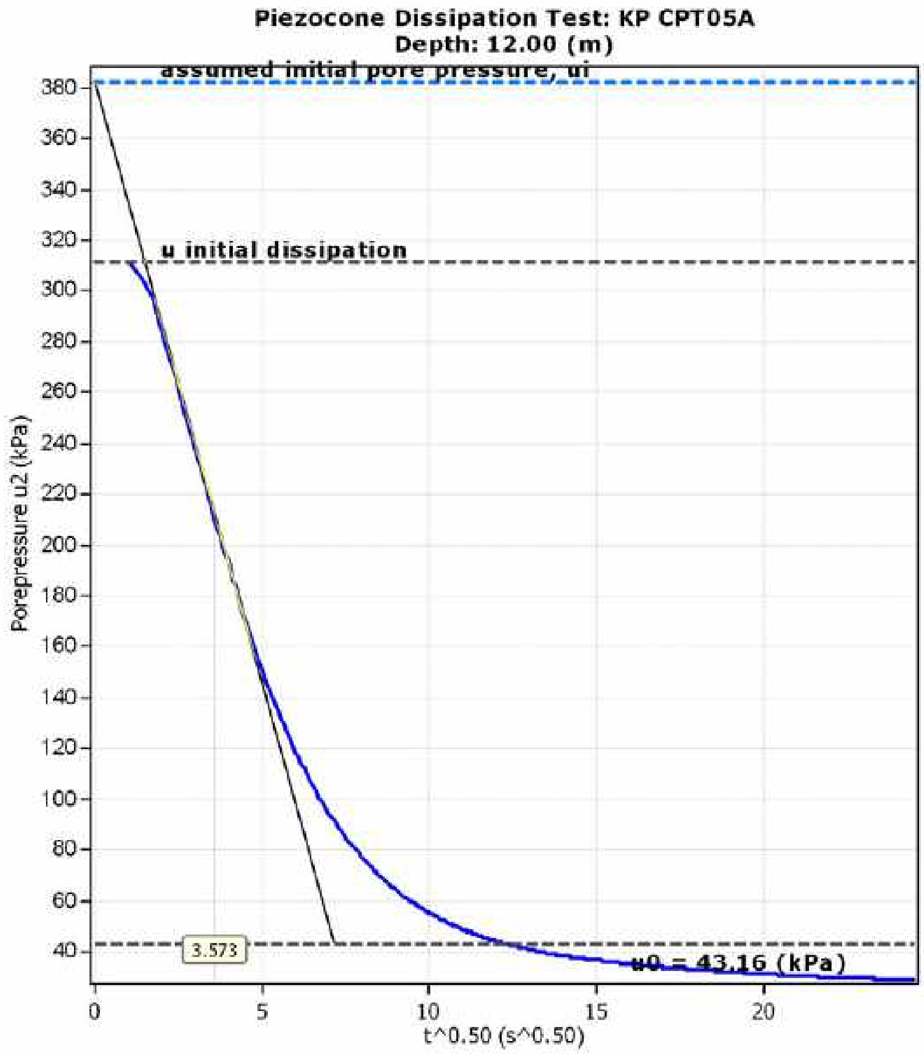
where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

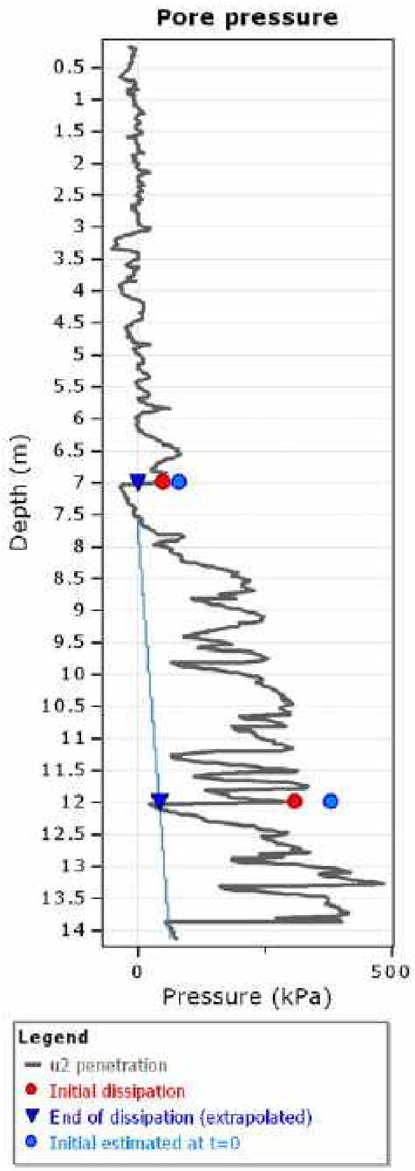
Tabular results

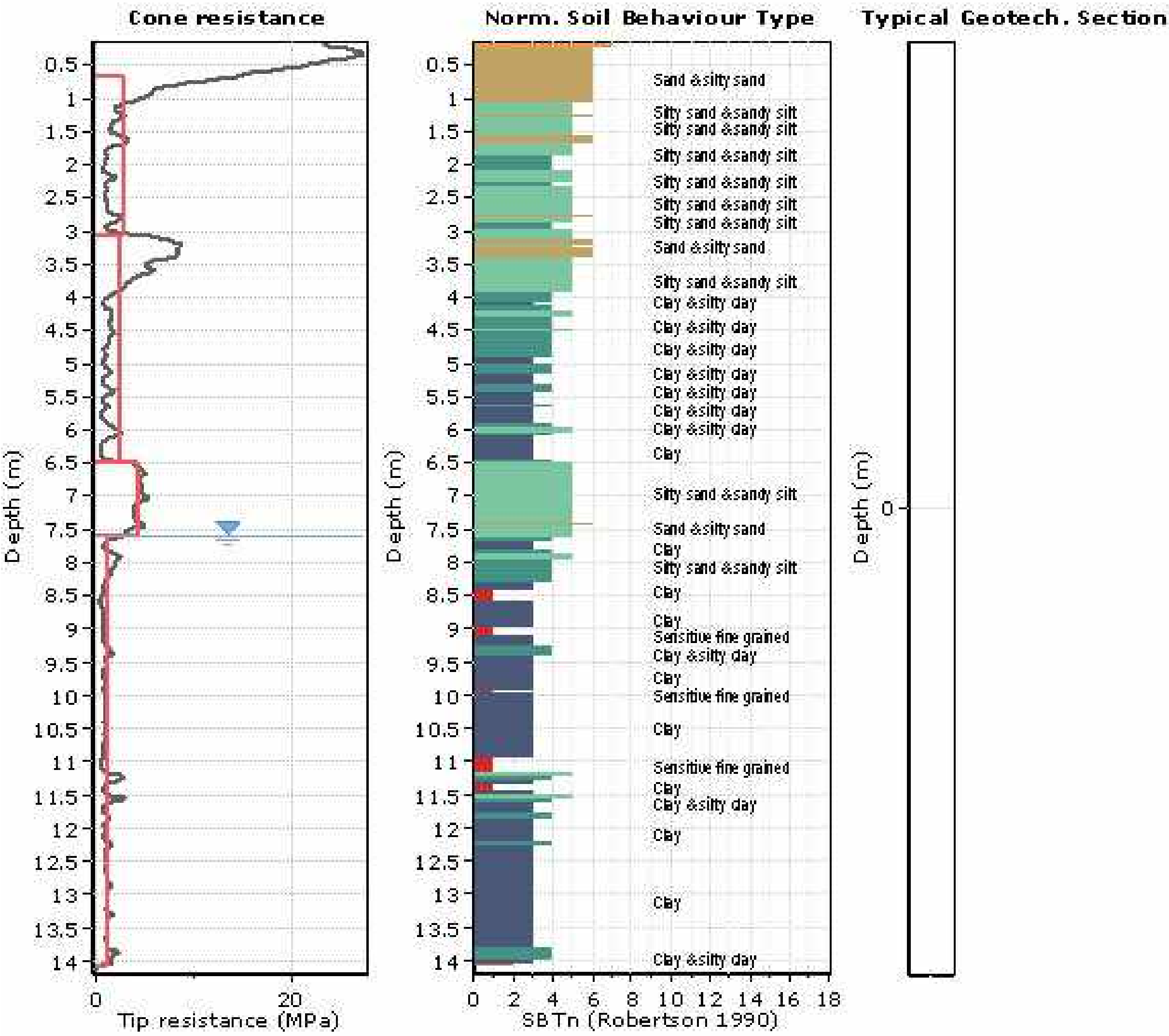
CPTU Borehole	Depth (m)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/S_u	c_h (m^2/s)	c_h (m^2/year)	M (MPa)	k_h (m/s)
KP CPT05A	7.00	5.2	27	8.59E-007	100.00	2.87E-005	904	71.47	3.93E-009
KP CPT05A	12.00	3.6	13	4.05E-007	100.00	6.08E-005	1917	4.37	1.37E-007


Piezocone Dissipation Test: KP CPT05A
Depth: 7.00 (m)
assumed initial pore pressure, ui
u initial dissipation
u0 = 0.00 (kPa)
5.205
Porepressure u2 (kPa)
t^0.50 (s^0.50)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80


Pore pressure
Depth (m)
Pressure (kPa)
0
500
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
10
10.5
11
11.5
12
12.5
13
13.5
14
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0


Piezocone Dissipation Test: KP CPT05A
Depth: 12.00 (m)
assumed initial pore pressure, ui
u initial dissipation
3.573
u0 = 43.16 (kPa)
Porepressure u2 (kPa)
t^0.50 (s^0.50)


Pore pressure
Depth (m)
Pressure (kPa)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0



Tabular results

.:: Layer No: 1 ::.

Code: Layer_1 **Start depth:** 0.66 (m), **End depth:** 3.06 (m)

Description: Silty sand & sandy silt

Basic results

Total cone resistance: 2.72 ±2.83 MPa

Sleeve friction: 27.08 ±30.94 kPa

Ic: 2.24 ±0.32

SBT_n: 5

SBTn description: Silty sand & sandy silt

Estimation results

Permeability: 1.55E-05 ±3.45E-05 m/s

N_{60}: 7.36 ±5.39 blows

Es: 26.74 ±13.04 MPa

Dr (%): 40.27 ±19.10

φ (degrees): 35.54 ±3.33 °

Unit weight: 19.00 ±0.00 kN/m³

Constrained Mod.: 37.12 ±31.54 MPa

Go: 31.92 ±15.58 MPa

Su: 0.00 ±0.00 kPa

Su ratio: 0.00 ±0.00

O.C.R.: 0.00 ±0.00

.:: Layer No: 2 ::.

Code: Layer_2 **Start depth:** 3.06 (m), **End depth:** 6.48 (m)

Description: Clay & silty clay

Basic results	Estimation results	
Total cone resistance: 2.36 ±2.29 MPa	Permeability: 1.36E-06 ±3.47E-06 m/s	Constrained Mod.: 34.68 ±43.61 MPa
Sleeve friction: 35.24 ±31.12 kPa	N_{60}: 8.24 ±5.45 blows	Go: 44.57 ±18.67 MPa
Ic: 2.69 ±0.41	Es: 0.00 ±0.00 MPa	Su: 71.17 ±28.41 kPa
SBT_n: 4	Dr (%): 0.00 ±0.00	Su ratio: 0.74 ±0.32
SBTn description: Clay & silty clay	φ (degrees): 0.00 ±0.00 °	O.C.R.: 3.41 ±1.50
	Unit weight: 19.00 ±0.00 kN/m³	

.:: Layer No: 3 ::.

Code: Layer_3 **Start depth:** 6.48 (m), **End depth:** 7.60 (m)

Description: Silty sand & sandy silt

Basic results	Estimation results	
Total cone resistance: 4.25 ±0.64 MPa	Permeability: 1.57E-06 ±8.60E-07 m/s	Constrained Mod.: 65.87 ±21.55 MPa
Sleeve friction: 31.22 ±10.66 kPa	N_{60}: 13.39 ±1.68 blows	Go: 62.74 ±7.70 MPa
Ic: 2.24 ±0.07	Es: 50.05 ±6.14 MPa	Su: 0.00 ±0.00 kPa
SBT_n: 5	Dr (%): 30.54 ±2.83	Su ratio: 0.00 ±0.00
SBTn description: Silty sand & sandy silt	φ (degrees): 33.15 ±0.68 °	O.C.R.: 0.00 ±0.00
	Unit weight: 19.00 ±0.00 kN/m³	

.:: Layer No: 4 ::.

Code: Layer_4 **Start depth:** 7.60 (m), **End depth:** 14.06 (m)

Description: Clay

Basic results	Estimation results	
Total cone resistance: 1.11 ±0.43 MPa	Permeability: 1.92E-08 ±7.24E-08 m/s	Constrained Mod.: 5.88 ±6.88 MPa
Sleeve friction: 12.33 ±6.62 kPa	N_{60}: 5.93 ±1.51 blows	Go: 38.59 ±8.85 MPa
Ic: 3.09 ±0.21	Es: 0.00 ±0.00 MPa	Su: 60.72 ±24.21 kPa
SBT_n: 3	Dr (%): 0.00 ±0.00	Su ratio: 0.35 ±0.15
SBTn description: Clay	φ (degrees): 0.00 ±0.00 °	O.C.R.: 1.62 ±0.68
	Unit weight: 19.00 ±0.00 kN/m³	

Summary table of mean values

From depth To depth (m)	Thickness (m)	Permeability (m/s)	SPT_{N60} (blows/30cm)	E_s (MPa)	D_r (%)	Friction angle	Constrained modulus, M (MPa)	Shear modulus, G_O (MPa)	Undrained strength, S_U (kPa)	Undrained strength ratio	OCR	Unit weight (kN/m³)
0.66	2.40	1.55E-05	7.4	26.7	40.3	35.5	37.1	31.9	0.0	0.0	0.0	19.0
3.06		(±3.45E-05)	(±5.4)	(±13.0)	(±19.1)	(±3.3)	(±31.5)	(±15.6)	(±0.0)	(±0.0)	(±0.0)	(±0.0)
3.06	3.42	1.36E-06	8.2	0.0	0.0	0.0	34.7	44.6	71.2	0.7	3.4	19.0
6.48		(±3.47E-06)	(±5.4)	(±0.0)	(±0.0)	(±0.0)	(±43.6)	(±18.7)	(±28.4)	(±0.3)	(±1.5)	(±0.0)
6.48	1.12	1.57E-06	13.4	50.1	30.5	33.1	65.9	62.7	0.0	0.0	0.0	19.0
7.60		(±8.60E-07)	(±1.7)	(±6.1)	(±2.8)	(±0.7)	(±21.5)	(±7.7)	(±0.0)	(±0.0)	(±0.0)	(±0.0)
7.60	6.46	1.92E-08	5.9	0.0	0.0	0.0	5.9	38.6	60.7	0.4	1.6	19.0
14.06		(±7.24E-08)	(±1.5)	(±0.0)	(±0.0)	(±0.0)	(±6.9)	(±8.8)	(±24.2)	(±0.1)	(±0.7)	(±0.0)

Depth values presented in this table are measured from free ground surface

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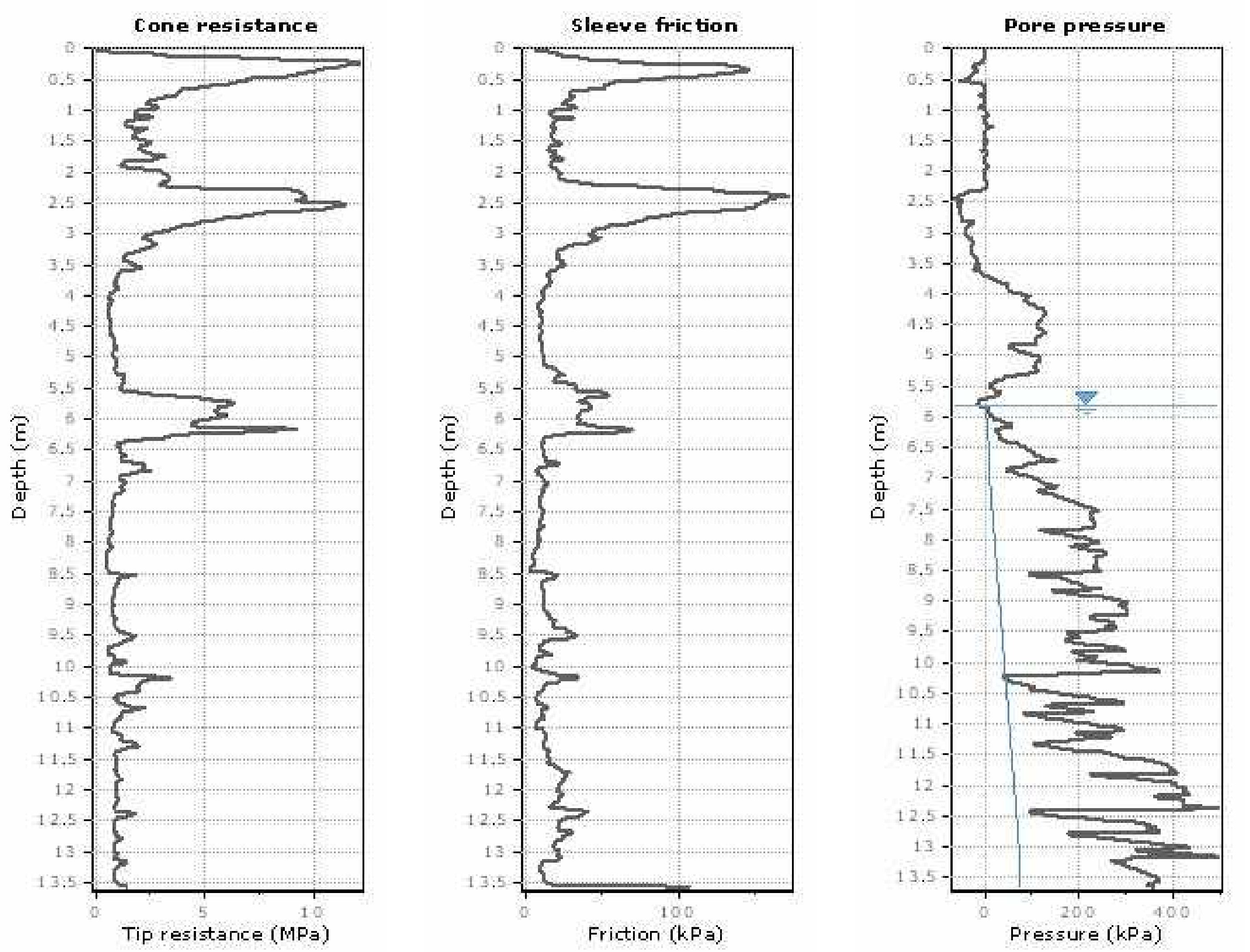
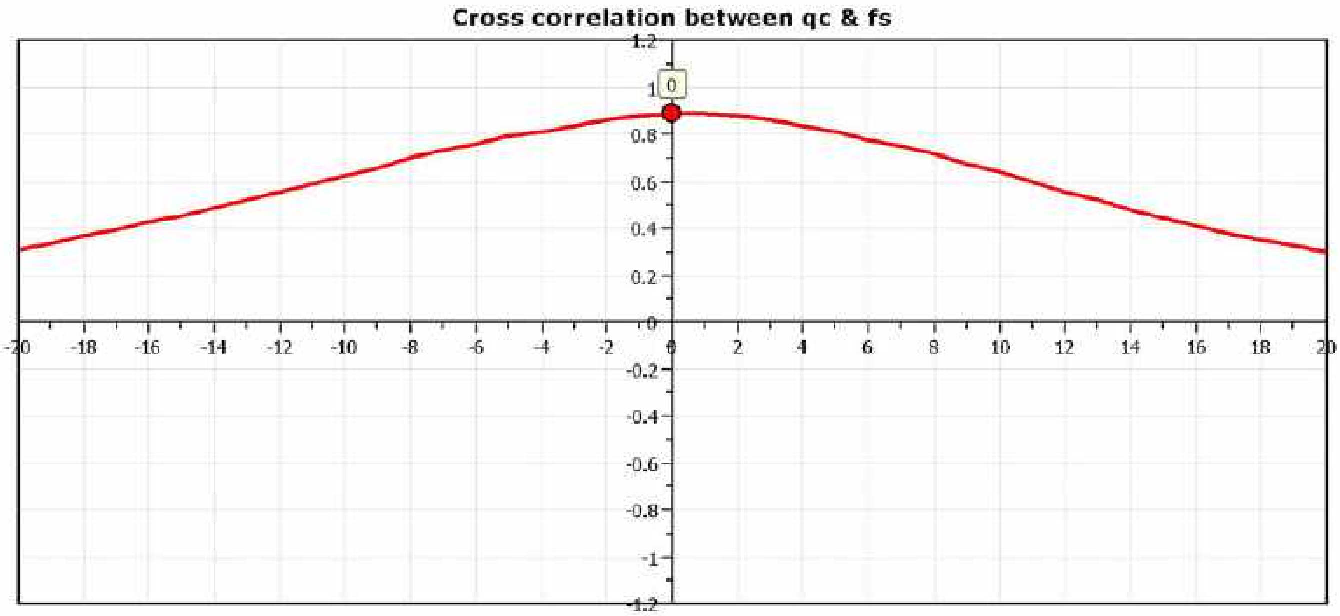
CPT: KP CPT06
Total depth: 13.64 m, Date: 4/09/2020
Coords: lat 305830.3° lon 6879972.3°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

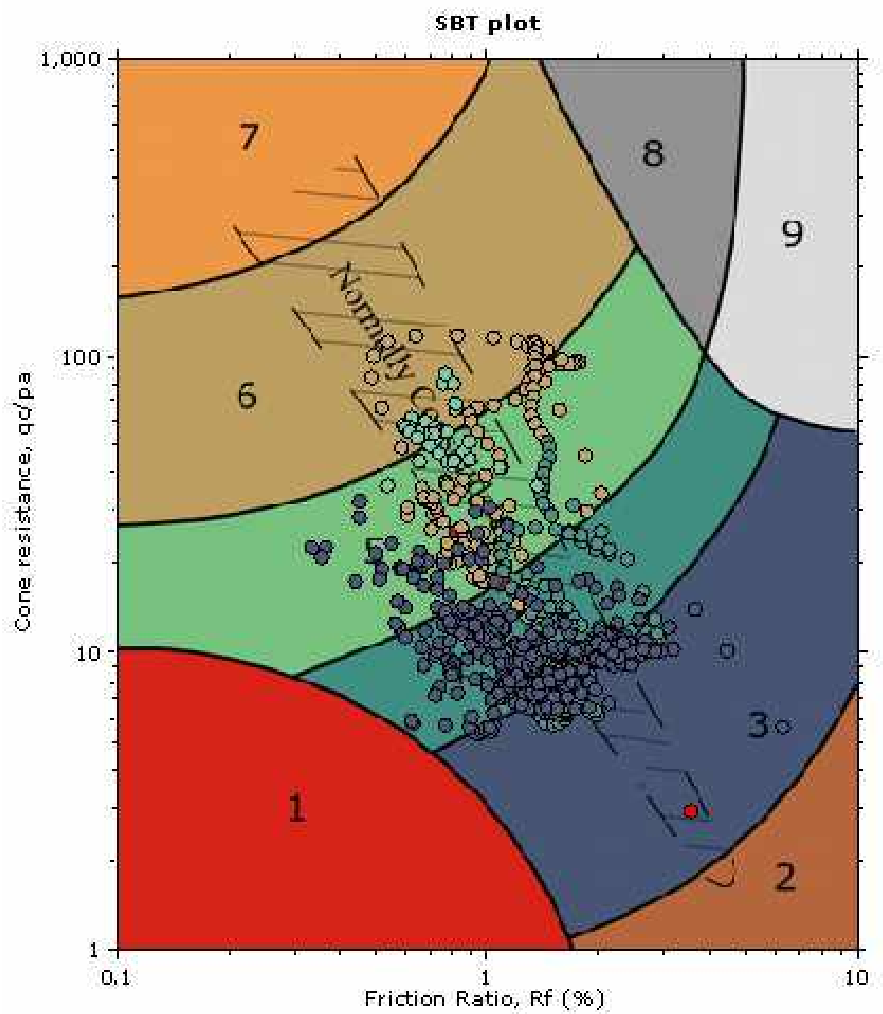
Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**

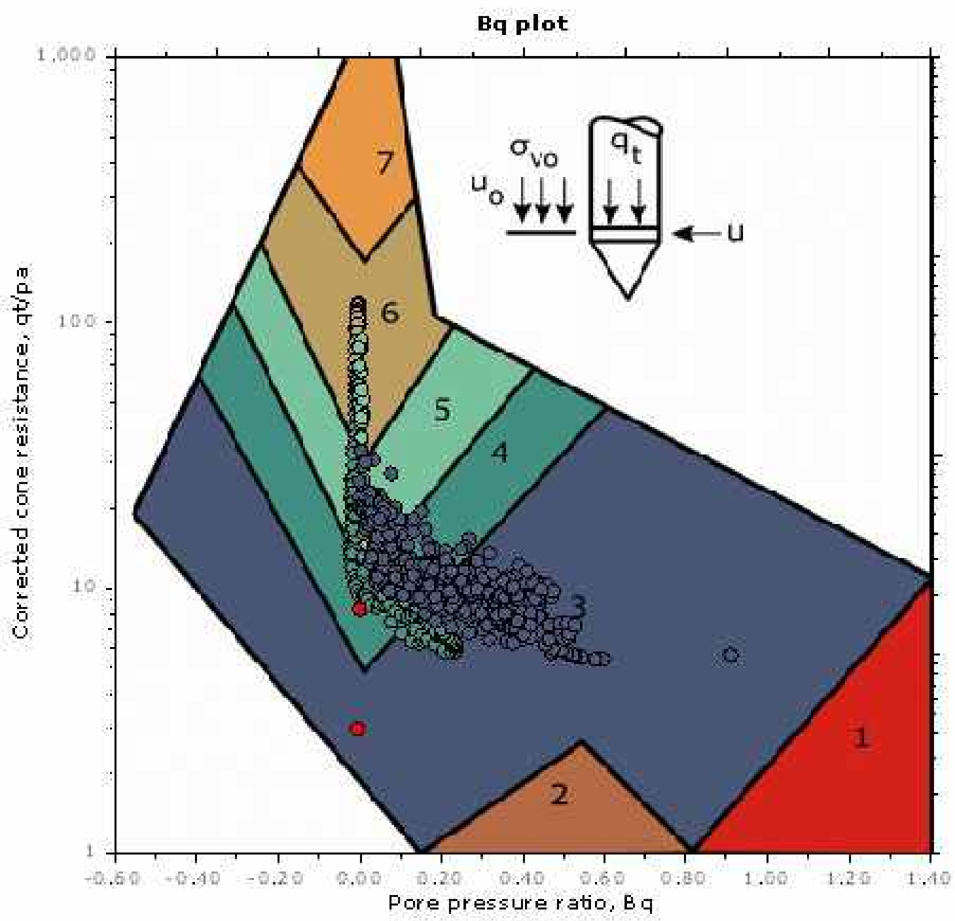


The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



SBT - Bq plots

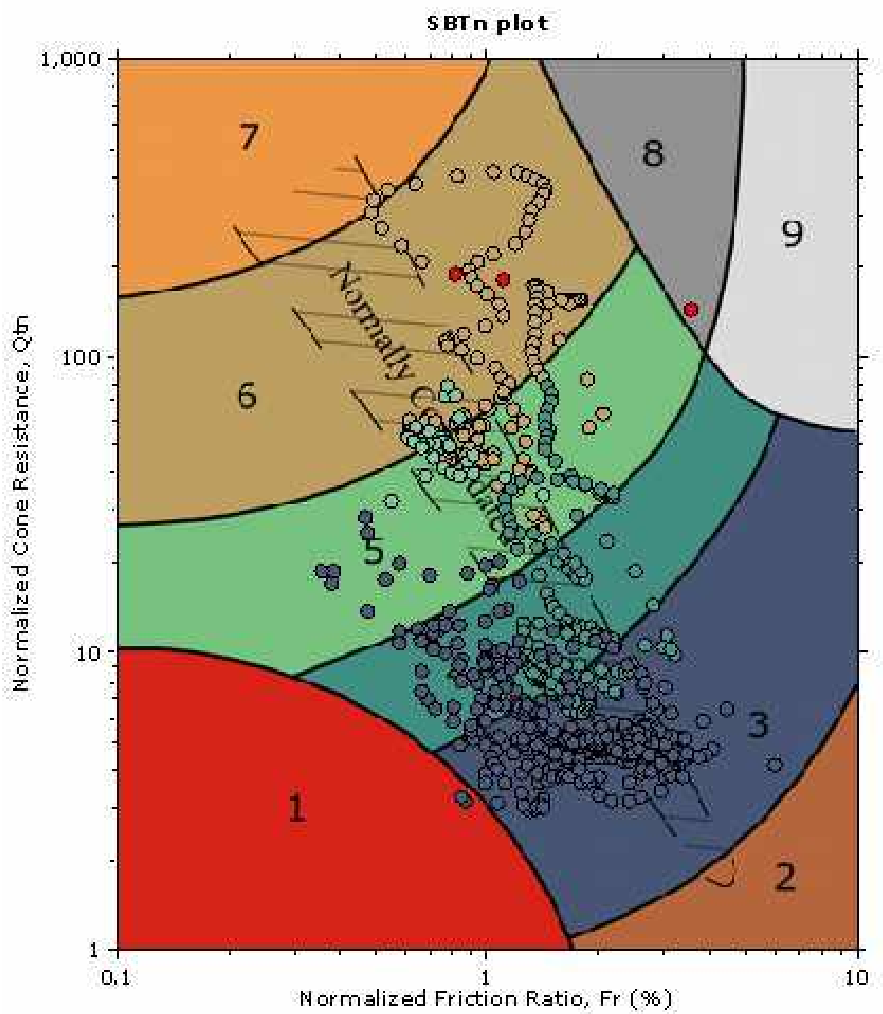


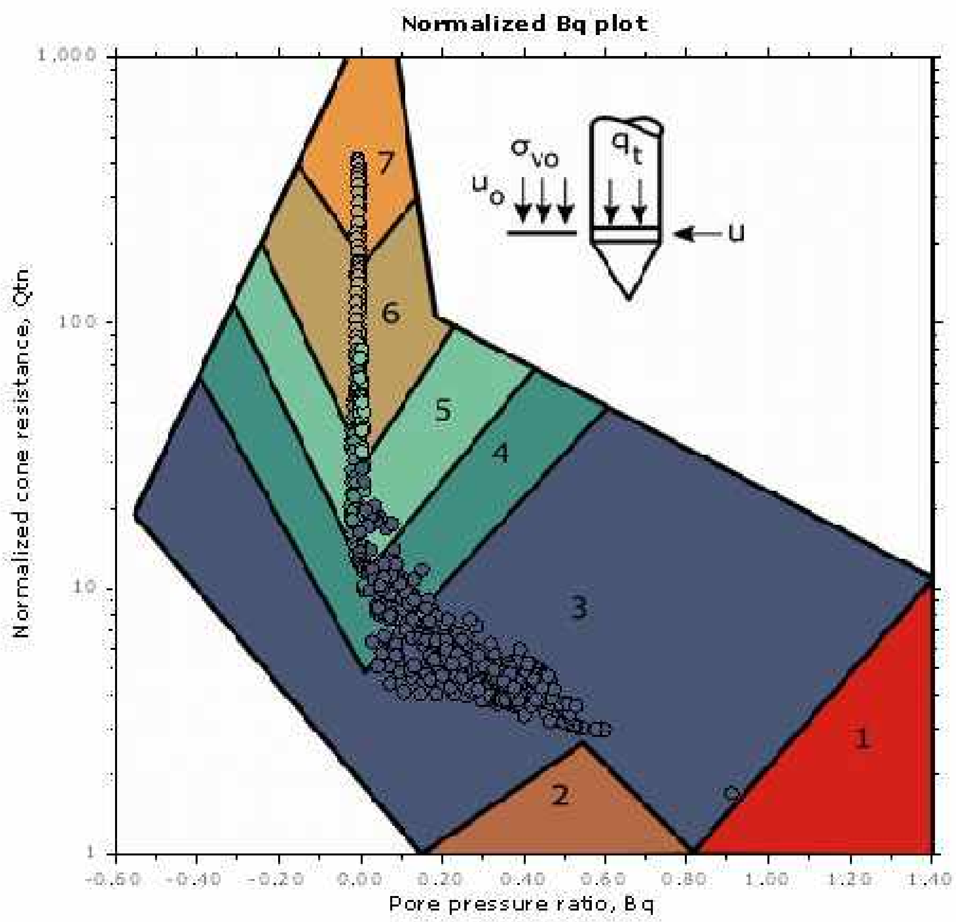


SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravelly sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

SBT - Bq plots (normalized)





SBTn legend

- 1. Sensitive fine grained
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- 4. Clayey silt to silty clay
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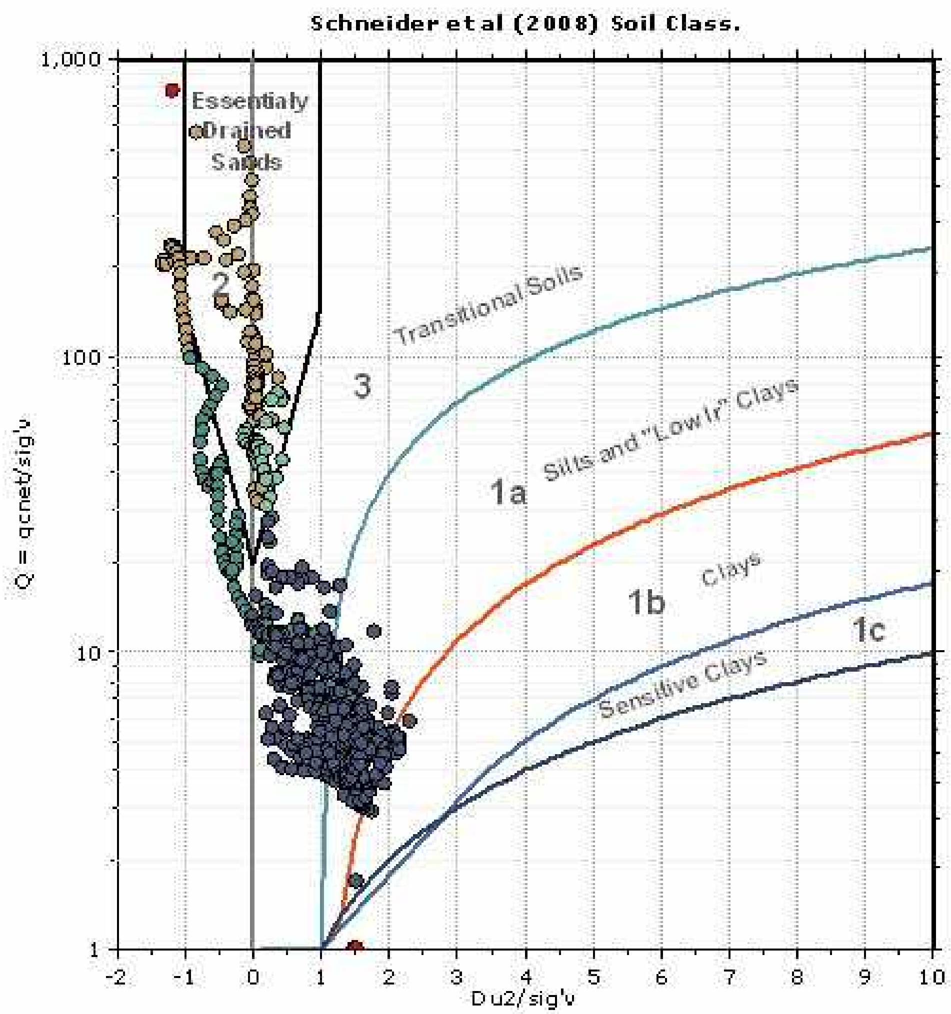
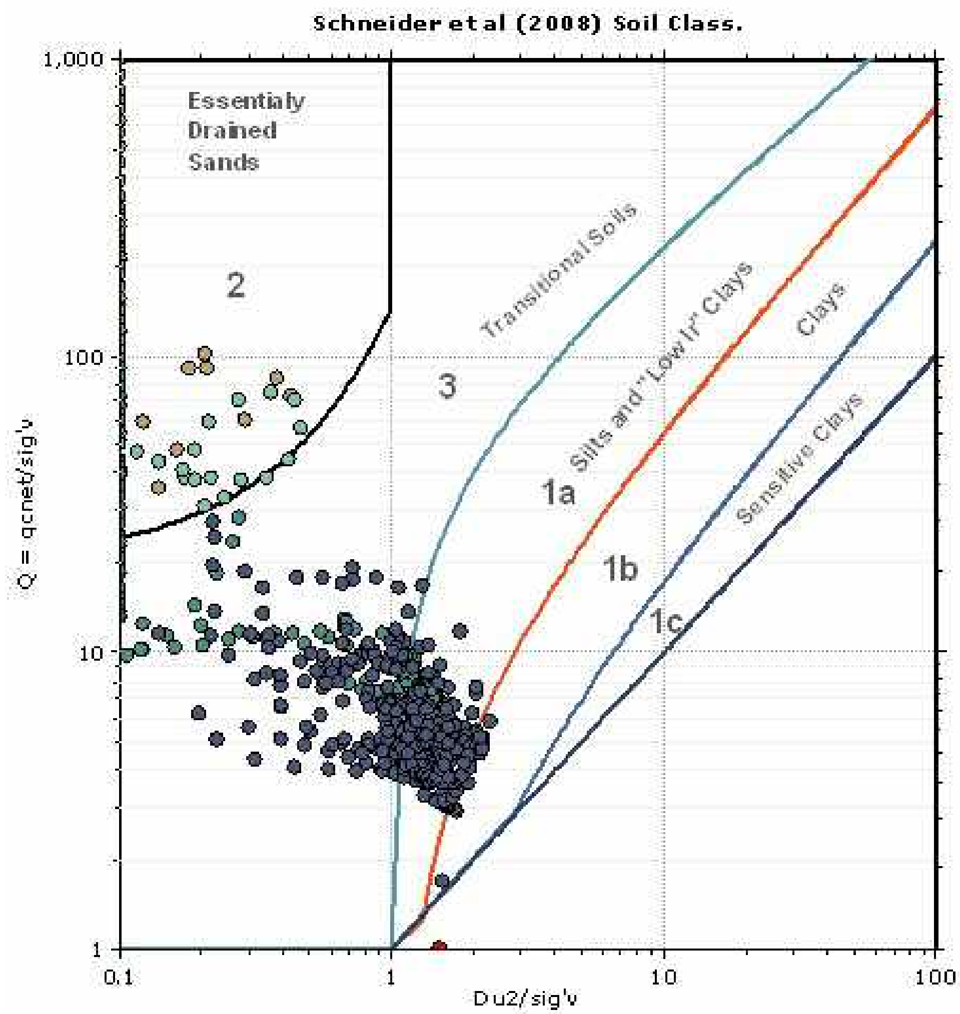
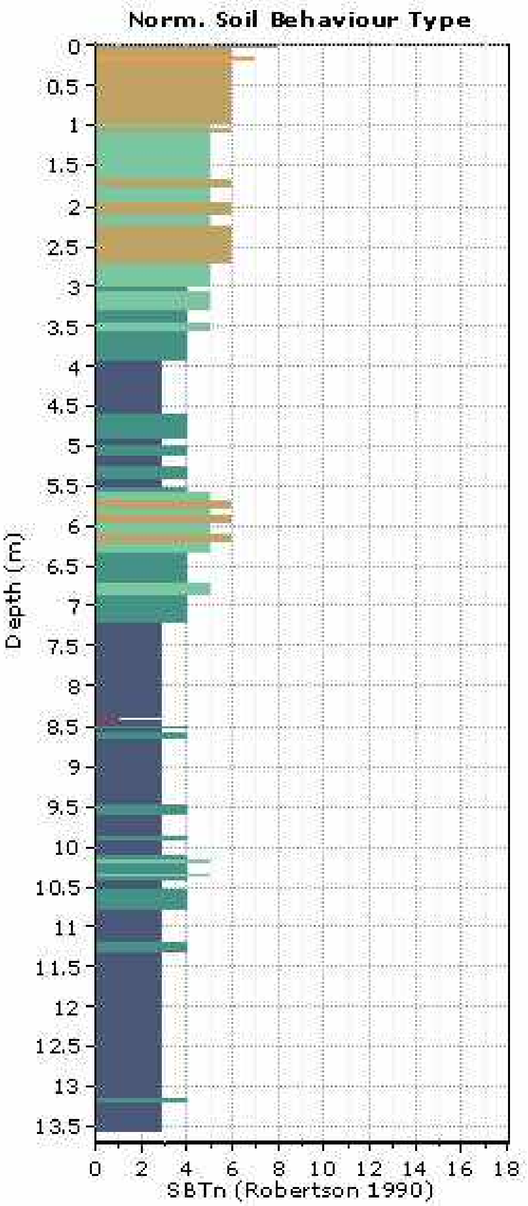
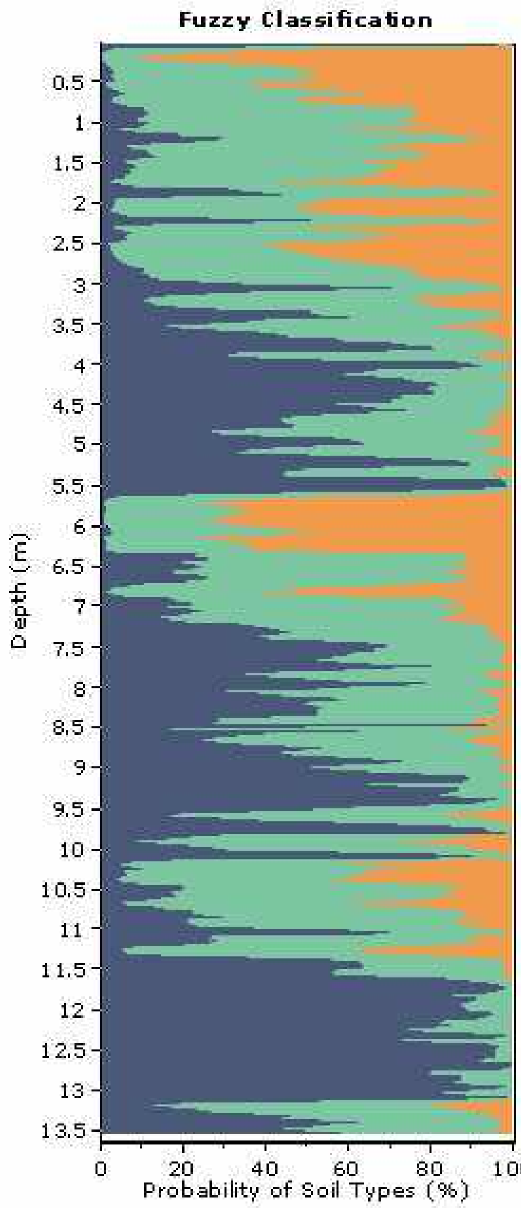
Bq plots (Schneider)






Norm. Soil Behaviour Type
Depth (m)
SBTn (Robertson 1990)


Fuzzy Classification
Depth (m)
Probability of Soil Types (%)

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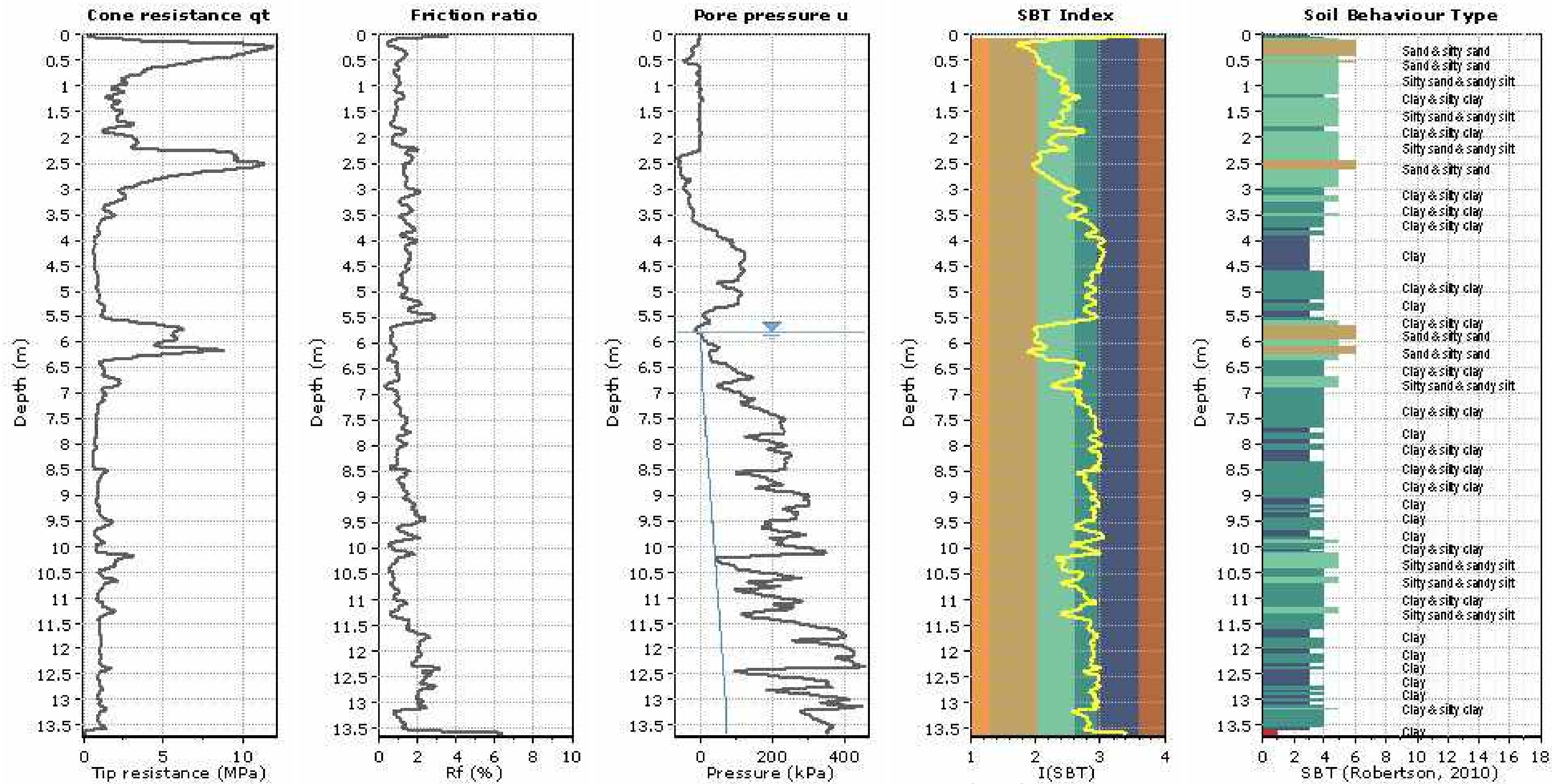

SBT legend

1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

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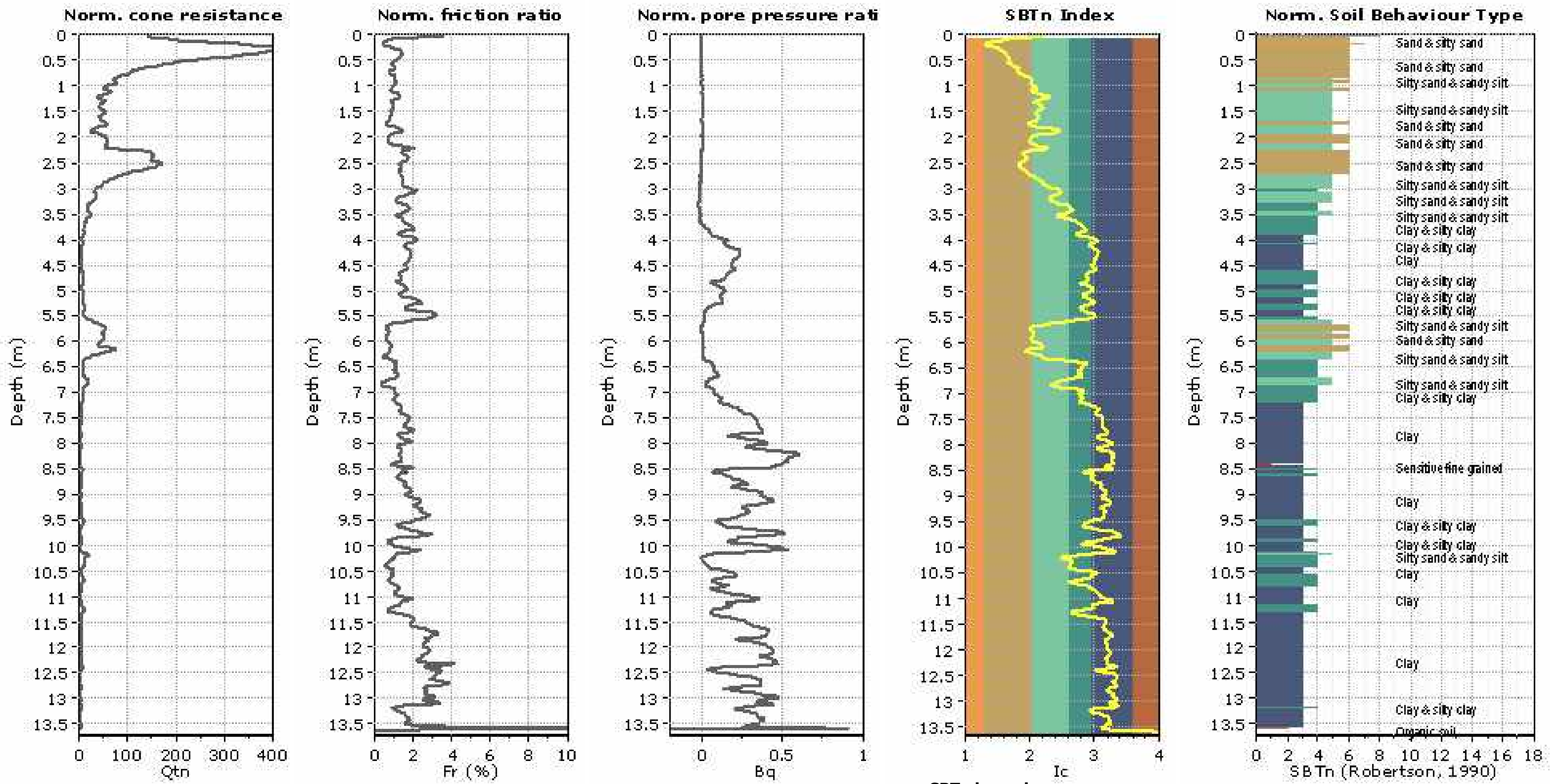

SBTn legend

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3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

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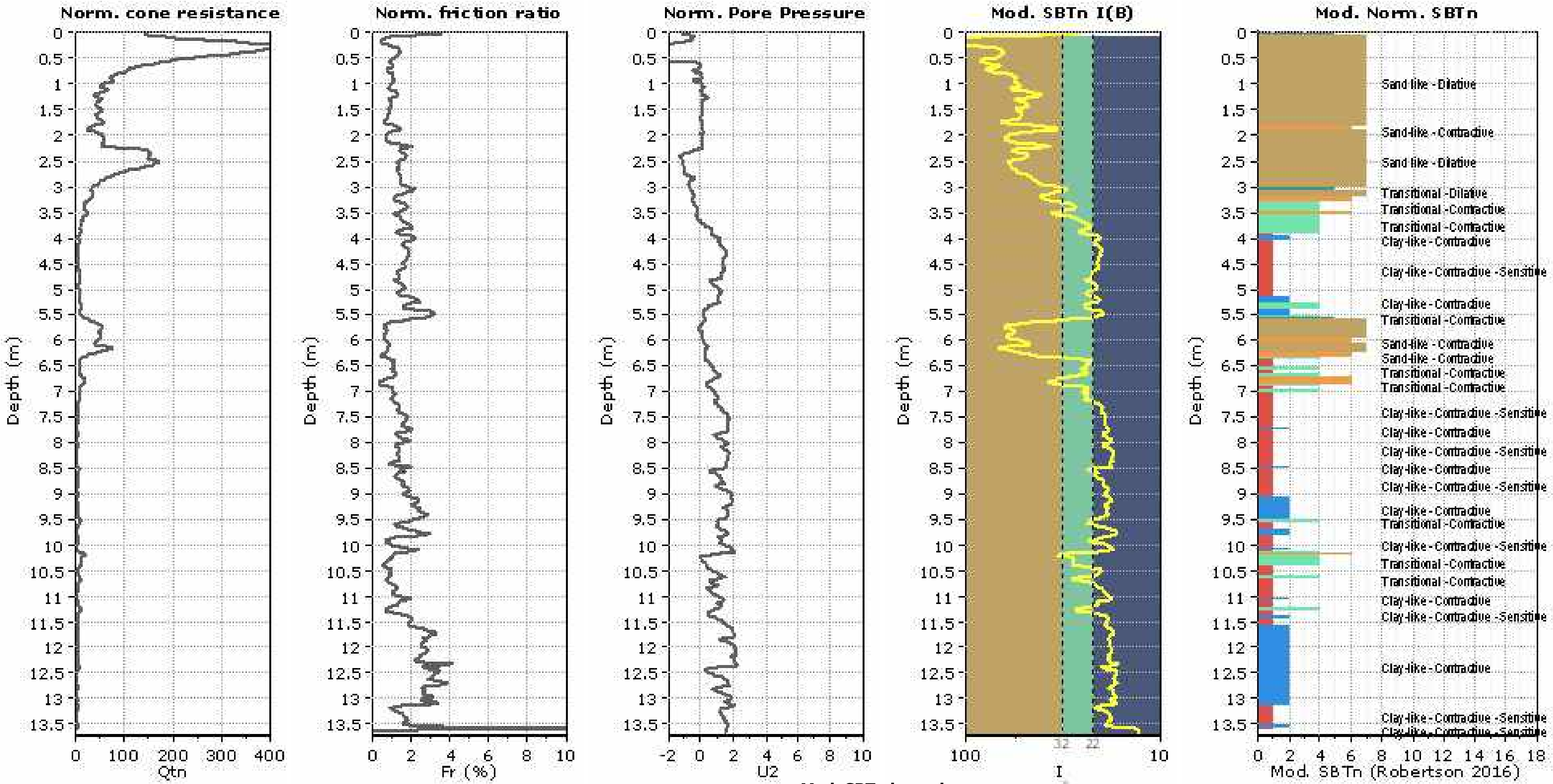
CPT: KP CPT06
Total depth: 13.64 m, Date: 4/09/2020
Coords: lat 305830.3° lon 6879972.3°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

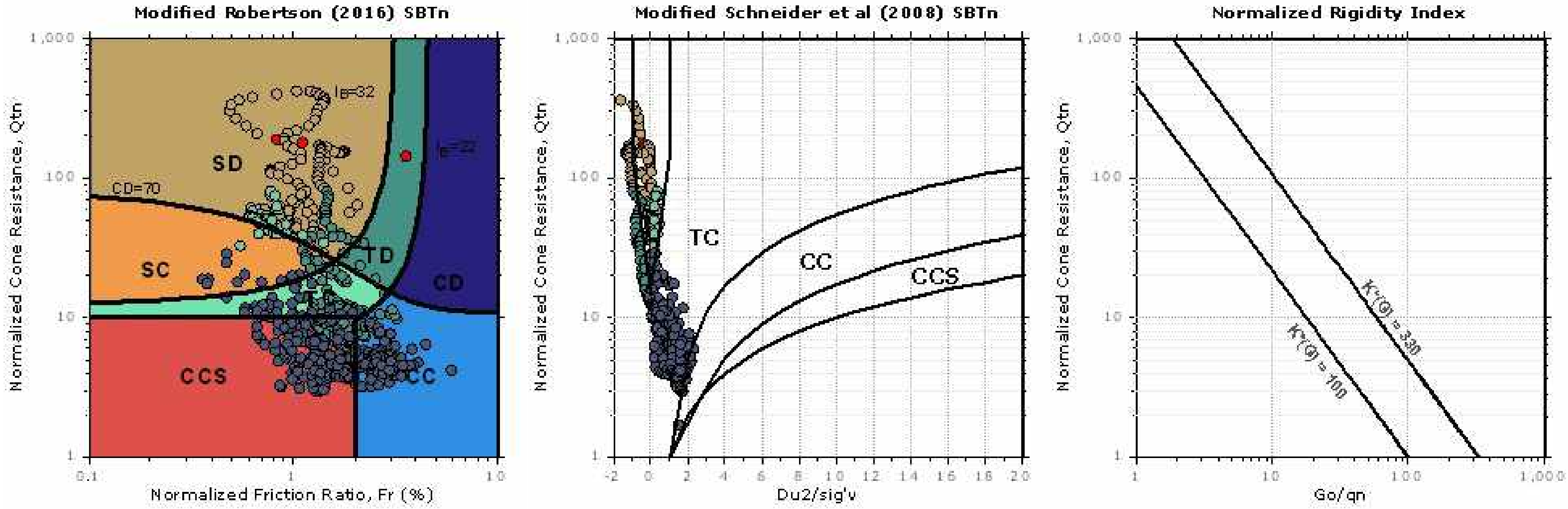
Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**



Mod. SBTn legend

- 1. CCS: ClayLike - Contractive, Sensitive
- 2. CC: Clay-like - Contractive
- 3. CD: Clay-Like: Dilative
- 4. TC: Transitional - Contractive
- 5. TD: Transitional - Dilative
- 6. SC: Sand-like - Contractive
- 7. SD: Sand-like - Dilative

Updated SBTn plots



CCS: Clay-like - Contractive - Sensitive
CC: Clay-like - Contractive
CD: Clay-like - Dilative
TC: Transitional - Contractive
TD: Transitional - Dilative
SC: Sand-like - Contractive
SD: Sand-like - Dilative

K(G) > 330: Soils with significant microstructure (e.g. age/cementation)

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Project: **Thunderbox Gold Mine**
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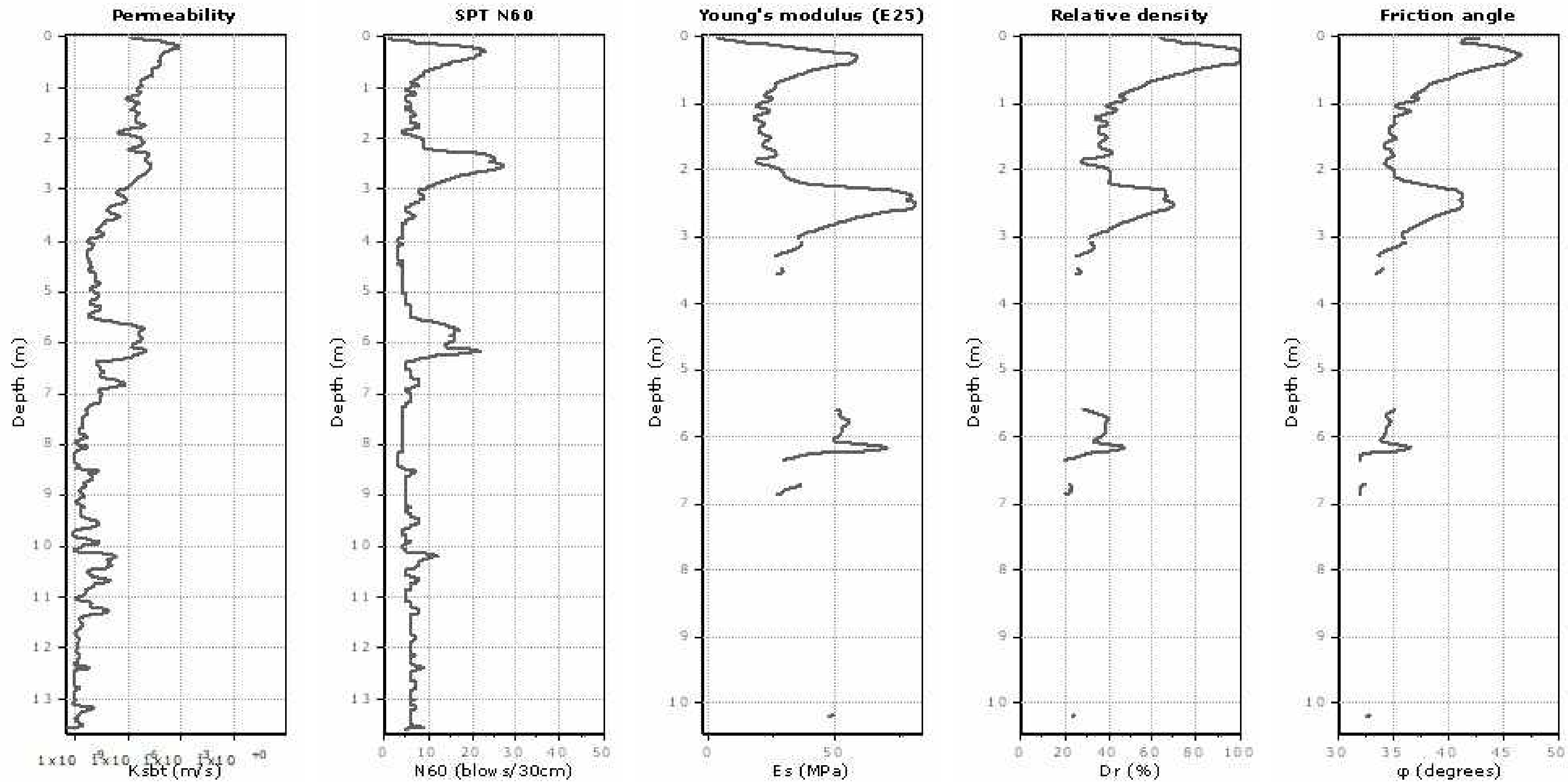

Calculation parameters
Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative density constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

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Coords: lat 305830.3° lon 6879972.3°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

Project: **Thunderbox Gold Mine**
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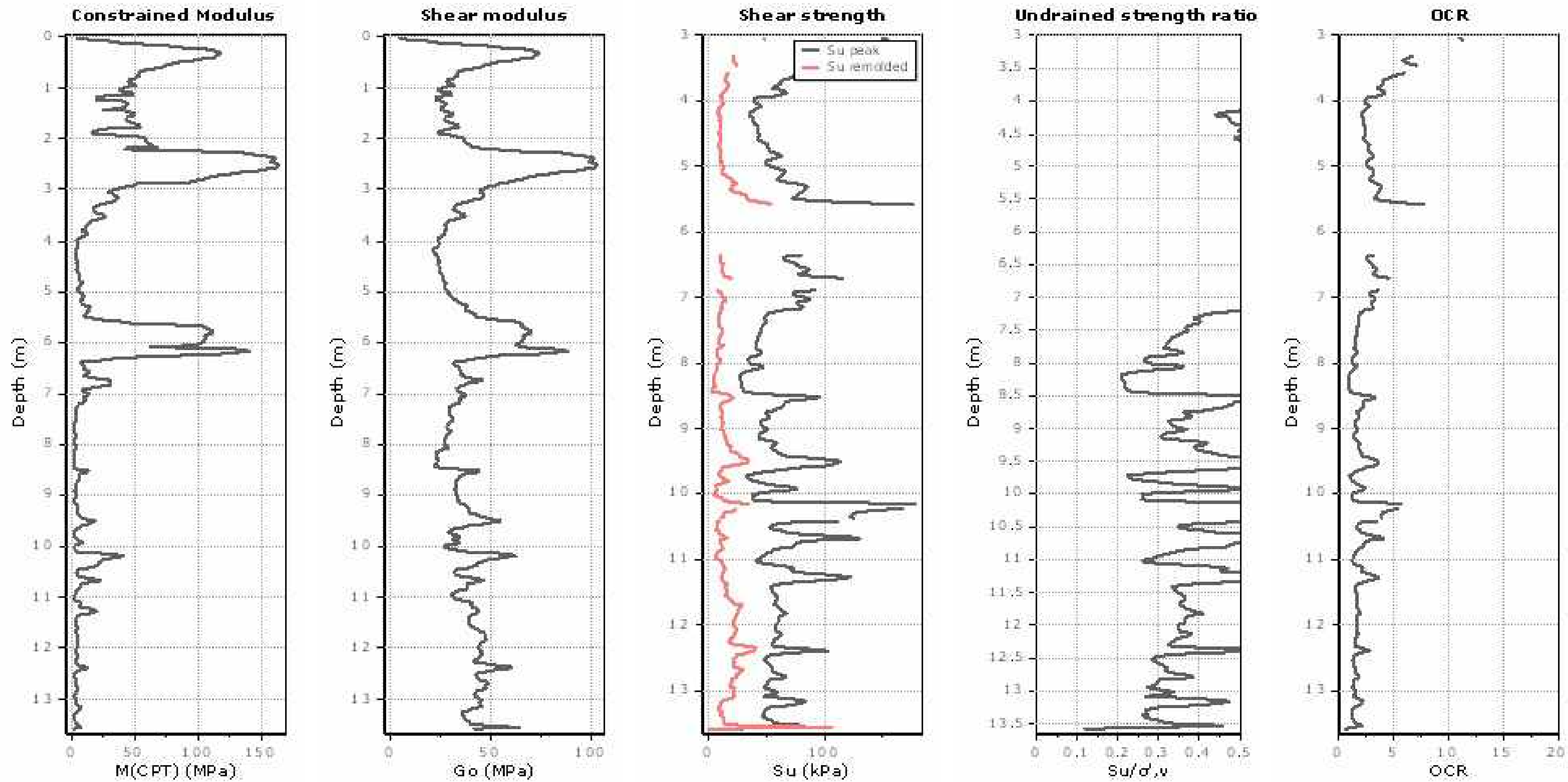

Calculation parameters
Constrained modulus: Based on variable alpha using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable alpha using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14

OCR factor for clays, N_{kt}: 0.33
User defined estimation data
Flat Dilatometer Test data

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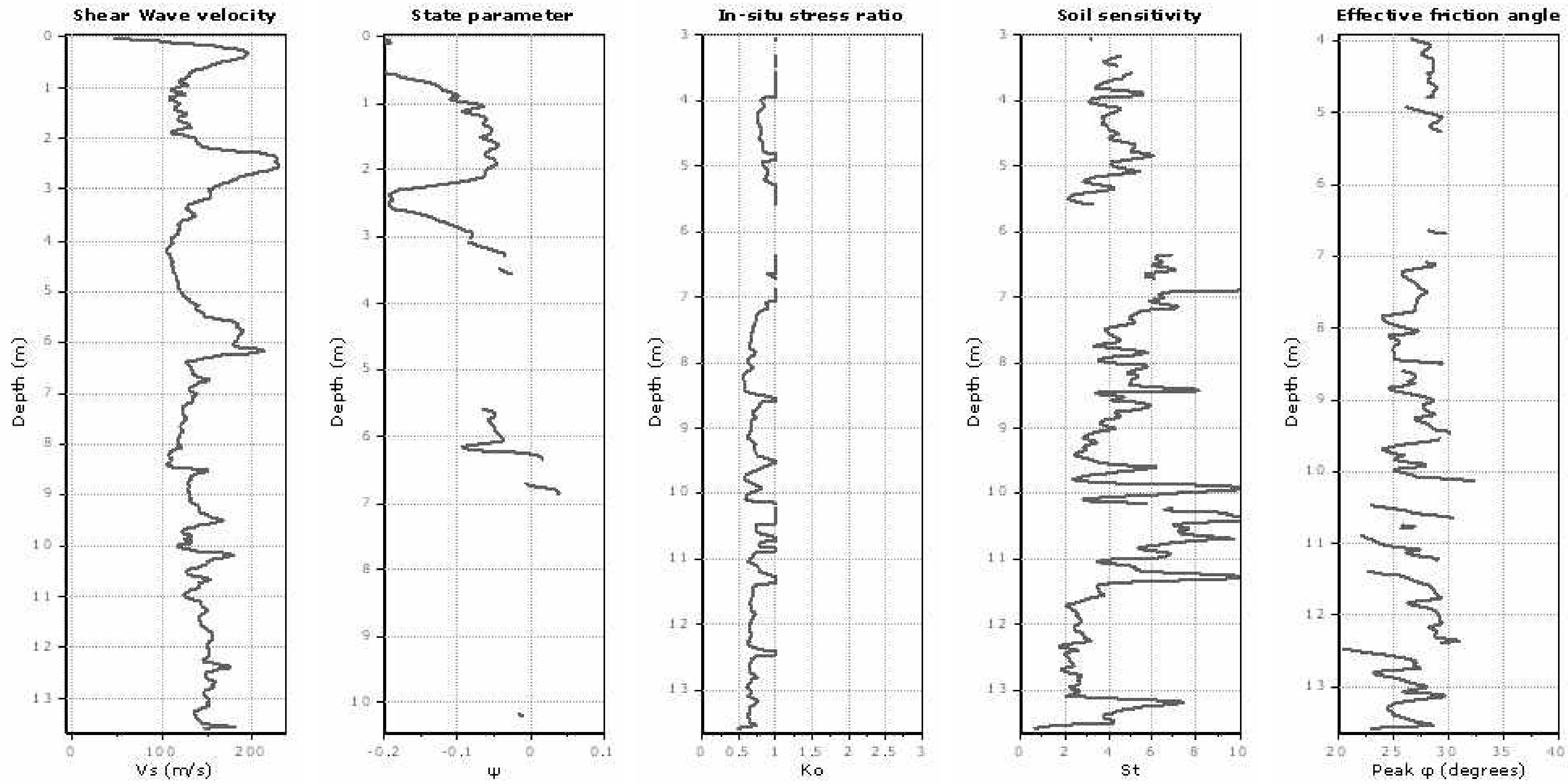
CPT: KP CPT06
Total depth: 13.64 m, Date: 4/09/2020
Coords: lat 305830.3° lon 6879972.3°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

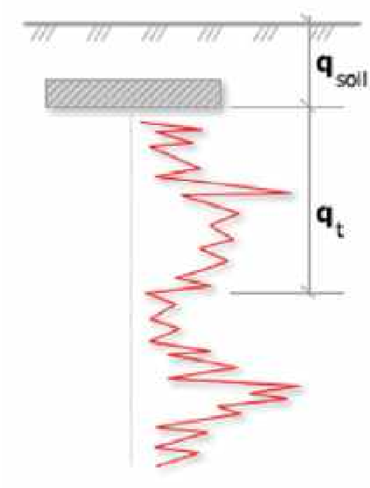
Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**



Calculation parameters

Soil Sensitivity factor, N_S: 7.00

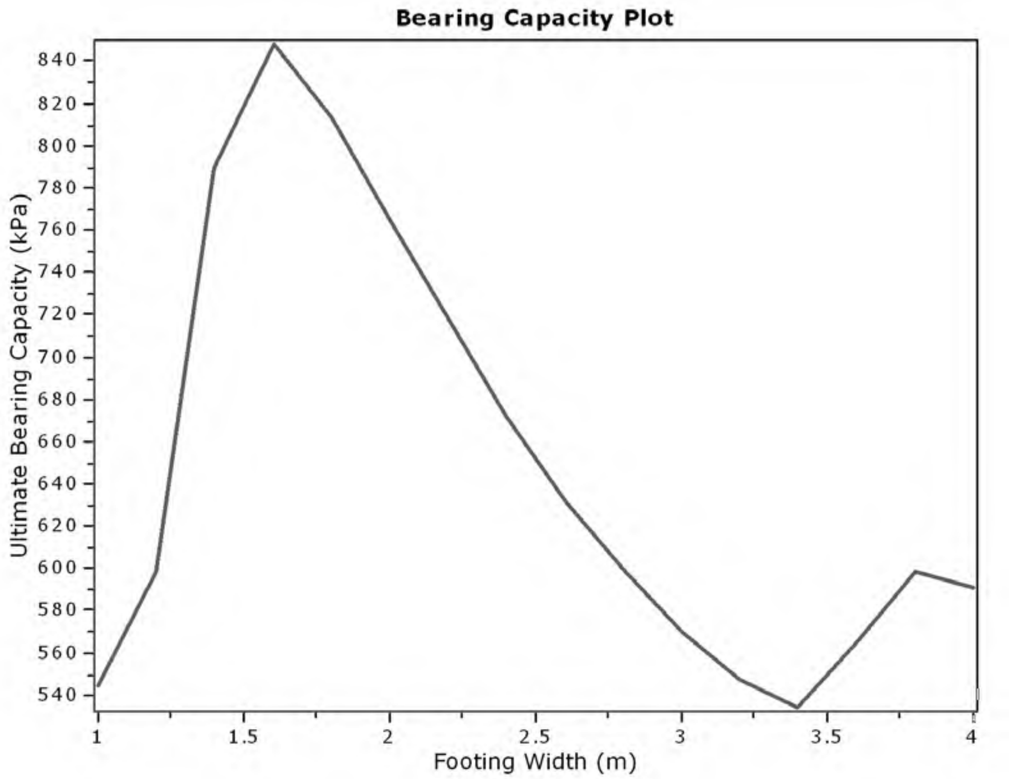
User defined estimation data



Bearing Capacity calculation is perfromed based on the formula:

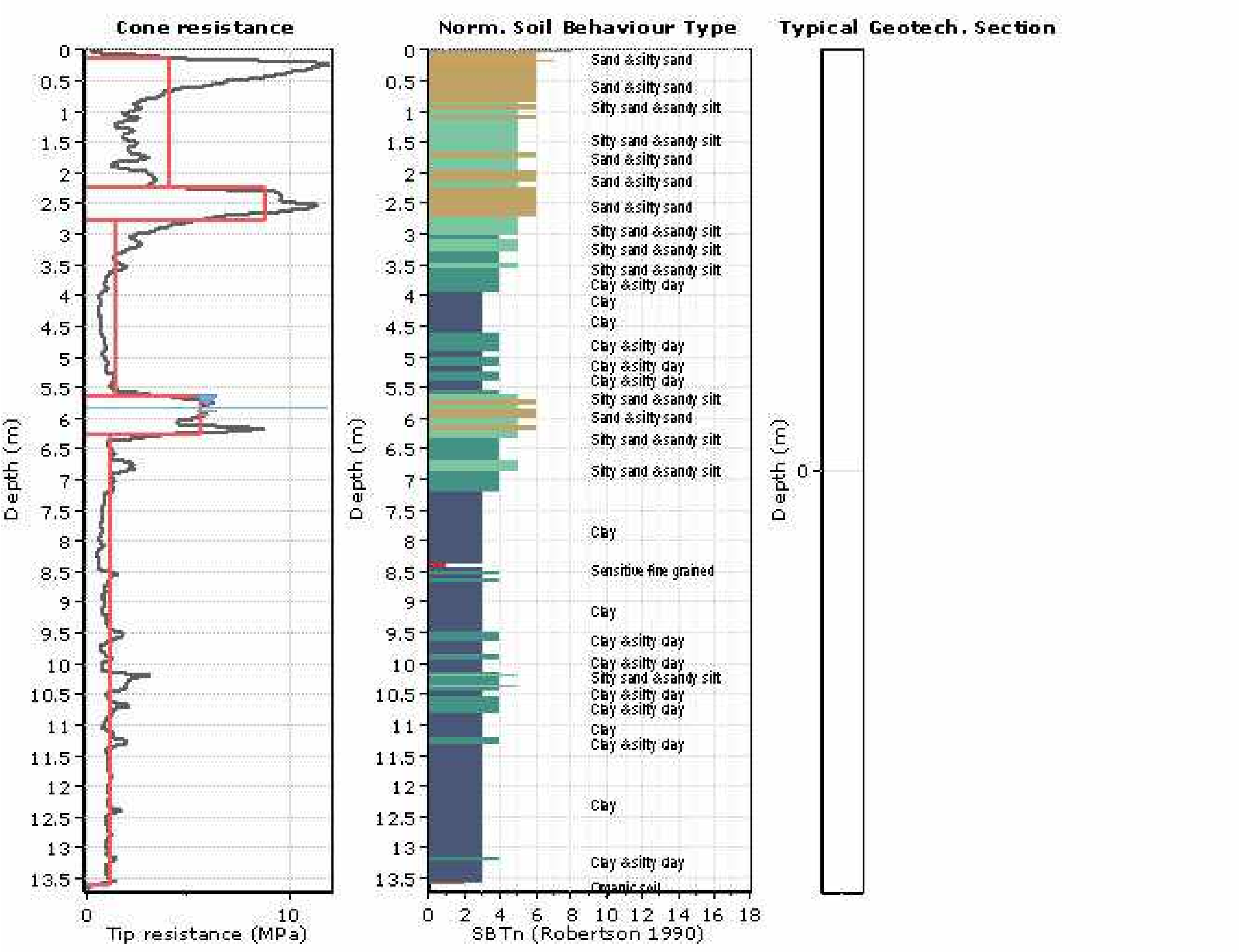
$$Q_{ult} = R_k \times q_t + q_{soil}$$

where:
R_k: Bearing capacity factor
q_t: Average corrected cone resistance over calculation depth
q_{soil}: Pressure applied by soil above footing



:: Tabular results ::

No	B (m)	Start Depth (m)	End Depth (m)	Ave. q_t (MPa)	R_k	Soil Press. (kPa)	Ult. bearing cap. (kPa)
1	1.00	0.50	2.00	2.68	0.20	9.50	544.56
2	1.20	0.50	2.30	2.94	0.20	9.50	597.96
3	1.40	0.50	2.60	3.90	0.20	9.50	789.11
4	1.60	0.50	2.90	4.19	0.20	9.50	848.01
5	1.80	0.50	3.20	4.02	0.20	9.50	812.70
6	2.00	0.50	3.50	3.78	0.20	9.50	764.95
7	2.20	0.50	3.80	3.54	0.20	9.50	718.12
8	2.40	0.50	4.10	3.31	0.20	9.50	672.46
9	2.60	0.50	4.40	3.11	0.20	9.50	631.32
10	2.80	0.50	4.70	2.95	0.20	9.50	599.47
11	3.00	0.50	5.00	2.80	0.20	9.50	569.78
12	3.20	0.50	5.30	2.69	0.20	9.50	547.76
13	3.40	0.50	5.60	2.62	0.20	9.50	534.08
14	3.60	0.50	5.90	2.78	0.20	9.50	565.08
15	3.80	0.50	6.20	2.94	0.20	9.50	598.43
16	4.00	0.50	6.50	2.91	0.20	9.50	590.98



Tabular results

.:: Layer No: 1 ::.

Code: Layer_1 **Start depth:** 0.10 (m), **End depth:** 2.24 (m)

Description: Sand & silty sand

Basic results

Total cone resistance: 3.96 ±2.90 MPa

Sleeve friction: 40.00 ±35.19 kPa

Ic: 1.97 ±0.26

SBT_n: 6

SBTn description: Sand & silty sand

Estimation results

Permeability: 6.08E-05 ±1.59E-04 m/s

N_{60}: 9.57 ±5.15 blows

Es: 29.62 ±11.32 MPa

Dr (%): 52.85 ±22.39

φ (degrees): 37.75 ±3.93 °

Unit weight: 19.00 ±0.00 kN/m³

Constrained Mod.: 56.00 ±25.13 MPa

Go: 37.12 ±14.19 MPa

Su: 0.00 ±0.00 kPa

Su ratio: 0.00 ±0.00

O.C.R.: 0.00 ±0.00

.:: Layer No: 2 ::.

Code: Layer_2 **Start depth:** 2.24 (m), **End depth:** 2.76 (m)

Description: Sand & silty sand

Basic results	Estimation results	
Total cone resistance: 8.81 ±1.84 MPa	Permeability: 1.32E-05 ±5.79E-06 m/s	Constrained Mod.: 143.59 ±20.04 MPa
Sleeve friction: 130.19 ±30.21 kPa	N_{60}: 22.56 ±3.86 blows	Go: 89.98 ±12.56 MPa
Ic: 1.93 ±0.07	Es: 71.80 ±10.02 MPa	Su: 0.00 ±0.00 kPa
SBT_n: 6	Dr (%): 62.26 ±6.61	Su ratio: 0.00 ±0.00
SBTn description: Sand & silty sand	φ (degrees): 40.24 ±1.13 °	O.C.R.: 0.00 ±0.00
	Unit weight: 19.00 ±0.00 kN/m³	

.:: Layer No: 3 ::.

Code: Layer_3 **Start depth:** 2.76 (m), **End depth:** 5.60 (m)

Description: Clay & silty clay

Basic results	Estimation results	
Total cone resistance: 1.40 ±1.00 MPa	Permeability: 2.69E-07 ±7.00E-07 m/s	Constrained Mod.: 17.48 ±20.70 MPa
Sleeve friction: 22.00 ±15.71 kPa	N_{60}: 5.62 ±2.72 blows	Go: 33.40 ±10.89 MPa
Ic: 2.76 ±0.26	Es: 0.00 ±0.00 MPa	Su: 63.25 ±25.06 kPa
SBT_n: 4	Dr (%): 0.00 ±0.00	Su ratio: 0.76 ±0.35
SBTn description: Clay & silty clay	φ (degrees): 0.00 ±0.00 °	O.C.R.: 3.49 ±1.61
	Unit weight: 19.00 ±0.00 kN/m³	

.:: Layer No: 4 ::.

Code: Layer_4 **Start depth:** 5.60 (m), **End depth:** 6.26 (m)

Description: Silty sand & sandy silt

Basic results	Estimation results	
Total cone resistance: 5.52 ±1.21 MPa	Permeability: 4.68E-06 ±2.76E-06 m/s	Constrained Mod.: 102.91 ±22.22 MPa
Sleeve friction: 42.09 ±11.09 kPa	N_{60}: 15.74 ±2.38 blows	Go: 68.22 ±7.59 MPa
Ic: 2.10 ±0.12	Es: 54.43 ±6.05 MPa	Su: 0.00 ±0.00 kPa
SBT_n: 5	Dr (%): 37.57 ±4.15	Su ratio: 0.00 ±0.00
SBTn description: Silty sand & sandy silt	φ (degrees): 34.54 ±0.78 °	O.C.R.: 0.00 ±0.00
	Unit weight: 19.00 ±0.00 kN/m³	

.:: Layer No: 5 ::.

Code: Layer_5 **Start depth:** 6.26 (m), **End depth:** 13.58 (m)

Description: Clay

Basic results	Estimation results	
Total cone resistance: 1.12 ±0.45 MPa	Permeability: 3.61E-08 ±1.67E-07 m/s	Constrained Mod.: 7.08 ±8.15 MPa
Sleeve friction: 14.98 ±8.57 kPa	N_{60}: 5.76 ±1.44 blows	Go: 37.67 ±7.85 MPa
Ic: 3.06 ±0.24	Es: 0.00 ±0.00 MPa	Su: 62.01 ±23.50 kPa
SBT_n: 3	Dr (%): 0.00 ±0.00	Su ratio: 0.42 ±0.17
SBTn description: Clay	φ (degrees): 0.00 ±0.00 °	O.C.R.: 1.96 ±0.80
	Unit weight: 19.00 ±0.00 kN/m³	

Summary table of mean values

From depth To depth (m)	Thickness (m)	Permeability (m/s)	SPT_{N60} (blows/30cm)	E_s (MPa)	D_r (%)	Friction angle	Constrained modulus, M (MPa)	Shear modulus, G_O (MPa)	Undrained strength, S_U (kPa)	Undrained strength ratio	OCR	Unit weight (kN/m³)
0.10	2.14	6.08E-05	9.6	29.6	52.8	37.7	56.0	37.1	0.0	0.0	0.0	19.0
2.24		(±1.59E-04)	(±5.1)	(±11.3)	(±22.4)	(±3.9)	(±25.1)	(±14.2)	(±0.0)	(±0.0)	(±0.0)	(±0.0)
2.24	0.52	1.32E-05	22.6	71.8	62.3	40.2	143.6	90.0	0.0	0.0	0.0	19.0
2.76		(±5.79E-06)	(±3.9)	(±10.0)	(±6.6)	(±1.1)	(±20.0)	(±12.6)	(±0.0)	(±0.0)	(±0.0)	(±0.0)
2.76	2.84	2.69E-07	5.6	0.0	0.0	0.0	17.5	33.4	63.2	0.8	3.5	19.0
5.60		(±7.00E-07)	(±2.7)	(±0.0)	(±0.0)	(±0.0)	(±20.7)	(±10.9)	(±25.1)	(±0.3)	(±1.6)	(±0.0)
5.60	0.66	4.68E-06	15.7	54.4	37.6	34.5	102.9	68.2	0.0	0.0	0.0	19.0
6.26		(±2.76E-06)	(±2.4)	(±6.1)	(±4.2)	(±0.8)	(±22.2)	(±7.6)	(±0.0)	(±0.0)	(±0.0)	(±0.0)
6.26	7.32	3.61E-08	5.8	0.0	0.0	0.0	7.1	37.7	62.0	0.4	2.0	19.0
13.58		(±1.67E-07)	(±1.4)	(±0.0)	(±0.0)	(±0.0)	(±8.2)	(±7.9)	(±23.5)	(±0.2)	(±0.8)	(±0.0)

Depth values presented in this table are measured from free ground surface

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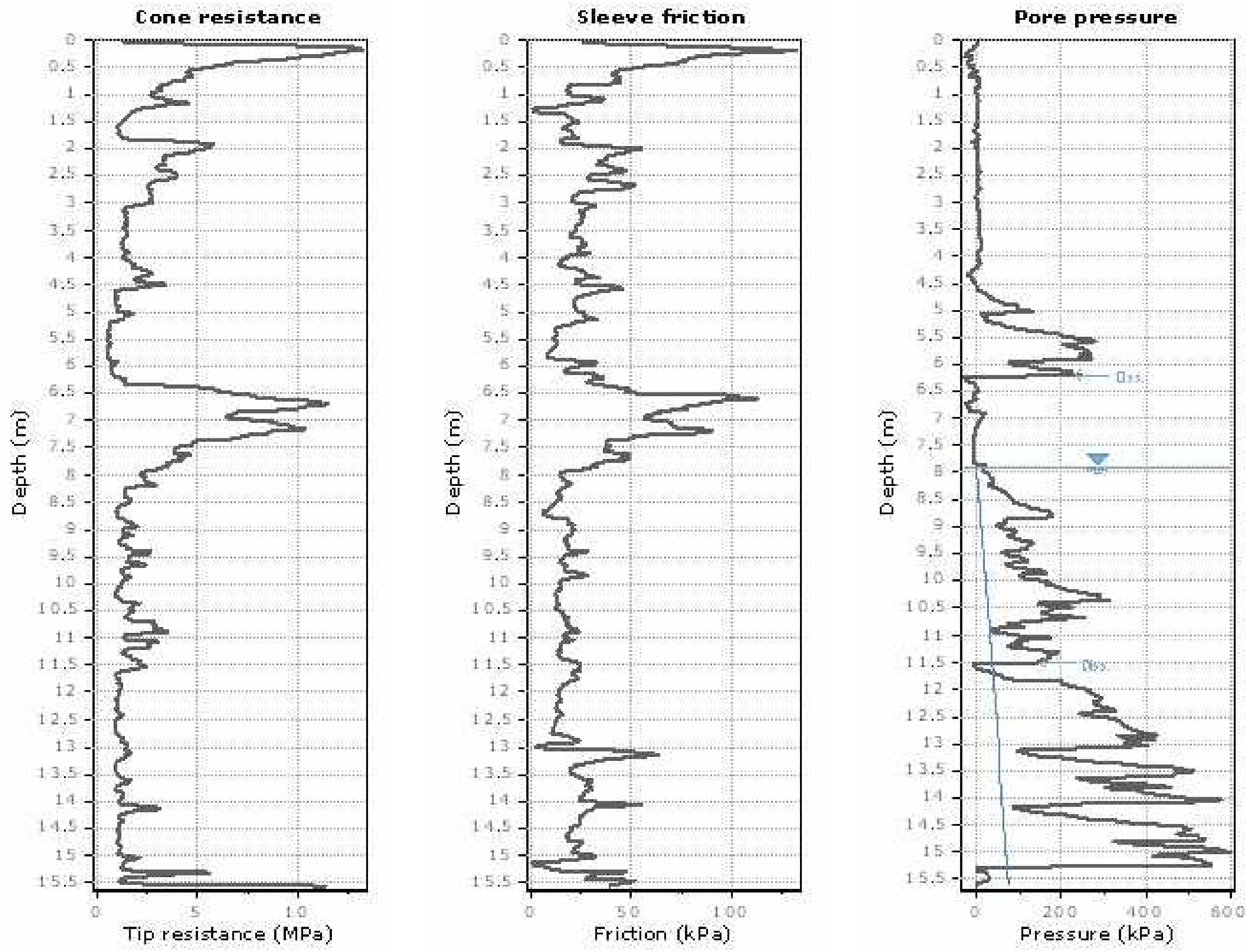
CPT: KP CPT07A
Total depth: 15.64 m, Date: 5/09/2020
Coords: lat 305898.1° lon 6879692.3°
Cone Type: 180911
Cone Operator: Hagstrom Drilling

Project: **Thunderbox Gold Mine**
Location: **Leinster, Western Australia, Australia**



The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).